

**Buying Time for the Farmers of Chengdu:  
Settlement Form, Labor Time Allocation, and their Implications  
for Resilient Land Use Planning in a Rapidly Urbanizing Region**

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**Abstract**

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The thesis explores differences among rural households in their allocation of labor to the different types of work – specifically food and non-food agricultural production and wage-jobs – and potentially related factors in the spatial transformation of a regionally distinct landscape: the densely populated settlements of scattered *linpan* housing in the Western Sichuan Plain around Chengdu, China. This study extends previous research that proposed indicators of agro-ecosystemic resilience based on landscape morphology in four communities exhibiting different degrees and types of change: (1) a traditional settlement form and a laissez-faire market-based practice of agriculture; (2) a traditional settlement form and an alternative community-supported agriculture (CSA) program; (3) a government-led Socialist New Countryside (SNC) redevelopment with a traditional field pattern and new housing in semi-concentrated settlements; and (4) an extreme example of SNC concentration of new housing and corporatized agricultural production. A new survey of residents in the first three of these communities finds that residents in the traditional settlements (1) and (2) tend to participate in a balance of

agricultural production and non-farm wage-jobs, while residents of the SNC redevelopment tend to engage in only one or the other type of work. This finding helps further interpret data on household income, household expenditures and debt from the previous survey for the same communities. The findings imply that the *linpan* landscape, with its traditional agro-ecosystemic diversity and decentralized network of social and marketing relations, may support a more dynamic and locally responsive choice of livelihood for rural households, than the newer, more concentrated housing settlements do. The dynamic balance partly explains the mechanisms of resilience of the *linpan* landscape and suggests that planning should find ways of supporting development within the spatial framework of this landscape rather than replacing it with completely new settlements.

# TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b>9</b>
1.1	PROBLEM STATEMENT.....	9
1.2	RESEARCH METHOD AND SCOPE .....	14
1.3	OUTLINE OF THESIS .....	17
<b>2</b>	<b>LITERATURE REVIEW: INTRODUCING RELATED KNOWLEDGE.....</b>	<b>18</b>
2.1	THE CONTEXT OF CHENGDU REGION AND THREE RURAL DEVELOPMENT MODELS .....	18
2.1.1	<i>Historical context of the rural areas of Chengdu region and the development of the linpan system.....</i>	<i>18</i>
2.1.2	<i>Recent challenges in rural areas of Chengdu region and two responsive rural development models.....</i>	<i>23</i>
2.2	RESILIENCE AS A METHODOLOGICAL FRAMEWORK FOR RESEARCH ON THE <i>LINPAN</i> SYSTEM .....	29
2.3	PREVIOUS RESEARCH: EXPRESSIONS OF DIFFERENT DEVELOPMENT APPROACHES IN SETTLEMENT FORM AND LANDSCAPE MORPHOLOGY .....	31
2.4	THEORIES AND PREVIOUS FINDINGS ON RURAL LABOR ESPECIALLY IN EAST ASIAN COUNTRIES .....	35
<b>3</b>	<b>SURVEYS OF HOUSEHOLD LIVELIHOOD AND LABOR ALLOCATION IN PI COUNTY: EXPLORING THE SOCIAL DIMENSIONS OF CHANGE IN THE <i>LINPAN</i> LANDSCAPE .....</b>	<b>37</b>
3.1	COMPARISON METHOD .....	37
3.2	TWO SUCCESSIVE SURVEYS .....	39
3.3	DATA COLLECTION.....	40
3.3.1	<i>Selection of variables.....</i>	<i>40</i>
3.3.2	<i>Data collection: the second cross-village survey.....</i>	<i>42</i>
3.3.3	<i>Data processing .....</i>	<i>44</i>
3.4	STATISTICAL TOOLS .....	46
3.4.1	<i>Comparisons among three villages.....</i>	<i>46</i>
3.4.2	<i>Comparisons between each two villages.....</i>	<i>46</i>
3.5	LIMITATIONS.....	46
3.5.1	<i>The limitations of the research framework .....</i>	<i>46</i>
3.5.2	<i>The limitations of sampling.....</i>	<i>47</i>
3.5.3	<i>The limitations of statistical tools .....</i>	<i>48</i>

<b>4</b>	<b>DISCUSSION: POSSIBLE RELATIONSHIPS BETWEEN SETTLEMENT FORM, ITS TRANSFORMATION, AND HOUSEHOLD LABOR ALLOCATION .....</b>	<b>48</b>
4.1	SUMMARY OF THE STATISTICAL RESULTS.....	48
4.2	ANALYSIS BASED ON THE STATISTICAL RESULTS AND THE RELATED KNOWLEDGE.....	49
4.2.1	<i>The role of labor bifurcates: doing a dual-work or transforming to be a professional .....</i>	<i>49</i>
4.2.2	<i>Question one: how the linpan system supports the dual-work feature.....</i>	<i>50</i>
4.2.3	<i>Question two: why people in the concentration form change their behaviors to do a single work .....</i>	<i>52</i>
4.3	TWO KEY ELEMENTS FOR RESILIENCE MAINTENANCE IN THE LABOR ALLOCATION OF THE <i>LINPAN</i> SYSTEM.....	54
4.4	SUGGESTIONS FOR FURTHER RESEARCH .....	55
<b>5</b>	<b>CONCLUSIONS.....</b>	<b>56</b>
5.1	MAIN FINDINGS ON HOUSEHOLDS’ ALLOCATION OF LABOR IN DIFFERENT VILLAGE MODELS .....	56
5.2	AN IMPORTANT VALUE OF THE <i>LINPAN</i> LANDSCAPE’S RESILIENCE IN LABOR ALLOCATION: FIGHTING FOR TIME .....	58
5.3	POLICY IMPLICATIONS.....	59
	<b>BIBLIOGRAPHY .....</b>	<b>63</b>
	<b>APPENDIX 1: THE QUESTIONS OF THE SURVEY .....</b>	<b>67</b>
	<b>APPENDIX 2: THE LIST OF THE FUNTIONS IN THE DATA PROCESSING.....</b>	<b>69</b>
	<b>APPENDIX 3: THE DETAILS OF THE STATITICAL ANALYSIS .....</b>	<b>72</b>
1.	THE RESULTS OF VARIABLE SCREENING .....	72
2.	THE RESULTS OF KRUSKAL-WALLIS ONE-WAY ANOVA .....	73
3.	THE RESULTS OF MANN-WHITNEY U-TEST .....	75

## LIST OF FIGURES

FIGURE 1 RESEARCH FRAMEWORK.....	15
FIGURE 2 LOCATIONS OF THREE STUDY AREAS .....	16
FIGURE 3 SATELLITE PHOTOGRAPH OF THE LINPAN LANDSCAPE .....	20
FIGURE 4 THE CONFIGURATION AND THE TYPES OF THE LINPAN SETTLEMENTS .....	20
FIGURE 5 A PORTION OF THE ECONOMIC LANDSCAPE OF THE LINPAN SYSTEM .....	22
FIGURE 6 THE MULTI-SCALE RELATIONS OF THE LINPAN SYSTEM .....	23
FIGURE 7 CHENGDU'S URBAN AND RURAL FACTOR MOVEMENT FRAMEWORK.....	25
FIGURE 8 A SIMPLE REPRESENTATION OF THE ADAPTIVE CYCLE .....	31
FIGURE 9 THE SUMMARY COMPARISON OF SPATIAL PATTERNS IN FOUR STUDY AREAS .....	33
FIGURE 10 A CANONICAL MODEL OF BACKWARD-BENDING LABOR SUPPLY CURVE.....	35
FIGURE 11 COMPARISON OF MEDIAN SUBSIDIES PER HOUSEHOLD (RMB).....	53
FIGURE 12 COMPARISON OF AVERAGE DEBT PER HOUSEHOLD (RMB).....	53
FIGURE 13 COMPARISON OF COMPONENTS OF HOUSEHOLD EXPENDITURE IN LAST 12 MONTHS .....	54
FIGURE 14 A HEATMAP OF THE VARIABLE SCREENING BY INTER-CORRELATION ANALYSIS .....	72
FIGURE 15 COMPARISONS OF THREE STUDY AREAS IN FOUR VARIABLES.....	75
FIGURE 16 COMPARISON OF PERCENTAGE OF CULTIVATED LANDS IN FOOD PRODUCTION PER HOUSEHOLD AMONG THREE VILLAGES .....	77

## LIST OF TABLES

TABLE 1 DISTURBANCES OF THE STUDY AREAS .....	17
TABLE 2 THE LIST OF VARIABLES IN THE STATISTICAL ANALYSIS .....	41
TABLE 3 LIST OF VARIABLES EMPLOYED IN KRUSKAL-WALLIS ONE-WAY ANOVA .....	73
TABLE 4 RESULTS OF KRUSKAL-WALLIS ONE-WAY ANOVA.....	73
TABLE 5 RESULTS OF PAIR-VILLAGE COMPARISON BY MANN-WHITNEY U-TEST.....	76

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# 1 INTRODUCTION

## 1.1 PROBLEM STATEMENT

This thesis is a new step in a series of studies by students and faculty of the University of Washington (UW) and Sichuan University (SCU), researching changes in the traditional *linpan* rural settlement form of the Chengdu Plain in Sichuan Province, southwest China. This thesis builds mainly on previous work by Jennifer Laura Tippins (2013) that measured indicators of resilience in the landscape of four settlements in Pi County, between Chengdu and Dujiangyan (details in section 2.3). In summer of 2014, a cross-village survey has been carried out for data collection on 12 issues, such as the household income, the labor timing budget, the changes of arable land leases, and so on (details seen in the section 3.2.2). Based on all the previous work, this research focuses on the allocation of the labor of households and tries to contribute to the series of research with more knowledge on the mechanisms of resilience of the *linpan* system.

The Chengdu region, known in China as a “heavenly state” due to its wealthy rural areas with the high productivity of various kinds of food and other agriculture products, faces a challenge of sustainability of its rural development. The historical abundance in food production has been made possible by the two-thousand-year old Dujingyan irrigation system (details in section 2.2.1) and its associated *linpan* landscape (details in section 2.1.1). But since the 1970s, and especially during the past decade, new chemical agricultural inputs, and then the rapid globalization and industrialization of the Chengdu region, has degraded the *linpan* landscape’s historic virtuous cycle. On the one hand, the food production in Chengdu region has declined recently, from 8,100 ton/hectare in 2008 dropping to 6,259 ton/hectare in 2011 (data from the Chinese National Statistics Bureau). This decrease is probably partly due to changes in popular diet that increased demand for meat and eggs and reduced grain production, and partly because urban sprawl has encroached seriously on arable land. Thirty-thousand acres of arable land were converted into urban land from 1998 to 2004 (Li 2005; Ji 2001). Also, more profitable and labor-saving non-food commodity crops, like flowers and nursery plants, have replaced all forms of edible crops, converting another thirty-thousand acres to nurseries in 2004 (Ren 2004). Young laborers have left the rural areas for wage-earning jobs elsewhere, generating the serious social problems of neglected elderly and children left behind in rural areas. Chengdu area schools report 103,600 left-behind children in 2005, or 15.8% of all students at rural schools (Zhou 2008).

To deal with the crisis of the rural development of Chengdu region, proper and effective policies and the applicable models or alternatives of the rural development are urgently needed for a better decision-making. Currently, there are a variety of rural development approaches, or alternative models, that co-exist in rural areas of the Chengdu region. For purposes of the current series of studies, UW and SCU have examined four approaches involving different degrees and types of intervention. These approaches are: (1) a *laissez-faire* individual household-based form of development that leaves the traditional *linpan* settlement pattern of scattered housing and patchy fields relatively intact; (2) the government-initiated Socialist New Countryside (SNC) program that relocates residents to new houses in more concentrated settlements and (3) also reorganizes and consolidates their former housing plots and fields; and (4) a non-governmental community-supported organic agriculture (CSA) model that preserves the *linpan* pattern. All of these models have advantages in some ways but disadvantages in other ways. Key to the earlier studies was the position that each of these approaches holds on a spectrum of dispersal-to-concentration of housing.

The traditional *linpan* settlement pattern (details in section 2.1.1) has developed and evolved for thousands of years since the construction of the ancient Dujiangyan irrigation system in upstream of Chengdu region. This type of landscape characterizes much of the rural plain around Chengdu, and has supported the abundance of region's agriculture production. It has developed several features, such as the high population density in small settlements surrounded with a highly diverse agro-ecosystemic environment to produce different products and the high-density networks of the marketplaces for the trade of the products, to maintain an adaptive capacity of food production. But recently, this model is decaying, partly due to the challenges of the rapidly regional urbanization and industrialization, and partly due to the replacement of the SNC settlement model hereafter. So whether this landscape can serve as a model for future development remains a question.

The SNC settlement model (details in section 2.1.2) is the result of a top-down Chinese government-sponsored campaign of "Constructing a Socialist New Countryside" in 2005 (Liu 2012) with the purposes of sharing the fruits of economic development with the farmers and narrowing the gap between urban and rural development. The municipal government of Chengdu promoted this campaign in an innovative way based on the Chinese Land Administration Law (Amended in 2004) and the national policy of Linking the Increase in Land Used for Urban Construction with the Decrease in Land Used for

Rural Construction (No. 138 [2008] of the Ministry of Land and Resources). Chengdu's SNC settlement model adopted a mechanism to transfer part of the development right from the rural homestead lands to the urban development lands. Accordingly, farmers in this model are encouraged to relocate from their scattered *linpan* settlements to a newly built, concentrated residential zone. Their vacated homesteads then become available for conversion to cultivation, thus allowing other cultivated land to be developed for urban uses without causing a net loss of arable land. In a country like China with a national law to constrain the expansion of the construction land and maintain a minimum area of arable land for national food security, the saved development right from the rural areas can be transferred into the urban land uses, such as industry parks and residential developments. Developers put a price on such rights by bidding for coupons representing a certain amount of land area to be converted. The value gaps between the urban and rural land uses are realized through this development right transferring process, and then part of the realized capitals flow back to the rural areas for the construction of the new concentration residential zones and the subsidies for the farmers who transfer their development right. In addition, farmers are also encouraged to rent out and concentrate together their individually small pieces of arable lands to the agricultural companies or the big farming households for the development of larger-scale agriculture. Because of the innovation that utilized the current laws and policies to achieve the goals of the balanced development between the rural and urban areas, this model won a lot of applause. It became a national pilot model for Coordinating Urban and Rural Development (Liu 2012), and then spread rapidly by the local governments' vigorous promotion.

However, implementation of this model has slowed down recently due to the decline in the real estate values in the Chengdu region. This is because to launch the cycle of transferring the development right from the rural homestead lands to urban land uses, farmers need to move into the newly built, concentrated residential zones at first to save up the transferable development right, which requires borrowing a great amount of capital before their new houses can be built. Repayment of these debts depended on the future increase of urban land values after transferring the development right. As the urban real estate market stagnated, the sustainability of this model is also questionable.

The third model (details in section 2.1.2), the *linpan* settlements with the community-supported agriculture (CSA) program, is derived from the bottom-up experiment run by an NGO named Chengdu Urban Rivers Association (CURA) (Loudon 2013). The CSA model was initiated at the beginning to

rehabilitate the upstream of Funan River, which flows through the downstream Chengdu city. The NGO adopted a village called Anlong to encourage the farmers there participating into the chemical free agriculture program to reduce the water contaminants produced by the industrialized agriculture productions, and then established the connections between the food producers and the urban customers to make the environment friendly agriculture sustained. This model is successful to receive plenty of praise for its contributions to the control of the agricultural pollutions as well as to the revival of the manually agriculture tradition. But the model is hard to replicate due to its disadvantages of the high labor input and the limited, niche food market that it relies on. So to what extent this model can be applied more widely is a question.

Three models above shed light on the potential policies, but much more knowledge is needed to make the proper implications of the models and associated policies. Insufficient knowledge on models may lead to risky results. For instance, the SNC settlement model is designed to achieve the scale economy in agriculture production but it also raised some other problems, one of which is that it replaced the *linpan* settlements and then might change the *linpan* landscape fundamentally if implemented too widely. Current SNC policy views the *linpan* landscape as “old fashioned” and an obstruction to the modernization of the rural environment, but actually it best fits into the regional Dujiangyan irrigation system in history and also contributes its potentials to an innovative way of upgrading the system to deal with a lot of current problems in rural areas, such as the deterioration of the agro-ecological environment which maintains the region with a high level of agricultural productivity. This deficiency of information made misunderstand both of the models and brought more other problems due to improperly implementations of the policies. Therefore, the incremental planning method may be more applicable in this complex context than the comprehensive one in terms of lack of enough certainty of the implication results. To apply this planning method, we should understand more how the systems function and monitor their changes after the specific policy implementation.

Moreover, the proper evaluation of these models is also problematic. The evaluation method requires a unified perspective and standard of value to make the proper comparisons among these models but this is not easy, especially for a system of complexity, like the problems of the rural areas of Chengdu region. It contains three domains of economy, society and ecology, as well as different scales from the *linpan* hamlets to the Dujiangyan irrigation and Chengdu region. This complexity cannot be simplified

as an established function, such as focusing on increasing the household income only, but a dynamic system, which asks for the proper management rather than for the simple model selection. For these reasons, the proper method of evaluation is critical.

The introduction of the concept of resilience provides a new research framework to understand a system of complexity such as the *linpan* system, as well as offers a method to evaluate the models and to track the changes after some policy implications for better modifications in future. Basically, resilience is the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks with the same identity (Walker 2012). The resilience provides a new way to look at the models and their advantages and disadvantages. It encourages managing the system of complexity in a dynamic state rather than solving a specific problem. If a village model with some degree of resilience, we may not say it is a good model or not, but may concern how to persevere through continuous development in the face of change if the change is considered as undesirable, and how to innovate and transform change into more desirable configurations (Folke 2012). In this sense, all the models are useful in terms of what the changes or impacts we have, and we can manage the changes to maintain the system within or facilitate the system to transform into a preferable state. So the key of resilience is to understand what the capacity of each of the models is in a specific concern. Based on these understandings, the process of dealing with the proper policy issue is to comprehend the capacity of the system and the models, and then capture the key elements to properly manage the system.

For this purpose, the research group from the University of Washington has continued to do some related research for the past several years and on understanding the *linpan* region and its resiliency. There are two critical steps have been achieved. The first one is that four study areas in Pi County are selected to stand for different models: Jiang'an, the *laissez-faire linpan* settlement model; Anlong "CURA", the CSA model; "Anlong SEMI", a semi-concentrated version of the SNC that leaves land division largely unreorganized; and Zhanqi, an extreme version of the SNC approach that concentrated all housing in one place and consolidated and reorganized all fields. And next, several data collection and research have been done on these four villages. Some of the work, completed in last year, was a milestone for the progress of the research on resilience of the *linpan* region. This critical research, done by a master student at the University of Washington, Jennifer Laura Tippins, pushed forward resilience research on the *linpan* model. She selected one sample area of the cultivated lands from each of the

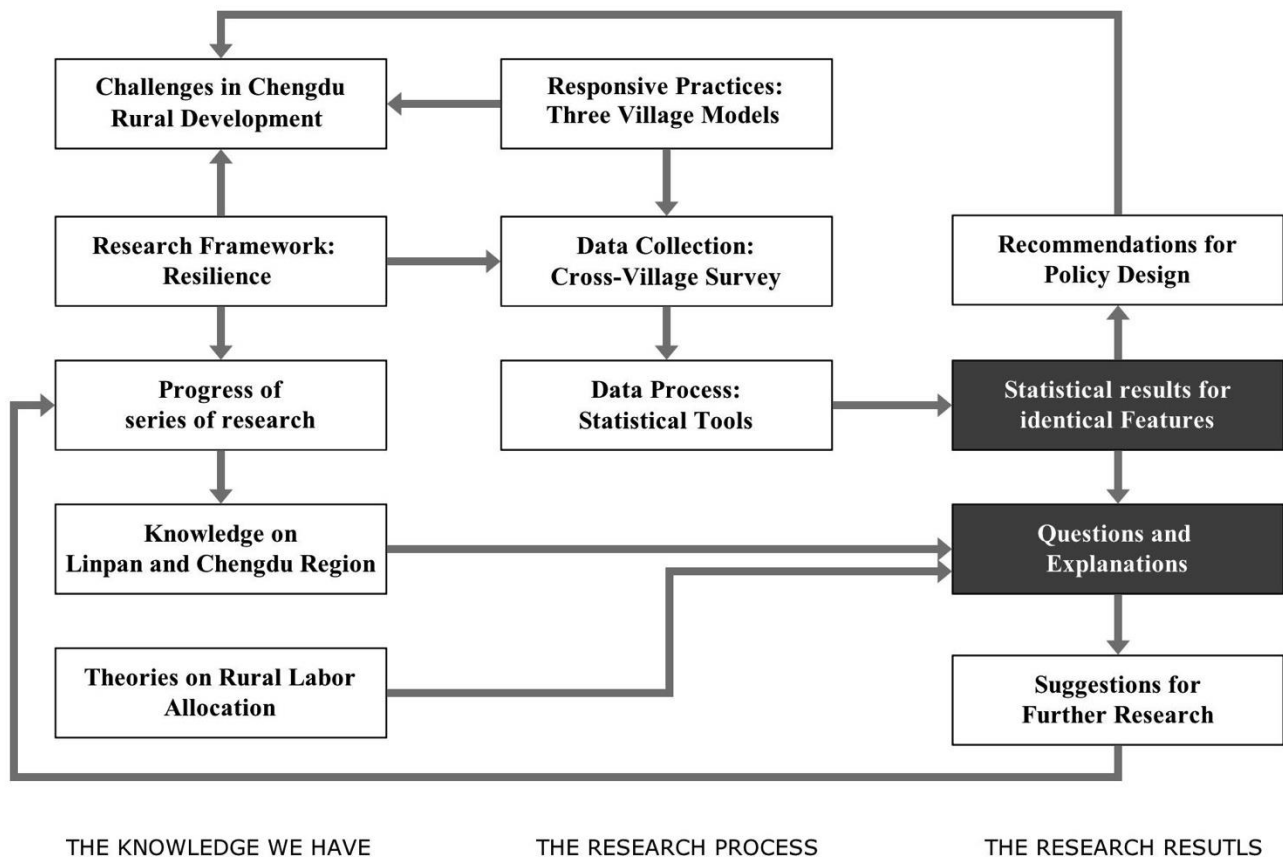
villages above, and then evaluated the selected area according to indicators of resilience based on research in other agro-ecosystems. She quantified how the different landscape types, from the CSA settlement to the SNC settlement, varied in the degree and presence of features of resilience.

Based on this finding, there is more research needed for the further study. Her research implies a hypothesis that differences in the spatial morphology of the landscape may correspond with differences in socio-economic activity, and that this correspondence adds to our understanding of what makes different spatial development approaches more or less socio-ecologically resilient. The allocation of labor is one factor in socio-economic resilience. For the reasons above, my research focuses on the question: **how do individual rural households adjust the allocation of their labor in a *linpan* landscape, in comparison to the other different rural development models available in the Chengdu region?**

## 1.2 RESEARCH METHOD AND SCOPE

The purpose of this research is to understand more the mechanisms of the rural labor allocation in the *linpan* model, and then use the new knowledge for some proper policy implications in the rural development of Chengdu region. To achieve this research purpose, three tasks are needed. The first task is to comprehend and introduce the related knowledge we have already had from the previous research into this new research. The knowledge includes the context of Chengdu rural development and three models, the concept of resilience as a research framework, the general features of the *linpan* system, the previous progress of the series of the *linpan* research, and the theories and empirical findings of rural labor allocation in Asian countries. The next task is to capture the different features of the labor allocation in three rural development models. The basic method for this task is to compare labor allocation in three study areas. The comparison method comes from the research framework of resilience (details in section 3.1), and the three study areas have been identified as the typical study objectives respectively representing for the three rural development models in previous research. For the comparisons, a survey across three study areas were carried out for data collection and the statistical tools, including the Kruskal-Wallis One-way ANOVA and the Mann-Whitney U-test, are introduced for data processing. The last task is to give a possible explanation for parts of the mechanisms of the labor allocation in the *linpan* system, based on the accumulated knowledge from the previous research and the new findings in this research. Some of the new findings with more confidence contribute into the policy

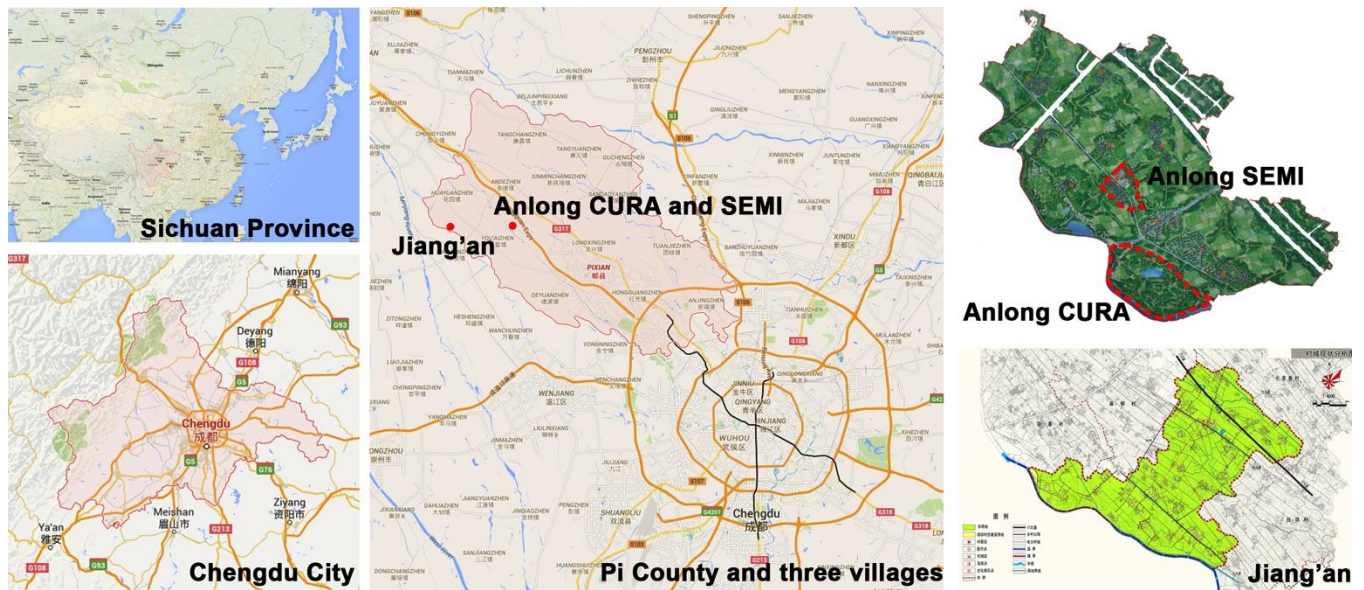
implications, and some with less confidence to the future research recommendations of the series of research.



**Figure 1 Research framework**

For research purpose and method, the research scope focuses on three study areas, including Jiang'an, Anlong CURA, and Anlong SEMI, for two reasons. First, the three study areas share a similarly regional context but with different degrees of resilience identified in the previous research. They are all in Pi County where is within the first tier (around 35 km away from the center of Chengdu city) of rural areas of the Chengdu region. Within this tier they all face with some similar degree of impacts of the regional urbanization and industrialization. Also, all of the three villages are close to each other and the location difference as a factor can be limited within a small range. Meanwhile, the previous research and work demonstrated that three villages are different in resilience in term of agro-ecosystem, and have distinct features to represent for distinct village models. Second, related surveys and data collection on these

villages provided valuable information that made the further research more viable. For these reasons, these three villages are selected as study areas in this research and the scope of research centers on the three villages with their locations shown in Figure 2.



**Figure 2** Locations of three study areas

For my research, one thing needing mention is my choice to exclude further study area of the most extreme SNC example at Zhanqi, which was included in Tippins’s study. For my study, I was interested in focusing on the possible effects or associations of labor allocation specifically related to the relocation of residents to new, more concentrated housing, and how that might express itself in the context of an otherwise un-reorganized landscape. This is the case for Anlong SEMI, but not for Zhanqi, which involved not only the concentration of housing but also the reorganization and consolidation of fields as well as the reorganization of employment according to the conversion of the village collective into a share-holding enterprise with an industrial park built around the settlement. While in fact it is impossible to “control” for other possible factors that may be in effect in the other cases, Zhanqi seemed too much of an outlier. In retrospect, this would have been a good reason to include it after all, as all of these cases are actually just that: cases, rather than representative samples of the region’s whole landscape.

In any case, the three study areas listed above are taken as data samples for my research. Their basic characteristics are shown in the Table 1 below.

**Table 1 Disturbances of the study areas**

Study areas	Disturbance	
	Community-supported agriculture	Propelled concentration form
Jiang'an	✗	✗
Anlong CURA	✓	✗
Anlong SEMI	✗	✓

### 1.3 OUTLINE OF THESIS

**Chapter 2** provides the research context and the related knowledge that helps understand the research topic, including the details of the rural development models studied in the Chengdu region (details seen in the section 2.1), the concept of resilience as the research framework and the method (details seen in the section 2.2), the progress of the previous research on resilience of the *linpan* system (especially the progress contributed by Jennifer Laura Tippins; details seen in the section 2.3), as well as the related theories of the allocation of the labor of farmers, such as the backward bending labor supply curve and empirical findings of the rural labor allocation especially in East Asian countries (details seen in the section 2.4).

**Chapter 3** gives more details about how to capture the new features of the rural labor allocation in the *linpan* system. First, it discusses the research method of comparison in detail (seen in the section 3.1). Second, it gives more details of the first round survey (seen in the section 3.2). Third, it offers more details on data collection and processing, including detailed reasons for the sampling and surveys, as well as several steps of the data processing (details seen in the section 3.3). Forth, it introduces two statistical tools and gives details on how to apply them in the research (details seen in the section 3.4). Fourth, it discusses some limitations of the research framework, sampling, and statistical tools (details seen in the section 3.5).

**Chapter 4** presents a possible explanation of the differences of the allocation of the rural labor in different study areas based on the statistical results and the knowledge we have. First, it shows the summary of the statistical results (details seen in the section 4.1 and appendix 3). Next, it interprets the statistical results to shed light on main findings of the allocation of the rural labor in different village models (details seen in the section 4.2). And then the findings point out some key elements of the *linpan* system that support its resilience in the rural labor allocation (details seen in the section 4.3). At last, it

also includes suggestions to do more research on the unclear questions that the research cannot cover (details seen in the section 4.4).

**Chapter 5** summarizes the findings and discusses the value of resilience in the *linpan* model (details seen in the sections 5.1 and 5.2). It also gives some policy implications for the rural development in the Chengdu region based on the findings and the recognized value of resiliency of the *linpan* model in this research (details in the section 5.3).

## **2 LITERATURE REVIEW: INTRODUCING RELATED KNOWLEDGE**

### **2.1 THE CONTEXT OF CHENGDU REGION AND THREE RURAL DEVELOPMENT MODELS**

#### **2.1.1 Historical context of the rural areas of Chengdu region and the development of the *linpan* system**

The Chengdu region, or Chengdu Plain, in the western parts of Sichuan is considered one of the most productive agricultural landscapes in the world (Luo 2011; Tippins 2013). As Ferdinand von Richthofen commented in “Baron Richthofen's Letters, 1870-1872”, there are few regions in China can rival with the Chengdu Plain as regarded wealth and prosperity, density of population and productive power, fertility of climate and perfection of natural irrigation (Richthofen 1872). All of the prosperity was gifted by a great irrigation system named “Dujiangyan” and its associated village system called “*linpan*”.

The Dujiangyan irrigation project is a world-heritage site at northwest of Chengdu Plain, riding on Min River, one of the biggest tributaries of Yangtze River, China. This irrigation infrastructure built in 256 BC by Qin governor Li Bing, and it is still in use to irrigate over 5,300 square kilometers of lands in the region (Zhang 2006). One feature of this irrigation system is to construct an artificial levee, instead of building dams, to redirect a portion of the river's flow and then to cut a channel through Mount Yulei to discharge the excess water upon the dry Chengdu plain beyond (Zhang 2006) to allocate water differently according to the high or low flow at different seasons. Apart from the main levee that separates the channels, the entire irrigation district's design is that it functions without levees or dikes; water is controlled entirely through channeling, which allows regular reinvigoration of soil fertility with fresh silt during flood seasons. The cost for this reinvigoration is that this non-dam irrigation system requires annual retrofitting works to maintain its functions, because without the dams, the sediments

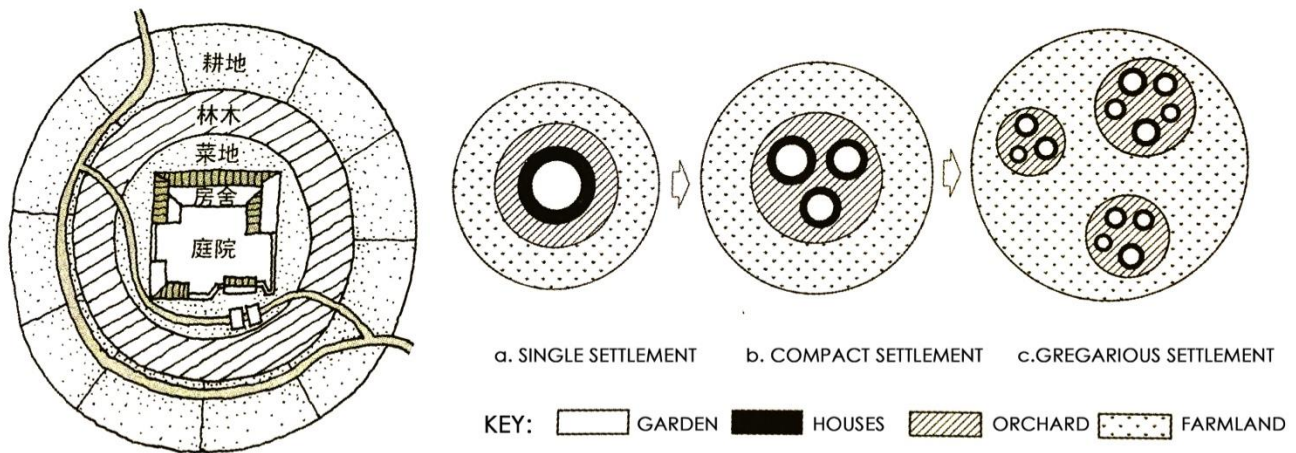
from the upstream areas are needed to clear out annually. The maintenance works are divided into two parts. One critical work is to maintain every year the three main head-works to discharge sediments and then control floods (Jin 1998). This activity has developed as a local ritual, organized by the government and the water district administration. Another is to mobilize and organize farmers to contribute distributed, low-cost (non-specialized) maintenance with significant local autonomy in decision-making. Farmers who benefit from the system carry out related plans and tasks on maintenance of the branch channel system (Jin 1998). These works consume a huge amount of labor inputs as a whole, but if which divided among a large population would not be burdensome, since individuals can fit the maintenance work into their intensive daily agriculture work. Therefore, the relations between the irrigation system and the rural development are that the irrigation system contributed to the high productivity, also to the resilience to extreme weather events and unusual seasonal weather patterns, and then supported the high density of population, and on the other hand, a great part of the maintenance of the irrigation system required a huge amount of labor inputs.

Rural farmers would contribute their labor necessarily to the system maintenance; otherwise they would not get enough irrigation water for their fields. This bundled relation facilitated the development of the unique *linpan* landscape form. The irrigation system favored the development of the almost even productivity of the fields because of the consistently dispersed irrigation branch channels. Under this condition, on the one hand where the farmers live is not determined by the differences of the productivity of the fields but how to yield crops more efficiently. So farmers might prefer to live in the center of the fields to make agriculture production convenient by minimizing the working radius. On the other hand, the lack of dikes and levees asks for the maintenance of the evenly dispersed branch channels, which require a great amount of consistent labor inputs. These two reasons tend to facilitate farmers live separately and their dwellings tend to disperse evenly to respond to the spatial distribution form of the irrigation system. This is quite different from the other flat areas of China with relatively even distribution of resources as well as similar arrangements of irrigation ditches, like the Pearl Delta and the Yangzte Delta, which actually do not require the intensive maintenance of the irrigation channels comparing with the Chengdu region. Therefore, one to five or so dwellings cluster together as a small settlement. The small settlement is named as “*linpan*”, which is characterized by a dense-but-dispersed settlement and spatial form, while in contrast, most rural settlements in China exhibit a concentration of dwellings surrounded by agricultural fields and resource lands (Tippins 2013).



**Figure 3** Satellite photograph of the *linpan* landscape

Source: google maps, Chengdu, Sichuan, China, 2015.



**Figure 4** The configuration and the types of the *linpan* settlements

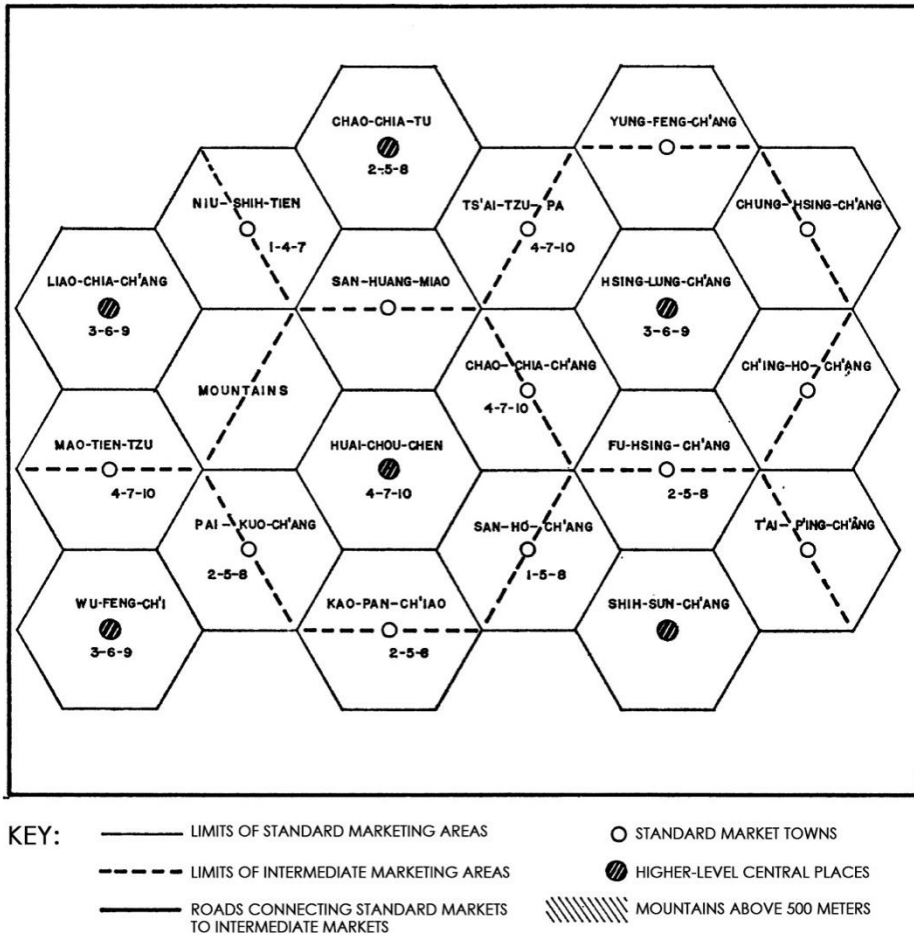
Source: Fang 2013.

The *linpan* means forest basin in Chinese. This name implies another unique feature of this rural settlement form. Within the working radius (200 meters), there is high variety of environmental elements, across from the groves and shrubs to the paddy fields and ponds (Fang 2013). In the center of

a *linpan* settlement, there are normally one or two, sometimes several dwellings with their yards in center. Small groves and bushes (around 30 % of lands covered by groves and bushes dotting in paddy fields) cluster surrounding the dwellings, and beyond the groves, there are paddy fields and small ponds with the tiny irrigation branch channels running through. Farmers working in this environment take advantages of the ecosystem services to yield various agricultural products at a low cost by performing the multi-functions in the process of agriculture production. Farmers can produce a lot of things, such as bamboo for building houses and food (Fang 2013), firewood and fruit, shrubs for medicines and decorations, and ponds for fishes and frogs due to the variety of the environment. Moreover, the patchiness of agro-ecosystem develops an intra-service web to make the production at a low cost. The groves supply a habitat for birds and other small animals, which can protect the rice from insects and mice in a large degree (Li 2009). Besides, some of the rice growing in paddy fields may drop into the water and feed the fishes living there, and the waste of these fishes can reciprocally provide natural manure to the grains. The fishes, shrimps and even snails living in these paddy fields and ponds are raised as farmers' food and valuable goods for trade. Also, the chicken raised under the bushes can be fed with the grains and fruits as well as some insects. The web of intra-services works well to increase the productivity of agriculture.

The high productivity of agriculture generated chain effects on the development of Chengdu region. The abundance of agriculture production facilitated the increase of population and then the increase of the density of the *linpan* settlements. The high density of the settlements and farmers supported a well-developed network of marketplaces surrounding the settlements for the trade of the various agricultural products. The evenly dispersed settlements conduced to the evenly distributed marketplaces (seen in figure 3 below), which in turn contributed to the convenience of the regular visits of the farmers (the distance between different marketplaces is as close as 5-8 kilometers; Fang 2013). The high frequency of the interactions between the *linpan* settlements and the marketplaces encouraged the development of the market economy in Chengdu region and the farmers got more market preference feedbacks from the marketplaces to adjust their agriculture production. On the one hand, the abundant products from the *linpan* settlements, including grains, economic products, breeding products, and crafts, facilitated a lot the prosperity of the marketplaces; on the other hand, the marketplaces became social centers for people exchanging materials and information in teahouses, guildhalls, ancestral halls, and temples (Skinner 1964). Even though the high density of population in this region brought the pressure of livelihood,

farmers can adjust their productions by the mechanism above to balance their lives somehow. The abundance of leisure time in rural areas of Chengdu region, compared to rural life elsewhere in China, has influenced the development of the famous Chengdu's leisurely and comfortable urban culture. Therefore, the rural-urban cultural distinction may be harder to draw in Chengdu than elsewhere, even though the urban-rural environmental distinction is so clear.



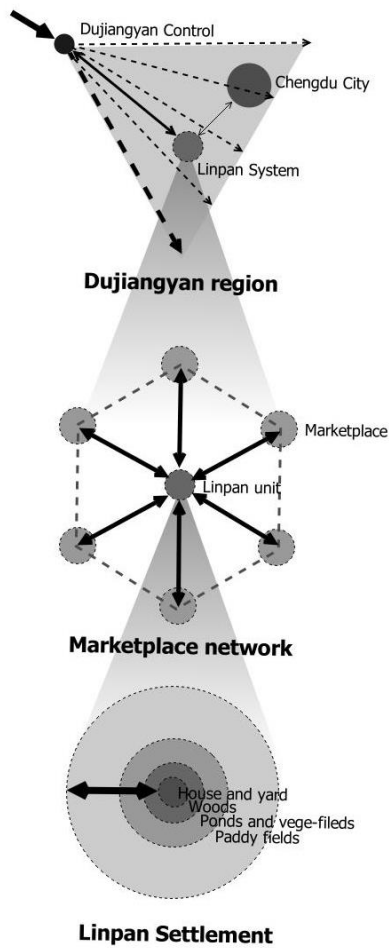
**Figure 5 A portion of the economic landscape of the *linpan* system**

*Note:* G. William Skinner firstly demonstrated that the distribution of the marketplaces in Chengdu region was in line with the Central Place theory created by Walter Christaller (1933) and modified by August Lösch (1954).

*Source:* Skinner 1964.

In sum, the Chengdu region, gifted by the Dujiangyan irrigation system, is a place born to producing foods (Thorp 1936). The high productivity of fields in this region generated a unique *linpan* system with the spatial feature of high density and even dispersion. Within a *linpan* settlement, there is a high

diversity of agro-ecosystem to contribute variously agricultural products. Beyond the settlements, a well-developed web of the marketplaces connects the farmers with each other in a way of trading products and sharing information. Farmers living in this region are endowed with a capacity of adapting their livelihoods by adjusting the agricultural products to respond to the market feedbacks.



**Figure 6 The multi-scale relations of the *linpan* system**

Source: Made by author.

### 2.1.2 Recent challenges in rural areas of Chengdu region and two responsive rural development models

Similar to other developing countries under its rapid urbanization process, the most important characteristic in China is a distinct dual economic structure: the coexistence of advanced modern sectors of prosperous cities and traditional backward rural areas (Lewis 1954). The Chengdu region shares the

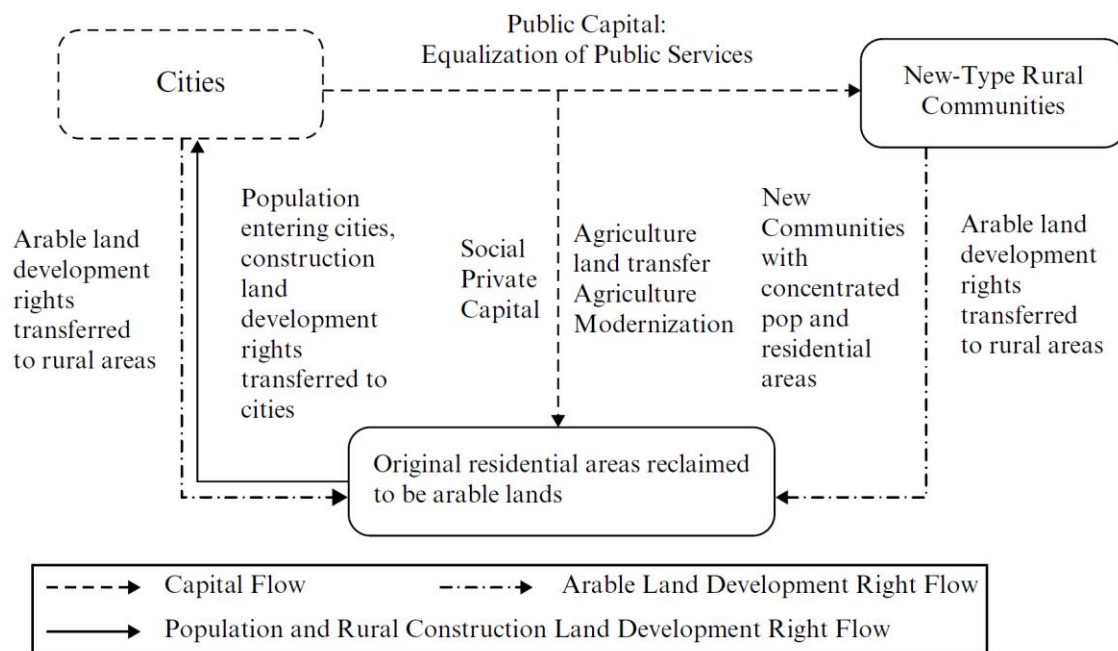
similar gap between its urban and rural areas, but the gap problem here is less serious than many other metropolitan areas in China. On the one hand, the Chengdu city has ranked the fifth-competitive urban economy in China and the top one in Southwest of China in 2014, according to the latest annual report of “Blue Book of Urban Competitiveness” issued by the Chinese Academy of Social Science.

Accordingly, the urbanization rates are 69.4% in Chengdu region compared with 44.9% in Sichuan Province in 2013 according to the data from Sichuan Province Statistics Bureau, and during 2007-2012 the urban population increased 1.6 million in Chengdu (*data source*: Sichuan Development and Reform Commission 2014). On the other hand, the rural areas are experiencing some transition process.

Although the grain production in Chengdu region has continued running down for a decade (seen in section 1.1), the loss of laborers has not been such a serious condition as the grain production drop. Only 60 thousands population migrated from the locally rural areas to Chengdu city during the same period from the year of 2007 to 2012, comparing the 1.6 million new urban immigrants (*data source*: Sichuan Development and Reform Commission 2014). The food production or the agriculture production changed a lot without the correspondingly rural population draining. Therefore, the Chengdu region faces a different challenge of mixture of the rapid urbanization process and the significant drop of food production, rather than the universally rural decaying problem that some other rural areas have in China.

To narrow the universally urban-rural development gap, the Chinese national government sponsored a campaign of “Constructing a Socialist New Countryside”. To respond to this national campaign and deal with the local challenge mentioned above, the Chengdu municipal government innovated on the implementation of the policy of New Rural Redevelopment and in 2007 became a national pilot zone for Coordinating Urban and Rural Development (Liu 2015), which emphasizes on taking the physical constructions of villages as a strategy to improve the infrastructure and service facilities, the environmental quality and the level of farmers’ livelihood, and through these constructions to console the gaps between the urban and the rural areas (Wang 2006). This top-down policy impacts significantly in rural development, especially when it is combined with the great transforming trend in mainly urban areas, where experiencing the rapid and drastic triple changes together: globalization, industrialization and urbanization process (Ye 2013). The Chengdu municipal government, seizing the policy opportunities and riding on the great transforming trend, innovated a local policy (similar to the transfer of development right applied in a lot of urban areas of the United States) to concentrate farmers living together and then to save individual curtilage and transform these saved lands into urban use, like

industry parks or real estate development, and even arable lands. This innovation can expand the urban areas to provide more lands, for which the rapid development in Chengdu city is eager, without transgressing the national Arable Land Preservation Law via transferring the development right from the saved one by moving farmers from the scattered, low density dwellings to the concentrated, higher density residential zone. And at the same time the farmers can benefit from transferring the development right from lower value use, like agriculture production and homestead use, to a higher value use, like industry and urban residential use. In addition, the arable lands are also concentrated to achieve scale economy in agriculture production to ensure the grain production. For these advantages, it spread rapidly (Ye 2013).



**Figure 7 Chengdu's urban and rural factor movement framework**

Source: Ye 2013.

This innovation in Chengdu region did not ensure to cover the locally urban-rural development gaps as expected as the national and the local governments advocated. Since the implementation of the Chengdu's experiment, however, the gaps in general between the urban areas and the rural areas of Chengdu has enlarged rather than reduced for the last decade, even though some experiments indeed succeeded somehow, like the specific case of the village of Zhanqi. The annual income per capita of

rural residents in Chengdu region grew from 4,072 RMB in 2004 (the year before China's Eleventh Five-Year Plan, details can be seen in below paragraph) to 10,394 RMB in 2012, but during the same period the annual income per capita of urban residents in Chengdu city increased from 8,972 RMB to 27,194 RMB (*data source*: Chengdu Statistics Bureau). Also, the scale economy may not be applicable in agriculture production, especially in Chengdu region, and then concentration of arable lands may not be a proper way to promote the agriculture productivity (Huang 2011). The continuous decreasing trend in food production did not reverse after the spread of the experiments. If the SNC experiment took little account for its implementation goals, the main reason for its widespread should stem from the logic of the capital flows, which fulfilled the interests of the urban developers as well as some wealthy rural farmers. The Chengdu's experiment has established institutions and mechanisms to promote the movements of population, capital and lands between urban and rural areas as part of its coordinated urban-rural development program (Ye 2013). The development right transfers to the urban areas and the capital for using the right in turn flows back to the rural areas. But the results of this experiment actually left a lot of issues unfixed, suffered by others. For example, the subsidies for the farmers who transfer their lands may not get enough to sustain their livelihoods (He 2010). Also, the cycle of exchanging resources highly depends on the development of the real estate market. Sometimes, the villages had to invest a lot at first to build the newly concentrated settlements for farmers to move in from their original houses, and then demolished the old houses to generate the saved individual curtilage lands. So the debt financing was generated and it highly relied on the development of the real estate market in Chengdu city. This brought a high risk to the rural areas, which have a much weaker economic base comparing with the urban areas. Moreover, the SNC movement in Chengdu region changed the unique *linpan* landscape in a draconic way that removed the settlements from the traditional settlements to the concentrated residential zones and changed fundamentally the way of agriculture production from the individual-based to the large-scale farming (Xiaoyi Yang 2011; Yan Wang 2014). The rapid disappearance of the *linpan* landscape brought a lot of awareness on the SNC model (Zheng 2008). Moreover, some other concerns below shed light on the chance of the rejuvenation of the *linpan* settlement model.

Another main concern of the rural development in China focuses on the agriculture production. The Green Revolution of agriculture has influenced greatly the development of Chinese agriculture production and the productivity increased significantly since 1980s. Since highly relying on the

agricultural machinery and the chemical products, such as the pesticides and the fertilizers, it also caused other negative byproducts, like the agricultural pollutions to soil and water (Zhang 2004), as well as the issue of food safety (Gong 2013). The seriousness of this problem increased in China due to the loosely controls and the lagged management on the use of chemical products. The serious problems exist in Chengdu region as well.

An NGO named as Chengdu Urban Rivers Association (CURA) found the value of the *linpan* landscape form in dealing with the challenges of the agriculture pollution to water. In 1992, the Chengdu city government launched the Funan River (running through the Chengdu city center) Project to clean up the river, and over the next decade invested a lot on pollution management, flood control, housing and infrastructure programs, and the construction of a greenbelt along the length of the river (Loudon 2013), which was praised as a greatly improvement in urban built environment. However, it emerged that the majority of Chengdu's river pollution did not originate in the city, but was the result of pollution from agriculture productions upstream. Then the Chengdu Urban Rivers Association (CURA) was formed in 2003 to address this problem, many of whose senior staffs were previous project leaders and participants in the Funan River Project (Loudon 2013). In recognition of the role of agricultural production in polluting rivers, CURA chose to focus its efforts on partnering with a group of ecologically-minded farmers in Anlong Village, around 40 kilometers upstream from Chengdu, as a new eco-village model to demonstrate how to rehabilitate water quality in the Funan River.

CURA supported Anlong villagers in practicing organic farming. Farmers found a way to replace the chemicals with the form of Bio-Gas digesters and urine diverting toilets (a Swedish invention) to provide the renewable energy to farmers' daily use and to reduce the waste. They also introduced the man-made wetlands, learnt from the features of the traditional agro-ecosystem, to filter the pollutions from the fields to river water. Besides, seasonal rotations of fields and growing different crops alongside one another allows for soils to replenish over the year (Faylo 2014). All of these newly developed infrastructures and farming methods made living more affordable and greener in Anlong village than the formerly chemicals relied way that the farmers used to since Green Revolution introduced into this region. In addition, a return to some of the more traditional ways of farming was important for raising enough crops and getting enough income to make a living. To support the organic food production and the environmental preservation, CURA, in cooperation with another NGO of "Partnerships for

Community Development”, brought farmers and urban consumers together (Schumilas 2014) to develop a Community-supported Agriculture program that helps farmers connect with urban consumers looking for chemical free produce and food. The CSA program invited urban customers to try their own hands at farming at Anlong village. This fulfills CURA’s desire to educate people about what they can do to protect the environment, and helps to create an urban-rural relationship that gives urban residents an appreciation for the work behind the food on their plates (Maye 2012).

This model achieved some progress on the organic food production and the environmental preservation. At the beginning of the implementation of this model, the loss in yields when switching from factory produced chemical fertilizers to natural methods was substantial, because the natural services required a certain period to recover and then to function. But over several years, a return in the natural investment paid off the loss in changing the models and benefited the farmers as expected with the supports of the CSA marketing program (Maye 2012). Also, the pollutants in water reduced in this CSA village than its concentrated neighbor. In 2013, Jenna Pang, a UW undergraduate student, tested the water quality in the irrigation channels within the Anlong CURA village and she found that water running through the organic agricultural area had fewer pollutants than water running past new concentrated housing development.

Therefore, taking all the models in Chengdu region at hand, the next question is whether the spatial forms of settlement associated with New Countryside Construction or the traditional *linpan* landscape with or without the CSA program are more or less conducive to the multi-goals, such as the governmental goal on the urban-rural development gap reduction as well as the non-governmental ones like environmental activism and food safety. And further, whether individuals in different models have an alternative paths that helps achieve their better lives when realizing the above goals that the models desire. To answer these questions, we need to get much more understandings on these models and their implications. Then first, **a compatible research framework** is needed to deal with complexity of the *linpan* system and the achievement of the multi-goals, and second, more studies on **the model evaluation and the underlying mechanisms** of the *linpan* system should be carried out for better decision-making and policy implementations.

## 2.2 RESILIENCE AS A METHODOLOGICAL FRAMEWORK FOR RESEARCH ON THE *LINPAN* SYSTEM

A resilience perspective helps establish a research and problem-solving framework to deal with the complexity of the *linpan* landscape. The dynamic interactions (among the various types of environmental elements as well as the settlements and the marketplaces) in the *linpan* region cross temporal (a long historical evolution of the unique landscape) and spatial scales (from settlements to marketplaces and then to the whole Sichuan basin). And these interactions are full of feedbacks and adjustments, and the relations between causes and results are not simply linear, but rather a back-and-forth process. A traditional method used in urban planning that views objects in a linear growing or shrinking way may not provide sufficient information on the complex *linpan* system for decision-making. Under this condition, the introduction of resilience may help provide an insight on the complexity of the *linpan* system and the problems at hand.

Resilience is the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks with the same identity (Walker 2012). So it does not simply talk about the growth of a system but its capacity and its identity. The purpose of this concept is to find a way to manage a system of complexity rather than to do a prediction or a projection for the future. From this point of view of resilience, the evaluation of the models in the Chengdu region is not to calculate or to predict whether a specific model can achieve or not some policy goals in the future, but to evaluate whether the model can maintain its original functions while absorbing the outside impacts. For example, one of the obvious functions of the *linpan* rural development model is to serve the high productivity of agriculture, and accordingly, the question in terms of resilience is whether the *linpan* model can maintain its agriculture production in face of the impacts such as rural labor draining and arable lands unification, which are two key elements in the *linpan* landscape to support its agricultural productivity.

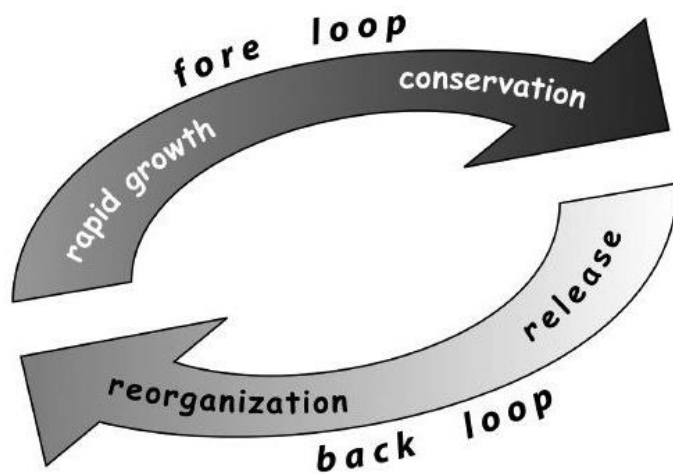
In addition, the policy implications of resilience should build upon the existing system. They do not intend to provide some new designs to solve the problems but to manage the system within a preferable state that can absorb the negative impacts. In this sense, resilience per se is not good or bad. Undesirable states of systems can be very resilient (Walker 2012), and sometimes it is not worth the effort to maintain the current system and sometimes it is not even possible. For example, if the NCS development model facilitates the soil contamination, resilience of the NCS model in this case is harmful, and then the mechanism of attracting more investments to help maintain this model in a more stable way should

be addressed. From this point of view, the resilience approach is concerned with how to persevere through continuous development in the face of change if the change is considered as undesirable, and how to innovate and transform change into more desirable configurations (Folke 2012). For example, if the *linpan* model fails to contribute the productivity of agriculture, which is considered as our preference, we may facilitate the *linpan* system to transform into a new state that adapts with the changes of the development of agriculture. One thing to mention here is that the transforming process is not to replace the original system as whole but to make it move to another state, within which new links are established based on the original conditions.

The basic framework of resilience follows two steps: understanding the complex system first and then managing the system staying within or transforming to a preferable state. To understand a system of resilience, the book of *Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function* offers six key terms as following: Self-organizing systems, Thresholds, Linked Domains, Adaptive Cycles, Linked Scales, and Adapting and Transforming (Walker 2012). The adaptive cycle is the key of the system of resilience, and it is defined by the thresholds and formed by the interactions and the feedbacks across the linked domains and scales. If the state goes beyond the thresholds, the dynamic cycle and all the related links will change together. Therefore we can understand the adaptive cycles better by capturing the thresholds. And if we understand the thresholds, we may better manage the system.

There may be several ways to capture the thresholds. First, the thresholds locate between different states and the comparisons of different states may help identify the thresholds between them. The SNC model and the *linpan* model, though within a same region, are different in a great degree, which even can be observed from a simple comparison in the differences of the spatial forms. For this understanding, my research then use the comparison method to serve a purpose of figuring out the differences in the allocation of the labor and then help understand how the *linpan* system functions. Second, among different states, there may be not only one but many thresholds related with each other. So the clue of capturing one threshold may be highlighted by another patent threshold. For example, the previous research done by Jennifer Laura Tippins validated that the arable lands in three village models have different degree of resilience in terms of agro-ecosystem. This finding may give an idea that the allocation of laborers in agriculture production may be accordingly different and can help understand the

system further. At last, the thresholds between different states of resilience are not stable - some of them can move because of other changes in the system (Walker 2012). If the system is still within a certain cycle, we can capture some thresholds by identifying their movements. For example, we assumed the CSA model does not change the *linpan* model fundamentally but reinforce the *linpan*'s agriculture function, so the comparison of the allocation of the labor between these two models may also contribute to understanding the mechanism that maintains the adaptive cycle. Therefore, the understanding of the concept and the theory of resilience shed light on **the feasibility of the methodology of comparison** in research on the *linpan* system of resilience.



**Figure 8 A simple representation of the adaptive cycle**

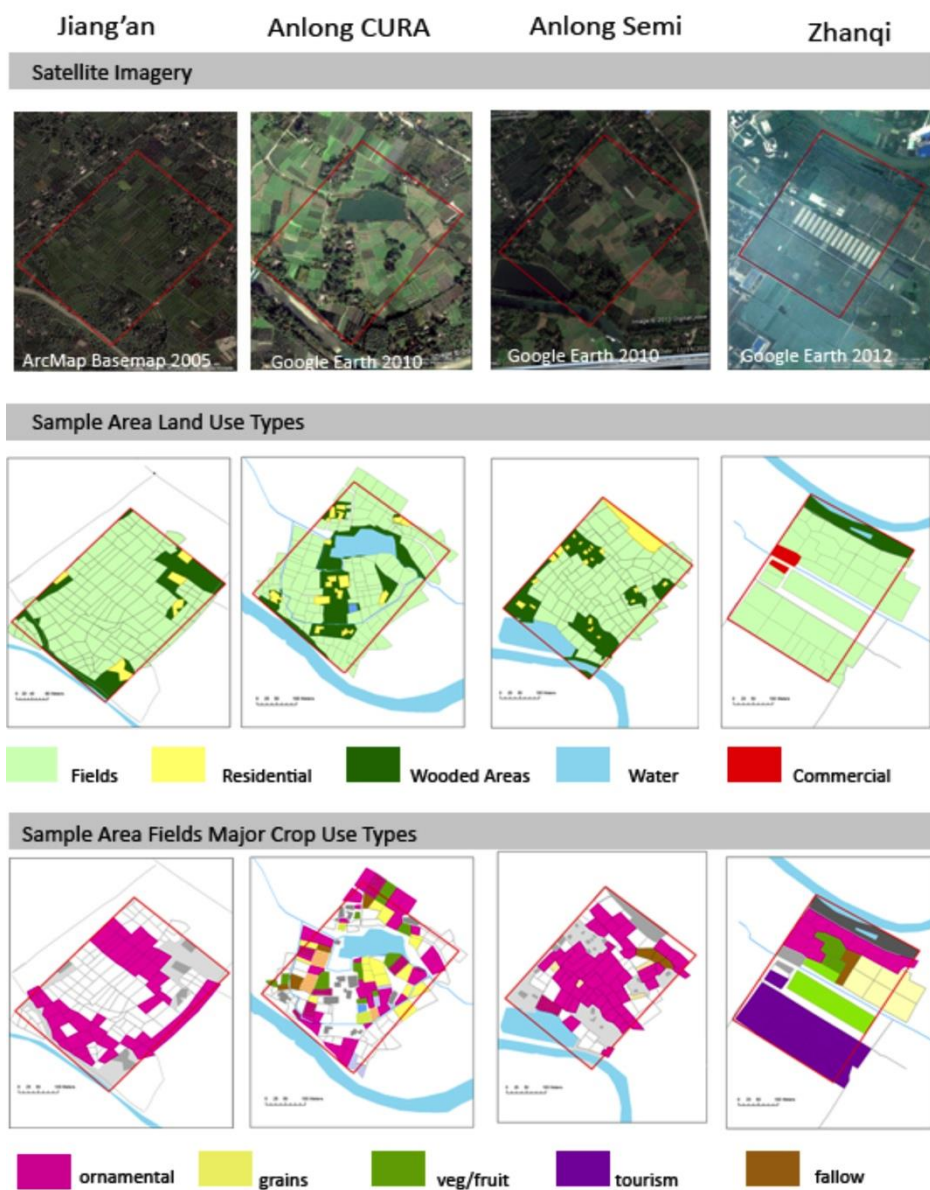
Source: Walker 2012.

### 2.3 PREVIOUS RESEARCH: EXPRESSIONS OF DIFFERENT DEVELOPMENT APPROACHES IN SETTLEMENT FORM AND LANDSCAPE MORPHOLOGY

The UW research group, cooperating with Sichuan University and other institutions, launched out the series of research on the *linpan* system of resilience several years ago. In 2013, a UW graduate student Jennifer Laura Tippins completed an important study and advanced the series of research onto a new stage. She introduced the concept of resilience to readdress the rural development issues in a long-term perspective rather than the short-term benefits that the drastic SNC movement mainly relied on. The long-term perspective changed the prejudice that the traditional *linpan* settlement model was old-fashioned to realize the “rural modernization” . Adversely, this introduced perspective refreshed an idea that the *linpan* model actually inherits some valuable

features from the historical evolution that can contribute to solve some important problems generated from the unmerited modernization, such as sustaining the productivity of the arable lands and the security of the agro-ecosystem.

In addition, she also measured and evaluated four types of settlement form and land use pattern, including the traditional *linpan* form, the eco-village form, the semi-concentration form and the extreme concentration form, via a quantitative comparison method. The evaluation did not serve for the decision-making purpose that requires some specific “values” of each model to indicate a best choice among the alternatives, but did update the knowledge on the characteristics of the *linpan* landscape form and laid a foundation of well-defined different research study areas, corresponding to the different rural development models, for further work. In detail, she developed three groups of indicators and measures, including appropriate scale, spatial heterogeneity, and biodiversity, based on the agricultural landscape structure that supports social and ecological resilience in other agro-ecosystems. Then she used these indicators and measures as well as the similar identities of the villages to establish a baseline typology to evaluate the four models across three scales (sample area scale, intermediate scale and village scale) from the perspective of the landscape pattern. She found that the eco-village model in Anlong best meets indicators of traditional landscape structure that support resilience. The extreme concentrated model in Zhanqi deviates the most from the traditional landscape structure. More details are shown in the figure below.



**Figure 9** The summary comparison of spatial patterns in four study areas

*Source:* Tippins 2013.

This research focused on field and settlement patterns that provide valuable information for understanding the differences in four study areas. In general, it seems that the field and settlement patterns should bundle together to account for the differences in the field pattern, not only the configurations of crop types in fields but also their distributions. We can see from the figure above

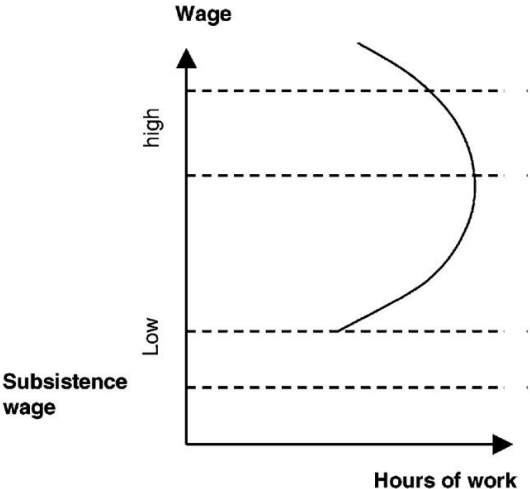
that both Anlong CURA and Zhanqi have the configuration of more crop types in comparison with the other ones Jiang'an and Anlong SEMI, but the distribution of these crop types in the Anlong CURA is scattered rather than concentrated in Zhanqi. If taking consideration of the different organizations of agriculture production applied in Anlong CURA and Zhanqi in comparison with Jiang'an and Anlong SEMI who without any specific programs, the CSA program indeed fits into the scattered *linpan* settlement pattern and helps maintain the corresponding diverse field pattern, and the agriculture industry in Zhanqi actually facilitates different kinds of agricultural products via a scale economy way which also corresponds to the concentration settlement pattern. Then it seems that, if without the corresponding agriculture organizations, the changes of the settlement pattern do not the trend of unification of the field pattern, like the similarity in field pattern of Jiang'an and Anlong SEMI. So are the Jiang'an and Anlong SEMI really as similar as the expressions of their field pattern? Or are there any other differences between them even though they look similar? In other words, it seems that only changing the settlement pattern does not affect a lot on changes of the field pattern. Is it true? Or actually are they significantly different in nature but just with the similar expressions of the field pattern for some other reasons? Likewise, it also seems that, if without specific agricultural program such as CSA, the *linpan* settlement pattern does not contribute to the diversity of the field pattern. Is it true? Or is it possible that the similar field pattern in Jiang'an is the result of more resilience but in Anlong SEMI is the result of less resilience?

In sum, the further questions are **how the settlement pattern associates with the field pattern and how the *linpan* pattern sustains the system with resilience and then how the changes of this pattern affects resilience of the system.** So the study areas for answering these questions should fulfill the following requirements of only changing the settlement pattern but without any agricultural programs or only introducing an agriculture program but without changing the *linpan* settlement pattern. Accordingly, the study areas can be targeted on Jiang'an (a *linpan* settlement pattern), Anlong CURA (a *linpan* settlement pattern with CSA program) and Anlong SEMI (a concentrated settlement pattern without any agricultural programs. Also, we have to explore more deeply, penetrating through the expressions of the landscape feature, to see what happens underneath. Jennifer Tippins shed light on a feasible way to discover the underlying mechanisms

that affect the expressions of the field pattern. She implied the labor allocation in agriculture production could explain somehow the differences in field pattern since rural laborers interact with the arable lands intensively in agriculture production. But if observing the labor allocation, we have to look at the picture broadly, not only the one allocated into agriculture production but also the one into other sections, like wage jobs. The reasons in detail are shown in the next section 2.4 of the associated findings on rural labor in East Asian countries.

**2.4 THEORIES AND PREVIOUS FINDINGS ON RURAL LABOR ESPECIALLY IN EAST ASIAN COUNTRIES**

The basic theory on how people decide to contribute more or less their labor to certain work uses the model of a backward-bending supply curve. The canonical theory of labor supply holds that, at low levels of income, the laborers respond positively to the increasing wage by continuing adding their labor input to work for the purpose of pursuing a satisfactory level of livelihood. The income effect will not stop functioning until the wage rate achieves a certain level that is high enough for the laborers to value other things, like leisure time, higher than earning more income, and the amount of hours of work with this high wage rate can just enough provide the sufficient income to achieve the satisfactory level of livelihood for the laborers. Beyond this wage rate, the laborers tend to work fewer hours even though increasing the wage rate, because the increase of the wage rate will contribute to more income per hour and then the labors can work less hours to achieve the same satisfactory level of livelihood. The figure 7 below shows the entire supply curve bends backwards like a C-shape (Dessing 2002).



**Figure 10 A canonical model of Backward-bending labor supply curve**

*Source:* Dessing 2001.

There are some debates on the application of this theory into the labor of farmers. Some economists concerned that farmers do not respond positively to market incentives in the form of increasing labor input to agriculture production if the price of agricultural products runs up. That is because farmers may not be maximizing profits but instead maximizing utility, such as diversifying the products for various daily uses rather than increasing the amount of products. This phenomenon is called the subsistence economy (Waters 2007). For example, the farmers living in the traditional *linpan* settlements may not continue increasing labor input into and expanding the arable lands for grain production, if they have got enough grains for their personal consumptions, even though the price of grains continues rising. But some other economists argue that under the subsistence level economy, farmers tend to behave according to the backward-bending supply curve notion (Huang 1976) to survive. This argument highlights that the farmers may have a different level of satisfactory income much lower than the laborers in an urban market economy, because there are less goods for trading in rural areas and then the farmers can survive easily only by the yields from the agricultural products.

Moreover, other empirical findings pointed out that previous studies on the labor of farmers have concentrated on farm activities and ignored off-farm activities (Huang 1976). In terms of off-farm activities, farmers may adjust to changing economic incentives not only by altering crop forms but also by adjusting labor efforts off of the farm. For example, the phenomena, that the young farmers tend to leave away the rural areas in Chengdu region for wage jobs in Chengdu urban areas and East coastal cities due to better payment than the agricultural activities, corroborates the argument above. The point here is the subsistence, which can be achieved from the farm activities in history, cannot be achieved any more only from the farm activities now, and then the farmers respond favorably to an economic stimulus of doing off-farm activities, such as going out for wage jobs. If farmers have limited aspirations, it is perhaps due to the limited economic opportunities surrounding them (Huang 1976). In other words, the subsistence levels can move if the farmers become involved more deeply in the urban economy.

These theoretical and empirical findings can be applied to explain somehow the phenomenon and features of the allocation of the rural labor in East Asian countries. Basically, the rice-based agriculture tradition characterizes the household labor behavior in most of East Asian rural areas as a semi-

commercial family farm with a competitive labor market (Ahh 1981). On the one hand, the rice-based agriculture provides various products to maintain a basic level of subsistence. For example, some rural areas in Thailand and Malaysia can produce grains, vegetables, construction materials and meats to fulfill the basic needs of the households. So the laborers in this context share the features of own-consumption of farm-produced goods. But on the other hand, the impacts of urbanization to the rural areas, especially the ones close to major urban areas, make the laborers change their behaviors due to the changes of expectations of the subsistence introduced by the urban market economy. This commercialized way is as more similar as the case in the *linpan* region that the marketing has been an important part of rural Chinese life for a long time from the early 20th century Chinese farm economy (Skinner 1964). There are several phenomena happen in East Asian countries. One was the process of transforming significantly the rural laborers from the rural lands into manufacture, or into service activities that are not agricultural (McGee 1982), because the increase of subsistence level makes the farmers respond positively to the incentives of higher wages in manufacture. Second, in agriculture production, the farmers tend to increase production of cash crops for both industrial and urban demand (MaGee 1982). This could be a similar condition in the *linpan* region, and the theories of the labor allocation would help interpret the underlying mechanisms explored in this research.

### 3 SURVEYS OF HOUSEHOLD LIVELIHOOD AND LABOR ALLOCATION IN PI COUNTY: EXPLORING THE SOCIAL DIMENSIONS OF CHANGE IN THE *LINPAN* LANDSCAPE

#### 3.1 COMPARISON METHOD

My research question restates as follows: **how do individual rural households adjust the allocation of their laborers in a Lipan region, comparatively, for each of the different rural development models available in Chengdu region, China?** To answer the aforementioned research question, the following sub-questions should be answered: 1) what are the main differences in the allocation of labor by household members in types of local settlements and landscapes? 2) and what may be a possible explanation for the differences?

The perspective of resilience offers a research framework that to understand some parts of mechanisms of a complex system is to explore the differences of the different adaptive cycles in this system. For this understanding, my research framework builds on the comparison method and then consists two parts of work: discerning the results of the impacts on the allocation of labor associated with different settlement types or development models, and then suggesting some possible explanations of how different models correlate with household labor allocation, via the captured the relations between the different effects and the distinct village models, and the previous findings on resilience of a system and the rural labor allocation economy especially in East Asian countries.

Subsequent visits to the settlement sites that Tippins analyzed provided data relevant to this discussion. These included an initial survey of physical housing conditions and qualitative data on household characteristics, carried out jointly by University of Washington and Sichuan University students in September 2014, followed by two rounds of questionnaire surveys, both by Sichuan University students, first in September-October 2014 and then in March 2015. The first survey covered several household characteristics, such as the household income and expenditure, the arable land leasing, the participation in agriculture production and wage jobs, the population structure, and etc. These characteristics provide more basic information on the differences in socio-economic status, which goes further from the perspective of the landscape patterns done by Jennifer Tippins. And then, based on these basic characteristics, the second survey focused on the labor allocation to specifically explore the more details in changes of the individual behaviors in different types of settlements.

To analyze data from the March 2015 survey of household labor allocation, I undertook the following two steps. The first step is to do a comparison analysis of the differences of the allocation of the laborers among different villages. The comparison analysis is comprised of two sections. One section is a three-village comparison and the other section is three groups of pair-village comparison, comparing separately two of the three villages pair by pair. The reasons for the two-section comparison are given in section 3.5.3. The second step is, based on the analysis results from the last step and the existing theories of labor allocation, to give a possible explanation for the changes in labor allocation in different villages in the *linpan* region. Beyond this new knowledge, there will be also a discussion of what other factors may be confounded together associated with the changes labor allocation, such as the social norm.

### 3.2 TWO SUCCESSIVE SURVEYS

I did a primary data collection by distributing two surveys, the first in September-October 2014 and the second at the end of March 2015, across three villages of Jiang'an, Anlong CURA, and Anlong SEMI. The first survey covers four villages including the three villages aforementioned as well as in the village of Zhanqi. It was executed in China Studio held by a research team from University of Washington (UW), U.S.A. and Sichuan University (SCU), China. The survey includes a pilot one-week survey done by several students (two PhD students from Chinese Rural History, three graduate students from Urban Design and Planning, one undergraduate student from Architecture, one undergraduate student from Community, Environment and Planning, one undergraduate student from Mechanical Engineering, one undergraduate student from Architecture, and 15 around undergraduate students from Urban Planning) of UW and SCU, and a final one-month survey done by undergraduate students from SCU. It contains 11 sub-surveys covering questions such as basic household information, labor timing budget per day, family education background, wage-jobs, other incomes, expenditures, arable lands, and so on.

The first survey provided a lot of useful information to describe basic features of the four villages, some of the results of which reveal important facts also used in this research analysis. After completing the first survey, the statistical analysis work was carried out in the following three-month studio. The analysis results covered most of the survey questions and provided more understanding on the basic household features of the four villages. The results pointed out two main findings: 1) the average household debt increased significantly after people moved into the new concentrated settlement and the most part of the expenditure is furniture; 2) the human capital features, including the average labor age and the average education level, perform best in the CSA community than other three ones. These findings raised some more questions in terms of the labor allocation, such as whether the increase in household debt affects the changes of the labor allocation because farmers in this condition may prefer to earn more income to offset the debt, and why and how the CSA community maintains a better human capital and labor locally? All of these specific questions cannot be answered by the first survey data. So the second survey was carried out in the following spring. And the data of the second survey provides abundant information for this research.

### 3.3 DATA COLLECTION

#### 3.3.1 Selection of variables

To capture the features of the labor allocation, I should translate it with measurable variables for data collections. Four principles considered for selection of variables. The first one is the unit of labor budget for measurement. Time is a measurable unit for labor budget that standardizes different activities in the same way and it makes the comparison across different activities feasible. Moreover, time for labor has its limit, like 24 hours a day or 365 days a year. This makes ratio calculation possible, which is more suitable for statistical analysis. The next concern is the contents of the allocation of the laborers. The allocation of the laborers can be divided into categories of activities: the work and the leisure parts. For the work, the farmers in Chengdu region normally have two choices: agriculture production or having wage jobs. For the leisure, the farmers there are two activities to participate in: entertainment and tending to families. The activity of entertainment in Chengdu region is characterized as teahouse time, which is quite popular in Chengdu region especially in rural areas. The activity of tending to families can be marked with the time spent with children, elders, and other family members. The last variable is the quality of labor. Individual laborers are different and should be standardized in a unified way for comparisons and calculations. The differences of individual laborers can be simplified into three variables the age, the gender and the education levels.

Other variables related with the allocation of the laborers are also selected based on the knowledge of the *linpan* model and the Chengdu region. The first related variable is where the labor live during the period they work. This variable is important in the *linpan* model since it concerns the question if the labor is maintained locally. It is important to clearly define the local labors in order to understand the dynamic features of labor budget in the *linpan* model since it may indicate how many laborers participate in the activities that happened in Lipan model. Another related variable is to capture the features of interactions between a *linpan* settlement and its surrounding areas especially in the marketplaces. There are several levels of the surrounding places, such as surrounding other villages, township centers, twons, and even the Chengdu city. All of these places provide a lot of resources, like production materials and market information, as well as the opportunities of wage jobs. How many times people visit these different types of surrounding places can depict the frequency of the interactions. We can much better understand the different levels of intensiveness of these interactions of

the laborers in a local region and how people get regional supports for their labor allocation. The related third variable is to look at whether laborers contribute into food production. Food production is one of the main functions of the *linpan* model, which is recognized with the capability of resilience of food production. So not only accounting for how much land is cultivated but also accounting for the areas of cultivated land specifically for food production. The last related variable is whether people are content with their dominant type of work. This variable is to test if they do their current work deliberately or involuntarily. If their answer is content, it means they deliberately do what they do, and vice versa. This is important because people adjust their laborers to a comfortable status if they have choice and choice in resiliency refers to the dynamic adaptability. In sum, all things discussed above explain what and why I include the specific variables in the process of data collections. The details of variables used in the statistical analysis are list below, and the process of these variables are shown in the section 3.3.4. All the survey questions can be checked in Appendix 1.

**Table 2 The list of variables in the statistical analysis**

Variables	Unit	Difinition	Related survey questions
Cultivated lands per household	Chinese Mu	The cultivated lands that farmers work on this year.	Q1
Percentage of cultivated lands in food production per household	%	The cultivated lands for food production, such as grains, vegetables, fruit and etc, that farmers work on this year.	Q 2 & 3
Average labor hours input in agriculture per capita per day	Hours	The total labor hours of all laborers in a household contribute into agriculture producion, including busy seasons and leisure seasons, divided by the 365 days* 24 hours and the munber of laborers per household.	Q 7, 8, 9 & 10
Average Labor hours input in wage-job per capita per day	Hours	The total labor hours of all laborers in a household contribute to any wage job including both part-time jobs and full-time jobs, divided by the 365 days* 24 hours and the number of laborers per household.	Q 11 & 12
Sum of local labor hours per household per day	Hours	The sum of the labor hours in agriculture production and local wage jobs (living locally when doing wage jobs)	Q 7, 8, 9, 10, 11, 12 & 13

Frequency of interactions with other places in region per household per month	Number of times	The sum of all the number of times that every laborer visit surrounding places in last year, divided by 12 months and the number of laborers per household.	Q 18, 19, 20, & 21
Frequency of adjacent interactions per household per month	Number of times	The sum of all the number of times that every laborer visit surrounding places in last year except of Chengdu and surrounding county center or county-level cities per month last year, divided by 12 months and the number of laborers per household.	Q 18 & 19
Days of tending to elders per household per year	Days	The sum of days spending with the elders per year	Q 16
Days of tendering kids per household per year	Days	The sum of days spending with kids per year	Q 16
Percentage of satisfaction on current work per household	%	The percentage of the laborers in a household who expect to do the same type of work in next year	Q 15
Ratio of dual-work labors per household	Number of ratio	The ratio of the laborers in a household who did agriculture production as well as the wage jobs.	Q 7, 8, 9, 10, 11, 12 & 13

### 3.3.2 Data collection: the second cross-village survey

Three approaches were applied to improve the data pertinence in the second survey. Based on the practice of the last survey, I specifically redesigned the questions in the second survey for the purpose of this research. There are in total 21 questions in the second survey, which focus on variables of labor budget mentioned in section 3.3.1. The details of these questions are shown in appendix 1. Also, the questions are redesigned to get more precise answers and to improve the quality of data, according to the problems identified in the last survey. For example, I found that respondents might not correctly answer questions consistently. For example the question: “how many hours on the activities below (including doing agriculture, doing wage-jobs, doing housework, having a meal, entertaining or visiting others, tending to elders and kids, commuting, and sleeping) you spent yesterday” was hard for farmers to answer because they did not remember the details and would give very unclear answers. Unclear responses made the results inconsistent. Often, it was bigger than 24 hours for a person to complete all

the errands listed above. The experience I got from the last survey is that the questions may not be proper to get precise answers. So when I designed the second survey, if it is a labor budget question, I considered the possible variety of answers and provided several options for respondents to describe more precisely. For example, when I tried to get information of labor time budgeting on agriculture work, I separated the question into two parts (busy seasons and leisure seasons) instead of a condensed question in the last survey. This is because the labor input into agriculture is not so evenly distributed as the labor input into a wage-job. This means that respondents can give two answers of average hours per day to describe different labor inputs both in busy seasons and in leisure ones. This improvement made the respondents give a more precise answer for my question. Most of the questions are reconsidered in the second survey and resulted better quality of data.

Second, four PhD students from Chinese Rural History department of SCU helped complete the second survey. All of them had some experiences of doing surveys before and were trained as professionals as well. One of the students had participated in the first survey and he is familiar with the situations. And all the students had some experiences of carrying out surveys and interviews before. Also, I communicated with him every day during the survey period via email and by the social software Wechat. We spoke about the details of the questions and what types of answers I wanted to get. I was confident in his understandings of this survey. In addition, some principles were taken into account, like no blanks were allowed (no answer or un-quantified answers should be recorded by descriptive words). For these reasons, the process of collecting data is convincing though I did not participate into personally.

The sampling in the second survey is qualified enough for statistical analysis. The survey was carried out during the third weekend of April 2015 and the households were chosen randomly. There are be more people at home during weekends and even the ones doing agriculture would likely be spending more time with their families. So a weekend survey could get more respondents randomly in a way that covers more types of respondents rather than only the ones like elders or children who could be at home during the weekdays. The sample size was enough for statistical analysis. The sample size for both Jiang'an and Anlong SEMI is 40, and the one for Anlong CURA is 28 (11 out of the 28 households participate in the CSA), covering almost all of the households in this village. For these reasons, the quality of data is good enough for the research analysis.

### 3.3.3 Data processing

Every household has a record, which contains several groups of data for every person in the household. These data use different units and concern different matters. The research tries to analyze the feature of labor budget in the household level because within one household people can cooperate closely with an appropriate division of labor. For this purpose, there are five standardized steps to process the rare data collected from the survey. The details of the functions applied are shown in the Appendix 2.

The first step is to standardize the labor time. Because the data is divided into days and hours per day in the survey for better responses, the labor time is translated to an accumulated data by a formula that includes days and averages hours per day. In agriculture labor, the formula changes to be days in busy seasons time and average hours per day in busy seasons, plus days in leisure seasons time and average hours per day in leisure seasons. The wage-job labor just follows the formula of days in wage-job and average hours per day in wage-job. So using this formula, all the labors in a household are translated into an hour-based data.

The second step is to standardize the labor quality. People in one household have different quality of labors, which determined by several factors, such as age, gender, and education level. For comparison and calculation, I have to subjectively weigh for these factors to standardize the labor data. In practice, the weight of age data for the agriculture labor follows a standard that the age from 16 to 60 as weights with 1, the age from 61 to 70 with 0.5, the age from 71 to 85 with 0.3, and others with 0. For the wage-job labor, the weight of age data follows a standard that the age from 16 to 45 as weights with 1, the age from 45 to 60 with 0.5, and others with 0. The reason for the division standard is that farmers in China may have advantages in finding a wage-job if they are younger than 45 years old, and most of people retired at 60 for male and 55 for female. The weight of gender considers that females may have disadvantages in labor-intensive work, like agriculture and wage-jobs, and therefore weight for female is 0.7 and for male is 1 for the agriculture labor but weight is the same for the wage-job labor. The education level is a little more complex. The illiterate level is weighted as 0, the elementary and middle school level (two stages of compulsory education in China) is 0.5, the senior high school and vocational school level is 1, the college level is 1.5, and higher than the college level is 2. All of the processes above translate the labor quality into the standardized data for further analysis.

The next step is to merge the data of interactions. The data of interactions consists of four levels,, interaction times per month with surrounding villages, with surrounding towns or townships, with surrounding county centers or county-level cities, and with Chengdu city. I sum all the interaction times per month across four levels together as the data for interaction frequency. Also, I aggregate the interactions above except from the ones with Chengdu city because these interactions can be considered as the adjacent interactions.

The fourth step is to divide the data of tending to family time. This data is collected by the question of how many approximate days are spent with respondents' children. This question covers two conditions of tending to children and elders. In the analysis, I divide this data into two variables, including taking care of children and taking care of elders. Most of the elders in a family may be left in rural areas but the kids may leave the rural area with their parents when their parent is doing a wage-job outside of their home village. This means that the time spent with kids may not reflect the local activities.

The fifth step is to introduce two calculated variables to describe the working status of laborers. In other words, I try to find some data to show how labor is allocated among the agriculture and the wage-job sections. For the agriculture section, since the *linpan* settlement model is considered as resilience to food production, the ratio of the cultivated lands for food production per household and the cultivated lands per household is calculated by the date in survey. I also introduce the variable of dual-work to describe the condition of the diversification of labors in the *linpan* settlement model. A lot of people in rural areas have dual roles both in agriculture and in wage-job work. So this variable is calculated in a formula in two steps. Firstly, find every laborer in a household that is doing dual-work and give them a number of 1, if not, give them a 0. The second step is to aggregate all the numbers of a household and then divided by the number of laborers of a household. Then I can get a degree variable to describe to what level a household allocates its labors in a dual-work manner. The following step is to calculate every variable in a household and average it by the number of people. To do this eliminates the disturbance of household size. Then every variable can be compared and analyzed in statistical tools.

### 3.4 STATISTICAL TOOLS

#### 3.4.1 Comparisons among three villages

The first step is to do comparisons among different villages. I use a statistical tool of Kruskal-Wallis One-way ANOVA. The Kruskal-Wallis One-way ANOVA (Analysis of Variance) is a collection of statistical models used in order to analyze the differences between group means and their associated procedures for **ordinal data, which are not normally distributed** (McCrum-Gardner 2008). The result of this analysis shows the significance of different variables involved into the comparison analysis. A variable with higher significance implies that the variable is significantly different across the compared groups. In other words, these groups are different in terms of this variable. By using this tool, I can discern what factors are significantly different across villages. The significant differences of some of the variables among different villages expose the essential features of the villages. In other words, these selected factors can be used to help tell the story of the allocation of the laborers because the result of the statistical analysis shows that these variables are sensitive and changed responding to the impacts.

#### 3.4.2 Comparisons between each two villages

The second step is to do comparisons between each two villages, because some of the factors could be not significantly different among three villages but may be only different between two of them. In this case, I need to identify these differences to get some information whether one of the three villages does not share similar specific features with the rest. For this purpose, I use the Mann-Whitney U-test, which is used to test whether two independent samples of observations are drawn from the same or identical distributions. If the two villages do not share the same or identical distributions with respect to several factors, then these factors can provide useful information for me that the two villages are different in terms of these features.

### 3.5 LIMITATIONS

#### 3.5.1 The limitations of the research framework

The research framework in my thesis constructs upon a basic assumption that the question of “how households allocate their labor responding to the changes of village models” can be answered by the differences of the allocation of the laborers in different models. This assumption cannot expel the

exception that there might not be any significant differences in labor allocation. If so, there may be some other important factors are ignored in this research.

Even if the differences in the allocation of the laborers are significant enough to figure out what variables can be used to disclose the phenomenon, the research framework cannot give a convincing causality for the phenomenon. The research framework can provide some understanding on the features of changes in the allocation of the laborers, and the reasoning process would be done in a manner of providing a possible explanation based on the discoveries and the existing theories on this issue. This explanation should be demonstrated in future research.

### **3.5.2 The limitations of sampling**

The sampling of study areas is not random, which leaves some limitations that should be discussed and acknowledged somehow in my thesis. The selection of study areas is based on the previous research on resilience of the *linpan* model done by the research group comprised of professors and students from UW and SCU. The sampled study areas are better understood and provided more related analysis than other villages. I choose three of the four study areas for sampling because of these conveniences.

But the problem or trade-off of this sampling is to sacrifice some qualities of statistical analysis that brings in some new problems. One problem is that the spatial distribution of the selected study areas is predetermined. So I cannot expel the effects from the settings of spatial features. In practice, Anlong CURA and Anlong SEMI are very close to each other and much closer to the highway than Jiang'an. It may be a problem especially for doing analysis on the sampling problem of locations. For my research, anything related to location should be interpreted with caution.

Finally, the resulting disturbances on different study areas each had their own length of application period and had distinctive initial conditions. These uncontrolled problems could affect the variables I capture with data. The CSA program in Anlong CURA has come into application since the year of 2005 (Maye 2012) but the one in Anlong SEMI was carried out in the year 2012 (Tippins 2013). The application periods for these two study areas are quite different and may affect the results. But, from the viewpoint of resilience theory, if the system transforms into another state, changes of the features would accelerate in the beginning. If the system maintains its current state the change of the feature may slow down to a stable status. And according to the previous research, the disturbance in Anlong SEMI seemed

to transform the model into another new state while the disturbance in Anlong CURA maintains the current resilience of the *linpan* settlement model (Tippins 2013). So the speed of the changes stimulated by these two disturbances can be different and reduces the effects of the length of application period to some extent. In addition, the initial conditions of these study areas vary in different domains, such as the political leadership, the history, the marketization degree, the specialty, and so on. For this reason, I rejected Zhanqi as a sample due to its uniqueness with strong leadership and a specialty bean source. The initial conditions among other study areas are not so significant and may not affect the analysis results.

### **3.5.3 The limitations of statistical tools**

There are some limitations in the statistical tools I use in this research. For the ANOVA tool, it requires a large sample size or the samples with the normality. The samples in my research are not large enough to ignore whether they distribute normally or not. For these reasons, several following tests are also needed to increase the confidence of the statistical results, such as the Kruskal-Wallis tests for the comparisons among the samples without normality. By doing these introduced tests, I can make reconfirm if the variables selected from the ANOVA can be more confidently used in this research though the samples do not distribute normally.

## **4 DISCUSSION: POSSIBLE RELATIONSHIPS BETWEEN SETTLEMENT FORM, ITS TRANSFORMATION, AND HOUSEHOLD LABOR ALLOCATION**

### **4.1 SUMMARY OF THE STATISTICAL RESULTS**

Three important results from the statistical analysis (details seen in Appendix 3) are list below:

- Four variables (including “cultivated lands per household”, “average labor hours input in agriculture per capita per day”, “frequency of adjacent interactions per household per month”, and “ratio of dual-work labors per household”) can be used to explain some features of the labor allocation in households in different study areas.

- All of the above four variables are generally higher in the two study areas with the *linpan* settlement form, such as Anlong CURA and Jiang'an, than the ones in the concentrated settlement, Anlong SEMI.
- Farmers in Anlong SEMI generally work on much more percentage of cultivated lands for food production than the ones in both Anlong CURA and Jiang'an. But the whole cultivated lands and the participation degree in agriculture production Anlong SEMI is lowest in three study areas.

## 4.2 ANALYSIS BASED ON THE STATISTICAL RESULTS AND THE RELATED KNOWLEDGE

### 4.2.1 The role of labor bifurcates: doing a dual-work or transforming to be a professional

The most predominant feature identified among different rural development models is the phenomena of doing dual-work in *linpan* model. People in *linpan* settlement model, both Anlong CURA and Jiang'an, tend to separate their households labor into two parts: doing both agriculture production and wage-jobs. But people in Anlong SEMI prefer to do only one type of work, doing either agriculture production or wage-jobs.

The farmers in Anlong CURA and Jiang'an work both on agriculture production and at the same time wage-jobs. It implies a possibility that the rural labor is maintained locally in these two villages, because people tend not to give up the locally agricultural work. It is not a normal behavior in terms of the commercialized rural laborers in the *linpan* region, since in line with the theory of the behaviors of rational-economic men, farmers tend to contribute as much labor as they can into wage-jobs to maximize their labor values due to the higher income. Maybe another reason for this kind of behavior is the lack of opportunities of wage-jobs in locality, and then people may respond to wage-job opportunities insensitively. But this tentative explanation does not take account of the phenomena that people in Anlong SEMI, though in the same region with the similarly local opportunities of wage-jobs, prefer to do a single work (discussion details seen below). So the *linpan* model and the *linpan* region may have some mechanisms to support the dual-work feature. In other words, people may gain some benefits in *linpan* villages from doing dual-work.

In contrast, people from Anlong SEMI transform their labor into the professional status. The low ratio of dual-work in Anlong SEMI and more than half of the laborers do a single work (the median of the ratio of dual-work is 0, seen in figure 15) indicate that the labor allocation of a household is polarized into different industries. It is understandable that some people tend to acquire wage-jobs and do not prioritize agriculture production any more due to the fact that much higher income can be earned from the wage-jobs. It is more difficult to understand the circumstance of only doing agriculture production. By looking at the statistical results of cultivated lands per household (see figure 15), the village of Anlong SEMI has the lowest result, which means people work on less land in general, which indicates many people do not do agriculture. But, the variance of cultivated lands per household in Anlong SEMI is largest, which reassure that some people work on large amounts of lands while others work on little lands. In addition, the percentage of cultivated lands in food production per household in Anlong SEMI shows an extremely large deviation, and half of the households contribute little lands into food production (the median number is 0, seen in figure 16). This manifests that the food production also tends to be a choice of doing or not at all. So it seems that people in this concentrated settlement form divide their labor into either doing agriculture production or doing wage-jobs, and even specialize in doing food production only or not at all. On the other hand, the labor contributes into the agriculture production (see figure 15, the average labor hours input in agriculture per capita per day) is generally lowest in Anlong SEMI than other two *linpan* villages. It indicates that people use less labor input into generally similar amount of cultivated lands to produce some certain types of agricultural products, such as food and cash crops. The phenomena imply that people in Anlong SEMI tend to utilize substitution inputs instead for their labor input and be more professional as agriculture workers. All of these analysis hint at a possibility that the laborer in Anlong SEMI participates in agriculture production as a wage-job worker.

#### 4.2.2 Question one: how the *linpan* system supports the dual-work feature

If the laborers in different models demonstrate bifurcation in dual-work and professional work, then how does the *linpan* region support this kind of dual-work feature rather than the professional one? To support the dual-work feature, there should be a higher frequency of interactions between the villages and their surrounding areas in order to offer more wage-job opportunities for the farmers staying locally. The statistical result responds to the above hypothesis. Both the two *linpan* study areas have higher level

of interactions with the adjacent places (within a daily-commuting distance) than the concentrated settlement form. In other words, people can locally achieve dual-work in the *linpan* settlements.

Furthermore, if earning wages in other non-agriculture jobs still can make much higher income, why do people still prefer to stay locally by doing dual-work, not to just give up doing agriculture production with the lower income? Primarily, farmers may prefer to maximize the income from the agriculture production at first, if it could help achieve a satisfactory livelihood, because doing agriculture production is much more familiar to the farmers, and then the risks of doing agriculture are much lower for them. According to the statistical results, both of the farmers in the two *linpan* settlements work on more cultivated lands for agriculture production than the concentrated settlement, but people in Anlong CURA produce much more food than the ones in Jiang'an, most of whom work on little lands for food production but for other products, such as nursery plants. The obvious different agricultural activities imply that, though both of the *linpan* settlements locate in the similar region, people adjust their products for better cash income in consideration of their specifically different conditions, which in Anlong CURA case is the SCA program and in Jiang'an case is without any specific disturbance. Also, the previous research found the high diversity of cultivated lands in the *linpan* villages (Tippins 2013), which bestows the farmers with a capacity of producing various products and then adjusting more easily their products to respond to the market feedbacks. Based on the above findings, the agriculture production can be adjusted to achieve a better income for the farmers, who are more familiar with these means of promoting their livelihoods.

Besides, on top of doing the secured agriculture production, people could then maximize their labor, especially the surplus rural labor, to earn more wage income if the surrounding areas have enough opportunities of wage jobs. So we could say that people living in Jiang'an and Anlong CURA can adapt with the increasing levels of livelihood by adjusting agriculture production and utilizing wage-job opportunities to achieve the balance between the securitization and the maximization of their labor through the main means of increasing the adjacent interactions in the web of the *linpan* region.

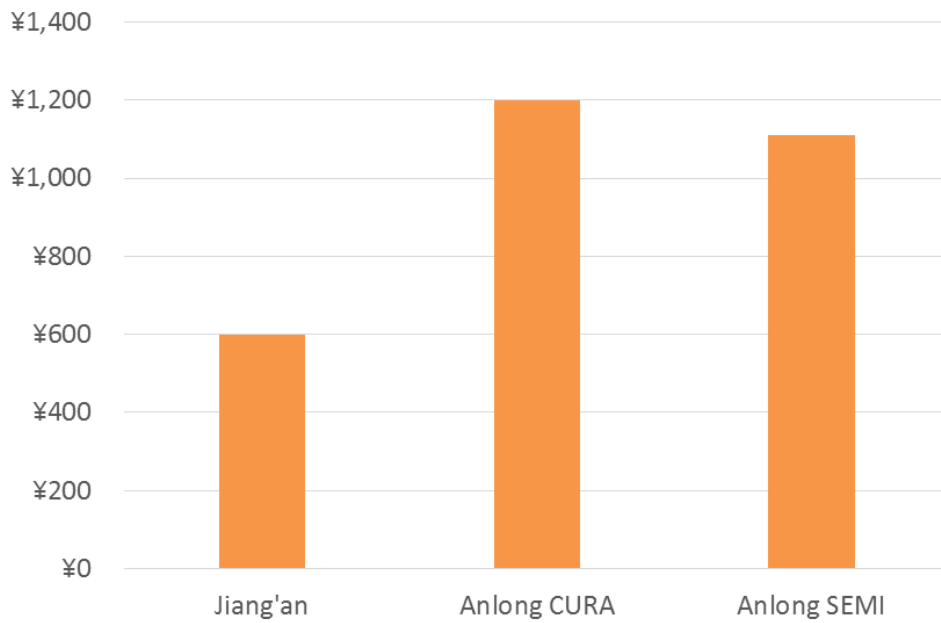
Therefore, the feature of doing dual-work in the *linpan* settlements is the result that farmers tend to maximize their labor value by doing wage jobs to get more income without losing the basic and secured choice of doing familiar agriculture production. The *linpan* model bestows farmers with a capacity of balancing the above options via the higher accessibility of the opportunities of wage jobs and

market information within a commuting distance (based on the well-developed regional networks) as well as the the high flexibility of adjusting agriculture production (based on the diversity of cultivated lands).

#### **4.2.3 Question two: why people in the concentration form change their behaviors to do a single work**

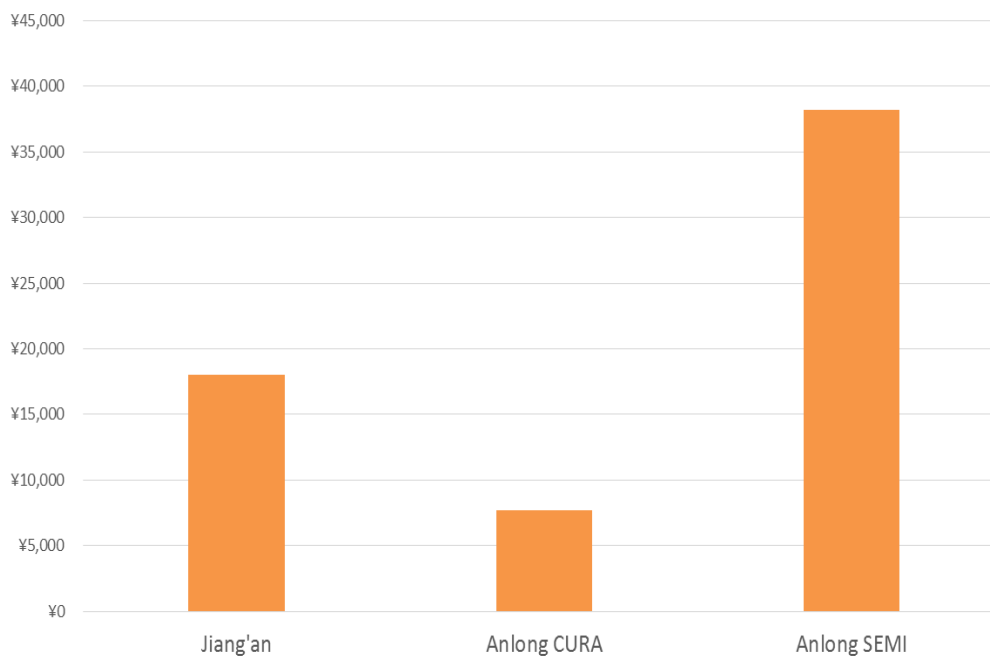
Another question here is why people in the concentrated settlements, like Anlong SEMI, change their behaviors from doing dual-work to doing single work as wage-job employees. The farmers from the two *linpan* study areas can achieve a livelihood balance from both adjusting agriculture production and doing wage-jobs in locality. More importantly, the income from the agriculture production can be adjustable to get better and may secure their livelihoods. Although not high enough in comparison with the wage jobs, this income can not be given up easily and then makes people tend to achieve a localized balance.

However, farmers in Anlong SEMI cannot. The subsidies for the concentration of settlements and the rent from the concentration of arable lands, though high in Anlong SEMI shown in figure 11, cannot offset the expenditures of households (see in figure 12, highest household debt in Anlong SEMI), which got highest comparing with the condition before the concentration because the brand-new houses with urban style facilities in the concentrated settlement requires much high costs (seen in figure 13; the expenditure in Anlong SEMI increased a lot in furniture in the last 12 months). So farmers in this case fail to adapt with the improvement of subsistence. The laborers in Anlong SEMI have to receive a better income in order to offset this insufficiency in income. If the local opportunities fail, they will look elsewhere. The cost for them is to give up their enjoyable and familiar lives in rural areas. The costs may even be much higher in terms of leaving their aging parents and young children in rural homes if urban areas cannot accept migrant laborers easily. The later condition is always the case. In sum, a *linpan* settlement can provide more chances to adapt with the improvement of livelihoods. This could be a possible threshold because failing to provide local capacity means that the behavior of the allocation of the labor of households will fundamentally change.



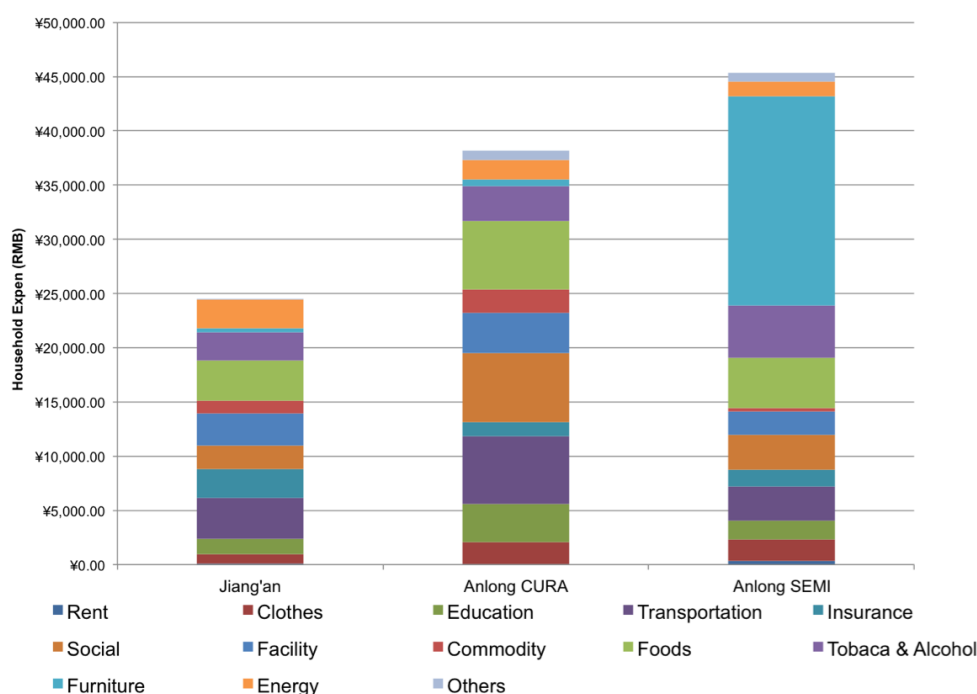
**Figure 11 Comparison of median subsidies per household (RMB)**

*Source:* First round survey 2014.



**Figure 12 Comparison of average debt per household (RMB)**

*Source:* First round survey 2014.



**Figure 13 Comparison of components of household expenditure in last 12 months**

Source: First round survey 2014.

#### 4.3 TWO KEY ELEMENTS FOR RESILIENCE MAINTENANCE IN THE LABOR ALLOCATION OF THE LINPAN SYSTEM

To support the resilience in the labor allocation, there are two elements that may function to alter the dynamic mechanism. The first element is the high diversity of cultivated lands (Tippins 2013). To some extent, the high production of arable lands in the Chengdu region comes from the diversity of the agroecosystem. This diversity endows the farmers with a capability to produce a lot of different goods to exchange in marketplaces and to receive better benefits based on the market. The prevailing increase of nursery plants in Chengdu region can be interpreted as a result of this adaptation.

Next, adjacent interactions and opportunities of wage-jobs in marketplaces supply more flexibility to the allocation of the laborers. The amount of wage-jobs in adjacent areas (within a daily commuting distance) can maintain the balance of dual-work features for laborers. Also, the network of information dissemination facilitates the flexibility of the agriculture production. The networks can improve more interactions if shortening the commuting time, which depends on the transportation mode and the physical distance. This feature also can be found this in Yangtze delta, where has a more typical

concentrated settlement form. It seems that the high density of the marketplaces and the location close to a regional core are important to develop this feature. But it is important to note that the spatial distribution of rural housing in Chengdu Plain is much more scattered than that in other agriculturally rich, core-metropolitan peri-urban contexts, like the Yangtze or Pearl River deltas. This characteristic in the *linpan* region seems not only to provide more opportunities to access to the urban jobs but also to bestow a capacity of maintenance of agriculture production by the market-feedback interactions. So the interactions in the *linpan* system may not be as same as the ones in other intensively farmed and urbanized regions where settlements are nucleated. In other words, both of these elements together help farmers maintain their livelihoods in a more flexible way.

#### 4.4 SUGGESTIONS FOR FURTHER RESEARCH

Regarding the data on household visits to surrounding areas, the reasons for such behavior are unclear. One possible explanation is built on a hypothesis that the increasing frequency of adjacent interactions is partly because laborers try to find or go to wage-jobs within a daily-commuting distance. The study requires more research on visiting purposes to clarify what may be more probable reasons for high frequency visits in the *linpan* model.

The second suggestion is to do more research on the mechanism of adjusting agriculture productions in the *linpan* model. It may be easy to have data that captures the features of the dominate products, but it may be much harder to understand how farmers complete the feedback cycles and then how they reallocate their resources to adjust their productions. Moreover, it is clear that the diversity of landscape in the *linpan* model makes it more resilient in terms of agro-ecosystem. But it is still unclear whether the feature of diversity contributes to the capacity to adjust. All of these questions should be explored in the future to help us understand the *linpan* model better.

Next, it is not certain whether the *linpan* landscape itself generates higher interactions with the regional marketplaces, or the study settlements' proximity to the metropolitan core contributes to this feature. Future research could compare the frequency of the interactions between the similar *linpan* settlements and the surrounding places in different locations, closer to or far away from Chengdu city or other cities.

Finally, it is unclear whether there are some other reasons except the economical perspective to explain the localized solution for the farmers to upgrade their livelihoods. Maybe one possible reason is the

social norm that makes living in the rural areas more attractive to the farmers. Also, the interviews, taken along with the survey, with some participants of the CSA program show that most of the participants are Buddhists and are consciously pursuing alternative development. This phenomenon can reaffirm the assumption that the social norms may associate with the preference of the localized solution in the *linpan* settlements, but it still requires more solid research. Such research might also focus on whether the *linpan* landscape better supports the pursuit of alternative rural development and livelihoods, compared with more concentrated new settlement forms.

## 5 CONCLUSIONS

### 5.1 MAIN FINDINGS ON HOUSEHOLDS' ALLOCATION OF LABOR IN DIFFERENT VILLAGE MODELS

The statistical findings challenge somehow my previous assumptions. Before doing this research, I hypothesized that people in *linpan* settlements would arrange their labor in a way to produce more food products and to do less wage-jobs in comparison with people in the concentrated settlements. Also, that the community-supported agriculture in the village of Anlong would facilitate farmers to commit their labor much more to food production. The findings from the statistical results, however, give some different answers. Four variables, including “cultivated lands per household”, “average labor hours input in agriculture per capita per day”, “frequency of adjacent interactions per household per month”, and “ratio of dual-work labors per household”, are generally higher in the two *linpan* villages, such as Anlong CURA and Jiang'an, than the ones in the spatially concentrated village, Anlong SEMI. Besides, farmers in Anlong SEMI generally work on much more lands for food production than the ones in both Anlong CURA and Jiang'an.

Based on the statistical results, I updated some knowledge on *linpan*'s features in the labor allocation. First of all, people in the *linpan* model contribute their labor to wage. The differences of the *linpan* settlement model and the concentrated settlement model are that people in the former model do dual-work much more than the ones in the latter model. In other words, people in the latter model prefer to be professionals, either in an agriculture industry or other industries. The community-supported agriculture may strengthen the dual-work feature. People in this case endeavor to maintain a balance of the allocation of the laborers between agriculture work and wage-jobs.

Second, an unexpected finding is the higher frequency of adjacent interactions in the *linpan* settlement model. One important thing to mention is that the significance of this feature in statistical results shows in the adjacent areas. In other words, the interactions happen within the limited distance of a daily-commuting distance. This distance maintains the laborers locally. Beyond a commuting distance, people may leave the village rather than live in their houses with families in rural areas. The preference of dual-work in the *linpan* model results in the higher frequency of adjacent interactions. This is because people prefer to do agriculture production at first for the securitizing their income, and then to figure out whether there are some wage-job opportunities in the adjacent areas to maximizing their labor values. This balance can be realized by the surrounding areas with high-density and evenly distributed marketplaces as well as connected networks among the villages and the marketplaces.

In sum, based on the findings above, I may give a possible explanation of the labor allocation in the *linpan* system. Farmers in the *linpan* settlements were used to keeping up with improvements of livelihoods by adjusting their agriculture production and trading frequently in surrounding marketplaces in history. This legacy is inherited. An impact of industrialization has meant that adjusting agriculture productions cannot catch up with the rapid improvement of subsistence by doing agriculture compared to wage-job opportunities in urban areas. But the original marketplaces and the networks in the region play an important role in dealing with the challenges mentioned above, and they also provide more opportunities for access to wage-jobs for the farmers -- even for those who prefer to live in their rural homes. The basic logic in this adaptive cycle is that farmers try to solve the problem of updating their subsistence “locally”.

This adaptive cycle would disappear when people break up the local ability to adjust productions. Farmers would leave rural areas permanently for better income if they could not get enough subsistence locally. The challenge of the concentrated settlements is that it provides limited but fixed subsidies for the farmers to rent out their cultivated lands, which cannot offset the increase in daily expenditure caused by the newly built dwellings in these concentrated settlements. They have to figure out what other means they have to make their household income away from the rural risks. Economic efficiency dominates if farmers go further away for wage-jobs with better incomes. This may not be a bad condition if only in consideration of food production, which increases to achieve a national policy goal of food security. But even in this case, some other concerns are still worthy of discussions below.

## 5.2 AN IMPORTANT VALUE OF THE *LINPAN* LANDSCAPE'S RESILIENCE IN LABOR ALLOCATION: FIGHTING FOR TIME

In theory of resilience, there is no judgment of good or bad in the resilience of a system. The systems with resilience do not have more merits. To achieve a better understanding of resiliency of a system is to manage the resilience, either to transform into another state if the original state is not preferable or to limit the activities to inside the thresholds if the original resilience is preferable. Changing a state of resilience will cause some chained changes in other domains and across other scales of the systems. So what seems like preferable resilience needs to address the broader picture of the system.

One of the dominant challenges of the urbanization in China is the speed of the process. The demand from completing healthy urbanization is high and the urban areas cannot absorb all the rural migrants smoothly within a short term. Specifically in the Chinese context, the education system and the social welfare system are not well prepared to provide enough capacity for the rural migrants to be urbanized seamlessly. The insufficiency of the current capacity of urban system generates many problems, such as the exclusion of rural migrants in some major urban areas as well as the crisis of the proportionally higher population of elders and children in rural areas. Failure in the delicate management of this process harms the future of China in both urban and rural areas.

What we need immediately is more time for the whole system to upgrade, as the resiliency of the *linpan* model sheds light on a localized method that deals with the problems generated from dynamic changes. In the *linpan* model, the rural households have a potential to improve the level of their livelihoods by a localized way. In other words, the impacts from the rural areas to major urban areas, like Chengdu, are absorbed internally to some extent in the *linpan* model. It offers more buffering time for the region, especially for Chengdu and other urban areas within the region, to upgrade their accommodation system. In this sense, it is meaningful to maintain the resilience of the *linpan* model.

Also, the *linpan* model provides a different vision of a healthy urbanization. Urbanization may not only mean that the settlements are concentrated, and then get increasingly larger. The process of urbanization is to intensify the economic activities in spatial distribution. With a perspective of agricultural civilization, urbanization refers to the concept of density. In essence, how many people can be accommodated within one square kilometers, and how are these people efficiently connected to opportunities to produce and consume goods and services (Zhou 2015). It could also mean that high

density but scattered settlements interact among each other with a higher frequency. Especially in an online-era, connections among people cannot be only realized by physical proximity but also by Internet technology. If so, the *linpan* model creates a better space for creative connections.

### 5.3 POLICY IMPLICATIONS

It is time to review the rural planning policy of Chengdu's SNC pilot program, after almost a decade since its implementation. The widely praised success of this policy does not mean it is flawless. Actually, the simple space-based policy of concentrating the settlements, converting *linpan* house plots, and consolidating small, patchy fields did not well serve the original goals of rural development, such as increasing and, more importantly, sustaining the productivity of the abundant farmlands in Chengdu region, facilitating every farmer's livelihood to catch up with the general economic growth in a more equal, but not more polarized, way, as well as constructing an attractive and identifiable countryside that strongly supports Chengdu's ambition of being a worldwide famous "Garden Metropolis" (Ni 2010). Moreover, the aggressive policy advance and the rapid pilot expansion replaced significantly the traditional *linpan* landscape, which has helped maintain the region's abundance and characterized the region for thousands of years. The debates on the fundamental changes in traditional landscape raised up the awareness of the values of the *linpan* system, such as sustaining the diversity and productivity of the agro-ecosystem, and other rural development models that could serve some policy goals better than the SNC pilot, such as CSA model that deals with problems of the agriculture water pollution and the chemical-supported food crisis. The recent stagnancy of the real estate market in Chengdu that supports the financial cycle of SNC pilot cooled down somehow the fever of the expansion of the pilot and gave us a rare moment of reflection on what could be a more proper rural development policy for the Chengdu region and its future in long-term.

One of the most valuable lessons we could learn from the policy review is that the rural development and the *linpan* system are much more complex than people expected when carrying out the SNC pilot policy. The elements of the *linpan* system are complexly linked across different scales and domains, within which the operating logics and values are distinct, and even incompatible. The SNC pilot policy, built on a single logic of transferring the development right from the saved individual curtilage lands to the urban land uses, cannot, in such a short time, fit seamlessly into the *linpan* system, in which the elements with different running logics have intensively linked and got a dynamic balance due to a long-

term process of systematic evolution. This incompatibility of the SNC pilot policy with the original *linpan* system generated many derived problems after it. As the inevitable consequence of the logic of the SNC pilot policy, the concentration of individual dwellings and their arable lands asked for the scale-economy agriculture and the urban-like residential development, exacerbated the rural development crises rather than alleviated them. The scale-economy of industrial agriculture may not increase the holistic productivity in this region without sacrificing its time-tested and well-functioning agro-ecosystem. Also, the concentrated settlement provides more “modernized” living quality for the rural residents but with much higher daily expenditure of the household, which then probably worsened the “hollowing problem” of rural communities as households reallocate labor to wage jobs outside the region to offset the increased daily costs. Localized employment programs are essential to offset this effect, and yet even Zhanqi village, perhaps the most famously successful example of locally generated new employment opportunities, exhibits a high rate of out-migration for wage-work compared to Anlong CURA. The cost of building new housing that includes empty rooms for much of the year needs to be assessed against the maintenance of traditional *linpan* dwellings with their own flexible space arrangement. More importantly, transforming the whole rural system in a single direction that highly relies on the urban real estate market imposed a high risk upon the much more fragile rural economy. We cannot ignore these problems, even more, derived from the pilot policy implementation. So first, what physical-spatial policies might be more appropriate in the *linpan* region? Next, what could a more properly planning method to apply into the *linpan* system of complexity? And at last, what could we do in the near future?

Primarily, two things, learnt from the research, could be done as the suggestions for the physical-spatial policies to serve the goals of the rural development, such as increasing the productivity of the cultivated lands and promoting the holistic quality of lives of the farmers, as well as to acclimate better with the original *linpan* system. First, diversifying agriculture productions of the *linpan* settlements may provide a localized way to maintain the productivity of the *linpan* landscape. It is not only a micro diversity feature in landscape that endows various products, but also a key element links with a much broader system to constitute a market-feedback mechanism that helps achieve the better agricultural profits. From this point of view, to maintain this feedback function, it is imperative to preserve diversity of the *linpan* landscape. Second, it is more cost-efficient and less risky to boost the farmers’ capacity of making a living and to promote their quality of life via strengthening the networks and the nodes of

marketplaces, rather than propelling people to move into the concentrated settlements. The *linpan* region has the highly connected networks and nodes of marketplaces, originally to help complete the market feedbacks for individual-based adjusting agriculture production, now also to provide more opportunities for farmers to access wage jobs or other businesses to realize the values of their surplus labor. It is not only about the infrastructure needs but also their choice of transportation modes that may fit best into the farmers' daily lives. Internet technology has also created more policy options. The localized way to absorb the surplus labor (He 1999) will benefit a lot of individually adaptive activities.

Next, the *linpan* system of complexity suggests a demand for a specific planning method. The popular planning method used in China, especially in Chengdu rural development, is the rational planning model. It is a process for making logically sound decisions but based on high certainty about how the targeted system functions and how the system changes when a specific policy implemented. The SNC pilot policy in Chengdu was designed to deal with some specific rural problems, such as agriculture production decline and the insufficiency of the infrastructures in rural areas. It established some evaluating planning criteria, like average household income, ratio of dwellings connected with the paved roads, and etc., and then selected the concentrated model as the best one in comparison with other alternatives due to its performance fulfilling most of the planning criteria. But actually, there are a lot of issues that were not included into this planning model but very important to the rural development of Chengdu region, such as the deterioration of the agro-ecosystem and the deficiency of the individual options. Also, the chained effects could not be easily, or even possibly, predicted at the beginning of employing the rational planning model. The stagnancy of the real estate market in urban areas and the exacerbation of hollowing-out of rural communities put these concentrated settlements at risk. All of these problems involved in this planning model can be fixed somehow by introducing a substitution of the current planning method. An incremental planning model helps a lot in this complex condition. The incremental planning model makes the whole planning process into multi cycles, which are divided up into smaller, more easily managed modules. Each module passes through the requirements, design, implementation and testing phases. It provides much longer time for monitoring and evaluating the results of the implementation of the small modules of the policy and then makes room for policy adjustment. The accumulated knowledge of the *linpan* system and the negative effects generated from the implementation of the concentrated settlement model reminds us the rational planning model may not be appropriate in this context and the incremental one can aid.

Finally, in the near future, it is imperative to clearly define different areas where different specific rural development models may fit properly. None of the models available in Chengdu's rural areas can solve all the problems and achieve the multi-goals together. This thesis's argument for the continuing value of the *linpan* landscape is not to suggest stopping the implementation of the concentrated settlement model but to clarify its limitations. Better understanding of all the models enables us to acknowledge where to employ which model. How to make this determination is a question left to answer now. Diversified spatial-based policies stemming from the different models may contribute to the rural development of Chengdu region by facilitating different villages to achieve better status based on their unique advantages.

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## **APPENDIX 1: THE QUESTIONS OF THE SURVEY**

Question 1: How many cultivated lands (Chinese mu) for the agriculture productions in your household?

问题一：现在耕作几亩地？

Question 2: How many cultivated lands (Chinese mu) for the food productions in your household?

问题二：其中，种植食物的耕地几亩？

Question 3: How many cultivated lands (Chinese mu) for the nursery plants in your household?

问题三：其中，种植景观林木植物几亩？

Question 4: What is your gender?

问题四：性别？

Question 5: What is your age?

问题五：年龄？

Question 6: What is your highest education?

问题六：最高学历？

Question 7: How many days last year did you work on the agriculture productions during the busy seasons?

问题七：一年中的农忙天数？

Question 8: How many average hours per day did you work on the agriculture productions during the busy seasons?

问题八：农忙时日均务农多少小时数？

Question 9: How many days last year did you work on the agriculture productions during the leisure seasons?

问题九：一年中的农闲天数？

Question 10: How many average hours per day did you work on the agriculture productions during the leisure seasons?

问题十：农闲时日均务农多少小时数？

Question 11: How many days last year did you do the “Dagong” (wage-jobs)?

问题十一：一年中的务工天数？

Question 12: How many average hours per day last year did you do the “Dagong” (wage-jobs)?

问题十二：务工时平均日工作小时数？

Question 13: Where did you do wage-job or where do the wage-jobs locate?

问题十三：务工地点？

Question 14: Whether did you live in the local village during doing the wage-jobs (especially in your personal home)?

问题十四：务工时是否居住在本地（本村本住宅）？

Question 15: Do you prefer to doing wage-jobs or doing the agriculture productions in future?

问题十五：是否希望将来更多务工或者务农？

Question 16: How many approximate days did you spend with your children last year?

问题十六：一年中平均与子女相处天数？

Question 17: How many average hours per day did you spend in Majiang or Teahouses last year?

问题十七：每日平均在麻将馆和茶馆中的小时数？

Question 18: How many times did you visit nearby surrounding villages per month last year?

问题十八：每月平均访问邻近村庄的次数？

Question 19: How many times did you visit nearby surrounding towns or townships per month last year?

问题十九：每月平均访问邻近乡镇的次数？

Question 20: How many times did you visit surrounding county centers or county-level cities per month last year?

问题二十：每月平均访问邻近县城或县级市的次数？

Question 21: How many times did you visit Chengdu per month last year?

问题二十一：每月平均访问邻近成都的次数？

## APPENDIX 2: THE LIST OF THE FUNCTIONS IN THE DATA PROCESSING

$$P_f = \frac{S_{fp}}{S_{cl}} \times 100\%$$

$P_f$ : Percentage of cultivated lands in food production per household;

$S_{fp}$ : Cultivated land areas on food productions;

$S_{cl}$ : Cultivated land areas on the total agriculture productions.

$$L_a = \frac{\sum n W_a \times W_g \times T_a}{n}$$

$L_a$ : Average labor hours input in agriculture per capita per day;

$W_a$ : A weighted factor of laborer's age in agriculture, 1 for ages from 16 to 60, 0.5 for ages from 61 to 70, the age from 71 to 85 with 0.3, and others with 0; For the wage-job labor, the weight of age data follows a standard that the age from 16 to 45 as weights with 1, the age from 45 to 60 with 0.5, and others with 0;

$W_g$ : A weighted factor of laborer's gender, for female is 0.7 and for male is 1 for the agriculture labor but weight is the same for the wage-job labor;

$T_a$ : Hours per day per laborer on the agriculture productions;

$n$ : Number of members of a household.

$$L_w = \frac{\sum n W_a \times W_g \times T_w}{n}$$

$L_w$ : Average labor hours input in wage-job per capita per day;

$W_a$ : A weighted factor of laborer's age, 1 for ages from 16 to 40, 0.5 for ages from 41 to 61, and 0 for others;

$W_g$ : A weighted factor of laborer's gender, 1 for male, and 0.7 for female;

$T_w$ : Hours per day per laborer on the wage-jobs;

$n$ : Number of members of a household.

$$L_{\text{sum}} = L_a + \frac{\sum n W_a \times W_g \times W_l \times T_w}{n}$$

$L_a$ : Sum of local labor hours per household per day;

$L_a$ : Average labor hours input in agriculture per capita per day;

$W_a$ : A weighted factor of laborer's age, 1 for ages from 16 to 40, 0.5 for ages from 41 to 61, and 0 for others;

$W_g$ : A weighted factor of laborer's gender, 1 for male, and 0.7 for female;

$W_l$ : A weighted factor of laborer's location, 1 for locality, and 0.7 for other places;

$T_w$ : Hours per day per laborer on the agriculture productions;

$n$ : Number of members of a household.

$$F_a = \frac{\sum n I_v + I_{t1} + I_{t2}}{n}$$

$F_a$ : Frequency of adjacent interactions per household per month;

$I_v$ : Frequency of interactions with the surrounding villages per month;

$I_{t1}$ : Frequency of interactions with the surrounding towns or townships

$I_{t2}$ : Frequency of interactions with the surrounding county centers or county-level cities per month;

$n$ : Number of members of a household .

$$D_e = \frac{\sum n d_e}{n}$$

$D_e$ : Days of tending elders per household per year;

$d_e$ : Days of tending elders for an individual member of the household per year;

$n$ : Number of members of a household.

$$P_s = \frac{N_c}{n} \times 100\%$$

$P_s$  : Percentage of satisfaction on current work per household;

$N_c$ : Numbers of content members in a household;

$n$ : Number of members of a household.

$$R_d = \frac{N_d}{n} \times 100\%$$

$R_d$ : Ratio of dual-work labors per household;

$N_d$ : Numbers of the members doing dual-work in a household;

## APPENDIX 3: THE DETAILS OF THE STATISTICAL ANALYSIS

### 1. THE RESULTS OF VARIABLE SCREENING

The purpose of screening variables is to make the variables independent for the ANOVA, which requires independent samples. The process of screening variables is displayed by the heatmap in figure 8. From this map, several variables are significantly correlated with each other and they may demonstrate the same story when applied into the following comparison analysis. Next, I take one of the correlated variables into account. The most significant variable is the “frequency of interactions with other places per household per month”, which is correlated with all other variables. I delete this variable for the next step of analysis. Another pair of correlated variables is “days of tending to kids per household per year” and the one of “sum of local labor hours per household per day”. I leave the variable of “sum of local labor hours per household per day” in analysis and reject the former one (the reasons seen in the fifth paragraph of section 3.3.4). Other variables in this heatmap are all included in consideration for the next step of analysis. Therefore, the variables employed in the ANOVA are listed in table below.

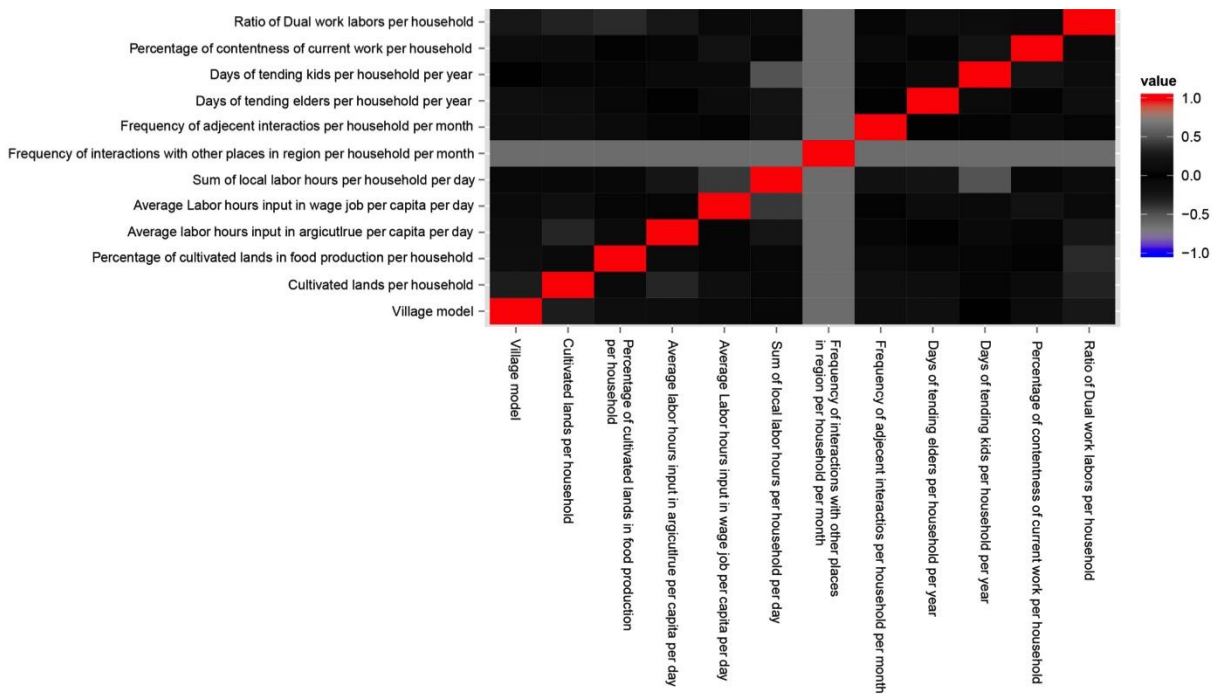


Figure 14 A heatmap of the variable screening by inter-correlation analysis

**Table 3 List of variables employed in Kruskal-Wallis One-way ANOVA**

Variables	Unit
Cultivated lands per household	Chinese Mu
Percentage of cultivated lands in food production per household	%
Average labor hours input in agriculture per capita per day	Hours
Average Labor hours input in wage-job per capita per day	Hours
Sum of local labor hours per household per day	Hours
Frequency of adjacent interactions per household per month	Number of times
Days of tending to elders per household per year	Days
Percentage of satisfaction on current work per household	%
Ratio of dual-work laborers per household	Number of ratio

## 2. THE RESULTS OF KRUSKAL-WALLIS ONE-WAY ANOVA

The results of Kruskal-Wallis One-way ANOVA are listed in table below. There are four variables across three villages that are significantly different, including the variables of “cultivated lands per household”, “average labor hours input in agriculture per capita per day”, “frequency of adjacent interactions per household per month”, and “ratio of dual-work laborers per household”, with the respective p-values  $1.576 \times 10^{-5}$ , 0.007666, 0.0583, and 0.01076. All of these p-values are less than 0.05, which means I can reject the  $H_0$  hypothesis of these three villages are the same. In other words, these villages are significantly different in terms of the above four variables.

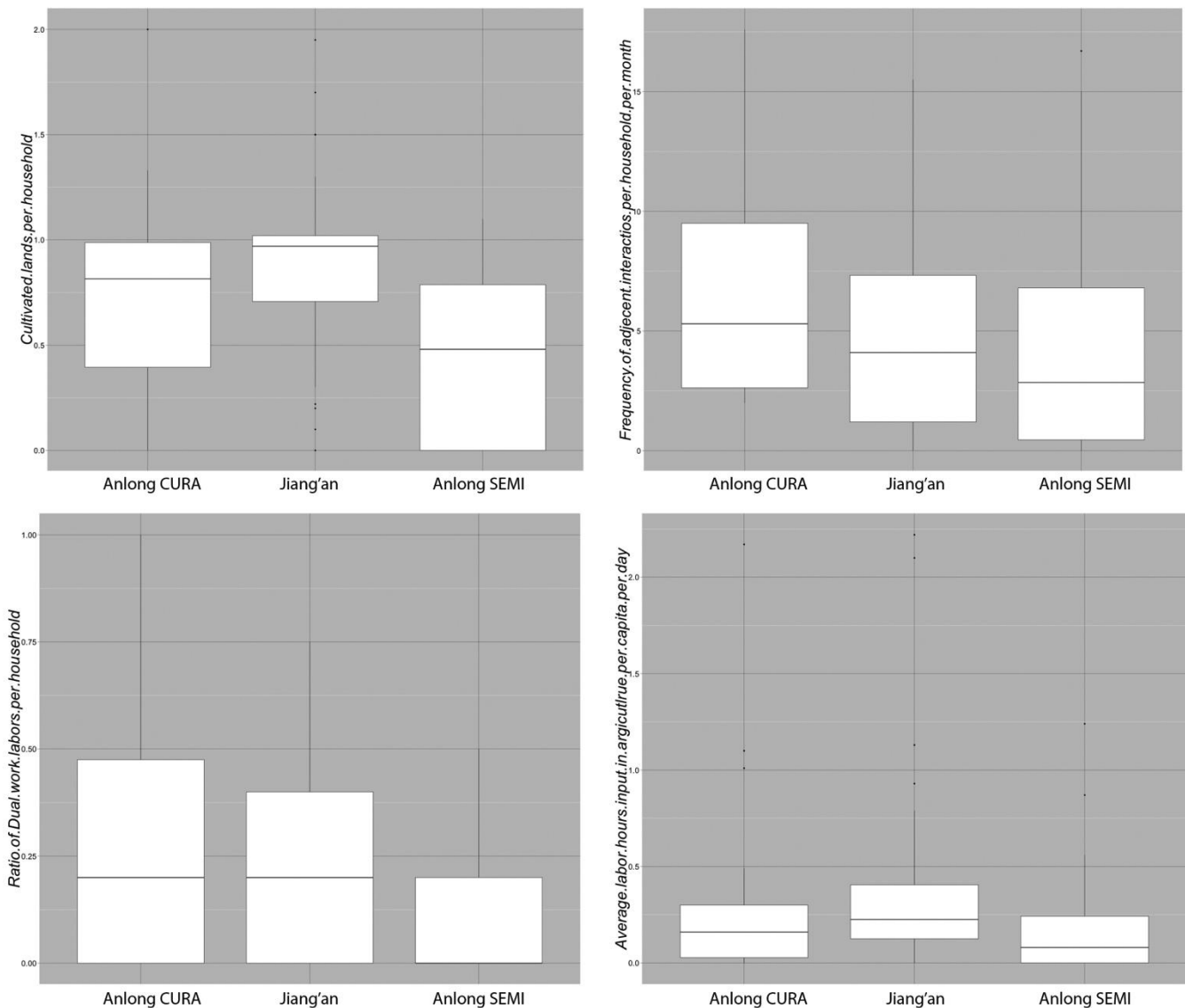
**Table 4 Results of Kruskal-Wallis One-way ANOVA**

	Kruskal-Wallis chi-squared	df	P-value	
Cultivated lands per household	22.1159	2	$1.576 \times 10^{-5}$	***
Percentage of cultivated lands in food production per household	4.4279	2	0.1093	
Average labor hours input in agriculture per capita per day	9.742	2	0.007666	**
Average Labor hours input in wage-job per capita per day	1.5444	2	0.462	
Sum of local labor hours per household per day	0.5222	2	0.7702	
Frequency of adjacent interactions per household per month	5.8812	2	0.0583	.
Days of tending to elders per household per year	2.9311	2	0.2309	
Percentage of satisfaction on current work per household	1.7967	2	0.4072	
Ratio of dual-work laborers per household	9.0642	2	0.01076	*

Significant codes: 0 ‘\*\*\*’, 0.001 ‘\*\*’, 0.01 ‘\*’, 0.05 ‘.’, 0.1 ‘.’, 1.

Also, I plot four figures of the comparisons of the three villages in terms of the four variables identified above. For the variable of “cultivated lands per household”, farmers per household in Anlong CURA and Jiang’an generally cultivate more lands than the ones in Anlong SEMI, which also shows higher

deviation among individuals. Some of the farmers in Anlong SEMI cultivate as many lands as the farmers in the other villages but some of them work on much less arable lands. For the variable of “average labor hours input in agriculture per capita per day”, laborers in Anlong CURA and Jiang’an contribute more hours to agriculture production than the ones in Anlong SEMI, and the ones in Jiang’an input most labor. For the variable of “frequency of adjacent interactions per household per month, it shows an obvious decrease of frequency from the Anlong CURA, Jiang’an to Anlong SEMI. At last, for the variable of “ratio of dual-work laborers per household”, it also shows a patent decrease of the ratio from Anlong CURA, Jiang’an to Anlong SEMI. Much more farmers in both of Anlong CURA and Jiang’an do dual-work (both participate into the agriculture production and find a wage-job) than the ones in Anlong SEMI.



**Figure 15 Comparisons of three study areas in four variables**

*Note:* The Line shows the samples' median number; the white range shows the samples' second and third quartiles; the vertical black line shows the samples' the first and the fourth quartiles; and the dots show the outliers.

### 3. THE RESULTS OF MANN-WHITNEY U-TEST

Besides the three-village comparison, I also do three groups of comparisons for each two villages by Mann-Whitney U-test. An advantage with the Mann-Whitney U test is that the two samples under consideration do not necessarily need to have the same number of observations (Explorable.com 2015). Due to the non-normality of variables, I use this test to compare the variables not analyzed in the

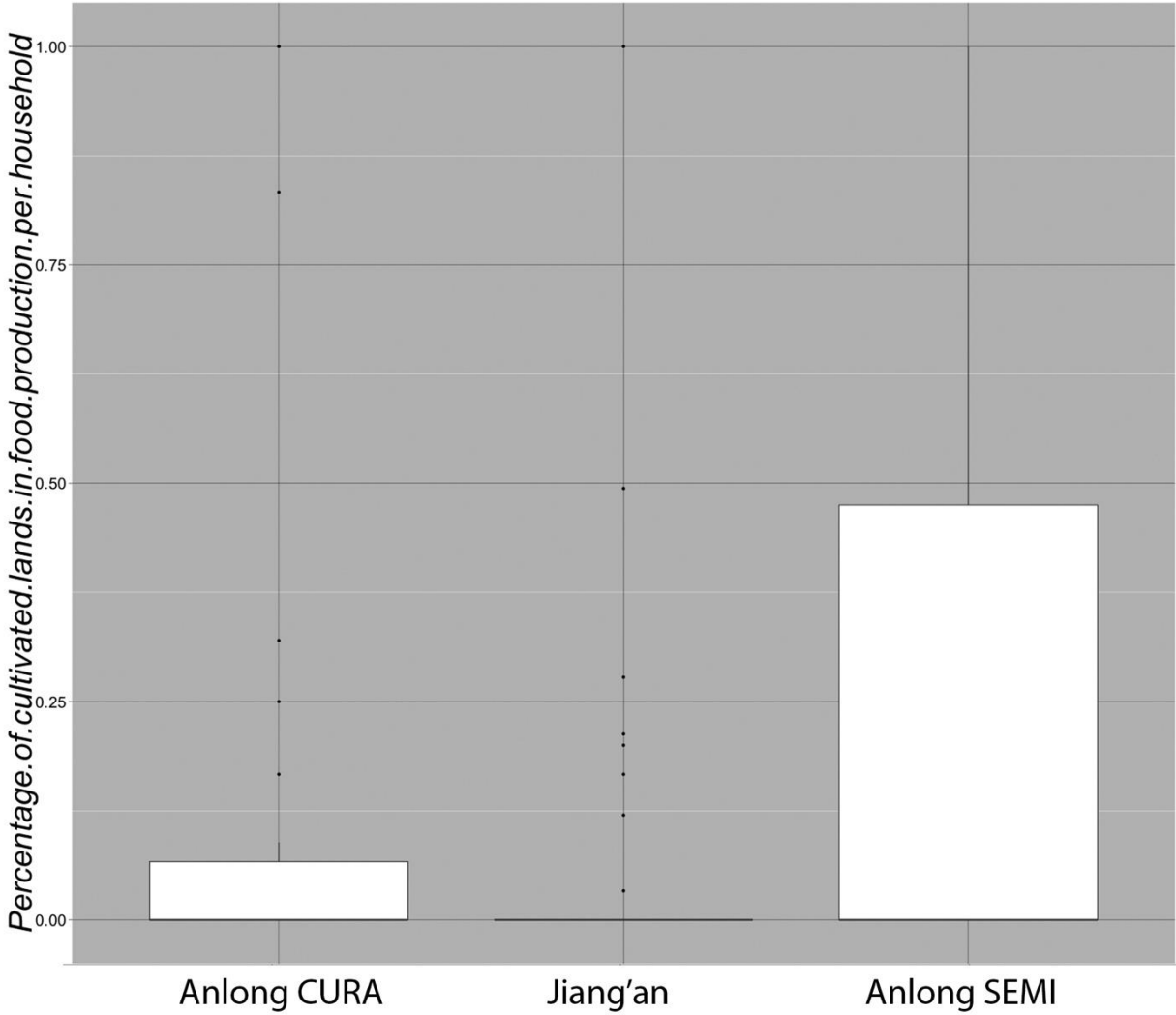
correlation analysis above across pair-villages, like Jiang’an versus Anlong CURA, Jiang’an versus Anlong SEMI, and Anlong CURA versus Anlong SEMI. The results of the Mann-Whitney U-test are shown in Table 9. Most of the P-values are larger than 0.05 except from the variable of “percentage of cultivated lands in food production per household” (P-values is  $5.667 \times 10^{-6}$ ) in comparisons between the villages of Jiang’an and Anlong SEMI. The results of p-values imply that the villages of Jiang’an and CURA and villages of Anlong CURA and Anlong SEMI are very similar if comparing with these variables, but only the villages of Jiang’an and Anlong SEMI are significantly different in the cultivated lands contributing to food production.

**Table 5 Results of pair-village comparison by Mann-Whitney U-test**

Variable	W	P-value
<b>Comparisons between Jiang’an and Anlong CURA</b>		
Percentage of cultivated lands in food production per household	564.5	0.4314
Average Labor hours input in wage-job per capita per day	475.5	0.5635
Sum of local labor hours per household per day	554.5	0.6554
Days of tending to elders per household per year	505	0.8458
Percentage of satisfaction on current work per household	474	0.5418
<b>Comparisons between Jiang’an and Anlong SEMI</b>		
Percentage of cultivated lands in food production per household	351.5	$5.667 \times 10^{-6}$
Average Labor hours input in wage-job per capita per day	889	0.1988
Sum of local labor hours per household per day	791	0.7603
Days of tending to elders per household per year	621	0.1556
Percentage of satisfaction on current work per household	882.5	0.2156
<b>Comparisons between Anlong CURA and Anlong SEMI</b>		
Percentage of cultivated lands in food production per household	431.5	0.3096
Average Labor hours input in wage-job per capita per day	546	0.4814
Sum of local labor hours per household per day	546.5	0.4767
Days of tending to elders per household per year	386.5	0.1374
Percentage of satisfaction on current work per household	553	0.4163

To understand the differences better, I plot the below figure of the comparisons of the three villages in terms of the variable of “percentage of cultivated lands in food production per household. From the information in this figure, Anlong SEMI has a significantly high percentage of food production lands than the ones in Anlong CURA and Jiang’an, especially the one in Jiang’an, which shows a very small amount of lands contributing into food production. But the deviation of the percentage is much higher in

Anlong SEMI. A lot of farmers in this villages work on very few lands, even none, for food production, meanwhile some of them work on the significantly large areas of lands for food production.



**Figure 16 Comparison of percentage of cultivated lands in food production per household among three villages**