TU Dortmund University

Towards Resilience

Adopting Local Knowledge in Rural Landscape Planning

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Abstract

The frequency of extreme weather events increases as climate change. Rural settlements are affected by various natural hazards induced by climate abnormality. As a system, rural settlements have the capability to resist, response, and recover from the external changes. This capability is regarded as system resilience. Enhancing rural system resilience is one orientation of rural planning work. One thorny problem in conducting rural planning is the lack of scientifically recorded data.

From the other side, rural residents boast local knowledge which has been inherited through generations. This research collects local knowledge related to land management and disaster prevention, elucidates the preservation status of local knowledge, testifies the correctness of local knowledge, and analyses how local knowledge influences settlement system resilience.

Through literature research, fieldwork and on site survey, this research collected local knowledge and traced its evolution. The local residents in Chongqing rural region practice terraced rice field cultivation facilitated with a gravity irrigation system of Yantang. There are also Fengshui forests preserved from exploitation. The local knowledge about land management changes with time. Local knowledge about natural hazard prevention is compared with SWAT model simulation results and official records to testify the correctness. Since the accuracy of simulation is hindered by the insufficient data, local knowledge is superior to simulation results in the research region. The accuracy of local knowledge about the date when natural hazards happened is higher than that of the simulation result, so as the accuracy of the maximum water level during the previous floods. Local knowledge still contains the keen observation of the natural setting changes, and is applicable for predicting natural hazards and making contingency plans.

Instructed by local knowledge, settlements apply different land use strategies and result in the divergence of system resilience. Since local knowledge has evolved in different directions, settlement resilience change accordingly in good way or bad way. The dissemination of local knowledge mainly depends on the social network of neighbors, relatives and local governors. But because of the disintegration of such social relationships caused by village hollowing and urbanization, the dissemination of local knowledge is hampered. The possessors of local knowledge are easily affected by foreign and new information. As a result, in some extreme cases, local knowledge is gradually forgotten and replaced by modern science and knowledge. This research suggests that the rural planning towards resilience to learn from local knowledge through its trails and fails, and urge the development of local knowledge alongside with modern science and technology.

Key words: local knowledge; resilience; natural hazard

Declaration

I hereby declare that this doctoral dissertation, entitled "Towards resilience: Adopting local knowledge in rural landscape planning", is the result of my independent investigation and it has been generated by me as the result of my own research. Where it is indebted to the work of others, acknowledgements have duly been made.

Zhao Li
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Chapter 1 INTRODUCTION TO THE STUDY

1 Introduction

Climate change and natural hazards have imposed major threats on urban and rural area around the world. The Intergovernmental Panel on Climate Change (IPCC) has reported climatic problems occurring across the world, including sea-level rise, increased intensity of droughts and floods, higher frequency of heat and cold waves, and melting glaciers in the first decade of the 21st century (IPCC, 2014). Environmental changes are observed in three aspects: water resource, food availability, and ecosystem. But it is also common that a small change of one meteorological factor imposes impact on all three aspects, due to the sophisticated consecutive effects in the environment.

Climate change causes a variety of sequential phenomenon in different regions. The precipitation increased in mid-latitude land areas of the Northern Hemisphere (IPCC, 2014). There is abundant of evidence on a general decrease of agricultural productivity in certain regions, in accordance with precipitation changes (IPCC, 2012; People's Daily, 2012; IPS, 2013). The increasing frequency of extreme weather events also leads to the decline of agricultural yield. Thus climate changes not only impose geophysical deteriorates, but also foster a threat of living substance shortage. Smallholders, self-subsistence farmers and fishers who reside in rural regions suffer most from those complex and localized negative impacts. Their living environment can be regarded as a human settlement system, within which the system itself could adapt to the changes and maintain its normal functionality. When exceed the threshold, both the direct and indirect effects of climate change might cause a gradual failure of the entire system.

In history, people have always been interacting with the nature. People are observant to the environment in which they reside. Their knowledge suggests appropriate ways to utilize natural resources, and how to cope with climate abnormality induced natural hazards. As climatic problems aggravate in the recent years, urban and rural planning theories started to aim at improving human settlement's adaptability to natural hazards. The fast development of modern technology supports new planning approaches. New approaches are based on multi-disciplinary information analysis. For the landscape planning aiming at mitigating and adapting to climate changes, observation data and statistics are the foundation for rational decisions. However, in developing countries or remote areas, the lack of scientific data has become a common situation. It still requires enormous monetary and human capacity investment to establish databases. Under this circumstance, can local knowledge supplement the insufficient data, so that better rural plans can be worked out?

In this research, human settlements, in particular small scale residential clusters, villages and towns, are studied as settlement systems. Individual settlement system has intrinsic capability to cope with external changes, including climate change, natural hazards, human conflicts, and other crisis triggered by human activities. This intrinsic capability is generally studied as system vulnerability, adaptability, or resilience. According to previous studies, many indicators decide system's resilience. In rural regions, land use pattern, the economic status of a settlement, and disaster prevention strategies are still largely determined by local knowledge, aside from official governance. Those factors are identical with the indicators of system resilience. Therefore, local knowledge shows its influence on system resilience. To what extent, and in which way local knowledge would affect system resilience, is also to be explored in this research.

Chapter 2 LITERATURE REVIEW

2 Theoretical Background

2.1 Settlement as a System

A town or a village can be regarded as a system. An instinctive interpretation of *human settlement system* by anthropologists is the social interrelationships among individuals within a specific social group. By social group, they refer to villages, towns, cities, and their external relations with other social groups. Ecologist from a professional perspective generally chooses *ecosystems* as research subject, in order to confine the research from the spatial demarcation induced by social-economic factors. In the trend of multi-disciplinary study, provident landscape planning theories define their research subject in a more comprehensive way.

Settlement has its own "life", as it was analogically interpreted by Christopher Chase-Dunn, advocator of world-system theory in 2005, by using the term "metabolism of settlement". This is not a new notion in the discipline of urban planning. The concept of urban metabolism can be traced back to the 1930s, when a city is perceived as a stable system for the first time. As early as 1965, Abel Wolman (1965) established a quantitative model based on the concept of urban metabolism for the first time. He focused mainly on the circulation of clean water and sewage, considering the living environment deterioration of American cities in the 1960s. The theories about urban system keep evolving and reforming for over 80 years. Many branch theories and hypothesis contributed to the prosperity of contemporary urban system study. From the other side, a rural settlement can be regarded as a primitive form of a city, or a simplified version of a city. It is helpful to set up a rural system in order to have a rational understanding of some issues, for instance, how a rural community is operated, how the residents exploit and utilize natural resources, how a rural community reacts to negative environmental changes, etc.

2.1.1 Urban System

As the urban system has been thoroughly studied, the research about urban system provides clue for the study on rural system, Before the WWII, Christaller (1933) and Lösch (1940) published their Central Place theory, which is universally acknowledged as the origin of urban system notion (Coffey, 1998). Later in the 1960s and 1970s, numerous economists and geographers contributed to the improvement and refinement of the Central Place theory. Their work marked the full establishment of urban system studies. In this primitive phase of urban study, urban hierarchy and the interactions between different urban settlements were predominant research directions (Coffey, 1998). Crisis raised, discussing whether the urban system study regard the city itself as the research object, or the integration of a city and its natural environment settings. Since the 1970s, technology and methodology of urban research significantly improved. Studies on specific issues, to solve the various specific problems in the city, sprung up. Urban metabolism and urban ecology fast developed, as increasing conflicts between human and nature were brought by industrialization. In energy and material flow study, entropy models were popularized after the publishing of "Entropy in Urban and Regional Modeling" (Wilson, 1974). The entropy concept is therefore attached with various interpretations in different field of studies. In the 21st century, bottom-up approaches are adopted in urban study. The connotation of bottom-up analysis contributes to the study of urban growth. One of the most frequently applied methods is the discrete model of cellular automaton, built on the Geographic Information System (GIS), and supported by GIS extension programs. To date, urban systems study covers too wide a spectrum that confusions might occur when clarifying the boundaries of each branch of study.

2.1.1.1 Central Place theory

Central Place theory is about the principles of human settlement hierarchy. It explains how the hierarchy of different settlement units (centers) is formulated, while each settlement unit is provided with similar primitive settings. To simplify the setting, factors such as topography, history and climate were excluded from the simulation. Focus was put on the variables in three dimensions, namely the marketing, transportation and administration. Central Place theory shows the impacts of economy, infrastructure, and policy on the pattern of settlement hierarchy, rather than the exact geographical distribution of rural settlements. While the economic status, political environment and infrastructure of a settlement reflect mainstream local knowledge.

Central Place theory was developed based on a series of assumptions. A settlement, or a center, is a functional unit. In this model, settlements evenly distribute on a homogeneous imaginary surface. All settlements are equidistant in a triangular lattice pattern. Population and resources are also evenly distributed. To simplify the transportation factor, the model applies distance decay mechanism. Each center has a threshold, within which the settlement is able to provide goods and service for itself. The range indicates the distance consumers are willing to travel, as they purchase goods and services from other centers (Fig. 2.1). The distance cost is directly proportional to the distance between the threshold and range. In general, distance cost exceeds the demand for goods outside the range. In the model, all sellers are in perfect competition, and pursue maximum profit. Consumers share identical purchase behavior and demand for products.

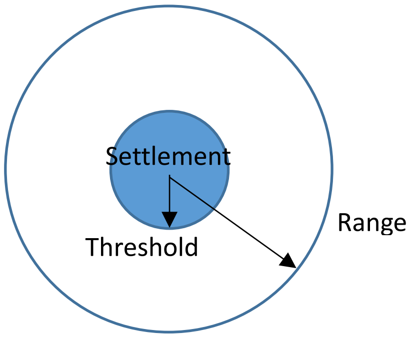

Figure 2.1 Illustration of the threshold and range of one settlement

According to the assumption, the configuration of settlement, including population, resource, productivity, threshold and range and so on, is represented by geometric features. That is to say, the default settings confine variables to geometric features, so that geometric algorithm can be applied for modeling. Given a minor variation in resource distribution at the beginning of modelling, the stable state of the system would soon be disrupted accordingly. Modelling results in a system of settlements of different sizes, or at different level of hierarchy.

Christaller (1933) deduced three patterns of settlement systems, subject to marketing, transportation and administrative principles, respectively. K-value represents the number of settlements influenced by a consecutive higher-order settlement.

The marketing principle influenced system (K=3) resembles the market-centered rural region (Fig. 2.2). Each marketing center serves two consecutive lower hierarchy settlement and the one itself. In this system, the travelling distance is minimized, but travel efficiency is not the optimal, as there is no direct routine between marketing centers of higher level of hierarchy. Marketing principle shall be applied in the regions, where the market determines system development.

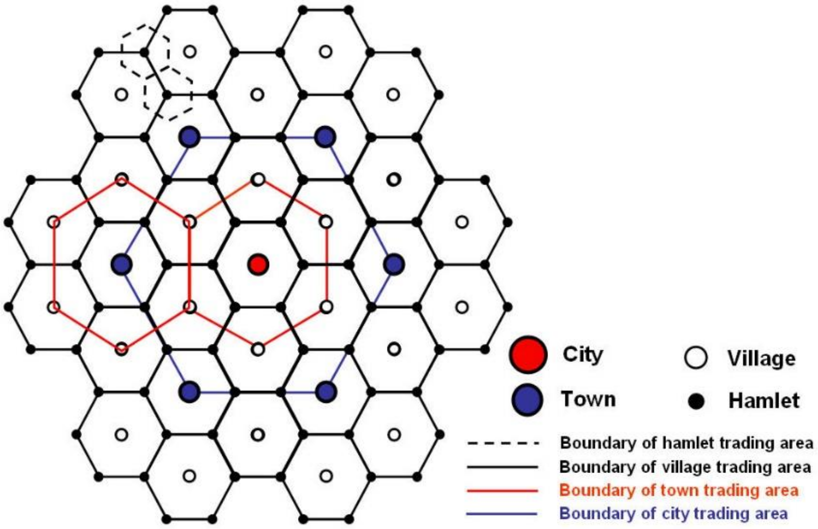

Figure 2.2 Market oriented system

Reference: http://cronodon.com/images/CentralPlace5.jpg

The transportation principle (K=4) ensures the configuration of a most efficient transport network (Fig. 2.3). Each marketing center comprises a half of the marketing area of six adjacent lower-order settlements and its own. The maximum settlement, most possibly locates in the center of the system, is directly connected with consecutive lower-order settlements. This pattern resembles the situation in newly-founded development areas and transit oriented development region. In the densely populated industrial regions, the principle of transportation overweighs that of marketing.

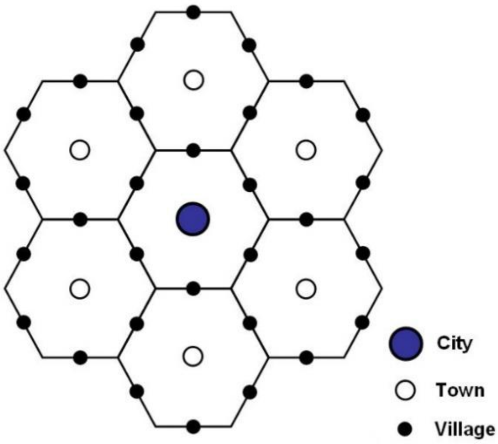

Figure 2.3 Transportation oriented system

Reference: http://cronodon.com/images/CentralPlace6.jpg

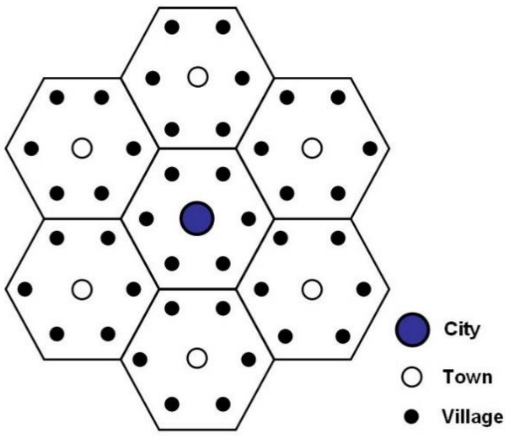

Figure 2.4 Administration oriented system

Reference: http://cronodon.com/images/CentralPlace7.jpg

The central marketing center completely encloses seven lower-order settlement according to the administrative principle (K=7) (Fig. 2.4). This principle is applicable in the regions where administrative power denies its subordinate settlements to be "shared" with other systems. Similar situation also exists in the remote regions where the entire system is isolated from other urban systems.

These three principles lead to the configuration of urban hierarchy. Christaller leveled the hierarchy based on the number of subordinate settlements which belong to one higher-order settlement. The five levels are metropolis, city, town, village and hamlet, respectively.

Central Place theory illustrates the patterns of settlement hierarchy. Given simplified assumptions, it deduced how the principles of marketing, transportation and administration shape the settlement system. Though Central Place theory is based on the data drawn from field research in the Southern Germany, the model is still criticized to be static and unrealistic, as the assumptions deviate from actual situation (Veneris, 1984; Openshaw, Veneris, 2003).

Central Place theory is conceived to be better applicable in agricultural areas instead of industrial or post-industrial areas. The three principles are helpful to understand the configuration of agriculture dependent settlements, say, villages and towns. It helps to reveal the relationship among villages and towns, and hence the dissemination pattern of local knowledge within certain rural region.

2.1.1.2 Dynamic central place theory

Scholars elaborated the Central Place theory in the following 30 years. Focus was still on the interactions between rural settlements or cities, rather than the interactions between the human settlement and the nature. In the 1970s, scholars proposed a dynamic central place theory (White, 1974; Allen, Sanglier, 1979), as a refinement of the original "static" one. In this theory, they shifted their focus from the abstracted geometric features of central places, to the dynamic growth patterns of each settlement in the system. The research object of dynamic central place theory is the behavior of each settlement during the formation of settlement system.

In the dynamic central place theory, a paradigm of growth is assigned to individual settlement. The size of a “center place” could be calculated, with the input parameters of growth, revenue and cost functions (White, 1977). White’s simulation model is driven by the difference in the profit of each settlement. The location of settlement is fixed, but the initial sizes of the settlements are not necessarily identical. Revenue is calculated based on a gravity equation, or an exponential equation. In these two interaction equations, a range of parameter N (the distance exponent) values are input to calculation. Parameter N is in positive correlation with distance. The transition zone of high and low value N is analyzed considering the initial settings of center distribution and interaction equation. Simulation result presents the state of settlement system, when it reaches an equilibrium position.

The interaction equation is the core of this model. Parameter N largely determinates simulation results. Results show, that in both interaction equations, given high components of N, the size of a settlement is decided by the distance between the settlement and its neighbors; given low N exponent, the major determinant of settlement size is the distance between the settlement and the geometric center of the entire region. When the influence of economic factors is considered, some remote settlements will eventually disintegrate. For high exponents value N, settlements tend to evenly distribute in a region, and end up in similar size (multi-center pattern), while for low exponents of N, few large settlements locate in the middle of a region (mono-center pattern). To some extent, calculation result indicates that the pattern of settlement system is determined mainly by the initial extent of discretion of the settlement, and the scale of the system. The introduction of Parameter N and the transition zone, contribute to a new interpretation about the definition for a settlement system. In the case of high value N, the multi-center region could be perceived as an aggregation of several mono-center systems with low value N. Thus individual mono-center system could be perceived as the basic unit of settlement system. This assumption is yet to be tested.

Dynamic central place theory illustrates how centers grow or demolish, given more plausible assumptions in market and transportation principles. It starts with a set of chaotically arranged settlements, and ends in an equilibrium state. It should be noted, that the limitation of productivity and resources were not considered as a parameter, throughout the evolution of central place theory (Allen, Sanglier, 1979). Dynamic central place theory provides a new perspective to analyze the growth or recession of settlements in the research region. To some extent, it resembles a process, during which the randomly emerged settlements are screened out, and only the ones with advantaged geographical location, preferable transportation accessibility remained, while the appropriate location and good transportation represent well-applied local knowledge.

2.1.1.3 Urban metabolism

In another branch of urban study, the focus shifts from the hierarchy (system) of settlements to an individual settlement (urban system). Urban metabolism is based on the assumption, that a city has its own energy flow and material flow, resembling a biological organism. Urban metabolism emphasizes the interrelationship between the society and nature, in order to study the material and energy flow of an individual city. In the 21st century, urban metabolism was given the definition of "the sum total of the technical and social-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy et al, 2007).

The origin of urban metabolism dates back to the Marx's sociology (1867). In his theory, metabolism is driven by capital flows, and reflected in the transformation of the nature as well as the human society. Through physical labor, human beings acquire living substances, and at the same time change the biophysical conditions of the nature, which in return affects human livelihood. As Foster (2000) stated, metabolism is the foundational concept underpinning Marx's interpretation of human-nature relationship as the mutual interaction through human activity.

The concept of urban metabolism then evolved into two branch subjects, the material flow analysis inspecting the material and energy flux (Barles, 2009); and the Emergy method which sees the metabolic flows by measuring the solar energy involved in the system (Odum, 1983). Abel Wolman (1965) tested the fundamentals of urban metabolism of the material flow in a quantitative approach. He calculated the inputs and outputs of material of a hypothetical American city with the population of one million. In his experiment, emphasis was put on the capacity of the nature to supply an expanding city. While Odum's Emergy method is more ecology biased, and difficult to integrate socio-economical parameters and biophysical parameters (Alberti, 1999), the approach of energy-material flux became the mainstream of urban metabolism, as it is more comprehensive and easier to practice by urban researchers.

One essential concept in urban metabolism research is the *threshold*, or *carrying capacity* of the natural environment, conventionally used to evaluate system sustainability. Since the theory of urban metabolism fast evolved in the context of industrialization, *sustainability* became the top priority of all issues in the discipline of urban planning. Models of urban metabolism were widely utilized to examine the energy and material budget, or in other words, the "sustainability" within an existing urban system or neighborhood (Kennedy, 2010). The energy-material flux can be clearly illustrated through modelling, so that urban planners are able to make corresponding adjustments, in order to stop a city system from exceeding the carrying capacity of the environment. Considering the specific conditions of particular urban systems, the model should additionally include the factors which are likely to impose significant influence, for instance, the population living in urban villages.

Contemporarily, the inner fluctuations and their effects on an urban system are studied in urban researches, as well as the inter-relationship between the external environment and the urban system. For the study about nature-urban relation, there are still unsolved problems in data integration and uncertainties in defining the scale of analysis (Pincetl et al., 2012). For more sophisticated natural processes, interdisciplinary cooperation is still required, in order to improve the urban metabolism framework.

To conclude, urban metabolism is a study concentrating on the mutual interaction between an individual city and its surrounding natural environment. A city or community is compared to a biophysical organism, which consume, transform, and release matter and energy. Models are established to investigate the energy and material flux of the urban system. Modeling results reveal whether a system is sustainable or not. This research perceives the human settlement and its natural environment together as a rural settlement system. The study of urban metabolism helps people to understand the interaction between an individual human settlement and the natural environment. Specifically, this research puts emphasis on the recovery of a settlement from physical destruction. Urban metabolism sheds light upon the energy flow and material flow during the process of reconstruction.

2.1.2 Rural Settlement System

The literal meaning of a rural area is the geographical region outside cities. However, it provides little specific characteristics of rural area its own. Another credible but perception-based definition, is even obscurer. Rural settlement is where most residents think of as it is (Thorburn, 1971). Researches based on this kind of definition reveal essential components of rural area by investigating people's mental cognition. According to those studies, rural region in the common sense is a place with the following features: lower population density; inconvenience transportation to modern cities; relies heavily on agriculture and attaches its specific emotional influence to people (Palmer et al., 1977). Though Palmer's investigation was launched decades ago, the conventional cognition of rural changed little. This cognition of a rural region is identical in China. In Chinese language, rural region writes "*农村*", the first Chinese character indicates agriculture, and the second means the human settlement with wooden buildings. The conjunction noun *农村*, refers to the human settlements and the agricultural land they attach to. Even in the modern times villages and towns resemble cities in many aspects, the understanding of rural settlements does not change much.

Reviewing urban system studies, three major categories can be divided based on the research subjective. The majority of urban system studies confine on the city itself, separated from natural environment. They focus on a single, or a limited number of factors affecting the operation of an urban system. A second category of urban study regards urban system as an individual human settlement together with its subordinate (or supporting) environment. The third, with the representative of the central place theory, focuses on a larger-scale system consisted of numerous human settlements. Compared with cities, rural settlements, including informal household clusters, villages, and un-urbanized towns have less complexity in social, economic and cultural structure.

Villages are admittedly more dependent on the natural environment. The nature provides inhabitants living substances. The changes in natural environment undoubtedly affect the functionality of the system. The prevailing economy pattern of single agricultural product economy in villages and towns makes the system hard to recover from disastrous events, once agricultural activities are suspended. That is to say, the reliance on natural resources is the critical feature of a rural settlement system. From another point of view, this feature of rural system induces lurking perils.

Each town can be regarded as a developing, juvenile city, thus analog could be easier made to urban metabolism. The system functions as a precise organism within a dynamic equilibrium: the circulation of energy and material, and the counterbalance of economic profit and political power. A town assimilates goods and services from the nature and its adhering villages, transforms or stores them, generates waste discharge and releases the wastes back to the nature. The feature which distinguishes a relatively independent town center and other rural settlement systems is the extent of dependence on natural resources. In some town centers, a considerable proportion of the inhabitants has long been alienated to agricultural work, and given up their land use right. This indicates that the town centers are in an intermediate state between the pure agriculture dependent rural settlement, and the commodity supplied city.

Except from the dependence on material resources, rural inhabitants also have a psychological attachment to nature. People’s respect for specific mountains, rivers, plant and animal species is still unintentionally revealed in their daily life and in the communication with foreigners. Due to the close relationship between local people’s livelihood and nature, this research mainly adopts the research scope of the second category of urban system study, and perceives the organic aggregation of rural settlement and its adhering natural environment as a rural settlement system.

The Central Place theory and its expansion, the dynamic central place theory, provide theoretical bases to the distribution pattern of the settlements, as well as the hierarchy of settlements in rural region. There are evidences of existing settlement patterns subjected to the three principles of transportation, market, and administration. For instance, the market principle in Central Place theory is convinced by the villages located within one-hour walking distance of the rural markets around 500 years ago. The transportation principle explains the fact that the settlements located alongside highways stand have the longest history, and always larger in size than other settlements away from main roads.

The dynamic central place theory, on the other hand, sheds light upon the question, why villages and towns decay. In the model, centers decay because of negative revenue in the equations of population, distance/accessibility and cost. However, none of the existing models take the constantly changing productivity and people’s livelihood in consideration. While in reality, this factor has become rather decisive for the growth or decay of a settlement. The agriculture bund productive activities and economic structure would change. In some cases the farmland resources no longer restrict population distribution, especially for the working population in the rural area. The market centers within the rural region still attract population and goods, but their attraction is incompatible with the fortune and working opportunities provided by centers outside the rural region, say, the cities and metropolitan. The social phenomenon that villages and towns lost their residents, is generally referred by scholars as “rural hollowing”, and will be introduced in a separate section (8.3.1).

In the research region of Chongqing rural area, the reign authority does not always fall in accordance with the effective organization structure. A settlement system is not necessarily confined to the administrative boundary of the settlement. Confusions on the effective authorities are frequently inspected in the places where administrative boundaries have been adjusted. In some cases, the local inhabitants still cling to the executively abolished administration structure, instead of the newly organized ones. For those specific settlements, the authority structure is considered in defining the boundary. In this research, the focus lies on the capability of a system to cope with natural hazards. Land use category, land management strategy, and the environmental settings are the characteristics of a system, as well as the decisive indicators of system resilience. It is easier comprehensible, if the basic unit of rural settlement system could be characterized by such limited number of major features. This basic unit can be an organized production team in a village, with the farmland, forest, natural creek and residential area under its jurisdiction. A basic unit shall be distinguished from adjacent units by the differences in the major determinative factors mentioned above.

Regarded as an organism, a settlement system not only deals with the fluctuations within, but also the external stresses outside. Especially for the micro-scale system, in which the relationship between human and nature is the closest, how would such system response to external changes, would the system survive through?

2.2 Urban and Rural Resilience Theory

2.2.1 Resilience

Increasing frequency of droughts and floods, heat and cold waves is taking place in urban and rural regions alike. The abnormal precipitation intensity leads to reduction of agricultural productivity in most of the affected rural regions (IPCC, 2012). Droughts and floods resulted from unevenly distributed precipitation would further impose life threat and economic losses.

Urbanization also imposes significant influence on rural settlement systems. Rapid growing economy and ambitious development policy in China urges rural settlements to urbanize, whether prerequisites have been fulfilled or not. In many rural settlements, working force leaves their homes to seek for fortune and a new way of life in a city. It has become the most common phenomenon, in which villages are left only with young children and grandparents. As consequences, social-economic structure is destroyed, leading to an irreversible deterioration in a rural settlement system (Chan, 2010). This makes an example of external economy and policy change.

As external changes occur at an increasingly higher frequency, a large number of researches are launched, to explore settlements’ responses towards equilibrium-threatening disturbances. Settlements’ response to external disturbance can be divided in three major categories, based on the severity of consequences. In the first type of response, forces and pressures brought by disturbance are absorbed by the system. The system functions just the same as before, no significant impact is imposed. For instance, increased precipitation intensity results in a higher level of water level, while the river bank successfully holds the flood. This type of response can be found in most of the successful disaster prevention projects. In the second category, external disturbances impede normal functionality in a settlement system to some extent, but the system is able to recover to its previous state, or even better, to an optimized new state. This indicates that there is the possibility, that a disaster affected settlement system survives the negative consequences. There is a specific type of planning, the post-disaster planning, aiming at helping a settlement to recover from both direct and indirect damages caused by disasters. As worse come to worst in the third category of response, in which disturbance leads to a sudden or gradual dysfunction of the system, making it impractical to recover. For instance, in a severe landslide disaster, the settlement was buried by debris and it beyond the ability to rebuild. Local residents therefore have to resettle themselves.

Those three categories of responses correspond to Thomé Schmidt's classification of society's response to natural hazards, namely resistance, resilience, and retreat (Schmidt et al., 2008). This classification is based on the efficiency of actions or measures against disasters. Considering the dynamic within the system and the practical significance, it is reasonable to put emphasis on resilience.

The concept *resilience* originates from the subject of psychology in the 1940s, in a study of patients' competence when facing danger. As a paper about Project Competence (Garmezy, 1973) published in 1973, the word resilience was first introduced into academic world. In the same year, another predominant interpretation of resilience in the discipline ecology emerged. Ecologist Holling (1973) defined resilience as "the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state". The notion of resilience further influenced disciplines such as climatology, business and policy making, and became a key word in various research fields. For instance, resilience is perceived as a synonym of recover and resistance in engineering study (Folke, 2006). Climate resiliency has also been integrated in urban development studies (McEvoy, 2019). The most acknowledged and accepted definition is from the IPCC SREX report (2012). Resilience is the ability of a system to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner. Accompanied by the widespread of this notion, misinterpretations emerge, especially when translated and introduced in none English context. In the past decade, resilience planning was frequently confused with flexible planning (Yin, 2006), since in Chinese language those two phrases are translated exactly the same.

According to Walker and Salt (2006), the conceptual idea of resilience has long penetrated in urban and rural planning. It was not until the 21st century, when resilience planning was studied as an independent branch of planning study. By the same time, the study of rural resilience emerges as in analogy to urban resilience (Heijman et al, 2007). With other scholars, Holling then expanded their research range with human related factors. Research objectives shifted from ecosystem to socio-ecological systems (SESs). They synthesized three fundamental characteristics of SESs, resilience, adaptability and transformability, respectively (Walker et al., 2004). The term *resilience* was redefined in spatial planning context as "the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still remain essentially the same function, structure, identity, and feedbacks" (Walker et al., 2004). Another definition given by Renschler et al. (2010) interpreted resilience as a "function indicating the capability to sustain a level of functionality, or performance…over a period defined as the control time”. This definition provides landscape planners with an operational inspiration instead of conceptual understandings.

Just as contemporary landscape planning study involves multi-disciplinary framework, major viewpoints of resilient planning falls in the following five realms. Ecological Resilience is one of the branches with the longest history, with Holling, Gunderson and Alberti (1999) as representatives. This school of thought works at establishing “adaptive cycle” simulations of ecosystems, for instance the Panarchy (Grunderson, Holling, 2002). Alberti developed an urban-ecological model (UEM) to predict changes of human induced stress on urban ecosystem. Technical Resilience proposed by Wildavsky (1988), Bruneau et al. (2003) and the research institution MCEER (2005), emphasizes on the rigidness and the speed of returning to equilibrium after disasters. According to Adger (2000) and Paton, Johnston (2001), Social Resilience indicates the process of community to learn from and resist disasters or stress. It is especially important for indigenous communities experiencing the overwhelming trend of modernization and globalization. Similarly, Economic Resilience (Rose, Lim 2002; Polèse, 2010) enables a city or community to reduce economical loss during and after hazards. Another realm mentioned in the MCEER (2005) is Organizational Resilience, indicating the capacity of organizations to manage major disasters, via public communication and decision making, etc.

Interpretations of resistance and resilience from several influential scholars in their own perspectives have been presented above. Distinctions are obvious. Yet it is still confusing: which roles resistance, resilience and recover play in a disturbed system?

As it is elaborated in Walker’s theory, two processes run simultaneously in a system undergoing disturbances. One process “absorbs” disturbance, and the other attempts to recover from damages and disorders. By absorbing disturbance, material components of the system initially resist the change, when reaches a certain threshold, they adjust to the new situation, without imposing irreversible destruction on the system.

Three chronical phases are identified in the dynamic of a resilient responding towards disturbance (Fig. 2.5). The first phase, pre-disturbance, is the stable state of system before the system gets struck by a disturbance. The second phase, system reacts to the disturbance by resisting and responding actively to external forces/pressures, and recovering from damages. In the post-disturbance phase, system returns to a stable state, though not necessarily the exact same state before disturbance (Renschler et al., 2010). Post-disturbance phase can also be regarded as pre-disturbance of the next recursion. The chronical sequence of a resilient response is in the pattern of an ascending spiral. Resilience constantly exists until it sees the demolition of the system.

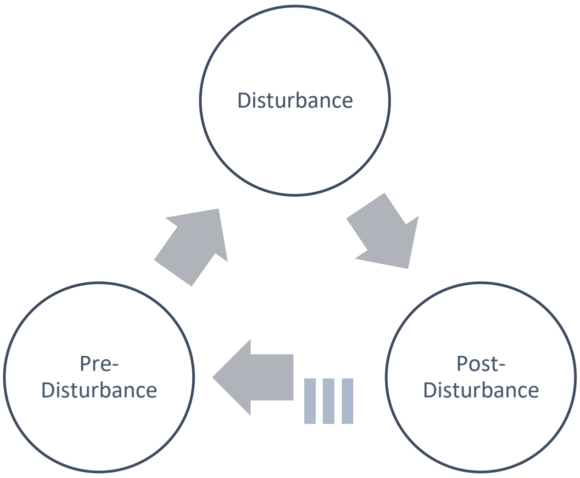

Figure 2.5 Three phases of system’s response to disturbance

Regarding to resilience enhancing in urban planning, an institutional dimension is studied by researchers. In many cases, the term of resilience is not explicitly referred, but “adaptation” and “sustainability” are applied instead. For instance, the governmental climate change adaptation strategies are evaluated (Lee, 2018), the stakeholders in relation to resource management are identified and their demands analyzed (Friend, 2018). These researches reveal the challenges and their influence in the near future, implying that they can support the branch of urban resilience.

A few studies applied resilient thinking strategically in actual planning practices (Baird et al., 2016). To practice resilience planning, practitioners develop a social-ecological system perspective, and clarify the goals of resource and risk management. Since the practices of resilience planning is normally focused on local or regional scale, and catering to specific issues of the research sites, very little synthesis have been achieved across the case studies (Sellberg et al., 2018). Without a general applicable framework for all research sites, each practice may lead to a new approach.

To conclude, resilience in this research is the intrinsic capability of a settlement system to sustain a stable state against external disturbances. Resistance and the ability to recover are impartible components of resilience, predominating in pre-disturbance, disturbance, and post-disturbance phases. A low-resilience system tends to deteriorate by ceaseless crushes of disturbance.

2.2.2 Disturbance

Not all disturbances lead to disasters. The severity and the frequency of occurrence of disturbance itself, and the resilience of system together determine the consequences of disturbance.

External disturbances come from all aspects in the world. The changes in the general condition of regional economy, land use policy, and even in the speed of economic growth of adjacent region, all impose certain influence on a settlement system. This research confines the focus mainly on extreme environmental changes, to be more specifically, natural hazards.

Considering the geographic and climatic conditions of the research area, this research concentrates on flood and landslide, as they are the major type of natural hazards in the region. Social economic changes are taken into consideration, where the content and transmission of local knowledge are influenced. They are also analyzed when assessing system's capability of recover.

In the research region, the fundamental triggering factor of flood and landslide is excessive precipitation, while not all excessive precipitation causes those natural hazards. The land use condition of a rural system could either impel or prevent such natural hazards from happening. For instance, the mountainous region covered by forest is less likely to flood, but given a land parcel without vegetation cover, the possibility of flood and landslide would significantly increase. In this case, land resource management determines the resilience of a settlement system. Viewing from the perspective of the settlement system, it is also obvious that the geographic location of settlement itself largely decides the risk of natural hazards. For many other reasons, such as the financial state of the household, local residents may not move and settle in other places to avoid the risk. Under this circumstance, the system is exposed to potential natural hazards. As the residents unable to bestow monetary in reviving the settlement system, the settlement system can be considered as sensitive to the negative impact of natural hazards.

What is the likelihood that a settlement would be affected by natural hazards, and how severe the outcome would be, requires further assessment on the resilience of the settlement system.

2.2.3 Evaluating Resilience

It has been a conundrum since the generation of resilience concept, to measure a system's resilience in practice. The Organization for Economic Co-operation and Development (OECD) developed a framework on resilient cities and launched projects in 10 cities as provided by the official website[1]. Resilience is measured in four areas: economy, society, governance, and environment. The statistics of 19 indicators are applied in the measuring. In the referential approach of PEOPLES Framework (Renschler et al., 2010), 7 components and nearly 100 sub-components presented all major characteristics of a community scale system, regarding to resilience. Sub-components, especially in several indicators of social-economic developments remain obscure and difficult to evaluate, for instance, cultural and heritage services, and place attachment. Other components, for example public participation, poverty, food supply, and water quality/quantity requires specialized evaluation work. What makes the task even laborious to accomplish, is to synthesis all components and to calculate resilience index. Since functionalities of components overlap or mutually influence each other, a proper mathematical function is required, taking all the interactions among components and weights of different components into account. Unfortunately in most of practical projects, neither time nor working force is abundant enough to fulfill such a sophisticated framework.

PEOLPLES framework provides instructions on how to evaluate system resilience based on its original functionality, yet in practice, quantitative measurements of resilience are seldom

[1] http://www.oecd.org/cfe/regional-policy/resilient-cities.htm

applied. In the majority of resilience planning work, qualitative evaluations of resistance and recover capability are made in the field of construction engineering. Those engineering approaches in general aim at quantifying the resistance of architectural constructions. For example, standards are made to evaluate the resistance of a bridge against river flood. Resistance, in the context of settlement system, has more meaning than the capability of a construction to resist certain intensity of disasters such as flood and earthquake.

2.2.4 Evaluation Methods Derived from Other Dimensions

In the study of disaster risk reduction, the term *adaptability* is widely used to represent the similar concept of resilience, as well as *coping ability*, *stability*, and *flexibility* (Smit, Wandel, 2006). Brooks (2003) defined adaptation as “adjustments in a system’s behavior and characteristics that enhance its ability to cope with external stress”. It is more *recover* oriented, according to this depiction. In various recent practices of adaptation strategy, community resilience is the qualitative index to evaluate adaptability (The State of Queensland, 2013). While the researches on adaptation and resilience remains conceptual and qualitative, a branch of adaptability study, the introduction of *vulnerability* from the reverse side sheds new lights upon an applicable approach.

Vulnerability shares common interest with adaptability and resilience. Planner and researchers bestowed various interpretations to the term “vulnerability”, catering to their research topics. In other studies, vulnerability is sometimes regarded as an indicator to other conceptual indexes. The study of adaptability includes two essential components within it concept. Adaptation Policy Framework further categorized exposure and sensitivity into policy-based approach, paralleled with vulnerability-based approach (Lim et al., 2004). In the elaboration of the central concept of Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), vulnerability is also explicitly differentiated from exposure to risk (IPCC, 2012), as a paralleling factor determining adaptability. In mainstream studies, vulnerability is composed of three fundamental properties, namely exposure, sensitivity, and adaptive capacity (Smit & Wandel, 2006; Adger & Neil, 2006; Polsky et al., 2007). This interpretation of vulnerability becomes the foundation of the conceptual model of the vulnerability scoping diagram (VSD). Gallopin used the term recover efficiency instead of adaptive capacity, to clarify the ambiguity between vulnerability and adaptability studies. By his elaboration, vulnerability evaluation could be reasonably predigested. It seems that vulnerability is an expansion of adaptive capacity, so it could be used as an umbrella to identify weakness of a system. Smit (2006) further interpreted *adaptation* as the manifestations of a system’s adaptive capacity. *Adaptation* can also be referred as “ways of reducing vulnerability”. That is to say, vulnerability reduces when adaptive capacity is improved.

This research attempts to trace back to the origin, and holds, that vulnerability stands opposite to resilience, as the intrinsic characteristic of a system negatively react towards external disturbance. It should be noted that a resilient system have relatively low vulnerability, but it does not mean that low system vulnerability guarantees a resilient system. To make the evaluation about system resilience reasonable and practicable, this research resorts to those three components of vulnerability. Not all three components are directly related to the resilience of system. The relationship between each component with resilience will be introduced later in this thesis. As those three components are determined by various factors, and have complicated impact on system resilience, this research gives a thorough argumentation in the following chapters. Practices on vulnerability studies provide theoretical and practical insights to this research about resilience. It is beneficial to learn from those advanced approaches, hence establish a comprehensive, problem-oriented research framework.

2.2.5 Three Components Contributing to System Resilience

The new paradigm of disaster management no longer sees disasters as the consequences of merely the natural environment changes, but as the joint cause of both the changes of environmental conditions, and the vulnerability of the human society itself. Vulnerability is acknowledged as a key factor which determines the actual impact of natural hazards. Since the 1960s, awareness has been laid on "improving preparedness" against disasters. Planners proposed enhanced governance in the places prone to be attacked by natural hazards, for instance, an increase the stock of relief goods. One of those measures is public involvement, which will be discussed in section 2.4. Methodology for assessing vulnerability could contribute to resilience study (Adger & Neil, 2006).

Just as it is with system's ability to recover, determinants of exposure and sensitivity consist of the features reflecting environmental, social, economic, and political conditions. One feature would affect the three components of vulnerability in different ways. For instance in a conceptual vulnerability assessment framework, water quality is an indicator for both exposure and recover ability. From the perspective of exposure, importance is attached to the amount of water polluted in study region, while in regard of recover ability, emphasis should shift to water's self-purification capability and purification ability of local sewage treatment plant, etc.

In mainstream research, the evaluation of vulnerability falls in three parts, in accordance with its three components. Exposure and sensitivity are the characteristics determining the extent of impact caused by disturbance, in another words, they reflect disturbance's potential impacts on the system. Recover capacity or also referred as adaptive capacity (IPCC, 2007)/ coping capacity (EEA, 2012)/ response capability (Swart et al., 2012), indicating the potential to overcome future disturbances or transfer future disturbances to opportunities. The mutual influence among those three components is not necessarily calculated, other than a depictive report or a series of maps layers. Results can also better facilitate decision makers, stakeholders, and the public to diagnose the contemporary situation of research site, as well as framing optimized resilience strategies.

The following paragraphs elaborate the three components and how are they evaluated in previous researches.

Exposure, as its literal meaning, refers to the extent a system exposes to external disturbance. Sensitivity is the degree to which a system is positively or negatively affected by disturbance. In most of the previous researches and projects, those two components are quantified by physical features rather than economic-social features of the system, portraying system's likelihood of potential impacts to harm. But as the study develops, both physical and economic-social features are considered. While the frequency, duration, magnitude, and areal extent are major features of environmental disturbances, the population, economic condition, and community structure etc. are all considered to be determinants of exposure and sensitivity.

Determinants of exposure and sensitivity are more concrete than the indicators of resilience. Data required for the assessment of exposure and sensitivity is generally easier accessible for researchers. As a result, even in the archetypal reduced-form models, where the terms “vulnerability” and “resilience” are only inexplicitly addressed, exposure and sensitivity can be quantitatively evaluated (Turner II et al., 2003). Though there are inadequacies in the cognition of system’ social-economic attributes, risk-hazard model (Burton, I. et al., 1978, 1993) was utilized to quantify exposure and sensitivity as the capability of a system to cope with natural hazards. In regard of global climate change, IPCC proposed a comprehensive framework of vulnerability assessment, providing more specific indicators of exposure and sensitivity. The Prevalent Vulnerability Index (PVI) is an ambitious approach to assess relative vulnerability, applying multi-disciplinary indicators and contributes referential experiences to later studies.

In the physical dimensions, the context for human-environment interaction, e.g., settlement patterns, architectural constructions, are powerful indicators. While from the social-economic dimension, the exposure of a system is also influenced by various factors. For instance, evacuated residents would still return to their hazard-prone settlement after devastative distractions for social-economic related problems. Their economic conditions might not allow them to settle in a new place, or their mental reliance to their hometowns stop them from abandon their hometown. Thus the exposure value stays high. As it is with exposure, sensitivity is also affected by the economic conditions of settlement system. Economic losses caused by hazards are conventionally assumed to impose larger impact where its residents suffer from poverty (Adger, 1999). In social dimension, certain population groups are more susceptive and vulnerable to disasters. For instance, children and seniors are more vulnerable to natural changes, because of their physical conditions (Bernard, Ebi, 2001; Gosling et al., 2009). Migrants who have little knowledge and information about local calamities may underestimate potential risk, thus fail to evacuate from disaster-prone area. Examples above also inexplicitly refer to the issue of public education and traditional culture.

Social-economic indicators of exposure given by the IPCC to calculate PVI are as followed: population growth, average annual rate; urban growth, average annual rate; population density; poverty, population living on less than US $1 per day PPP; capital stock in millions US dollar/ 1,000 km^2; imports and exports of goods and services as a percent of GDP; gross domestic fixed investment as a percent of GDP; arable land and permanent crops as a percent of land area. In PVI, socioeconomic fragility resembles the concept of sensitivity. Indicators of socioeconomic fragility listed in the PVI are: Human Poverty Index; dependents as the proportion of the working age population; inequality is measured by the Gini coefficient; unemployment is represented by the percentage of the total labor force; annual increase in food prices; share of agriculture in total GDP growth; debt service burden as a percent of GDP; soil degradation resulting from human activities (GLLASOD). Those indicators are extracted to represent the fragility of a system confronting risk and disasters (Cannon et al, 2003; Wisner et al, 2004).

It is obvious that indicators of exposure and sensitivity overlap, but the calculation of PVI undoubtedly provides a practicable approach to quantify exposure and sensitivity. It should be noted, that PVI works for the national scale research, some measuring units of the indicators above are apparently not adequate for this study.

The third component, recover ability resembles system adaptability as previously mentioned. Most of the research frameworks cited above perceive adaptability or adaptive capacity as a determinant of vulnerability. Though boasting a broader connotation, adaptive capacity is assigned as recover ability in this study, to confine the research focus. Controversy would abate after elucidating the practices of recover capacity evaluation in the framework of system vulnerability assessment.

Recover capacity not only represents the extent to which physical impacts could be repaired. It is also the ability to resume or evolve livelihood activities, community networks and even politic structures after disasters. When physical infrastructure, livelihood patterns, and social-economic structure are severely impacted, given sufficient recover capacity, there would also be opportunities for the improvement of the previous structure (Birkmann et al., 2010). Consequence can be a new local land use pattern, adapting to frequent seasonal floods. It can also be a modification of agricultural production, catering to the ever changing local weather conditions. Contemporarily, approaches towards recover are generally proposed in reconstruction/post-disaster plans. Such plans are resulted from the tradeoff among hazard management, economic development and the political orientations. It is not easy to achieve. In practice, the process of making a successful reconstruction plan is even more difficult, as time is always limited for the planners to collect data and make long-term plan within a short time right after hazards. The plan can turned out to be unsound. And the failures are always aggravated if the region was previously in poverty (Hutton, Haque, 2003). An ineffective reconstruction plan would fail to improve system's capability to recover, unable to satisfy the material or spiritual needs of the local residents. In extreme cases, bad decisions induce more potential risks, making a rebuilt settlement more vulnerable to the future environmental changes.

From the perspective of ecosystem, recover capacity is highly dependent on the ability to reproduce. Mainstream researches use net primary productivity (NPP) to represent the robustness and recover ability of an ecosystem. Primary production, which indicates the photosynthesis and chemosynthesis process generating organic compounds from carbon dioxide, is the fundament of all living beings on the earth. NPP after disturbance is decisive to the speed, at which the biomass returns to the original amount. Yet another comprehensive approach is launched by IPCC. The Environmental Performance Measurement Project (Esty et al., 2005) calculates the international Environmental Sustainability Index (ESI), which is an integration of 50 environmental, socioeconomic, and institutional indicators, but the evaluation covers a larger range of environmental issues rather than the capability of recover itself. The selection of environmental indicators provides practical experience for this research. ESI maps of North America are now available on NOAA website, offering a reference in presenting research outputs.

Factors determining recover capacity listed in the PVI frameworks, are composed of Human Development Index (HDI); Gender-related Development Index (GDI); social expenditures on pensions, health and education as a percent of GDP, Governance Index (Kaufmann); infrastructure and housing insurance as a percent of GDP; Television sets per 1,000 people; hospital beds per 1,000 people; Environmental Sustainability Index (ESI). Each of those indexes is the evaluation result of sub-indicators. But in assessing the recover capability alone, such indexes involve too many indicators. Some overlap with each other, while some are irrelevant to the subject of assessment. Some indicators are obsolete, for instance, the indicator of television sets per 1,000 capitals is not competent to represent the efficiency of mass media. For a practical and relatively small scale research, the indicators do not necessarily indiscriminately imitate previous studies. Representative and problem-oriented indicators should be selected, in order to better analyze recover capability.

Other than the system-based approaches to evaluate vulnerability, there are also researches which see the issue from an opposite angle. EEA (2012; 2016) starts to assess vulnerability from the impact of future climate change. Indicators are assembled to evaluate the changes in climate system, and the impacts on environmental system, society and multi-sectoral vulnerability and risks. This provides the theoretical base for analyzing the nature of disturbances in this research.

2.3 Ethnography Theories

2.3.1 Local Knowledge

Cases are abundant, in which rural settlement systems are completely destroyed by natural hazards and beyond rebuild. This also raises awareness of the researchers, about how vulnerable to hazards some local communities can be. It is universally acknowledged, that the settlements are more susceptible to external stresses, when it shows the following features: possess small population; geographically isolated from developed regions and rely on single natural resource.

Unfortunately those features resemble the conventional impression of rural settlements referred in 2.1.2. The paradox is those affirmed as vulnerable and weak local communities survived numerous disasters till today. Their longevity is greater than expected. One creditable assumption indicates that the fact rural inhabitants heavily rely on their environmental, social and cultural assets, resulting in an enhanced settlement resilience, rather than the other way around. Inhabitants' local knowledge acquired from their observant eyes to most subtle changes of physical environment, from their life routine and accumulated practical interaction with the environment, may have positive effect on system resilience.

To scope the research, local knowledge is differentiated from other types of knowledge. Knowledge refers to information and concepts acquired through living experience or education. In the initial state, driven by the elementary needs (for instance, food and water), human beings explore the world and develop knowledge of how to better satisfy their biological needs. It then served to higher level of demand. Scientific knowledge, or Western Knowledge, is accumulated by delicately designed researches, and organized with the foundation of basic scientific principles, for example mathematics and physics. On the contrary, local knowledge derives mostly from unintentional interactions between human and the nature. It is the reflection of local people's recognition and interpretation of both material and immaterial world. It also contains the methodology, which people practice to interact with their living environment. Information they received are verified by experiences, regulated through analyzation and re-organized by deduction (not necessarily rational). That is how new information/knowledge generates. As Lindblom and Cohen (1979) wrote, local knowledge "does not own its origin, testing, degree of verification, truth, status, or currency to distinctive … professional techniques, but rather to common sense, casual empiricism, or thoughtful speculations and analysis".

According to Warren (1991) and Flavier et al. (1995), local knowledge is the ground for local communication and decision-making. It gives the culture of a community identity. Ellen and Harris (1996) listed ten features of local knowledge. The predominant features are to the contrary of scientific knowledge. They defined local knowledge as place-based, more empirical, constantly transforming, and widely known by the residents in the community. In this research, the term of local knowledge refers to the knowledge possessed by the residents in the research region. Under this presumption, local knowledge fits better into the research topic.

The characteristics of local knowledge guarantee keen observation on environmental changes and corresponding actions catering to local condition (Salick, Byg, 2007). Local knowledge stems from perception of the physical and cultural environment. The reason is obvious. Natural resources are an indispensable foundation of rural settlement's material structure. It is the satisfying natural environment firstly attracts residents. People consider environmental conditions including the layout of landscape, water resources, weather condition, and the distribution of arable land. On the early stage of settlement growth, human power, capital and technology are limited. Under this circumstance, a low-cost and robust development of agriculture is of vital importance to the survival of a settlement. Thus the conditions of the natural environment are priorities when deciding the location of a settlement. Local people always have to pay attention to the environment, so that they can have further development of agriculture and industry. Equipped by all knowledge which they directly draw from perception, people can spare more time and efforts exploring better practice in productive or other activities. Through interaction with the nature, hypothesis would be made, deducing the consequences of different actions. As it has been synthesized by Corburn (2003), two types of basic claims are made by people derived from those observation and practical experiences: identification of problem, and the hypothesis of interrelationship between phenomenon and activities.

In the aspect of dissemination forms, scientific knowledge is conventionally recorded and spread in written form, while local knowledge through informal ways. It is the contents and features of scientific knowledge and local knowledge determine the way they are disseminated. Most scientific knowledge is obtained in a specifically designed teaching/learning environment. As its contents are most likely to be conceptual and abstract, learning scientific knowledge relies on meditation. The requisitions for scientific practice and experiment are so rigidly controlled, that they are seldom carried out by the ordinary people. The dissemination of local knowledge, on the contrary, takes place in many casual scenarios. Local knowledge generally deals with practical problems that people encounter in daily life. It covers a wide range from tactics in housework, to the sacrifice for a sacred mountain spirit. The dissemination of local knowledge is closely associated with practice. For example, the knowledge of wood craft develops and inherits through apprenticeship through generations. Local knowledge about land management can be narrated in vivid stories and legends, encompassing the perception and understanding of all storytellers. Such ways of knowledge dissemination make it easily accessible for the majority of rural residents. The transmission of knowledge also enhances community cohesion, which further facilitate information collection and interchange among community members.

Why would the community members believe in the information/ knowledge they acquired from one another? As local knowledge derives from the evidence one has tested himself for a relatively long time, if not through several generations. It becomes an issue of trust among the community members. And the trust in reverse is built on the validity of knowledge, the reputation and professionality of the knowledge possessor.

Local knowledge distinguishes from indigenous knowledge, since it is not confined to reflect the intelligence of indigenous or aboriginal residents. It is possessed by the residents within a certain range of region. Geographical factor is the only delineating criteria of local knowledge. That is to say, local knowledge is shared by indigenous people as well as new-comers to the region. The study of local knowledge shall take the transaction between traditional knowledge and the foreign knowledge in to consideration.

Regardless of the educational level, age, gender, and social position, all people have at least one of the following three categories of local knowledge: common knowledge, shared knowledge, and specialized knowledge to some extent (FAO, 2004). Common knowledge is the common sense in the local community. Shared knowledge is possessed by most of the member of social groups, for instance, the same profession group. Compared with the other two categories, fewer possess specialized knowledge, since long time professional training is required. Viewing the local knowledge in a certain region, the quality of common knowledge and shared knowledge is decisive for the general knowledge level, while the rare specialized knowledge determines the vitality of local knowledge and culture.

Through trails and fails, innumerable skills and productive techniques have been gradually abandoned and forgotten by local people, if they prove to be ineffective to help people achieving their goals. Knowledge which better fit into the conditions at their times is passed on down, and adapts to new situations as time goes by. From this perspective, knowledges which out lived all the ordeals to the contemporary world are of certain value for the later generations. Those abandoned knowledge, on the other side, becomes counterexamples. The new generations can therefore intentionally avoid adopting them. This research of local knowledge shall not only investigate the contemporary local residents, but also the ancient knowledge recorded in all forms of literature or oral history.

2.3.2 Evolutionary Epistemology

Three theories about evolutionary epistemology are conceptualized in respects of different research subjective. In this research, evolutionary epistemology stands for the evolvement of cognition and knowledge. The basic assumption, that knowledge evolves the same way of human beings, could be dated back to the 19th century, while the theory retrieved scholars' interests in the 1970s (Popper, 1972; Campbell, 1974).

Knowledge in general derives from the experiences of living, and from the opposite point of view, it is also confined by living conditions, especially in the case of local knowledge. Living conditions encompass the natural environment and sociocultural scenarios. The development of knowledge has physical and cultural constraints. Human biological structure determines the capacity people have to process knowledge. The direction of knowledge evolvement largely depends on sociocultural factors. Both biological and cultural evolution are associated with knowledge gaining process, thus the knowledge evolves accordingly (Wuketits, 1990). Irrational knowledge, for instance, religious belief, is formulated and preserved as it is the reasonable creation in certain contexts.

The underpinning assumption of evolutionary epistemology is that human thought evolves through blind variation and selective refutation (Radnitzky et al, 1993), then thoughts and hypothesis form concepts and theories. Evolutionary epistemology holds that, in accordance with Darwinian philosophy of natural selection, those concepts and theories selected through the sociocultural environment are privileged to exist. They are able to adapt to the future changes, and the fittest would pass on down generations. It should be noted, that the fittest knowledge is not necessarily scientifically correct. It proves to be true and reliable, only in the specific situation where it is created. In evolutionary epistemology, knowledge is open for criticism and refutation in a particular spatial-temporal context. Evolutionary epistemology denies the justification of all theories, and claims that both the beginning of evolution and its results are unjustified.

Conventional epistemology sees observation to be the source of all knowledge. Originated from the representationalism, human perception is not recognized as the reflection of the real world, but the cognition of the reality, influenced by individual sensation. Knowledge is formulated through a series of processes, including information accumulation, combination and logic deduction, dominated by human consciousness. Observation, in evolutionary epistemology, reflects real natural and cultural context. But the formation of thoughts and theories are not trimmed by observation until the process of "natural selection". Knowledge can then adapt to future situations, through the interaction between human beings and the natural environment and cultural environment. Unsuccessful trails are remembered and hence avoided from applying to similar situations. Thus the natural environment and cultural environment are in charge of screening out the fittest knowledge.

The theory of knowledge formation from the perspective of cognitive science is not of crucial importance in this research. It is the theory of knowledge evolvement that contributes to the understanding of current preservation state of local knowledge. Evolutionary epistemology sheds new light upon the development of knowledge. According to which, the existing knowledge is from the survivor through natural and cultural selection. As it has been inexplicitly inferred in the theory, natural and cultural context is also changing over time. The culture serves as the hotbed of knowledge, while at the same time culture is bred by the conjunction of contemporary knowledge. On the other hand, the natural environment is constantly interacting with, and reshaped by human activities instructed by knowledge. The ever changing context decides the dynamic of knowledge, and only the fittest becomes the mainstream and passed down through generations. It is important to notice, that the mainstream knowledge is not necessarily scientifically correct, but representing the most reasonable interpretation or solution in the contemporary context. With this concern, the natural and cultural settings shall be given adequate attention in order to judge the validity of local knowledge.

2.3.3 Precautionary Principle

In practical planning work, when scientific consensus is insufficient, some planners would consult to the local residents about disaster-prone area, so that they could avoid potential risk from natural hazards in the future. It is a plausible application of local knowledge, based on the precautionary principle.

One basic assumptions underpinning the precautionary principle, is that the proposed human action, or a decision of not taking action, has a probability to harm the environment or the public, though no potential harm has not yet been foreseen by scientific research. This principle is a decision making strategy, weighing the potential risk and the cost of risk prevention measures.

The crucial point of this principle is how to identify potential risk. As the other assumption indicates, scientific evidence is sometimes not sufficient enough for risk identification. Is it possible that local knowledge can be perceived as the evidence in decision making? It has been mentioned in the previous sections, that local knowledge derives from perception and practice at local scale, while it is unrealistic that modern science covers all spectrum of important local situations. Local knowledge provides information of a certain degree of “uncertainty” in its correctness, just as the way insufficient scientific knowledge does. In addition, local knowledge provides new insights in inspecting lurking perils behind certain actions, towing to its observation from a local-scale perspective. Thus it can be reasonable to resort to local knowledge, if precautionary principle is to be considered in planning.

The precautionary principle has several interpretations in different fields of study. The most acknowledged interpretation in the field of environment protection is announced in Earth Summit, 1992. Rio Declaration writes that in order to prevent environmental degradation, measures shall not be postponed due to the lack of full scientific certainty. This interpretation is conventionally referred as strong precaution. The weak precaution is under the premise that taking (or not taking) certain measure might lead to irreversible damages. To improve system resilience and reduce the potential risks, the reverse approach should be applied. Distinctions between strong and weak precautionary principles lie in the probability of system destruction in the initial state. In strong precautionary principle, there is a premise that the action (including the action of “not taking action”) would definitely lead to damage on the environment or the public. While in the weak version, the uncertainty of damage is much higher. Both principles advocate measures to be taken in order to avoid risk, but distinguish themselves also in the tolerability of cost. In the weak version of precaution principle, there must be some evidence about probability of destructive incidents, their predicted impacts. The cost of measures against the incidents is to be cautiously considered. Decisions of taking or not taking action are influenced by social-economic factors such as economic consideration and public willingness.

In practice, the strong precautionary principle is not indiscriminately applied. Criticisms mainly point out that the strong version completely denies the innovation of science and technology, since only the fully mastered technics which have been proved to be “safe” shall be applied. Therefore, experimental activities shall be unconditionally called off, no improvement can be achieved. From another perspective, avoid risk at whatever cost is too extreme an approach, that seldom accepted by decision makers. Generally a cost-benefit analysis is conducted in advance. This analysis does not evaluate the susceptibility of risk, but the cost-efficiency of different disaster prevention/remedy approaches. Results of the cost-benefit analysis are reflected in the timing of intervention and specific solutions. In this way, a strong precautionary principle degraded to the weak version in practice.

Considering the application of local knowledge in improving system resilience, both strong and weak precaution principles can be applied to different situations. For instance, there is one type of forest in China, which is strictly controlled by religious communities that on no occasion could the trees be cut. All local residents have the belief that there would be sequential disasters if these forests are destroyed. From a scientific point of view, protecting these forests contributes to water and soil preservation in the region, which promoted the sustainability of the ecosystem (Youn et al., 2012). But apparently, no evidence demonstrates that by cutting a small number of trees in a forest would definitely lead to disasters. This makes an appropriate example of strong precaution principle. Nowadays, the power of traditional religion rapidly declined, people start to weigh the benefits of cutting the forests and the risk of deforestation. In the cases, where the fear of disastrous consequences still outweighing benefits, the weak version of precautionary principle manifests.

To conclude, the precautionary principle is the theoretical ground for the adoption of local knowledge in planning. Especially in the rural regions, where scientific knowledge is not of full sufficiency, local knowledge is the origin of information, estimating the potential risk of all kind of actions. Only after the identification of potential risk, could the issue be set, and then ready for the decision making process under the guidance of precautionary principle. Weak precautionary principle is more acceptable as it granted the decision makers with the competence to weigh the stake.

2.3.4 **Implications of local knowledge in rural planning**

Originated from information collection about natural surroundings, perception then extends its range to cover a broader spectrum in human activities and social networks. By formulating those scattered pieces of information and speculations, local knowledge with a basic structure is generated. Local knowledge instructs daily life, productive activities and construction work in rural regions. Developed in the rugged primitive environment, the productive activities and skills under the instruction of local knowledge gradually reduce the requirement for human power and material, and effectively improve productivity. Local knowledge shows strong influence in rural planning, especially in production related planning.

On the flood plain of Huang River in China, residents of the Han nationality created their unique knowledge of agriculture. In the late summer when floodwater recedes, local farmers sow the wheat seeds into the naturally cracked up soil without sparing effort in plowing and fertilizing. Then before winter of the same year, they have an additional harvest of wheats (Lv, 2004). The Hani nationality resides in the southwest of China also develops their local knowledge about settlement planning and water management. On the steep slopes, local farmers plough up terrace fields to grow rice, effectively used the limited space. They make use of the mountainous landscape to control irrigating water by constructing simplified irrigation channel networks. Water is conducted over the terrace fields mainly by gravity flow. Little human power and maintenance is required thereafter. The morphology of their settlements are also planned and constructed in accordance with the local landscape, in order to avoid flooding and landslides (Li et al., 2007).

In many cases, behavioral regulations and social norms reveal local residents' awareness about environment protection. Specific activities are even ritualized in a symbolic dimension, urging people to observe, respect, and preserve natural order. For instance, restrictions in fish spawning seasons are set in Chisi Island, as the inhabitants are subconsciously aware of ecological balance concept (Kalanda-Sobala et al., 2007), contrasting to the overfishing crisis in modern fishery industry. In southwest of China, desertification is one of the most serious geo-ecological disaster in the karst area. Soil erosion and the exposure of basement rocks drastically reduce the area of arable land. Government has launched several compulsory plans dealing with this problem, including fence of the hills for afforestation and artificial reforestation, but achieved limited progress. In practice, it is very difficult to estimate how thick the arable soil layer is beneath the cracks of the rock. Improper choice of the tree species in a reforest project leads to unnecessary dissipation of project revenue, and even aggravates rocky desertification. The Miao People in Guizhou Province has long developed their knowledge of how to alleviate this ecological problem. They are able to identify the condition of underlying soil layer by inspecting the vegetation cover as well as the topography of the land parcel. They choose to plant bamboos to retain soil and water on steep and rocky mountain slopes (Luo, 2011). On the contrary, in the past 200 years, local government had introduced cotton, corn, potato and sweet potato in order to improve agricultural yield. As consequence, all their attempts failed, and aggravated soil erosion. With the help of a local NGO, Partnerships for Community Development, the traditional knowledge is reviving. Local people are encouraged to follow their custom to plant bamboos. In the recent years, water and soil resources are better preserved.

Though not testified by scientific methodology, local knowledge has not only been supporting livelihood in rural region for centuries, covering aspects of agriculture, animal husbandry, resource management, but also playing a vital role in hazard prevention. The survival of decent towns during the catastrophic 2004 tsunami in Indonesia made the world aware of the value of resilient planning as well as local knowledge. With local knowledge, the Moken people predicted tsunami occurrence and intensity (Elias et al., 2005). Inhabitants in Gunungsitoli built their houses that survived for nearly a century in a flood-prone region without major destruction. Another example is an indigenous underground irrigation system Karez against drought in Xinjiang, China's most arid area. Outflow of Karez systems in Turpan Basin take up 20% of the total diversion water of the basin (Fang, 2008). In the recorded history, settlements in Xinjiang region have survived many severe droughts, thanks to the Karez system.

People are instructed by local knowledge in the interaction with nature, from the choice of residential places, to planting vegetables in their yards. Those activities include but are not confined to crop planting plan, natural resource management, and disaster prevention. Accurate perception of environmental changes and cost-effective activities are expected to reduce the exposure to disaster, and improve settlement system's capability to recover from disturbance, respectively.

2.4 The Potential of Applying Local Knowledge in Planning

2.4.1 Public Participation

The precautionary principle provides a theoretical foundation that local knowledge can be applied in decision making process. As Corburn (2003) asserted, local knowledge provides insights of hiding risks which are frequently neglected by scientific studies. Local residents, as the possessors of valuable information shall be involved in the decision making process of planning. That involvement is a type of public participation.

Similarly, in the framework of vulnerability assessment, Turner II et al. (2003) inferred of the participation of local people in vulnerability assessment. They advocate that "place-based" resilience strategies are of considerable value. By the term "place-based", they implied the coexistence and interactions of human and their living environment. It is also preached, that multiple stakeholders take part in vulnerability assessment process, contributing their localized wisdom and thoughts, or in another word, their local knowledge. There are already numerous persuasive examples, proving that public participation promotes commune's resilience by assimilating local knowledge. For planners and researchers, it is unrealistic to spend years actually living and socializing, and build up such intimidate interest relations in the community as the local people. Hence, their limited perspective could possibly lead to a biased research direction or an inaccurate interpretation of major conflicts. Therefore, participation of local stakeholders could undoubtedly contribute to the assessment of system resilience. Practices of place-based resilience planning found it also important to retrieve the strong social ties within the community (Salvia & Quaranta, 2017), which can be effectively accomplished by public participation.

An early application of public participation method is civic survey in urban planning, advocated by Patrick Geddes (1911). Geddes then proposed the "survey-analysis-design" (SAD) theory. Later in his experimental practice in India, he explicitly asserted that town planning must be folk-planning to succeed (Tyrwhitt, 1947). The interest, life style, and the wishes of the residents were regarded as first priority which the planners should consider. Survey, as well as questionnaire is most frequently adopted by landscape planners to gather information from local residents. Other common forms of participatory planning include interview, workshop, forum, mental map drawing etc. The fast development of GIS technology provides a new form of participatory knowledge gathering, PPGIS (NCGIA Workshop, 1996; Sieber, 2006) for abbreviation. To evaluate the level of public participation, Sherry Arnstein (1969) established a ladder of citizen participation. The form and intervention timing of public survey largely determine the effectiveness of public participation. It should be noted, that public participation shall be guaranteed with envisioned general public, instead of a motley crowd. By investigating the content of local knowledge and motivations of the rural residents, this research deduces whether the pre-requisitions for public participation are fulfilled in the study region. This research also intends to explore the appropriate extent and implementation form of public involvement.

Regarding to local knowledge investigation, approaches are not confined to those forms. Research methods in the field of anthropology and ethnography contribute greatly to local knowledge study. Fieldwork of those disciplines put special emphasis on authentic and objective information collection from various social groups. Though the majority of anthropology and ethnography researches require delicate methodology and a long-term fieldwork, there are several simplified approaches that can facilitate the process of local knowledge investigation.

Via efficient public participation, knowledge and expertise could be integrated in the planning process. Studies about public involved landscape planning have provided many plausible frameworks, and those frameworks most likely turn out to be fruitful in practice. A number of researchers even introduced public participation into all stages of conventional landscape planning work. Public participation is resorted to from the identification of problems to the implementation of reconstruction work in rural planning against natural hazards, identical to the suggestions for a vulnerability assessment work.

The approach of public participation is based on the belief that through frequent and effective communication between interest-involved groups and the planners, more innovative and rational results of planning would be achieved. Instead of the conventional top-down directive and prescriptive decision making scheme, public participation promotes two-way communication, enabling local knowledge to be conveyed to decision makers. It provides the opportunity for residents, officials, and other related interested groups to share information and knowledge, to make better decisions towards current and future problems, and to joint their wisdom and power for execution. Scholars in the field of policy and governance say that those local information and knowledge helps to improve decisions formulated through centralized planning schemes (Rydin & Pennington, 2000). In Germany, the notion of participatory planning is embedded in a newly developed governance learning process in flood risk management (Newig et al., 2016). In this practice, local knowledge was collected as the information base, while the experts and policymakers were the major contributor to the planning. A rigid working process was designed to ensure the launch of participatory planning. Similarly, public participation in planning or governance remains a democratic way for information collection, rather than involving the general public in decision or policy making process in most cases (Bobbio, 2018).

From the perspective of the participants, they become motivated as their opinions can be actually taken into consideration. The sense of involvement increases their confidence in maintaining their own communities, and the improved confidence in reverse further enhances residents' execution capabilities, and fosters the sense of cooperation within their own group as well as motives other interested individuals and groups. From the perspective of the government officials, benefits of public participation are also remarkable. The collaboration with the participants helps to identify interest related groups and know about their concerns. It is also easier to define a common goal for a planning project, so that they can better concentrate on it. Through public participation, participants exchange information and opinions, so that the outcome could be more acceptable for the entire community. From a broader point of view, the concept of public participation itself represents common respect to all individuals and minority groups. Ideally, it provides the opportunity to establish a communication platform of equals, delivering the political proposition of democracy (Elster, 1998; Dryzek, 2000). Sound communication among different interest groups advocates community development and hence accelerates human growth (Meyer & Theron, 2000).

In practice, several drawbacks of public participation should not be neglected. The major drawbacks include the excessive time and monetary expenditure invested on preliminary work. All forms of public participation undoubtedly slow down the decision making process. Additional costs also lay burden on the entities which host the planning work. The mostly disputed controversy is still about to what extent shall we trust public's voices, and to whom we shall listen to. These questions point to one consideration: the reliability of participants' information and knowledge. The theory of public participation is based on the belief, that the general public has independent and rational understanding towards certain issue. It is important, that the participants are well acknowledged about the things being discussed, so that they are fully aware of the aftermath of their decisions, based on their living experiences and wisdom. The political event of Brexit resulted in an increasing distrust of the decisions made by the general public. Data of the internet search engine shows that a sudden outburst of British people searching for what EU is after the vote for EU referendum, which indicate the voters may have no idea of what exactly they have voted for (Fung, 2016), not to mention a rational thought about the consequences of Brexit.

There are also concerns about the public opinion manipulated by provocative entities. Again, take the Brexit as an example, public opinion was deviated by what the parties' leaders proclaimed. Vote result shows the significant difference in the regions of different leading parties. The ability of independent thinking of party members reduces, as they want to or have to show their obedience and loyalty to the social group they belong to. The worst situation for the governors, however, is the consequential uncontrollable collective actions during the participation process. The chaos of different interest groups may trigger fierce social conflict and impose risk to the safety of all citizens.

Such potential risks of public participation in planning process must be addressed before implementation. Brexit has triggered tremendous chain reactions in the world. This event could probably become an example, of how dangerous it could be, if public participation is launched without fulfilling essential pre-requisitions: making sure the participants are well aware of the problem and have their independent, rational opinion.

2.4.2 Legal Environment of Public Participation in China

In China, deteriorated environmental conditions and the intensified tension between economic development and environment protection is urging Chinese citizens to actively address their concerns and protests. Citizens have become aware of the role they can play in government decision-making. Nevertheless, public participation in China is still in a predicament. The increasing support from stakeholders and mass media still show limited effect on the governance, and the legalizing process against environment deterioration is relatively laggard. What's worse, even in the situation, where public participation is required in planning or decision making, , there is still disjuncture between legally guaranteed vision and practical implement. For instance, the Temporary Methods of Public Consultation for Environmental Impact Assessment Act (SEPA, 2006) calls for public participation for environmental impact assessment, while in practice, the general public and NGOs still have limited access to report their opinion to the governors (Li, 2016).

As mentioned in 2.4.1, behind this phenomenon lies the government's concern of public disorder. Among the approaches to resolve potential crisis, early public involvement is expected to alleviate the tension between the citizens and the government. This research intends to argue that early local knowledge investigation via public involvements, in the forms of public survey and local specialists' interview etc., could facilitate resilience improvement in the first place. On the other hand, settlement resilience improvement is a continuous task that should be carried out step by step in a long period of time. Hence local knowledge should accordingly support rural planning throughout the whole process. A mutual promotion of local knowledge and rural planning work could be foreseeable in this public participation scenario.

In China, though public response transmitted by the mass media has been occasionally adopted in governmental decision-making process, the concept of public involvement is not guaranteed by laws as civil right until the beginning of the 21st century. From then on, public participation is no longer a non-binding consulting mechanism, but citizen's right protected by laws. The implementation of public participation mainly falls in the following categories: public hearing, intergovernmental coordination conference, advance briefing, public opinion survey via internet, telephone or face-to-face questionnaire, interview and informal workshops.

In 2008, Urban and Rural Planning Law of the People's Republic of China (URPL) issued by Standing Committee of the National People's Congress (2007) came into force. This law regulates the developing and implementing of urban and rural plan, as well as constructive activities which might affect public interest or the environment. In Chapter II, Article 18 and 22, it is explicitly elucidated that a rural settlement planning shall be established over a throughout understanding of the actual local conditions, respect the will of the residents, and also reflect unique features of the rural region. In addition, a village planning shall be presented and discussed in local residents' or residents' representative meetings, before subjecting to upper governmental level for examination and approval. According to the following amplifications, rural settlement planning shall incorporate all conventional planning objectives with special emphasize on the protection of natural resources, historical cultural heritages, and the prevention and mitigation of natural hazards. The implementation of rural plan is also bind to the willingness of the general public, as it is expounded in Article 28. The entity rejects to establish, examine and approve, or adjust urban and rural planning according to URPL shall receive corresponding political or punishments.

Though URPL apparently reveals its concern about “the willingness of the public”, it is still only a metaphor of the public participation concept, rather than an applicable decision making method. As it is mentioned in the relative URPL articles, the effect of public willingness mainly falls in 1). Direct the general planning aim, 2). Examine the details of a plan and 3). Supervise the implementation of a plan. The willingness of the public is not required to complete a specific plan-making task, but by examining the plan, chances exist that a certain section of the plan could be modified according to the willingness of the public. The concept of public participation is distinguished from willingness of the public, for the former presents positive civic right and obligation, while the later a passive supervisory mechanism.

At the present stage of the overall political context in China, it is rational not to radically preach public participation in all aspects of nation-building, due to the imperfection in organizing and regulating public participation work. It is also because that the general public has relatively low education level, lack of the ability to distinguish authentic information disseminated on various media platforms. The general public might not always think rationally and independently. However, the legislation ensuring the willingness of the public is still considered as a great progress. In rural landscape planning, the planning area and the resources to be managed are restrained hence make it easier to establish a pilot planning program. The small population and intimate social relationships enable an overall control of public involvement. Opportunities exist that by appropriate governance, local residents shall be able to contribute their knowledge and experiences via some different forms of involvement.

Not only is the interaction between civils and the government emphasized in the term public participation, but also the absorbance, rejection, and interplay process between local knowledge and modern planning knowledge. In this research, public participation is regarded as an approach, which introduces public wisdom and willingness in rural planning work.

Chapter 3 RESEARCH DESIGN AND METHODOLOGY

3 Research Design

3.1 Research Question and Hypotheses

The ultimate goal of this research is to testify whether local knowledge helps improve the resilience of rural settlement systems. It is composed of three major issues. The first is the content of local knowledge among those local residents. This research intends to investigate the preservation status of local knowledge in the research region, and he contents of local knowledge regarding risk control, disaster prevention, and land use strategies. Secondly, can local knowledge supplement modern science and contemporary rural planning? The correctness and preservation statue of local knowledge are decisive factors which contribute to its applicability. The correctness of local knowledge shall be testified through contrastive analysis. The third issue is how local knowledge is currently applied in rural planning process. The extent of public involvement and the society context for incubating effective participation determines the probability that local knowledge can be applied in planning work. The research then seeks a conclusion, of whether local knowledge positively affects settlement's resilience or not, by evaluating local knowledge's impact on the three components of resilience.

There have been both theoretical and empirical evidences that indigenous knowledge contribute to the improvement of productivity, resource management and disaster prevention in various regions of the world. But contemporarily, indigenous knowledge is only preserved in remote regions where have not been affected by modernization. Indigenous knowledge is also acknowledged to be valuable in the small regions where the minority groups live in. Distinguished from indigenous knowledge, local knowledge has a much larger group of possessors. However, it is not paid enough attention in current rural planning work. The limited representativeness of local knowledge requires more attention, so that more value can be drawn from it.

Literature research has revealed local knowledge's influences on productivity, hazard mitigation and ecosystem preservation. It is plausible to deduce that local knowledge changes the resilience of rural settlement system. It is anticipated that local inhabitants are easily involved in, and contribute to rural planning work.

This research proposes the following hypotheses:

a) Local knowledge can be applied to supplement scientific knowledge.

b) Local knowledge about land and natural resource management strategies can improve system's resilience to some extent.

c) It is both cost-effective and fruitful to involve local participants in rural planning work, especially for disaster management and risk control.

3.2 Research Structure

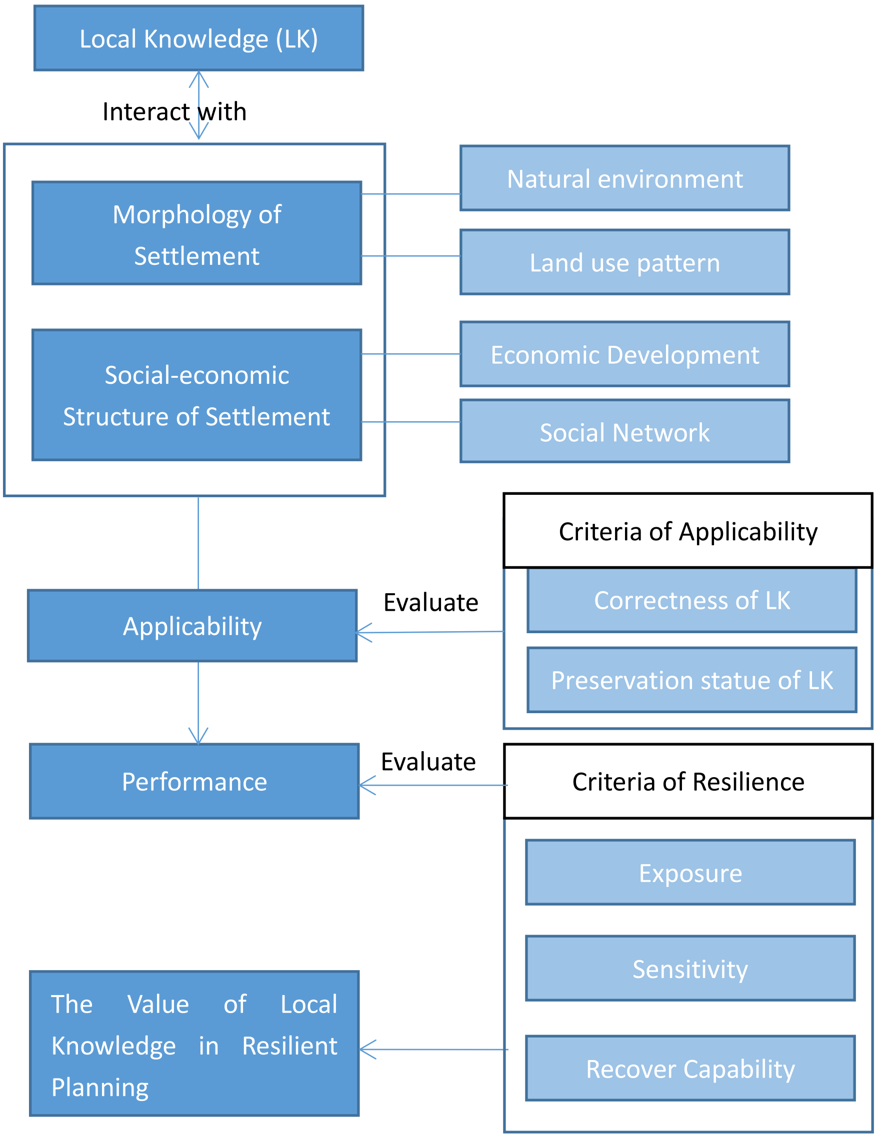

Figure 3.1 Overall research structure

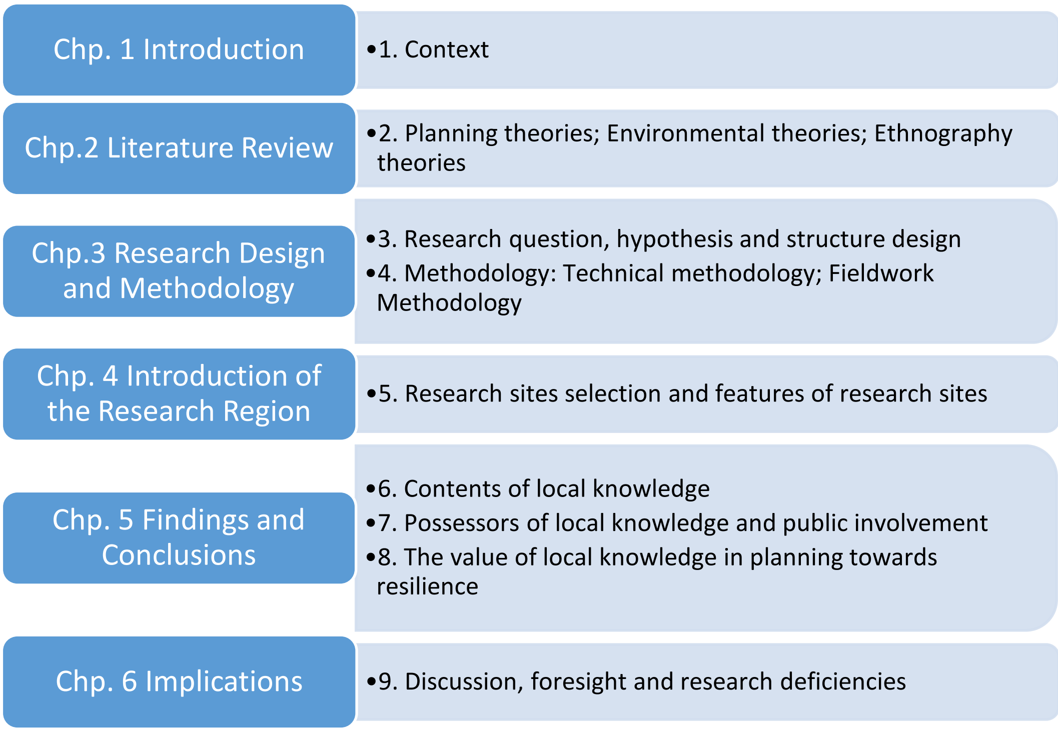

Figure 3.2 Dissertation structure

Answering to the three issues about local knowledge mentioned in 3.1, this research is consisted of three sections. To investigate the content and preservation status of local knowledge, the local knowledge in both the ancient times and in the contemporary world is studied through different approaches (literature research and fieldwork investigation in general). The content of local knowledge is then checked for its correctness, by comparing with scientific data and available official reports (Fig.3.3). The influences of local knowledge on settlement resilience are revealed by both qualitative and quantitative analysis. Throughout the investigation, the extent of public participation, or to be more specifically, the involvement of local knowledge in rural planning work is paid special attention, as it provides practical experiences to the future participative planning projects.

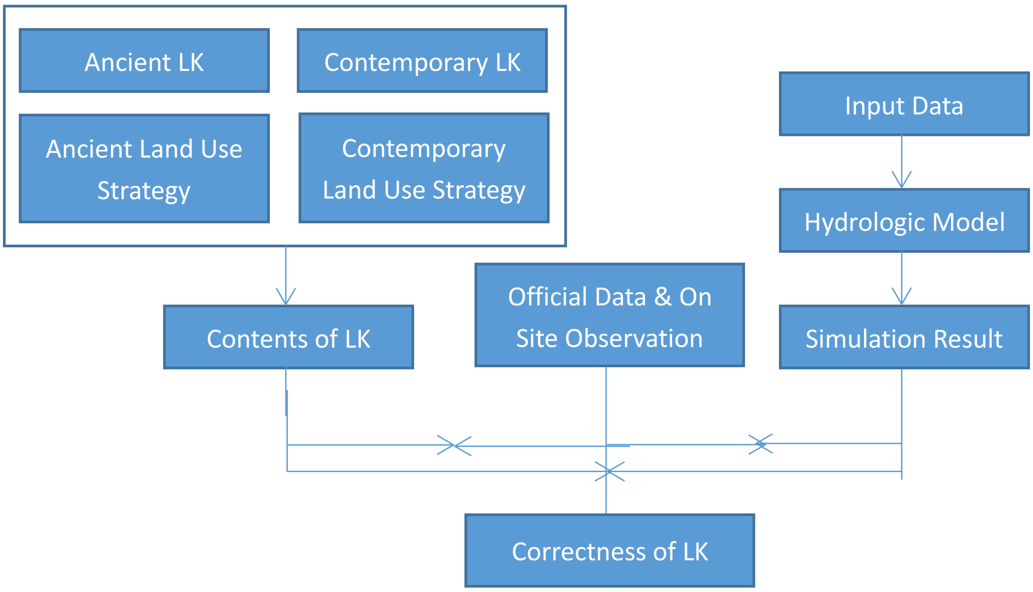

Figure 3.3 Research structure for testifying the correctness of local knowledge by comparison

The content of local knowledge covers a wide spectrum. It becomes unrealistic to testify how each segment of local knowledge would affect system resilience. Except from the information that can be quantified and compared with recorded data and simulation results, much more is conceptual and obscure. Since local knowledge is reflected in the morphology and social-economic structure of the settlement (Fig.3.3), the function of local knowledge is mainly assessed, by evaluating the performance of individual settlement systems when encountered natural hazards.

3.2.1 Investigation of the Contents of Local Knowledge

Local knowledge is the subjective of this research. According to evolutionary epistemology, local knowledge derives from the ancient knowledge and practical experiences, and is preserved through natural and the social-economical selection. Culture is the cumulative deposit of shared knowledge, experiences, and cognitive constructions possessed by a group of people. The evolution of knowledge is fostered in specific culture, and in reverse, newly formed knowledge reshapes the cultural environment. Thus the culture constantly changes as time proceeds. Local knowledge and culture play an important role in the formation of a settlement system, and hence determining the resilience of the system. In order to have a comprehensive understanding about local knowledge, it is helpful to review in which natural and social/cultural environment local knowledge is formulated and evolved.

To investigate the content of local knowledge, the research goes to two directions. First, the ancient knowledge and cultural background in the research region are studied, as well as their major transitions. This is a top-down approach, concentrating on the synthesis the general characteristics of the ancient local knowledge, and also deducting the rules of its evolution. The rules of evolution help to form a better comprehension about the current preservation status of local knowledge. This direction is expected to portrait the contemporary local knowledge in general.

The other direction is to acquire local knowledge from its current local knowledge possessors. That is to say, the pieces of local knowledge are collected through field investigation methods, including interview, survey and mapping, with the local people. This branch of research work focuses on the detailed contents of local knowledge. Comparing the local knowledge now people possesses with the ancient local knowledge and modern science, we can tell which part of the local knowledge has changed or now developing. Deductions can be drawn, as we inspect how the settlement changes accordingly, and thus how system resilience is affected. By conducting field work to collect the existing local knowledge, we can also draw out quantitative data. This research compares the data with scientifically recorded data, as well as model simulation result, to assess the scientific value of local knowledge. Questionnaire and structured interview during the field work not only focus on investigating the contents of local knowledge, but also the dissemination means of local knowledge. Local people's involvement in rural planning is investigated as well. This work caters to the preservation state and applicability of local knowledge, and will be further introduced in Chapter. 6.

From above we get to know the information, thoughts and concepts that local people possess. But there is a large proportion of knowledge, which can hardly be narrated by the possessor, rather, directly reflected by people's living environment and lifestyle. The history of agriculture development sheds light upon the content of local knowledge in the aspects of ecology and the first industry economy. In rural area, agricultural land use and natural resource management strategy reflect the most appropriate way of human-nature interaction the local inhabitants have in mind. Except from the subjective initiatives of the people, there are various external constraints and stimulus. Local knowledge instructed land use and resource management strategies do not necessarily reflect people's ideal, but the practical ways to maximize the common good under specific conditions. Some agricultural development plans issued by the local government always impose significant influence to land use pattern. Those strategies might not be accepted by the members of the settlement at the beginning, but later prove to be fruitful, and in the end, absorbed in local knowledge However, there are also government issued strategies launched, but failed to win the support from the local community due to various reason. Local knowledge is formulated under the influences of local economic and external notions. When researching about local knowledge, especially about the contemporary local knowledge, it is not plausible to separate it from those factors. To simplify and be more objective, this research sees the prevailing land use strategy and natural resource management as the outcome of contemporary local knowledge.

Aside from agricultural land use pattern, there are still countless features of a human settlement reflecting local knowledge, for instance, the naming of places, the site selection for the settlements, and architectures with special connotations. It requires keen observation and high sensitivity about the local culture, so that relative information could be extracted from the complexity of the phenomenon. Last but not least, since pieces of local knowledge spread in many different disciplines, they are categorized in this research, so that it could be easier comparable with the corresponding conventional knowledge.

3.2.2 Evaluate the Correctness of Local Knowledge

In the vast terrain of rural region in China, more investment is yet to be bestowed, in order to establish well-structured databases. The quality and academic level of scientific research in these areas are lagged behind, due to this problem. This is also a vital obstacle, in evaluating the correctness of local knowledge, as conventionally, the correctness shall be verified by scientifically recorded data. In this research, three sets of resilience related information are compared with each other, to testify their correctness. This research mainly focuses on the local knowledge in the aspect of hydrological environment. Itis consisted of water resource management, as well as the historical events of extreme weather and disasters. Subjects compared are: the information drawn from local knowledge, available official records, and hydrology modelling results. The official records and statistics published by the mass media are generally considered reliable, though exceptions exist in specific situations. In this research, official data are assigned with the highest credibility. Official records are supplemented with the information gained from on-site observation by the researcher. Information drawn from researcher's observation shall demonstrate the official records by on site evidences. From the other side, model simulation is applied, using the limited scientific data, to generate an easier comparable parameter for the verification of local knowledge. To be more explicitly, in this research, there is a lack of historical record of the water level of mountain creeks, while alarm water level is an important component of local knowledge. By comparing the simulation result, official hydrological records, and information drawn from local knowledge, it can be rationally judged, whether local knowledge is of scientific value or not. The difficulties when launching a simulation model and conducting an investigation of local knowledge are also compared, in order to show the applicability of those two means in rural planning.

Thus, the local knowledge is evaluated, by the comparison with scientifically recorded data and the simulation result based on scientific theories. By examining the correctness and applicability, advantages and disadvantages of adopting both local knowledge and the conventional scientific research methods are therefore revealed.

3.2.3 Evaluate Local Knowledge's Value in Improving System's Resilience against Natural Hazards

As land use and natural resource management strategies are set and accomplished under the instruction of local knowledge, the function of local knowledge in changing system resilience can be identified by assessing the applied strategies. Literature research on the ancient land use pattern also shed light upon the effectiveness of different land use strategy against extreme natural events. This research defines typical settlements by their sizes and land use strategies. What role does local knowledge play in different settlement systems in changing resilience shall be identified. The three components of resilience help to evaluate the overall resilience of typical settlement systems.

Local knowledge also determines people's reactions to emergency events. As land use strategies shall improve or impair system's ability to handle extreme natural events, the efficiency of emergency plans also reflect system's resilience from human behavioral aspect. For towns, emphasis lies on the local knowledge about emergency plans and reconstruction. While for the less developed settlements, both emergency plans and farmland/forest management are important.

4 Research Methodology

4.1 Technical Methodology

4.1.1 GIS and Flood Simulation Models

In the recent years, GIS technology has become extensively applied by urban and rural planners. It is regarded as a platform, on which the planners are able to analyze and visualize current situation, process geographic information, predict future scenarios through modelling, and exchange information and thoughts among the practitioners. The fast development and popularization of GIS propels the development of quantitative geographic information analysis and scenario simulation.

In this research, GIS hydrologic model is mainly applied in simulating flooding events based on official record data. Simulation results are used as references to check the correctness of local people's perception of environmental settings. In order to complete the simulation, two extensions of ArcGIS are utilized, namely ArcHydro and Soil and Water Assessment Tool (SWAT).

ArcHydro is developed to establish a hydrology database, launch flooding simulation, and visually present the result or various scenarios to decision makers (Esri Water Resources Team, 2011). The ArcHydro tools are embedded within the default toolbox of ArcGIS for desktop. Some advanced functions require Spatial Analysis extension. The geodatabase established by ArcHydro can be easily integrated with several other hydrologic models as a hub, SWAT included. This feature of ArcHydro enables a wide range of data process approaches to be experimented. Major functions of ArcHydro are as the following:

a) Generate a specific ArcHydro geodatabase, which contains both spatial and temporal information derived from vector or raster inputs.

b) Establish inter-relationships among input layers. Input parameters are generally consisted of elevation, slope, flow direction, etc.

c) Trace the water flow in a river system based on geometric attributes.

d) Visually present characteristics of water resource, for instance, the range of watershed, the location of water courses.

e) Conceptualize the river system, using node-link schema.

In this research, ArcHydro tool is applied for the preliminary division watershed in the research region. The basic functions applied include terrain processing, watershed processing, and terrain morphology. To practice these functions, the digital elevation model (DEM) of the research region is the input. Results are roughly divided watersheds, which provide basis for the subdivision of watersheds of smaller tributaries. Therefore, SWAT could have better performance in the following work.

Programmers in Texas A&M University developed SWAT, based on the structures of previous Simulator for Water Resources in Rural Basins (SWRRB) model. It is compatible with the geodatabase generated in ArcHydro. SWAT is developed to simulate and present scenarios, according to different land use patterns and meteorological conditions. Compulsory working principle of this model is composed of three parts. Firstly, to divide watershed into sub-basins based on the configuration of the research region. Then generate hydrologic response units (HRUs) for further analysis. The last part is to set up algorithms (Fig. 4.1) and run the model. When measured hydrological records of the site are available, a calibration of SWAT model could further improve the accuracy of simulation result. The simulated hydrologic cycle is based on the water balance equation (Neitsch, Arnold, Kiniry et al., 2011):

$$SW_t = SW_0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$

Where SW_t is the final soil water content (mm H_2O), SW_0 is the initial soil water content on day i (mm H_2O), R_{day} is the precipitation amount on day I (mm H_2O), Q_{surf} is the amount of surface runoff on day i (mm H_2O), w_{seep} is the amount of water entering the unsaturated zone from the soil profile on day i (mm H_2O), and Q_{gw} is the amount of return flow on day i (mm H_2O).

The general sequence of land phase hydrologic cycle processes are illustrated as the chart below:

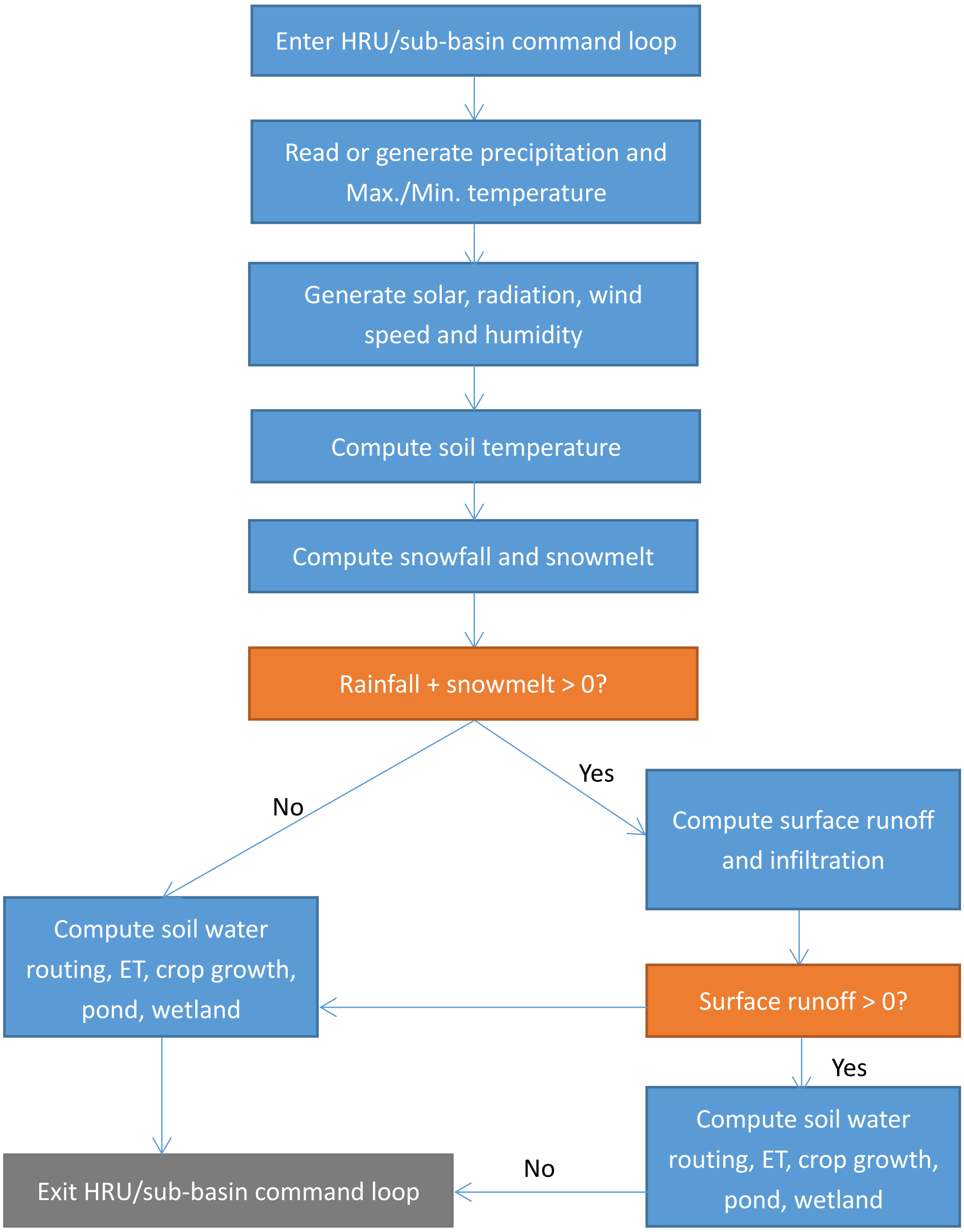

Figure 4.1 HRU/sub-basin command loop in SWAT model

Reference: Fig.0.4 in Soil and Water Assessment Tool Theoretical Documentation Version 2009 (Neitsch, Arnold, Kiniry et al., 2011)

Compared with ArcHydro, SWAT simulation reflects more localized hydrologic features of a research region. By categorizing a watershed into HRUs, the homogeneity of each calculation unit is improved, and different units are farther distinguished from each other. Specific algorithm is applied to the types of HRUs. SWAT encloses more input variables than ArcHydro, including meteorological data and land surface features. It also involves a significant amount of computer processing work for a research site. SWAT operates smoothly when handling geo-information in a smaller range of area. Considering the working competence of a general PC configuration, SWAT model is better applicable for small to medium scale research regions. The SWAT model has proved to be effective simulating runoff of three different scales: the entire United States, three watersheds in Illinois, and one tributary of Mississippi (Gassman et al., 2007). Nash-Sutcliffe Efficiency (NSE) was utilized to verify if the simulated data fits with recorded data. The value of NSE shall be considered unacceptable when it is below zero. When NSE equals one, the model is perceived to reach its optimal performance. NSE of streamflow using SWAT could generally exceed 0.5, according to Bracmort et al (2006). Like most of the models, simulation performance is less satisfying for shorter time steps than for longer ones (Engel et al, 2007). In the case of SWAT, most studies adapt daily or monthly time step, as it is expected, simulation performance of monthly time step is better than daily time step (Moriasi et al, 2007).

SWAT has already been modified and applied in many other countries other than the US. In other regions of the world, inputs of weather condition and the underlying land surface properties also lead to satisfying simulation results. The successful practices in different regions provide valuable experiences for users and model developers in other countries. The study of Bekiaris et al. (2005) shed light upon the research scale, under which the SWAT modeling can achieve better simulation result. The simulation of annual or monthly surface runoff simulation is better restricted to an area of 250 km^2, while daily runoff simulation to 1,000 km^2. Simulation of area over 1,000 km^2 should be calibrated using measured data covering 12 to 15 years. However, there is one problem hard to be neglected. Since SWAT model is designed for the utilization of American researchers, the units and measuring methods of the input parameters cater to US standards. More importantly is that, the US has a perfect database for urban and rural researches, while for developing countries it is hard to achieve. Jayakrishnan et al. (2005) addressed, that the data pre-procession of SWAT should be more adaptable for the sites lacking of specific forms of input data.

In China, successful SWAT practices have been launched in many different regions (Sun, Zhang, 2010). NSE in calibration and validation processes reached 0.71 and 0.73, respectively, in monthly streamflow simulation of Sanchuan River watershed, Shanxi Province (Luo, R et al, 2008). However, the researches mainly focus on the major rivers, rather than the tributaries of lower hierarchy. SWAT users in China undoubtedly face the problems of insufficient and under-prepared input data. In order to solve those problems, developers of SWAT recommended and developed several supporting programs. For instance, WGEN is designed for weather data preparation and SPAW Hydrology for soil property inquiry. Such computer programs or models help convert the unit of mismatched input data, or calculate required physical parameters. A number of foreign researchers also developed their specific approaches to prepare input for simulation. For input parameters, which cannot be calculated by existing data, and not recorded by professionals, SWAT practitioners have set up empirical formula.

Except from the input, the other factor which determines the quality of simulation result is the practice of calibration. Conventional model for SWAT calibration is SWAT-CUP 2012, integrating mainstream calibration procedures of SUFI2, PSO and GLUE etc. By testing the sensitivity and the uncertainties of watershed parameters using measured data, the accuracy of model simulation can be improved. As Abbaspor et al. (1999) stated, one watershed can have many calibrations so that goes in accordance with different research orientations. That is to say, given different research subjects, it could be expected that calibrations of one specific watershed shall have their own set of parameters. In this research, focus lies on daily stream runoff. However, as it has been addressed before, the insufficiency of measured data is the major problem which encounters rural landscape planners and environment researchers in China. In this case, the lack of measured daily water level data for tributaries of lower hierarchy in a river system makes it impossible to calibrate the model. More effort needs to be spent on the establishment and maintenance of hydrological database, in order to achieve a more accurate simulation result for daily runoff.

Figure 4.2 The role of modelling in the research structure of testifying the correctness of local knowledge

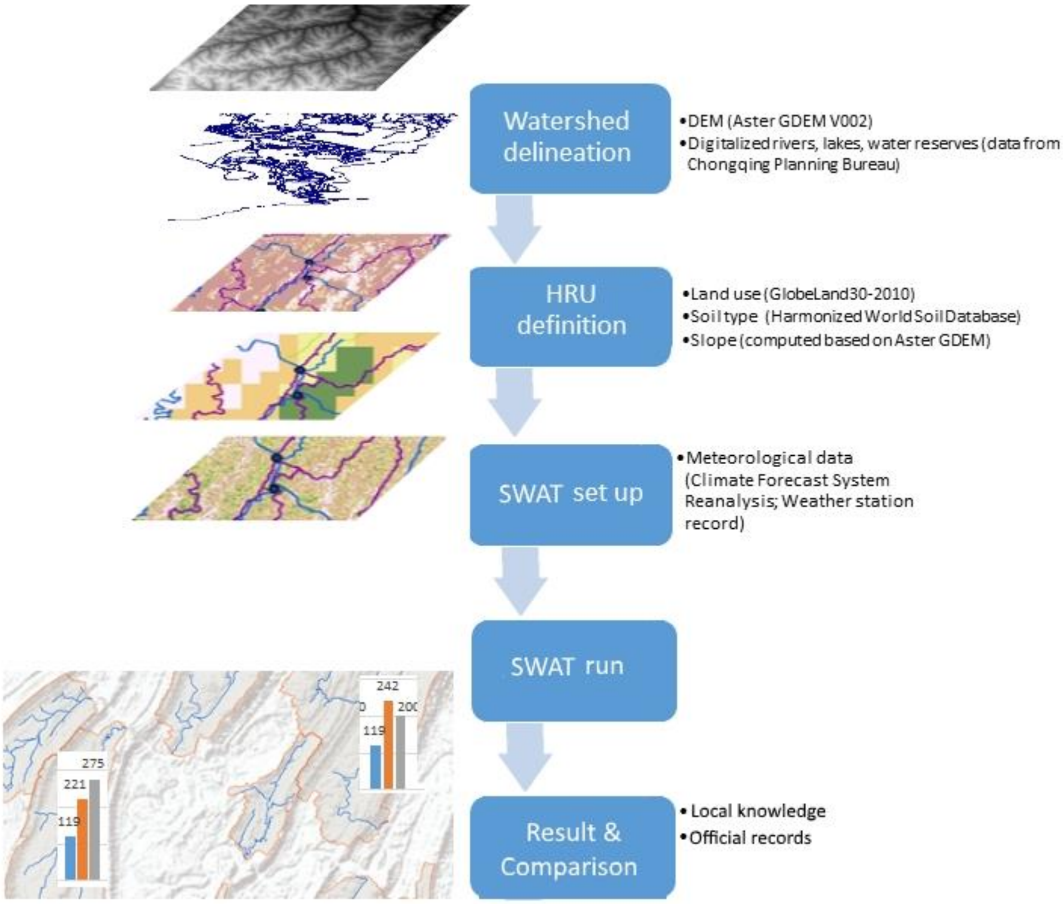

Figure 4.3 SWAT model workflow and expected result

To conclude, ArcHydro and SWAT model are well acknowledged as the cutting-edge, reliable models in hydrology related analysis. There have been successful cases in China. This research applies those ArcHydro as well as SWAT model, in order to obtain convincing results about the historical extreme water level events. Comparison with data from other sources is be made, and the final comparison contributes to evaluate the correctness of local knowledge.

4.1.2 Input Data Management for Hydrologic Models

This research attempts to elucidate that local knowledge could to some extent supplement systematically recorded or analyzed scientific data. The scientific methodology of geo-information analysis and flood process simulation is adopted in this research, in order to assess the susceptibility of water level raise and flooding. This approach has strict requisitions of input data, including the methods of measurements, dimensional units, etc. By applying the models, the current state of scientific databases, which are available to general rural planners, is revealed. Additionally, the accessibility of available data shall also be evaluated, so that planners and researchers can be able to decide which datasets to apply for.

Due to the specific requirements of those two models, pre-process of the input data is necessary. This research exemplifies how the original data are transformed to satisfy model requirements. Detailed methodology shall provide suggestions to other researchers, who would use SWAT for flood simulation modelling.

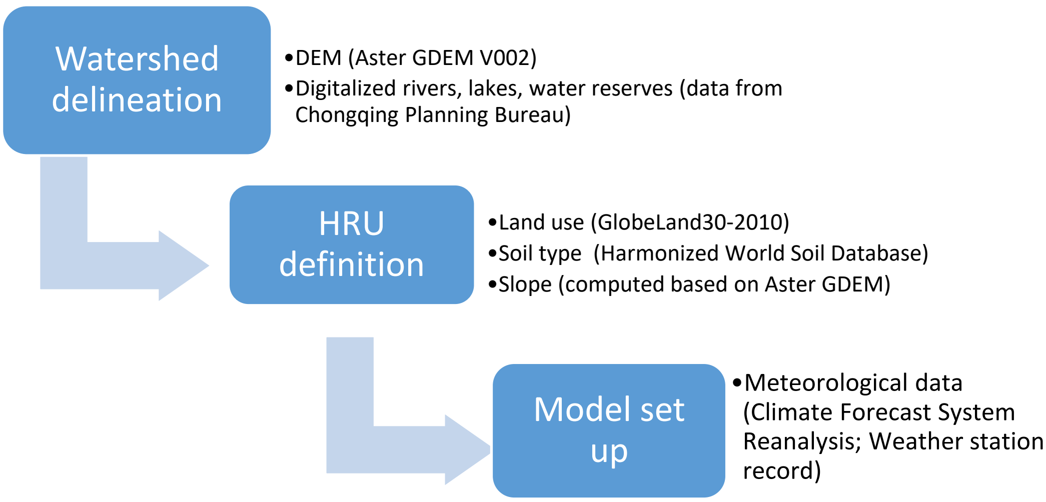

Figure 4.4 Input data applied for SWAT model

The topography is decisive to the drainage system of the settlement. Both ArcHydro and SWAT require accurate DEM as the base for drainage process simulation. This research applies the ASTER Global Digital Elevation Model (GDEM) V002[1] as the input terrain data. It was published as open data across the world in 2011, with improved vertical and horizontal accuracy and higher resolution than its previous version. ASTER GDEM has the resolution of 30 meters. This resolution agrees with other available input data applied in the SWAT model. The data apply 1984 World Geodetic System (WGS84), so that it could be easily imported to the ArcGIS system.

This research site covers a relatively large range of area. The area of basins ranges from 90 to 860 km^2. Downloaded raster files are merged in ArcGIS, then trimmed to exclude Central Chongqing city.

ArcHydro is applied to roughly divide the GDEM according to the main watersheds. The Yangzi River and Jialing River which flow across the research area are surrounded by highly

[1] https://asterweb.jpl.nasa.gov/gdem.asp

urbanized lands. As the research mainly focuses on rural region, watersheds of those two rivers are excluded.

The principle of ArcHydro tools is to draw out the route of conceptual water drop flowing across the research site. Flow direction is a determinant to the modelling result. Since flow direction is decided by the elevation difference of coherent terrain cells, it is compulsory to preprocessing the terrain data before activating further terrain analysis. By terrain pre-processing, a hydrologically correct DEM (HydroDEM) is generated.

In order to correct the DEM for hydrological analysis, three defining elements are taken into consideration, namely sinks, known lakes/water reservoirs and known rivers.

Sink indicates the area where water accumulates, but does not leave as runoff. It is common, that sinks are resulted from the interpolation artifacts of DEM construction. Lakes and water reservoirs are the second key element in terrain preprocessing. Generally speaking, the water network in Chongqing belongs to the typical dendritic drainage pattern. Water in the entire basin drains through one single outlet, to be more specifically, the downstream of Yangtze River. Except from some water reservoirs, all waters flow downstream instead of retain in an isolated basin. In accordance with the local water management strategy, the majority of smaller scale water reservoirs are constructed on top of low hills or mountains. This means that the reservoirs only collect water from natural precipitation directly above its surface, rather than collecting the runoff from surrounding area. For the dendritic terrain, the first step of terrain preprocessing is to fill sinks. This function is embedded in ArcHydro. It automatically fills all sinks within the site. A filled DEM is then generated.

The third element is the known water course. The geographic data of known water network are provided by Chongqing Urban Planning Bureau. Both rivers and lake/ water reservoirs are drawn in irregular vector polygons. The centerline of the river is redrawn with help of the automatic vectorization tool, and then adjusted based on satellite imageries manually. ArcHydro enables user to preprocess the terrain, so that it agrees with the observed drainage system. This is realized by the function Burn In in DEM reconditioning, which imprints the polylines of known water course on the DEM by drastically decreasing the elevation at the polylines. An agreed DEM is therefore generated for further utilization.

The flow direction algorithm draws a grid based on the preprocessed DEM the slope direction of each cell. If there is no abnormal warning, the rest of steps could be carried out smoothly. Sequentially, those steps are as follows: Flow Accumulation, Stream Definition, Stream Segmentation, Catchment Grid Delineation, Catchment Grid Delineation, Catchment Polygon Processing, Drainage Line Processing and Catchment Processing. In flow accumulation process, upstream cells are identified and stored in a grid. Then in the stream definition process, cells are defined as stream as a larger area than a specific threshold is drained through them. Recommended threshold value is 0.5-1% to the flow accumulation value. Lower threshold leads to smaller watershed delineation. The thresholds of 0.6% and 1% generate similar results. It is also recommended that the number of catchment shall not exceed 1,000. The 0.6% version is adopted in this research. After the catchment delineation and polygon processing, the boundaries of catchments are generated in vector format.

The vectors of major basins are applied to roughly divide the tributary basins. Similar procedure for watershed delineation is launched for each tributary in SWAT for the second time. Final output of this procedure is base maps of tributaries, containing geo-information about the water courses and their sub-basins.

The following procedure is to define and classify HRUs. In this step, land use, soil type and slope data are the basis for HRU division. For country outside the US, there are more obstacles in data acquiring and pre-processing. Data from all available sources are sought, and measures are taken to re-organize the data into SWAT required format.

Land cover type is the synthesized feature describing the physical attributes of the earth's surface. If land cover type can be subdivided by more specific measure or strategy of land use, the result is expected to be more helpful to understand the ecological, and the socio-economic status of the research region.

This research applies GlobeLand30-2010 database as the input land cover data. The resolution is 30 meters in accordance with the DEM. The dataset is generated by classifying remote sensing images, including Landsat TM and ETM+ images and Chinese Environmental Disaster Alleviation Satellite HJ-1 images, into ten major land cover types. Approximately 80% of all satellite images are taken from 2009 to 2011 (National Geomatics Center of China, 2014). GlobeLand30-2010 data are geo-referenced to the coordinate system of WGS84.

For the simulation of runoff process in SWAT, land cover data provide information about the vegetation types the land surface, which is decisive to the land's capability to retain soil and water. On the other hand, land cover data contain land use types. In SWAT model, default parameters are set for each land use types. It should be noted that there are mismatches between SWAT default land cover types and GlobeLand30 land cover categories.

According to the categorization of GlobeLand30-2010, land parcels are divided in cultivated land, forest, grassland, shrub land, wetland, water bodies, tundra, artificial surfaces, bare land and permanent snow and ice. Cultivated land includes terrace field, dry farmland and fruit gardens, etc. Forest is identified as the deciduous or coniferous trees cover over 30% of the land parcel. Shrub land and grass land are identified as their dominant vegetation type covers over 30% and 10% of the land parcel, respectively. Artificial surfaces are constructed areas, including residential, industrial, commercial area, urban infrastructures, etc. Bare land is rare in the research region, as it indicates the lands with less than 10% of vegetation cover. According to sample tests, overall accuracy of GlobeLand30-2010 is 83.51%. Chongqing Municipal is making efforts to establish an open geo-information platform for planners and researchers. Contemporarily, only the land use of constructed area is available from Chongqing Urban Planning Bureau. Scientific researches about land cover changes in Chongqing interpret remote sensing imageries (Zhao, Yang, 2008), but land cover type are categorized even roughly. Only water, constructed area, forest, and farmland are interpreted from remote sensing imageries.

For SWAT model, it is compulsory to set up a link between the input land use/land cover categories and the built-in land use classification table. That is to say, all land use categories shall be assigned to SWAT Land Cover default database. This procedure could be manually operated by filling in lookup table. Land use is preliminarily divided in two main categories, namely crop and urban. The user is thereafter enabled to associate actual land cover to the US standard land use type based on the major plant types. For the urban/constructed area, population intensity and functions are the indicators. For instance, a large proportion of farmland in Chongqing region is classified into rice field, and the rest into vegetable and corn field. Constructed area in each watershed is defined as low-medium populated residential area. Once the land uses are assigned to default land use categories in the SWAT database, water management for each category is simultaneously assigned according to default settings. User modification could be activated after writing in all data.

SWAT is extremely sensitive to the changes of soil layer input according to previous practices. Since the model mimics the natural process, it is not difficult to comprehend that soil type is important for SWAT model, considering the principles of surface runoff. Surface runoff occurs in the following situations. First, the precipitation rate exceeds the soil infiltration rate and the capacity of depression storage. Second, the soil is fully saturated and the depression storage is filled. Third, infiltration and saturation process are impeded by impermeable land surface. All situations are directly related with the physical condition of land surface and soil layer settings. In the SWAT model, physical features of the soil layer are decisive to the process of water cycling in the HRU.

This research adopts the Harmonized World Soil Database (HWSD) version 1.1 as geo-information about soil layer. The 1:1,000,000 scale soil map of China is distributed by the Institute of Soil Science in Nanjing (Shi et al., 2004), based on the Second National Soil Survey of China. It is the state-of-art database available for researchers. HWSD compiles the geo-information of soil distribution, physical and chemical parameters of topsoil (0-30 cm) and subsoil (30-100 cm). HWSD succeeds the FAO-UNESCO soil taxonomy FAO 90. Scholars from the China Agricultural University and the Ministry of Natural Resources produced a lookup table to link the Chinese soil taxonomy based soil textual classes to FAO 90 taxonomy. In the application of SWAT, the difference in soil taxonomy causes even more confusion. SWAT requires soil data entry with the taxonomy issued by USDA, which is acknowledge to be more sophisticated than the FAO system. All three referred soil taxonomies differ in parameters and the level standards. Though researchers in the western countries have attempted to establish a lookup table between FAO and USDA soil classification systems, currently there is no satisfying achievement available.

Considering the mismatch of soil taxonomies, this research returns to the primary physical and chemical parameters of the soil, to set up user defined soil database in SWAT. Based on the requirements of SWAT on soil data entry and the information contained in HWSD, the following table (Tab. 4.1) is drawn, depicting the interrelationships between the parameters in each database systems.

Table 4.1 The list of soil parameters required in SWAT model, data included in HWSD, and preprocess methods

Parameters required for SWAT soil data entry	SWAT abbreviation	HWSD Ver 1.1	Methods of data preparation
Soil name	SNAM		User define
Soil hydrologic group (A, B, C, or D)	HYDGRP		Classify based on Saturated hydraulic conductivity
Fraction of porosity	ANION_EXCL		Default value 0.5
Texture of soil layer	TEXTURE	T/S_USDA_TEX_CLASS	
Soil layer depth (mm)	SOL_Z	300 mm/1000 mm	
Moist bulk density (g/cm^3)	SOL_BD	T/S_REF_BULK_DENSITY	
Available water capacity of the soil layer (mm water/mm soil)	SOL_AWC	AWC Range	Calculate by SPAW
Saturated hydraulic conductivity (mm/h)	SOL_K		Calculate by SPAW
Organic carbon content (% soil weight)	SOL_CBN	T/S_OC	
Clay content (% soil weight)	SOL_CLAY	T/S_CLAY	
Silt content (% soil weight)	SOL_SILT	T/S_SILT	
Sand content (% soil weight)	SOL_SAND	T/S_SAND	
Rock fragment content (% total weight)	SOL_ROCK	T/S_GRAVEL (% volume)	Convert unit
Moist soil albedo	SOL_ALB		Calculate with formula
USLE equation soil erodibility (K) factor	USLE_K		Calculate with formula
Electrical conductivity (dS/m)	SOL_EC	T/S_ECE	
Soil $CaCO_3$ (%)	SOL_CAL	T/S_CACO3	
Soil pH (3-10)	SOL_PH	T/S_PH_H2O	

The preparation of the soil data entry starts from converting the soil property data. USDA and FAO have slightly different cutting value for diameter of the soil particles in defining silt and sand. In the FAO system, the cutting value is 0.0625 mm, while in USDA, it is 0.05 mm. This difference could result in variations in infiltration rate and soil erodibility factor. Soil-Plant-Atmosphere-Water Field & Pond Hydrology model (SPAW) is applied in this research as a tool to calculate physical parameters of the soil layer. Fig. 4.5 below shows the working interface of the Soil-Water-Characteristics (SWCT) module in the SPAW software. Input parameters are sand, clay, gravel organic matter and salinity content, the software calculates wilting point (% vol.), field capacity (% vol.), saturation (% vol.), available water (cm/cm), and saturated hydraulic conductivity (mm/h). Matric bulk density displayed is always lower in value than the reference bulk density provided in the HWSD data, as the former indicates gravel particles have been screened out from the soil sample before measuring. In the options, it is easy to convert measure unit of the entry parameters.

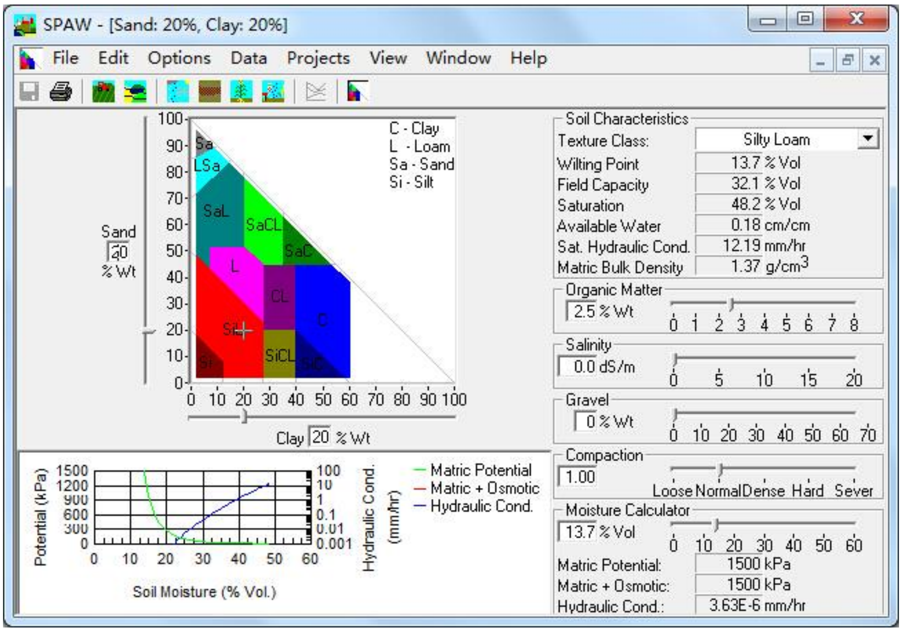

Figure 4.5 The interface of SWCT module

Though the unit of gravel content data entry can be changed by selecting the option in the software, it is still necessary that the user manually calculate the gravel content in % weight, as it is required by SWAT. Converting formula is shown below:

$$\text{Gravel (\% weight)} = \frac{Gravel(\%vol)*0.01*MineralBD}{Gravel(\%vol)*0.01*MineralBD+BD*Vol-Gravel(\%vol)*0.01*BD}*100$$

Bulk density (BD) refers to the dry weight of soil, gravel included, divided by the total soil volume, which encloses the volume of soil and pores. According to the user manual of SPAW, Mineral BD equals 2.65 g/cm^3. The equation eliminates a portion of soil matrix which took the place of gravel volume.

SWAT requires the final constant infiltration rate to categorize topsoil into four hydrologic groups according to the American standard. (Tab. 4.2) SPAW provides the saturated hydraulic conductivity of the soil, which is calculated based on the physical structure of soil matrix. The empirical formulae applied in SPAW are adapted from Rawls et al (1998). Yet another approach, Darcy's Law sheds light on the hydraulic factors in the infiltration process, which may have more accuracy than Rawls' approach. According to the simplified Darcy's Law, infiltration rate is also decided by the wetting front soil suction head and the depth of ponded water above the ground surface. Infiltration rate shall be larger than the hydraulic conductivity, where extra pressure is imposed on the ground surface. However, it is difficult to apply in the SWAT simulation, since the water depth of river and water reservoirs is constantly changing, while the setting of soil condition is fixed. Considering the applicability, this research still applies the calculation result from SPAW.

Table 4.2 Hydrologic soil group rating criteria in the US National Resource Conservation Service (NRCS).

Hydrologic Soil Group	Hydrological properties	Infiltration Rate (mm/h)
A	Low runoff potential; High infiltration rate even when thoroughly wetted	7.6-11.4
B	Moderate runoff potential and infiltration rate	3.8-7.6
C	High runoff potential; Low infiltration rate	1.3-3.8
D	Highest runoff potential; Very low infiltration rate when thoroughly wetted	0-1.3

Available water capacity equals the water content at field capacity minus water content at permanent wilting point. SPAW calculates available water capacity based on soil textures.

Moist soil albedo value is sensitive to soil organic matter content (He et al., 2009). Chinese users established empirical formula by exponential regression analysis based on the SWAT soil database. Two of the equations are widely applied, this research chooses the more accurate one, with coefficient of determination R^2=0.9944, average error 2.3% (Dong, 2013). OC indicate the organic matter content.

$$ALB=0.2313*EXP\ (-1.9448*OC)$$

Universal soil erodibility factor USLE_K indicates the susceptibility of soil erosion. SWAT required unit is (0.013 metric ton m^2 h)/(m^3 -metric ton cm). The complexity of measure unit is based on the primary soil erodibility experiment design conducted by USDA since 1929 (Renard et al., 2011). USLE_K is the soil loss rate per erosion index unit of the sample soil which is measured on a unit plot. The unit plot is specifically designed (Fig. 4.6) and implemented in 10 experimental stations in the cultivated agricultural areas of the US, with uniform slope and in continuous fallow. Runoff and soil erosion is measured for each plot. The measurement is so complicated to conduct outside experimental stations, that USDA kept developing algorithms to calculate soil erodibility factor. Wischmeier and Smith (1978) summarized and analyzed over 10,000 plot-years soil erosion and runoff data and proposed the first USLE soil loss equation. Williams (1995) proposed a simplified equation to calculate USLE_K using soil condition parameters.

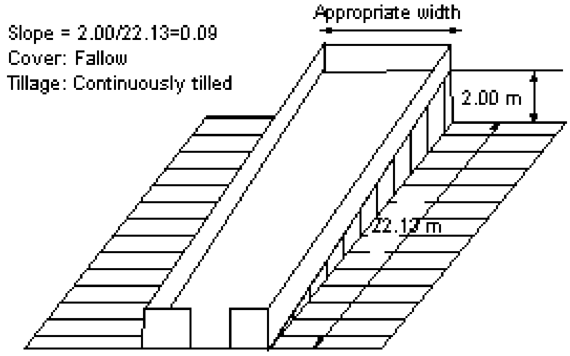

Figure 4.6 Illustration of the unit plot in measuring USLE_K

Reference: http://ag.arizona.edu/oals/malawi/Reports/Image357.gif

Williams' equation of soil erodibility factor is as follows:

$$USLE_{\mathrm{K}} = f_{\mathrm{csand}} * f_{cl-si} * f_{orgc} * f_{hisand}$$

In which:

$$f_{\mathrm{csand}} = 0.2 + 0.3 * \mathrm{EXP}[-0.0256 * \mathrm{m_s} * \left(1 - \frac{m_{silt}}{100}\right)]$$

$$f_{\mathrm{cl-si}} = \left(\frac{m_{silt}}{m_c + m_{silt}}\right)^{0.3}$$

$$f_{\mathrm{orgc}} = 1 - \frac{0.0256 * OrgC}{OrgC + EXP(3.72 - 2.95 * OrgC)}$$

In the SWAT user manual, one parameter in the f_{orgc} equation is mistakenly recorded as 0.256, instead of the correct value of 0.0256.

$$f_{hisand} = 1 - \frac{0.7 * (1 - \frac{m_s}{100})}{\left(1 - \frac{m_s}{100}\right) + EXP[-5.51 + 22.9\left(1 - \frac{m_s}{100}\right)]}$$

m_s: the content of sand in percentage, m_{silt}: the content of silt in percentage, m_c : the content of clay in percentage, OrgC: the organic carbon content in percentage

This research uses Excel to calculate all required parameters for SWAT data entry. SWAT provides easy access to user defined databases. User defined database can be edited in SWAT software program, or directly modified in corresponding Access file. In this research, 31 soil types in the HWSD are involved in the research region. Related data are copied to Excel file for parameter calculation, and then uploaded in the user defined soil database Access file for all tributary watersheds.

Based on the Chinese Agriculture Bureau's provisions about the amenity of agricultural land development, four slope categories are defined (Tab. 4.3). Reclassified slope layer is created for SWAT simulation.

Table 4.3 Slope classification for SWAT input

Slope Category	Slope in percentage (Input)
0-6°	0-10.5%
6-15°	10.5-26.8%
15-25°	26.8-46.6%
Over 25°	Over 46.6%

All data preprocess procedure for land use type, soil layer type and slope gradient are followed by reclassification. Reclassified layers are thereafter overlaid, so that the model is able to synthesize and generate HRUs with unique combinations of all three parameters: land use, soil type, and slope class. SWAT encourages users to determine specific criteria for HRU distribution by assigning multiple HRUs to represent each sub-watershed. Users are able to try out their assumptions about the sensitivity of the hydrologic model to each of the three parameters. This is achieved by the user setting threshold level. For instance, when the threshold level of land use parameter is set to 30% of all area, HRU synthesis would eliminate land use types which cover less than 30% of all area, and involve left land use types proportionally for further analysis.

In this research, hydrological model is considered to be most sensitive to soil type. Threshold levels of the three parameters are set as the following table (Tab. 4.4).

Table 4.4 Threshold level for multiple HRUs definition

Parameter	Threshold
Land use type	20%
Soil class	10%
Slope class	20%

The system automatically checks if all HRU data fall within the valid range. After successful HRU definition, a Final HRU Distribution report is generated, describing the HRUs features for each sub-watershed.

One of the most important indicators in modelling watershed hydrology is the weather input data (Bleecker et al., 1995). As all watershed hydrology models, SWAT is extremely sensitive to weather input data, especially precipitation data. It is always a challenge to acquire and preprocess accurate data for hydrological models (Kouwen et al., 2005), in China and in the western developed countries alike. This research attempts to acquire and apply meteorological/precipitation databases from different sources, therefore discuss about the applicability in SWAT model, and make comparison of the sequential simulation outcomes. The ultimate goal of this section is to provide scientific analysis result for further comparison with the flood event related information obtained from the local residents. It should be noted, that the principle of SWAT is simulate water flow on the land surface. As it is with the ArcHydro model, elevation determines the flow direction. In reality, there are cases, where the inverse flow causes flood in specific river sections. SWAT has limited capability to handle such complex processes.

In preparation of the meteorological data, virtual gage location, or the location of weather observation stations shall be drawn on the base map. Daily precipitation, temperature, solar radiation, wind speed and relative humidity data shall be input in ASCII, in order to fulfill specific format requirement. The model then computes the hydrological processes in each HRU, and generates the flow pattern in the watershed.

This research intends to apply meteorological data from two data sources. Data quality, availability, sufficiency and the accuracy of simulation result are compared.

Considering that the flash flood in the mountainous are generally triggered by intensive rainfall within a short period of time (1-3 days), this research initially intends to apply the rainfall data with a shorter time interval of one hour. In principle, SWAT supports precipitation data entry in sub-daily time intervals. Sub-daily precipitation data is easily available from the China Meteorological Data Sharing Service System. The .grd format of data can be visualized through the professional software GrADS.

However, GrADS ASCII conversion could not match the displayed contour-line map. Due to the programmatic error, this GrADS data is not applied as input meteorological data for the SWAT model in this research. The hourly precipitation data are expected to improve simulation performance for sub-daily flood event. Accordingly, the amount of data multiplies. In this approach, all contour maps shall be loaded and converted to required data format. The output data from GrADS shall go through further manual processing procedure, since the quality of output data is far from satisfying. Considering the amount of data, it is time consuming to verify the large amount of entry data.

The maximum 1/2 hour precipitation value regulates runoff volume in the SWAT model. Though not mentioned in the SWAT input list, this parameter is compulsory in establishing virtual weather station, according to WGNmaker 4 User manual. The basic weather station dataset contains the average maximum 1/2 hour rainfall intensity for each month. This parameter controls the weather data simulation function embedded in SWAT, so that the results do not exceed maximum allowed value. Maximum 1/2 hour rainfall is not available in conventional open source weather databases. It is generally recommended that maximum 1/2 hour rainfall value asset by 1/4 maximum daily rainfall value. The Meteorology Bureau of Chongqing offers supplementary data of rainfall events at different intensity level, with the record time interval of 5 minutes. Data contains heavy rainfall events during 2009 to 2011. The escalation of rainfall intensity is based on the empirical formula of local rainfall reoccurrence period (Guo et al., 2015) and relevant regulations of rain storm precaution. The most intense rainfall is the one in 4th to 5th July, 2010. Its intensity reaches the criteria of "exceptionally heavy rainstorm", reoccurrence period approximately 3 years, with the 1/2 hour precipitation value of 35.5 mm.

There are successful applications of global weather data in SWAT model, based on the weather data by the National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR). This open source database can be downloaded in SWAT required format[1], though minor adjustments are still needed, based on the actual condition of research region. CFSR dataset contains hourly global weather data at approximately 38-km resolution from the year of 1979. For the places where no observation data are available, CFSR gives simulation data based on the condition of global atmospheric circulation. It is established in order to supplement historical weather data, as well as fill the gap between distantly distributed weather stations. Performance of CFSR in SWAT simulation is tested by researchers. Tests demonstrate that the CFSR generates as good as or even better runoff simulation results than conventional weather station record data (Fuka et al., 2014). The improvement of simulation result is especially significant where actual weather stations are too sparsely distributed. Fuka et al. also speculated that a grid of gage stations with farther proximity (indicating CFSR data, 38 km) offers more referential data than unevenly distributed stations with closer proximity (10-20 km). In places where data are scarce, CFSR proves to be of significant value in hydrological prediction (Dile, Srinivasan, 2014).

In this research, downloaded database contains 304 virtual stations in the range of the research region. Default starting hour of day is 12:00 a.m. UTC (China Standard Time 20:00 p.m.). Time period from 1st, Jan. 1979 to 31st, Dec., 2014. Parameters are temperature (℃),

[1] http://globalweather.tamu.edu/

precipitation (mm), wind speed (m/s), relative humidity (fraction), and solar radiance (MJ/m²). One additional parameter is required by SWAT, the dew point. The programs dew.exe and dew02.exe are designed to calculate average daily dew point per month based on daily air temperature and humidity input. Calculation by these two programs employs daily data of an entire year. This research applies the dew point calculation computing program. The principles of dew point calculation are show below.

According to Allen, R. (1998), the saturation vapor pressure e_s is calculated based on daily air temperature value T (℃).

$$e_s = 6.108 * \exp(\frac{17.27 * T}{T + 237.3})$$

exp =2.7183 (base of natural logarithm)

The average daily actual vapor pressure e_a is derived from e_s and average humidity (%) (Häckel, 1999).

$$e_a = RF * e_s/100$$

Daily dew point is calculated based on the following experimental equation (Liersch, 2003):

$$\text{dew} = (234.18 * log_{10}(e_a) - 184.2)/(8.204 - log_{10}(e_a))$$

Calculation results are stored in separate text files, and hence facilitate further processing procedures.

All above weather data are processed, in order to establish virtual weather stations for SWAT simulation. WGNmaker 4 is the official recommend program for this task. This computing program is embedded on the base of Excel. By organizing all ASCII text files in the document, WGNmaker is able to generate basic settings of each virtual weather station in batch. Processing time depends on the amount of data. Calculation result of one virtual weather station is shown as below (Tab.4.5).

Table 4.5 Sample of a virtual weather station

2731050 run 2015/4/12 15:59:30											
		27.32			105.00						
		1647.00									
		36.00									
6.82	9.83	14.86	18.60	20.64	21.88	24.07	23.76	20.06	15.13	12.03	7.95
0.06	1.72	4.80	9.02	11.88	14.42	16.03	15.44	12.92	9.59	5.91	1.82
5.01	6.31	6.87	6.18	5.29	3.91	2.95	3.38	4.32	4.30	4.52	4.30
2.96	3.33	3.48	3.16	2.91	2.38	2.02	2.01	2.80	2.95	3.27	3.05
57.45	51.07	63.25	104.42	181.92	239.61	239.78	230.30	191.77	153.96	94.72	65.45
1.90	1.79	2.42	3.84	7.08	10.07	10.89	10.57	8.60	4.96	3.63	2.06
3.02	1.69	2.53	2.37	3.48	3.13	3.30	3.34	3.52	2.45	3.77	2.32
0.78	0.55	0.58	0.64	0.60	0.75	0.73	0.76	0.57	0.51	0.60	0.57
0.96	0.94	0.93	0.94	0.94	0.95	0.96	0.96	0.95	0.98	0.97	0.97
29.56	25.69	27.67	27.69	28.33	27.89	29.44	29.71	27.60	30.00	28.66	29.49
4.3354	2.426	3.9592	5.6546	14.9936	22.689	19.4884	18.8354	19.0834	9.7188	8.295	4.1996
8.78985	12.0124	15.9118	17.0196	16.3034	15.8729	20.6743	19.2652	13.717	8.06654	7.73341	7.21673
1.13555	2.67491	5.62824	9.83379	13.0665	15.8886	17.4381	17.8517	14.5005	10.8032	7.15865	2.83785
2.40352	2.59612	2.65593	2.64945	2.43338	2.18427	2.19361	2.19361	2.2151	2.10005	2.20928	2.29036

Figures show meteorological data on the monthly basis:

Row 1-4: basic information of the virtual weather station

Row 5-6: average daily maximum/minimum temperature (℃),

Row 7-8: standard deviation of daily maximum/minimum temperature,

Row 9: average total precipitation of the month (mm),

Row 10: standard deviation for daily precipitation,

Row 11: skew coefficient for daily precipitation,

Row 12-13: probability of a rainy day following a dry/wet day

Row 14: average numbers of wet days in month,

Row 15: most extreme 30-minute rainfall intensity (mm)

Row 16: average daily solar radiation (kW/m^2)

Row 17: average daily dew point (℃)

Row 18: average daily wind speed (m/s)

The output of virtual weather station data is stored in .xls format, and can be directly written into SWAT. A complete weather database for the research region is set, when data of all virtue weather stations are uploaded.

The second weather data source is China National Stations' Fundamental Elements Datasets V3.0 (NSFED V3.0, Ren et al, 2012). Under the treaty of the United Nations Framework

Convention on Climate Change (UNFCCC), the Chinese meteorology institutions shall provide national-level data for international scientific research. National Oceanic and Atmospheric Administration (NOAA) built an on-line platform for weather data application and download. NSFED V3.0 is available for the general public. In the range of the research region, there is only one national-level weather station. It is Shapingba Weather Station, located in the center of Chongqing main city. It records data from 1956 to present (data available to the general public till 31st, Dec. 2015). All conventional meteorological parameters are recorded, while the same as the CFSR dataset, maximum 1/2 hour precipitation data are not included, calling for identical data supplementation.

The differences between the CFSR and NSFED data are obvious. Since there is only one actual weather station in NSFED, the virtual weather station with closest geographical distance is chosen for comparison. The coordination of the actual weather station is 106.467E, 29.583N, while that of the virtual station is 106.562E, 29.506N. Considering that the hydrological model is most sensitive to precipitation, comparison of this parameter is made. The following table lists the rainfall intensity in descending order (Tab. 4.6). The number of events at each level of rainfall intensity also significantly distinguishes between the two sets of data. For normal rainstorms, 17 events are listed in CFSR, while 83 are recorded in NSFED during the same time period of 1st Jan. 1979 to 31st Jul. 2014. Event dates later than 31st Jul. 2014 for NSFED input are omitted in the statistic, and the event dates are partially omitted from the list due to the limited space. The dates of severe storm events also differ.

Table 4.6 The comparison between the two sets of precipitation data.
The left table presents CFSR data at the virtual station closest to Shapingba Weather Station. The right one presents Shapingba weather station records from NSFED. Filled colors indicate the level of rainfall intensity. Dark orange color refers to heavy rainstorm, with daily precipitation between 100 to 200 mm, yellow indicates normal rainstorm with daily precipitation between 50-100 mm. Two red color filled items are extreme rainstorm with daily precipitation over 200mm.

Date	Precipitation (mm)	Date	PCP (mm)
8/31/2012	114.2578548	7/17/2007	271
7/10/1989	103.2028423	7/21/1996	206.1
9/18/2011	101.3334066	6/13/2002	190.1
9/11/2012	97.89843348	8/4/2009	164.8
5/10/1981	97.60321728	6/15/2008	163.1
7/1/2013	86.31479196	7/30/1980	148.1
8/27/1998	77.47078612	8/28/1996	144.7
8/12/1985	66.2682168	7/2/1981	143.4
5/15/1990	61.05989664	8/2/1998	133.9
8/28/1979	60.80414508	6/23/1979	125.1
6/6/1987	60.22909368	7/11/1994	124
8/20/2012	58.1073912	9/2/1988	122.1
6/9/2013	57.35210184	6/18/1998	116
6/17/2011	56.98984716	6/6/1996	114.9
3/20/2014	56.7993294	6/22/2003	113.6
8/4/2009	55.26633924	7/15/1999	102.9
7/11/2007	55.0998977	8/17/2015	97
3/28/2014	53.89138386	7/14/2015	94
7/22/2012	53.67511519	8/29/1983	89.6
5/12/2012	52.43909682	5/21/2012	89
6/24/1984	49.93456932	5/15/1990	88.4
7/27/1989	49.93113312	6/8/2013	87.6
3/30/2014	49.29776263	9/18/2014	87.1
6/6/1999	48.61618621	8/5/2009	86.1
8/18/1986	47.98620603	7/25/1984	85.6
10/11/2011	47.95020072	6/17/2011	85
8/18/1990	46.2867625	5/27/2004	84.8
5/1/1998	45.74771532	7/5/2010	84.5
7/8/2006	44.45682948	6/30/2003	83.9
6/25/2012	43.9625052	8/19/1989	83.2
5/3/2014	43.66375253	8/6/1984	82.5
8/19/1986	43.00116732	5/10/1981	80.4
9/17/2011	42.69386956	6/20/1986	80.2

Data from CFSR is still applied for simulation, and will be compared with the simulation result generated based on NSFED dataset. When CFSR dataset is applied, a virtual weather station within or at the minimum distance to the monitoring point shall provide meteorological data for the runoff simulation. When NSFED data are applied, all sub-basins are assigned to the data from Shapingba Station. By writing in weather station information and data of all parameters, the weather data entry is completed.

When all input data are well prepared, the write-in option of the SWAT model is activated. This function double check all input data, and enables data modification after entry. All write-in tables are compiled in .mdb document. Other detailed input parameters such as the storage capacity of water reservoirs can then be added in the input file. In this research, a considerable number of small scale water reservoirs have been contracted to private owners. Local workers have no permission to hand out the inflow and outflow statistics of those water reservoirs. Thus the water reservoir in the model functions only as a water container. The water circulation process of evaporation and infiltration are computed in the SWAT model.

Before starting the simulation, the output settings for the report, and the time durance of simulation and shall be assigned. For this research, the start date of the simulations using two weather datasets are both 1st Jan. 1979. The simulation using CFSR data ends on 31st Jul. 2014, while the one applying NSFED data ends on 31st, Dec. 2015. Output file records daily water depth, flow volume and flow speed of each section of reaches. Among them, water depth and flow speed are of specific importance in assessing the potential risk of flood.

4.2 Fieldwork Methodology

4.2.1 Questionnaire and Interview

The research method of questionnaire was invented by the Statistical Society of London in 1838. It is widely applied for collecting data for statistical analysis. Based on the conventional principles of questionnaire design, the questions in this research are arranged in the order of warm-ups, transitions, skips, difficult, and classification (Foddy, 1994). Since the questionnaire is conducted on site, the researcher can make sure that the respondents complete the questionnaire. The screening method in a conventional questionnaire structure is left out. The questionnaire contains a total of 40 questions (Appendix I). The questionnaire design aims at: 1). recording the basic information of respondents, including their general well-being, education level, etc.; 2). investigating the local knowledge storage of respondents and 3). evaluating the current resilience state of the settlement. Catering to the purposes, questions are divided into three parts. Considering the situation, that the respondents are not experienced with disasters might have no knowledge about rehabilitation and compensation at all, corresponding questions are designed not to display to them, in order to spare time and effort. The investigation for system resilience also falls in three parts, in accordance with the phases of disaster management process, namely precaution, emergency action, and post event recovery. It should be noted, that answers to these questions not only reveal the reality, but also represent the information, true or not, possessed by the respondents. In this case, both the casual residents and the officials who are in charge of disaster management or land use management are interviewed. This research collected 189 valid questionnaires in the 14 sites. The questionnaires which are answered by experienced residents are attached with higher referential value in understanding the environment setting of settlements. The preservation status of local knowledge in general is not judged only by the answers from those local professionals, but also the general public.

Considering that it would be inconvenient to carry questionnaire copies in fieldwork, and it is effort-consuming to re-write and organize accumulated information in office work, Computer Assisted Personal Interviewing (CAPI) with the terminal device of tablet is applied in this research. Compared with similar type of products, the one from Data Acquisition and Processing [1](DAP) Company is chosen for questionnaire editing and data processing. Computer Assisted System (CAS) is well developed by DAP technicians. General work flow of CAPI is composed of four stages, namely user and authority management; project editing and management; project implementation; data analysis. Project management enables the project manager to easily adjust the content of questionnaire after pilot research. In project implementation stage, the project manager is able to set specific criteria to determine whether the quality of questionnaire meets requirements. Substandard questionnaires are automatically drawn out from the information pool for further analysis. Raw data are downloadable from the internet. The CAPI also offers basic analytical and data presentation functions.

The CAPI applied agrees with the logical interrelationship among the questions. In the questionnaire, some of the questions are logically related. Certain answers to one question would activate or deactivate a series of logically related further questions.

4.2.2 Oral History

Oral history is a conventional anthropology research method widely applied by human geographers, journalist and specialists in other related disciplines. The aim of oral history collection is to acquire chronical information about individuals and their households. This method is also applied to record people's long term reaction to drastic changes in their living places, and social-economic conditions. Oral history is extracted from in-depth interview. Unlike questionnaire and structured interview, the oral history interpreters shall be given the permission to talk relatively freely around specific topic, for instance, how their lives change after certain events in various aspects (Mullins, 2014). Interviewers, on this occasion, shall avoid putting forward a subjective or leading question, which would interfere the thinking and interpreting process of the interviewees. This is acknowledged as the basic guideline of oral history interview (Brown, 1988).

In this research, oral history is collected from whom affected by destructive natural hazards. The interviewees are asked to narrate remarkable influences of the event on their lives. They are also encouraged to recall their family affairs in time sequence. Experiences of individual households reflect the resilience of the system it belongs to. By collecting oral history, this research summarizes information about influence of disaster on individuals in a system. Information about specific disaster prevention measures, emergency reaction and reconstruction measures the individuals take can be extract from oral history as well.

[1] http://www.dapchina.cn/

4.2.3 Mental Mapping

A mental map is a type of cognitive representation of information about the geographical or spatial attributes of individual's life events. Edward Tolman in the late 1940s has first introduced this concept in the discipline of psychology (Tolman, 1948). In the field of human geography and landscape architecture, the prevailing application cases were to investigate public cognition of elements in the city (Lynch, 1960). In Lynch's study, participants were asked to draw a mental map, which can be used to introduce a stranger to a city, and give them a general idea about the urban space and the city's predominant features. Those mental maps were not expected to reveal the accurate distance or direction, but the perception and cognition of the general public about the urban space. Results of his research contribute greatly to the understanding of urban space and urban morphology. More important and meaningful to this study is, Lynch's research method in acquiring the general public's spatial cognition about their living environment.

A key procedure in the survey on site is the mapping of important elements for disaster prevention. In this research, a revised version of mental mapping is applied. Every respondent who has completed the questionnaire is presented with a map by the end of interview. The base maps are acquired from google satellite map, and printed to a resolution of approximately 10 meters, covering villages and the most adjacent town center. In order to further facilitate the respondents, names of the villages are labelled on the base map beforehand. The last three questions in the questionnaire show the competence of the respondents of recognizing satellite imageries. Additional information would be given, when the respondents claim that they have difficulty understanding the map. They would then be introduced about other landmarks, for instance, the provincial highway, the town center, or some large scale building complexes by the interviewer. The respondents are encouraged to draw on the base map, to mark the water courses which have potential risk of flooding, and circle the area susceptible to flood and landslides. Other related information, such as the date of flood, water level, and the severity of the disaster can be noted on the map, if the respondents would like to. To complete the mapping task, one final question is set in the questionnaire. Respondents are asked about the range of area (in the number of villages and towns), in which the respondents have solid knowledge about water resource.

This revised version of mental mapping has two major contributions in this study. Firstly, it is applied to record local individual's memory of physical changes of the surroundings. Participants are given the freedom to draw out whatever they remember about the natural setting changes which impose impact on their livings. In the picture below (Fig. 4.8), Participant drew his mental map about the streams in the mountain valley. He simply lined out the natural streams, rice fields, and the road to the nearest inter-city bus station. Secondly, mental maps drawn by the local residents provide local knowledge about natural resources and land management strategies, which could support related analysis.

Figure 4.7 Mental map drawing

An interviewee in Chongqiao Village casually drawing a mental map of the irrigation system in his village.

Chapter 4 INTRODUCTION OF THE RESEARCH REGION

5 Research Sites

Chongqing is the largest national central municipality in southwestern China, directly administrated by the Chinese Central Government. The research region covers nine major watersheds. The municipality locates on latitude 29.3°N-29.8°N, longitude 106.3E-106.7E. The nine administrative districts, namely Yuzhong, Jiangbei, Shapingba, Jiulongpo, Nan’an, Dadukou, Banan, Yubei and Beibei District, constitute Central Chongqing. Total area is 5472.82 km^2. To clarify, the research cases are sample rural settlements within the nine districts, located in the watershed of eight chosen main tributaries.

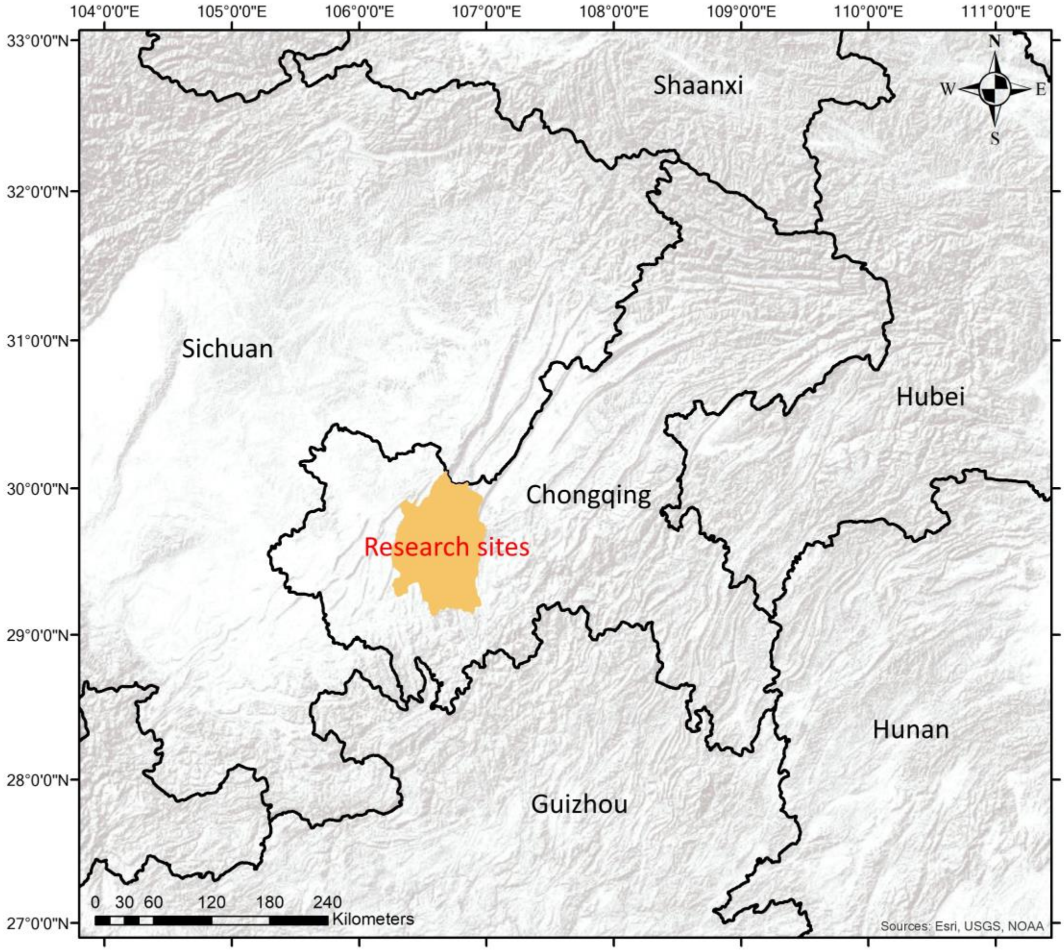

Figure 5.1 The location of Chongqing municipality and research sites.
The large map shows Chongqing municipality in red color. In the small map, red shows Chongqing central city, red and yellow area together composes the research region.

In 2010, parts of Yubei, Jiangbei and Beibei District were enclosed in the boundary of Liangjiang New Area, which is the third national level, sub-provincial new area of China. Establishment of Liangjiang New Area is expected to provide experiences for comprehensive urban-rural reform. The urgent need for regional planning brings about the opportunity of this research. In those nine administrative districts, there are 73 towns and 896 villages, adhering to the bustling urban region by the year 2010. Alongside with the fast pace of urbanization, appropriate rural planning in the surrounding areas could further guarantee the overall development in the entire municipality.

5.1 Identification of the Settlement System

Rural settlement system in this research is categorized according to the economic and governmental composition. The basic settlement system is natural village or a cluster of inhabitants who are closely interrelated by the collective possessions and interest. This research focuses on the agriculture dominant settlements at village scale. Those agriculture-dependent settlements are subdivided based on land use strategies. Each settlement is an inter-connected productive system, heterogeneous to external environment and other systems. In the research region, seven arable land cultivation patterns are investigated (Tab. 5.1). Farmlands in this research region distribute on mountainous and low hill regions. The term “slanted” in the table refers to the farmlands on slope of 6 to 25 degree, without recognizable terrace and field balk. Detailed land use strategies are introduced in Chapter 6.1, with references to system resilience.

Table 5.1 Classification of rural settlement system in regard of production strategy

System	Topography	Cultivation variety
1	Dry slanted farmland	Crop, beans, oilseed rape, potatoes
2	Dry slanted farmland	Fruit trees, landscape trees
3	Dry terrace farmland	Crop, beans, oilseed rape, potatoes
4	Dry terrace farmland	Fruit trees, landscape trees
5	Wet terrace farmland	Rice
6	Wet flat farmland	Rice
7	Mixed	Rice, beans, oilseed rape

Due to the population shrinkage in villages, it becomes common that two or three previous natural villages merged to a new one. In this case, the governmental structure of those natural villages is not decisive to the division of systems. Different land use strategies tell them apart.

Town centers are at higher hierarchy than the villages, and town level government manipulates its sub-villages to a limited extent. When mentioning town system in this research, it refers to the town center itself, excluding adhering villages. These town systems are expected to be more urbanized and modernized than villages. They are less dependent on agriculture than villages, as the local economy is also composed of commerce, industry, tourism etc.

There are principles for choosing the sample towns. Ideally, sample towns shall distribute on different sections of each tributary. It would be better, if there are official reports of landslide or flood events taken place in the towns. Distinctive industries of the sample towns shall cover all major industry types. Table 5.2 shows the list of towns for sample selection. For the column of “Reported flood/landslide”, red font indicate severe landslide or flood happened on that date, blue indicate moderate severity.

Table 5.2 List of towns for survey sample selection.

No.	Towns	Watershed	Section	Area (km²)	Population (1000)			Distinctive Industries /Tourist Attraction	Reported flood /Landslide
					Total	Non-Farmer	Farmer		
1	Tongjing	Yulin	Middle	112.3	45(2013)	15	33	Hot spring	20140913
2	Shichuan	Yulin	Middle	129.7(2007)	67.6(2013)	15.7	51.9	Fruit plantation	20140913
3	Longxing	Yulin	Lower	103.68(2007)	82(2013)	18	64	Ancient town	20140913
4	Shiping	Dongliang	Middle	45.5	24.4	14.5	9.9	None	20070717
5	Jindaoxia /Pianyan	Heishuitan	Upper	74.2	16.7	3.5	13.2	Jindao Gorge, ancient village	20120430; 20140913
6	Liuyin	Heishuitan	Middle	63.4	27	3.3	23.7	Landscape trees	20130514; 20140913
7	Jingguan	Heishuitan	Middle	72.5	54.2	9.5	44.7	Landscape trees	
8	Chengjiang	Bibeihe	Lower	72	36	16.8	19.2	Ancient inland port	20040904; 20120722
9	Xiema	Liangtanhe	Middle	58.58	57.4	12.7	34.7	University town	20070716-20
10	Taojia	Daxihe	Lower	42.5	19	3.1	15.9	Heavy industry	20020612
11	Tiaoshi	Yipinhe	Upper	136.04	37.5	1.5	36	Foying Gorge	20120521
12	Nanquan Neighborhood	Huaxihe	Middle	84.26	51	9.3	41.7	Hot spring	20070717; 20090608
13	Jielong	Wubuhe	Upper	188.15	63	7.1	55.9	Ancient town	20120521
14	Dong(wen)quan	Wubuhe	Middle	122.7	37.9	2.7	35.2	Hot spring	20140614

5.2 Environmental Setting of Sample Rural Systems

5.2.1 River Network

Chosen sample settlements are distributed along major tributaries and creeks in the study region (Fig. 5.2). The basins and river streams layers are the hydrological analysis result from SWAT.

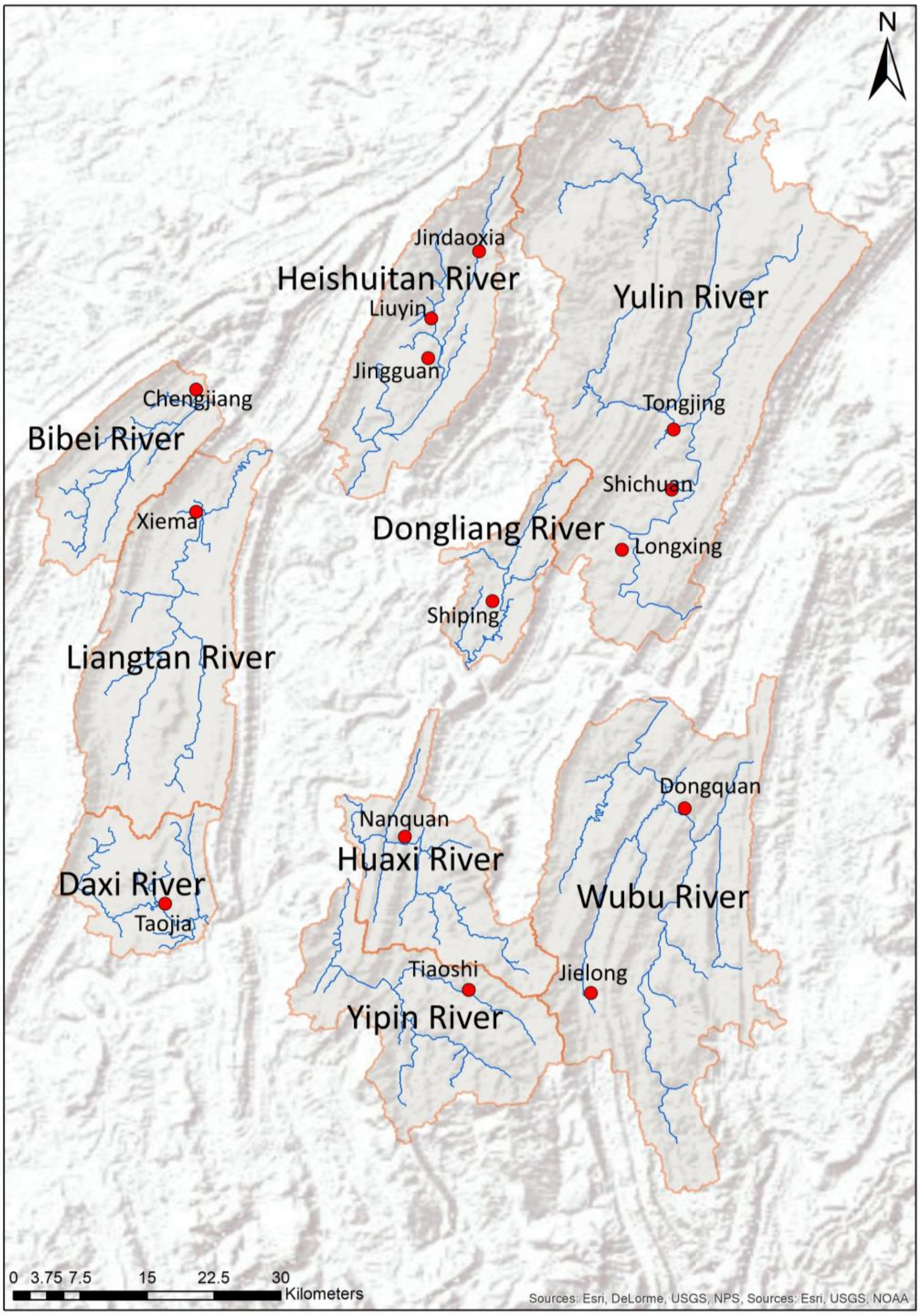

Figure 5.2 Geographical distribution of sample towns

Yulin River is a major tributary of Yangtze River. It originates from the mountain ranges of Sifang, and flows approximately 50 km across Sichuan and Chongqing Town before joining Yangtze River. In 1406, Jianwen Emperor, the emperor of Ming Dynasty attempted to escape from his rebels along Yulin River. This region gained popularity since then. The settlements along Yulin River gradually prospered. Yulin River became an important shipping channel, connecting the rural areas along the river with Chongqing city since the 1950s. Grain and meat were transported to the city, salt and cloth to the villages. The transportational function was soon replaced by modern provincial highways. Tongjing, Shichuan and Longxing Towns are chosen as sample towns in this research.

Dongliang River originates in the north of Yubei District. It is a tributary of Yangtze River. Its length is approximately 34.1 km. Due to the ecological deterioration in its upper section, the base flow significantly reduced in the recent years. River flood is rare in this watershed, but torrential flood and landslide are common. Shiping Town and adjacent clusters are chosen as samples.

Heishuitan River is one tributary of Jialing River with the length of approximately 5km. It once had two sub-tributaries. Though Heishuitan watershed is rather small, the frequency of river flood is one of the highest of all tributaries in this research. In 1980, Shengtian (meaning humans conquer nature in Chinese language) Water Reservoir with the capacity of 5.84 million m^3 was constructed to block one of its sub-tributary, in order to reduce the risk of river flood. Nowadays, river water of Heishuitan River flows from the mountains in Majiawuji. Pianyan and Liuyin Town are chosen as samples. Villages and residential clusters adhering to those two towns are also good examples of rural settlement system.

Gaotan River is the ancient name of Bibei River in Ming Dynasty[1]. The name derives from a great waterfall in the middle section of the river. Bibei River joins Jaling River in Chengjiang Town. Its lower reach was broadened in the 1930s, so that the water course could be used to transport coal. Chengjiang Town is selected as the sample settlement.

Another primary tributary of Jialing River is Liangtan River. It is 88km’s long, originates in Jinyun Mountain Ridge. Liangtan River flows close to the city center of Chongqing. Due to the city expansion effect, all settlements, villages and towns, along Liangtan River are also fast urbanizing. Among all settlements, Xiema Town has the largest proportion of farmer/non-farmer ratio, according to available statistics. Thus Xiema is chosen as a sample town in the watershed of Liangtan River.

Daxi River flows through Xipeng and Taojia Towns, and joins Yangtze River in Tongguanyi Town. It is small in scale, similar to Heishuitan River, but normal water depth is larger than Heishuitan River. Tongguanyi Town grown up as a key courier station in Ming Dynasty, as it locates at the junction of Yangtze River and the ancient road from Chongqing to Chengdu. The lower reach of Daxi River was therefore canalized to facilitate goods transportation. In the recent years, artificial embankment has been constructed on the main stream of the lower reach of Daxi River. In Taojia section, torrential streams join the artificialized main stream. Taojia Town and its adhering villages are especially studied on the effectiveness of river flood management.

[1] Depicted in the History book of Ba County: A record of mountain ridges, written in Qing Dynasty, Qianlong Era (1736-1796).

Yipin River and Huaxi River are Yangtze River's tributaries in Ba'nan District. Yipin River originates from Shengdeng Mountains, flows 49.9km through Tiaoshi Town, Yipin Town, and finally joins Yangtze River in Yudong Neighborhood. Huaxi River originates from Shilinggang Mountain Ridge, flows northwestwards parallel with Yipin River. Six towns/neighborhoods locate along Huaxi River. Geographical conditions and hydrologic features of these two rivers have little difference. Tiaoshi Town and its adhering villages, and Nantuan Neighborhood are investigated.

Wubu River is the second largest tributary in the research region. Wubu River flows northwards from the Jinzi Mountains in Wansheng District, and joins Yangtze River in Mudong Town. The watershed of Wubu River is rich in geothermal resources. The natural resources are very attractive to foreign investors. Dongquan Town, whose name came of the numerous hot springs and mountain springs in the local, have developed to a modernized tourist center. Under this circumstance, do the local residents still possess keen observation to the natural environment? Inhabitants in Dongquan and Jielong Town are interviewed, in order to understand the status of local knowledge preservation under the shock from the modern world.

5.2.2 Landscape

The research regions locate to the east of Sichuan Basin. Sichuan Basin is folded by mountains with the elevation from 1000 to 3000 m, sprawling to the middle plain of Yangtze River. Chongqing is frequently called Shancheng (meaning the city of mountains) by Chinese people, indicating its mountainous topography. The area is featured by its typical karst landscape, with stone forests, limestone caves, and deep valleys (Fig. 5.3). Yangtze River cuts through the Daba Mountains to the east of the study region, forming the famous Three Gorges to the northwest of the region.

Figure 5.3 Deep valley and cave formulated by limestone erosion in Jindao Valley Scenic Spot.

5.2.3 Climate

The research region is in sub-tropical monsoon climate zone. The average annual temperature is 18.2℃. The climate is very humid for most of the year, with an annual precipitation between 1,000-1,300mm. Precipitation is unevenly distributed both spatially and temporally in the research region. Monthly rainfall normally exceeds 100 mm from April to September, taking up 70% of annual total precipitation. Hot and humid summers last a relatively long time, making this region susceptible to flood. In the recent years, the fluctuation of annual precipitation intensified slightly (Fig. 5.4).

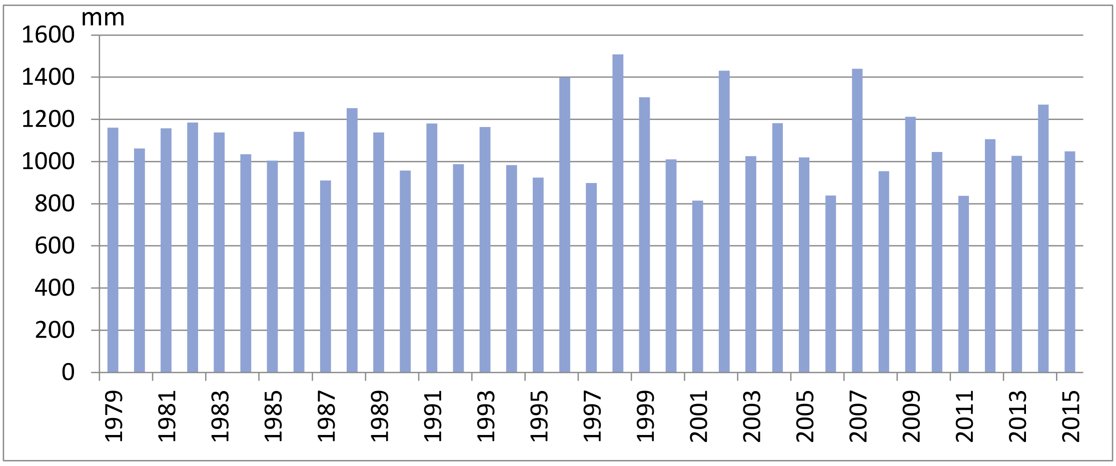

Figure 5.4 Annual precipitation in Chongqing from 1979 to 2015.
Data source: Chongqing Water Resources Bulletin

Due to the topography and climate conditions, the average sunshine hour of this region is 1,055 hours, the lowest in China.

Since 2005, the frequent droughts and floods raised public concern about environmental problems in Chongqing. It is deduced by some experts that the construction of the Three Gorges Dam and global climate change exacerbate the problems of soil erosion, deforestation, biodiversity reduction and other related ecological system degradation. The loss of water and soil resources also imposes risk to the rural settlements in the mountainous area.

5.3 Social-Economic Status

Chongqing was once a part of Sichuan Province. In 1997, it became an independent municipality. The aim of this administrative division is to stimulate its economic development as a pilot city in the vast western China, as it is addressed in China Western Development strategy.

Yangtze River, the most important transportation water way in China, runs east-west in this region. Chongqing has been an inland port for centuries, connecting the southwestern regions with the center of China. Nowadays, Chongqing is still of great significance in China's economic development strategy due to its strategic meaning in the country's transportation system. Constructive measures have been successfully taken to mitigate the water transportation problem brought by the water level raise caused by the Three Gorge Dam. The advantages of transportation development enable fast growth of heavy industries along Yangtze River bank. As the third largest center of vehicle manufacture, and an iron and steel industrial center, Chongqing has accumulated large fortune after the WW II. Till 2009, GDP has increased to 65.3 folds of that in 1949, most of which contributed by automobile manufacture and steel industries. On the other side, robust industrialization imposed severe damage to the environment. Chongqing was once called Wudu, meaning the foggy city, because of its misty weather. In the past century, the city was filled by smoke and waste gases. This phenomenon has raised the awareness of the Chinese government. Since the beginning of the 21st century, the general trend of economic development in Chongqing is redirected to a green economy, with specific emphasize on the service industry, high-tech and green industry and so on. In 2015, primary, secondary and tertiary sector ratio is 7.3:45.0:47.7 according to Chongqing statistical yearbook. However, only the city center and the New Area in Chongqing start to advocate and promote the green economy and green industry. In the rural region, primary industry is still the economy pillar as it has always been in the near future.

Statistics show that the nine districts have contributed 376.29 billion RMB to the GDP in 2015. The nine districts have been fast urbanizing. The primary industry merely took up 2.35% of their total GDP. Primary industry in this region seems to be a trifle proportion in its own economy structure. However, compared to the output of primary industry in other economic zones in Chongqing Municipality, it is obvious that primary industry in this region is of great importance, and should not be disregarded (Fig. 5.5). Considering the area of rural land, an astonishing 11.23% primary industry output was achieved in the central nine districts, with the output value per area of 1.25 million RMB/km^2 .

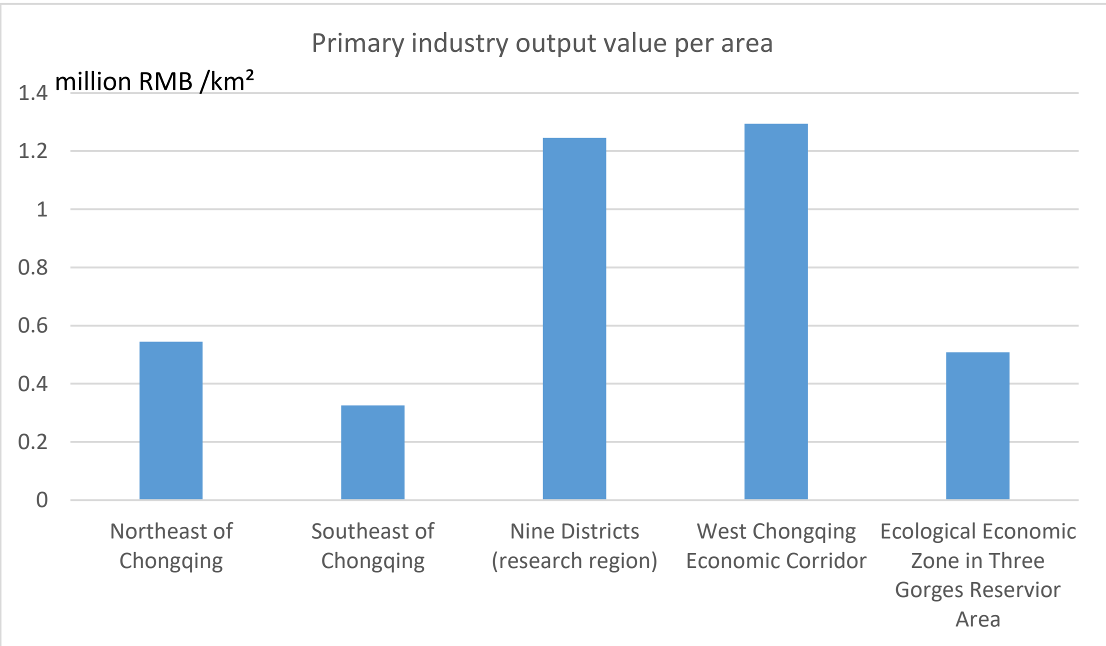

Figure 5.5 Primary industry output value per area in different economic zones.

Data source: Chongqing Statistic l Book 2014

In recent years, the gross output value of farming, forestry, husbandry and fishery increased steadily. On the contrary, the area of cultivated land shows an evident decrease in Chongqing

Municipality. According to Chongqing statistic yearbooks, average decrease rate of farmland ranged from 0.6% to 2.4% in the past two decades. Farming took up 53.86% of the primary industry, followed by husbandry with 39.56%. Main crops in this region are rice, corn, wheat, and sweet potato. Among them, rice tops the annual crop yield. Major cash crops are oil rape, tobacco, fruits and ornamental plants.

The population is unevenly distributed in Central Chongqing. Chongqing Statistical Book 2015 shows year-end population according to registration statistics in the Nine District was 4.6 million. One third of them are non-agricultural profession. Agricultural population mainly distributed in Beibei, Yubei, and Ba'nan Districts. Rural area or not, the lands of Nine Districts are highly populated, with the average population density of 1098 persons/km^2.

Ancient settlement relics in Chongqing city date back to 316 BC, ascribes Chongqing a rich history. Though originated from settlements of the Ba People, according to the 2000 national census (the 2010 national census book does not enclose the census of nationalities), over 93% of the population in Chongqing is taken up by Han nationality, followed by Tujia and Miao ethnic groups at the proportion of 4.66% and 1.64%, respectively. One mainstream academic viewpoint addresses Tujia people are the descendants of the Ba people (Pan, 1955), but disputations have never ceased. Most of the minority people reside in minorities regional autonomy regions outside the Nine Districts. Only scattered stockades can be seen in the remote mountain area within in the range of the research region.

5.4 History and Cultural Background of the Inhabitants

In the vast territory of China, there are over 50 existing ethnic groups. Each of them has its own culture. The number of ethnic groups was much larger in the past. In Qin Dynasty, over 10,000 ethnic groups were recorded. The interactions among ethnic groups lead to cultural fusion and the emergence of new culture. The residents in rural region of Chongqing are the possessors of local knowledge. Their culture and knowledge also went through the entire process of evolution. The constantly changing cultural environment that they lived in fosters their unique knowledge system.

Chongqing and Sichuan are joint-named by Chinese people as Chuanyu Region, due to their similarity in geographical location and cultural background. According to historical documents, the ancient inhabitants in Chuanyu Region were the descendants of Ran People and Qiang People. In the language of Ran, "Ran" means living in the mountains and looking towards the rivers. The distribution range of the Ran People stretched along the Min River (Southwest to Chongqing) around B.C. 2000. Little was recorded about the Ran People and their small kingdom of Ran. Unlike the local originals of Ran People, Qiang People migrated in Chuanyu Region from now Shaanxi, Gansu and Qinghai Province, adjacent to Chuanyu Region. They soon outnumbered the local Ran People, and first established the ancient kingdom of Shu. Their culture is preserved in the relics of San Xing Dui. In Shang Dynasty (around B.C. 1600), the Qiang People were defeated in Min Mountains and fled through Yulei Mountain Range into the northwest of Sichuan Basin.

A few lines in The Biographic Sketch of Shu Emperor[1] and History of the Huayang Kingdom[2] depicted the establishment and development of Shu. The Can Cong Clan of the Qiang People first claimed dominion of the ancient Shu. According to the archaeologists, it was not until the unification and reign of Shu by Yu Fu Clan of the Ran People, that the monarchy of Shu Kingdom was realized. In around 1050 B.C., Du Yu Clan of a branch of Chu People migrated from Yunnan Province and conquered Shu. The new conquerors brought a branch of Chu Culture to Chuanyu Region. The culture of Chu adds in the culture environment of Chuanyu Region. In Chu Culture, the gods of the rivers are worshiped. This is because the places where Chu Culture originates are frequently flooded. Chu People relied on witches and the supernatural power to stop the flood, and developed sophisticated sacrificial and divination rites. They believe that the river flood is caused by an imaginary creature, the flood dragons, and iron cows are effective in flood control due to the principles of five phases philosophy. These conceptions have already been proved to be superstitions by scientific research, but still remembered by the local people.

Another important connotation of Chu Culture is that people shall allow anything to take its course. This connotation resembles many other ancient local Chinese cultures, including Han, Ba and Shu. *The Classic of Mountains and Seas*[3] depicts a place in Chu called Xi Rang. It is where Gun, the father of Emperor Yu failed to control the flood. Archeologists found that Gun moved the plowed earth of farmland to build embankment for frequently flooded rivers within a short time, but the embankment soon broke. Arable lands were destroyed, and then famine began. Gun was then killed by the Emperor of his time for his failure. People owed his failure to not following the farm seasons and insolently moving the earth. They kept learning about appropriate farming season during the past centuries.

According to Guo (2001), B.C.1000-900 saw an anomaly climate with excessive precipitation. Thus the Shu Kingdom moved to high lands northwest of Sichuan Basin led by Du Yu Clan. The Sichuan Basin was then reclaimed by Kai Ming Clan. Few deduced that the Kai Ming Clan was consisted of Ba People, originated in the west of now Hubei Province (Tong, 2004). Luo (1984) argued that Kai Ming Clan was one of the Chu tribes residing close to rivers, worshiped turtle totem. But due to the deficiency of archaeological evidence, all hypotheses are yet to be demonstrated. However, it is generally accepted, that the culture of Shu (late-term Shu, B.C. 770-316) is a mixture of mid-term Shu, Chu and Ba Culture. This mixed culture of Shu is the foundation of the cultural environment in Chuanyu Region, and imposes its influence today.

As it is with the Shu Culture, Ba culture is also a mixture of different ethnic cultures, and contains various branches. The Ba People lived in the Three Gorges region, the west of Hubei Province. The Lin Jun Ba Clan, which established Ba Kingdom, belongs to the Wu Zhi/Dan[4] branch. Wu Zhi Culture is acknowledged as one of the prevailing cultures of Ba Culture at that time. The People of Lin Jun Ba worship Ten Witches in Wu Mountain and their divinations.

Before Ba and Shu Kingdoms step into steady progression, due to the frequent migration, cultural

[1] In Chinese Pinyin, Shu Wang Ben Ji

[2] In Chinese Pinyin, Hua Yang Guo Zhi

[3] In the volume Classic of the Regions within the Seas, Gun stole the Xi Rang earth from the Emperor to build embankment to control river flood.

[4] Book of the Later Han (in Chinese Pinyin, Hou Han Shu)- Treatise on the Nanman, Southwestern Barbarians, citation of *the origin of the world* writes that, the ancestor of Lin Jun Ba comes from Wu Dan

exchanges frequently took place among Ba, Shu and Chu Culture. The culture transition between Ba and Shu was most significant, when the Ba People retreated westwards to Jiangzhou (now Chongqing) during the war against Chu Kingdom in Dongzhou Dynasty (B.C. 1100). After that, Chuanyu Region was governed by Shu Kingdom in the west part and Ba Kingdoms in the east part, respectively. The retreat of Ba Kingdom to Chuanyu Region accelerated the culture merge between Shu and Ba. There should have been little cultural conflicts, as Ren (1985) asserts, as the people of Shu had already been familiar with Wu Zhi Culture, the prevailing culture branch of Ba.

Since Qin Dynasty (221-206 BC), Ba and Shu were even more closely related with each other. Ba and Shu people became localized, while the ancient Ran and Qiang People gradually fade from the limelight. Chuanyu Region was a distant and uncultivated land to the eyes of the emperors in the Central Plain of China. The first tide of migration of the Han People took place in the late Qin Dynasty. Since then, the Han People from China Central Plain settled down in Chuanyu Region, and brought Han Culture to this region.

In this period of time, the Culture of Ba and Shu fosters the only local religion of China, Taoism. The founder of Taoism, Zhang Ling regulated the scattered supernatural myth and legends in Ba and Shu Culture to formulate the pedigree of gods in Taoism. The essential philosophy of Taoism is that people shall live following the order of the nature. At the same time, Buddhism was introduced in Chuanyu Region from south Asia. Those two religions went through a long time of development, and prospered in Chuanyu Region. Their philosophies leave invisible but formative influences on local people’s spiritual life.

In Han Dynasty, Han migrants outnumbered Ba and Shu People. By the western Han Dynasty (206 BC- AD 24), Chuanyu Region was no longer the place where criminals were relegated to (Ge, 2014). Ba and Shu Culture were significantly influenced by, if not integrated into Han Culture. Ba Shu has become a collective noun indicating the now Sichuan and Chongqing region, in the perspective of nationality and culture. The worship of natural spirits and witch divination was constrained to formal and solemn ceremonies. Among all migrants, those came from Hubei, Jiangxi and Guangdong Province imposed most significant influence on Chongqing rural region. Increasing importance was attached on the family clan. Since the merge with Han Culture, human activities were regulated by the moral standards Confucius proposed. But some of the cultural survivals of Ba and Shu passed down from generation to generation in the form of traditional customs, idioms, music, and so on.

The Chinese Cultural Revolution from 1960s to the late 1970s is catastrophic to the traditional culture and knowledge. During this movement, historical and cultural relics were labelled “the way of outdated thinking” by the radical politicians. Cultural relics and ancient books were destroyed under the name of “break the outdated thinking”. The new ideology is extreme materialism and communism, distinguished from the central connotation of Han, Ba and Shu Culture. One prevailing thought in this period is “Man can make the land produce as much as he likes, as long as he is willing and bold enough”. Such radical thinking goes opposite to the traditional culture of respecting the nature. People who intended to protect their culture, for instance, preserve ancient literature documentations, genealogies and local religions, were brutally punished. Numerous local scholars were tortured to madness, and no one dare to speak up for them.

Remedies were implemented by the central government decades later. But the traditional culture is reviving at a low speed. Modern transportation enables the local residents to travel far outside Chongqing region, and also let the outsiders in. In rural regions of Chongqing, the population flow is generally a one-direction movement from the rural area to urban and metropolitans. The demographic composition changed accordingly, so as the knowledge and culture people possess. The polarization in the age structure of rural settlements becomes the most significant feature of rural demography. As the young and middle age people walk out of the relatively isolated rural region, they bridge the culture of the modern, international world with their own culture. Additionally, due to the fast development of the mass media, the mainstream knowledge and culture are easily introduced to the inhabitants, even if they never set foot outside their villages. For the first time, the traditional culture faces the fierce compete with new thoughts. As it is with local knowledge, there are still disputations about whether traditional culture shall be preserved, and in which way shall people make use of it.

To conclude, the culture of the people in Chuanyu Region went through five major phases of evolution: the formation of various cultures; the merge of Ba and Shu Culture; the merge of Ba Shu and Han Culture; the destruction of traditional cultures and religions during the Cultural Revolution; and the revival of culture and religion and the cultural conflicts in the modern world. People's way of thinking changes accordingly. The aboriginals in Chongqing are descendants of Shu and Chu People, and they built up their separate culture of Ba. People from different ethnic groups worshiped different gods and spirits, and deeply believed in supernatural forces of the nature and the witches. Through conflicts among ethnic groups, culture and customs of the stronger ethnic groups survived, while those of weaker groups merged into the prevailing ones or completely demolished. The frequent tides of migration in the ancient times promoted cultural integration of the various cultures. The philosophy of Confucius regulated the sacrifice and divination ceremonies since Han Dynasty. Witches descend from the divine altar, while moral and humanity rule of the society. All traditional cultures alike emphasize that people shall live in harmony with the nature. The Cultural Revolution in contemporary time preached people to "fight against the nature", as all traditional culture and knowledge were criticized to restrain the development of productivity. As time proceeds, people realized the mistakes they have made, but the cultural conflicts with the modern world takes place to challenge the traditional culture and knowledge. Local people are not in awe of nature as their ancestors. This encourages bold attempts in land use and land management adjustments.

Chapter 5 FINDINGS AND CONCLUSTIONS

6 Contents of Local Knowledge

6.1 Productive Land Management Instructed by Local Knowledge

6.1.1 Agriculture from the Past to Present

6.1.1.1 Agriculture history

People began to practice agricultural activities long before Qin Dynasty. According to history records and archaeological discoveries, Shu People were the first nationality stepped into the era of agriculture (Guo, 1993). Qiang People from the Central Plain of the ancient China brought their agriculture knowledge in Shu. Demonstrated by the farming implements unearthed in San Xing Dui, the Shu People proved to be experienced in dryland farming. Their major crops were gramineous crops such as millet (Setaria italica) and broomcorn (Panicum miliaceum) which are suitable to plant on dry farmlands (Lin, 1989).

The start year of rice cultivation in Shu and Ba region remains unknown due to the lack of written history records. Since Du Yu Clan migrated from Yunnan Province, which was by then already famous for rice cultivation, some experts assume that rice cultivation knowledge was vigorously advocated in Shu and Ba region by Du Yu Clan (Peng, 2012). As an evidence, archaeologists found more rice than grain in Jinsha Ruins, the same time period of Du Yu Shu, as well as farming implements especially used for rice planting (Fig. 6.1). While Shu was advocating rice cultivation, the Ba People migrated westwards into Sichuan Basin. The Ba People obtained their knowledge to grow rice thereafter. The impact of Du Yu in agriculture is indirectly demonstrated by *History of the Huayang Kingdom: History of Shu*, as both the Ba and Shu farmers offered sacrifices to Du Yu, the god of agriculture[1].

[1] The English translation of this narrative is: “People in Ba are taught to farm, till present the Ba and Shu People hold sacrifice ceremonies for Du Yu“

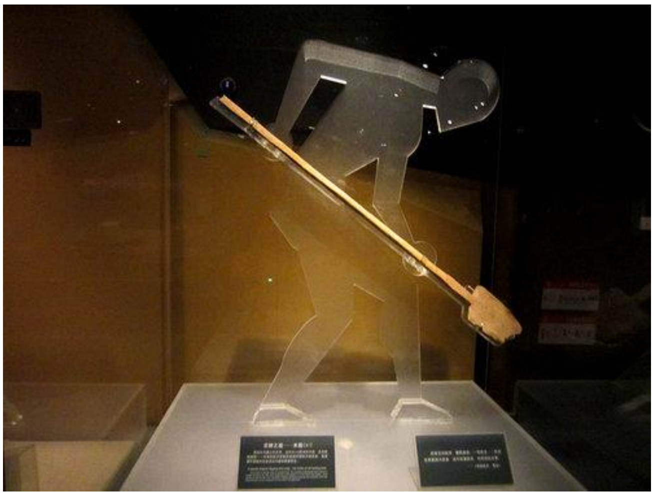

Figure 6.1 The farming tool of Musi.

Musi was used specifically for rice field plowing. This one is displayed in Jinsha Site Museum, Chengdu

Reference: http://e.share.photo.xuite.net/iambaby_161/1ee07d6/10623072/492537718_m.jpg

Before the climate abnormal period of BC1000-900, Shu People have settled down on Chengdu Plain. The average elevation of Chengdu Plain was approximately 500 meter. Deducted from the siltation in Jinsha Site, this place became severely flooded in that period (Lin, 1987). Dryland farming could no longer be applied in the swamps and ponds. The Kai Ming Clan, who took place in Chengdu Plain, is acknowledged to be more experienced with rice cultivation (Guo, 1993).

Shu and Ba were annexed by Qin in 285 BC and 314 BC, respectively. After the first Han migration tide, agriculture in Ba Shu fast developed, as migrants from China Central Plain introduced their mature agricultural knowledge and technics. By the end of western Han Dynasty, prestigious descendants of the Han People even set up their manors. In their manors, they built wells, water channels, and planted fruit trees as in the China Central Plain (Wang, 59 B.C). Thanks to the famous water conservancy project in Chengdu Plain, Du Jiang Dam, river water was directed to irrigation channels, supplying over 46,000 km² gravity irrigation farmland, as it was recorded by Sima Qian in Records of the Grand Historian: Hequ Treatise in Han Dynasty. Gravity irrigation farmland also appeared along the middle reaches of Jialing River, as Gu Zuyu puts in *Essence of Historical Geography* Volume 68. Production pattern in Ba transited from farming-pastoral to sheer agriculture (Fig.6.2).

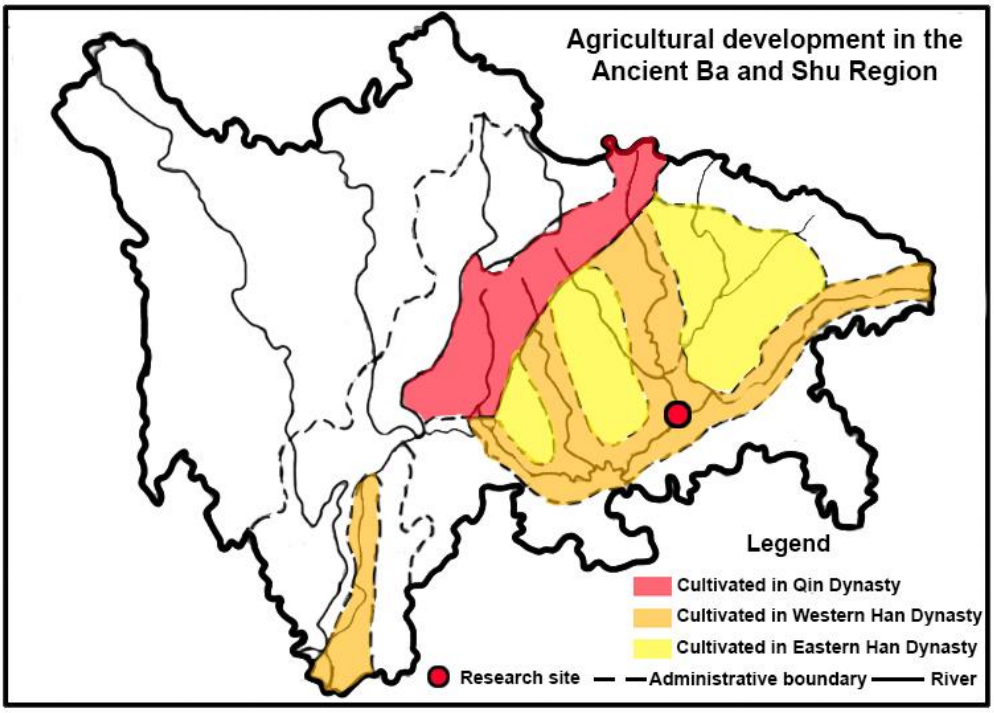

Figure 6.2 The development of land cultivation in Ba and Shu Region.
Illustration adapted from Guo (1993)

According to Guo, in the western Han Dynasty, the area of farmland in Ba reached approximately 40,000 km^2. Farmers were accustomed with rice cultivation in Chengdu Plain. Some eastern Han stone inscriptions unearthed in Chengdu Plain depicted rice farmland system facilitated with pond (Tang) and water ditches. It seemed identical with the terraced field nowadays. But the details reveal more differences. It is obvious that the ancient farmland system was located in approximately the same altitude (Qin, 1984). They were a set of adjacent farmlands, rather than a well-designed farming system spreading over a mountain slope. Characteristics of those ancient rice farmlands are as followed:

a) The farmlands were irrigated by an irrigation system, which is composed of ponds and ditches for water storage and drainage.

b) The ponds were regulated by small dam and artificial water outlets, so that they could be utilized to retain or drain off water, managing water resource for the farmlands. Those functionalities resemble the Yantang in a mature terraced field system later in the history.

However, located in mountainous area, arable land was scarce in Ba. The lack of irrigation water also constrained the development of large scale wet rice cultivation. Inhabitants resorted to dryland cultivation introduced by the Han People. The cultivation culture of the Ba People was merged into Han civilization by the end of western Han Dynasty (Ma, 1986).

The Three Kingdoms era saw a great retrogression of agriculture development in Ba Shu. After numerous wars, the Liao and Man People from preliterate cultures migrated in Ba and Shu from the southern mountainous area. They settled down in the stockades in the mountains of eastern Sichuan Basin. As they stuck to their own primitive cultivation pattern, the survivors of Han, Di and Qiang People rehabilitate wet-rice cultivation along the natural rivers at a very small scale.

There were no irrigation systems constructed. The development of agriculture in eastern Sichuan Basin lagged far behind other regions.

Before Tang Dynasty, the policy of Land Equalization stimulated the inhabitants to better manage their own farmlands (Huo, 1983). In eastern Sichuan Basin, Shetian (similar to slash-and-burn cultivation) became the prevalent land cultivation and management methodology (Fig. 6.3). This methodology was generally considered to be utilized by the minority nationalities. People perceive Shetian as a traditional folk custom of Ba, as Zeng and Ding(Ming Dynasty) wrote in the poem Wolong Mountain, people set fire in the mountains according to Ba Culture. Fan[1] illustrated in detail about how Shetian was practiced in hills and mountains in Song Dynasty. In early spring, farmers hacked all shrubberies and trees on the land and left them on the ground. When it came to the seed time, they burnt the vegetation remaining to plant ashes one day before the spring rain. The next day the farmers planted the seeds when the soil was warm and wet. In the land parcels where topsoil was shallow and extremely infertile, the hack-and-burn method would be repeated two or three times before sowing. Main crops were millet, soy bean and wheat, as it was recorded in Fan's another poem, *Reside in Gongzhou at night.* It wrote,

"Barren land in Bi Mountain (located in now Chongqing region) was cultivated with great effort. Human settlements were established in the region where millet and bean harvested in autumn".

The application of this primitive cultivate methodology in mountainous region was mentioned in many other poems compiled in Tang and Song poetry collections.

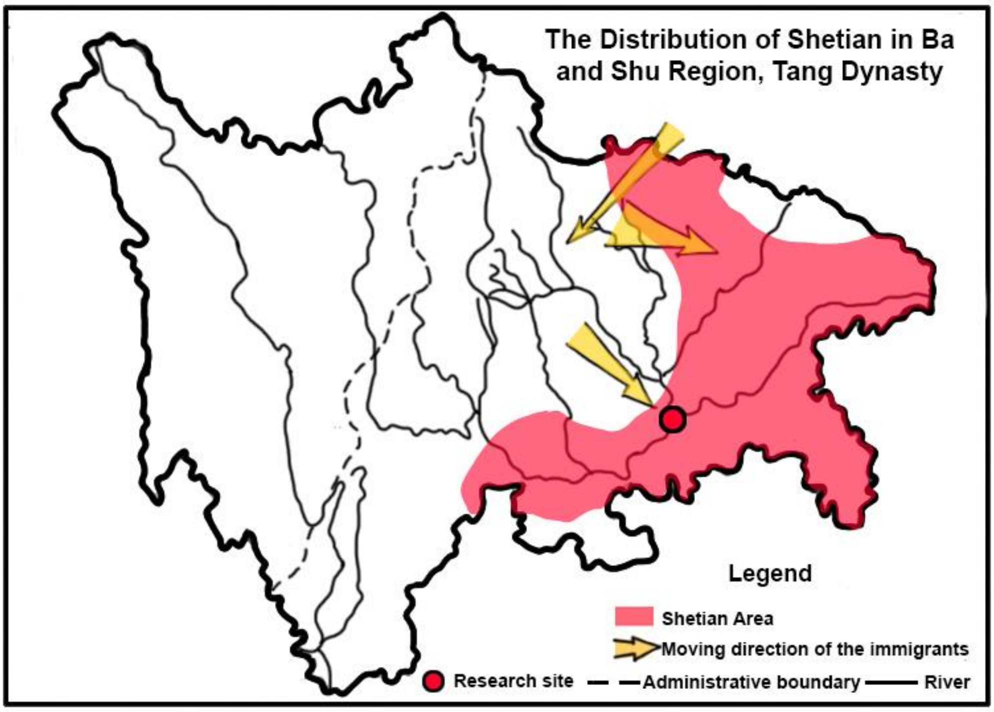

Figure 6.3 The distribution of Shetian area in Ba and Shu Region in Tang Dynasty
Illustration adapted from Guo (1993)

The population in Ba steadily increased, arable land became even scarcer in Song Dynasty.

[1] Fan Chengda (960-1279) is a poet, a government official, and a geographer. The following narrative is translated from his literature work, Lao She Xu.

Irrigation projects were attached with great importance, and followed by a rigid scheme of irrigation system maintenance. The rate of multiple cropping exceeded 110%, calculated by harvested area of land divided by the total area of Chengdu Plain(Guo, 1993). By that time, the wet-rice cultivation was fully developed in Chengdu Plain, mainly practiced by Han People. Little spare land was left for cultivation. People averted their attention to the low hills area, especially the previously cultivated Shetian farmland. The rice cultivation system in the low-hill land parcels distinguished from that in eastern Han Dynasty. Those on the top of flat hills were named the thundering field or highland field, and were the regarded as the early form of terraced field. Those farmlands in Chengdu Plain were not irrigated by channeled rivers or existing lakes. Irrigation but heavily depended on rain water, hence the name thundering field (Pan, Song Dynasty). Yet in the eastern Sichuan Basin, the name of thunder fields had a different interpretation. Fan wrote that “the remaining nimbus triggers another rainfall, rainwater from high farmland rumbling downwards” to describe the rumbling sound of water runoff. This interpretation was accepted by the most of local people.

By the late Song Dynasty, rice was harvested in terraced field at a large amount, thus Fan and Li Fan[1] discussed about a situation, in which the trading price of terraced field rice was as low as yellow soil.

To conclude, the major farming pattern in Tang and Song Dynasty was slant slope dryland planting practiced by Liao People, and the major crops were millet, wheat and beans. Han and localized Liao People grew rice at the foot of the mountains along riversides. In some region, people learned to plant commercial crops such as tea, fruit, and oil crops. This cultivation strategy in Ba region is generally identical as the dryland cultivation nowadays, except that sweet potatoes and corn replaced millet since Qing Dynasty (Guo, 1993).

After the second migration tide in Qing Dynasty, agriculture development achieved a significant progress. The high productivity of Sichuan Basin was known across the country. Accordantly, the number of water control projects increased. Statistics made by Perkins (2013) shows, that the number of projects in Qing Dynasty exceeded the sum of all earlier dynasties (Fig. 6.4).

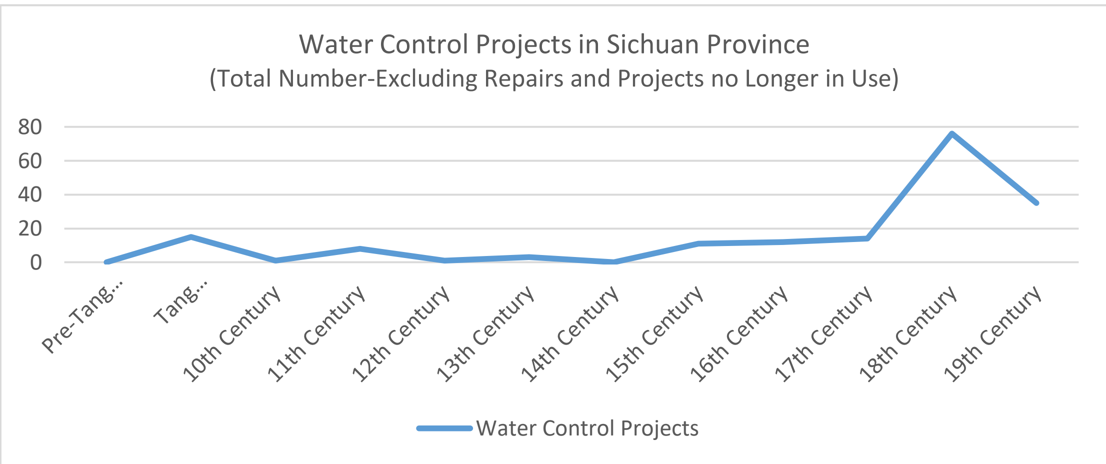

Figure 6.4 Water Control Projects in Sichuan Province.

[1] Recorded in Qin Ding Xu Wen Xian Tong Kao Vol.27, which is a collection of memorials to the throne and the debates about the memorials.

Data Source: Perkins (1968) Table H-I

Perkins used local gazetteers edited in between 1816 to 1931 as data source. The data source has an obvious deficiency, as projects in earlier era might not be included. For instance, the prestigious Dujiang Yan was not counted as a Pre-Tang project, and at least 20 major projects were launched in Tang Dynasty according to ancient local history records (Guo, 2001), whereas Perkins only counted 15. However, the data can still prove that in 18th Century, the government spared a considerable amount of effort on water resource management and agriculture development.

In the vast area of flood plain, large scale of rice cultivation developed. In hilly regions, various farming and irrigation technics improved productivity. Those technics were brought by migrants from Hubei, Guangdong and Fujian Province. The favorable agriculture and tax policy in Qing Dynasty enable both local inhabitants and the migrants to cultivate a parcel of land. Even the refugees and their offspring who have evaded registration during the first migration tide, got registered as residents by the local government and hence could practice agricultural activities. Consequently, the government gradually reclaimed control of agriculture development in this region.

Terraced rice field took over the dry farmland of Shetian in mountains. Rice fields located on the low hills with the average altitude of 1,200m, compared with the 400-800m altitude of the central Sichuan Basin. Initially the rice fields were distributed along natural creeks in the mountains in the shape of narrow strips, but as the farming technics improved, they fast expanded in area. In the period of Jiaqing, Qing Dynasty (1760-1820), the average ratio of wet field in all farmland across Sichuan reached 60% (Lu, 1988). Especially in the Y shaped land between Yangzi River and Jialing River (now Chongqing), the area of wet field extended significantly. Rice was transported and sold in the lower reaches of the Yangzi River. Shetian was only conducted sparsely in the remote mountains at the edge of Sichuan Basin.

Ponds and reservoirs collected rain water to supply irrigation of the terraced field, but not all terraced field systems functioned perfectly without the risk of water shortage. The number of ponds and reservoirs were critical, deciding whether the system could healthily sustain (Pei, Qing Dynasty).

Due to the fast growing population and economy, the trend of cultivating wasteland lasted for over one century till the 1930s. This phenomenon of excessive land cultivation was recorded by Dong (1931). The intensive slant slope dryland farming became once again the prevailing cultivation type. Local history books specifically documented related methodologies. Based on the topography and shape of land parcel, the government gave corresponding instructions on farmland management. For instance, in the relatively shallow ditch between two hills, Caotian should be practiced, and on the slope halfway up the mountain, Daitian should be practiced. Detailed instructions on how to manage terracing fields are elaborated in the following chapter. Almost all types of unoccupied drylands were thereafter cultivated. Dong's report demonstrated that hillsides with 70-80 degree slope were cultivated, as well as the thin topsoil over rocky hills. Especially in the now Chongqing region, wet-rice field, terraced field, and dry farmland together covered almost all land parcels (Fig. 6.5, Guo, 1993). The cultivation of barren land started in Ming Dynasty, and agricultural potential of all land parcels have been completely exploited.

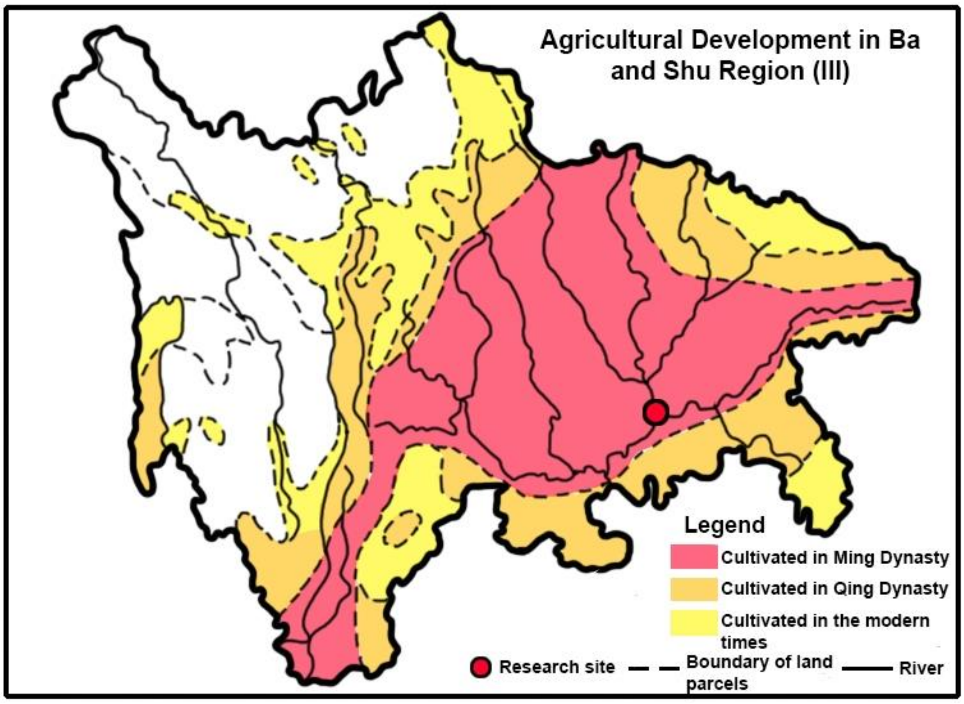

Figure 6.5 The third stage of agriculture development from Ming Dynasty to present.
Illustration adapted from Guo (1993)

When it came to the period of the war of resistance against Japan (1937-1944), farmers began to learn about the commercial market and government policies. The local government was performing the strongest role in governance ever since. Critical agricultural and water managing techniques were practiced by local experts, and then taught to the farmers. For instance, the agriculturalists popularized Jintai 2095 (a species of high yield wheat), and taught local farmers of its planting techniques. It resulted in a 10% increase of production (Ye, Yang, 1945). Experts also give instruction on the details of fertilization and pest control.

Soon after the establishment of the P. R. China, Land Reform (1950-1952) regulated rural land ownership. Rural land was collectively owned by the people's communes. Individual farmers had no right to purchase and sell the land, either agricultural or residential, that they worked or lived on. The Great Leap Forward proposed unrealistic goals for agriculture development. In order to achieve the goals of crop yield, land ownership was decentralized from the people's communes to the production teams.

Suffered from the wars and the Three-year Natural Disasters (1959-1961), agriculture in Chongqing went through a tough period. Impacts of the People's Commune and the Great Leap were sophisticated and still discussed by scholars, thus this research will not focus on this issue. However, one fact should be marked, that the attitude of the rural residents towards agricultural production completely changed ever since. The egalitarianism in the commune era and household responsibility system did not function as stimuli to promote productivity, but a psychological burden they would try to get rid of. It was not until the 1980s, when land use rights were slowly returned to farmers. There are still strict restrictions on agricultural land management. For instance, farmers shall not change the land use type from agricultural production to other types. Transfer of land use right to local or foreign contractors must be approved by the local government. But undoubtedly, farmers are given more liberty in managing the land, which motives productive activities to some extent.

In the 21st Century, modern agricultural technology enabled agriculture to develop as a modern industry. Large scale farmland cultivation facilitated with machinery becomes the mainstream agriculture production pattern. Sown area gradually dropped since the 1990s, but the total output of farm crops remained at the same high level. Take grain for example, total output was 11.4 million ton in 2014, compared to peak annual yield of 11.84 ton in 1997. Among the major types of grain crops, the annual yield of rice, corn and beans increased, while wheat drastically decreased to 17.3% of peak year in 1995. The improvement of agricultural technology is proven in the increase of yield per area. In 2014, rice yield per hectare in Chongqing was approximately 7.3 ton, almost doubled that in the early 1990s. In high-quality rice production base such as Nanchuan, top annual yield per hectare easily exceeds 10 ton. Other rice production base is prestigious across China for the good taste of rice products, for instance, Qiaoping Rice in Nanquan town. The ragged farmland parcels lost its advantages, as cultivation machineries could not be applied in such areas. Compared with other provinces, where arable farmland locates on plains, food grain yield per area is still relatively low in Chongqing region.

In all, Chongqing Region has a long agriculture history. The cultivated crops changed, as the productive capability increased throughout the years. The primitive cultivation strategy of Shetian has gradually been discarded. A comprehensive agriculture land management of terrace rice fields becomes mature, while on the other side, the urgent requirements for grain stock prompts irrational barren land cultivation at certain time periods. Successful or not, those various land cultivation strategies are remembered by the local people, providing knowledge and experiences to their future practices.

Ancient local knowledge about agriculture can be drawn from the agriculture practices in history. Possessors of local knowledge are mostly Han People, but their culture is influenced by Pu and Ba Culture. Agriculture was monocrop and the farms were extensively managed in the ancient time. Local knowledge at this stage only contributed to the selection of the major crop for the years after. It was not until in Song Dynasty, when a great progress was achieved in agriculture development. The practice of Yantang system, which will be introduced in detail later in this section, propelled this great progress. The new migration tide in Ming and Qing Dynasty stimulated regional development of Chongqing. Migrants from the southeastern China were skilled in mountainside agriculture. The primitive farming method of Shetian was soon replaced by intensive slant slope dryland farming and never practiced again in the modern times.

Benefited from the advanced agriculture technics and favorable policies, agriculture productivity significantly improved therefore. However, constrained by the mountainous topography and unproductive soil, the crop yield was still lower than the average of Sichuan Basin. Another fact is that the local residents paid too much attention on improving agriculture knowledge. The development of the traditional linen industry and husbandry lagged far behind. Fish cultivation was also impeded, as fishery centralized only on certain sections along the major water courses. The self-sufficient small-peasant economy is predestined to decay, while it would still be beneficial for the rural region to explore various commercial crops and other industries.

Nowadays, there are two major types of agricultural land use existing in the research region, the

Yantang system agriculture and dryland agriculture (Tab. 6.1). In specific settlements, Yantang system has adapted itself to the modern society in different directions, while in other places Yantang system remains in its original pattern. Dryland cultivation also adapts itself to the time. Modernized agriculture takes place in regions suitable for intensive agricultural activities. Local knowledge about specific agricultural land use types develops or demolishes in accordance with the changes in local agriculture.

Table 6.1 Major agriculture types in the research region

Agricultural land use type		Year of Origin	Year of Extinction
Shetian		600 A.D.	1800 A.D.
Yantang system	Traditional Yantang system	1000 A.D.	N/A
	Yantang for aqua-cultural use	1990s	N/A
	Improved irrigation system	1970s	N/A
Dryland cultivation	Slope vegetable planting	600 A.D.	N/A
	Greenhouse and mechanized farming	1990s	N/A

6.1.1.2 Yantang system and its evolution to date

Yantang system is an irrigation system for a traditional multiple–crop cultivation strategy in particular. In this research, Yantang system is used to refer to this land use strategy. As it has been briefly introduced in the history of agriculture development, Yantang system is primarily formed in the Song Dynasty (960 A.D. - 1279 A.D.), and gradually matured by the era of Qing Qianlong (1711-1799) (Guo, 1931). Through centuries of evolution, the system encompasses more technics of cultivation, and becomes a relatively resilient system from the perspective of landscape planning. The form of existence keeps evolving, so as the local knowledge, which guides human actions development.

In a traditional Yantang system, three major types of cultivation pattern listed in the table above could be found in the research region. Initially, this system was designed to cultivate rice as the dominant crop. The essential environmental component of a Yantang system is the natural valley in the mountains, in which rain water confluences to temporary or permanent creeks. The terraces of wet farmland parcels descend alongside with the creek. The strip shaped land parcels at the same elevation are approximately perpendicular to the creek. Rice is planted in those wet farmlands.

Successful water management supports this system. In the upper reach of the creek, water reservoirs are built on the top of the hills to collect rain water at the maximum. The area of such reservoirs could easily exceed 1000 km^2, with a depth of 0.8-2.5 meter (Fig. 6.6). Smaller sized reservoirs and dikes are built along the creek every 300-1000m (Fig. 6.7). It is also instructed by the local knowledge that the reservoirs shall not be built upon the limestone layer. Such attempts have failed due to its high infiltration rate and erosion problems. Irrigation water flows into farmlands through both natural creek and artificial ditches driven by gravity. Those ditches together with bamboo pipes form the irrigation network, which transports irrigation water to every farmland parcels. In the case where the farmland is higher than the creek, a water wheel shall be installed on the water gate, so that water could be transferred to irrigate higher farmlands. For the land far away from a natural creek, the number of water reservoirs within a

Yantan system is relatively large, in order to retain sufficient water[1]. The distribution of Yantang system generally concentrates on lower mountains regions, thus the rain water is abundant for irrigation.

Figure 6.6 Yantang located on top of a low hill (to the left of this photo)

[1] History of the Ba County, Vol.11 P. 443, edited by Guojun Luo, Zhihong Zhu etc. in the period of the Republic of China. Re-published in 2014.

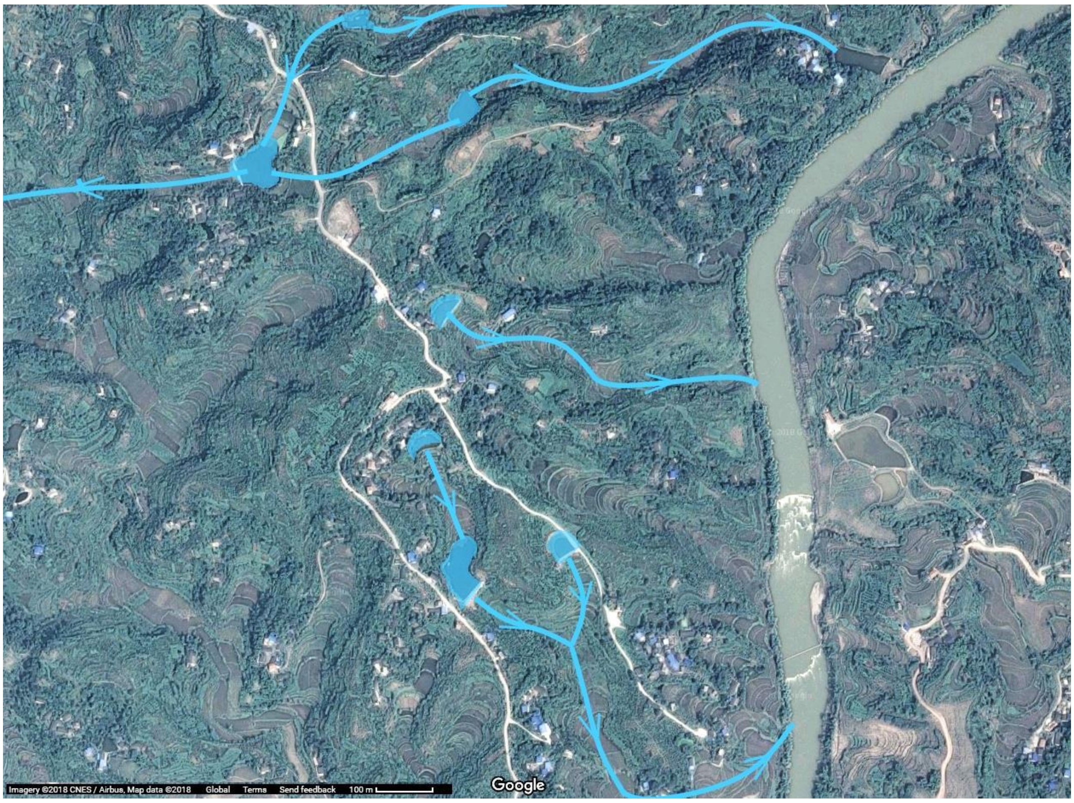

Figure 6.7 The distribution of Yantangs and water courses

Blue shapes indicate Yantangs in Jianglin Village, Tongjing Town. Blue arrows indicate the direction of irrigation water flow.

Map source copyright @ Google Maps. 2015[1]

Each farmland parcel is facilitated with an irrigation ditch, which parallels with the ridge. The ridge is built with different material catering to the height difference, the velocity and volume of the flash flood during the rainy season. In some of the farmlands, small willow trees are planted on the ridge, if the ridge is built up by rammed earth and wide enough. This has been recorded in the local records since Ming Dynasty, as a methodology to strengthen the ridge. The ridges function as small-scale dams, equipped with water gates every 5-10 meters (Fig.6.8). Those dams are 40-60 centimeters higher than the farming plate. Rammed earth, rocks and stone bricks are the conventional building material for the ridges. The physical stability ascends sequentially. As the construction materials are easier accessible in the modern time, local people come up with the invention of new ridges. Those modernized ridges have pipes built in, so that the normal reservoir level could be easier manageable (Fig. 6.9).

1 All cited Google Maps in this dissertation are North-up.

Figure 6.8 (left) & Figure 6.9(right) Modernized water control infrastructures.
Water gates along the ridge (left) and modernized ridge built with stone bricks, and have water pipe built in (right).

The completion of irrigation system enables the area of wet terrace farmland increases to its maximum. Since Qing Dynasty, agricultural technics were recorded in local records. Among them, the shape of terrace farmland was studied, and the optimal samples on different landforms are given. The farmland in the valley between two hills was called Caotian (meaning the field in a ditch). Daitian referred to the strip shape of the farming field, located on the middle of a hill. Such phrases are still used in Chongqing dialects. Every pieces of arable land, no matter the shape and location was made full use of. Thus the area and shape of farmland parcel in the system various significantly. The ideal wet farmland shall be crescent shaped, with the length of 20-50 meters, and width of 5-20 meters.

In the places, where the rain water is not sufficient enough, the land parcels located upper to the irrigation system are cultivated to slant slope dryland or terrace dryland (Fig. 6.10). They are considered to be a part of Yantang system instead of a separate category of agricultural land use strategy, as they are managed by the same households in Yantang system. The other reason is that those land parcels serve mainly as the productive land to make the household/settlement self-sufficient, rather than to replace the pillar agricultural yield and income. As the photo (Fig. 6.10) reveals, the dominant land use type is still the wet terrace farmland, with water reservoir, gravity irrigation system as principle components, while dry farmlands are much smaller in area proportion.

Thus the Yantang system is evolved as a multi-crop production pattern. Major cultivation crops on terrace dryland are bean and oil rape, vegetables (mostly Chinese mustard, cabbage and potato) and grain crops such as corn and wheat. Given the condition, that the soil layer in the middle-hill land parcels is thin or unproductive, the farmers grow orange, pear and plum trees instead. Occasionally, farmers sell those fruits to merchants, and gain extra income. This multi-crop cultivation brings about higher annual income with extra yield other than rice. As the water resource is well managed, the potential risk of yield decrease caused by draught and flood is reduced to a lower level. On top of the hill, natural pine forest supplies woody fuel to the local households. It is also commonly observed, that the uncultivated land are covered with bamboos, especially in the lower reach of the creek where the creeks becomes wider, or confluences with other creeks or rivers. This planting strategy is aimed at reinforce the embankment and preserve soil from seasonal flooding. Bamboos are also consumed by the local people. Bamboo shoots can serve as dishes in the spring, while the bamboo trees as economical and high quality building and crafts material for the local residents.

Figure 6.10 Multi-crop cultivation in Yantang System

Yantang system is maintained by all working force in a settlement system. Previously the maintenance was led by production team leaders. Despite that the People's Commune has already been disintegrated, inhabitants still work on and maintain the Yantang farmlands elaborately. In most of the sample villages, inhabitants collaborate with their neighbors managing their farmlands at the similar altitude. However, there are disputes concerning water management issues between the residents living on upper and lower river reach. This problem would possibly lead to the collapse of traditional Yantang system.

To illustrate the collapse of traditional Yantan system, it is important to understand the transition of Yantang system in the modern time. In all 14 sample towns, one common phenomenon is that the traditional Yantang cultivation unit is dispersing (Fig.6.11). Over two thirds of water reservoirs in Yantang systems are contracted to businessmen for fish cultivation. The contractors hire either local residents or migrant workers to do the maintenance work. In order to keep water and fish, workers close up the water gates of Yantang. Thus the irrigation system of terraced field is completely disrupted. In a conventional Yantang system, the wet rice fields need to be filled with water for once or twice per year, so that the crops can survive the arid season. Now that the scarce water resource provoke conflicts between fish cultivators and rice farmers. In numerous cases, even when a negotiation could finally be reached, it is often too late to remedy the yield loss of the year.

Figure 6.11 Previous Yantang now used as fish cultivation pool in Ma'an Village, Yubei District

Fish cultivation in Yantang resulted in a regression of rice cropping, thus rice cultivation retreats to a primitive state (Wu et al., 2007). The farmers have to once again rely merely on natural precipitation for irrigation. To remedy, farmers pump water from river and major tributaries to irrigate the farmlands at lower altitudes. They also channel subterranean river and pump up water from permanent wells to irrigate the farmland in the mountains. Those labor intensive remedies are not applicable for all farmland parcels, constrained by the geographical condition, economic state and human work forces. Vast rice fields are still left unattended during the arid season nowadays.

6.1.1.3 Dryland farming and its evolution to date

The history of dryland farming in the hilly region traces back to the era when Shetian methodology was first implemented. As Shetian has been banned concerning ecology conservation, the previous extensive dryland farming has also been replaced by intensive ones to reduce the total area of cultivated land on slopes. In accordance with the general state of agriculture development of Chongqing region, dryland farming has yet not been industrialized, restrained by the sophisticated landscape.

Generally speaking, dryland farming is applied where available water resource is scarce, or where the topography restrains arable land parcel from being cultivated as flat or terraced farmland. Over 70% of such farm parcels have a slope greater than 15°. Dryland farming on mountain slopes are common across the world, but large scale slope planting is relatively rare. For instance in Germany, most of farmlands locate on the vast plain area, or on the flat valley floor of the mountains. Farmlands on mountain or hill side are mostly cultivated as vineyards in the southern Germany (Fig. 6. 12). Recommended rooting depth for wine grape is 76.2 cm. In order to produce high-quality wine grapes, soil and irrigation is prudently managed.

Figure 6.12 Dryland farming in Germany
A steep vineyard overlooking the Mosel River. Copyright© Author Friedrich Petersdorff
Reference: https://upload.wikimedia.org/wikipedia/commons/7/78/080110_zell_mosel.JPG

Compared with the rigorous requirements for the environmental condition of land parcel, and the heavy front investigation for Germany vineyards, slope cultivation in Chongqing rural region has much lower-level requisitions. Even though, the key to sustain slope farming is identical for Chinese and German farmers, which is to retain water, soil and natural fertile. The choice of crop is of crucial importance for Chinese farmers. Limited soil layer thickness in the karst landform in Chongqing restrains the cultivation of taller annual crops. Only on lower parts of the hills and mountains and in the valley where the soil layer is relatively thick and stable, are tall crops such as corns planted in large scale. In most of the sample settlements, short annual plants dominate arable mountain slopes. Major crops include bean, rapeseed, Chinese mustard (Brassica juncea subsp. tatsai) and potato (Fig. 6.13&14).

Figure 6.13 Typical dryland farming on slope and plain in Chongqing rural region

Figure 6.14 Soybean planted on dry farmland

Take soybeans for example, the recommended rooting depth is 30 cm, compared to over 100 cm for corns. Soil depth requirement for beans could be easily satisfied even on the steep slopes with poor soil. Though not knowing the theoretical concept of the nitrogen fixation of bean plants, the local farmers are aware that beans have low requirements for extra fertilizer, and utilize the top soil and biomass residues in the bean patches as fertilizer for other dry farmland parcels. Similar concept of environmental friendly fertilizer management is also applied for rapeseed patches. Such residues contain 4.2% total nitrogen, 0.52% total phosphorus and 2.58% total potassium.

After rapeseed harvest in April, beans and potato are planted, thus further increases agricultural yield. Additionally, the residues of rapeseed are fermented to fertilizer, rapeseed meal cake, which is ideal for rice field fertilization.

Though short annual crop planting significantly enlarges the area of arable land, and increases agriculture yield, it should not be overlooked, that excessive and intensive cultivation brought risks in the aspect of landslide prevention. Firstly, weak root systems of the crop imply low capacity of soil stabilization, which is sometimes overlooked by the local farmers. The capacity of soil stabilization of the plants is decided by several factors. The most important one is the architecture of root system, considering the length, strength, orientation and density of roots. Deeper-rooting plants are acknowledged to have better performance in soil stabilization, as the deep main roots would bind soil layers together, and reinforce loose soil layer with fine root networks (Morgan, Rickson, 1995).

Bean plants have well developed root network, which is strong enough to retain surface soil. But other than bean plants, other crops planted on slopes have shorter roots (Fig. 6.15). The lack of strong network of fine roots would possibly leads to limited capability of soil and water retention. Planting such shallow root vegetables may even deteriorate the soil layer, due to intensive farm work. The photos below show the main roots of Chinese mustard and oil rape plants. They have the typical tap root system, but the parental root is rather short (less than 15 cm). Lateral roots are less in number and have limited soil retention ability. Secondly, as the crops are mainly annual or biennial plants, farmlands are harvested and sowed twice, or in some extreme cases, three times a year. Frequent ploughing activity loosens the topsoil, but at the same time repeatedly breaks up the stabilized soil structure, making the soil layer vulnerable to flash floods. This deduction is convinced by the local farmers. According to the interviews, farmers in Yong'an and Jinqiao Village convinced that intensive dryland farming on slanting land parcels prone to be affected by landslide.

Figure 6.15 Root of mustard (left) and root of oilseed rape (right)
Reference: http://1.im.guokr.com/gkimage/kl/1a/71/kl1a71.png
http://www.redmills.ie/getmedia/bba0be9f-5803-40a8-b74b-6d74f876ad53/Winter-cereals-and-oilseed-rape.aspx?width=400&height=384

In Yong'an Village, where landslide is frequently reported, interviewees are eager to provide their answers to the question, "Which kind of land do you think, is most prone to landslides?" All of the interviewees believed that the slopes planted vegetables are most susceptible to landslides, and additionally pointed out that the terraced rice field is relatively less likely to be affected. Terrace field is considered landslide-prone, only where the upper slope has slid in the past due to unstable geological condition. Except from the uncontrollable external meteorological stimuli, long period heavy rainfall, interviewees believed that earthwork for example, coal mining, loosens the soil and disrupts the geological structure and hence trigger landslide. Though aware of the phenomenon that current slope cultivation might lead to landslide, the interviewees prevaricate to admit the causal link between them.

Industrialized dryland farming distributes in relatively flat valleys and flood plains. Such form of agriculture is rare in all the sample settlements. All settlements which practice modern agriculture are designated by the district or upper level government as agricultural experimental zones in the 21st century. Modern farming significantly improves agricultural yield and realized the agriculture development goals.

Located on the flood plain of Yangtze River, Taojia Town is advantaged in its relatively flat landscape and fertile soil layer. It is planned to transform to industrialized new town center according to the development strategy proposed by Chongqing Municipal Government. Agriculture industrialization is one of the key steps realizing the entire development strategy. Though advocated by the local development strategy, not all farmlands are industrialized, since over 50% of farmland locates in hilly area. Industrialized farmland in Taojia Town (Fig. 6.16&17) has never been affected by flood and landslide according to the interviewees and the official records in Taojia Town and Wenfeng Village, where this kind of farmland locates.

Figure 6.16 Greenhouse vegetable planting in Taojia Town

Figure 6.17 Wide terrace farmland used for dryland farming in Taojia Town

Not advantaged in the conventional grain cultivation, since 1990, district level governments started to develop their own strategies, in order to promote agricultural production. Based on the trust to the local government, and assured with foreseeable economic profit, rural residents show little reluctance in converting their cultivation type. Such phenomenon could be observed in most villages where farmlands are under preferable conditions. For instance, according to regional planning, the rural area of Tongjing, Shichuan and Longxing Town shall promote fruit cultivation and so on. In specific places, previous farmlands were turned to fruit forests. Local farmers convert their farmland to orchards, or transfer their land use right to businessmen. Under this circumstance, local knowledge about the traditional agricultural farmland management become less practiced, and the local knowledge risks forgotten by the local people.

6.1.2 Forestry from the Past to Present

Evergreen broad-leaved and deciduous forests are the major forest type in Sichuan Basin. In the mountains over 2000 meters in altitude, subtropical broad-leaved and coniferous mixed forests grow. Among the abundant tree species, Chinese giant redwood and bamboo were used as timber resources since Shang Dynasty. The development of agriculture always means the sacrifice of forest. After the first leap of agriculture development, primitive redwood forests in Chengdu Plain had been exploited and replaced by farmland (Guo, 1993).

As it has been mentioned in the agriculture development history, Shetian is an integrated cultivation methodology. The initial form of Shetian is different from the Shetian practiced in the modern times. If practitioners strictly follow the instructions in the ancient local knowledge, Shetian shall not cause irreversible damage to the forest ecosystem. This is confirmed by scholars through field research in Yuannan Province, where the ancient knowledge of Shetian still instructed agricultural activities. In the initial form, in every early spring, the farmers hack down the primitive vegetation and burn the remaining for soil fertilization. The entire Shetian cycle takes nine years. Crop cultivation normally lasts for three years (Du, Tang Dynasty). Fast growing pine forests can grow up in six to seven years. Three land parcels are required to keep sustainable

Shetian farming in a long term (Fig. 6.18).

Year	1-3	4-6	7-9
Land Parcel 1	Crop Cultivation	Fallow	Forest Formation
Land Parcel 2	Forest Formation	Crop Cultivation	Fallow
Land Parcel 3	Fallow	Forest Formation	Crop Cultivation

Figure 6.18 Illustration of the initial form of Shetian strategy

In Tang and Song Dynasty when the population boosted with migrants, the forests in mountainous area severely shrank, on the other hand, the demand for grain abruptly increased. The traditional way of Shetian could not meet the demand of land cultivation. Influenced by the Han migrants, ancient instructions were gradually neglected. The period for crop cultivation started to increase, while for fallow and forest grow shortened. Thus later in Qing Dynasty, the prevailing Shetian method has changed greatly, as crop cultivation period extended to 4-5 years, whereas fallow was left out. Deteriorated topsoil would be flashed away by mountain torrent, revealing the rocky surface. The land parcel would therefore become inarable. Local people then waited until topsoil naturally accumulated again, enabling weeds and trees to grow. It was extremely difficult as soil erosion had already been severe by that time (Yan, Qing Dynasty). As a precautionary react, this cultivation strategy, regardless of the ancient or the revised one, is now strictly prohibited by the Chinese government. Practitioners would receive the punishment from fining to detain, based on the extent of ecosystem damage.

Back to the Tang and Song Dynasty, deforestation was aggravated by uncontrolled exploitation of timber resource and farmland reclamation. Primitive forests distributed only sparsely in remote mountains and never recovered. While in the same period, artificial forests appeared in the form of large-scale manors. Among the various commercial trees, tea and orange were most common in Jialing-Yangzi region, as it is today. The local officials were also aware of the timber resource shortage, so that relevant regulations were promulgated. For instance, the Kaiyuan 25 Land Equalization Act (735A.D.) wrote, every Mu (approximately 666.7 m^2) of farmland should be planted at a minimum of 50 mulberry trees, 10 elms and 10 jujubes, infertile land should be planted with appropriate tree species instead of herbal crops (Du, Tang Dynasty). Pine and cypress were planted around religious buildings and family tombs. Along the creek side, fast-growing alder forests or bamboos were planted to provide fuelwood, and more importantly, to preserve soil and water (Lin, 1989). This is the origin of Fengshui Forest, which will be introduced later in this section. Literary persons and prestigious families in Song Dynasty were fond of afforestation. Their contribution to the ecosystem should not be neglected, as the artificial forests were immense in scale. According to the prestigious poet Su Shi, he himself planted over 10 thousand pines in the mountains (Song Dynasty). Numerous literaturists followed his lead. The trend of pine planting lasted for generations, nowadays, the traces of those artificial pine forests still exist in Chongqing rural area.

Forest ecosystem recovered during the war times in Yuan Dynasty, and the turn of Ming and Qing Dynasty. The second rapid-growth period of agriculture in the middle of Qing Dynasty, led to the deforestation of secondary forests. Nevertheless, farmland reclamation was not the only cause of deforestation in the modern times. It is because of the energy demand of crafts and industry, and the energy was provided by burning wood and charcoal. Though the Nationalist Government has promulgated regulations to promote re-forestation, large capital groups and troops were not restricted at all in forestry resource exploitation. But orchards are preserved to a large extent, due to the satisfying economic profit they generate.

In the neighboring Chengdu Plain, a unique settlement system is composed of cottages, flat farmland, and an artificial forest generally referred as Linpan. Such system is formulated under the influence of Kejia Culture. In Chongqing, the formation of Linpan system is suppressed by the complex topography. Instead, one type of artificial forest, Fengshui forest, sparsely distributes in the mountains. When asked about the "conservation forests" in the region, a number of the interviewees still use the term "Fengshui forest" in their narrations. In fact Fengshui forest and Linpan share a common culture origin, but distinguish from each other in functionality.

There are several types of Fengshui forest in Chongqing rural region. The one originates from the trees planted behind the tomb of ancestors of a family clan is called grave forest. In Chongqing, following the traditional custom, family tombs are seated on low hills or the middle of mountains. If the family could afford, pine trees would be planted behind the tombs on the hills. The evergreen pine trees are chosen, as they are symbolic of everlasting spirit in the common belief. There are also religious reasons for planting trees. Ideas and concepts of Buddhism and the Chinese traditional Taoism prevail in the rural region, people are conscious of accumulate "virtuous achievements", so that they would have corresponding rewards for doing good in the near future or the afterlife. Planting trees is one of the ten good deeds in Taoism[1], and one of the seven methods to harvest merits in Buddhism[2]. Constrained by the area of land and assets, excepted from prestigious and rich family clans, grave forests are generally small in size. One large grave forest locates to the east of Pianyan Village, boasting a history of over 200 years. According to the residents, pines once covered the top of the mountain. Now only two of those ancient pines live. Temple forests are planted around temple on top of the mountain, generally larger in size than grave forests. They are donated and conserved by the residents who would attend the temple. Some virgin forests are also regarded as Fengshui forest (Fig.6.19). The ancestors of inhabitants prohibited all productive activities in such forests, except from picking up the fallen twigs for wood fuel. Setting fire to those forests was even strictly banned, thanks to the commandments in Taoism[3]. In the research region, this type of Fengshui forests is the largest in area. Around some villages such forest covers the entire mountain or even a mountain ridge.

[1] "The seventh good deed is to liberate domesticated animals, plant fruit and trees." Anonymous, Sui and Tang dynasties, *Dongxuanlingbao Taishang Liuzhaishizhishengji Jing*

[2] "The second method is to build orchard and bath pools, and plant trees to have cool shades" translated from Sanskrit to ancient Chinese language in Western Jin Dynasty, *Foshuozhufutian Jing*

[3] "Abstain from intentionally or accidentally setting mountains and forests on fire" Anonymous Song Dynasty, Lord Superior Wen Chang's Tract on the First Step Towards Non-Abidance , *Wenchangdijun Yinjiu Wen*

Figure 6.19 A Fengshui forest (left) in Liuyin Village

The reason why Fengshui forests are preserved from land reclamation is not clear. Mainstream assumption traces to the philosophy of Fengshui, one branch of Taoism. According to Fengshui, all features of topography have certain effect on the residential area. The location of forests would change the effect, and therefore improve the general living condition of the local people. The philosophy of Fengshui is so obscure and aspirational, that often recognized as superstition, but even in the modern time, it is still a part of local knowledge. Other assumptions point to the limited productivity in the ancient times, as local people do not have full competence to cultivate all land parcels. Scholars also presume that the Chinese officials were aware of the negative consequences of destroying forest ecosystem, so that they adjusted the dominant ideology through acculturation. All those factors are synchronized in local knowledge, presenting in local beliefs and manifesting human activity. Nowadays, when asked why the virgin forests are forbidden from cultivation, the majority of the interviewees are not able to give clear reason. Few of them give a vague description of how the forest helps to gather “Qi”, the key element in Fengshui philosophy, for prospering a family clan and the entire human settlement.

The recognition of Fengshui forest, which is deeply entrenched in the ideology of rural inhabitants, alleviates deforestation in certain area. Intentionally or subconsciously, the forest resource and other natural resources are protected. However, like all other local knowledge, the knowledge about forest conservation subjects to the shocks caused by modern technology, globalizing market economies, and radical development policies. Since 1950s, the urge to exploit natural resource and promote regional development converted the mainstream ideology held by the local inhabitants from forest preservation to massive forest cultivation and timber industrialization. This transition is guaranteed by increased productivity accompanied with modern manufacture and production technics. Instead of unconditionally obeying the vague spiritual injunctions of forests exploitation, local people weigh the practical benefits. Large scale illegal logging was mostly conducted by timber companies, operated by local governments (Vajpeyi, 2001).

Choices have been made and consequences followed. The 1998 Yangtze River Flood rang the alarm of ecosystem degradation in the upper reach of the river. According to published data, average forest coverage in Yangzte basin once remained approximately 85%. In 1986, the number dropped to 10%. Among the major tributary basins, for instance, Jialing basin, forest coverage was less than 3%. 19 counties had less than 1%[1]. Worldwatch Institute in Washington, DC confirmed the situation of deforestation, providing a report of 85% tree clearance in Yangtze basin (Worldwatch, 2001). In the following year, the Chinese Government promulgated the policy of "Return Farmland to Forest" (in Chinese pinyin Tui Geng Huan Lin), Chongqing is one of the pilots of the policy. Under the strict regulation and control, the destroyed Fengshui forests gradually recover. According to mainstream Chinese news media, Xinhua and People, forest cover in Chongqing Municipal has returned to 45% in 2016. The annual report of Chongqing confirmed the quick recovery by providing the forest coverage of 43.1% in 2014. Some previous illegal timber companies received governmental funding transited to tree planting companies. The central government also encourages local individuals to return their cultivated farmlands back to forests in specific regions, and distributes financial support annually or one-timely for different projects. Massive re-forestation and forest conservation movement is therefore enforced. Guided by the central government, local knowledge about forest conservation changed again. Alongside with the strong advocacies from governmental departments, ancient philosophies quietly permeate in the contemporary ideology of the local residents. Local governments are aware of the revival of ancient knowledge and beliefs, and make full use of it. In many villages, slogans printed on the building or roadside publicity board use the term "Fengshui forest". Some phrases even appear to be a little superstitious to people with higher education level. Considering the effectiveness of popularization, such phrases are even more powerful, as it could be more comprehensible for the rural residents, and at the same time exert spiritual deterrent to some extent (Fig.6.20)

[1] http://www.fox2008.cn/ebook/qnwzh/qnwz1998/qnwz19981137.html

Figure 6.20 Warning of forest fire

.Outside Shengtian Reservoir, a board writes “It took one thousand days to accumulate virtuous achievements by planting a tree, but all merits would be eliminated by forest fire within one day”. It cautioned the residents not to set fire in mountains otherwise their previous efforts in achieving merits would fall in vain.

Fengshui forest serves more as a spiritual symbol, and has no economic meaning. Current economy forestry in Chongqing rural region could be divided in three categories. The conventional forestry industry provides timber and bamboo material and a minor proportion of fuel. The second is orchard and tea plantation. They are the pillar of contemporary forestry revenue. For the year 2014, year-end area of orchards and tea plantations in Chongqing region reached 353 095 hectares, one tenth of total forest area. Major fruit trees planted are citrus, with the annual yield of 3.5 million ton. An emerging mode of productive forestry is landscape trees and shrubs planting. Since 2000, this category of forestry is advocated by several district level governments, and gaining increasing economic profit ever since. The third is ornamental tree plantation, which originates in the 21st century. Accompanied with the large scale afforestation in the 21st century, orchards were re-established, where the forests were cut during the Great Leap period. Following the new strategy of forestry and agriculture development, modern experimental orchards were planted in specific villages, and gradually became the economic pillar of corresponding settlements.

As it has been introduced, orchard planting has a long history in the research region. Citrus and pears were most commonly planted in orchards. Other fruit trees include apple, peach and plum. A large number of ancient orchards demolished, due to the wars before the establishment of PR China and the depletion of timber resource in the period of Great Leap. After the turbulent period, local residents set up orchards according to the knowledge passed down from their ancestors. One of such orchard locates alongside the bank of Yulin River in Chongqiao Village. Chongqiao Orchard shares the similar irrigation system as the Yantang system. One feature is the construction of water reservoir/ pond on the upper slope. Water reservoir of Chongqiao Orchard (Fig.6.21) was first constructed in 1970 and expanded in 2010, with the current capacity of 1,200 m^3. It serves 5.33 hectares of land. The water reservoir locates 80 meters of higher than the lowest part on the orchard. It serves an average radius of 500 m. In addition, due to the fast expansion of the orchard, the water reservoir alone could no longer satisfy the irrigation water requisition of the approximately 100 hectares of citrus forest. Citrus trees on lower slope have to be watered in other way twice or three-times, catering to the actual amount of precipitation. Households which manage the orchard purchased water pumps themselves, to pump water from Yulin River for irrigation. Facilitated with pipe and trench network, this work does not require much human power. The association of production team remains, and enhances cooperation of neighboring households in managing the numerous citrus trees.

Figure 6.21 Yantang for a conventional citrus orchard.

As in all other places, the wet season from May to September threatens the productive land parcels along the bank of the rivers. For Chongqiao orchard, where the fruit trees replace the previous natural vegetation cover (mainly bamboos), flood prevention measures should be taken, in order to avoid potential economic loss. In this aspect, farmers in Chongqiao orchard show their ignorance about flood prevention. Though they could clearly recall two severe floods which affected their orchard in the past 40 years, they still plant citrus trees till the edge of embankment, leaving a horizontal distance of less than 10 meters to the ordinary water level of Yulin River. In 2014, one third of the orchard was flooded, and the impact lasted till the beginning of 2016. Over 600 of all 900 dead trees were then replaced. This demonstrates the outcome of the trade-off by the local farmers, between the economic loss brought by a 20 year re-occurrence flood, and the economic gain from additional citrus cultivation.

The annual yield of conventional citrus orchard ranges from 7.5 to 30 ton/ha, depending on the natural condition and the efficiency of management of the orchard. Single household working on fruit cultivating manages from 0.5 to 2 hectares of orchard. The economic income from sweet orange selling experienced a devastating setback in 2013. Due to the slacken demand for sweet orange within Chongqing city, over one million tons of oranges became dead stock and rotted in the fields. One farmer from Zhonghe Village, a village famous from citrus cultivation, recalled, that the price of sweet orange gradually dropped from 2.4 RMB/ kg to 0.7 RMB/ kg. The interviewer's household owns 0.5 hectare of the orchard. In that year, he sold less than one third of all his 15 tons of yield at low price, and lost money. As many of his peers in this business, he once lost confidence in continuing the work. In the spring of 2014, officials of Zhonghe village updated the orange stock in the website in advance. Within one month, almost all product were sold to procure from neighboring provinces, some were sold at high price of 6.0 RMB/ kg. With the help of information exchange online, the pillar economy of Zhonghe village sustained, and will be strengthened in the foreseeable future.

Contracted intensively cultivated orchards are currently smaller in area and number of all orchards. The reason is identical with the constraints for the development of industrialized farming. Only the land with outstanding natural conditions and abundant water resource (from creeks, water wells and also water ponds) could it attract foreign investors. The fundamental distinctions from the conventional orchard stem from contracted orchard ownership. The later has two characteristics, the increased capital inflow, and the alienation from the conventional settlement system. The long-existing forest system is difficult to change in the near future, even though the local farmers have already been familiar with modernized orchard management and technics. But for the orchard investors, their operating funds enable large scale earthwork and replantation of better variations of fruit tree species. The expenditures on pesticide and fertilizer are also on the company's account. Some local residents are hired as working force, but more employees come from other villages and even other provinces. This way of cultivation gradually alienates those orchards from the settlement system, to become relatively independent from both the settlement and the ecosystem. The orchard systems are sensitive to the variation of capital flow. For instance, several contracted orchards in Lianghe Village are now left abandoned, as the investors stopped investing, and terminated the employ contract with all workers ahead of due time. Local farmers who signed the contract no longer have the land use right to conduct productive activities in the orchards, nor are they willing to plant any crops at all.

Investors started to abandon the orchards since the severe overstock of oranges in the 2000s. The price of major product, sweet orange dropped to less than 0.2 RMB/kg. The annual yield of those delicately managed orchards generally tripled that of conventional ones. Large amount of oranges were left rotted in warehouses. Learnt from this experience, the local government started to promote off-season cultivation and multi-product cultivation. According to the development strategies in each village or town, the local government would also designate specific land parcels to implement innovated types of fruit tree plantation. For instance, Shichuan Town developed a planting strategy, enclosing detailed location of each experimental fruit tree plantation bases. Grape, loquat, apple and plum plantation bases were established in different villages, while the citrus plantation base converted focus to breed new variations. The Shichuan local government also propagated the concept of the integration of agriculture and tourism, by inviting city residents to spend holidays in the farmhouses, and pick fruits and vegetables in the planting bases. For a further comment, this strategy also implies local government's consideration of multi-sector economy development, which is meaningful to improve system's resilience to natural hazards.

Similar to the contracted orchards, local farmers in experimental plantations have low level autonomy and take low responsibility in their work. But superior to the contracted orchards, these experimental planting bases are generally operated by the local government, so that there is little risk of operation termination. Realizing the function of scientific research, experimental plantations are more systematically managed (Fig.6.22). The experimental citrus planting base in

Ma'an Village is even fenced by iron nets. Trees are planted in neat lines, which is unimaginable for the conventional orchards which generally located on difficult terrain. There are two prominent advantages of the experimental plantations in promoting economic benefits. On one hand, high annual yield is guaranteed by high resistance to plant diseases and pests, and fine management. Several species variations of the citrus trees, which have high resistance to diseases and insect pests are planted in experimental plantations for test. And unlike the farmer managed orchards, experimental plantations are less likely to suffer from excessive management, as the hired workers more frequently look after the fruit trees, and take measures at an early stage against forest diseases. Irrigation is also under strict control. Infrastructure and human power are sufficient, that all area of the orchard can be taken care of. Thus it is less likely to have a decreased yield caused by low health state of the fruit trees. On the other hand, the type of product and product quality are more attractive to the market, so that there would be little worry about the overstocking problem. Market research is conducted and thoroughly discussed before the establishment of an experimental plantation. Related entities generally include the local government, and the scientific research center, for instance, the Chongqing Academy of Agricultural Sciences, and local universities. New varieties of fruit trees are planted, which produce the fruit of better taste. The variation of Wogan (English name "WO", a hybridization of navel and tangerine) was introduced from Jeju Experimental Plantation, Korea in 2004. The fruit of Wogan is delicate and juicy, with high sugar content. They are sold at higher price in the market, than the ordinary oranges, and are welcomed by the customers. High annual yield and excellent product quality ensure the large economic profits of experimental plantations. Those plantations also contribute to the fruit production industry in general, as they promote and distribute good breeds to other orchards when required.

Figure 6.22 Experimental citrus planting base in Ma'an Village

Last but not least, fruit tree plantation on scattered land parcels. Chinese farmers are prestigious for their wisdom to utilize all available land resources. On the road banks of the highway, at the edge of terrace farmland, and around the water reservoirs on top of the hills, citrus trees or pear trees are planted. It is most common in Chongqing, that difficult land parcels with the slope gradient of over 45° are planted with fruit trees (Fig.6.23), and hence create additional economical income or living materials for the household. As it has been mentioned, the main reason of this method of land use is to increase land productivity in general. None of the interviewees claim that they plant fruit trees on difficult land parcels for other reasons. From the perspective of ecology conservation, fruit trees help stabilize the edge effects between different settlement system components. Increased biodiversity and the complexity of vegetation structure improve the land's capability of soil and water retention. Compared with barren and herbal vegetated slopes, steep slopes vegetated by fruit trees are less susceptible to landslides. In order to further improve the utilization rate of the steep slope, the local farms plant soybeans and mustard under the canopy. It becomes a simplified version of micro eco-system, but has the significance in soil retention as both deep and shallow soil layers are stabilized by the root systems. For a quick review, fruit trees planted on steep slopes are included as an important component of the traditional Yantang system..

Figure 6.23 Citrus trees and soybean plants planted on steep slope along the highway

As the experimental fruit tree plantations, landscape trees planting is also led by district and lower level of local government. In the sample settlements, villages which develop landscape trees economy distributed in different districts. The Beibei District first proposed this new type of rural business. There is one appropriate base for the business of landscape and gardening plants. Jingguan Town in Beibei District has a history of gardening flower cultivation since the Southern Song dynasty. In 2007, alongside with the greenhouse cultivation for herbal plants, the Beibei District government proposed that the strategy, that grain cultivation gradually replaced by landscape trees cultivation in pilot towns. This direction adjustment of the primary sector achieved great success, that Ba'nan District followed lead.

In the pilot town of Jingguan, the local government encouraged land use right transferal from the farmers to the investors of ornamental tree cultivation projects. Similar to the situation with experimental fruit tree plantation, farmers who gave up their land use right receive rent and draw profit share from previous land parcel. Local farmers have the priority to be hired as workers. They are also given the choice of converting their rural Hukou to city Hukou, enabling them to move to the adjacent newly established urban regions. But choice means that the farmers waive the right to conduct productive activities on agriculture land parcels permanently.

Over 2700 hectares of grain production farmland in Jingguan town were transferred to landscape trees plantations by 2012 (Fig.6.24). Major tree species are mume and hickory trees. Hedge brushes, for instance boxwood and privet are planted on smaller land parcels. According to the managers of plantations, generally over 20 species of trees and bushes are planted in each plantation. During the field research in early spring, workers also prepared to plant herbal flowers, in order to make full use of the space under canopies.

Figure 6.24 Landscape tree plantation in Ruyi Village, Jingguan Town

The average income of ornamental tree and garden flower plantation workers is the highest of all agriculture practitioners according to field investigation. Average annual income per household reaches 125,000 RMB, compared to 25,000 RMB of grain growers and 52,000 RMB of fruit tree growers based on the questionnaires. Significantly improved income guaranteed better living condition. Residential houses are rebuilt in Ruyi Village with more stable architectural structure. Also improved is the infrastructure in the village. The old woody bridge is replaced by a concrete one, so that in summer, when the water level easily reaches the bottom of the bridge, the local residents no longer worry about safety when crossing the bridge. External transportation is guaranteed when floods take place.

6.1.3 Aquaculture

Experts assumed that aqua-cultivation in Sichuan and Chongqing region emerged as early as wet-rice cultivation was popularized in Kai Ming Shu era (Guo, 1931). Aqua-cultivation was practiced on flood plains, and in most cases accompanied with rice cropping. This pattern of production were found along the lower reaches of Jialing (ancient name of Chongqing) in Han Dynasty, demonstrated by unearthed fish pond pottery molds. The fast development of terrace field rice cultivation pattern restrained aqua-cultivation since Ming Dynasty. Ponds in the low mountain region were mainly utilized as water reservoir and flash flood control facility. Fish and lotus root cultivation were the minor and supplementary function of the ponds. In the ancient times, aquaculture in this region mainly depended on fishery in large river and tributaries, for instance Jialing River and Yulin River. In is not until in the 21st century, that fish nursery begins to take relatively larger composition of the total aquatic yield. Even though, the annual gross output value of fishery and aquaculture takes approximately 2%-3% of the total gross output value of agriculture and agricultural services according to Chongqing statistic yearbook 2015. The status of aquaculture development slightly fluctuated, by the end of 2014, no significant increase trend is observed. Limited by the scarcity of unoccupied natural wetland, and plain land which can hold modern fishery cultivation pool, massive fish nursery is not advocated by the local government. In most of the primary economy planning in Chongqing rural regions, aquaculture development is not included as a good direction in the near future. It should be noted, however, that though aquaculture does not enlarge in proportion, the value of aquaculture output indeed increases alongside with the total agricultural output. Propelled by the instant and tempting economic benefits, many previous water reservoirs and ponds in Yantang system are being converted to fish nursery ponds, according to the instructions from town or village governors. Such water reservoirs lost their functions, and induce troubles in irrigation. Conflicts between reservoir contractors and rice farmers become even fiercer.

6.1.4 Other Livelihood Related Water Resource Management

Except from regulating irrigation water, water resources related land management includes river bank reinforcement, drinking water resource protection, etc. Strategies of water source management reveal local people’s knowledge on this specific issue.

In the present, over 95% of the sample settlements are facilitated with tap water. The two settlements, a cluster in Tongxin Village in Yubei District, Shilong Village in Beibei District and (Fig.6.25) They still using the traditional rainwater collection constructions, Dangdang in Chongqing dialect. Generally two or three households share one Dangdang for domestic water.

The size of Dangdang varies, but much smaller in scale than Yantang. In the ancient times, they are of vital importance for the survival of local people in dry seasons. But nowadays, the majority has been discarded.

Figure 6.25 Dangdang in Tongxin Village

The one on the left was frequently used before 1990s, when there were still over 20 households living. Now only three households remain in this cluster. They share use one Dangdang, which is better in construction quality nearby.

River embankment is attached with importance by the local residents, especially those who live along the rivers or creeks. In the rural region of Chongqing, rivers and mountain creeks are characterized by the fast rising water level and the upsurge of flow volume. Especially for the major water course, a security zone is of critical importance to secure the personal and proprietary safety. Regardless of human intervention, wild bamboos grow along the bank of water courses. This fact could be confirmed by most of the unattended creeks and river tributaries, which locate distant to human settlements and cultivated lands.

Since the local farmers tend to make the most of arable lands, the land parcels close to the river have little chance to be excluded from land resource for productive activities. In specific sections of major tributaries, for instance Yulin River and Huaxi River, the local government advocated bamboo plantation along the riverside, in order to reinforce the embankment and retain soil. Bamboo planting along the river bank agrees with the general principle of ecological revetment. According to the local officials, the outcome of this approach resembles the natural condition of ecosystem, and the additional product of bamboo shoots could supplement agricultural income. After seeding, the bamboo forests require little human force for maintenance. Effect of this approach is better demonstrated by the performance during flood events, than the variation in flood frequency. This is due to the consideration, that the frequency of flood is multi-factor related, hence difficult to distinguish the effect of one single factor.

However, few interviewees acknowledge positive effect of river bank bamboo forestation. One extreme sample is the survey in Maliutuo Village, which was severely flooded in 2014. There the interviewees even blamed the bamboo planting approach in flood prevention. Maliutuo village locate on the lower bank of Yulin River, and since 2000, bamboos were planted along the riverside under the instruction of the local government. The Maliutuo Bridge was under construction when the flood in 2014 happened. This incident left deep impression on the residents, as the Maliutuo Bridge was completely destroyed, and half of the village center was flooded. Local officials made video records of the entire event. The flood peak reached the bottom of Maliutuo Bridge, bamboos on the river bank were washed away by the flood, and smashed to the bridge (Fig.6.26). Within five hours, the bridge collapsed, under the pressure of accumulated bamboos and other large obstructions. Approximately one hundred villagers witnessed this incident, hence the induction spread across the village, blaming that bamboo planting alongside the river impose negative effect on flood management. Interpretations of this flood event were confirmed through an informal screening, in which twenty local residents affected by the 2014 flood were invited to watch the video record. During the screening, local residents exchanged their opinions about the flood event. Seeing again the bridge crashed by bamboos, they could not withhold themselves from blaming the bamboo planting embankment approach.

Figure 6.26 Video of a flood played in a local retailer's store.

DVD borrowed from the local official. In the video, bamboos were washed into the river, and horizontally dashed against the bridge structure.

6.2 Settlement Establishment Instructed by Local Knowledge

6.2.1 Principles for Site Selection

Ran and Qiang People are among the first peoples in China who have permanent settlements. They congregated in the unit of clan. Their primitive social structure decided their residence pattern. Ran and Qiang People built Qiong Long, a type of multiple floor building, distributed sparsely on low hills or in the mountains. People of the same family clan lived together, thus they could secure themselves from the intrusion of foreign clans. By living in clusters, they could also better endure natural hazards, as people could offer help to each other. Later in the history, Ba and Shu People came and settled by the rivers. Primitive settlements were in linear pattern. There are also relics of nucleated settlements. They were undoubtedly higher in hierarchy that the linear patterned ones, and mostly functions as palaces of officials. Those nucleated settlements were composed of high-terrace buildings, and with trenches surrounding them. In this way they were protected from the river flood. As the migrants of Han reached Chongqing region and settled on the plain, some of the primitive clans moved further into the remote mountains and clang to their living style,

Since Tang Dynasty, the majority of migrated Han People lived and worked in manors on the vast plain of Sichuan Basin. Those aboriginals who had close contact with Han people changed their life style accordingly. Those “Hanlized” people either set up their own manors, or were hired by landlords as workers. Those manors are known as Linpan. One single Linpan is formulated by households of one family clan. It is also a relatively stable system (Lin, 1986) composed of residential houses, crop fields, and a variety of forests, providing tea, fruit and wood resources etc. for its residents. Those self-sufficient settlement systems ensure the stability of the society and sustainable development. It is not until the foreign invasion and continuous wars in southern Song Dynasty, when the numbers of Linpan fast declined. After the wars, conventional villages and towns were rebuilt to replace the destroyed Linpans.

Parallel with the fast development of Linpan settlement in late Tang and Song Dynasty, rural markets and courier stations started to appear due to the increasing demand of goods exchange (Li, 1988; Jia, 1985). By early Ming Dynasty, commercial network has become sophisticated. Those commercial hubs bund people from different ethnic groups and clans, and this new social network stimulated the new organization form of settlement. The places where rural markets located were called “Chang” in dialect, and the courier stations “Yi”. Businessmen and their households, regardless of the ethnic groups they belonged to, settled down near those commercial hubs, as it has been induced in the transportation principle in central place theory. However, as Chongqing was constantly affected by wars and ethnic invasions, the formation of large-scale settlements of this type was constrained by frequent population movement. Several such settlements survived to date, for instance, Chengjiang Town (known as Yilai Town in Song Dynasty), as the water courier station by Jialing River, and Longxing Town, as the settlement adhered to rural market.

Population movement imposed great influence on the formation of settlements. There is a famous idiom in Chinese describes people from Hubei, Jiangxi, Fujian and Guangdong Province migrated to Sichuan Province after wars. It was advocated by the emperors of that time, in order to stimulate agricultural and economic growth. The migration tides occurred twice, at the turning of Yuan and Ming Dynasty, Ming and Qing Dynasty, respectively. However, due to the high burden of taxation, a considerable proportion of migrants resided in the mountains to evade the burden of tax, and reclaimed farmland from forests. The fact that not all migrants were registered in the formal demographic system could be demonstrated by the mismatch of the population records in relevant provinces. According to (Guo, 1993) migrants double numbered the local people in the first migration tide. 24.2% of the migrants were not registered to the local government and thus beyond the arm of law, and taxation rules as well. Their choices of site aggravated the dispersion of settlements. During the second migration tide, a favorable taxation policy was released. Registered population and the area of farmlands boosted dramatically (Li, 1987). Especially for the majority of Han People, they were given the opportunity to rehabilitate in accordance with their traditions and cultures.

By the modern times, the vast of rural landscape in Chongqing were dotted with cottages. This pattern of settlement configuration is categorized by the scholars as dispersed settlement. One famous example in the western world is Steeple Barton in Oxford shire, England. The pattern of dispersed settlement is generally perceived as the primitive or newly founded residential place. In fact, the stockades Ran and Qiang People lived in also belong to this pattern. Even after Song Dynasty, when nucleated settlements (towns) first appeared, the dominant pattern of settlement is still dispersed pattern.

This pattern of settlement is the result of many factors. It has been well acknowledged, that the location of settlement decisive to the topography and natural resources (Huggett, Cheesman, 2002). In order to have easier access to the farmland resources, local people have to distribute themselves in accordance with the location of arable land parcels. In the ancient times, the productivity was also relatively low. Each production units might still have trouble surviving, let alone stocking surplus capital for cluster expansion.

Very few clusters are composed of over ten households, since this adds difficulties to govern region. As a result, clusters which are close in distance, or have frequent cooperation in productive activities, are governed as one village. A town is connected with adjacent villages, as the place for goods and services exchange. The conventional settlement hierarchy is hence established in the rural region. In the modern world, the politic and economic conditions distinguish greatly from those in the early times. Cities and towns fast evolve, benefited from the concentration of human power and material resources. The concept of rural govern also develops. New configurations of the economic entity emerge according to the regional development plan of Chongqing City. Those new entities could easily break the conventional division between urban and rural region, or re-divide the administrative district/county. For instance, the Liangjiang New Zone encloses part of the urbanized region in Beibei and Yubei District, as well as the current rural settlements adjacent to Yangtze and Yulin River.

Yet another type of dispersed settlement was created by the minority ethnic groups. They did not impose significant impact on the mainstream culture, or the settlement pattern of the majority of Han People. As it has been introduced, minority ethnic groups retreated to the mountains during the wars with Han People. The Tujia People, descendants of Ba People is one of them. Hakka People, who settled down in the remote mountains after the migration tides, also cling to their own culture and life style. As long as they could sustain thanks to their own production techniques, they would confine themselves to the stockades of their clans. Those peoples were quite reluctant to communicate with other peoples. Due to the insulation, their unique settlement system was preserved to their original state, as well as their own cultures, until the outburst of the Cultural Revolution. As their culture was severely damaged in the Cultural Revolution, and new conceptions generated under the influence of the modern society, the majority of ethnic groups abandoned their stockades. In the research region, inhabitants in conventional villages confirm that there are still several ethnic groups living deep in the mountains, but they alienate each other. Neither communication nor conflict happens in these years.

By all means, the clusters are still the basic unit of a relatively complete productive entity in the rural region. Some villages equal the scale of cluster, while the majority is composed of several clusters, of the same type or not. Towns are regarded as the rural commercial centers. Less is emphasized on its own capability of production. They are also perceived as the intermediate form between village and city. The newly established large scale economic zones are not included as the research object, due to its complexity of structure. Though it must be interesting to investigate the stockades of the minority groups, it is expected to be less universal value for the perfection of modern rural settlements.

6.2.2 Morphology of Rural Settlement

The field research chose 14 towns for in depth study. Among them, Longxing and Pianyan boasted the longest history dated back to Ming Dynasty, though, by that time, they were known as Chang instead of the modern sense of town. That is to say, they serve more as central markets. Most of the current towns are transformed from ancient Chang, though they may have much shorter histories than Longxing and Pianyan. The formation of those towns agrees with the central place theory and dynamic central theory in the previous section. By Ming Dynasty, those Chang have already been advantaged in transportation and the amount of services they could offer. Especially in the case of ancient market centers, most of them are distributed along rivers (for instance, Longxing and Pianyan Village), or in places where land-based transport infrastructures could be easier constructed (Shiping Village as an example). More resources, including capital and human resources, relocated there. Subsequently, the accumulated wealth advocated and guaranteed permanent settlement of the itinerant merchants, and was applied in completing the infrastructures of Chang, for instance, the permanent buildings and roads. Such settlements could not expand unlimitedly, as they are still under the restrictions of transportation, natural resources, and administrative polities in a larger scale. On the local scale, they are also highly dependent on the adjacent villages, which would constantly provide them with living necessities. In the case of Chongqing, major limitations are the dampened transportation due to its mountainous topography, and the limited productivity hampered by scarce arable farmland. These limitations severely impeded resource and capital accumulation in central places, even in the modern time, the development status of those rural centers lags far behind the city center of Chongqing. But there is an obvious tendency that those towns are slowly “urbanizing”, as more residents in the towns renounce their rights of agricultural land use to live a city lifestyle.

The pattern of old towns indeed, is one of the factors intriguing natural hazards. Weighing the benefit and risk of settling along rivers, some ancient inhabitants still chose the riverside to reside. River on one hand, provide aqua-cultural products, water resource the convenient goods transport, while on the other hand, impose potential threat of flooding on the settlements.

Severe floods have been recorded in local chronicles of Pianyan Town, which is on the bank of Heishuitan River. Despite of the frequent flooding of Heishuitan River since Ming Dynasty, local people did not relocate, due to the superiority in goods transportation of this place. The most disastrous flood happened in 1938. Local stories exhaustively narrate the flood. According to the stories, the area along Heishuitan River was flooded. The ancient town never recovered its original condition. The stores along the streets were flushed away, one of the theatre stages at the end of street was destroyed, and until present it has not been rebuilt due to the lack of funding. However, the majority of local people still chose to rebuild their houses at the original site. It was not until the 1970s, as the fast increased population demanded more space to reside, that the farmland of west bank of Heishuitan River were gradually turned into residential area with elevated foundations.

It is not the only case, that the town residents collectively resettle themselves in nearby places and establish a new town. History of Jielong Chang dates back to the early Qing Dynasty. It was under the risk of frequent flash flood. Interviewees pointed out the water level in the old village site, which reaches half meter above the street. In the past, residents of the old town had to rebuild the houses and reclaim the farmland each time after floods. The last time of large scale reconstruction is during the period of the republic of China, judged by the existing architectures. It was not until in 1994, that people relocated in Tangbian Village in the valley to the east of the previous site (Fig. 6.27). Currently, over 80% of the buildings are left unoccupied there. Reason shall not be accredited to the well-developed transport system in the new site, as the time of transit highway commissions shows no coincide with the time of town relocation. Several reasons contribute to town relocation. The scarcity of residential place in the previous site and the administrative authority were the predominant forces which push the transition of Jielong town. No sufficient proof is found, demonstrating that flood prevention was the primary aim of settlement relocation.

One predominant ideology which discouraged settlement relocation out of the consideration about the natural hazards is place attachment. In the discipline of environmental psychology, the main factor influencing place attachment is time dependence (Hashemnezhad et al, 2013). In the case of Pianyan and Jielong, not only the inhabitants themselves have lived their entire lives in the town, but also their ancestors. The ancient residential and commercial buildings are regarded as the treasures inherited from the family clan, so as the accumulated social relationships in the community. It is reasonable that the local residents refuse to place themselves in a relatively foreign environment, as long as they are capable of reconstructing their flooded buildings at the previous site.

In all, local knowledge about flood has no critical effect on the site selection of a town. The predominant ideology even prevented relocation of settlement to less disaster-prone areas. Instead, market and land resource conditions are the most effective factors, deciding the scale and geographical location of new towns.

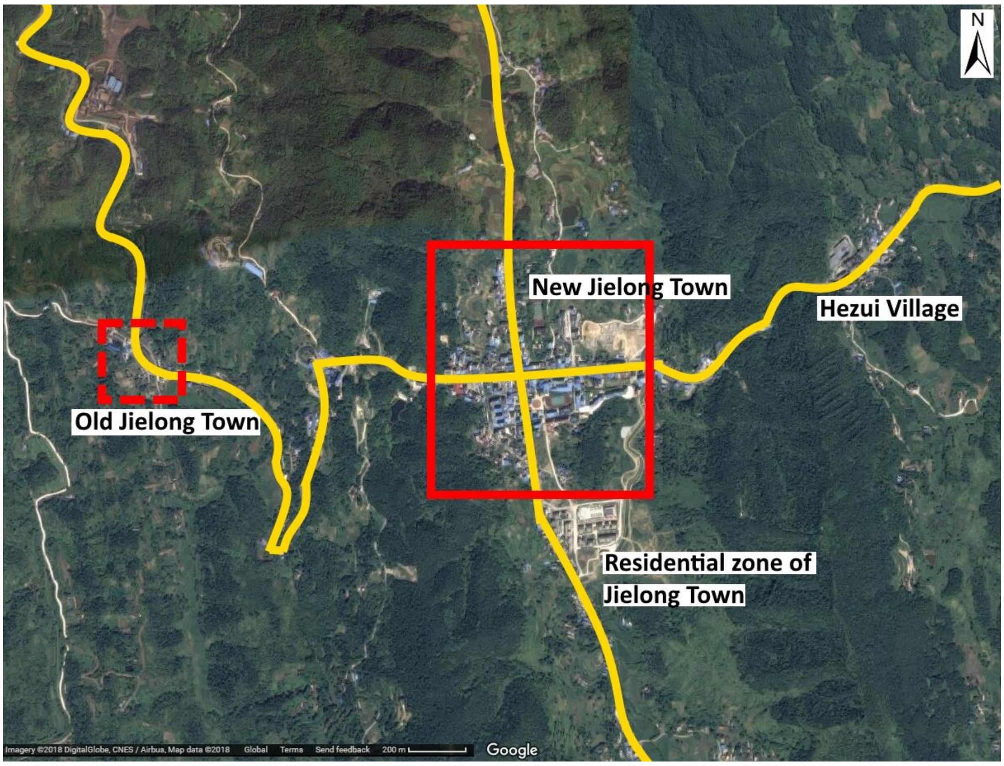

Figure 6.27 The location of the Old and New Jielong Town.

The dash lined square marks the old location of Jielong Chang. The solid lined square marks the new location. White lines are provincial highways, construction commissioned in the 1980s and 2009, respectively.

Map source © Google map 2015

Villages and clusters of households could be regarded as the sub-central places in a larger scale of rural region. They could not compete with the towns in population and resources, but those settlements have higher level of self-sufficiency. The close relationship with the natural environment makes it inevitable, that the structural pattern of villages and clusters are decided by the natural settings.

In the contemporary world, such small scale settlement systems are most susceptible to the rural hollowing effect. Some of those small scale settlement systems are completely disintegrated due to population displacement, while those preserved do not change much of the form of their existence. The structure of villages and household clusters has several forms.

Small and concentrated residential area and population, simple market and social structure make villages and clusters easier to adapt themselves to the natural environment. In the traditional Yantang system, residential buildings are located on the middle or upper level of the mountain. Those buildings are less likely to be flooded by the mountain torrents, thanks to their elevated foundations. Now that the Yantang system is evolved (or rather, degenerated), the geographical relationship between the natural environment and human settlement does not change, as the buildings seldom collapse and need reconstruction. In the regions prone to landslide, cottages are situated more sparsely in the valleys, dispersing the pressure on unstable soil layer. Unless the landslide completely changed the landscape, meaning the previous residential place or the farmland could no longer serve their primary function, local people would not relocate themselves in other places. This is identical with the situation in town reconstruction.

When landslide or flood caused irreversible damage to rural households, village or household clusters did relocate. Relocation is advocated by the local government, who offers financial and humanitarian support to the disaster affected households. According to the interviewees, the most preferable decision is to build the new houses on higher places, but not too far from the household farmland. This kind of relocation is affordable by the local government and the disaster affected households, and thus easier to implement. Such minor adjustments of few cottages do not affect the basic structure of settlement system. But it significantly reduces exposure to further natural risks, and enhances resilience of the system as a whole.

According to the field research, relocation of the entire village is most frequent seen where large scale water control constructions took place. Administrative decision is the ultimate driving force behind. In order to mitigate the flood in the middle reaches of Heishuitan River, Shengtian Water Reservoir was constructed in the upper reach in 1980. Over 8 villages were evacuated, financed by the government. The villagers are thereafter assimilated in adjacent towns and villages, as their lifestyle and knowledge. This kind of administrative rearrangement has no difference as the abolishment of vacant villages.

Top-bottom administrative decision, considering disaster prevention, is the reason of relocation for a number of villages. In these cases, natural elements that may impose threat to the national security are the subject of issue. Frequent flooded area along Yangtze River and Jialing River is under rigorous monitoring by water management bureaus and local administration bureaus. Some of the villages within the range are evacuated, but unlike the case above, the villagers are designated in farther towns or villages. They lost their farmland, and have little or no new farmland to cultivate. It is difficult for them to integrate in the new settlement systems, as they are deprived of the resources which underpin the conventional production pattern. It should be noted, that though the ultimate goal is alleviating the disastrous after-effect of natural hazards, the theoretical foundation of such decision comes from conventional knowledge and scientific research, differentiated from local knowledge.

To conclude, the majority of rural inhabitants, both from the towns and sparsely located household clusters, hold negative attitude towards settlement relocation. Except from the situation, where the land resource of the original settlement is, or will be irreversibly undermined, the inhabitants would not relocate themselves. Conventional ideology and lifestyle stop the rural residents from moving away from their original settlement and farmland, while local knowledge helps them to choose a relatively safe place to relocate, within the range of acceptance. Villages and clusters of households are easier transformable than towns, due to the lower requirements for external financial support and the area of new construction space. Generally speaking, drastic changes of settlement location and administration are determined by governmental decisions, not the knowledge and willingness of the public. Goals of those top-down decisions include the consideration of population variation, land resource, and disaster control on national or regional level.

6.3 Local Knowledge about Natural Hazards

6.3.1 Prediction of Natural Hazards

Since the 21st century, it is a must that the compulsory education offers safety education. In Chongqing, safety training about the types of natural hazards, self-rescue skills during earthquake, landslide and flood are involved. However, the inhabitants are mostly seniors, who did not take the compulsory education. When asked about whether they have taken systematic training to assess the potential risk, and take appropriate action during disasters, 88.4% denied. Those who take the training are mostly officials of the local government. Training providers are disaster prevention office in town and village government, school and production team (Fig. 6.28). Topics cover the prediction of flood and landslide (36.8%), self-rescue (44.7%), relief and reconstruction (10.5%) etc. The majority (72.2%) confirm the practicality of the training.

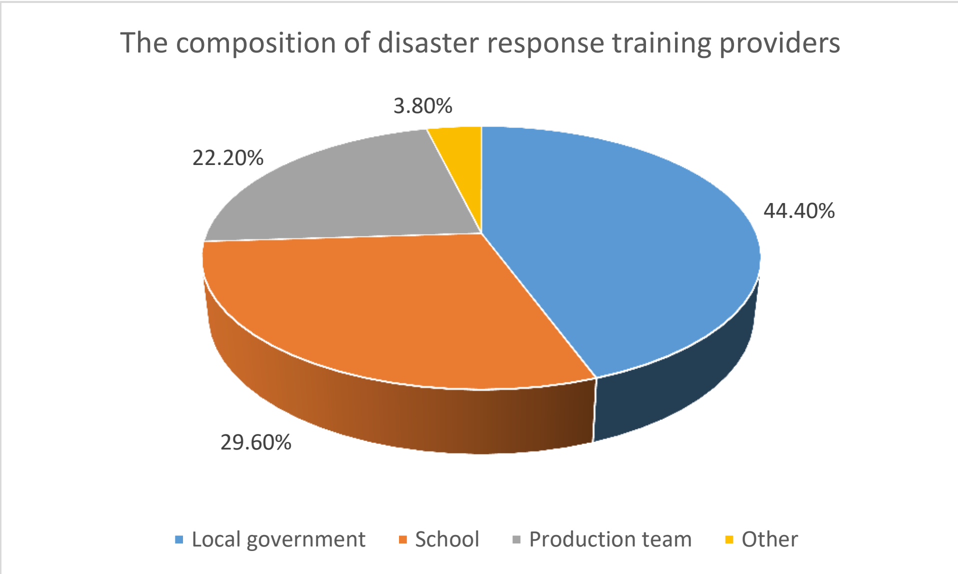

Figure 6.28 The composition of disaster response knowledge and training providers

All respondents were asked whether they have knowledge about natural hazards, aside from the knowledge they acquired from educational institutions and systematic trainings. Only 46% think they have. Among them, 47.1% claim that the knowledge is derived from their own experiences, 29.6% think the most part of the knowledge is passed to them from their elders. Only 21.7% of the respondents will intentionally impart their knowledge to their later generations. The majority reason that there is little sense to do so, since they expect their descendants would work and reside in urban area.

Only half of the respondents explicitly asserted that they do not have disaster prevention and mitigation knowledge except from conventional education. This research continues to investigate which field of knowledge they are acquaintance with (Fig.6.29). In order to further clear up misunderstanding of the respondents about local knowledge, questions about the knowledge contents are included in the later section of the questionnaire. In this way, it is also helpful that we find out the general level of knowledge of the local people, no matter they themselves are aware of whether they have local knowledge or not. In fact, local people are unaware that they possess local knowledge about disaster prevention and mitigation, as over 87.4% of the respondents claimed that they know about the topic of prediction of natural hazards alone.

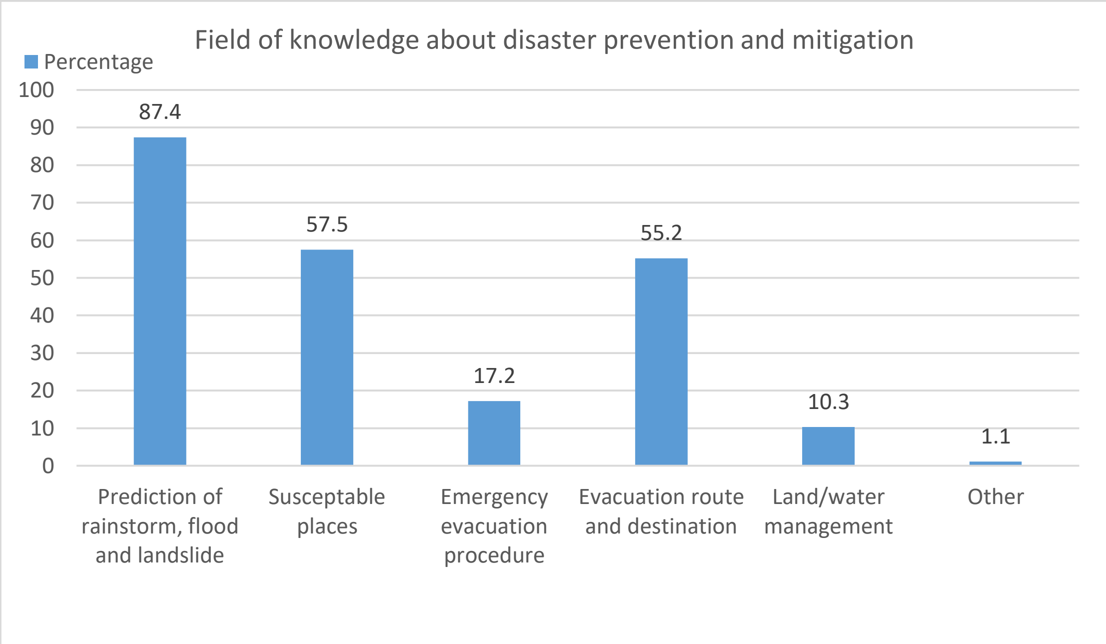

Figure 6.29 Topics of knowledge about disaster prevention and mitigation the respondents are familiar with.

The majority of local residents rely on their judgement about potential risk. In the multiple-choice question their basis for risk prediction, 28.6% of all respondents claim that the daily weather report on television provides valuable information. 56.6% of the respondents judge from their own observations of the precipitation producing process to assess the potential risk. Through visual observation, they know about rainfall intensity. In their perception, accumulated precipitation amount is the fundamental cause of flood and landslide (Fig.6.30). They also pay special attention on the time durance of intensive rainfall, as 75.7% of the respondents relate this factor with disaster formation. Aside from the observation of precipitation process, another essential factor which helps to judge the risk is the water level of the adjacent water course. 49% of the respondents checked this choice. Minor people (6.3%) chose the extent of damage on the objects, for instance, crop, dam of the terrace field and the house, as their judgement criteria.

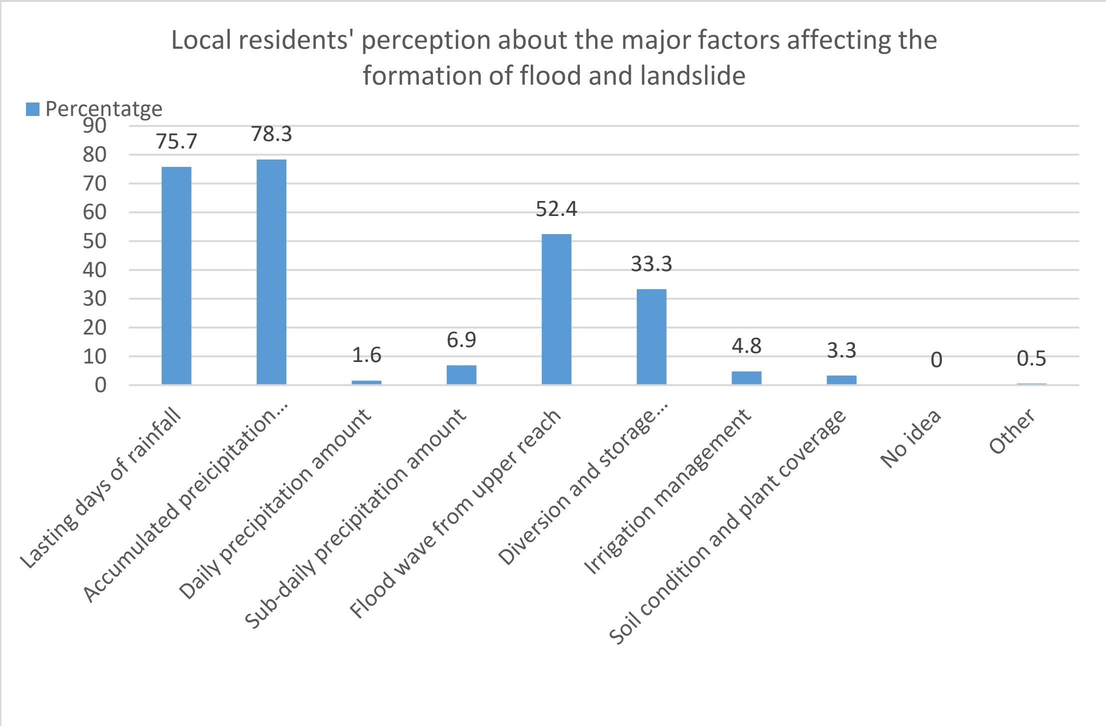

Figure 6.30 Local residents' perception about the major factors affecting the formation of flood and landslide

Following the lasting days of rainfall and accumulated rainfall amount, interviewers also chose flood peak from upper reach, and water management constructions as the main factors affecting disaster formation. The latter two options are mostly chosen by the residents who live in the settlements on the bank of Jialing River (Chengjiang Town) and Yulin River (Tongjing Town etc.), where river floods are more frequent than torrent floods. Some of them even explicitly denied the relationship between the rainfall in the local and the risk of flood. They are also eager to find out the causation of the strong flood wave, and account the failure of water management constructions on the upper reach for the flood disasters. Surprisingly, few consider the land surface condition would result in flood and landslide, except from those who have been involved or witnessed the process of landslide. One of them blamed the coal mining construction on the mountainside for loosening the geological structure, hence leads to landslide. Daily and sub-daily precipitation is also excluded from the factors of disaster formation. The respondents hold that, the farmland, especially their traditional Yantang system and terraced farmlands are competent to drain or retain the rain water from short time intensive rainfall.

The respondents who chose the options related with the amount of precipitation were further asked about the exact value that they would consider of high risk. Few (7%) is able to give an exact value. Those who came up with accurate precipitation amounts are either government officials or production team leader. They think a daily precipitation of over 50 mm, accumulated precipitation of 100-150 mm would raise the risk of flood and landslide. For the duration of rainfall, the majority (60.1%) of the 143 participants consider 2-3 days of intensive rainfall is enough to increase the risk. 28.7% consider 3-5 days is the danger line. It requires scientific knowledge base to know about the exact amount of precipitation. Conventional weather report and compulsory education only introduce the intensity level of rainfall, so that it is unrealistic for the general public to have a clear cognition about the exact figures. It is also unrealistic to expect them to measure precipitation at home. If we compare the exact amount of accumulated precipitation provided by respondents with the official defined level of storm alert, it is obvious that the respondents tend to define higher flood risk than the local forecasts. As the sample number is small for this issue, this conclusion is still need to be verified. But for the duration of precipitation, it is much easier for people to memorize and make simple hypothesis. Chongqing meteorological center defines a destructive storm if intensive rainfall process lasts for over 3 days. Local residents also provided a stricter standard for storm flood precaution. Their knowledge and experience lead them to prepare themselves for potential landslides, if it continuous to rain for 2-3 days. This thesis considers that local people's precautionary principle helps them to avoid flooding risks.

6.3.2 Cultural Remains in the Naming of Settlements about Historical Disasters

The names of villages and towns sometimes reflect the geographical condition and people's understanding of the nature. It could be perceived, that the reason behind the naming is a piece of local knowledge.

For instance, the current Chengjiang Town is previously known as Yilai Town. It once served as an inland port, where all merchant vessels on Jialing River, Qu River and Fu River would anchor. In 1870, the entire town was submerged because of the severe flood of Jialing River. The town was then reconstructed, and given the name Chengjiang Town. It is widely known as Chenjiang Town by local pronunciation, which literarily means a town submerged beneath the river. Such names of the settlements help people remember the historical disasters happened in that place.

Some other naming reveals the perception and cultural background towards disaster. Pianyan Chang was renamed from Jielong Chang in 1844 by the local official. The name Jielong (meaning "welcome the dragon") was applied to many villages and towns in the past. In order to avoid confusion, names applied to multiple places are gradually changed. But as evidence, the current administrative town named Jielong lies miles away from Pianyan Town, which was also called Jielong Town in the past. Places and sites named Jielong definitely locate adjacent to a river or creek. There is a cultural background that people would apply this specific name. Influenced by Chu Culture, Ba and Shu people also believe, that dragon is the god of the rivers. This is slightly different to the original conception of flood dragon in Chu Culture. Jielong expresses the attitude about rivers of the local people. They are both respectful and fearful of the river dragon, similar to their attitude towards the river itself. At the beginning of the year they hold traditional dragon dance ceremony, to worship the dragon and pray that no flood would happen in that year. In the modern times, local people's attitude towards these ceremonies gradually changes. The ceremonies are held more for the sake of tourist attraction and family reunification. But there are still unneglectable remanence of people's perception about the vagaries of the river, in the ceremonies and the names of places.

Figure 6.31 Cultural remains in rural settlements.

Stemmed from the same ideology, the sacrifice activities differ in Pianyan and Jielong. The left photo shows the family of Tang's paper craft, used for dragon dance in Pianyan. The right[1] is a music band in Jielong. Tang's paper craft and Jielong sacrifice music (including the performance style and repertoire) are inscribed on the List of Intangible Cultural Heritage of Beibei District and China, respectively.

6.3.3 Recorded River Water Level

Observation of the natural environment is one of the fundamental content of local knowledge. Water resource is of crucial importance to people's daily life. In the rural region of Chongqing, it is common that settlements are established near rivers and creeks. People pay attention to the variation of water level, so that they could avoid the area within the range of flood zone to set up houses. In the questionnaire, all respondents were asked about the flood or landslide events they could memorize. The majority of respondents (95.2%) have a general idea about the normal and highest water level of the nearest river, creek, and also main drainage ditch for flash floods. For the places which repeatedly suffered from flood, senior inhabitants are easily able to recall the water level of each event. 42.1% recall two flood or high water level events. Two of the respondents provide information about as much as four events. Most of the irespondents use specific constructions as comparator, instead of telling the exact water depth in meter (Fig.6.32). Their observations are compared with modelling result as well as available official records in later sections, to testify their accuracy.

[1] http://news.hexun.com/2012-09-14/145834594.html

Figure 6.32 Interviewees in Chengjiang Town (left) and Maliu (Right) Neighborhood, showing the flood water level with abandoned houses.

6.3.4 Oral Narratives about Historical Disasters

Realizing the importance of traditional culture conservation, several local scholars collected and published story collections. The adopted stories are previously orally narrated by the local people. It is a convention, that people in Ba and Shu region would to leave their work aside, to exchange gossips and absurd stories with each other for fun in teahouse. The local idiom refers to this custom is “Bai Longmenzhen” (literally meaning “arrange troops according to the Dragon Gate tactics”, semantic translation is “spin a yarn”), which originated from Rengui Xue, one prestigious military general in Tang dynasty. Though the stories have long been attached with absurdity to some extent, in order to make the story vivid and attracting, they have valuable information stored inside. Categories of the local story include ancient legend, folk tale, and stories adapted from historic events. Themes have a wide range. The majority praises traditional virtues and criticizes greedy, dishonest and lazy habits. Those who disobeyed traditional virtues are punished in unimaginable ways, so that people have to believe that the punishments come from local gods.

Ancient legends are most dramatic and fantastic, which makes them extremely charming to the story listeners. In this way, they could pass from generation to generation in the local. Some folk tales are closely related with the ancient legends, and share the identical cultural background. Those folk tales are about the interaction between normal people and the local gods. As the example of water dragon mentioned in the paragraphs above, the belief in local gods is stemmed from Ba and Shu Culture. People believe that every natural process is under the control of one local god in charge. If they deviate from the ordinary rules of activities or impose damage to specific objectives, they would receive punishment of certain kind. For instance, some of the tales show that few specific white figs (Ficus virens) are detached with divinity. In related stories, villagers cut the divine fig, abnormal weather followed, causing severe drought or flood in the following year. From the modern point of view, this legend is mere a superstitious interpretation of sequential natural phenomenon. However, the legend is still effective nowadays. As they are still being told, villagers would think twice before cutting white figs, even those figs are not the few divine trees of the region. This type of stories becomes the base of local people's precautionary principle. Another type of story derives from widespread stories of Chinese ancient heroes. In the ancient tale, Yu, the emperor of Xia dynasty (B.C 2070-B.C 1600) contributed himself in flood control of the Yellow River, and achieved great success. Yu is then conceived as the god of flood control across China. A common theme of the local stories in villages near large tributary or river is the construction of Yu's temple. The local story of Pianyan depicts in detail about the reason, time, investors, and the entire process of construction of Yu's temple. It also gave the consequence of the construction of Yu's temple, for instance one of the Yu's temple was curved with the following sentence "in the following years (after 1833), there were no destructive flood on the reach of Heishuitan River".

Some local stories have no relationship with fantasies at all. Those stories contain information of more scientific correctness. The story, "flood flushed Pianyan Chang" tells in detail the timeline of the flood in 1938, before the start time of the systematic disaster record in PR China. This story records the flood happened on 18th August, 1938. It gives depictive introduction about the precipitation at that time, "put a pot outside and take it back in no time, the pot would be full of rain water". The water level exceeded the first floor of buildings on the old street. Local people's reactions are also recorded. The early morning it began to rain, water level raise at an incredible speed. Some of the residents haven't got up and have not been aware of the danger in the early morning. They were then awakened by the sound of river current and also the cries from the neighbors. Some managed to escape to the low hills behind the old street, others climbed onto the white figs alongside the river. The story focuses not only on the flood incident, but also its aftermath. Several hours later than the quick rise of water level Lvjia Dam over the downstream burst. As the floodwater on the street rushed to the low point, a secondary damage took place. A number of wooden houses had only their bearing structure remained. Over 20 houses were completely destroyed. Landslides along the reach of Heishuitan River caused irreversible damage to the rice fields. Now they are left barren, serving as the buffer zone for future floods. There is another valuable fact embedded in this story. There is an open ceiling Karst cave to the upstream of Heishuitan River in Weijia Yakou (a narrow mountain pass). On rainy days, rain water would flow into the cave, but few hours before the 1938 flood in Pianyan Town happened, local residents reported that water came out of the cave, and even flushed away their hog pens nearby. Interpretation of the local people about this phenomenon is "the evil water dragon came out of the cave". However, this information could contribute to a more comprehensive understanding of the natural settings, if interpreted in a more realistic way. From a scientific point of view, water coming out of the cave indicates the location of an underground river, and demonstrates that the water level of this underground river had drastically increased before the flood event in the downstream of Heishuitan River.

In addition, local knowledge not only helps people to observe and take appropriate actions to potential natural hazards, it also strengthens system resilience against man-induced disasters such as rebellions and wars.

Chongqing region's difficult terrain provided shelter to the inhabitants, but at the same time, the valleys and caves could be used as hidden place by villains. Stories with the theme, such as traveler or trader hide in caves to escape from the villains, or bandits seek chance to rub the village in the mountains, take a large portion of all local tales recorded. In ancient times and the early days after the Liberation, conflicts and wars were common in Chongqing. Dispersed settlement would fast reform to stockades, in order to better protect its residents. Local knowledge about the terrain provided the inhabitants with insights, about where the villains were likely to hide and from which direction they would encounter firefight, so that they could better prepare to resist. They would also store abundant food and water backup in the stockades, making it tough to be conquered even if the firefight lasts long. While in the villages, residents gather all forces to confront the bandits, while hide their valuable properties in the mountains. Those who are not able to fight would easily flee to nearby friendly villages. As the rioters never stay long in one village, escaped residents are able to return to their homes and fetch back their properties. This enables the villages a soon recovery from the rebellions.

7 Possessors of Local Knowledge and Local Knowledge’s Public Involvement

7.1 Possessors of Local Knowledge

Population ageing is one significant feature of Chongqing rural settlements. According to Hukou registration data, in 2014, people aged over 60 took 23.56% of total population in Ba’nan District, slightly higher than the core metropolitan function area (22.07%). It should be noted, that this demographic survey does not consider the factor of urban migrants. In the research region, all rural villages are alike, in terms of the age structure of residents. Long-term residents in villages are mostly the seniors and children. In reality, it is rare that people from the rural area find stable job in large towns and the center city. They tend to compromise to part time jobs, which are always low-paid, in town centers. It is most common, that the mid-aged residences give up those jobs, and focus only on agricultural activities. Though intentionally choose the working force as interviewee, the 65-plus age group still takes up one fourth of the total respondents (Fig.7.1). They are physically restrained from heavy farm work, and depend mainly on their children or grandchildren to live. Those who previously endowed insurance also receive basic pensions from the country at around 400-600 Yuan per month, but generally the pension merely subsist their running expenses. The majority of the younger generation working in the local operates family business in retail and catering. This research also attempts to get a respondent group with balanced occupation. To achieve this goal, the number of respondents in modernized town centers is limited. In reverse, respondents in villages and residential clusters are chosen at a much higher sample density. Field of occupation distribution of the respondents is illustrated (Fig.7.2).

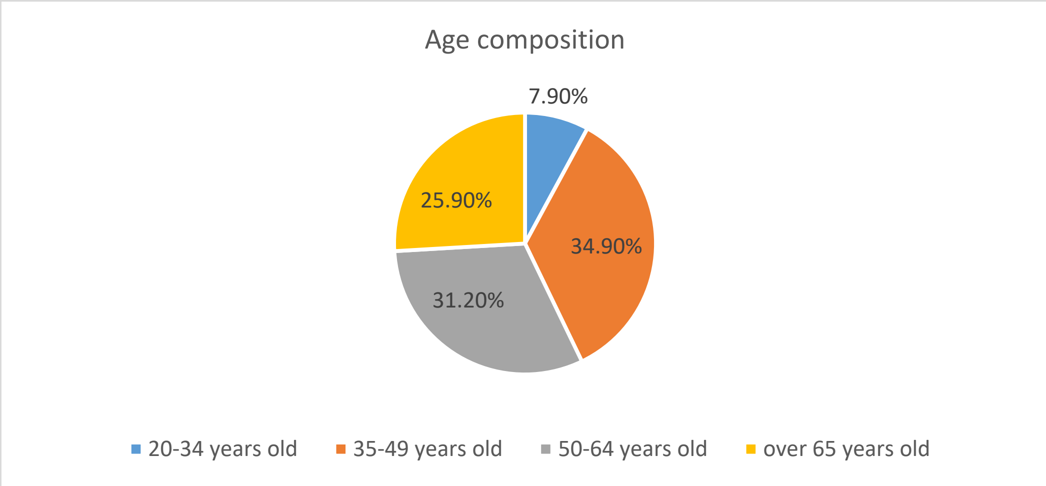

Figure 7.1 Age composition of the respondents

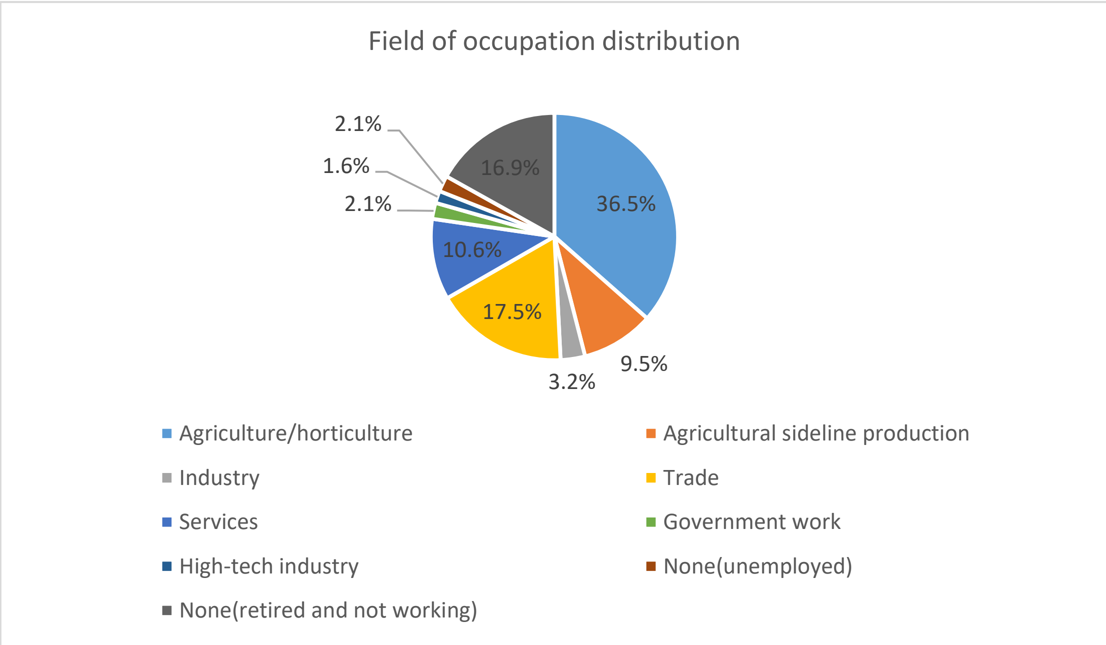

Figure 7.2 Field of occupation distribution of the respondents

The questionnaires keep record of the respondent's working/permanent residence places. Among them, 36.7% chose the villages where they were interviewed. Over half of them (56.4%) currently work or reside in the town center, which their registered birthplace belongs to. In all, 7% respondents work or live in other towns or the center of Chognqing city. Of all respondents, 62.5% possess farmland or forest land and still work on it. The rest either have leased their farmland to others, or leave their land fallow. This record reveals the relationship between respondents and their productive land. Considering that the research is rural region oriented, the percentage of residents who are bind to agricultural land is low. It reveals that local people's daily life is less related with agricultural activities than expected. As it has been claimed in the previous session, people's keen perception about the natural environment is on the premise that their livings are dependent on it. In this case, the possibility that local people no longer show much concern to the environment is expected to be much higher than the past.

According to the statistical books published by Chongqing government, the level of household annual income is classified. In 2014, annual income of rural household across Chongqing was 9490 Yuan per person, and there were averagely 2.9 persons in one household. Considering the increase of general income, and the economic state of the research region, this research expects an average household income to be 30,000-35,000 Yuan annual per household. However, the questionnaire shows a quite evenly distributed pattern (Fig.7.3). The complicated household income sources contribute to the variety of income classes. The value of annual household income is directly related with the distinctive crop they plant, details will be elaborated in 7.5. To explain the large proportion of households with low annual income (less than 25,000 Yuan), reasons can be found in the investigation about age composition and field of occupation. In the survey, the percentages of seniors and no-income inhabitants are exceptionally high. For the middle class, the income of household largely depends on the salary of the younger working generation. The salary of those younger working force varies greatly, thus result in an even composition of household income level.

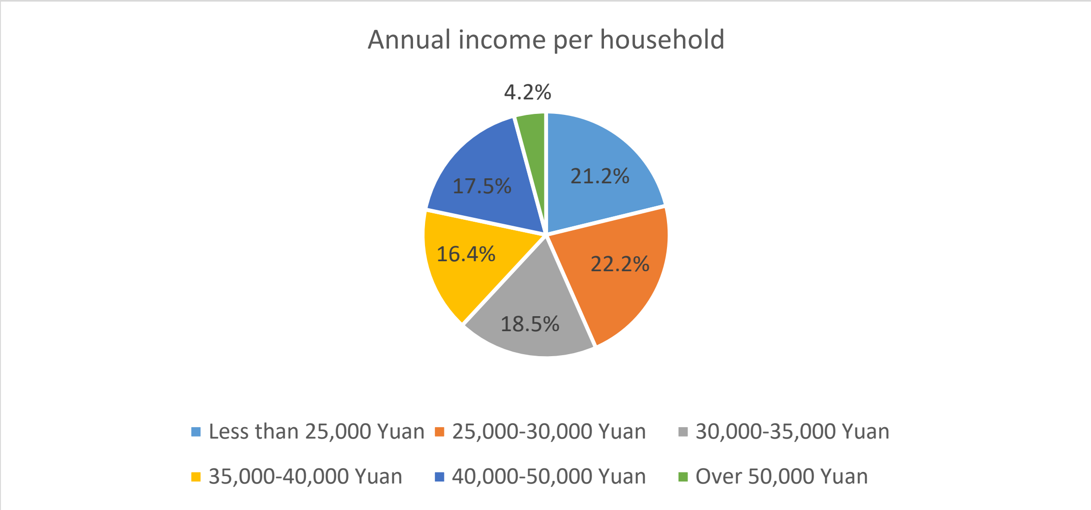

Figure 7.3 Annual income per household

According to statistics, Engel coefficient (Engel, 1857) of Chongqing rural region was 40.5% in 2014 This could be the criteria to evaluate the living standard of residents, but the opinions of the residents themselves are also important. All Chinese citizens are familiar with the term Xiaokang. This term indicates that the household has a middle class income, and lives a moderately comfortable life. Only 3.2% of the respondents consider that their household lives up to this standard. The majority (75.5%) conceive that they have just enough income to support their lives. Slightly over one fifth (21.3%) of the respondents claimed that they live in poverty. The economic status of household significantly influences the capability to mitigate disaster, which will also be expounded in later section.

Economic status of the household partially reflects the knowledge level of the local residents and their descendants. From one perspective, adult residents with higher education level, which is to say, graduated from high school or university, have better opportunities in the job market, thus are more likely to earn stable and sufficient salaries. While from the other perspective, families with relatively good economic status well understand the importance of education, and have the ability to support their children with higher education. There are also cases, that the younger generation from low income family continues their studies, sponsored by educational loans, scholarships or part-time jobs, but such cases are rare and the percentage is negligible.

Those dwellers born before the 1970s in Chongqing rural region received little primary education at the school ages. To a large extent, this is due to the continuous wars during the period of Japanese aggression and the following civil war. After the establishment of the PR China, the notorious Cultural Revolution (1966-1976) aggravated the problem of illiteracy. In that period, while the higher education system was completely destroyed in the cities, compulsory education in the rural region popularized, at the expanse of reducing education quality and the completeness of knowledge structure. According to the Summary of National Education Working Conference (Mao, 1971), conventional primary education shall be offered in rural regions. Each production team and brigade was facilitated with elementary school and middle school, and each commune shall have its own high school. Other educational institutions, for instance, vocational schools, agricultural schools, and part-time technological schools, were abolished. The Quotations from Chairman Mao Tse-tung, which is of strong political implications was once the only textbook in those Party-manipulated educational institutions. Except from the few designated textbooks, almost all other publications were condemned. The core of the primary education on the issue of human and nature is to convince people that man shall conquer nature, to the contrary of the traditional knowledge. Thus the literacy rate in the rural region increased, while the stock of modern knowledge dwindled.

In accordance with the process of regional development, the promotion of education conditions is faster in the cities than in rural regions. The general education level today in the rural region is still unsatisfying. The majority of the respondents only received elementary school education, though the country is preaching a nine-year compulsory education in the present. It should be noted, that the majority of the younger generation, who would have benefitted from the compulsory education, were not interviewed, as they now live and work elsewhere, and hence excluded from the local knowledge possessors in this research. Additionally, the quality of compulsory education varies in different regions. Compared with the educational institutions in urbanized town centers, those in villages are smaller in scale, some lack of teaching staff and educational materials, few pay attention to a systematic emergency training.

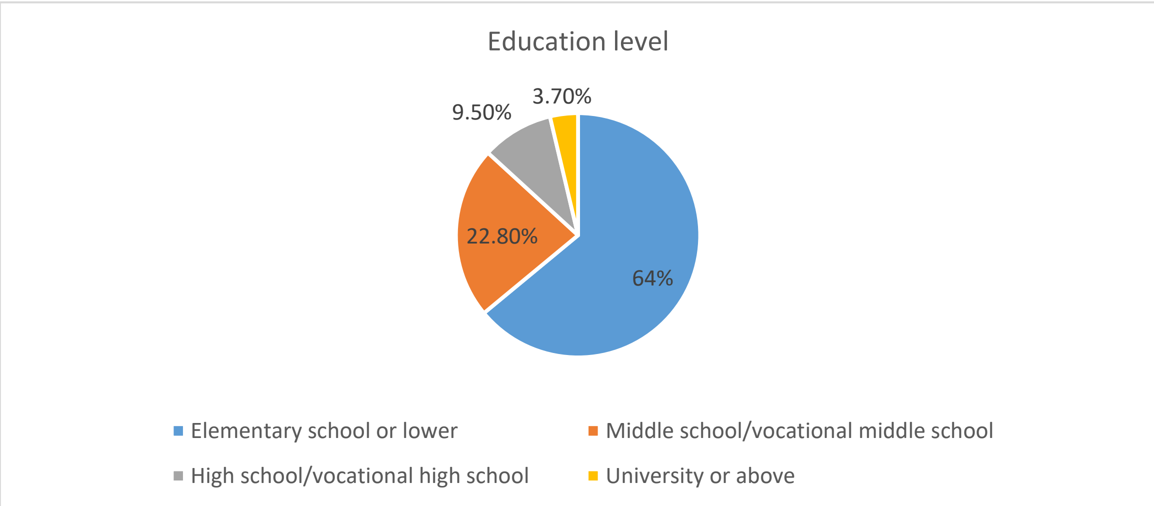

Figure 7.4 Education level of the respondents

Since the 21st century, rural residents are endowed with more freedom in land management. However, it is still rare, that the individual makes serious adjustments to his accustomed cultivation pattern. According to the field study, several remote villages (for instance Shilong Village), which are not involved in the regional agricultural development plan, still follow suit of traditional Yantang System. Those who have been working in the extensively managed orange forest for their lives have never thought of changing the fruit species or cut off all the trees to plant crop and vegetables instead. It is complicated to get to the deduction, whether it is the personal subjective factors, for instance, low self-esteem in mastering new technics or their knowledge, which prohibit them from any changes in cultivation strategy, or it is the material and economic conditions that restrain them from doing so.

It could be absurd to see, that now the majority of agricultural land parcels have actually been changed from their previous conditions. It is undoubtedly, that there are overwhelming external forces that propel them to change. Those external forces mainly come from two sources, the local government, and the foreign investors.

In urban and rural regions alike, officials are eager to stimulate local economic growth, and prove that they are competent to govern the region. For the villages and towns, the local government at district level takes lead to propose specific agricultural development plans for them. Although sometimes the plans prove to be radical or unrealistic, local governments have to obey, and persuade their residents to participate in the plan. As mentioned in Chapter 6.1.2, there was an overwhelming trend to integrate land resource from the production team and establish large scale orange orchards in the late 1990s. This strategy directly led to orange over stock in the conventional harvest season. To avoid the over stocking problem, a couple of district governments started to adjust their strategies, by advocating new species of fruit and off-season cultivation. During this entire evolution of land use strategy guided by regional agricultural plan, there are villages whose pillar of the primary industry shifted from grain to fruit and then ornamental tree cultivation (Maliu Village in Nan’an District as an example). It is impossible for a normal farmer alone, nor a small group of farmers, to think of and implement such drastic adjustment of land use strategy. Even if the production team leaders, who might have the vision, and have the charisma to prompt their people with their will, their plans are doomed to failure. They do not possess sufficient fund as the government, and compensate the people who are forced to change their accustomed cultivation pattern.

Foreign investors involve land use changes in two approaches. The most common approach is to cooperate with the local government and support their development strategy as introduced above. On one hand, the foreign investors procure large amount of fund and material to support the land use transition projects. In some cases they also bring in professional skills, and extra working force. On the other hand, the local government encourages the investors by helping to persuading the farmers who possess land use right, and simplify the otherwise miscellaneous procedure of land use right transfer. Contemporarily, this approach is prevailing in the research region. The other approach is the foreign investors propose their own farmland exploitation plan to the local government, and convince them by its potential benefits to the region. This generally requires long-term negotiation. Only several investors with abundant capital have succeeded. Cases include the ecological farmland and modernized grape plantation in Pianyan Village, Xiangshui Village and Yong’an Village, proposed and launched with help of Chongqing Public’s

River (an NGO institution) and Shijin Grape Plantation Shareholding Cooperation, respectively.

How would the general residents react, as the basic response unit of the settlement system, encountered with the stimuli of internal change? In the situation, where the local government at village or town level decided to launch new land use scheme, there are little objections from the general practitioners. It would be radical to deduce that the general public is deprived of the right to question governmental decisions. In fact, the involvers are quite satisfied with the financial support and compensation for land use change or land use right transfer. In addition, all the land use strategy adjustments took place in the research region, indeed brought significant amount of profit in the initial stage of implement. For instance, annual income of the households which participated in Shijin grape plantation project has increased to 170% in the first 2-3 years. But in the long run, the local farmers are apparently not well prepared for the dynamic of the market, just as the strategy proposers themselves.

This research still holds that the general rural residents are reluctant to change their previous lifestyle and productive activities. However, they are most likely to be tempted by short term economic benefits, which the local government or investors promised. Thus they willingly implement the plans as they are told to. The fact that they follow the strategy even when its defects start to reveal, also indicates that the local knowledge possessors have limited vision about the long term consequences of such system evolution.

7.2 Knowledge Dissemination and Public Involvement

7.2.1 Social Network: Local Governance in the Past

Considering the political situation before the establishment of PR China, scholars asserted that the central government seldom imposes direct impacts in rural residents' daily life (Perkins, 1968), especially in the remote regions. Exceptions generally accompanied with the instability of the central government during the alternation of dynasties, in other words, during the civil wars or shortly before or after. In such time periods, local government or local parties spared effort on improving the strength of their manor. Another frequently debated issue derives from the hypothesis that the flood control constructions reveal the concentralisation of the higher hierarchy governing class. Even in this aspect, history records demonstrated that since Tang Dynasty, water control constructions were generally managed by the villages themselves. In the case where an irrigation system supplies various villages, conflicts among villages would be solved by regional government instead of the central government (Perkins, 1968). The central government would intervene in rural development, when natural or man-made disasters could not be controlled by the local officials. The national policies have, however, indirect and long-time impacts to rural regions, in the perspective of market regulation and taxation. It is the local government who effectively governed the rural settlements.

The ecological sustainability of a rural settlement system heavily relied on the prosperity of economy, or to be more specific, the status of agricultural development in the ancient times. Due to the relatively low productivity, and the limitation of natural resources, the majority of households in the rural region could manage to accomplish farming activities on their own, or together with the help of several neighboring households. Surplus products were traded in local markets or Chang. The cells of rural society did not necessarily divided by higher ruling classes, in the aspect of agriculture related activities.

This situation changed during the Commune Movements of the late 1950s. This pattern of social organization dissolved the conventional rural settlement system, by reforming the administrative structure and re-distributing material resources. The People's Commune was preached and practiced across the country. The new form of governance pattern replaced townships or small-scale production groups based organizations in rural area. The highest administrative communes were subdivided in production brigades and then production teams. The communes are equivalent to administrative towns or counties in the present, production brigades similar to natural villages. A commune functioned as both a production unit, and a governmental authority. Hence the rural households were closely bounded to the central government. Though People's Commune is regarded as the sub-entity of the commune's Party, leaders of production brigades and production teams were elected through democratic elections by the local public. By that era, the people were fanatic about collectivism and bestowed their enthusiasm into all political affairs, the leader's election included. General characteristics of such voted leaders include: well educated, with good morals, loyal to the Party, and have the willingness and the competence to guide productive activities. According to relative regulations, each commune should be composed by approximately 4000-5000 households, which would be irrational to practice in places where the population is sparsely located as Chongqing. In practice, take Jiangjin County as an example, the largest commune consisted of over 12,000 households, the smallest 792 and average 2927. Confronted with the Three-year Natural Disasters, the scale of communes significantly reduced to one half or one third of original size. The basic production unit, production team was generally consisted of 20-40 households. Each team was managed by one or two leading officials.

In the commune, production resources, from farmland to privately owned farming tools were evenly shared, as well as the products and profits they gained. In the first one or two years, annual reports asserted a dramatic increase in three main crops (grain, cotton and oil-bearing crops). As time proceeded, the disadvantages of this revolution were completely revealed. Later in the commune movement, the collective production structure failed, the central government proposed 8 types of rural land contacting (Griffin, 1984). Among them, the most commonly adopted one was the household-responsible system, in which farmland was collectively owned by the town, whereas the peasants had their own properties. The land property rights were then distributed equally to all individuals. The product activities and taxation were to be accomplished in the unit of household. In Chongqing rural region, each household was assigned from 3 to 10 Mu (approximately 0.13 to 0.46 ha) of arable land. The exact number was set according to the total area of arable land and the total number of working force in the commune. In all, the production units were gradually set back to small scale households, but the structure of the commune left deep impression in the minds of the older generation.

7.2.2 Prevailing Governmental Structure and Its Impact on Social Relations

This radical approach of collectivization lasted for over thirty year, ended by the fast development of market economy. The political system of production brigade and production team was replaced by two parallel political systems, the town/village committee and the Party's branch committee. The former can be regarded as the remanence of the people's commune. Leaders (Town/Village Head) are elected by all members of the town/village. The Party's branch committee is composed by elected Party members of the town/village. Leaders of Party's branch committee can either be elected from the committee members, or designated by upper position officials of the Party. Contemporarily, the Chinese government advocates new-village projects, requiring the local officials have more knowledge in governance. In order to cover the shortage of local officials with high educational background, the proportion of designated university graduates significantly increased. Those young and foreign officials are not quite familiar with the local conditions when they first take their work place. It can be easy for them to learn about the local conditions in a short time, but extremely hard for them to be considered an interest related member of the community. This alienates them from the local residents, and in some villages, leads to a vicious spiral. It is expected that the two governing systems, the town/village committee and the Party's branch, have equal authority and clearly defined responsibilities in governing. However, in many settlements, no unified regulations or implementation measures have been issued to segregate the responsibilities. The distribution of responsibilities between two governing systems distinguishes in different towns/villages.

Where did the rural residents' dependence on the local officials come from? In the era of Commune Movement, the farmers lost their rights of farmland management. All agricultural development was planned beforehand, that the farmers followed the instructions from production team leader without independent thinking. Though in the household responsible system, land use right was partially returned to the farmers (Chen, Davis, 1998), they could pursue economical profits in premise of accomplishing the rigid State procurement. Generally, there would be little remaining yield after State procurement, and the surplus products should only be purchased by the State commercial institutions at a low price. Thus the farmers lost the right to make production decisions because of the abolishment of the land use right, and therefore lost the willingness to explore more types of cultivation.

In the ancient times, rural development and the life of individuals were seldom affected by the national policies, though the local officials should frequently report the agriculture development, population growth and natural hazards to the central government In the recent history, the enthusiasm for production brought by the Great Leap Forward and People's Commune (1958-1961), and the struggles during the Great Proletarian Cultural Revolution (1966-1976) left inextinguishable impression in rural residents' minds. They became more aware of the national policy. As the nation becomes stable and prosper, such concerns gradually reduce. Instead, local policy and the market demand become their new focus. The rural residents become increasingly dependent on the local officials, whom they trust in, to instruct their productive activities and thus make good fortune.

But who are the local officials? What is the actual politic authority that rules the rural communities? It has been referred in the first paragraph of this section, that nowadays, two authority structures parallel in practice, the central authority represented by the branch of the Communist Party since the 1950s, and the democratic authority by elected villagers' Committees. Since the de-collectivization and the introduction of elections in the 1980s, centralized governance attenuated at village level, and the authority is increasingly shared with village Chairs

(Bernstein, 2006). Guo (2001) synthesized four models of authority structures based on the portion of authority distributed between the Party branch and elected committees. According to the survey in the rural regions, 75% of studied villages (Zhang, 1995) belong to Bernstein's model C, in which the Party branch imposes stronger authority than the village committee. This survey result resembles the situation in contemporary rural Chongqing.

Interviewed villagers assert that the production team leaders or the village committee officials are the priority to consult to when they come across problems in productive activities and natural hazards. It should be noticed that the title of production team leader has long been abolished, and most of the previous leaders have already retired from work. Undoubtedly, the village committee plays a dominant role in governance.

In contrast to the interviewees in villages, the residents in towns would rather consult to the Party's branch committee, encountered with disaster induced problems. In the in-depth interview with the residents who suffered from the flood in Tongjing Town, interviewees argue that it is meaningless to consult to the town committee about disaster related issues. The Party's branch committee is blamed of not giving flood alert, and not providing adequate compensation to flood affected households.

The Party branches are responsible to interpret the political goals set by higher administration level, for instance, the district or province level. The committees assist in detailed implementation. All local officials would cooperate in advocating the central idea of development and providing technical support. The majority of rural residents are willing to participate, as long as they are ensured by foreseeable profit. Field research indicates that, since the elected local officials initially possess closer relationship with the residents, and are frequently designated to actually solve local problems, they are often described as "trustworthy" and "knowledgeable" by local residents. The Party branch officials, on the contrary were related to township authority, thus are more likely to bear the brunt with unfavorable policies (Sun et al., 2013). In the issue of disasters or significant transformation of the economy, biased configuration of the Party branch officials would evoke and even impede governance activities. The working ability and knowledge level of the Party branch officials shall not be judged only by the complainants from the residents. But there are few cases, that foreign officials designated by the higher level of authority (in Chinese slang "airborne landing to the local") have limited knowledge about the geography and land use conditions within their jurisdictions, thus they are disrespected by the local residents.

Since late 1990s, fast-paced urbanization enlarged the discrepancies between the life in urban and rural area. Migrant workers left their hometowns in the rural area, and moved to large cities. The remaining residents are mostly the old and the young. Thus the number of long-term residents in rural area significantly reduces. The number of administrative entities reduces accordingly (Fig. 7.5). It has been a common phenomenon, in which geographically adjacent production teams merge in one, so as the villages. The increase of jurisdiction would not necessarily cause much difficulty in governance, thanks to road construction and the popularization of modern vehicles. The jurisdiction range of a village is significantly enlarged.

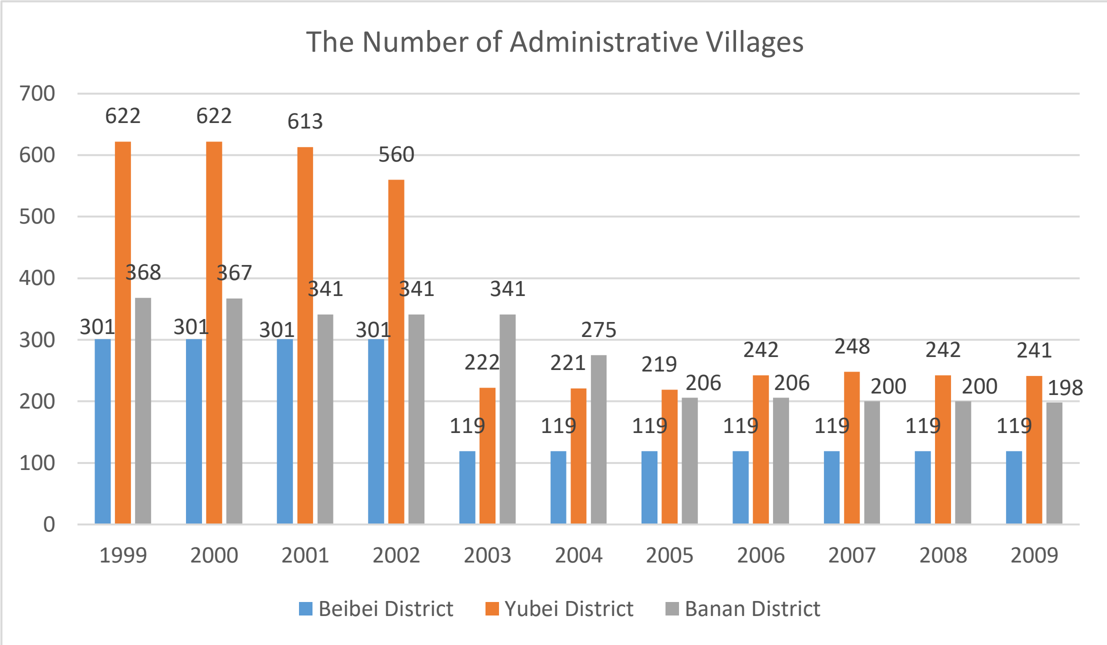

Figure 7.5 The number of administrative villages,
Data Source: Chongqing Statistical Yearbook 2000-2010

The transformation of administration structure might impose little impact to the social structure of the rural settlements, but as the migrant workers taking a major proportion of the rural population, the social structure within a settlement loosens. The young people are no longer bond to the local affairs. The chance that they communicate with the local officials reduces to the minimum. This does not necessarily reflect a reduced obedience to the local officials, but an estranged social relationship. The estranged social relationship therefore changes the way people obtain local information and knowledge.

To conclude, in times of peace, the central government and national policy generally impose no direct or significant impact on rural lives. The local government and officials were fully responsible to all practical issues happened under their jurisdiction. Centralized governance during the Commune Movement left negative influences on the rural development in Chongqing, but the commune administration system has been adopted till present. In the modern times, rural residents gradually adapted to the conventional township administration, regardless of the variation in the size of single jurisdiction. They also show great trust in local governance, while from the other side, young rural residents become estranged to the social network in their own settlement.

7.2.3 Unauthorized Community Groups

In dispersed informal settlements, the relation between households and farmland is closer than that in cluster towns. On the other hand, the dispersion of residential places inevitably leads to the alienation from other social groups and the local government. Those settlements developed their own social structure to form an operational governance unit. In contrast to the clusters, whose social network goes alongside with clanship or governmental administration, social network among remote cottages are determined by geographical location and the various social events attached (Lu, 2013). Among them are the commercial activities in Chang, which still plays an important role in present rural life. One other social relationship is established by the regular cooperation in productive activities, for instance, guild, and water resource management. Before the establishment of PR China, there had long been “brotherhoods” (gangs) figured in history. Almost all rural inhabitants were involved with the various brotherhoods, by becoming either member or victim. Nowadays, only some local stories about gangster’s vicious works remain.

There is no solid evidence that this unauthorized community groups contribute to change the contents of local knowledges, nor improve system resilience against natural hazards. How local knowledge is disseminated among those unauthorized community groups shall be analyzed case by case.

7.2.4 Governmental Information Exchange System Regarding Natural Hazards

Speaking about local knowledge, especially on disaster prevention and risk control, various means of knowledge dissemination are involved. The most conventional method of information dissemination is supported by the governmental, scientific disaster prediction system and early warning system.

In Chongqing, flooding and landslides are most tightly associated with the abnormal meteorological changes and hydrological processes. In order to improve the forecast capability, scientific data collection is advocated by the government from two aspects. China’s Meteorological Disaster Prevention Plan (2009-2020) asserts the research force on disaster prediction and ability to mitigate sequential damages in rural regions shall be enhanced. Specific measures about data collection and processing including: collect data through general survey in rural regions; establish space-based, air-based and ground based observing systems and accelerate basic data processing and information dissemination. Upon these requests, the meteorological administration of Chongqing Municipal accomplished the establishment of a disaster forecast and information transmission network, enclosing one municipal level, 38 district level institutions, and 1328 town/village level working stations. Considering the insufficient financial support, it is difficult to set up weather stations with full functionality in short time. Special emphasis is laid on the monitoring of precipitation, as it is of vital significance for flood prediction. As it can be seen in the distribution map of precipitation monitoring stations in use (Fig. 7.6), since 2008, precipitation monitoring stations are gradually built across the region. Six stations locate within the research area, another four are very close in distance. Those stations supplement the main weather station in Shapingba. Data are managed by district level water resource bureau, hence contribute to an improved accuracy of rainstorm forecast in remote rural area. The enlarged monitored area improves the precision of forecast.

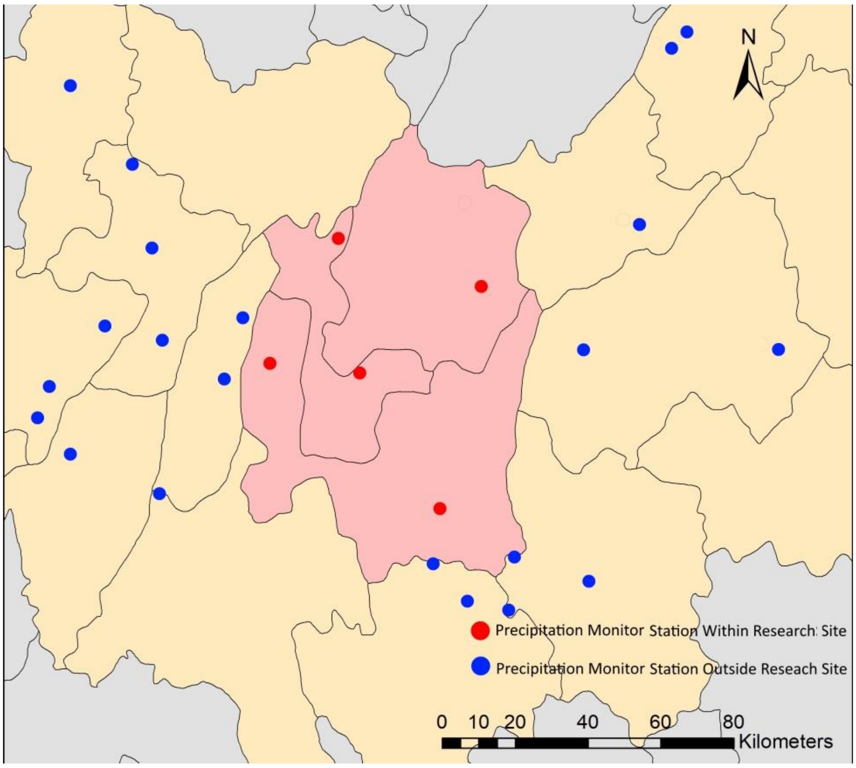

Figure 7.6 Precipitation monitoring stations in use in the research area.
Reference: Chongqing Water Resources Bureau.[1]

The other direction focuses on river flood monitoring. According to Chongqing Water Resources Bureau, five water level monitoring stations in the research region are in use (Fig. 7.7). Among them, Cuntan Station which is located on the bank of Yangtze River has the longest history. It continuously records water level observation data of Yangtze River since 1936. As it is with Cuntan Station, Beibei Station for Jialing River also has the update interval in days. In the field research, Dongquan Station on Wubu River, and Tongjing Station were paid visit to. These two stations are expected to put to use in 2010 and 2012, respectively. According to the provisional Measures for the Implementation of Flood Forecast of Chongqing City (Chongqing Headquarter of Flood and Drought Control, 2015), the monitoring period of all tributary stations is from 1st May to 30th September. Though newly founded, Dongquan Station is attached with great importance by the local government, and supports the pilot of new system of flood forecasting and emergency management. Since 2014, flood drills are annually organized in Dongquan Town. It can be presumed, that in the following decades, water level simulation in all major tributaries will be launched, and hence improve the prediction accuracy of river flood.

[1] http://www.cqwater.gov.cn/gis/ylz/Pages/Default.aspx

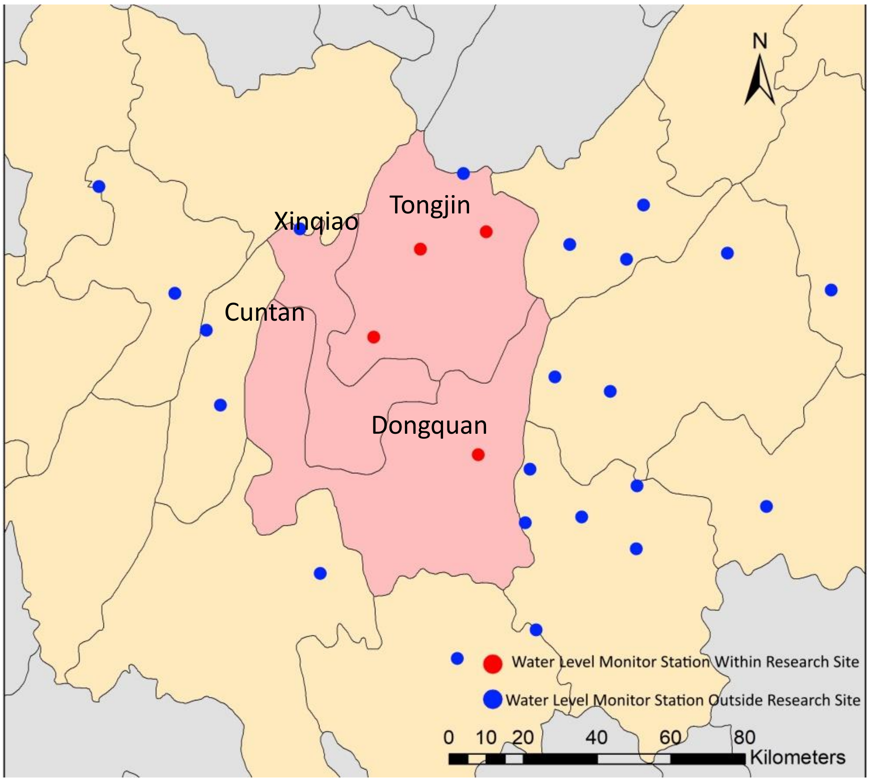

Figure 7.7 Water level monitoring stations in use in the research area.
Real-time water level information is available on official website since 2014
Reference: Chongqing Water Resources Bureau[1]

The headquarters of flood and drought control at municipal and district level are in charge of flood monitoring, precautionary information dissemination, and sequential deployments. They are set up as subdivision of the water resource bureau. The headquarters are competent to dispatch working forces and support from other related functional departments, for instance, the press and publication bureau, agriculture committee, meteorology bureau, water resources bureau and public security bureau, etc. All related entities shall share information, especially the water level and precipitation prediction and observation data. There are fixed criteria defining the level of flood/rainstorm risk (Tab. 7.1).

Table 7.1 The Hierarchy of rainstorm risk.
Reoccurrence period is calculated based on local experience formula

Alert	Criteria	Reoccurrence period
Blue	Over 50 mm precipitation within the next 12 hours	NA
	Accumulated precipitation exceeds 50 mm, and the rainfall is expected to continue	
Yellow	Over 50 mm precipitation within the next 6 hours	NA
	Accumulated precipitation exceeds 50 mm, and the rainfall is expected to continue	

[1] http://www.cqwater.gov.cn/gis/sqz/Pages/Default.aspx

Orange	Over 50 mm precipitation within the next 3 hours	1 year
	Accumulated precipitation exceeds 50 mm, and the rainfall is expected to continue	
Red	Over 100 mm precipitation within the next 3 hours	20 years
	Accumulated precipitation exceeds 100 mm, and the rainfall is expected to continue	

For Yangtze River, Jialing River and Wubu River, there are also criteria defining the potential risk of river flood. Other tributaries, regrettably, have no such risk assessment measures yet. The table below represents the hierarchy of river flood risk of Wubu River (Tab. 7.2) H indicates the water level (elevation) at Dongquan hydrological station. Broadcasts of Yellow Alert were announced through the loudspeakers installed in the town center, while for other villages along the Wubu River, local officials practiced other form of early warning, catering to their own situations.

Table 7.2 The Hierarchy of river flood risk.

The table revised from the Measures for the Implementation of Flood Forecast of Chongqing City (provision).

Level of Alert	Criteria
Blue	$216.50 \leqslant H < 217.00$
Yellow	$217.00 \leqslant H < 219.00$
Orange	$219.00 \leqslant H < 220.50$
Red	$H \geqslant 220.50$

Forecasts are broadcasted by television and radio for red level alerts. Given extreme events, text messages are sent to the citizens who reside in affected region. In remote rural regions, it is the responsibility of the local officials to make sure that all residents are well informed. Officials of the headquarters are also responsible for arranging evacuation, transporting and distributing relief supplies, and managing disaster’s aftermath.

However, the implementation of disaster prevention plans is not completely carried out as expected in the rural region. In the first place, there are unneglectable problems in disaster forecast and information dissemination. The reasons do not only lie on the construction infrastructure. The most recent Yulin River flood in September, 2014 imposed severe damage to Tongjing, Shichuan and Longxing Town. It is reported by the interviewees that the hydrological monitoring station on the upper section of the river in Sichuan Province has already sent high water level alert to Sichuan residents one day before the flood reached Chongqing. According to the disaster prevention plan, such alerts from monitoring stations should have been conveyed to the local government, and therefore the local government should broadcast the information to the general public. In Tongjing Town, none of the local residents, including those who lives less than 200 meter away from Tongjing hydrological station, and on the same street where the local government offices locate, were informed by any officials through any forms of media. No suspension for work and classes in town was issued. The only information source is the residents who lived along the Yulin River bank and witnessed the speed of water level rise with their own eyes. It is obvious that the water level monitor system might not be so reliable as it is affirmed by the publicity, whether this failure was due to the technical problems of Tongjing Station, or the local officials' dereliction of duty.

In the same flood incident, the situation in Maliu Neighborhood shed light upon the competence for flood precaution in the modern, scientific way. Maliu Neighborhood is reformed from the previous Maliu Village. Alongside with this administrative transformation, modern disaster prevention schedule is embedded in settlement management. The officials received phone call from the district's disaster control center at 10 a.m. about the abnormal water level rise in the upper section of Yulin River. They soon went to the residential clusters along the river to inform the residents. At 1 p.m., the water level reached its peak. It can be inferred, that there was significant delay of information transmission among the monitoring stations, the center of disaster control, and the local government. In this specific case, the delay might occur as the monitoring stations in the range of Sichuan Province were not effectively associated with the headquarters of Chongqing, thus led to an alert only 3 hours ahead of time, while the earliest water level alert on the upper stream (Linshui County in Sichuan Province) was released at night of the previous day.

Flood and landslide are hard to forecast, as various factors contribute to their formation. Compared with the prediction and precaution of torrential flood in the mountains and landslides, weather forecast system is relatively mature. At present, professionals in meteorology bureau are competent to make satisfying weather forecast, and report to the headquarters of disaster control. There are also obstacles in conveying alerts than making trustworthy prediction. In all sample towns and villages, the broadcast systems have already been installed. Loudspeakers are installed in the center of settlements, and in major clusters of residential houses. Television and mobile phone possession rate have reached approximately 100%, while internet possession rate ranges from 20% to approximately 90% in settlements at different development stage. Officials in charge of disaster prevention regard television and radio to be the media with widest audience who are susceptible to potential risk. The interview and questionnaire would shock them, as only 6.1% and 8.3% of respondents received alert from television and loudspeaker announcements, respectively. In fact, few reported that the loudspeakers were in use, when flood or landslide was about to occur. According to the result of this multiple choice question, the majority of respondents (75%) would exchange opinions with their neighbors and friend about the potential risk, before making their own decision on how they should react. This generally happens before any alerts from the mass media or the officials reach them. 15.9% of the respondents recalled that it is the local officials or production team leaders who came to their places and conveyed the message about a potential disaster. When asked about the reason, why they missed the officially released announcements, respondents explained that, they were otherwise engaged in farm work or other household businesses, and had no time to watch television. Radio is also considered to be "out of date", that no one would listen to, except from private automobiles owners. The only media that directly convey weather and disaster forecasts from the headquarters is the network of loudspeakers. But in the majority of the settlements, such broadcasting systems were not made full use of.

In the actual disaster incidents, experienced local people are always first to notice and react to abnormal environment changes. Information is immediately exchanged through the social network, as they talk to their neighbors, friends and other members in their social group. This explains a reason why the rural residents would pay no attention to the mass media: they have instant observation of the situation, and have people who share intimate social relations with them to consult to. Leaders of production teams are generally regarded as the most experienced and knowledgeable people in a settlement. They would also take action at the same time, if not earlier than the residents. They either receive messages in through official disaster prediction system, or make their own judgement based on real-time weather broadcasts and observation. In numerous cases, production team leaders set out to the households who reside in disaster susceptible area, beat gongs and shout out announcement through handheld loudspeaker. The most common situation is they convey the message to the residents face to face. Informal temporary teams are immediately formulated under the guidance of production team leaders. All members follow suit, to inform their neighbors and help out with the rescue and relief work. It is therefore clear to see, that the interpersonal relationships play a dominant role in information dissemination.

This type of information dissemination is practiced in all remote settlements, where flash flood and landslide are more likely to occur. The majority of those remote settlements have no rigid implementable strategy about disaster prevention and contingency plan. Though local governments have gradually re-organized and attempted to establish a plausible disaster forecast framework, for those remote settlements, the commune governing system still manipulates and fulfils its responsibility in disaster prevention. The general public bestows trust upon the leaders, and this relationship remains even after the production team leaders are dismissed or retired from their positions. Therefore, the former bureaucracy transformed to be an inherent social network structure in those settlement systems, and contribute to the improvement of disaster prediction and information dissemination.

To conclude, the current precipitation and river flood monitoring system covers a limited range of the research region. The early warning system for river flood needs to be improved, especially in the aspect of the efficiency of communication among corresponding bureaus. Severe deficiencies of the official disaster prevention plan are found in alert dissemination. Two major factors lead to the deficiencies, namely the dereliction of the local officials and inappropriate choice of media platform. The informal social network in rural settlement proves to be valuable for risk alert dissemination. Its “nodes” have the primary information, and its sophisticated “links” ensure fast, direct, and hence the most effective information diffusion than the mass media. Local governance also plays an important role in disaster prevention action. Though the rural settlements are experiencing governing structure changes, the former commune system still assist, if not preside over, the alert issuing work.

7.2.5 Conclusion to Knowledge Dissemination among Local Residents

The knowledge transmission is determined by the means and quality of information exchange among people. It has been introduced in 7.2.1&2 about social network structure. The social activity of attending Chang becomes a platform for establishing and strengthening social relationships, and hence to improve information exchange. Chang is the dialect term indicating rural market. People might not live in the settlement where Chang is located, but pay regular visit from adjacent places in order to exchange goods and information (Fig. 7.8). Chang is held every three to four days, the exact date varies for different village/towns, but generally on the day ended with number 1, 4, 7, or 2, 5, 8. Some urbanized towns hold Chang only on weekends, catering to the majority of office workers. Nowadays, though commercialization took place in all villages and towns, and it is no longer difficult to purchase goods from supermarket, this tradition does not vanish. The only thing changed is now that every village holds its own Chang, but according to field investigation, people still prefer travelling far to larger Chang in towns.

Figure 7.8 The site where the dissemination of local knowledge happens: Chang
When Chang is held, main streets are always crowded with people, selling and purchasing goods, as well as exchanging information.

On the days when Chang is held, both the young and the old would come to exchange goods, and meet friends in other villages. Sellers place their goods, mostly agricultural and poultry products, along the main street or in specifically delineated markets. Though most of the towns have set up modernized market center, itinerant stalls are still popular on streets. The place where people meet and exchange information is important, as it largely decides the time duration, content, and efficiency of communication. As Richardson (1982) states, being in the market, people act smart and quickly, interactions between seller and buyer is more like an intellectual competition, with the award of material advantage. Though in the modernized markets, communication is confined to the simple buying-selling activities, local people still exchange monotonous information when comparing the goods in different stalls. In the less organized street stalls, people spare relatively more time looking for what they need. More opportunities of information exchange are available in this process. According to the observation, owners of the street stalls do not come to Chang every time when Chang is held. They set up their stalls in a section of the street, but not in a fixed place. Communication between buyer and seller, in this case, starts with non-business related topics, for instance, the location of the stall and the time when the sellers would come. This kind of informal and personal chat quickly establishes a smooth interactive communication platform among participants. Aside from the topic aiming at business related issues, they also share information about crop yield, crop variety and other production related issues.

Living in the rural region, the percentage of acquaintances in a community is much higher than in a city, due to more frequent interaction and small size population. Chances are abundant for a rural inhabitant meeting his acquaintance in Chang. They talk while walking, or if they are both willing to establish further conversation, they stop and smoke together for a while. Such random communication among acquaintance also takes place in restaurants and mahjong (one kind of popular table game in Sichuan and Chongqing region) rooms, in the afternoon after Chang. People cherish the time escaping from the tough farming work. They talk or complain about family trifles, farm work, yield etc. Through the casual chatting, information exchange is easily accomplished. The abundant information therefore, is utilized as source material for the development of local knowledge, if its receiver would spare time and effort digesting it.

Yet another important information exchange platform among the rural residents is the long-distance transportation related situations. It distinguishes from the daily communication places, as the vehicles provide the passengers with an intuitive perception of the local geography. Such information exchange is most common on the local bus, whose routine connecting villages in several adjacent towns. Passengers, no matter previously know each other or not, are willing to build casual conversations, with the topic about the landscape outside the bus window. The rural public transportation system is operated by contracted vehicle fleets. The type of vehicles varies, with the passenger capacity in between 12 to 60. Generally the situation where passengers are all seated in minibuses facilitates more conversations, as the limited space on minibuses shortens the psychological distance among strangers. Approximately one thirds of the rides the researcher took on local bus, passengers talked about the farm work, flow routine of water courses along the highway, and previous flooding situations, based on what they saw on the road. Thus the information about local environment and livelihood is effortlessly transmitted to a wider range of places. It should be noticed, that quality of this kind of information exchange platform is restricted, as there is a more rigid time limit than the casual chats in Chang.

8 The Value of Local Knowledge in Planning towards Resilience

8.1 Correctness of the Local Knowledge about Disastrous Events

This research investigates local knowledge about the following issues: environment condition observation; interaction with the nature; and disaster prevention, risk control related information. Contents of local knowledge are mainly drawn from questionnaire, interview, and mental mapping. In addition, the current land use status reflects the content of local knowledge, especially on how people interact with the environment. Model provides a reference to the probability of flood event, by stimulating water level based on historical meteorological and geographical data. Simulation result requires calibration, but due to the lack of systematically recorded hydrological data, the information drawn of the residents is applied to make biplane examination. News reports and statistic yearbooks are regarded as reliable data, though in rare cases, possibilities exist, that such official records are manipulated by local media for complicated reasons, especially in the aspect of the severity of disasters. The date of flood and landslide event, on the other hand, is expected to be of relatively high accuracy. In all, the correctness can be evaluated by making comparison with researcher's investigation on site, publications, and official data. This research also seeks to make a comparison between observation data and model simulation result.

Watershed delineation of the research region was conducted applying ArcHydro(Fig. 8.1) Basins of tributaries were generated by SWAT, based on preprocessed DEM(Fig. 8.2)

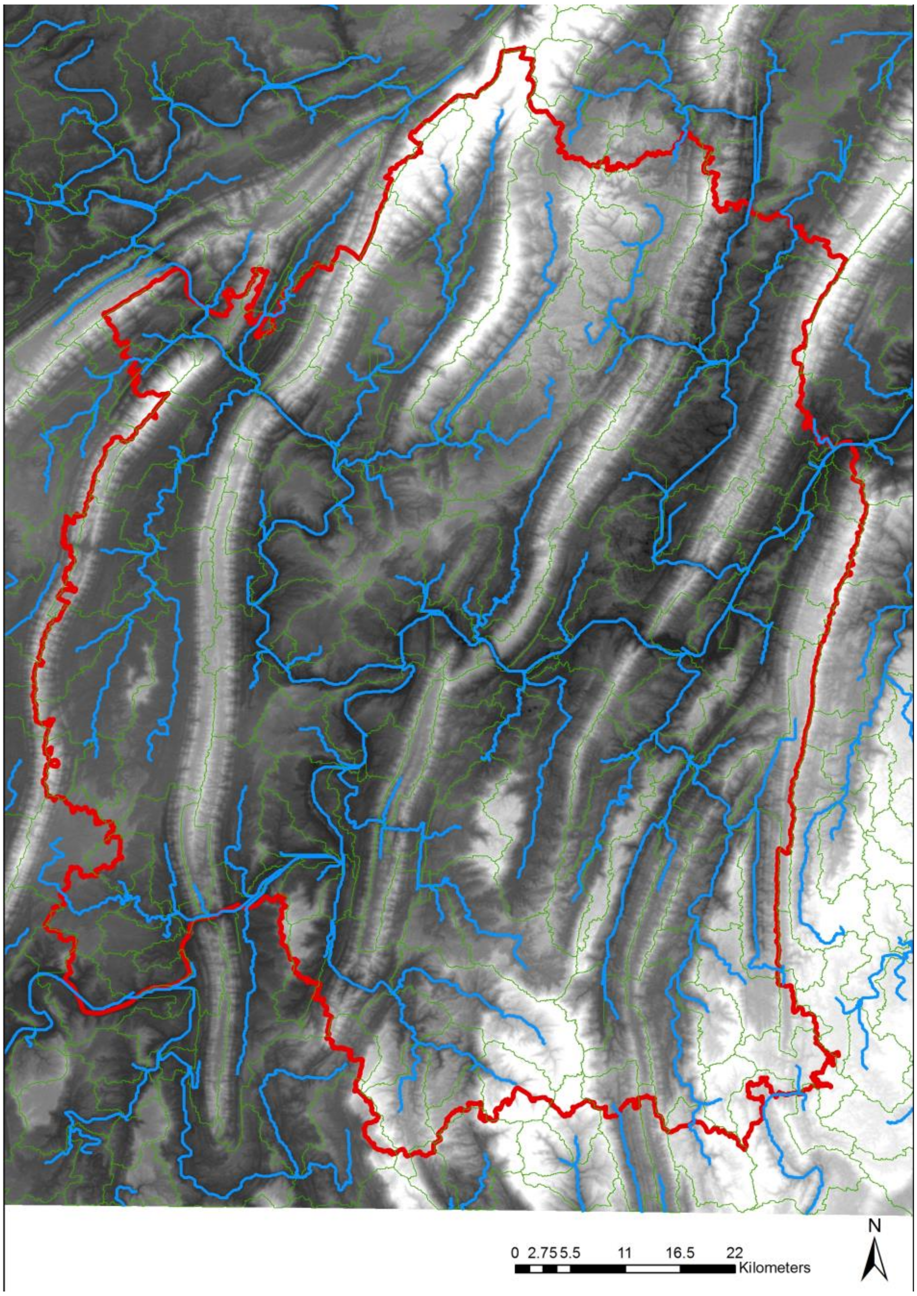

Figure 8.1 Watershed delineation of Central Chongqing in ArcHydro.

Blue lines show the water courses, red line circles the administrative boundary of Central Chongqing.

Figure 8.2 Watershed delineation of tributaries by SWAT.
Blue lines show the rivers, orange lines show the boundary of watersheds

Before setting up the model, input data of land use, slope, and soil type were written in. Maps below show the input layers for Wubu River (Fig 8.3-5). The soil names applied Latin names provided in HWSD V.1.1 (Fig. 8.5; Tab. 8.1, 2), while detailed physical and chemical features of the soil layer is modified manually in the user defined SWAT soil database, to correct the differences between HWSD V.1.1 and American soil taxonomy systems.

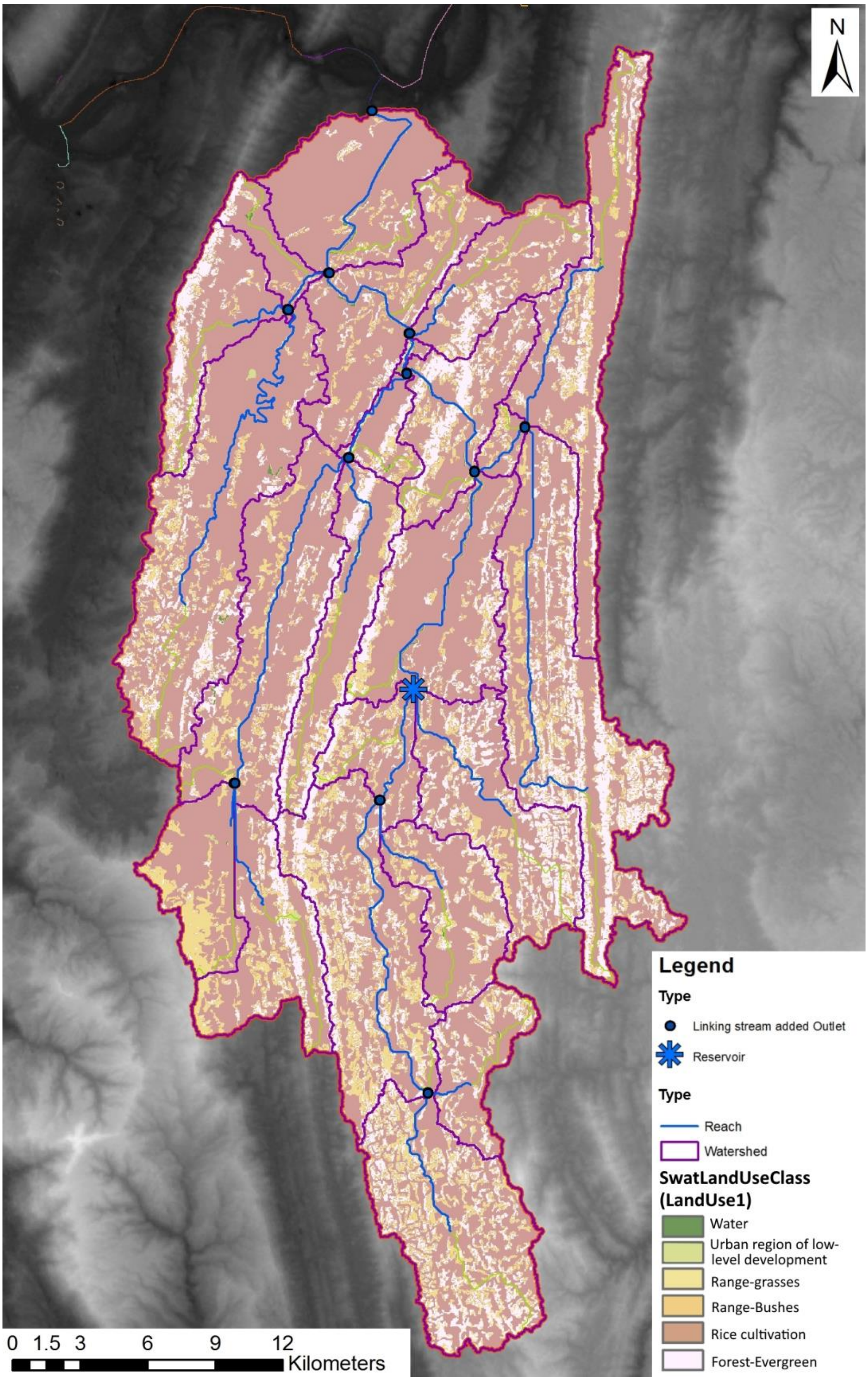

Figure 8.3 Land use type layer of Wubu River watershed.

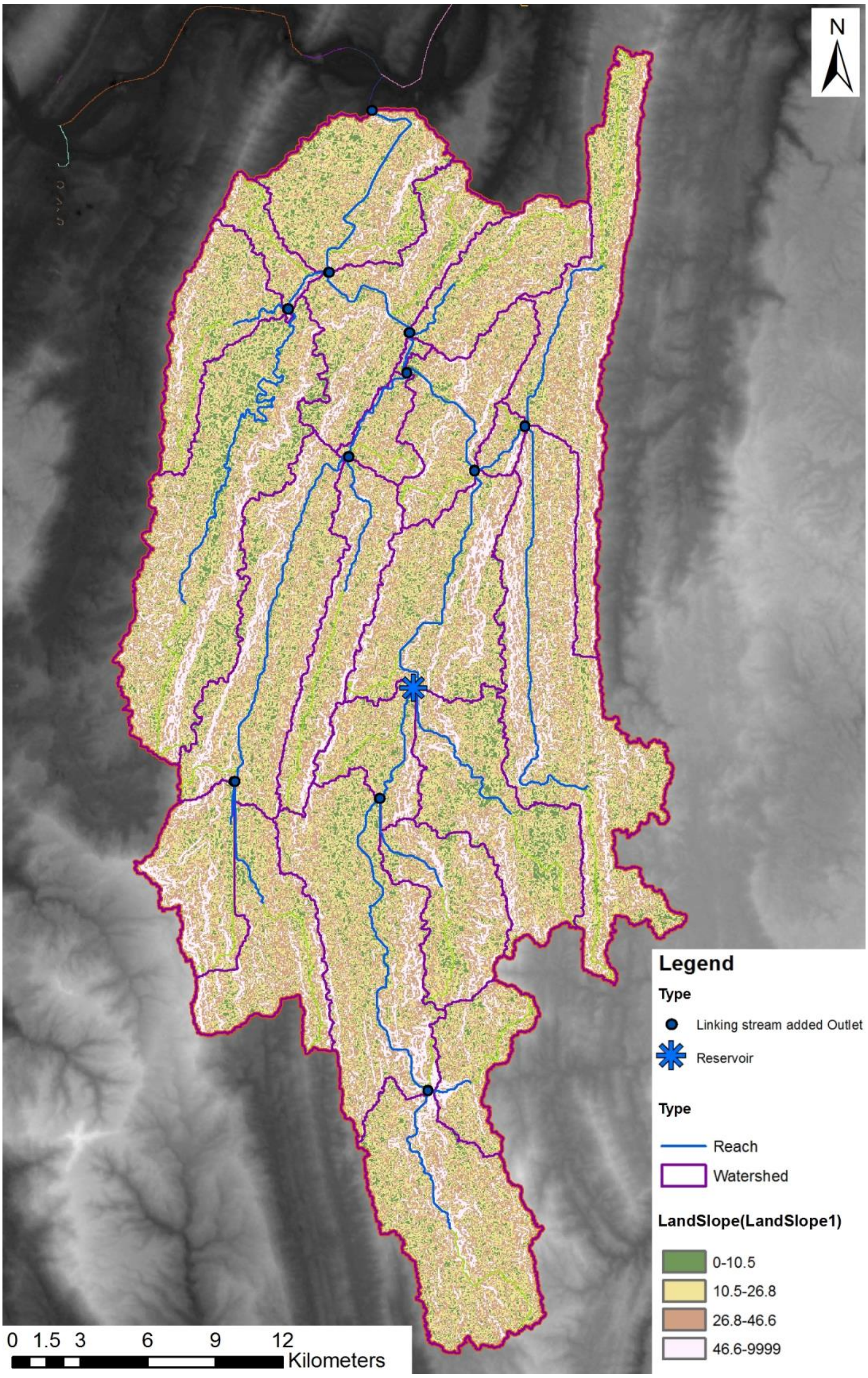

Figure 8.4 Slope classification of Wubu River watershed.
The values of land slope is presented in the unit of degree

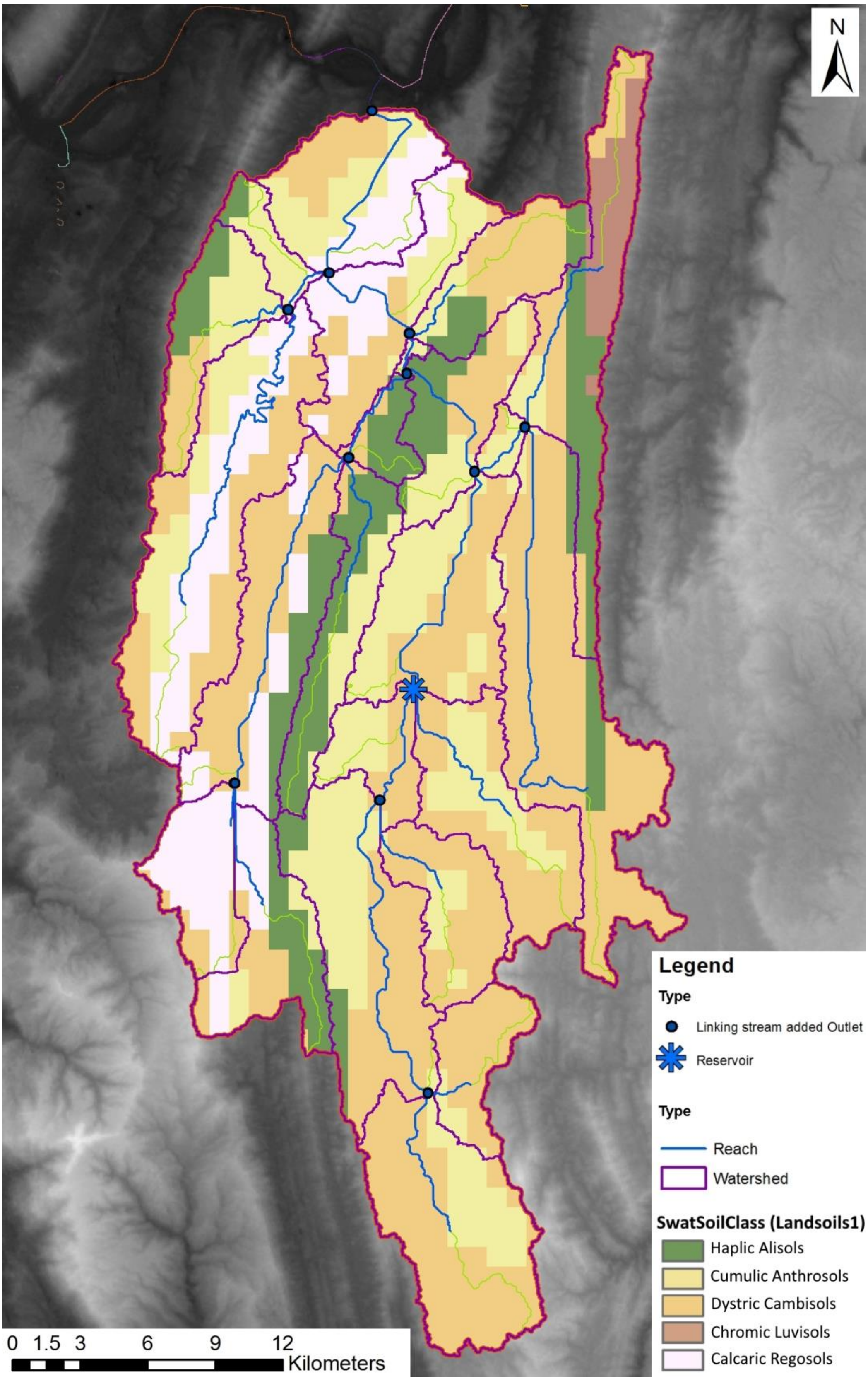

Figure 8.5 Soil type layer of Wubu River watershed.

Abbreviations of soil class are user defined coding, and are not based on international or American soil taxonomy.

Table 8.1 HRU report of Heishuitan River watershed

SWAT model simulation Date: 11/12/2015 12:00:00 AM	Time: 00:00:00		
MULTIPLE HRUs LandUse/Soil/Slope OPTION	THRESHOLDS: 20/10/20 [%]		
Number of HRUs: 172			
Number of Sub-basins: 23			
	Area [ha]	Area[acres}	
Watershed	35875.1229	88649.2224	
LANDUSE:	Area [ha]	Area[acres}	% Wat. Area
Rice --> RICE	24628.8328	60859.0772	68.65
Forest-Evergreen --> FRSE	10877.6480	26879.2122	30.32
Agricultural Land-Generic --> AGRL	368.6421	910.9331	1.03
SOILS:			
Haplic Alisols	10188.5503	25176.4173	28.40
Dystric Cambisols	15785.4284	39006.5829	44.00
Chromic Luvisols	2150.0073	5312.7755	5.99
Cumulic Anthrosols	7751.1369	19153.4468	21.61
SLOPE:			
10.5-26.8	16308.8067	40299.8769	45.46
26.8-46.6	9752.7255	24099.4722	27.19
46.6-9999	3720.1088	9192.5749	10.37
0-10.5	6093.4819	15057.2985	16.99

Table 8.2 HRU report of one of the sub-basin of Heishuitan River

			Area[ha]	Area[acres]	%Wat. Area	%Sub. Area
SUBBASIN#		1	943.2165	2330.7351	2.63	
LANDUSE:						
	Rice -->RICE		705.0042	1742.1007	1.97	74.74
	Forest-Evergreen --> FRSE		238.2123	588.6344	0.66	25.26
SOILS:						
	Haplic Alisols		292.5397	722.8802	0.82	31.02
	Dystric Cambisols		261.9083	647.1884	0.73	27.77
	Chromic Luvisols		388.7686	960.6666	1.08	41.22
SLOPE:						
	10.5-26.8		483.4093	1194.5286	1.35	51.25
	26.8-46.6		411.4586	1016.7349	1.15	43.62
	46.6-9999		48.3486	119.4717	0.13	5.13
HRUs						
1	Rice -->RICE/Haplic Alisols/10.5-26.8		47.8095	118.1396	0.13	5.07
2	Rice -->RICE/Haplic Alisols/26.8-46.6		47.4562	117.2666	0.13	5.03
3	Rice -->RICE/Dystric Cambisols/26.8-46.6		117.3741	290.0374	0.33	12.44
4	Rice -->RICE/Dystric Cambisols/10.5-26.8		144.5341	357.1510	0.40	15.32
5	Rice -->RICE/Chromic Luvisols/26.8-46.6		134.2689	331.7851	0.37	14.24
6	Rice -->RICE/Chromic Luvisols/10.5-26.8		213.5615	527.7211	0.60	22.64

7	Forest-Evergreen --> FRSE/Haplic Alisols/46.6-9999	48.3486	119.4717	0.13	5.13
8	Forest-Evergreen --> FRSE/Haplic Alisols/26.8-46.6	94.5085	233.5352	0.26	10.02
9	Forest-Evergreen --> FRSE/Haplic Alisols/10.5-26.8	54.4170	134.4671	0.15	5.77
10	Forest-Evergreen --> FRSE/Chromic Luvisols/26.8-46.6	17.8510	44.1106	0.05	1.89
11	Forest-Evergreen --> FRSE/Chromic Luvisols/10.5-26.8	23.0872	57.0497	0.06	2.45

As it has been introduced in the research methodology, two approaches are adopted in processing weather datasets. In order to assess the accuracy of simulation, water depth simulation result based on different weather datasets is checked. The Shapingba weather is most adjacent to the watershed of Liangtan River, and most distant to Yulin River. Simulation results of those two watersheds are compared. (Fig. 8.6 & Fig. 8.7)

When water depth of the lowest reach (Sub-basin 4 for Liangtan River, Sub-basin 1 for Wubu River) is arranged in descending order, it is clear to see that the occurrence dates of exceptional large water depth generated from two meteorological datasets, are not consistent with each other. Evidently, the values of water depth also differ applying those two datasets. The average water depths of Liangtan River calculated from CFSR and weather station data are 0.127 and 0.142 m, respectively, while of Wubu River 0.144 and 0.187 m. The gap is the largest in the simulated maximum water level. In the graphs above, top 30 water depths are displayed. The maximum water depth calculated using CFSR dataset is only 56.15% of that applying weather station data. Simulation based on weather station data is further compared with local knowledge and official records, due to its higher accuracy in the aspect of input precipitation data.
As it has been introduced in Chapter 7.2.4, there are few hydrologic monitoring stations for the sub-tributaries. The actual historical water level information could only be obtained from news reports and the locals. To further investigate the simulation output, local news reports published online, and the annual reports of meteorological disasters (Chongqing Meteorology Administration, 2013) are used as important reference. Search key words Chongqing rainstorm/ Chongqing flood in Chinese in google news, the numbers of records for each time period are listed in the table below (Tab. 8.4). There is an increase in the frequency of flood incident reported by the media. It should be noted, however, that the popularization of the internet also contributes to the broadened news cover.

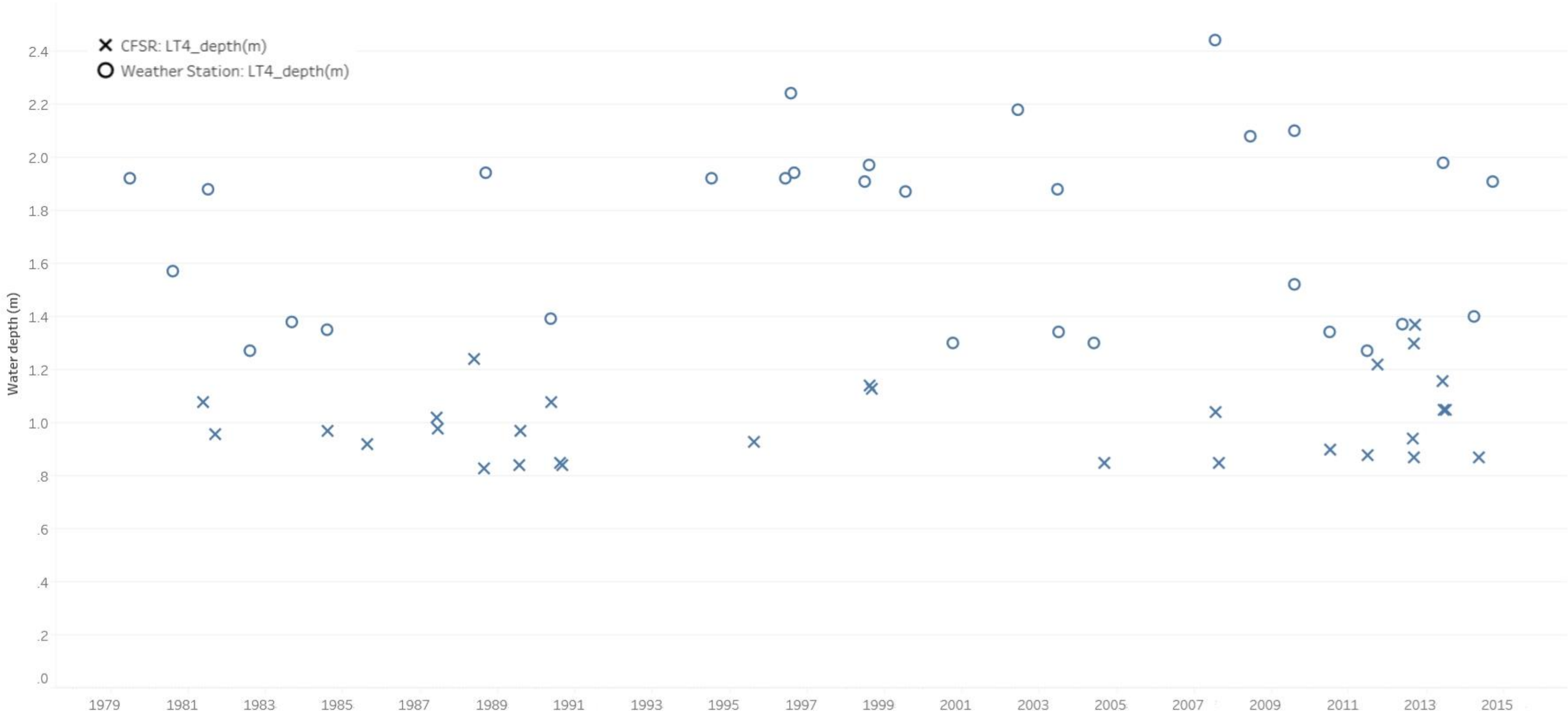

Figure 8.6 Simulations of water depth at No.4 sub-basin of Liangtan River.

Two simulations are launched using CFSR data and Shapingba weather station data, respectively. The graph displays top 30 water depths of each simulation.

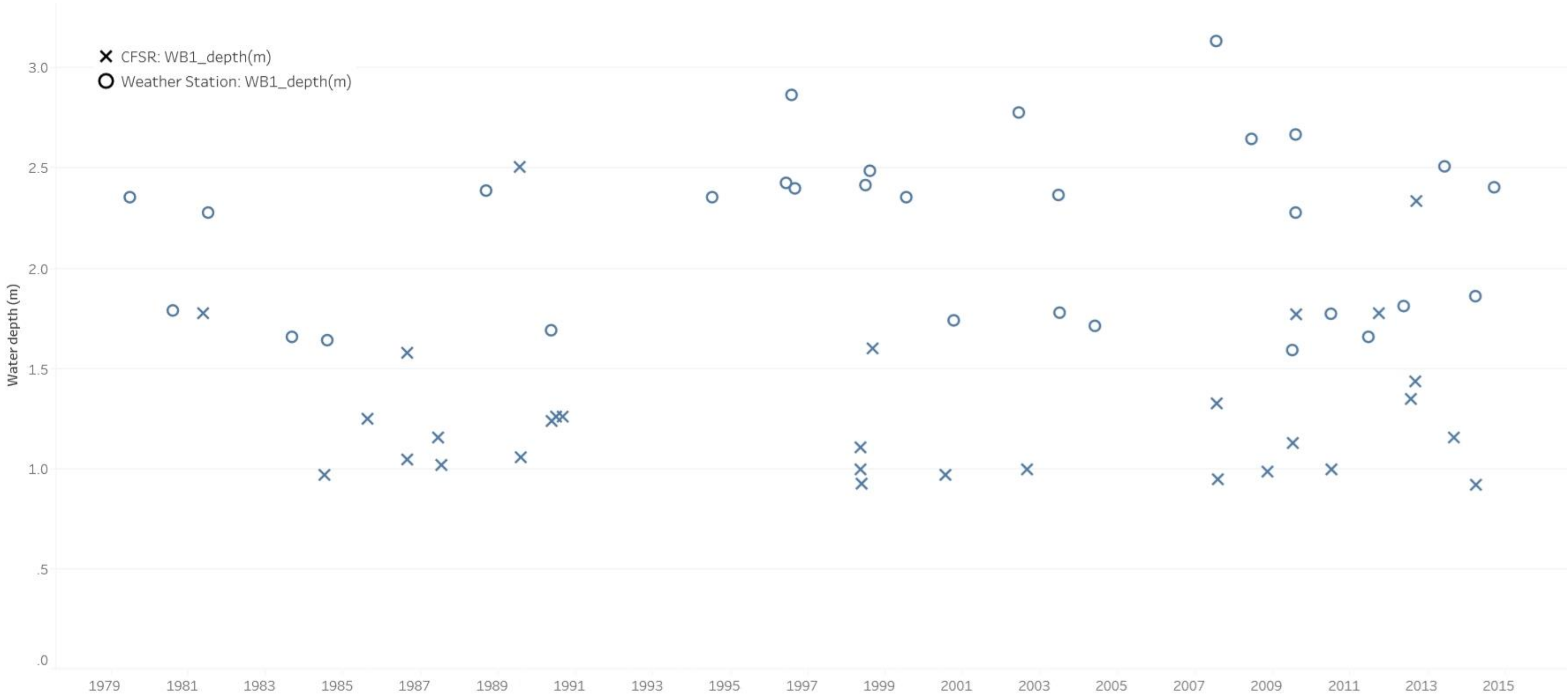

Figure 8.7 Simulations of water depth at No.1 sub-basin of WuBu River.

Two simulations are launched using CFSR data and Shapingba weather station data, respectively. The graph displays top 30 water depths of each simulation.

Table 8.3 Google and Baidu search result about Chongqing rainstorm and flood events.
Each entry could contain more than one news reports. For instance, the entry of 4th Aug. 2009 Chongqing flood includes 478 similar news reports.

Time Period	Number of flood events
Before 31.12.1999	0
1.1 2000-31.12.2004	2
1.1.2005-31.12.2009	33
1.1.2010-31.12.2014	76

Rainstorm, flood and landslide records (since 1980s) from official publications are collected (Tab. 8.5). It should be noted, that there are other records focusing on disasters at local level, not displayed in the google search result, and not included in the annual statistics.

Table 8.4 Published official records of rainstorm, flood and landslide disasters in the research region.
Data source: News reports online; Chongqing meteorological calamity yearbook (2006-2010)

Date	Location	Severity and disaster type
1981/7/6-14	Yangtze River, Jialing River	Most severe flood since 1905
1996/7/21	All tributaries	Flood, severe rainstorm
1998/8/2	Yangtze River, Jialing River, all tributaries	Severe flood, rainstorm and landslide
2002/6/13	Central Chongqing	Severe rainstorm
2003/6/22	Central Chongqing	Severe rainstorm
2004/9/6-7	Yangtze River	Severe flood, rainstorm
2006/5/24	Yubei District	Severe rainstorm
2006/8/18	Ba’nan District	Drought, Wubu River dried up
2007/6/16	Yubei District	Severe rainstorm
2007/7/6	Huaying Village, Yubei District	Landslide
2007/7/17-18	Major tributaries	Extreme heavy rainstorm since 1996, flood, landslide
2008/6/15	Shichuan Town, Yubei District	Rainstorm
2009/8/2-5	Jialing River, small tributaries	Rainstorm, flood and landslide
2010/6/18-20	Ba’nan District	Flood, rainstorm
2010/7/4-5	Shapingba District	Severe rainstorm
2010/7/18-20	Yangtze River, Jialing River	Flood

2012/5/21	Ba'nan District	Flood, rainstorm
2012/7/22-25	Yangtze River	Most severe flood since 1998
2013/6/8-9	Central Chongqing	Flood, heavy rainstorm
2014/9/13	Yulin River	Flood
2014/9/18-19	Yangtze River, Jialing River	Flood, rainstorm

Considering the runoff accumulation time for storm events, 2 days deviation for the occurrence of large water depth is regarded acceptable. Nevertheless, the date of flood/ landslide news report show no obvious coherence with the simulation result based on CFSR dataset. On the other hand, simulation result based on weather station records has more relevance to the recorded flood incidents. Especially for the severe floods and landslides after the year 2005, when more records of disasters are published online and in statistic yearbooks, simulation result of top 50 water depth date includes all recorded floods and landslides during the same time period.

Simulation result can be checked by a built-in program. This program reads the output of a SWAT model, and provides suggestions to inspect potential errors in the result. The warnings show the abnormality of simulation results compared with standard settings, but do not necessarily meaning that the results are unreliable. Fig. 8.8 shows the error check result of Wubu River. For other basins, the error check program gave identical warnings. The warning reminds user that the first year of simulation (year 1979) should be regarded as model warmup. From 1980-1984, the results become more stable and reliable. The warning also suggests that the water yield of the basin might be excessive, as the annual precipitation reaches 1107.8 mm. According to data and statistics from weather stations, annual precipitation in the research region ranges from 1,000 to 1,350 mm, thus the water yield is in the normal range. As no other warnings are provided by the error checker, the simulation results can be regarded as reliable in the first place.

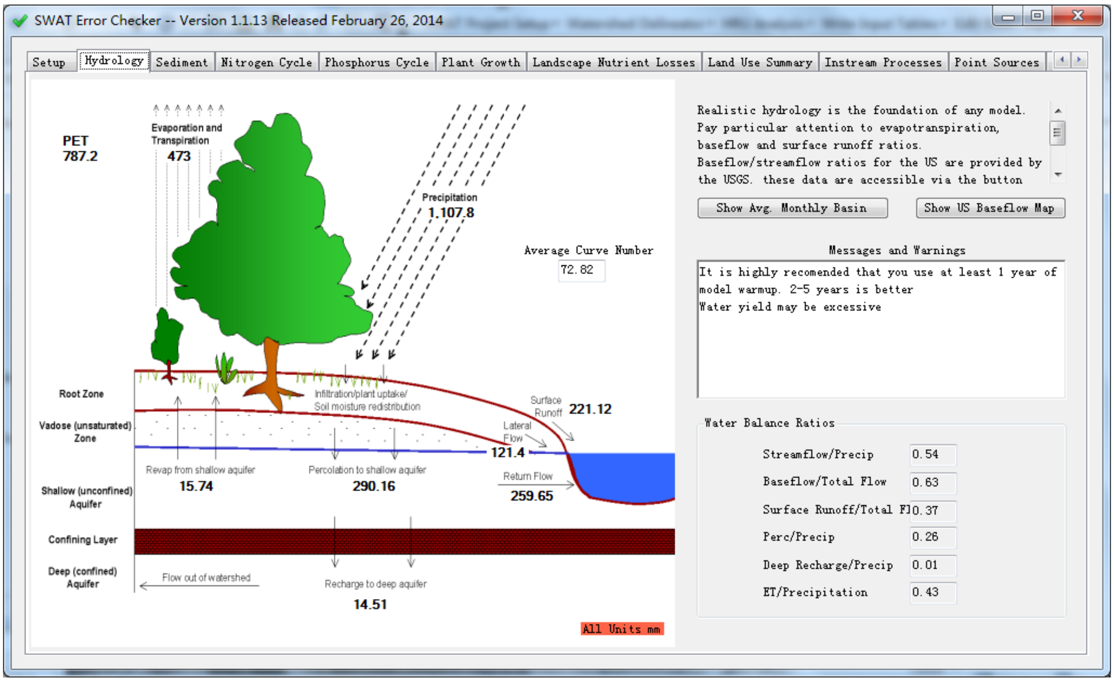

Figure 8.8 Simulation result check of Wubu River with built-in program

Above shows the simulation result, based on data available and applied mainstream hydrological model. Due to the lack of calibration, comparison between simulation result, and the information collected from local residents and officially released disaster records is made, in order to assess the validity of them.

For the settlements which have been flooded, respondents were asked about the date of flood event. News reports and yearbooks are generally trust worthy in the recording of event time, so they are used as an important reference for checking the correctness of local resident's answers. 95.2% of all respondents remembered the recent flood or landslide events (in 2012 or 2014 for different settlements) which took place in their living settlement or nearby settlements. Among them, 36.7% gave the precise date of the flood, and recalled the water level and affected area. Over 90% of respondents were able to provide information about more than one flood and landslide events, including the date of the incident, the damage caused, and their economic losses during the event, etc. (Fig. 8.9). The precision about event date varies greatly. The majority (72%) of the respondents gave obscure answers. Instead of the exact date of event, they remembered only the month or season of the year in which the flood or landslide happened. Some referred merely to the decade, but such answers mainly indicate the flood in 1981. There are 3 respondents who misremembered the year to be 1989. But still, for the events in the 1980s and 1990s, 87% of the respondents gave correct month and year, if not the precise date. This performance is understandable, since the event happened long time ago, local people were left with only vague impression. The relevance between the precision of local knowledge and the respondent's life experience is obvious. Those whose family or relatives have directly suffered from the disastrous events generally have a more vivid recollection, so as the respondents who live in flooded settlements but they themselves were not directly affected.

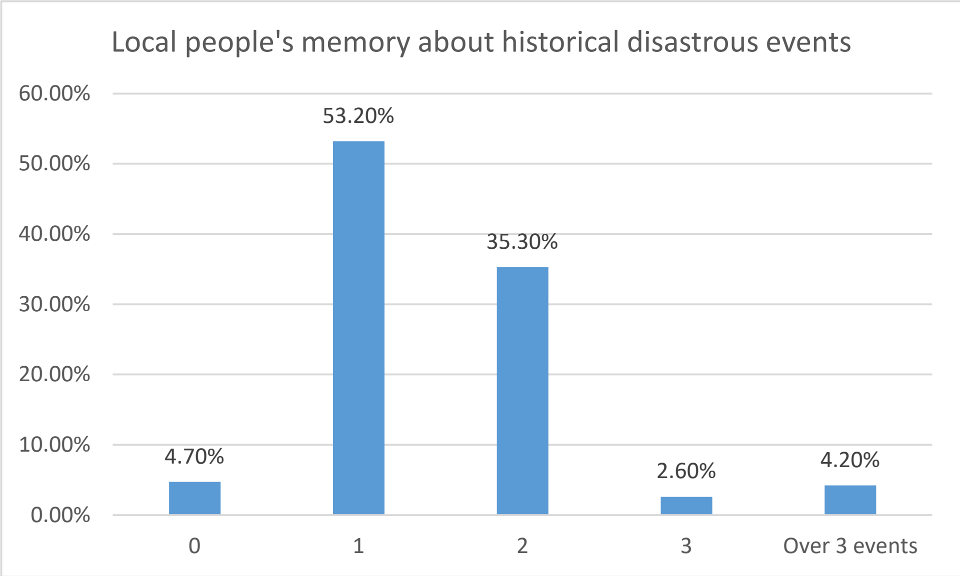

Figure 8.9 Local people's memory about historical disastrous events.

Columns show the percentage of respondents who give no information, and information about 1, 2, 3, over 3 events, respectively.

This research then chooses the answers which contain precise dates to make comparison with recorded references. The answer is perceived to be incorrect, when it is not only different from available records, but also from other interviewee's narration who live in the same settlement. A total of 92 answers are in accordance with official records, while 2 of the answers are obviously wrong. The interviewers mistakenly claimed that the flood event happened on 1st, Sept., 2004, instead of 6th -7th, Sept., 2004. The other 12 answers which give the exact date of flood or landslide events are proved to be correct, as they fall in accordance with the observation of other residents in the settlement. Those answers indicate two small scale landslides and one sub-tributary flood, which could not be found in official records and from the mass media, but confirmed by other residents. Additionally, when asked about flood and landslide events which affected their daily lives, some respondents' first reaction falls into two extremes. They gave quick answers such as "there's no flood/landslide at all", or "such flood and landslide happen almost every year". The events which people would like to report to the interviewer, usually completely destroyed several houses or caused fatality. The local people have been accustomed to small scale floods and landslides. A large proportion of respondents do not regard such events as "unsettling", even flood water washes over their floors, or less than a half to one Mu of agricultural field is affected. They perceive such incidents "ordinary", though a considerable amount of monetary costs are paid for remedy. It also proves that, generally a rural system is resilient enough against this level of natural hazards. According to the residents, it is quite common that such events happen once every two to three years. The water level and susceptible area of such events are also kept in record with help of map and portable GPS by the researcher. Details about the water level records will be presented in the following section.

Model simulation results provide much more presumed extreme high water level event dates than the local residents' memories and official records. The graphs below show the comparison between the top 30 peak water level dates generated by model based on weather station data, and available official records. Since in few cases the official record referred to the water level, the value of water depth is excluded from the comparison. Averagely, 10.72 out of 21 official recorded dates fall in complete accordance with simulation results for all simulated tributaries, 2 or 3 records have a deviation within one week (Fig. 8.10). For official records and residents' recollections alike, little information is available about the flood events in the 1980's, while the simulation result suggests 5 such events. For the decade of 1990's, two records of actual events are found, while the simulation result shows 8-9 events, including the two which the official records confirmed.

The dates of extreme water level simulated by model are listed in descending sequence. We see that the first several dates fall in accordance with reality. There are 8 floods which actually happened, that are not included in the computed top 30 extreme water level events. Possibility exists, as the official record documents less severe flood events in the recent years, so that those events are not in the top 30 list. A single intense rainfall process or a momentary water level raise are not the only triggering factors indicating a flood. As it is presented in the official record, several flood events lasted for days, due to consecutive strong precipitation or excessive floodwater coming from the upstream. From the perspective of the computing method, there are several reasons which contribute to the failure of simulating consecutive high water level dates. The complexity of the actual hydrological process adds to the difficulty in simulating the flow process. For instance, Tongjing Town was flooded, as the flood water from the mainstream Yulin River flowed backwards to its sub-tributary (Fig.8.11). It is an unpredictable situation for the SWAT model, as the model operates upon a fixed flow direction initialization, thus does not have an operation method for a backflow. Other reasons could be the inaccurate precipitation data from the weather station, and the incomplete water management data of the upstream. The lack of calibration would also leads to the failure of identifying the consecutive flood days. Without calibration, the model would be less sensitive to certain influential factors, leading to an under-estimated accumulated water amount, and thus an unfavorable performance in inspecting consecutive high water level events.

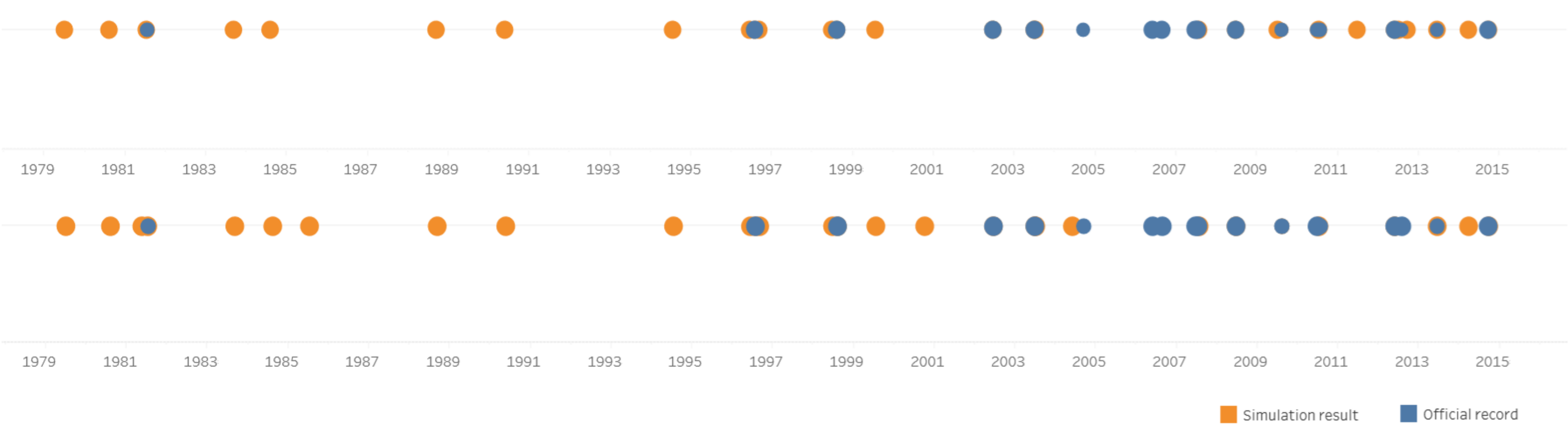

Figure 8.10 Extreme water depths compared with official flood event records.

Above shows the comparison at No.7 sub-basin of Bibei River, below at No.6 sub-basin of Huaxi River.

Figure 8.11 Illustration of river flow direction and the backflow flood affected area in Tongjing Town.

In order to check if the unrecorded local level floods, which the local people reported in the interview, exist or not, this research chose additional check points in the model on corresponding water courses (in Longxing Town along Yulin River and Nanquan Neighbourhood along Huaxi River). Unfortunately no significate water level raise on those dates (29th May, 2012 and 24th June, 2014) are confirmed by the simulation results. Judging from the depiction provided by interviewees, those two floods were caused by long lasting rainfall, and affected a relatively small area in the settlement, say, the farmland of less than 3 households. If the flood of this scale is to be identified by the model, the precision of the input data must be significantly improved.

Above discussed about the accuracy of event date indicated by local knowledge and modelling, the next focus will be put on the accuracy of extreme water level value. All respondents were asked about their observation of maximum water level of nearby water courses. As the table shows, the maximum water depth suggested by the model generally ranges from 1.8m to 2.6m in all water courses, from 1979 to 2014. The maximum water depth in all simulation result is 3.49m in downstream, Yulin River, 9th June, 2013. Field research tracked two to three simulation points in each tributary, asked the local residents about the highest water level they could remember, as well as searched for water level mark or other convincible evidence.

Figure 8.12 Official water level mark on the bankside of Heishuitan River.
The two buildings in the photo are Buddhist temples.

Official water level mark is rarely observed in rural settlement. Exceptions are in settlements with relatively large population density, and once affected by disastrous flood events. In the photo above (Fig.8.12), the mark on a religious building in Pianyan Town shows the historical highest water level. That flood event happened in 1981, and the water depth in Heishuitan River was 6m, twice as much as the water depth calculated by model. Likewise, for the other 18 monitor points, simulation result shows much lower water level than reality (Fig.8.13).

In most of the cases, local knowledge about the maximum water depth is close to official record available. There are, however, two monitor points (Chengjiang and Dongquan) at which the maximum water depth recorded in literature significantly surpass that in local knowledge. The reason is there were extreme flood events hundreds of years ago in Qing or Ming Dynasty. Though literature and water level marks by the bank reveal the maximum water level, local people are not aware about it. Instead of the extreme floods happened long time ago, they care more about floods with a reoccurrence of less than 4-5 decades.

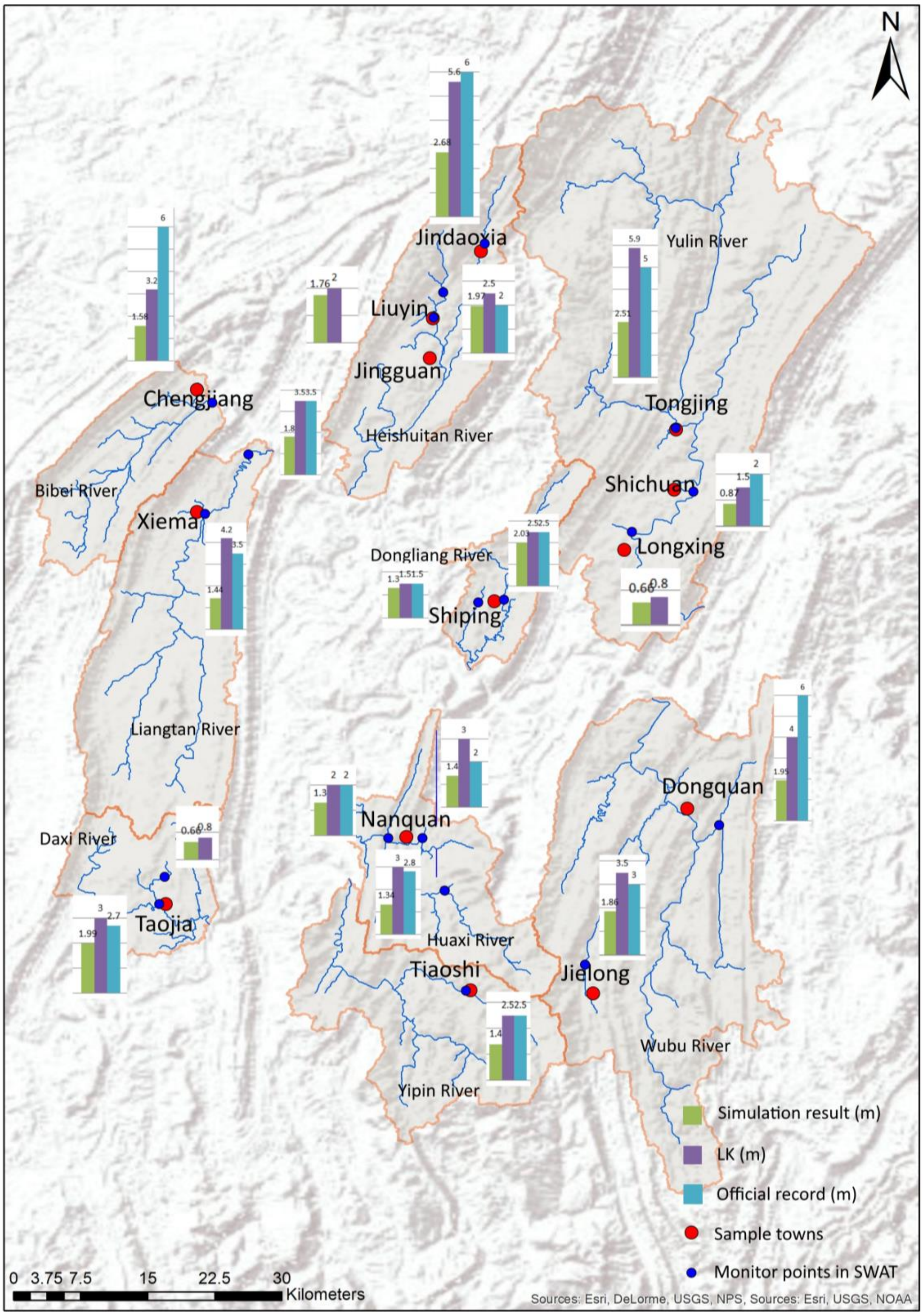

Figure 8.13 Comparison of water level information at SWAT monitoring points

There are several reasons which lead to the imperfectness of water depth simulation. The most important factor is the lack of model calibration. If a complete dataset of the actual water level was available, the model could be calibrated by adjusting distribution of weight for input parameters, thus the overall water depths would increase and fall in accordance with the reality. In some other situations, where the gap between the simulation and reality is large, the existence of underground river system would be an influential factor. For instance, in Dongquan Town center, the underground river comes up and joins a tributary of Wubu River. SWAT model does not have subterranean river module, thus the water level would be underestimated by simulation model.

Another deficiency of the model is also caused by the currently limited data resource. Soil layer condition is one of the essential parameters in water process simulation, while the HWSD soil data available is at the scale of 1:1,000,000 for the region of China. This data precision is not ideal for SWAT modelling, especially for the small scale sub tributary runoff simulation. Thus the simulation result provides little reference for lower hierarchy water courses. In comparison, the local people are very confident about the water level of the water courses within their residential area and farmlands, whichever hierarchy of the tributary they belong to. The residents easily recall the highest water level in an ordinary year, and estimate water depth with help of some reference objects (for instance, a coarsely built stone bridge, or a farmland parcel on the nearby slope which would be frequently flooded). Local people observe some specific farmlands located on temporary water courses or the natural slopes by the water course, to help assess the severity of flood and landslides. Mustard and oil rape are planted on such fields prone to be affected by natural hazards, in order to make full use of the land resource. The residents are easily able to point out the water level in a previous flood event with such fields as comparators. On the other side, though those specific vegetable fields are flooded more frequently than the majority of the ordinary farmlands, there will be little economic loss, as the crops are generally of low economic value and the yield mainly supplies the household itself. After being flooded, the top soil could regain its fertility thanks to the rotten vegetation. This introduces the issue of system recover ability, which will be discussed in Chapter 8.2.

In all, the majority of the local residents remember at least one flood event which happened in or near their settlements. Their perception shows a satisfying accuracy, both on the date of the natural hazard incidents, and the detailed circumstances, including the water level, the cause of formation of the natural hazards they deduced, etc. The local residents are also able to provide information about less-known local events, which would facilitate the data collection work by planners or model builders. On the other hand, SWAT simulation result provides much more incidents with extreme water level than those was officially recorded or remembered by the local residents. The accuracy of simulation is acceptable, compared with records available. However, since the available data cannot support calibration for sub-tributaries in the research region, the accuracy of water level simulation requires improvement. Local knowledge and the model simulation reveal different aspects of the previous natural hazard frequency and severity. To acquire information about the history of disaster, both local knowledge and computer modelling are worth consulting to.

8.2 Local Knowledge Instructed Land Uses and Their Impact on Resilience

In this research, resilience is evaluated from three aspects, namely exposure, sensitivity and the recover ability, as it has been introduced in the theoretical background. System's exposure to natural hazards is closely related with the characteristics of natural hazards. It is also determined by the interrelationship between the settlement system and the disturbance. While sensitivity and recover abilities are mainly affected by the intrinsic characteristics of the system itself. There are some overlaps of the factors deciding exposure, sensitivity and recover. Details will be explained in the following paragraphs.

Start with an analysis of the occurrence of natural hazards, in this research specifically, flood and landslide. Floods are subdivided into two categories, the flash flood triggered by intensive local precipitation, and drastic water level raise in pass-by major tributaries. This research intentionally chooses sample settlements, which have been affected by natural hazards. The majority of the sample sites are mentioned in the available disaster records and reports. In all, 90% of respondents were affected by natural hazards to various extents. According to the survey, 42.9% of all participants claimed that flood or landslide have changed their normal lives, 48.1% asserted that those events have imposed significant negative influences on their livings. Among them, 70.5% live in villages, while the others live in town centers. It demonstrates that the sample settlements have the probability to be affected by natural hazards, and it is meaningful to evaluate their resilience.

The exposure of a settlement system is determined by the frequency of natural hazard occurrence on site, and the geographical adjacency between the settlement and the site of historical disasters. It can be studied at two scales, to investigate the exposure of a settlement as a whole, and of certain land parcels within a settlement. Maps drawn by the local people during fieldwork are collected and reorganized (Fig.8.14). Valuable information is digitalized.

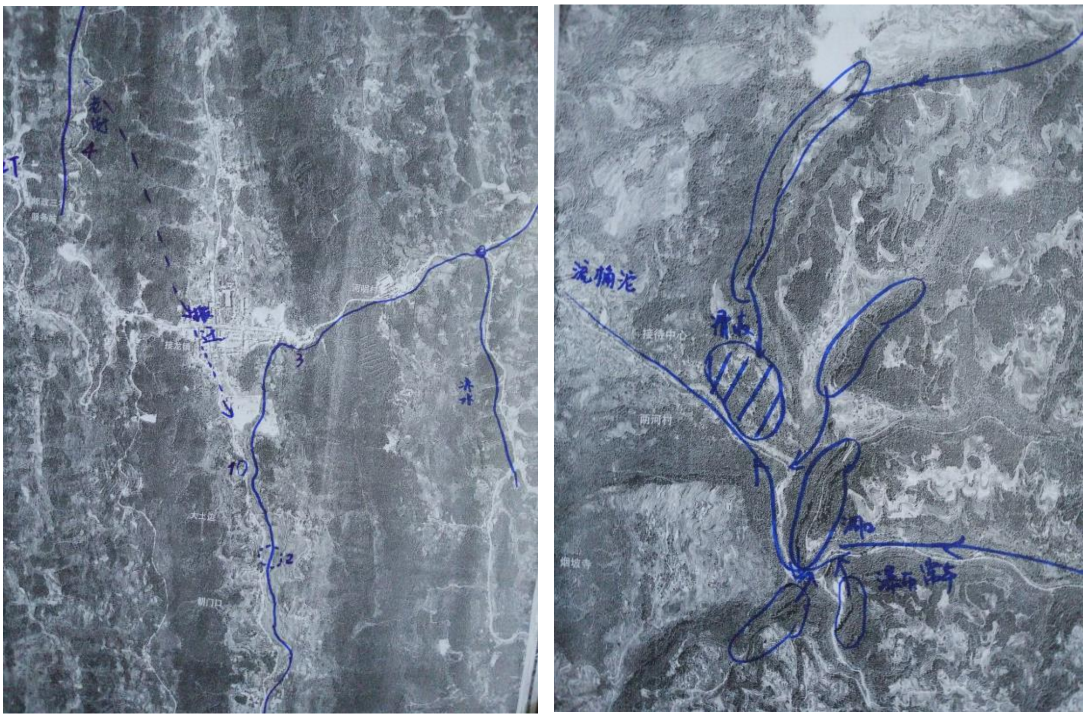

Figure 8.14 Maps marked by the local people

The left map shows the underground water course (dash line) in Jielong Town; right circles out landslide prone area in Lianghe Village

By mentioning exposure, the frequency of natural hazards happening on site is the essential issue. One inducing factor of flood and landslide is the pattern of precipitation. From the geographical perspective, all sample settlements in the research region share the similar meteorological condition, as they all distributed in southeast of Sichuan Basin. Although there are differences in the detailed local weather condition, the general status remains the same, for instance, the length of continuous precipitation process, and the maximum precipitation intensity. Thus the meteorological factor assigns all settlement identical value in exposure. Hydrological and geographical setting has more significance in deciding system exposure. From the investigation, specific hydrological factors are identified which generally indicate high exposure to natural hazards. High gradient (over 25°) of irrigation/drainage water course, long flow path (over 1-1.5km) before the runoff enters a settlement system are the common hydrological features of settlement systems, which make a system susceptible to floods and landslides. Simulation results show the trend, that the flow velocity is higher in the basin with larger average gradient (Fig.8.15). Local knowledge agrees with this result.

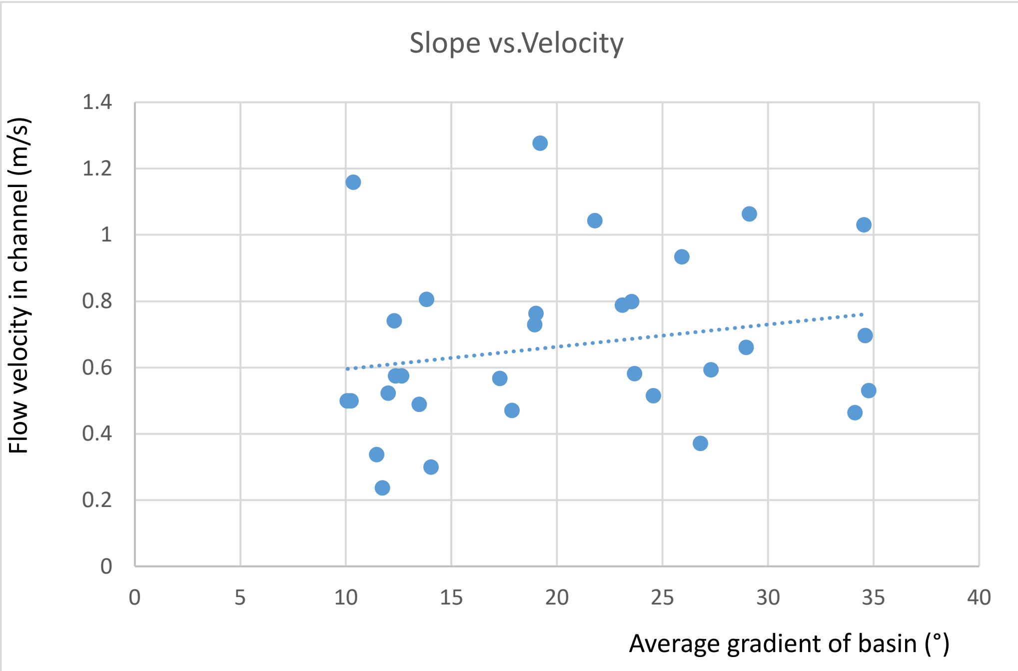

Figure 8.15 The relationship between average slope and annual average flow velocity in channel
Data presented is the simulation result of Bibeihe River, 2013

The adjacency of a settlement system to a water course has predominant significance in evaluating the exposure of system. As it is intentionally decided, all sample settlements selected for this research locate near water courses, which mean they all have the possibility to be flooded due to water level raise of the rivers. Aside from the flood caused by water level raise in rivers, flash floods caused by excessive surface runoff on slopes are also common in the sample settlements. In some other situations, landslide accompanies flash flood and river flood. The cause of flood varies, and for individual settlements, there is a tendency that they are more susceptible to certain type of flood. This cause of the tendency is also related with the factor of geographical location.

The town centers are more susceptible to the flood in large pass-by tributaries. 9 of all investigated 14 town centers were affected by water level raises in Jialing River or primary tributaries of Yangtze River. Jielong Town (previous location) is the only one affected by secondary tributary. Xiema Town is the most urbanized towns among all samples, problems reported by the interviewees are more related to road waterlogging, rather than the river flood. Shichuan, Shiping and Taojia town centers are not affected by any kind of flood. Except from Jielong and Shiping Town, all town centers locate along the bank of large tributaries. Catchment area of those main tributaries ranges from 358km² to 1235km². The largest catchment locates in Yulin River basin, with the maximum average daily out flow of 1818 m³/s. When heavy rain storm takes place in the region, large catchment accumulates an excessive amount of rainwater, which would make water level to rise abruptly. Thus the town centers by the large tributaries are more exposed to river floods.

Both the primary tributary flood and flash flood in low hierarchy water courses occur in investigated villages and informal clusters. The type of flood is determined by the geographical location of those settlements. Even in the same basin of tributary, settlements are affected by different types of floods due to their locations. For instance, entire Pianyan Town was flooded due to the river flood of Heishuitan River, while in the same basin, Yongan Village constantly suffers from the flash flood from the tributary of Heishuitan River, which originates from Oujia Mountain approximately 1.5 km to its east (Fig.8.16).

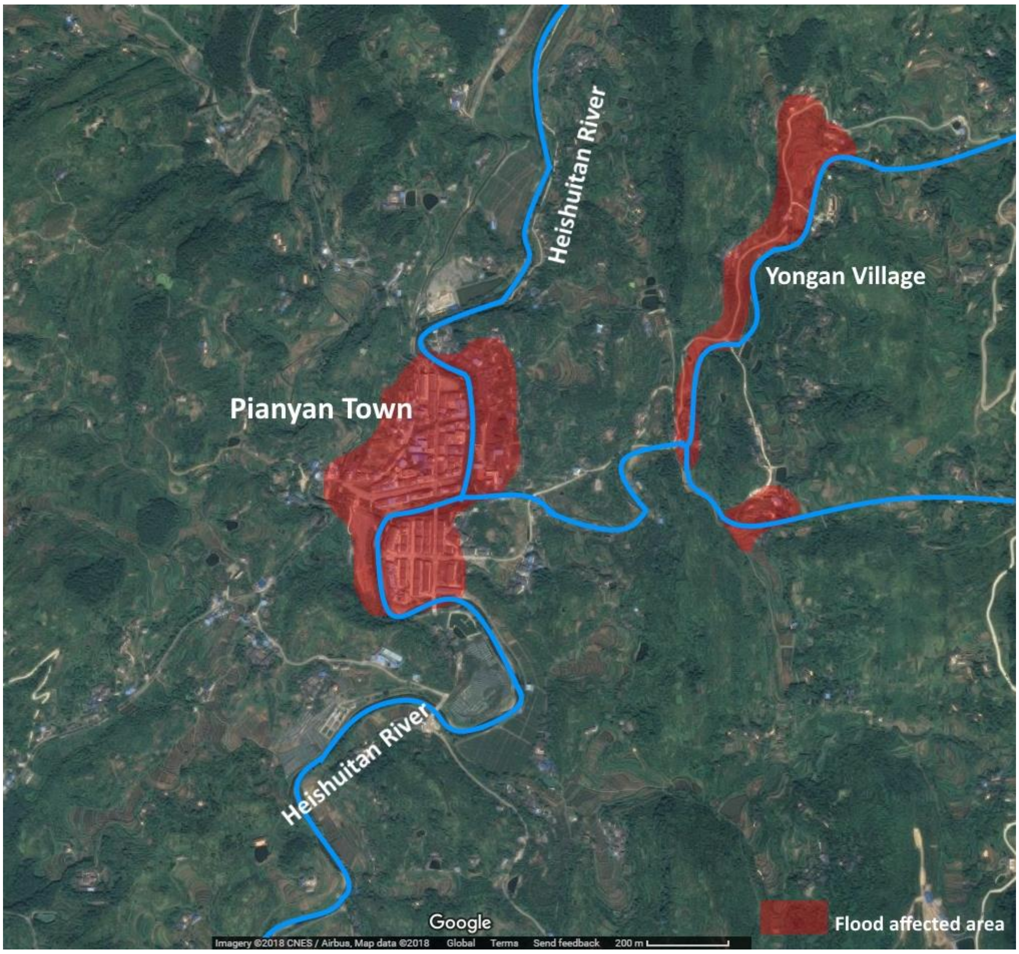

Figure 8.16 Adjacent area affected by different type of flood.
Map source © Google map 2018

Flash floods in mountainous area are sometimes accompanied by landslides. Flash floods and landslides have occurred in some of the sample settlements together. The landslides in Xingshu, Chongqiao and Yong'an Village which happened in the recent years are triggered by long-lasting precipitation.

The frequency of flood and landslide is related with the location of settlements, while the location of settlement is a determinant of their level of development. Villages and residential clusters are less developed than the town centers, partially because of their disadvantaged geographical locations. Most of the under-developed settlements locate in hilly area, or along the bank of low hierarchy water courses, which hinders water way transportation. For those settlements, the occurrence of flash flood and landslides is much more frequent than town centers. On the other hand, floods caused by pass-by river water level raise are not so common in villages and informal clusters, but frequently seen in town centers.

System's exposure to landslides shares the similar features with flash flood. In the research region, landslide is most frequently triggered by flash flood, but apparently, not all flash flood leads to landslides. The causation of landslide is generally considered complicated, thus landslide is often conceived unpredictable. From the perspective of system resilience, there are some factors which undoubtedly determine system's exposure to landslides. The most decisive factors are the frequency and intensity of seismic activities. Seismic activities are considered to be the major reason which would significantly increase the risk of landslides. This natural process could directly fracture the bedrock, and the fluctuation loosens the soil. Bedrock and soil layers fluctuate, making the soil easily slide when triggered by either internal or external forces. However, till today, it is still difficult to predict and identify the exact place where such small scale earthquakes would happen. But it has been proved, that the Huaying mountain ridge is a belt of seismic activities. Sample settlements of Shichuan, Longxing and Tongjing Town are located in this belt. A 5.2 magnitude earthquake struck in the area of Tongjing Town in 1989. Most of the recent and intense earthquakes recorded took place in this region. Others are rather indistinct earthquake tremors, and no sequential landslides are recorded. Except from the settlements on the earthquake belt, other settlements share a similar but low frequency of seismic activities. Likewise, the meteorological factor of long-lasting precipitation in the research region also parent consonant exposure among all sample settlements. Most significant distinctions are brought by human activities. For instance, coal mining and the excavation of rock as construction material would completely change the physical structure of the bedrock and soil layers. This human induced disturbance would directly prompt cave in and small scale landslides. Nowadays, such construction work is under rigid inspection, so this type of landslides has not been recorded for years in the research region.

We can say that the geographical location of a settlement is the choice of its inhabitants, and the morphology of a settlement is decided by inhabitants' collective intelligence. But those principles about how a settlement grows, steered by human activities, are of universal relevance. The uniqueness of the local knowledge of the research region lies in the specific land use strategies, say, a combination of terrace rice farmland, irrigation system and various kinds of forest land. In this research, land cover and land use maps are available as input for SWAT model. The land use pattern is stored in HRU dataset, and can be easily calculated for each sample settlements. For each settlement, we can easily categorize the settlements by their major land use type. Land uses types in the region include rice-planting, corn/vegetable planting, fruit/landscape trees planting, and residential/commercial area. The combination of land use formulates the profile of each settlement, and also affects system's resilience. As the dominant land use strategy decides a settlement's resilience to a large extent, it is essential to investigate the contribution to system resilience of each land use type. Except from the dominant land use strategy of a settlement, there are still excessive variables, for instance, the proportion of each land use types, and the geographical location of each type of land parcels. Considering the complexity, this research first gives an overall investigation of each land use types, and then analysis of combined land use strategies. Concrete analysis of specific situations shall be made, so as to tell the influences of different land use strategies on typical settlement systems.

As it is with the settlement as a whole, the geographical distribution of each land use type has rules to follow. The decision of the local people, about how they manage their productive land, makes a big difference in system's exposure to flood risks. Compared with land covered by natural forest and Fengshui forest, farmlands are generally more exposed to the danger of being flash flooded. One reason is their location. The high geographical adjacency to a drainage system (natural or artificial) brings wet terrace farmland the highest exposure to potential danger of flood, as the once the drainage system fail to hold the rush of the current, those wet terrace fields would be flashed in a short time. The other reason has overlapping with system sensitivity and will be elaborated in the sensitivity assessment. For natural forest and Fengshui forest, the soil is able to absorb more rainwater than cultivated lands. That is to say, as surface runoff is larger on cultivated lands, these land parcels are more exposed to the danger of flash flood. From another perspective, dry farmlands locate either on the few flat plains in the research region or on steep slopes, where rice could not grow. Those on steep slopes have a high exposure to flash flood, as the surface runoff on slopes would flash over the farmland, before the flash water reaches the drainage ditches.

Above explained how geographical features and the land use pattern of a settlement system would change system exposure. In social-economic dimension, there are other indicators of system exposure to natural hazards. With the reference of the framework proposed by IPCC, which is applied to evaluate system vulnerability, indicators of exposure shall include population density, capital stock per thousand square km, and the percentage of arable land and permanent crops in the whole area. The choice of indicators are comprehensible, as they represent how many residents, capital stock, and land resources are at stake of a flood or landslide event, once the event takes place in a settlement.

Natural hazard imposes threats in a confined spatial range. The population density and capital stock accumulation in a system have direct impact on system exposure, so as the frequency of human activities in a certain place. Though in the rural region, farmers would spend a long period of time working in the field away from their residential places, or travel to nearby markets for commercial activities, they are tightly bonded to the settlement system they belong to. The registered population density of a settlement precisely represents how many people are exposed to the hazards in the settlement system. There is, however, an unneglectable relationship between the type of agricultural production and the geographical distribution of residents' daily activities. For different category of crop and planting strategy, the intensity of land management differs, and hence the distance between the residential area and the productive lands. There are crops which require relatively intensive farm work, for instance rice, oil rape, and a number of herbal landscape plants. Every farmer works on a relatively small area of land. Their residential housings are close to each other (Fig.8.17). On the contrary, orchards are originally set up in the area where it is difficult to cultivate annual crops, due to the limited area of flat land and infertile topsoil. Unlike the herbal crops, fruit trees do not require intensive management. Residents have more choices with their living places. Though each household processes much larger area of land than rice farmers, the households tend to organize small clusters on their preferred land parcel, rather than alienate each other and stick to one's own land property. For experimental orchards, workers claim that even if intensive maintenance is required for specific growth stages, they live close to the orchard only temporarily, rather than permanently. There are temporary housings built close to the orchard, to store farming tools and for the workers to take a short-time break. Without the restraints of constant orchard maintenance, many workers even live and work in town centers for the most time of the year. As people live away from the farmlands, they become less exposed to potential flood and landslides. There are cases, in which the orchards were flooded due to the water level raise of nearby rivers, but the farmers' residential area in the settlement was unaffected, as the residential area lay far from the orchard. Compared the settlements which launch labor-intensive production work, with those relay on less intensive maintenance work, this research presumes that the labor-intensive farmland management indicate higher exposure of a settlement system.

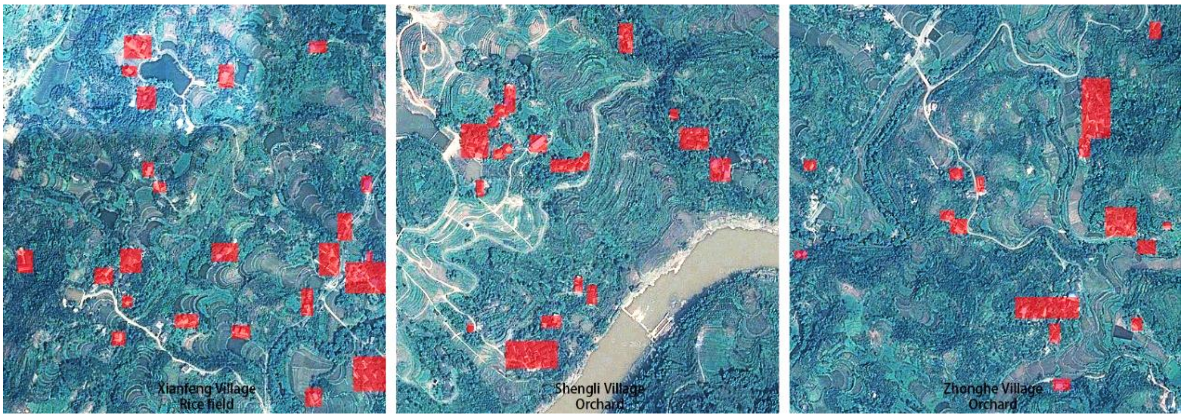

Figure 8.17 Distribution pattern of residential area (red squares).
Residential area in Xianfeng Village (rice field). Shengli Village (orchard) and Zhonghe Village (orchard), from left to right. All three images are in the same scale.
Map source © Google map 2016

Among all sample settlements, the population density of town centers is apparently higher than that of villages and informal household clusters. Population density in village and residential clusters ranges from 978 to 1609 per km², while in town centers, population density easily reach 2500 per km². Town centers with high urbanization rate, for instance, Xiema Town and Chengjiang Town, generally have a population density of over 5000 per km^2. Though in villages and clusters, people tend to shorten the distance among their neighbors, the distribution of residential houses is still dispersed compared with that in town centers. A small scale flood or landslide event might not afflict the entire system, thanks to the geographical dispersion. more property and capital stock are accumulated in town centers and hence exposed to destructive flood and landslide. Examples of Chengjiang Town and Pianyan Village have been given in the previous chapters. Official records show that the entire town or main streets were flooded. Destruction to residential and commercial architectures also caused trouble to the local people. According to the interview with local residents, none of them consider that the flood events impose no negative effect on their lives. Moreover, new environmental problems emerge in large scale settlements, and sometimes cause unexpected consequences, for instance, waste water leakage in chemical industrial areas. Such problems would make even more people exposed to the aftermath of an event. To conclude, in the premise that a disaster is inevitably to take place, the percentage of residents and properties, which are exposed to the risk, is lower in villages than in town centers. Among all types of villages, the level of expose in rice-produce villages is even lower, as its population and property is highly dispersed.

Contemporarily, rural development is driven by industrialization and urbanization. The geographical adjacency significantly boosts the assimilation process from the village to a city. Xiema Town is only 9km from Chongqing Central City, and benefits greatly from the close distance from a metropolitan. Settlement infrastructure is relatively modernized. One can hardly tell the town from Chongqing Central City, only judging from the quality of infrastructure. Nowadays, the capability of construction and infrastructure to resist natural hazards has significantly improved. Larger settlements are better equipped with facilities which control the river system. Rivers which flow across the town centers are embanked with concrete material, so that the risk of riverbank burst and erosion has been effectively reduced. For instance, the town center Taojia has never been severely flooded, though there have been drastic water level rise in Daxi River and its tributaries. Records of floods were taken since Qing Dynasty in Youai Village to the northeast of Taojia town center till today. The bank of Liangtan River in Taojia town is built tall enough to avoid river flood (Fig.8.18).

Figure 8.18 Water line on a bridge across Daxi River in Taojia town center.

The Chinese characters painted show the highest water level appeared in June, 2008. While the residents claim that in 2012, the water level almost reached the bridge floor. Under all circumstances, river flood never actually affected Taojia town center, as the river bank has been well designed and constructed.

The embankment of Liangtan River, which flows across Xiema Town has been constructed. It protects the riverbank from soil erosion, and regulates the river in its channel. The extreme rainstorm in July 2007, however, resulted in a 4.2 meter water level in the river section of Xiema Town, and problems of water logging took place. Factories and stores along the river were flooded, and the town’s power supply facilities had to terminate, in order to avoid short circuits and electricity leakage. In all, the urbanization process strengthens the settlement’s ability to with stand extreme environmental events, but the high density of population and capital stock in town centers indicate high system exposure, nevertheless. From the perspective of social and economic, town centers have higher exposure to natural hazards than villages and helmets.

As it is with the evaluation method of system exposure, the sensitivity of a settlement system shall also be assessed from two perspectives, the environmental setting and social-economic features. Unlike exposure which needs to be analyzed case by case for each settlement, due to their different geographical locations, the sensitivity of settlement systems can be categorized for simplification. The sample settlements can be divided based on the major land use strategy applied. By major land use strategy, it implies that the land use strategy is applied on over 80% of the total area of the settlement. On site investigation supplements land cover data to categorize settlement type. By the end of sensitivity analysis, a table listed all types of settlements and each factor of system sensitivity is given. It should be noted that vegetable planting on slopes is never a pillar land use strategy in a sample settlement. Fengshui forests can sometimes cover a large proportion of area, but it does not contribute to system's economy. These two types of land use are listed at the bottom of the table for reference.

Some of its indicators overlap with that of system exposure, but can be viewed from a new angle. For instance, the gradient of slope is one of such overlapping indicators. The topsoil and surface water tend to move downwards due to gravity. When there is turbulence on the upper slope, the topsoil layer on a steep slope is more likely to slide, thus the large gradient often indicates higher sensitivity. And as previously explained, large gradient also indicates higher exposure to landslides and floods. Except from the slope gradient, vegetation cover on a slope also affects sensitivity, as the physical structure of root system changes the stability of topsoil (Reubens et al., 2007). Tree planting has been long perceived as an effective method to prevent shallow landslide in local knowledge. Compared with woody plants, non-woody ones have weaker and shallower roots. Weak root networks reduce their soil cohesion. It indicates that they have limited ability to resist soil crack, thus the sensitivity of the soil layer to shallow landslide could not be significantly improved. Alongside with the choice of crop, artificial facilities within the settlement, used for controlling water resource also affect sensitivity greatly. This research elaborates the state of sensitivity according to the major land use types in sample settlements.

The basic agricultural land use types include plain field cultivation, slope planting, the comprehensive land use strategy of Yantang system, and several types of forests. For plain field cultivation, local farmers tend to choose the crops which could be attended by machinery, most commonly corn. Terrace field planting is a variation of plain field planting. Plain or terrace field planting are the pillar of the economy. Generally, local farmers in the sample settlements invest most time and effort in managing the lands. Farmers in one production team gather their economic contributes and work forces to build up and maintain the irrigation/ drainage system, as it is easier to launch large construction work on these land parcels. Artificial drainage facilities effectively gather rainwater, and protect soil from being washed away by heavy rain storms. Thus the irrigation/drainage system helps regulating soil water balance. To some extent, the physical properties of the topsoil are improved, makes it easier to infiltrate excessive rainwater, as well as retain water in dry seasons. Thus the soil is expected to be less sensitive to extreme precipitation conditions. There is one other thing to be mentioned. Due to the situation that plain land parcels in the research region are rare, they are less likely to be left fallow for the soil to regain fertility. Non-stop planting and the misuse of chemical fertilizer add to the risk of soil condition degradation. As local farmers do their best to retain the precious topsoil of the plain farmlands, and have learned from experience, such degradation has been reduced to a controllable status. The sensitivity of plain field planting is intentionally controlled by the local residents.

Slope planting, unlike plain or terrace field planting, is seldom the pillar agriculture production mode in all sample settlements. As long as a hill is cultivatable, local farmers would avoid launching large scale slope cultivation. Instead, they reform the landscape into terrace landscape. For the rest of cultivatable slopes, there are differences in the plantation type, in accordance with the slope and soil condition. In most of the settlements, farmers choose beans, oil rape or mustard to plant on slopes under the gradient of 15°. Cases are rare, in which such crops are planted on steeper slopes of between 15°-25°. In order to keep topsoil and help retain rain water, slope planting has a higher requisition for the crops, compared with plain field and terrace field planting. While according to the interview, in most cases, water and soil preservation is not the major consideration of the farmers for the choice of crops. Local farmers have other concerns when choosing crops, relying on their knowledge and acquired information about the market. Soy beans, oil rape, muster and so on, the choice of crop is quite flexible, but generally speaking, the roots of those crops have limited ability to grab soil when being flash flooded, and the land retain less rainwater than terrace farmlands. As it is with the plain and terrace field, vegetable cultivation on slopes also introduces the problem of overdue exploitation of the soil resource. The soil fertility gets worst due to the non-stop cultivation. In order to remedy, 2-3 intertills are practiced during the growing season, to loosen the topsoil as well as add chemical fertilizer. The intertills further reduce the stability of topsoil, making the topsoil more susceptible to surface runoff erosion. As the crops chosen for slope planting, say, potato, corn and herbal vegetables, require less amount of water to grow than rice. To plant these types of crops, there is no need to keep water with dams, especially as slope planting is generally practiced in a smaller scale. Without the artificial dams, potato, corn and vegetable fields are more sensitive to soil erosion caused by surface runoff. This also results in the increase of sediment amount in lower reaches of tributaries. In some larger vegetable fields, the farmers dig drainage ditches along the slope every 5 to 20 meters to regulate surface runoff. The net of ditches is denser as the slope more slant is. The ditches function as the drainage system in plain/terrace field, helping excessive rainwater to fast flow over the field and join the natural tributaries. It reduces the time, in which the soil would be soaked in rainwater, and hence decreases sensitivity.

While for the slopes with the least preferable condition, which involves a gradient of over 25°, distant from irrigation system, and scattered in small area, local farmers choose woody plants to cultivate. As it has been introduced in detail in Chapter 6.1.2, those economic woody crops include tee plant, orange tree and pear tree. It should be noted, that the tree planted slopes are different from landscape trees planting and orchard, as the previous does not represent an individual land use strategy. Those land parcels with least preferable condition are not regarded as the productive land resource which the farmers can live on, but the land resource which brings about some supplementary income or material yield. Generally speaking, the woody plants have deeper and stronger root system, which enhances the land’s capability to absorb rainwater and retain topsoil. Additionally, woody crops have lower requirements for plough compared with annual or biannual herbal crops. Topsoil structure is not disturbed by frequent intertill activities. Rather, due to the loss of work force in the rural regions, tee and fruit tree planted on such scattered land parcels are almost never intertilled. According to the interview, even when the yield of fruit trees would reduce for sure as the soil becomes infertile. Such land parcels are still left unattended. As a result, topsoil condition could be easily changed by the dry or wet season. From another perspective, the woody crops have higher endurance against changes of water and soil condition than their herbal counterparts. This could also be reflected by the difference in the amount of efforts the local farmer put in those two types of cultivation strategies. If water management is not prompt and appropriate, herbal crops would easily die out due to draughts and floods, leading to a total crop failure of the season, while for the woody crops, there are more chances for a reduction of yield rather than a total crop failure.

The majority area of hill slope is cultivated as orchards in the research region. Unlike the micro patches of woody plants on scattered land parcels, those large scale artificial forests have more evident ecological functions. The large demand of water through evaporation, and the foliage on the ground increase the total amount of rain water infiltration, as well as slow down surface water dispersion. Thus both water and soil resources are preserved. Distinguished from the groves planted within a small range, more efforts are devoted by orchard owners and workers, as their livelihood depend on the yield. Water and soil managements are practiced, which enhances the orchards resistance to draughts and floods.

Regardless of the type of forest, natural or artificial, tree cover increases infiltration rates, thus significantly reduces surface runoff and soil erosion. Economic forests contribute to local resident’s income, while natural forests have more significant value in improving ecosystem’s stability. To maximize the yield from a single plant species, plant diversity in an orchard is sacrificed. Aside from the risks of plant diseases and pests, this characteristic brings about differences in system sensitivity between orchards and natural forests. In regard of the extent of human activity intervention, Fengshui forest stands in between orchards and natural forest. Tree species in some of the Fengshui forests are in control by forest rangers. Only pine trees are respected as spiritual symbols while other trees (most common wild orange tree, mangrove and lacquer seedlings) are cut off, so that the forest remain “divine”. In some of the Fengshui forests, shrubs are also cut off to make space for pine trees to grow.

Due to the intervention of human activities, those three types of forest differentiate from each other, and the core issue is the forest structure. The shrub vegetation is completely removed from orchards to ensure yield, so as the majority of herbal vegetation. A large proportion of the land surface under canopy is left barren. Compared with those forests with more complicate vegetation structure, the capability of orchards to absorb rainwater is weaker, as their total demand of transpiration is less. From another aspect, though the weather in the research region is generally humid, with little coverage of herbal plants and shrubs, the topsoil is exposed to frost in the early spring. Thawed soil becomes more porous and would be easily washed off by summer storms, thus increases system sensitivity.

Human activities and the natural environmental changes sometimes influence both system’s exposure and sensitivity. Seismic activities underground would break the balance between withstanding and collapsing inner forces of the substrates. Once such balance is disrupted, sector collapse or landslide would happen, and follows the physical change of topsoil. The construction or mining work could also trigger this entire process. As it has been affirmed by the geologist, that post-landslide erosion is so common and compelling, which could cause over 30% of the topsoil loss (Walker, Shiels, 2013). In the case of continuous rainwater infiltration, and substrates fluctuation, loosened topsoil makes a slope more sensitive to environmental changes. Thus the destabilization of topsoil increases system's sensitivity to landslide. A variety of human activities have effect on the sensitivity to landslides, as they cause the change of topsoil condition, either in good way or bad way. Except from the barren lands without a vegetation cover to retain topsoil, farmland and artificial forests still managed by the local residents generally improve the stability of top soil layer, and hence reduce system's sensitivity to landslides. The most common cases of topsoil deterioration are the result of inappropriate cultivation strategies. In the ancient times, the intensified slash and burn cultivation strategy once caused severe soil erosion, as it has been depicted in the previous section. This piece of knowledge has been eliminated as the strategy banned by the local government. Nowadays, comparing all prevailing agricultural land use types, slope planting has the largest likelihood to deteriorate top soil condition. Though the farmers would intentionally choose several crops with favorable root reinforcement for slope planting, the needs from modern market imposes undeniable influence on their crop choice.

In the aspect of ecological function, the ditches and water reservoirs could effectively prevent flash flood by slowing down flow velocity, as well as retain rain water. The wet terrace farmland further mitigates flash flood during the rainy season. In a simplified calculation, one single wet terrace farmland parcel, with 30 meter length and 10 meter width, can easily retain approximately 120 cubic meter of rain water. Compared with the average precipitation intensity of an extreme rainfall event (200mm per day), rain water accumulated on such land parcel shall be 60 cubic meter. The infiltration and evaporation processes will also add to the total amount of rain water the land could handle. This indicates that the terrace farmland is more than capable of mitigating a flash flood caused by a heavy rainstorm event. As the technology of terracing field matured, ditches are enhanced with stone bricks or in some cases, concrete material, thus lessen the risk that the ditches and dams would be destroyed by strong currents. Consequently, topsoil is better conserved, and the sensitivity of wet terrace land is rather low.

Table 8.5 Factors of system sensitivity of different settlement types.

Settlement type	Slope gradient (+)	Soil retention ability(-)	Water retention ability (-)
Traditional Yantang system village	Low	Medium	High
Yantang for aqua-cultural use village	Low	Medium	Medium
Improved irrigation system village	Low	Medium	High
Greenhouse and mechanized farming village	Low	Medium	Low
Conventional orchard village	Medium	High	High
Ornamental tree plantation village; Experimental fruits plantation village	Medium	High	High
Urbanized town center	Low	Low	Low

Slope vegetable planting (not a settlement type)	High	Low	Low
Fengshui forest (not a settlement type)	Medium	High	High

(+) indicates this factor positively contribute to sensitivity, (-) indicates negative effects. The rating is based on a general consideration of all types of settlements. For minor differences among similar types, and other factors affecting settlements due to their geographical locations, please refer to the paragraphs above.

After a drastic change in the local environment, or a disaster, the settlement system has the tendency to return to its previous state. From the perspective of the natural environment, the recuperation process of the vegetation cover begins, as soon as the flood recedes. In the case of landslide, plants start to grow within days after the topsoil stops sliding. Similar recovery processes can be found on other natural environment components, for instance, the soil, river network, and all fauna species. From the perspective of social science, the inhabitants would rather try to return to their normality, instead of seeking for a brand new way of living. They spend effort in making their settlements/housings the way it once has been. Since none of the sample settlement has endured disasters, this research focuses on the disaster affected households, and the household is the basic units of a settlement system. Interviews are conducted with the local people, whose residential housing or productive lands were once damaged by disasters. Interviewees show their reluctance to move to other places, except for two conditions. First, their homestead or the majority of agriculture land is lost because of a landslide. By “lost” it means that the topography drastically changes, beyond all of the working force of a settlement system to remand. Affected households are forced to leave and find other land parcels to settle in. In the second situation, local government or insurance entity offer those landslide affected households with abundant monetary compensation, as well as a satisfying plan of rehabilitation. If the younger generation takes part in the negotiation, there is a higher possibility that the household finally determines to move. But in general, the resistance of rural households to move away from their lands, on which they have lived and worked for decades, is so large, that they would rather invest much time and money on reconstruction. Whether easily capable of reconstruction or not, local households generally show a strong will to recover from a disaster.

Only a minority of the disaster affected households gives in to the disaster, while the majority chooses to rebuild their homes. Their activities play a vital role in the recovery of the settlement system. Aside from the recover ability of the nature itself, human activities contribute to the recovery of a settlement system in various aspects. In a rural settlement, reconstruction works are mainly supported by the amassment of the settlement itself. In another word, the economic condition of the settlement before natural hazard is the criteria to judge a settlement’s recover ability. Ideally, reconstruction shall be subsided with a variety of property insurances and governmental compensation. However, in the process of compensation application, the criteria for property damage evaluation are strict. Disaster affected households do not always receive adequate amount of compensation from commercial insurance companies, nor do they receive the compensation on time. In the aspect of the contents of compensation, the amount of money is determined by the local governments and insurance enterprises, based on the overall status of destruction in the settlement as a whole, and the general economic status of affected households. The situation of property loss of individual households is difficult to evaluate, and it is hard for the policyholders and insurance company to reach an agreement on the loss in a short time. As a result the household afflicted by disasters receive a roughly calculated amount of compensation 14 to 35 days after the disaster, though the households require financial support urgently for the reconstruction. According to the field research, in the case of a complete destruction of a private housing, compensation from the local government and commercial insurance entities ranges from 10 to 25 thousand Yuan in total. The complete destruction of farmland brings about much higher compensation (30 to 50 thousand Yuan), and the households which lost their farmlands are designated to other arable lands, or provided with other means of livelihood through negotiation. Compared with the labor price in the local, the compensation for farmland destruction alone is relatively fair.

From the other side, questionnaires show that the disaster affected households have endured more economic loss than the average compensation they could acquire, according to their estimation. Of all 21 households, whose residential or commercial housings were destructed in flood or landslide, an average direct economic loss of 100,000 Yuan was estimated by themselves. For some commercial buildings, local residents reported a loss of 200,000 Yuan, including the value of stock within. None of them consider that they have received sufficient monetary support from a third party. It should be noted, that the local people tend to exaggerate their loss, in order to get more compensation. Some households admitted that they submitted a false declaration about their direct loss to the insurance company. After investigating the construction market and commodity prices in the local, a direct loss of approximately 40,000 Yuan is estimated by the researcher, if the residential housing was completely destroyed. For a commercial building which stores commodity of fruits, vegetables and common groceries, the estimation is about 90,000 Yuan. The affected households started reconstruction as soon as the disaster past, using their own savings or borrow money from their relatives or friends in the same settlement. Some households considered about bank loans but none of those interviewed households practiced, since they finally managed to collect enough from the means above. Thus the recover ability closely related to the economic status of those households.

Previous assessment of recover ability has presented the economic status of interviewed households. The economic status of the sample settlements varies, and also that of individual households. From a macroscopic view, the geographical location of the settlement does not make significant distinctions in the most cases, as the transportation, commodity price, and labor resource have become equalized in the modern world. However, exceptions exist in several distant and under developed settlements (for instance, Gekou and Liangxi Village in Shiquan Town). Rice, vegetables and fruits are sold at 70%-90% of the price, which other settlements sell at. This directly causes a lower household income in distant settlements. Annual household income of the distant settlements is approximately 70% of that in normal settlements, given identical major agricultural products. The major difference of annual household income, however, is caused by agricultural production structure. The average annual net income is approximately 20 to 30 thousands RMB per household, with the agricultural strategy of wet terrace land rice cultivation. For households applying Yantang irrigation system, annual income is higher, due to the yield of byproducts (fish, vegetable, and a small amount of orange). It ranges among 30 to 48 thousands. Orchard workers earn slightly more than rice farmers at an annual income of 50 to 55 thousands, according to the questionnaire. The households which practice landscape plants cultivation have the highest income. But there is a fluctuation in their annual income (Fig.8.19). To facilitate the establishment of landscape plant cultivation bases, local government offers financial and technical support to involved households in the beginning years, in order to stabilize this new forestry economy. In this period, they cultivate fast-growing trees, herbal plants and a small proportion of slow-growing trees. After a peak in the 3-5 years, the annual income went down to a stable level. As more households in the region follow the trend to cultivate landscape trees, the need of the market becomes satisfied, and the annual income of household gradually reduces to a stable level. Some of the settlements began to seek for further industry transformation, for instance the tourism industry. Those settlements take lead in the new construction of the rural area. In general, households which practice landscape plant cultivation earn approximately twice as much as those practice conventional grain agriculture. The economic status of a settlement, whose pillar economy is landscape plant cultivation, is better than all other settlements. It should be noted, however, that the household income presented in this paragraph only applies to the household with working force, while in reality the working force in a rural household may not spend much time practicing agricultural activities in their home towns. That is why the interview result shows a lower annual household income.

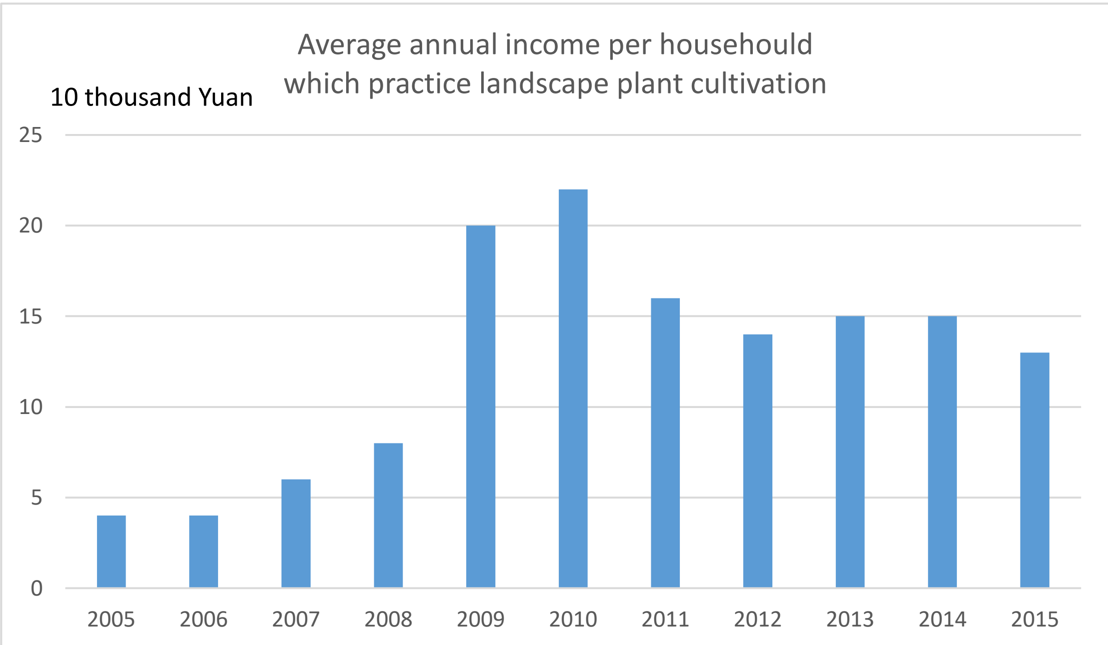

Figure 8.19 Annual income per household in Yipin Town, Banan District.

The pillar economy of this town is landscape plant cultivation, and since 2014, featured tourism is advocated. Data draw from interview with 30 forestry workers in Yipin Town.

Settlements which practice fruit cultivation are going through a similar development process as those who practice landscape plant cultivation. They have a much longer cultivation history, but the transformation took place only several years earlier.

The recover ability of a system is related with the vegetation structure, economic losses per event, and the economic status of the households. In all types of settlements, those which plant vegetable and corn on slopes and rice field planting of all kind are most frequently reported suffered from flood and landslide. Average income per household is the highest for those households maintain Yantang system, followed by artificially irrigated terrace rice field. But considering their estimated direct and indirect economic loss, it is still tough for a single household recover on its own. That is why most of the households have to ask for loan and borrow money from their relatives. Helping them to regain land productivity, these types of agriculture production are bestowed most compensation from the government and insurance entities. For severe flood event, as the flood generally takes place in summer, it takes the rest half a year to clean up the field and plow. For landslide, it takes much longer time. Due to the lack of working force, it takes over 1 year to make a full recovery, provided with external financial and technical support from the local government. It should be noted, that those disaster affected households still face a significant reduction of income, in the period of 1-3 years after the event. For the farmers, it is not because of their lack of knowledge in maintaining the farmland that results in yield reduction after disaster. The fragility of the farmland itself, insufficient human power input and financial support are the major deficiencies in the recover process.

Oral narrates reveal that orchards and economic forests do not need intensive human power or investment to recover from flood and landslide. Either excessively or intensively managed forests are more resilient than agricultural fields. For excessively managed orchards, workers and the owners do not care much about the yield and let them recover on their own. For intensively managed forests, the likelihood of trees being destroyed is even smaller. Workers can pump up the ponded water, and clean up sludge and waste soon after the event. With sufficient human labor, forests recover faster. It is common that the disturbance of environmental changes do not result in a reduction of yield in the same year. As the farmers cultivating farmlands, they also practice multiple cultivation methodologies. Their knowledge facilitates the recover process.

Reconstruction and natural resource re-arrangement after event do not necessarily act positively to the recovery, and sometimes generate more sophisticated outcomes. For instance in Maliutuo Village, where the several residential housings along Yulin tributary were flooded away, some developers seek the opportunity to advocate real estate at site, giving in to the huge economic profit. Such bold develop strategy goes against ordinary resident’s judgement by neglecting the potential risks. Some farmlands buried by landslide are left unattended, the instable soil layer might trigger landslide for a second time.

As a conclusion to the analysis of system resilience, settlements classified by land use strategies have different extent of resilience, due to the variation in the three components of resilience namely, exposure, sensitivity and recover ability. Traditional Yantang system with improved constructive structure is maintained according to the ancient local knowledge, with improvements in irrigation facilities. Exposure in a Yantang system equals that in conventional terrace farmland, while sensitivity is lower. Natural recover ability of traditional Yantang system resembles conventional rice field and slope planting, but the economic status of Yantang practitioners slightly improves system recover ability in general. Vegetable and grain planted on dryland and slope perform worst in resisting strong precipitation and recover from flash flood and landslide. Excessively managed orchards are exposed to potential landslide and flood, but sensitivity is one level lower than those fields planted with herbal crops. Their high recover ability further improves the general resilience. Supported by most modernized agriculture and forestry production technics, experimental orchards and ornamental tree plantations have low exposure to flood and landslide, as the security of the land is well concerned in the process of site selection. They are, however, sensitive to the variation of precipitation, pests, and plant diseases. But such problems can be remedied by the sufficient labor forces and productive material bestowed. Though the economic profits fluctuate, households practicing experimental orchards and plantations have a higher level of annual income, ensuring artificial remedies for post-disaster damages.

In the current state, possessors of local knowledge in the settlements are undereducated. The old generation boasts rich experiences and knowledge about the environmental settings, but receives limited compulsory education. Their local knowledge about their land is less likely to be passed to their offspring. The young, on the other hand, formulate their own perception about the world and new knowledge, under the influences of the mass media and modern science. Local knowledge instructs the site selection of the settlements, the land use strategies, as well as the detailed production technics. Local knowledge in the modern times outweighs the convenience of transportation and adjacency to the market as the major determinants for settlement site selection, rather than keeping a safe distance from flood/landslide prone area. But the productive interactions between the rural residents and the environment still show people’s consideration about natural resource management and ecological security. However, as it is with the site selection for the settlement, contemporary local knowledge instructs residents to practice the agricultural strategies, which ensure high economic profit in the near future. Long term sustainable land management starts to sink into oblivion. In the aspect of disaster prediction, local people are not familiar with scientific parameters. They concern about the possibility of extreme weathers, and prepare themselves instructed by their knowledge and experiences. Local legends are created, and information about severe disasters in the ancient times is preserved. Containing a wide range of information about the local environment as well as the cultivation strategies, the correctness of local knowledge is evaluated by comparing with modeling result and official records. In settlements which have been flooded or affected by landslide, local knowledge shows high accuracy in water level perception and memorization. Local people’s memory about the date of extreme disastrous date is also accurate. Appling high-quality input data, SWAT simulation model provides more flood dates than local people’s memory. The accuracy of water level requires calibration otherwise the water level simulation would be unreliable.

This research suggests that planners and scientists learn about local knowledge. Local knowledge provides valuable and relatively reliable information about previous natural hazards, which can facilitate the calibration of models. The dissemination pattern of local knowledge can help to design an efficient natural hazard alarm system. The contemporary local knowledge shapes the form of a rural settlement, and determines the land use strategy and economic structure. Planners and scientists can learn from both good and bad examples, to develop or improve rural planning. Local knowledge about natural hazard prediction and contingency plan can also contribute to the modern natural hazard control scheme.

8.3 Social-Economic Phenomenon Influencing the Preservation Status of Local Knowledge and System Resilience

8.3.1 Rural Hollowing and Its Impacts

One of the thorniest problems plagued the Chinese government is rural hollowing across the entire country. Since the late 1990s, new inventions of the economy occurred in urban areas in China. The pace of urbanization accelerated ever since (Fig. 8.20). Rapid urbanization brought abundant material and cultural resources to urban residents, which stimulate the rural working force to seek new fortune far away from their hometown. Consequently, large area of farmlands is left unattended, dwelling houses left temporarily or permanently unoccupied. Associated with the outflow of workforce and capital, rural economy recession is observed. Thus the rural region lost the capability to revitalization. Another relevant phenomenon is the expansion of villages or towns in the geographical direction towards sub-urban and urban ranges, driven by the higher real estate values in these areas. Such phenomenon imposes critical threats to the existence of rural settlement systems.

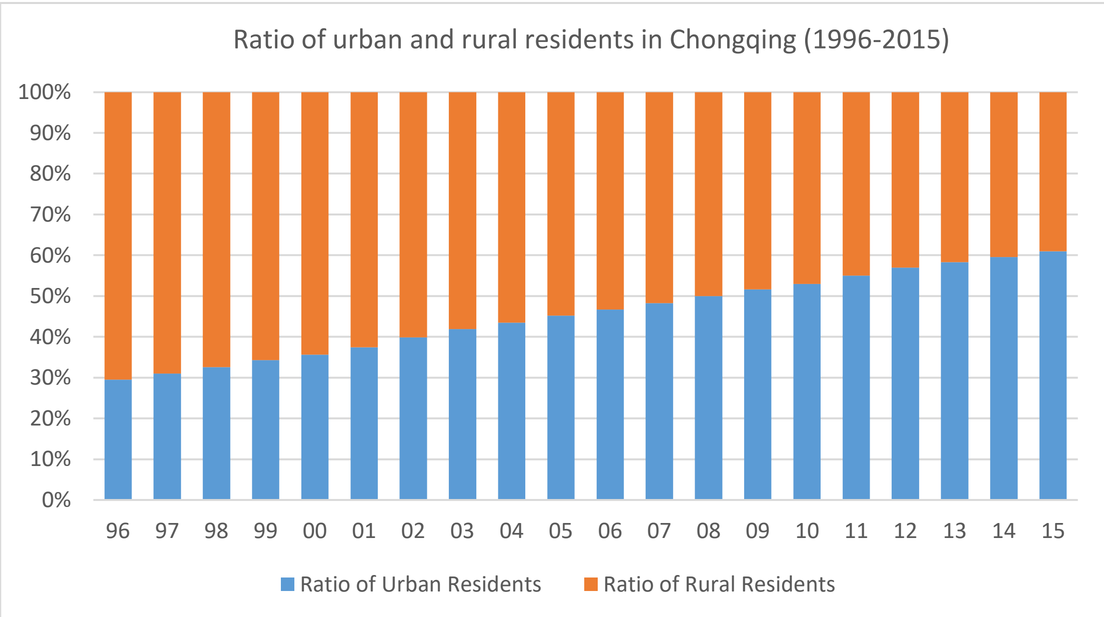

Figure 8.20 Ratio of urban and rural residents in Chongqing from1996 to 2015

Data source: Chongqing Statistic Yearbook 2000-2011 (data from 1996-2010); Chongqing Statistic

Bureau[1]. 1% population random sampling was conducted in the surveys from 2011 to 2015

Urbanization is the transform of rural population to urban population. Conventionally the extent of urbanization is presented by the ratio of urban residents to rural residents. Statistic yearbooks of Chongqing from 2000 to 2015 provided three sets of rural-urban resident data. Each dataset is slightly different in the value of radio, due to the difference in sampling and calculating method. The chart above presents the most complete and convincing dataset. Though there are differences in the exact values from three datasets, the trends of urbanization are identical. In 2015, the ratio of rural residents in Chongqing has reached 39%, compared with 70.5 in 1996. In less than 20 years,

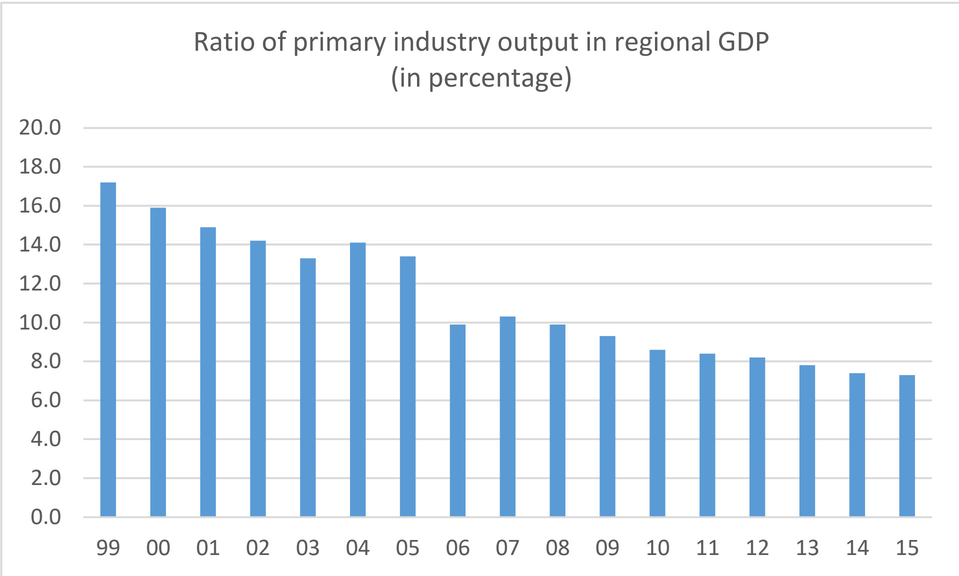

Figure 8.21 Ratio of primary industry output in regional GDP from 1999 to 2015

Data source: Chongqing Statistical Bureau[2]

Though rural hollowing has become a common phenomenon happening around the world, especially in the fast urbanizing countries (White et al., 2009), the term has not yet been attached with a universally-accepted definition (Liu et al., 2010). It is difficult to define, to what exact state, could the term be applied. Among all related studies, researchers give distinguished interpretation from different perspectives. Though not targeted at the rural hollowing phenomenon in the study, Cheng's research (2001) is still referential to this study. Cheng enumerated identifying points as follows: the ratio of actually used years to the service life of residential buildings in a rural settlement; the function transformation of a settlement; the area of discarded residential areas, and the demographic structure of a settlement. Rural settlement hollowing indicates the phenomenon of irrational village expansion, stimulated by advantageous land property policy. In this research, emphasis is paid on the changing aim of productive activities. For instance, the profit-gaining agricultural industry might degenerate to a self-sufficient production pattern. The residential places would either expand or shrink in a hollow rural settlement, but since the residential buildings is only a minor part of all rural land resources, such changes can be neglected. It is more appropriate to use the percentage of uncultivated arable land as a

[1] www.cqtj.gov.cn
[2] http://www.cqtj.gov.cn/tjsj/sjjd/

parameter of rural hollowing effect. In the research region, the area of uncultivated arable land in different sample settlements differs. The highest percentage of uncultivated land is around 40% in Changtan Village, indicating severe problem of rural hollowing. Beside of the context of urbanization, two unique policies in population and land management also aggravate the problem of rural hollowing, namely the system of resident registration (Hukou system in Chinese) and the land ownership system. According to the national demographic data, during 1996-2008, 135.2 million rural residents migrated to urban areas (Liu et al, 2010). The annual report of Chongqing confirms this fact (Fig.8.22).

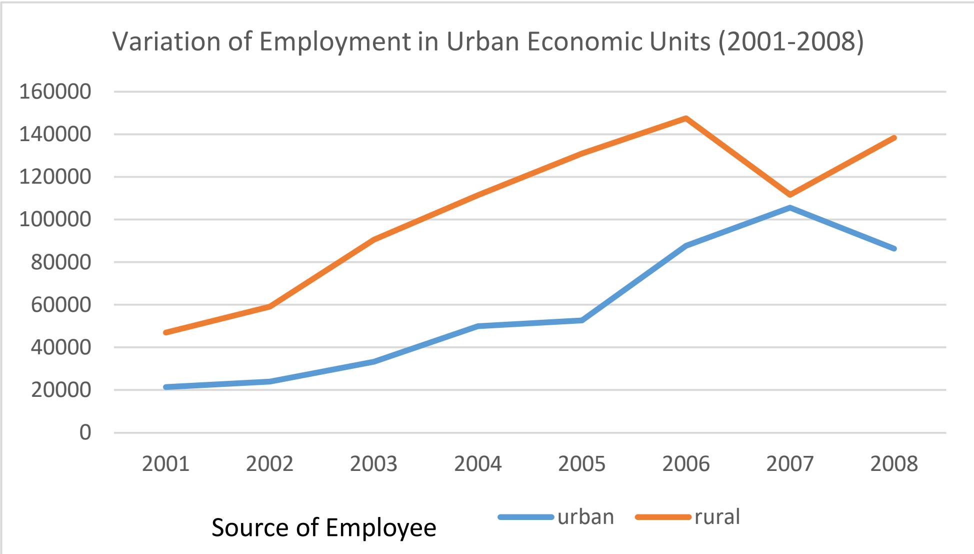

Figure 8.22 New job vacancies in urban economic units are constantly taken by more workforces holding rural Hukou.

Data source: Chongqing Statistic Yearbook 2002-2008

The rural-urban migration is under government control through the resident registration system, in order to maintain the stability of society structure. Every Chinese household shall officially register their identifying information to the country. One of the most important information is the “urban” or “rural” classification of a household. Distinguished by the type of Hukou, the households are under different management schemes in the aspects of, for instance, housing, social insurance and compulsory education. The rural Hukou holders are disadvantaged in purchasing apartment in cities, as they do not have housing accumulation funds and housing loan as urban Hukou processors. School-age children holding rural Hukou shall not be enrolled in urban public schools. They shall either go to the schools in their registration address or to private schools in the cities at the extremely high expanse of tuition fee. These policies under different schemes together resulted in the polarization of the age structure of rural dwellings. For some households, young adults would come back home to help with farm work in the sowing and harvesting time, but for the majority, it is the responsibility for the elder to look after the farmland as well as the young.

The system of resident registration alone would not directly lead to geographical variation in rural areas. It is the land ownership policy, which plays a greater role in this problem. According to the Chinese law of land property, agricultural land is owned and managed by rural collectives, the previous production brigade and production team. After the de-collectivization in the late 1980s, ownership of the land become quite ambiguous in rural region, as the newly formed township does not fully take charge from the previous commune system. Regardless of the assigned land ownership, individual peasants only have limited land use rights to gain profit through agricultural product activities. Land use right is contracted in the unit of household. Conventionally, such contract has validity period of 30 years. In this period, adjustment of land use type or transfer the rights of land use to other individual or entities must be approved by two thirds of the village committee, and report to higher level of agriculture administrative institutions.

It could therefore be deduced, that on one hand, the rural workforce migrates to the cities, but are not engaged within the urban welfare system. The elder and the young are left to stay in the rural settlements, clinging to the agriculture dependent lifestyle to a minimum. On the other hand, the right of agricultural land use is rigidly controlled by the government. In all, dislocation of rural workforce make the rural settlement lost its vitality.

The significance of investigating the phenomenon of rural hollowing lies in two aspects. First of all, rural residents, as the core capable component of settlement system, determine the resilience of the system. The ageing population in the rural region, or in essence, the displacement of work force, directly weakens agricultural productivity. In the vast of Chongqing rural region, due to the sophisticated topography, the development of industrial agricultural which could be facilitated by modern machinery is severely confined. Agriculture is still human power oriented. The amount of workforce directly links to agriculture productivity. Since agriculture is to date still the cornerstone of rural economy, decreased productivity leads to the recession of economy, and hence the reduced capability to actively response to and recover from disaster.

In the perspective of system resilience, the young and old are particularly vulnerable, due to their insufficient physical strength. In the 2014 Tongjing Flood, the only casualty was an 80-year old man who was confined to bed (not reported by the mass media but proved by neighbors during fieldwork). Generally speaking, children in the rural region are well protected by local schools in school days, but still, it would be dangerous for them if disasters strike out of school hours. The outburst of disasters would also impose psychological trauma on children. For a settlement system with an hourglass shape population pyramid, the system’s sensitivity towards disturbance is much higher, and the resilience is low.

From the perspective of knowledge development, the dominant groups of rural residents are the possessors of local knowledge. Rural residents who have received conventional public education seize the opportunity to work elsewhere. The dominant group of a rural settlement changed as the better educated members detached themselves from the community. Living away from their hometown for years, the younger generation consequently has little concern about the rural environment. The vitality of local knowledge, once guaranteed by frequent information exchange among different generations, is lost. Local knowledge becomes fragmented. Observation and reasoning of natural phenomenon turn to be the chatting topic among the seniors, but such process of local knowledge evolvement is unfavorable among the young adults. Field research certifies this fact, since 78.7% of all respondents assert that they would not pass their knowledge about local environment and disaster prevention down to their kids. Among those who are reluctant to pass down their local knowledge, the majority claim that since their children have received or will receive public education, and most likely to work in cities rather than rural settlements, it is unnecessary, as well as pointless for them to master local knowledge. This could be rebutted that the younger generation would acquire local knowledge through indirect transmission channels, for instance, by mimicking the production activities and lifestyles of the senior inhabitants in their early years. As rural tourism develops, some young adults retreat from the competitive cities back to their villages. They intentionally explore local legends and traditions, in order to attract tourists by narrating those stories. The ignorance towards local knowledge of the majority, however, shall not be overlooked.

The preservation status of local knowledge differs, judged from the contents of local knowledge. Two major topics concerning system resilience are investigated in this research, about productive activities and disaster precaution, respectively.

Despite of the prevailing trend of urban migration, no revolutionary changes in lifestyle are observed among the people who remain in the rural settlements. The scale of agricultural production shrank, and the agricultural yield retreats to the standard of self-sufficient. It is to be noted, that the traditional lifestyle depending on agriculture does not change. Local knowledge about agricultural related activities is still applied in practice, and evolves owning to the information exchange facilitated by the mass media. As long as the knowledge is practiced, it is more likely to be preserved.

On the other hand, the preservation status of local knowledge about disaster precaution varies significantly among different settlements. For settlements which heavily rely on agriculture and forestry industry, residents are more observant to the environmental changes. In other settlements, especially modernized town centers, only the residents who live along the tributaries care about the environmental changes. Those people take a tiny proportion of the population, and their influences on the local conception as a whole are easily neglected. It is undoubtedly that the keen perception about the nature is gradually eliminated from the modernized local knowledge.

8.3.2 Urbanization

The Chinese economic reform since the 1980s stimulated economic development in the urban regions, especially along China's east coastline. On the opposite the vast land of central and western China remains under developed. Scholars realized the under developed situation in rural regions. The political belief of Chinese Party was then changed to build a "harmonious society", instead of pursuing high GPD growth. This aim would be achieved by satisfying the material and cultural needs of all people. Though problems in the rural region were identified, there were lots of confusions and obstacles in solving them. To be more specifically, in Chongqing region, the mountainous topography hinders agricultural machinery to be applied. People have limited space for agriculture development. Local farmers could hardly follow the market trend, nor do they have the ability to practice other cultivation strategies. Problems of underdevelopment could not be solved by adjusting agricultural policy or further market reform. The government then sought to stimulate rural development by reform the rural life.

The State Council approved the Experiment of Balancing Urban and Rural Overall Development proposed by Chongqing Municipal Government in 2009. This regional plan intends to bridge the gap between Chongqing center city and rural regions by improving the industrialization and urbanization level of Chongqing region to 70% by 2020[1]. The secondary industry in turn provides capital and work force for the primary industry. The local government also encourages urban expansion. The One Hour Economic Circle Plan intends to expand the radius of Chongqing city center to one-hour-drive distance. Enclosed rural area is fast urbanized. Out of the One Hour Economic Circle, town centers and a number of county centers are also urbanized, and cast influences to a small range of adjacent area. Townscape is completely changed due to urbanization, which imposes the most significant influence to the resident's ideology. Modernized infrastructure and architecture replace the previous ones. Compared with the conventional rural house clusters, the high quality and well-structured infrastructure provides protection to personal and property security against natural hazards. From the perspective of system resilience, those towns as systems possess stronger resistance to natural hazards. From the perspective of local knowledge, urbanization imposes great threat to local knowledge in rural settlements. In those newly urbanized regions, land use is converted from agricultural to industrial, residential and commercial. As the government has anticipated, rural life routine is reformed. Local residents are provided with more opportunities to earn a living, for instance, work for manufacturing or service industry. Just like the people who leave for working in other cities, they isolate themselves from agricultural activities, and no longer have to pay attention to natural environment changes. Those who have yet given up their accustomed agricultural dependent life style are eagerly seeking for the chance to change. Their focus shifts from the crops, to how to maximize their benefits from land tenancy. If some of their acquaintances have experienced an "urbanized life", they are even easier incited. In fact, according to the interviews, nearly all residents in urbanized town/ county centers have leased out their agricultural land or stopped cultivation any crops. Given no chance to practice, local knowledge about agricultural techniques and disaster prevention is soon forgotten. Instead, for those newly urbanized area, the compulsory primary education is of better quality than in villages. Emergency preparedness training is offered in all elementary and middle schools, as it is instructed by Chongqing Education Bureau, while in less developed rural regions, systematic emergency training is not attached importance by educators. As urbanization takes place in an increasingly larger area around Chongqint central city, local knowledge's possessors are more likely to embrace a modernized new urban life. The local knowledge which would contribute to improve agriculture yield and improve resilience is gradually replaced by modern science and technology.

[1] http://www.cq.gov.cn/publicinfo/web/views/Show!detail.action?sid=1031530

Chapter 6 IMPLICATIONS

9 Discussion and Foresight

9.1 Discussion

9.1.1 Pre-requisitions for Local Knowledge Applied in Rural Planning

Answering to the research question of whether local knowledge can be applied as supplement for modern science and contemporary rural planning, a rational respond is quite positive. It would be prejudiced to regard local knowledge as mere superstitious stories and legends narrated by ignorant people.

This research shows in two aspects, local knowledge contributes to rural planning. Firstly, it provides the insights about disaster prevention and reconstruction, which are most likely to be overlooked by modern science. To some extent, local knowledge supplements and rectifies scientific data, and thus facilitates the sequential data analysis process in rural planning. In the stage of post-disaster reconstruction, local knowledge acts as the collective wisdom of a group of people, instructing the work as well as upgrading as the time changes. The impact of local knowledge on system resilience is confirmed by several facts depicted in this research.

Local knowledge contains valuable information about historical disaster in their living region. The senior local residents are easily able to recall details about severe floods and landslides happened in the recent 30 years. They provide the correct date and time of historical disasters, and the extent of damage caused by the disaster. For the households which have been affected by disasters, the senior members of the households are able to narrate the process of the event, as well as how they reacted to each stage of the flood or landslide. More importantly, local residents are familiar with the natural environment of their settlements. Their knowledge about the river system generally contains the historical highest water level in certain river channel and the average water level during the dry and wet season. In the research region, water stations on branches of the major tributaries have just been put in to use for less than 3 years, while one of the most prevailing hydrological models, SWAT, calibration requires over 20 years' continuous daily water level record. There will be at least 17 years when the current water stations could provide the required input for the model. For the near future, local knowledge about the hydrologic status would keep supplementing the limited recorded data. It should be noted, that the water level records provided by the local residents are not continuous daily data as well, and thus cannot be adopted as the model input directly. However, those data still help modeling practitioners to make a comprehensive judgement, about the quality of simulation result, and inspect if the simulation generates the correct date of flood. Aside from the hydrologic conditions, local knowledge also contains geological information. Due to the consideration of territory security, the official geological hazard maps are kept by the local government and not available for ordinary residents. In all sample settlements, there are only four warning signs with a detailed map put up in landslide-frequent area. Without the official geological maps, the residents are still able to identify the exact land parcels which have been affected by landslides. Given moderate instructions on mapping, they are able to circle out natural hazard prone area on satellite imaginaries. Those maps can be utilized as references to create a risk map in GIS.

Above synthesized local knowledge related to historical disasters in the study region. Those knowledges are solid, originated from the observation of local people's living environment. They are more a collection of facts, remembered and concluded by their possessors, than a set of conceptualized thoughts or theories. The knowledge about disaster prediction and aftermath mitigation are more to the latter type. A large proportion of the residents appear to be shy to claim that they possess the knowledge about flood and landslide prediction in the interview. However, the questionnaire presents a higher quality of such knowledge than expected. Local residents are not familiar with the measuring method of precipitation, nor can they relate the precipitation intensity in the unit of millimeter per hour in accordance with scientific data collection standards. But they are well aware that the time duration of strong precipitation event is closely related with the probability of flood and landslide. This triggering factor of flood and landslide is not mentioned in the flood control and drought relief scheme issued by Chongqing local government, but the majority of respondents in the research are able to give a referential number of rainy days, which they consider threatening. Their attention on the rain duration has helped them to avoid damage to their personal and property security in previous natural hazards.

Local knowledge suggests flood/landslide-prone area. Local residents are well aware about the risk, and avoid production and life on those land parcels. But they may not take special measures to manage all disaster-prone land parcels due to various reasons. Residential and commercial constructions are built on flood-prone land parcels along main tributaries, as residents outweigh the convenience on living and transportation over the risk of river flood. Such buildings are equipped with high doorsills, in order to resist normal water level rise in the rainy season. Such buildings are generally cheap and shabby, so when a river flood is considered to be life-threatening. Their possessors would discard the housing immediately without hesitation. For the agricultural lands which are susceptible to surface flood and landslides, farmers plant other crops instead of rice, to reduce economic loss when encounters natural hazards.

Compared with their previous generation, the young generations possess vague cognition about long past disastrous events. Their limited knowledge comes from the narration of the elder. As the lifestyle of the young has changed greatly in the past decades, knowledge about the nature is undervalued and even completely forgotten. Exceptions exist, where tourism is well developed, as the young residents have more enthusiasm to learn about the history of their settlement, in order to tell local legends and hence attract foreign tourists. On the other side, the young generation receives longer year of compulsory education. This remedies their lack of empirical knowledge of emergency and disaster prevention. Though the majority of the respondents deny that they received a specific course about this issue, the basic disciplines, namely, nature and science in elementary school, geography in middle school and high school contain common knowledge about the local geography and meteorology. The young are able to adapt the taught knowledge to practice, as the accuracy of their answers to disaster prevention related questions show no evident differences in correctness than those given by the seniors.

Above proves that local knowledge about the natural environment and disaster management are generally correct, and hence valuable for a rural planning towards improving system resilience. This is one of the pre-requisition for local knowledge's involvement in planning work. Secondly, local knowledge is acquired through public involvement, and reflects the status of civilization and culture in the rural region of China. By understanding local knowledge, rural planners could be aware of the local traditions. Many confusions and disputes can be avoided, as a rural plan caters to local residents' physical, as well as psychological requirements. In the study region, there are still remains of the Ba and Shu Culture. The local residents attach their emotion to certain substances, for instance, the divine tree, Taoism and Buddhism temples. Even the young generation attaches their nostalgia to the old architecture. But the modern society changed the way of local knowledge's dissemination and the form that they can be adopted in rural planning. The production team structure in the contemporary era is demolishing, while the modern governing structure is established. As it is propelled in the recent policies, rural planning and construction projects shall all resort to local people's suggestions. A platform, though still not mature enough, is established, facilitating the public participation activities. In the near future, the platform is being more convenient and effective for use, and more transparent for supervision. The policy support fulfills the pre-requisition of local knowledge's application in the perspective of governance.

9.1.2 Local Knowledge in Development

The contents of local knowledge throughout the history mainly cover the observation of the natural environment, the collective memory about disasters, and most influential, the revere of the nature. The vulnerability of local knowledge to outside interventions stems from the characteristics of its possessors, that is to say, the dominant local inhabitant group. Fieldwork reveals an unsatisfying status of the public education level. There is a strong tendency that the quality and quantity of the ancient local knowledge are fast demolishing. To clarify, the young generation does not possess much knowledge about agricultural production, religious belief and disaster prevention, etc. in most of the sample settlements.

The predominant reason behind the demolishing ancient local knowledge is the changing thoughts possessed by the local residents. There are two external factors interfering in the knowledge evolution and dissemination processes. First of all, the rural hollowing effect, causing a significant reduction in number of the young in rural settlement, who ought to become the descendant of local knowledge. Secondly, fieldwork reveals that the local residents have low motivation to further develop local knowledge in the contemporary rural resident communities, let alone learning from their elders. The young would resort to the taught modern science, in order to solve problems they encounter in the modern society. For instance, the younger generation seeks the potential economic profits brought by aquaculture, therefore occupied Yantang, causing the disintegration of the Yantang system (indicating the ancient local knowledge). The failure of Yantang system makes the settlement as a whole suffer from the short of water resource and increased susceptibility of flashflood and landslide. The origin of local knowledge, say, the keen perception about the natural setting and the careful inspection of new or modified land use strategies is losing. Thus local knowledge may lose its vitality, as its foundation collapses.

On the other hand, the improved resilience in the settlement system which sticks to the traditional Yantang irrigation system, but applies modern construction technics demonstrates that, by adding in new technics, can the ancient local knowledge evolve in a positive way. Similar cases are settlements which orient their production strategy catering to the market. Those settlements launch projects of experimental orchards and landscape trees plantations. They absorb more modern knowledge in planting and knowledge about the need-require relationship of the market in a larger scale. Those settlements have the highest resilience to natural hazards, as well as the highest annual income per household, which indicates an improvement of residents' livelihood. If local knowledge's evolvement is correctly directed by the local government or leaders of the social group, an improvement of settlement's resilience can be ensured.

9.1.3 The Acquisition of Local Knowledge and Modelling Input

There are two approaches in this research, to establish a thorough understanding about the local environment, to collect local knowledge and extract useful information from it, and to collect data for simulation model. In this case, scientific data for model are insufficient, so this research also seeks to draw quantitative data from local knowledge, in order to ensure that the best result could be achieved from modelling. This research takes various methods to acquire local knowledge. For the simulation model, this research applied scientific data from various data platforms.

In an actual planning project, time, human power, and professional expertise are limited, thus the practicability of research method is of vital importance. This section intends to explore the feasibility of the acquisition of local information through the two approaches. And also, it estimates the possibility, of combing the two approaches in practice, to achieve the greatest of their functions.

To collect local knowledge, field research is conducted in each sample settlements. A questionnaire and the structure for interview shall be designed in advance. In order to make the questions comprehensible to the local people, a pilot research is needed. The questionnaire and interview structure are then refined, and supplemented with questions, and catered to unexpected situations. The questionnaire and interview design in this research have an aim of understanding the general status of local knowledge in sample settlement, so that the field research becomes relatively time and human resource consuming. For actual planning projects, field research can be significantly simplified. Experiences from this research reveal that the senior residents and the leaders of production teams possess rich local knowledge about the environment and disaster prevention. They are valuable consultants, in defining the flood or landslide prone zone in the settlement, as well as setting up water level warning line along the bank. Much time and effort can be saved, if they would be invited to workshops or public hearings on site. For questionnaire and short interviews, software companies such as DAP provide tools for CAS management. Compared with the traditional method of questionnaire, the processes of information collecting and preliminary data analysis can be facilitated. There would be no need for printing out hundreds of questionnaires, and transcribing data by interior work afterwards. But there will be higher requisition for the preliminary processing of raw data on site, all researchers shall be trained and adapt unified standard for information entry.

Contemporarily, input data for SWAT model are not all easily available. Some entries require complicated process of data application from related institutions, while some are completely inapplicable or missing. Since details have been mentioned in the section of simulation modelling, these paragraphs make a summary to clarify the problem.

Firstly, the data sets which would cost researchers much time and effort to acquire. Historical precipitation data are the most important input for the model. For planners from local planning bureau, they have the authority to contact with the meteorology bureau and apply for required data. But generally, planners would not bother the complicated process of data application, unless the risk of natural hazards in their sites becomes unneglectable. For individual researchers, they have no such authority. Exceptions exist, where they corporate with the planning bureau, or work for research projects which have been officially approved by the government. For other situations, the researchers shall search for other available data sources. Meteorological data are available from international institutions, as WMO obligates its member countries to share them on some data platforms. Historical data are recorded since 1979 in China, but NSFED contains data from only one weather station in the research region, providing sufficient raw data as model input. The number weather stations for the vast area of the research region are inadequate. On the other hand, CFSR dataset contains serial meteorological data from virtual weather stations, which are evenly distributed in the research region at an adequate density. But the simulation result generated from CFSR data is far from satisfying. This research suggests that, at least for the research region, meteorology data from NSFED shall be applied as input instead of CFSR data. Land use map is an input layer for model. They are kept by the planning bureau, and require certain level of authority to acquire. The feasibility to acquire official land use map is slightly higher than that of the acquisition of meteorological data. Without such authority, there is another way to obtain land use map. Preprocessing and interpretation result from satellite imagery can be applied as substitution. The vegetation cover map can be draw from satellite imagery by interpretation, hence enables further identification of different land use types. This method, undoubtedly, adds to the required technical abilities of the researcher. The planning bureau possesses geological map and landslide risk map. It is even harder to get the permission to acquire those imageries, as the maps are confidential, and generally for military use only. In settlements which frequently suffer from landslide, the local government has put up warning signs on site. For a planning or research project which is not approved by the government, the only way to draw out officially defined landslide zones on map is to circle them out during fieldwork, with help of portable GPS.

Those data above are available from corresponding institution and organizations, though additional workloads for data preparation are inevitable. Preprocessing of those dataset do not involve much in-depth study in other disciplines. The preparation for soil map, however, calls for a certain level of knowledge in the discipline of agrology. For Chinese SWAT users, calculation and conversion must be made to various soil properties, thus SWAT users would be able to establish user defined soil dataset. Aside from the high requisition for professionality, setting up the input database for simulation model is also time and effort consuming.

Most importantly, simulation always calls for calibration, while data for model validation are not available. SWAT model requires historical water level in all tributaries for calibration, while in the rural region of China, water stations are rare, and do not possess continuous records for long years. It becomes implausible to verify if SWAT generates acceptable simulation for water level.

To conclude, from the perspective of the feasibility, the approach of collecting local knowledge through ethnology research methods is much more practicable than modeling. Contemporarily, water level in major tributaries in the rural region can be simulated by model, if only supported by local knowledge.

9.2 Research deficiencies

The definition of a rural settlement system is suggested in this research. But it is still difficult to draw out a spatial boundary for a settlement system. A thorough investigation about the settlement shall be made, enclosing all land parcels managed by the households in the settlement. This is not hard to achieve for an administrative settlement. This research finally decides to use the administrative boundaries of the sample villages and towns, instead of defining the boundary for each settlement as it becomes even harder, to decide whether or not to enclose adjacent forests, wild land, water courses etc. in a system. This research deficiency might lead to a biased characteristic analysis of individual settlement systems.

Though concerned about the methodology in evaluating system resilience, this research does not apply a quantified assessment. The factors influencing system resilience are numerous, and sometimes overlap with each other. Besides, the components of resilience, namely exposure, sensitivity, and the capability of recover impose influence on resilience in different ways. In this research, the evaluation of system resilience is based on the actual situation of individual types of settlement. There is no uniform standard evaluating resilience of all types of settlement. For future researches, which focus on larger scale, containing more diverse settlement, an uniform standard shall be made, in order to reduce work load as well as the subjectivity of the researchers.

9.3 Innovation points

As the planning theories develop, professional planners have been aware of the importance of multi-disciplinary cooperation in order to achieve a comprehensive plan. In this research, local knowledge is investigated, to test and verify whether it could support planning work. Local knowledge must be collected through ethnology study. The integration of ethnology studies, geo-information analysis and conventional disaster management study is one of the innovation points in this research.

As it has been mentioned, many scholars hold that local knowledge is referential for planning work, while others question this ideal. This research intends to investigate the current status of local knowledge, evaluate its value by mainstream knowledge and science, and verify the authenticity of local knowledge by comparing with recorded data of simulation results. This comprehensive study about the significance of local knowledge in rural planning is still a minor branch in the planning field. It is expected that this research would provide basis for future studies related to local knowledge and its possible application in rural planning.

Also, this study makes a preliminary investigation about the methodology of information collection in a planning work. To evaluate the correctness of local knowledge, this thesis adopts three ways of information collection in all. First of all, the methodology to collect local knowledge is adapted from the fieldwork method in ethnology study. Secondly, literature study, including collecting ancient literature as well as news reports in the mass media in the modern times. Third, the advanced modern science of runoff simulation process simulation. The applicability and effectiveness of those three methodologies are compared, providing references to the future planners.

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Appendix I. Questionnaire

Part I Demographic profile of the respondents

Q1. What is your current age? <single choice>

A. 20~34
B. 35~49
C. 50~64
D. Over 65
E. Other

Q2. In which town/village do you currently live? <short answer>

Q3. What do you do for a living? <single choice>

A. Agricultural/horticultural work
B. Sideline production
C. Traditional industries

D. Commercial work
E. Service industry
F. High-tech industry
G. Governmental work
H. Job loss
I. Other

Q4. Does your household possess (the tenure of) agricultural land or forestry land? <yes/ no>
A. Yes
B. No

Q5. Where do you currently work? <single choice>
A. The village in which I live.
B. Other villages than where I live.
C. The town centers.
D. Chongqing City or other cities in China.

Q6. What is the annual income of your household? <single choice> *Household income is applied in the evaluation of recover ability
A. Less than 25,000 yuan.
B. 25,000 to 30,000 yuan
C. 30,000 to 35,000 yuan
D. 35,000 to 40,000 yuan
E. 40,000 to 50,000 yuan
F. Exceed 50,000 yuan

Q7. How do you perceive your household economic condition? <single choice>
A. Poor
B. Fair for a living
C. Satisfying
D. Rich

Q8. What is your highest education level? <single choice> *Education level is also applied in the evaluation of recover ability and possession of local knowledge
A. Elementary school or below
B. Middle school/ secondary technical school
C. High school/ vocational senior school
D. Bachelor/ Associate degree or above

Part II The preservation status of local knowledge in regard of natural hazards
Q9. To which extent was your life or work influenced by flood or landslide events? <single choice>
A. Not influenced at all.
B. Some tolerable negative impacts.
C. Severe negative impacts.

Q10. Have you ever received formal training about natural hazard prevention and avoidance? <yes/no>

A. Yes <to Q11-13>
B. No.<to Q14>

Q11. Which organization/institution organized the training? <single choice>

A. Educational institutions (i.e. schools)
B. Local government (i.e. relevant departments of village or town level government)
C. City government
D. Spontaneously organized by residents in the settlement..
E. Other

Q12. Which issues were taught in the training? <multiple choice>

A. Prediction of flood and landslide.
B. Emergency evacuation plan
C. Post-disaster reconstruction work plan
D. Other

Q.13. To which extent do you think the training is practical and useful? <single choice>

A. Not useful at all.
B. Useful to a limited extent.
C. Generally useful and practicable.
D. Very useful and practicable.

Introduction before Q.14: Local knowledge is the knowledge that you possess, about all aspects of the natural environment (e.g. the climate conditions, landscape); socio-economic structure; (e.g. the local market, administrative structure); culture (e.g. traditions & customs) and the experiences dealing with the nature (e.g. agricultural work).

Q14. Do you think that you possess local knowledge, as above introduced? <yes/no>

A. Yes <to Q.15-16>
B. No <to Q.17>

Q15. Where or how do you acquire local knowledge? <single choice>

A. Mostly based on my own perception and living experience.
B. Half based on my own perception and living experience; half inherited from the senior generation
C. Mostly taught by the senior generation.
D. Hard to tell.

Q16. About natural hazards prevention, which of the following aspects do you know well about? <multiple choice>

A. Predicting extreme precipitation events, flash floods and landslides.
B. Identify natural hazard (flood and landscape, specifically) prone areas
C. Actions for avoiding natural hazards
D. The location of shelter for emergency evacuation
E. Reduce the losses caused by potential natural hazards, through changing land use strategies (e.g. change the crops, irrigation plan etc.)

F. Other aspects

Q17. If applicable, before how much time could you tell a severe flood or landslide event would happen in your surroundings? <single choice>

A. 1 day in advance
B. 12 hours in advance
C. 6 hours in advance
D. 3 hours in advance
E. Cannot tell.

Q18. From which sources does information about natural hazards reach you? <multiple choice>

A. Broadcast in village/town
B. Warnings displayed in television programs (e.g. weather forecast, local news)
C. Neighbors, other villagers.
D. Other

For all checked answers in Q18:

Q19. Was the warning in time? <single choice>

A. Left less than 1 hour for reaction
B. Left around 1-3 hours for reaction.
C. Left abundant time of over 3 hours for reation

Q20. If applicable, please list the activities you did during the disasters? <short answer>

Q21. As far as you remember, on which date did floods/ landslides happened in your surrounding? How severe they were (you can describe the water level, property loss, casualty etc.)? <short answer>

Q22. Which of the following would contribute to flood or landslides in your surroundings? <multiple choice>

A. Duration of precipitation <to Q23>
B. Accumulated precipitation of continuous rainy days <to Q24-25>
C. Daily precipitation amount <to Q.24-25>
D. Hourly precipitation amount <to Q24-25>
E. Upper river flooding
F. The (failure) of dams on the upper river
G. The (failure) of irrigation system
H. Soil and vegetation cover conditions
I. Other

Q23. How many days of continuous rainfall would most probably leads to flood or landslide? <single choice>

A. 1-2 days
B. 2-3 days
C. 3-5 days
D. Over 5 days

Q24. How do you tell the intensity of precipitation? <multiple choice>

A. Read/ watch weather report
B. Observe precipitation phenomenon
C. Observe other reference objects
D. Observe water level of nearby rivers or ponds

Q25. If applicable, at which amount of daily precipitation / accumulated precipitation, would you be prepared for potential flood/ landslide? <short answer>

Q26. Would you spontaneously think about and synthesis the experience regarding disaster prevention and avoidance? <yes/no>

A. Yes
B. No

Q27. To whom would you like to exchange knowledge and information regarding disaster prevention and avoidance? <multiple choice>

A. Nobody
B. Family members
C. Neighbors and friends living in the same settlement
D. Local officials who are in charge of natural hazard management
E. Local officials who are in change of rural landscape planning
F. Local specialists
G. Other

Q28. Would you pass your knowledge about natural hazards prevention and avoidance to your next generation? <yes/no>

A. Yes
B. No

Q29. How do you perceive the quality or effectiveness of your knowledge? <single choice>

A. The actual situation is usually complicated. My knowledge could not help much to avoid natural hazards.
B. To some extent, my knowledge can help to prevent or avoid natural hazards.
C. My knowledge can effectively help me to avoid the risk of natural hazards.
D. Not applicable

If a respondent in Q21 has given information for at least one historical disaster, Q30~36 are displayed to him/her. For the event that caused most economic loss:

Q30. How much direct economic loss did it caused? <single choice>

A. Less than 5,000 yuan
B. 5,000~10,000 yuan
C. 10,000~30,000 yuan
D. 30,000~50,000 yuan
E. 50,000~100,000 yuan

F. Over 100,000 yuan
G. Details

Q31. If applicable, how much indirect economic loss did it caused? <single choice>
A. Less than 5,000 yuan
B. 5,000~10,000 yuan
C. 10,000~30,000 yuan
D. 30,000~50,000 yuan
E. 50,000~100,000 yuan
F. Over 100,000 yuan
G. Details

Q32. How long did it take you to return to normal work and life after that event? <single choice>
A. Within a week
B. 1-2 weeks
C. 2 weeks to 1 month
D. 1-3 months
E. 3-6 months
F. Over 6 months

Q33. Did you receive financial subsidy for that event? <yes/no>
A. Yes <to Q34-35>
B. No

Q34. Which entity/ institution provided subsidy to you for that event? <multiple choice>
A. Local (village/town) government
B. National subsidy
C. Self-purchased insurances
D. NGO (e.g. Red Cross etc.) donations
E. Other

Q.35. How much money did the mentioned entity/ institutions provided after the natural hazard? <short answer>

Q.36. Have there been other types of subsidy after the disaster? If applicable, please list them. <short answer>

Q37. For reducing the potential loss caused by natural hazards, have you intentionally worked on refining the pattern of land use/ irrigation strategy/ water management constructions? <yes/no>
A. Yes <to Q38>
B. No
C. Not applicable

Q38. Which adjustments have you made? Please list below. <short answer>

The respondents are given printed satellite imagery. When asked, the researcher shows the settlement respondent lives in and a nearby river section.

Q39. Could you identify river system, Yantang, and other surface features on the map? <single choice>

A. No, I can't.

B. Yes, with help. <to Q40>

C. Yes, easily without hints. <to Q40>

Q40. To which spatial extent could you cognize the river system on the map? You should be able to identify one or two surface features (e.g. the river source, the joint of rivers, the location of subterranean river etc.). <single choice>

A. The land property of my household.

B. The village/ town center they live in.

C. Other villages and adjacent towns

Appendix II Semi-Structured Interview Transcripts

Semi-structured interview is applied to questionnaire respondents, who feel like to express themselves regarding to the following issues:

Issue A- The acquisition of knowledge about disaster prevention and avoidance.

Key points are:

1. The entity which offered knowledge.
2. Contents of taught knowledge.
3. The accessibility of taught knowledge.

Issue B- Impacts of flooding/landslide events and how they cope with such impacts afterwards.

Key points are:

1. The impact of flooding/landslide events.
2. Efforts taken to recover from disasters.
3. Experiences learnt from previous disasters.
4. Preparedness for future natural hazards.

Interviews were conducted after the respondents finished their questionnaire. One issue was chosen for one interviewee by the interviewer, concerning the contents obtained in the questionnaire. In all the cases, respondents did not refuse to take a following up short interview. Some gave rather short answers and the interview would therefore stop after asking key questions. Several interviewees had strong intention to communicate. Their interviews developed to oral history, when interviewees gave an abundance of information about past events.

Interview 01

Questionnaire Respondent No.10	Issue A
Date: 23rd Feb. 2016	Place: Maliutuo Village

Q: You have mentioned that you received systematical training about disaster prevention, who offered you such training program?

A: One was hosted by the village committee, and I went to the town government twice for their training.

Q: Could you tell me more about the training program in the town? How often did they host such program? And what did you learn from them?

A: I remember they offer the training once a couple of years. As a village governor I first took one somewhat 8-9 years ago, and the next, two years after (the first training). Similar things were taught, so I didn't go thereafter.

Q: What were the forms of training?

A: They have some trainer from relative departments. They gave us lectures in two days. Maybe in one day, I can't remember… But I think two day. I remember I lived in their dorm for one night.

Q: Maybe quite intensive for trainees? (The interviewee nodded.) What exactly did you learnt from the trainings?

A: To make emergency plans, and how to inform villagers to evacuate and find themselves some safer places.

Q: Did you learn any natural hazard prediction from their trainings?

A: Yes, they said if the daily precipitation exceeds 80-100mm per day, there would be flash flood or landslides in the local. But no one really cares about the precipitation except from us governors. I say over 50mm per day would be dangerous, if it rains continuously for some days. And sometimes the daily rainfall can be 150mm or more, we were very anxious in the office.

Q: Were you in the office when there would be risk of flood or landslides?

A: Yes, we need to broadcast the rainfall and flood alarm to the villagers. That's obligatory (by the government). Then we would organize villagers to inform their neighbors and so on.

Q: You also mentioned your village hosted training, what was it like?

A: Actually some villages which are frequently flooded make flood prevention drill almost each year. Our village is not frequently flooded. We made one drill three years ago when the government officers from the town came to visit. That was a quite successful drill. Villagers learnt a lot.

Q: Did you also teach them how to assess the risk of flood or landslide?

A: No, that was not taught. The farmers know very well about the situation. Sometimes they report to us when they think some slopes get too soft (would lead to landslide).

Q: Thank you. And one last question: did the trainings cost a lot?

A: The two in the town government costed nothing. They (the town government) paid for it (training and accommodation for the trainees). For the one hosted in our village, we had a budget for it so it's just fine.

Interview 02

Questionnaire Respondent No.18	Issue A
Date: 25th Feb. 2016	Place: Chongqiao Village

Q: You have mentioned that you rely on yourself for predicting floods. How did you do that?

A: We work in the farmlands so we know when the floods would come. When the water level reaches the top of the ditch, there must be floods from the mountain down here. A very simple thing, everyone knows.

Q: So did your parents teach you or you learn by yourself?

A: They don't need to teach. If you work in the farmland you definitely know, though I only went to primary school. We have many experiences about it (floods).

Q: And you said you didn't have any other training from the schools or the village government.

A: Yes, I didn't have the chance to go to school. I don't know if the village has trainings or not.

Q: What about the landslides? Do you also evaluate the risks yourself?

A: Ah, the landslides, we had one some years ago in our village, not in my place. Landslides are hard to predict. There are some places prone to landslide. Before that, our product team leader and some strong male adults always come to us door by door, to inform about the risks of landslides.

Q: Don't you have loudspeakers for broadcast?

A: Aye, we have. But they keep doing it this way, to inform us face to face and help us if needed.

Q: Then you actually know the places prone to landslides?

A: Eh, I can say that. Because every time they (product team leader) come and tell me where landslides happen or about to happen, I got the idea of where they are.

Interview 03

Questionnaire Respondent No.20	Issue A
Date: 25th Feb. 2016	Place: Liangshui Village

Q: You have mentioned that you know how to predict floods and landslides?

A: Yes, I think it's common here. When it rains heavily in summer, there will be floods.

Q: Did any one teach you about it?

A: People talk about natural hazards quite frequently. As I grew up I learnt from my parents and neighbors. But actually no one “teaches”, we just observe how they react when heavy rain comes.

Q: Sounds like you have a lot of experiences dealing with floods. But you said there was only one happened in 1989.

A: Every year there are several floods, but we are not quite affected. I know Chongqiao Village was severely damaged in the recent years, but for us it’s okay. The terrain is much lower than here.

Q: Have there been any village officials arrange disaster prevention training here?

A: No, not in our village. I heard Chongqiao Village has evacuation trainings after their flood disaster two years ago.

Interview 04

Questionnaire Respondent No.23	Issue B
Date: 25th Feb. 2016	Place: Chongqiao Village

Q: We have talked about the 2014 flood event. Do you mind if I ask what exactly was destroyed?

A: It would be better if you tell what I said to our government officials or journalists! (Interviewee lives by Yulin River). My house was flooded. All houses along this street were flooded. The house got full of mud, furniture was completely destroyed.

Q: And you said you spent over 5000 yuan to clean up your house.

A: Yes! I heard the government sent workers to help with the cleaning, but they didn’t come to our place at all.

Q: Did they give any compensation for your loss?

A: The officials asked all affected households to evaluate their losses and then distribute money. I only got 500 yuan. I have to borrow money from relatives to do the cleaning.

Q: Sorry for your loss… Were there any one hurt during the flood?

A: Nobody was hurt. The local officials set alarm quite early. (The flood came from upstream) They lead us to higher places before noon (when water level reached its peak).

Q: You mentioned that you also have farmlands, were they affected?

A: My farmland was on the hill (to the east of the village), not affected. I’d rather my farmland was flooded. There’s a national funding for destroyed farmlands, but for housing the compensation is too little.

Q: So how long did you finish cleaning up your house and return to normal life?

A: I’m too old for all the work, but I have neighbors to help me. It took 2-3 days I remember. I lived in (a local official’s) home before I can return. I have to make bed to sleep and do a lot of things… For at least half a year things got as usual.

Q: Did you pay back borrowed money then?

A: I never able to give back all the money. I paid back some, but they (her relatives) know I don’t have more, so they didn’t ask. If you count the debts, I’m now still affected by that flood.

Q: After this event, did you pay more attention to the water level or other factors which might raise the risk of flood?

A: I always pay great attention to the water level, as Yulin River just flows from my front door. I watched more TV news during that period, but now I guess I didn’t watch as much as I should.

Interview 05

Questionnaire Respondent No.33	Issue B
Date: 26th Feb. 2016	Place: Changyan Village

Q: You have mentioned that 2014 flood have severely impacted your livelihood, would you like to tell me

what exactly was your loss?
A: My lands over there (on the foot of a hill) were flooded. I have no yield at all for that year.
Q: And you estimated your direct monetary loss was?
A: Around 10,000 yuan. I only count on these lands for a living. And I still need to buy seeds and fertilizer for the next year.
Q: Did you get any compensation for the loss?
A: No I didn't. I heard Chongqiao Village was flooded and the government distributed a large amount of money to them, but I don't see any for our village.
Q: Were there many household affected in Changyan Village?
A: Not many, only me and my neighbor. Our lands are close to Yulin River.
Q: Then how long did it take to return to your normal life?
A: By the end of that autumn. I don't have anything to harvest, just cleaned up the land and dug a deeper drainage beside the terrace fields. Since I'm too old, I didn't plant much crop thereafter.
Q: Then what do you do for a living?
A: I have pension, and my children (working in the town center) give me money occasionally.
Q: Did this event remind you to better prepare yourself in the future?
A: Yes, I would think about the risk of flood and landslide when it rains continuously. And I would examine the condition of my water retention and drainage canals when it rains.

Interview 06

Questionnaire Respondent No.38	Issue A
Date: 29th Feb. 2016	Place: Longxing Village

Q: You are very familiar about the floods around here according to the questionnaire. Where did you get the knowledge?
A: Because I lived here all my life. If you live here, you'll also know.
Q: Does it mean you learned all about the place all by yourself?
A: Yes of course.
Q: Not from the local officials or your parents?
A: Parents never teach such things to their children, except from not to play around rivers and no one would listen. We do chat with local officials. I bet they learn about this village from us.
Q: Do you often talk about how to prevent floods or manage the farmland?
A: Quite often. The production team leader is my friend, he also tell me what he learnt from their training. To watch out when it rains heavily, and run to the primary school (a school playground is the emergency shelter for Longxing Village).
Q: Do you find the information he told you important, or not practical?
A: Some are quite useful, now I also watch weather forecast.
Q: Does he only talk to you, or also with other farmers?
A: When we do not have much farm work to do, we gather to play Mahjong and chat a lot. We talk about the farm work and yield.
Q: Do you also about floods?
A: Aye, we don't have severe floods, but there Shichuan Village has a lot. Sometimes we have flash floods and sometimes landslides by the hillside, but this (damage) cannot be compared with Yulin River flood.

Interview 07

Questionnaire Respondent No.45	Issue B
Date: 1st Mar. 2016	Place: Wenfeng Village

Q: You had a lot of experiences regarding disaster prevention and mitigation, as you said in the questionnaire. Could you please feed me more about it? For example, what were the consequences of the flood in the 1990s?

(There was a bridge placed above Zhujiagou River, connecting the east and west parts of Wenfeng River. A new bridge was built at the same place after the old one flashed away in a flood. Both bridges are called Zhujia Bridge by the local people)

A: The old Zhujia Bridge was made of woods, and the bridge arch was relatively flat. That bridge was built in the 1960s. It's not surprising that it was smashed into pieces. You can see this new bridge made of concrete. It's not so good looking, but strong enough against floods.

Q: Are there still floods nowadays?

A: Yes, but the new bridge has higher arch, for most of the cases, the water level never reach the bottom of the bridge. In the recent years water level seems higher than before, but we think the bridge is still safe.

Q: Shall we talk more about the 1990s flood? What was the impact of the collapsed bridge to your household or to the village?

A: That caused much inconveniences to the village. It was okay for the adults. We quickly built a temporary simple bridge across the river using woods and bamboo after it stopped flooding. And there is a detour, though much farther.

Q: Can you still remember how long it took to rebuild the bridge?

A: Around one week after the collapse, or less.

Q: Then what happened to the children you mentioned?

A: Children need to go to school in the eastern of village. They cannot go across the bridge without help. We organized some adults to help them across the river.

Q: Was there any other property loss in that event?

A: Aye, some farmlands near the hill have landslides. You see, we don't have any farmlands close to Zhujiagou River. So we didn't have casualty or other losses.

Q: Happy to hear that. As I understand, as a production team leader, you have organized a group of villagers to manage the mitigation work, like the restoration of the bridge and so on. What else did you do, and how long did it take to recover from that event?

A: Actually I have retired by then but any way I'd offer help. Many just volunteered for the work at first. We helped to make that simple bridge, and to clean up some farmlands. But for rebuilding the bridge it took a very long time, like 3 or 4 months. The local government needed to design the bridge and purchase building material using their budget.

Q: Did that event change your concern about floods or not?

A: I can't do anything to control the flood obviously. I think we now notice the importance of a flood rescue team in our village. The local government also encourages this informal organization. It is good for our village.

Interview 08

Questionnaire Respondent No.46	Issue A
Date: 1st Mar. 2016	Place: Wenfeng Village

Q: Could you tell me more about what do you know about natural disaster prevention?

A: In the past, we assess the risk of floods and landslides by ourselves. I watch weather forecasts on the

TV, though even my family would not do so. We had landslides along the hillside, when it rains hard continuously. Most households near the hills have already moved to other places. Floods don't really matter to us, except from the one crashed our bridge.

Q: Do you ever received training about evacuation, restoring or other natural disaster related things?

A: Yes. As production team leader, the government asked us to attend training. That's also why I watch weather forecasts every day. Otherwise I've no idea about it (the weather forecast). We have a list of contact people, so when the local government or any of the production team leaders recognize flood or landslide risk, we contact those people and see where people need help.

Q: How do you reach them?

A: Some has telephone, now they also have mobile phone. Previously we visit them in their places.

Q: How many training do you attend in all?

A: 2 or 3 times I remember.

Q: What's the form of training? Did they provide lectures or organize drills etc.?

A: Mostly video watching. We don't have drill here.

Q: Do you think the training you received practical?

A: Yes. I think watch the weather forecast is a good way. And I have a mobile phone, sometimes there are text messages about the coming rainstorm (Automatically sent rainstorm alarms by the meteorological bureau).

Q: Do you see the need of more training programs?

A: Not for me, maybe more useful to the younger people.

Interview 09

Questionnaire Respondent No.54	Issue A
Date: 3rd Mar. 2016	Place: You'ai Village

Q: You have mentioned that you have participated training for disaster prevention, when was it? And who held it?

A: That quite long ago, maybe 5-6 years. I went to the town center as the town government held lectures there.

Q: What was taught during the training?

A: We watched a video showing the impact of flood and landslide. Then the lecturer told us how to organize local people to help each other during the disaster, and how to find shelter, etc.

Q: Did they show you how to predict flood risk?

A: I think they told us to watch weather reports every day. But I'd rely on observation by villagers and myself.

Q: Is it the only source that you receive training against natural disasters?

A: Emm, you can't say that. Every school offers safety education since around 2000. I think everyone is well educated but they just don't remember.

Q: For you, are you also trained on how to deal with the aftermath of natural disasters?

A: Yes, the lecturers told us people need psychological assistance after disasters. But for our village, there is only one tributary with flood risk, and there wasn't floods severe enough (to offer psychological assistance to the affected residents). Besides, I only met one psychiatrist for my entire life, and that was on the training program in town.

Q: What about land management?

A: You reminded me… We must implement the "converting of farmlands back to forests" project. This is the most important work we do regarding land management. It is also good for reducing floods and landslides.

Interview 10

Questionnaire Respondent No.65	Issue B
Date: 6th Mar. 2016	Place: Dongquan Town

Q: You said that the flood happens every year, but also you are not really affected by the floods, how it comes?
A: Well, we all have farmlands, but we do not plant crop, only some vegetables for the household. And we are now living in the residential quarter (In Dongquan Town, the residential quarter resembles the one in cities, with residential housings arranged in line).
Q: But still you are conscious about the floods.
A: Yes, as the floods occasionally cover our main road. But that's only a little inconvenient for us, compared with the past.
Q: And that's because you no longer work a lot in the farmlands?
A: Exactly. My husband and I work in the factory, and our daughter goes to a boarding school. We just work in our land for fun.
Q: You still hold that land, not leasing to other farmers?
A: We currently only have a small piece of land, between the main road and the river over there. No one in the town would like to lease it. Besides, man cannot earn much money by farming.

Interview 11

Questionnaire Respondent No.71	Issue B
Date: 10th Mar. 2016	Place: Tiekuang Village (new location of Jielong Town)

Q: You mentioned you moved from the old town here. Do you remember any flood events in the past in the old town?
A: I think I heard some old people talked about floods in the past, but that's more or less all that I know. Besides, it floods every year in summer. Some farmlands along the river get flooded, and the residential quarter in the town as well, but not severe at all.
Q: Then in this new town, there are no floods?
A: Actually I only come here occasionally during my leave from work. I haven't heard my parents talking about floods in this village, so I guess it doesn't matter.
Q: Do you also care about rainstorms where you live in the city?
A: Not really, I care more about the traffic restriction based on the last digit of license plate numbers, which decides whether I can drive in rainy days.

Interview 12

Questionnaire Respondent No.74	Issue B
Date: 10th Mar. 2016	Place: Jielong Town (old location)

Q: You mentioned that the old town was once flooded. When was that could you still remember?
A: I can't remember, but I'm sure it was in the 1970s. The river flows around this hill (pointed to the base map I presented). This old Jielong Town located by the turning of this river so it was frequently flooded. It was also flooded for several times in the 1980s and 1990s, but the 1970s flood was most severe. Houses collapsed and people got hurt in that event.
Q: Do you know how many people were hurt then?

A: No I can’t recall, that’s too long ago and I was not affected. The local government must have the number, you can go ask them.
Q: So after the 1990s you have no flood, am I right?
A: You see here they have lifted the embankment along the river. I asked the workers and they said it’s tall enough for secure this place. But I say, in 3-5 years there will be flood exceeding this embankment.
Q: Did you tell this to the local officials?
A: Yes I did. They said they have data of water level, and the engineers also have their concerns. So I wouldn’t ask again.
Q: And for yourself, what did you do to better prepare yourself for the future floods?
A: For myself? I’m too old, so I don’t really care about the future. Now they have built a new village up the hill, and the younger people will move there in these years.

Interview 13

Questionnaire Respondent No.89	Issue B
Date: 13th Mar. 2016	Place: Nanquan Neighborhood

Q: Could you tell me more about the floods which affected you in the past?
A: You know now we don’t depend on agriculture any more, but in the past, the flood was problematic to the lower terrace fields on this hill. Luckily our farmlands are on the middle (slope of the hill). I can’t remember more details, but you can go down this road and ask the villagers there. Our farmlands were once flooded in the 1980s, due to the outburst of Yantang on top of the hill. All the farmlands were a mess and we got some compensation for that.
Q: So you didn’t have any yield from the rice field for that year?
A: Yes, we received like 3000 yuan compensation. To be honest, I feel fine about it. Though some villagers argued that’s not enough. Men always ask for more, you know?
Q: You said only in 1-2 weeks your life was back to normal, that’s quite fast, compared with other cases I’ve learnt?
A: My family spent less than one month to restore the drainage system together with our neighbors. The reconstruction of Yantang took much longer, but since we could not plant a lot in autumn, we didn’t rely on their progress. Last year our village launched the natural gas project. Tubes were buried 4 meters beneath the ground. We were told not to plant rice for security concern. We plant some oil rape and other vegetables now. Actually I’m not worried about floods, as we are not making much money from agriculture.
Q: So do you now pay more attention to rainstorms, or any other risks of flash floods?
A: I think it is the responsibility of the owner of Yantang. As long as he remember to discharge water before it exceeds the capacity of the dam, we’ll all be fine. But they now cultivate fish in Yantang, I’m not sure about this point.

Interview 14

Questionnaire Respondent No.97	Issue A
Date: 14th Mar. 2016	Place: Dongquan Neighborhood

Q: Could you tell me in which level of education were you taught knowledge about disaster prevention or avoidance?
A: I remember my primary school, middle school and high school in this village offered lectures about it.
Q: But not in the college?
A: Right. I go to a university in Chengdu (the provincial capital of Sichuan Province). Flood isn’t a big

problem in cities.

Q: What were taught in those lectures, if you still remember?

A: About how to escape from earthquake and fire disasters. Teachers played video, but actually we didn't care much about it.

Q: Were flood and landslide also referred in the video?

A: Well, I can only remember earthquake and fire drill. Flood was not a big problem to me.

Q: But earthquake and fire are important, as you perceive?

A: Earthquake happens frequently in Chongqing and Sichuan, and since the 2008 Wenchuan Earthquake, the government attached great importance on earthquake avoidance. Maybe it's because there wasn't any drill for flood or landslide event that I could not remember what was taught about them…

Interview 15

Questionnaire Respondent No.108	Issue A
Date: 15th Mar. 2016	Place: Tiaoshi Town

Q: You mentioned that the local government offered a training program about flood avoidance. Could you remember when?

A: Last year in summer.

Q: What was it about?

A: Waterlogging on the streets.

Q: About how to predict if waterlogging is going to happen?

A: No. There was once a waterlogging event in September, 2014. Water flooded one factory to the south of this main street. I remember 2 workers died of electric shock due to short circuit. The training was to remind us (occupation of this interviewee was street cleaner) of security during waterlogging events.

Q: Did they provide lectures for you or play video about this issue?

A: The village officials gave us a short lecture and brochures. But to be honest I can barely read.

Q: Except from the brochure, how do you find the training? Could you understand the contents?

A: All the villagers knew the consequence of that waterlogging event. I can get what they intended to express easily. I'm not saying it's unnecessary. I think it's important to tell all street cleaners to mind their own safety.

Interview 16

Questionnaire Respondent No.116	Issue B
Date: 16th Mar. 2016	Place: Shiwan Village

Q: You have mentioned that a flood two years ago affected your landscape tree plantation, how bad it was?

A: I plant landscape trees on the terrace lands. To be precisely it was not the flood, but landslide which caused trouble. I've just planted some cedars (Platycladus orientalis (L.) Franco cv. Aurea Nana, which has light yellowish needle leaves) behind the hill, they were flooded. Even though I tried to drain the excessive water out of the field, the trees still dead like a month after.

Q: But you said the landslide caused trouble.

A: Aye, floods happen every year. It was my bad luck that I chose the wrong tree species, and at the same time the drainage canal was blocked by mud. But I can do nothing against landslides. It simply happens and ruins your land. Especially the land parcels on a steep slope, they may slide or be buried, and people can do nothing to retrieve. I'm quite unfortunate that a small part of land was ruined. I got some compensation, though.

Q: Would you now be more cautious about landslides then?
A: I should be. But landslides are likely to happen in the same area, and I think the land parcels I currently possess are safe from them.

Interview 17

Questionnaire Respondent No.124	Issue A
Date: 16th Mar. 2016	Place: Emergency center in Tiaoshi Town

Q: What were the measures to communicate with the local people about flood and landslide risks?
A: We (the interviewee was a local official in charge of disaster prevention in Tiaoshi Town) provide lectures in this center every summer. And we have invited specialists to give lectures in middle and high schools in the town. Since last summer, we carried out flood drill once a year in the town. It was I big success. We are planning to make it a yearly event.
Q: Why are you sparing so much effort on flood control? Were there many floods in the past?
A: Yes, if you paid attention on the mountains along the river when you came, there was a cave on it. In Ming Dynasty that cave was submerged completely as it was recorded (the cave is about 4-5 meters above the water level when the interview was taken). Besides the flood events in 1989 and 2014, there were also quite dangerous floods in this main tributary, and landslides in the mountains. We need to monitor the water level closely in summer, especially for emergency discharge from dam.
Q: So I suppose those measures you are now taking are drawn from experiences with flood events in the past, am I right?
A: Exactly. Local government is very concerned about natural disasters. Since we've made a great progress on disaster prevention, we now become the "best example town" in Chongqing. Occasionally there are officials from adjacent village and town visit us.
Q: I see. You've done a great job. Are there any plans in the near future?
A: Of course. Now our water level data can be uploaded to the hydrology bureau of Chongqing, and we receive directly the weather alarms from the meteorological bureau. We have installed loudspeakers not only in the town center, but also nearby villages. The broadcast system will be in use this summer.

Interview 18

Questionnaire Respondent No.149	Issue B
Date: 21st Mar. 2016	Place: Chengjiang Town

Q: You moved to Chengjiang Town, due to the flood in your village. When was it?
A: Yes, as I said, I was born and lived in Baiyangbei Village. (Baiyangbei Village was on the opposite bank of Jialing River. There were several houses distribute sparsely on the top of a small hill when the interview was taken.) In 1981, the flood in Jialing River destroyed my house and farmlands. My family was resettled in Chengjiang Town.
Q: Were there other households resettled from Baiyangbei Village?
A: I remember about half of the villagers moved to other villages and towns due to that flood. Now there are only a couple of households remain. You can see from here, the farmlands are left barren. People cannot earn much money by farming.
Q: So why did you choose to resettle here, not other villages?
A: My relatives live in this town and they gave us some money to help. That's why we moved here. Other villagers went to their relatives to find a new place to live.
Q: Did you receive any kind of help or arrangement by the local government?
A: Well, the village officials suggested towns and villages to us and helped to handle our Hukou

(registration).
Q: Did it take long to settle in a new place?
A: What do you mean? Just living in this town was simple, we lived with my relatives. But it took much longer to build our own house and become registered in the town.
Q: Like a year?
A: More or less, I can't remember the details.
Q: Though you don't work in the farms now, do you still pay attention to the flood risks?
A: Not really. Chengjiang Town was flooded several times in the 1980s and 1990s, though not so severe as the 1981 one. Then the government has built a hydropower station on the upstream of Jialing River, therefore no flood happens here, except from flash flood from the mountains in the south.

Interview 19

Questionnaire Respondent No.165	Issue B
Date: 29th Mar. 2016	Place: Yong'an Village

Q: You have talked a lot about disaster avoidance in your village. What exactly did those events affect your life?
A: I think they only brought inconvenience to me, when extreme rainstorms happen. Bridges are sometimes submerged, as well as highway, so people have trouble travel among villages. Especially for us (retailers), we have trouble keeping our stock.
Q: So the flood and landslide in your village didn't directly affect your normal life?
A: Well, I think so.
Q: I wonder whether you have paid more attention on natural hazards or not, after experiencing those inconveniences, as you said.
A: I think the government has paid attention on disaster prevention. They'll tell us when rainstorms, floods and landslide are going to happen. I also know that I should care more about the weather forecast, and the SMS weather alarms when it rains. Though for the most of cases I just judge by observation.

Appendix III Oral History Transcripts

Oral history focuses on recording specific flood events which imposes significant impact on the local people. Narrators were encouraged to recall details about the flood event itself, their feelings, as well as how their life was influenced during and after the flood event. This research recorded three relatively complete flood events based on oral history. A check list was designed for oral history research as below:
Check list:
Issue A: The flood event

- When did the flood event take place?
- How did it develop in a time sequence?
- Where did it affected?
- What was your response as the flood happen?
- What were the responses of others (including your neighbors, acquaintances in the village, officials of the local government, etc.)?
- How did the flood happen? (If applicable)

Issue B: The impacts of the flood event

- Who were influenced by this flood event?
- What were the losses of your household?
- What were the losses of your neighbors, acquaintances in the village, and the village as a whole? (If applicable)
- What did you do to recover from the flood event?
- Who helped you with the reconstruction and how? (If applicable)
- How did you feel about the negative impacts and the process of reconstruction?

Transcript A

Narrator: Liu Lijuan, female, age 57. Her family lives in Tongjing Town, by a tributary (Wentang River) of Yulin River.
Date: 23rd Feb. 2016
Place: Interview took place in the narrator's house. Her family members drop in pieces of information during the interview.

"I remember it was on 13th Sept 2014. In the morning I heard villagers said about the unusual water level in Yulin River. I didn't pay much attention to it, as my house is not close to Yulin River. But at around 10 or 11 a.m. things went wrong. The water level in Wentang River rose abruptly. When I realized, the road before my house was already covered. I called my father-in-law to pack our things and helped him out the house. There was a small pavilion up the hill built by Tongjing Hotspring Resort. We went there and later on, several workers from the resort also came there.
The water level in Yulin River rose too fast, and exceeded that in Wentang River. We saw from above that the Wentang River flew back, that was why my place got flooded. The yard you see here was completely ruined, and water level was around the knees in the house. You can still see the water marks on the walls.
There were a couple of families affected like us, as our houses were built right beside Wentang River. No one along Wentang River was hurt during that flood, but I heard an old man dead in Yulin Town, as he was stucked in the basement when the flood came. I'm not sure if it's real. There are also people say

that the man dead due to heart attack.

Our farmlands are to the south of the hill, by the upper stream of Wentang River. The only thing mattered was my yard. It didn't take long to repair, within half a month as I remember. But I heard that there were houses flooded by Yulin River in our village. The village and town government sent armed police to rescue and the following cleanup work. There was also an embankment project launched for this section of Yulin River after the flood event. For our household, it didn't leave permanent impact.

Transcript B

Narrator: Wang Jun, male, 53 years old. He lives in Maliutuo Village by Yulin River, running a small retail store.

Date: 24th Feb. 2016

Place: Interview took place in narrator's store. As the interview went on, neighbors and the local official who clipped the flood documentary joined the interview, kept feeding more information for that flood event.

"The Yulin River flood happened on 13th Sept. 2014. I had no idea before the early morning of that day. It didn't rain at all in our village, but I watched the morning news on TV, saying that Guang'an (upper stream of Yulin River in Sichuan Province) was flooded the day before. It was said that a dam in Sichuan failed because of continuous heavy rain there. I became anxious, and woke up my wife. We started to watch out for the water level.

At around 9 o'clock, the water level to our front door was already high. I thought the speed of water level rise got too fast, that a large flood must happen in a short time. I asked my wife to pack our living necessities and called our officials. They soon came to us and observed the water level. At around 10 o'clock, they broadcasted alarm in the village.

Many villagers came to this street to observe the water level rise. The local officials were busy informing all households along this street to evacuate. At noon, the Maliutuo Bridge was washed away. People there shot a video and it was edited into a documentary by our local officials.

This street by the river was completely flooded. The main street approx. 10 meters above in the village center was also flooded. Water level reached half meter above the ground of the main streets. Some people were afraid that the water level would continue to rise, so they stayed overnight on the rooftops of other villager's housings and wait for the recede. Though I thought the flood was over, my wife and I still kept awake that night. As we were prepared, we had food, water and clothes with us, but still that night was cold and desperate.

On the morning of the next day, flood water receded. I could see the rooftop of my house at around 5 a.m. By the afternoon the water level was back to normal. We went back to our house.

Luckily the building structure was not damaged. But all the furniture was beyond repair. The goods were completely ruined. Our bedroom on the second floor was blocked by mud and other trash brought by the flood water. My property damage was approx. 30,000 yuan, half for the lost goods and half for our living articles. We helped each other and spent a week to clean up the mass in the neighborhood. I have some deposit, but several households had to borrow money to cover the expenses. I received 1,000 yuan compensation from "small enterprises foundation", food, water and 500 yuan from our local government for that week. It took more or less one month that our life back to normal, though some still have debts to pay. We don't usually apply for loan from the bank unless we can't borrow any from relatives or friends.

The market in our village was severely damaged. You can see it is still empty now, due to safety concerns. And the Maliutuo Bridge is also left unrepaired till now. People say that the local government is waiting for financial appropriation from the province or the central government."

Transcript C

Narrator: Ou Daiqun, male, age 69. He was a middle school teacher before retirement. He lives in Pianyan Village by Heishuitan River. In 2013, Ou established the Pianyan Folklore Culture Research Association, and self-published the book "Guahen Laokan"(English translation "Folklore of the Ancient Town"). This transcript records the oral history which Ou collected about a flood in Pianyan Village.
Date: 28th Mar. 2016
Place: In the office of Pianyan Folklore Culture Research Association in Pianyan Village

"It was on 23rd July (on Chinese lunar calendar), 1938, when the flood event happened. By local people, this event was referred as "Floodwater smashes Pianyan Chang" (in Chinese "Shuida Pianyan Chang".
In the morning, it started to rain heavily. According to the old people, if people put a washbasin outdoor and immediately draw it back without a pause, the washbasin would be full of rainwater. When people were having breakfast flash flood happened, but many were still sleeping. Along Heishuitan River there were landslides happening on the hills. Rice fields by the riverside were flooded. Farming tools were also flashed away before people react. Then the old street was flooded, and the water level soon submerged the ground floor. The architectures were built of wood, as a result some houses floated on the flood water.
Villagers were too astonished. Some cried and shouted and ran to higher hills or large fig trees. Some lost their lives when trying to collect their properties.
Then all of a sudden the Lvjia Dam failed. From one side the flood water on the old street started to recede and from the other side, a sudden water discharge came from Lvjia Dam. Almost all houses along Heishuitan River were flashed away, and 20-30 people as well. They don't know the exact number of casualty, as there were no statistics by that time.
A strange phenomenon happened in Weijia Yakou, to the upper stream beside Shengtian Water Reservoir. There was a natural gulf. On normal days, the gulf was empty, and rainwater would keep filling it. But on that day of flood, water gushed out from the gulf. The water from gulf intensified the flood down in the village. Old people interpreted the phenomenon as "dragon came out". They also elaborated their own sayings, that Dragons were good beings and would not trigger disaster, while Jiaos (flood dragon) were evil. Jiao would not accomplish their errand to the East Sea, but destroying farmlands as they pass by… But those are merely local legends.
The belief that flood was caused by dragon was also accepted by merchants who came to sell opium in the village. When the flood came, some merchants shot in water to "kill the dragon", but soon submerged in the flood.
Due to this flood, farmlands were ruined and never recovered. Buildings on the old street were slowly rebuilt during the past decades, but an ancient theatre (built in Qing Dynasty) was not restored. In 1833, villagers together built a Yuwang (an ancient king known for manage river and flood) Temple. Decades after Yuwang Temple's construction, there were no floods in Pianyan Village. The temple was maintained by Ou's family for generations, before the last maintainer died in the 1950s. The temple was destroyed during the Cultural Revolution. In the 2000s, villagers volunteered to repair the temple, and now it represents local culture and history."

Appendix IV Mental Mapping

Mental map was used for collecting information the local people could provide about the village they lived in. Base maps were printed out to facilitate the informants. Informants were encouraged to drawn on the map. In case the informants would not like to draw or write on the map themselves, the researcher asked them to point by fingers on where they wanted to mark, and wrote down the information they provided.

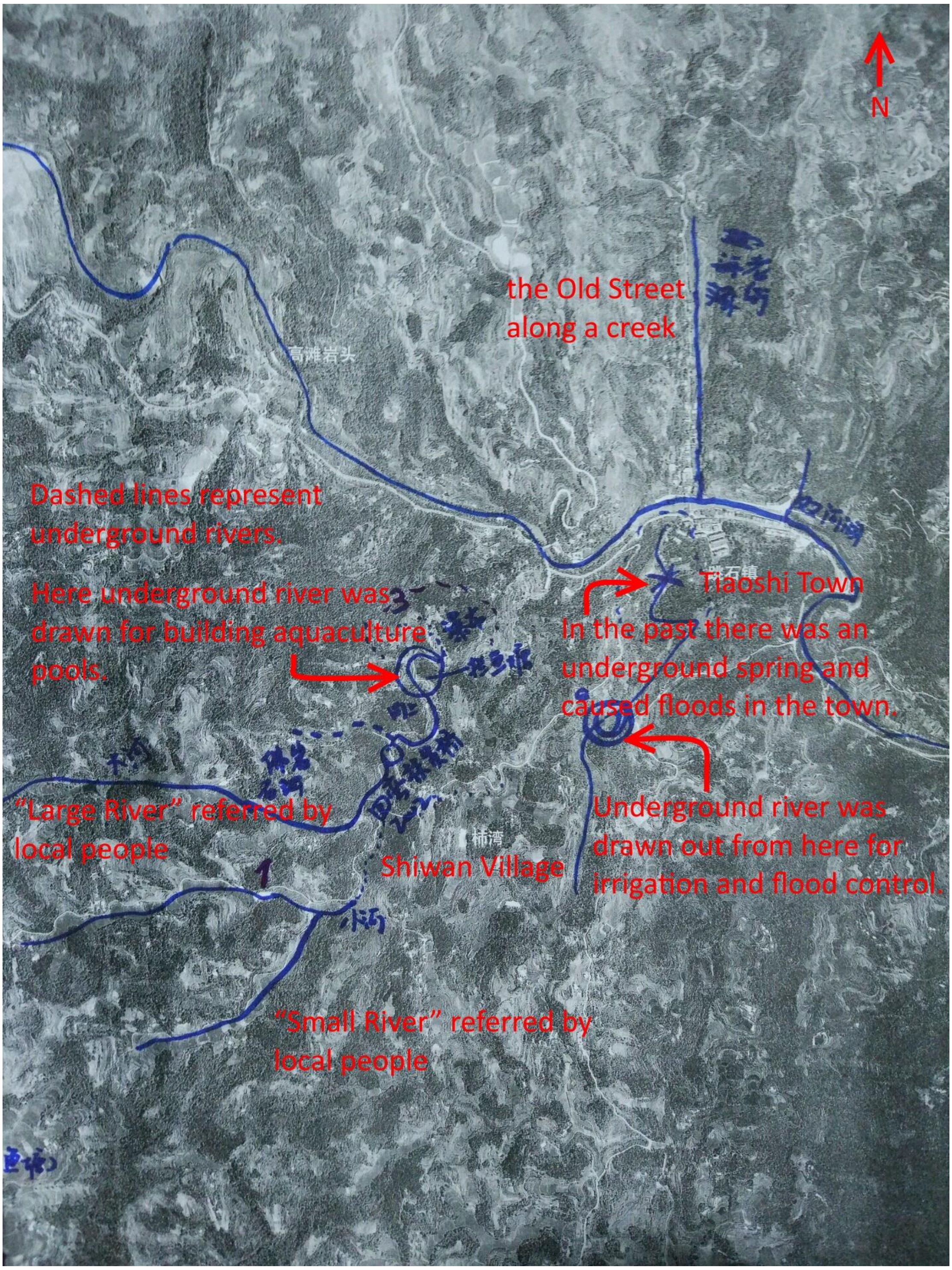

Figure 9.1 Mental map for Tiaoshi Town and adjacent villages

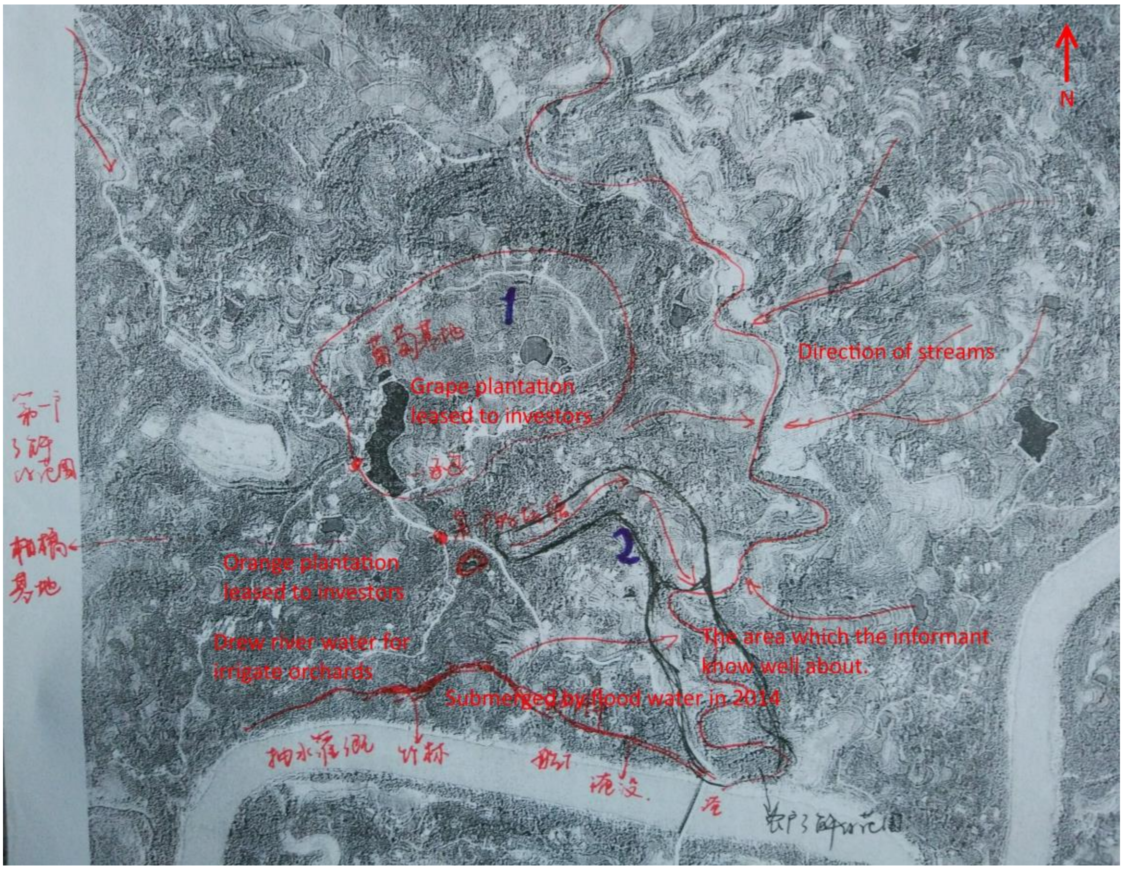

Figure 9.2 Mental map around Chongqiao Village and Lijiawan

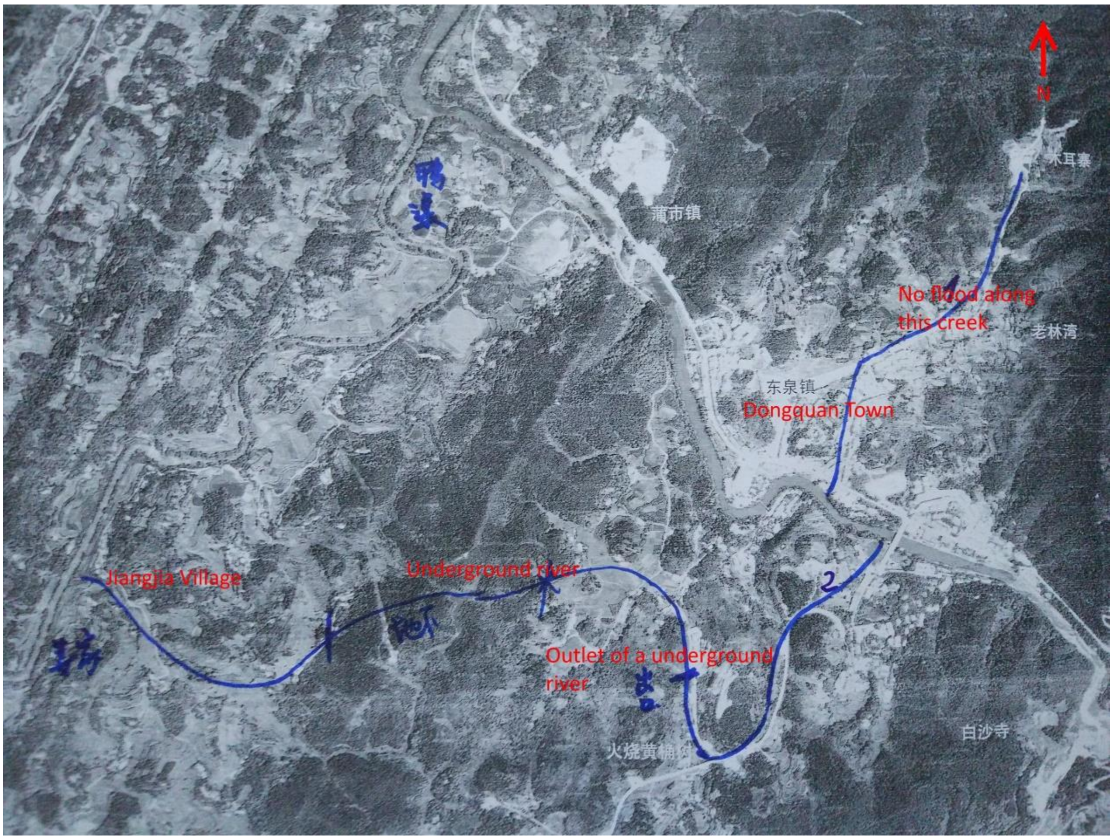

Figure 9.3 Mental map around Dongquan Town

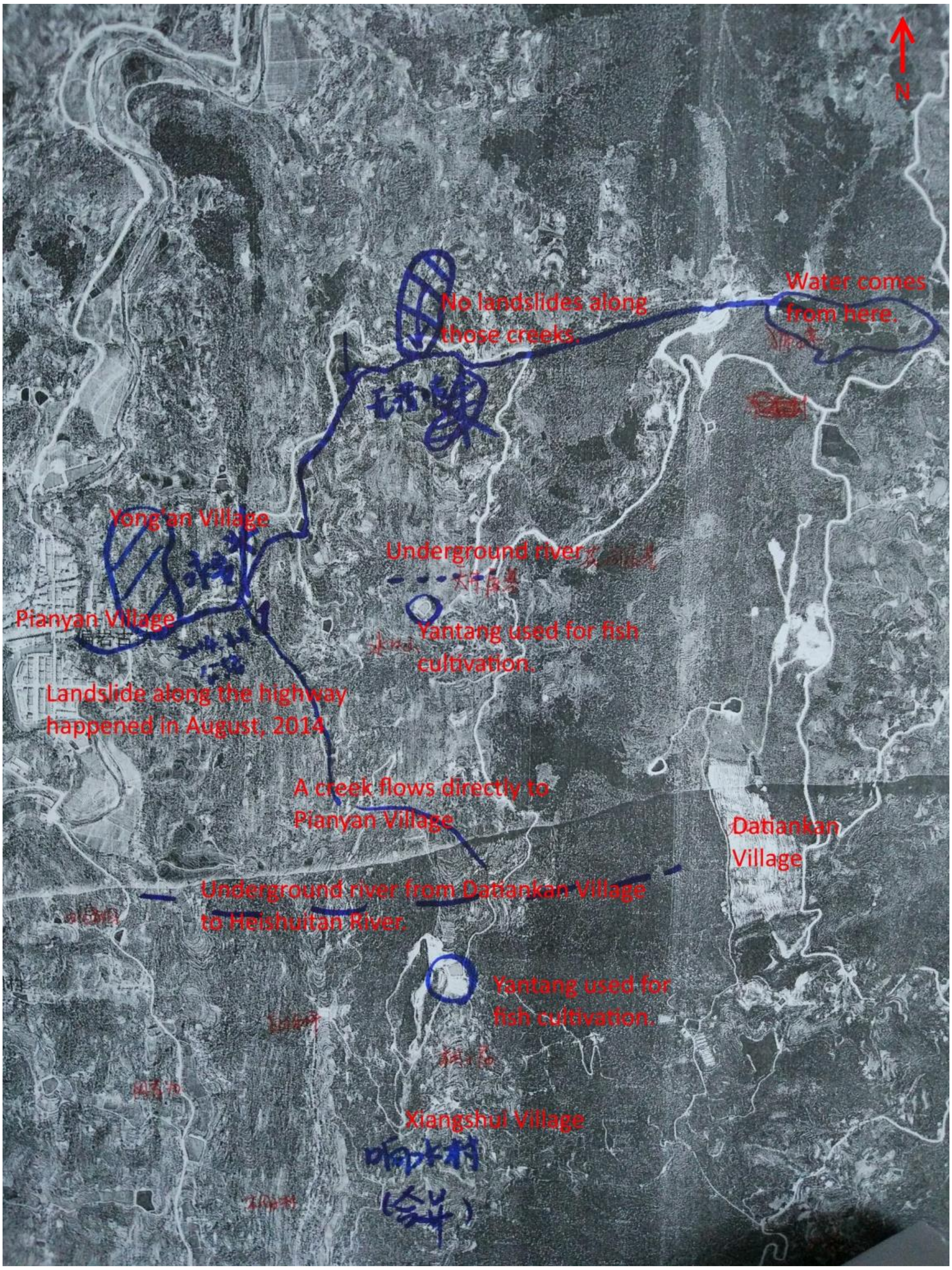

Figure 9.4 Mental map around Pianyan Village and Xiangshui Village

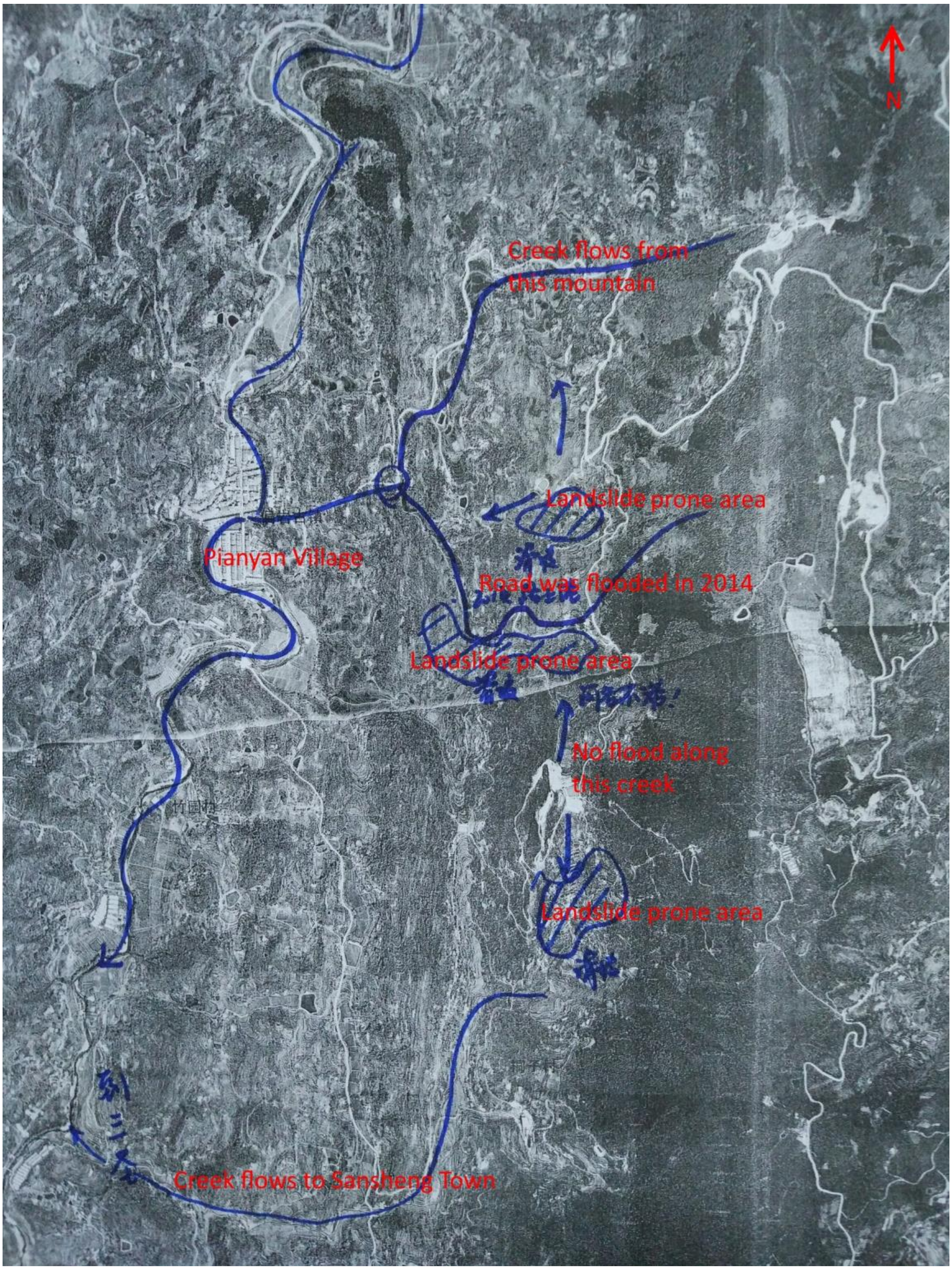

Figure 9.5 Mental map around Pianyan Village and Xiangshui Village

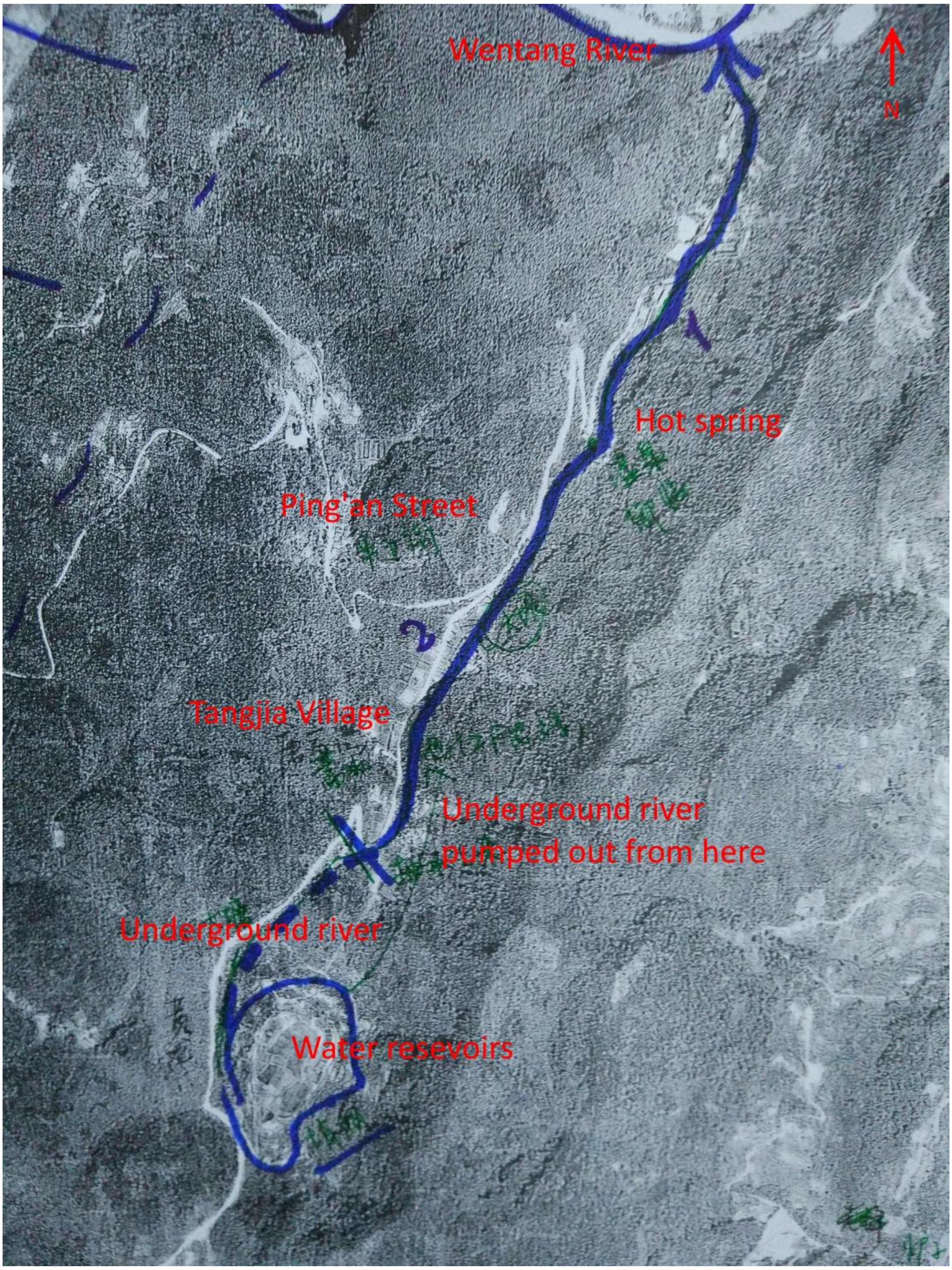

Figure 9.6 Mental map to the west of Tongjing Town

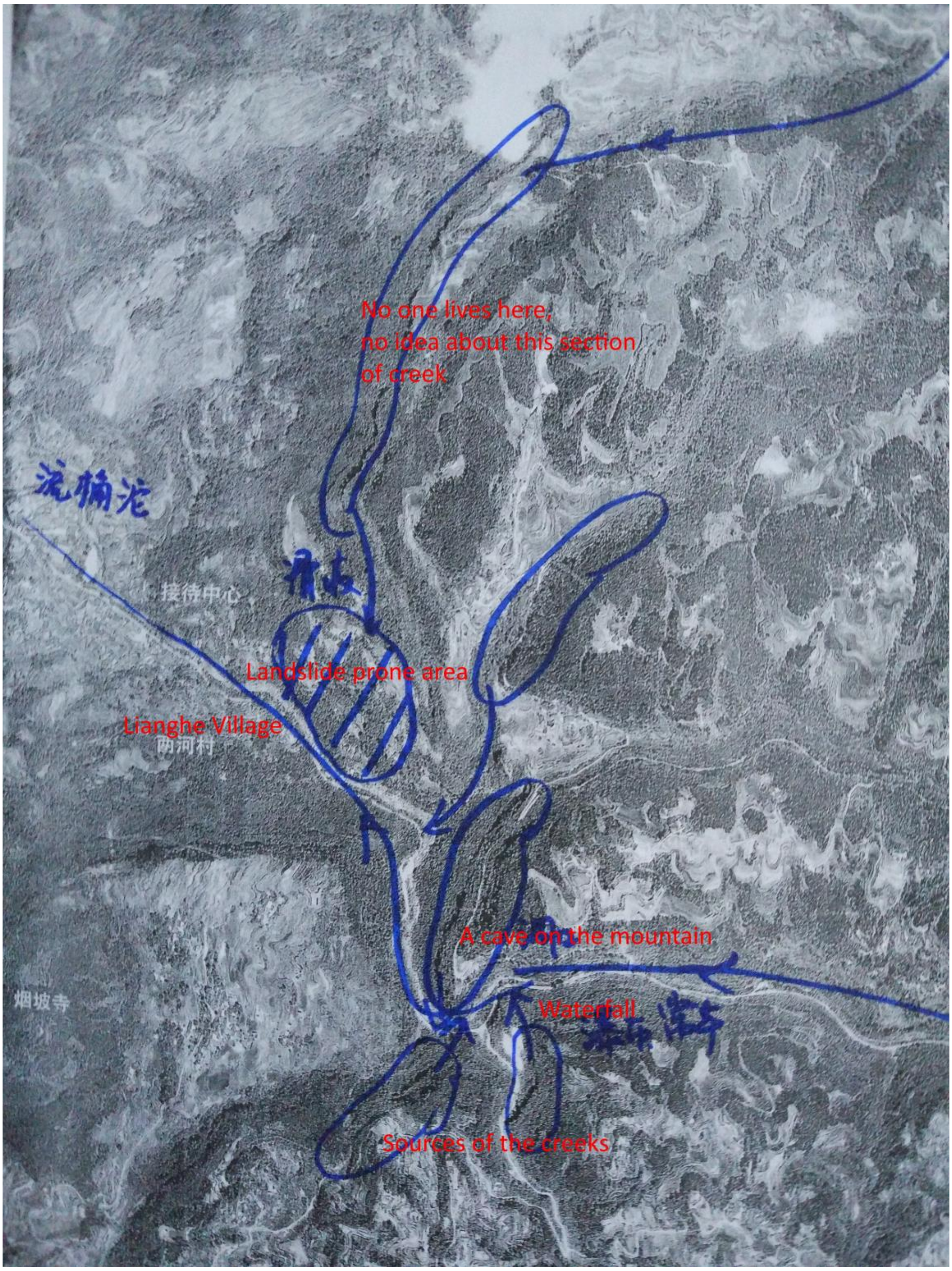

Figure 9.7Mental map in Dongquan Scenic Spot Area