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Assessing Resilience in the Spatial Patterns and Socio-ecological Functions of the Chengdu Plain

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A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2022

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University of Washington

Abstract

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With the rapid process of urbanization, many traditional rural landscapes in the world have shrunk or even disappeared. As a special type of rural landscape, the *linpan* landscapes interwoven with the scattered market towns on the Chengdu Plain, Sichuan, China, and especially the Dujiangyan Irrigation District – China’s largest and one of its oldest – constitute a fine-grained mosaic in which ecosystems are traditionally well utilized for human development. With the accelerating loss of the *linpan* landscapes recently, there is an increasing need to broaden and deepen the recognition of their values. In this study I combine advanced geo-spatial tools with sociological interviews and built-environmental typological approaches to understand: (1) the configuration and spatial pattern of the *linpan* landscapes and market towns; (2) their functioning roles in delivering services; (3) the socio-economic connection of the *linpan* landscapes through hierarchical market towns; and (4) the resilient features of the rural societies of the Chengdu Plain in coping with external disturbance. The spatial pattern of *linpan* and their densities are related closely to local topography, population density, availability of water supply and accessibility to market places. *Linpan* are smallest in area and occur at highest densities in flat areas closest to the historic center of the irrigation system, and are larger and less densely distributed in the gentle hills peripheral to the irrigation system – suggesting that *linpan* were integral to the historical

resilience of the irrigation system. The layouts of traditional cottages present a “line” shape, “L” shape, “U” shape, or “compound” shape with an evolutionary process of family expansion, and all of these layouts often reflect the adaptation to the surrounding environment such as the orientation of houses. As a coupled social and natural system, *linpan* provides multiple goods and services to lives and livelihood of local communities including provisioning (foods, fuel woods, or water), regulating (air, temperature or pollination) and cultural (ecotourism or spiritual enrichment) services. *Linpan* dwellers have been integrated into a holistic society through rural markets, where public spaces provide them a commercial agora or socio-cultural platform for socializing themselves through public exchange. Easy accessibility and cheap logistic flow contributed greatly to the development and prosperity of market towns. The alternative periodicity of neighboring markets becomes convenient for local people and puts the most disadvantaged villager within easy walking distance to one of market towns flexibly. Public spaces in market towns provide local people an area for socializing themselves through public exchange, which are important venues for social harmonization and the “epitome” of rural development. Finally, using the COVID-19 pandemic as a shock, I assessed the resilience of rural districts in Chengdu using four categories (Health-care Index, Economy Index, Governance Index and Landscape Index) including 11 indicators. I combined quantitative method (statistical analysis) with qualitative method (interviews) to give weight to each index. The results showed a close relationship between resilience value (R) and post-pandemic (mainly economic) recovery in rural Chengdu. Statistical analysis also shows that the economic recovery in post-pandemic period is closely related to the strength of socio-ecological resilience. Agriculture functions as a stabilizer for the local economy in the face of the COVID-19. Among the four categories of indexes, landscape domain contributes most to the economic recovery, but it was underestimated by both farmers and experts. Considering the pandemic has not been fully terminated, a comprehensive assessment of the relationship between socio-ecological resilience and external disturbance still needs a longer period for further verification.

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ACKNOWLEDGEMENTS

I would like to first and foremost thank my Chair, Prof. Daniel Abramson, for his continuous advice and support for my study over the past five years. Because of his passion for research in China I, as a Chengdu native, was able to join the University of Washington's big family of Sichuan-related research professionals and could study my hometown in more depth than I have ever known for years. Thanks to Prof. Manish Chalana for his advice as a historic preservationist and urban historian on various aspects of my research and the opportunity for allowing me to work with him as a teaching assistant during the past few challenging quarters of online learning. Thanks to Prof. Bo Zhao for leading me into the exciting world of digital geography and exposing me not only to digital technologies but to humanistic theories in Geography. Many thanks to Prof. Monika Mosal for her generous supports - much more than a GSR, she has provided me with so much valuable advice and resources. Last but not least, I would like to thank Prof. Stevan Harrell, who has retired from the Anthropology Department of the University of Washington, but has continued to provide me with detailed advice during this whole process. His reading of my dissertation provided many valuable comments and suggestions for improvement. His true love of this topic also motivates me to keep moving forward and believing in the value of what I am doing.

I would like to thank the PhD program of the Built Environment and the College of Built Environments, the Department of Urban Design and Planning, the Quaternary Research Center, and the Department of China Studies at the University of Washington, for their academic and financial assistance during my study and research process.

Special thanks should also be given to professors and student assistants at Chengdu. Because of the pandemic, the *in-situ* fieldwork became difficult, but due to your wholehearted help I was able to continue accumulating resources and data, and to finish this project in time. In particular, I am very grateful to Mr. Bo Zhong, PhD candidate from the Chengdu Institute of Biology, Chinese Academy of Sciences, for his kindly help in field survey and data analysis. Our collaboration in article writing is also fruitful. The author is indebted to those who personally contributed material and provided valuable information for this dissertation. Particular thanks are due to Mr. Yang Xiande, Mr. Liu, Mr. Luo and many local interviewees from Dantu market, Dantu Cun and Paotong Cun, whose support has helped greatly to produce this study. I am also grateful for my advisors and peers from the Tongji University and the University of Pennsylvania, who have influenced me so much during the period of my undergraduate and graduate study.

Finally, I would like to thank all of my family members for their continuous support and encouragement. It would not have been possible to finish the doctoral study without your love and patience. Thanks to my cohorts, friends and peers who helped me during this special journey. It was an unforgettable experience!

Chapter 1 Introduction

1.1 Problem identification

Thoughtful observers of global landscapes cannot fail to see that we live in a human-dominated world (Nassauer, 1997), which means that all ecosystems have been modified by humans to some extent. In the past 50 years we have seen the most rapid transformation of the biosphere ever occurring in human history (Steffen et al., 2004). Intensive land use and overexploitation of natural resources have become the largest drivers of environmental change as we have shaped the landscapes to fulfill our demands and aspirations for food, water, shelter and transportation (Turner et al., 2007; IPBES, 2019). Along with environmental factors such as climate change, various anthropogenic factors (both socio-economic and cultural) have altered ecosystems, creating managed farms, forests, wetlands, and human settlements, which form different cultural landscapes. Growing evidence indicates that land use and land cover change brought about by rapid industrialization, urbanization and agricultural intensification have accelerated the degradation of land resources and the fragmentation of natural or semi-natural ecosystems (Stavi and Lai, 2015; IPBES, 2018).

Among the globe's diverse landscapes, urban nodes and their hinterlands are highly human-dominated environments with a new set of ecological conditions created by changing landscape dynamics, which become a socio-ecological system (Alberti, 2008).¹ It has become evident that earth's landscapes are increasingly influenced by the pace and patterns of the urbanization process, which have brought about impacts on the local environment and beyond (United Nations, 2014; Turok and McGranahan, 2013).² Generally, as a socio-ecological system, the urban-rural continuum has many specific characteristics, whose structure and functions are different from other natural ecosystems. In the last two or three decades, urban agglomerations in China have expanded very rapidly, mainly by occupying or fragmenting croplands (Xu et al., 2016). Apart from on-going physical expansion, urban land-use

¹ Studies of interactions between humans and their environments have received increasing attention in a number of scientific fields, contributing to the conceptualization of these landscapes as complex “coupled human and natural systems” or “socio-ecological systems” (Redman et al., 2004; Folke et al., 2010), terms used interchangeably in this study. This term explicitly points out that humans and nature are corresponding actors in the ecosystem.

² In this context urbanization indicates the process of population concentration by the movement of people from non-urban to urban areas, with an increase in the ratio of urban people to the total population. This shift is usually accompanied by the change from a largely agricultural economy to an industrial one (Larkin and Peters, 1983).

change is predominantly characterized by peri-urbanization, where rural lands become enveloped by, or transformed into, extended metropolitan regions (Simon et al., 2004; Lee et al., 2015). This produces a complex mosaic of traditional and modern land uses or land covers and associated socio-economic and governance systems (Elmqvist et al., 2013; Holt et al., 2015).

In the global development of nations and of people, rural landscapes are losing ground. For some decades, development planners, government officers, and peasants themselves have tried to bolster, modernize, or fundamentally transform the agrarian way of life with diverse motives and aims. Individual peasants have sought to cope with pressures by such adaptive mechanisms as labor migration, the intensification of agricultural production, the diversification of livelihood, or the pursuit of education. Large sectors of entire agrarian societies have been involved in planned development programs and urbanization processes coordinated by governments, with the collaboration of administrators, planners, technicians, and extension officers (Shultz, 2009). Consequently, the pressures derive inevitably from unsustainable “modernization,” such as the large-scale transferring of peasants into the non-farming economy (through resettlement programs, forced commercialization, a relative drop of the value of agricultural products, and similar pressures), and of measures that directly deprive peasants of their former share of economic life (by the transformative change of land tenure).

Currently, many rural landscapes have been intensively managed and dominated by strong agricultural and urbanization pressures (Borgström et al., 2006; Laterra et al., 2012). Within this kind of landscape, ecosystem services are produced under high human population densities and farming intensity (MA, 2005).³ Anthropogenic drivers and socio-ecological interactions have affected the spatial pattern of ecosystems and the availability of their services (Alberti, 2005; Power, 2010; Turner et al., 2014). Moreover, with the process of socio-economic development and the associated change in demands, rural landscapes are utilized for different purposes (e.g. industrial, commercial, and settlement), leading to spatial trade-offs of ecosystem services within a given territory (Rodriguez et al., 2006). In the Chengdu Plain trade-offs between agro-ecosystems and green spaces and their associated services due to recent Park-City Construction (“*Gong Yuan Cheng Shi Jian She*” in Chinese) program may cause one service, e.g., enhancing recreational or aesthetical services, to influence another service, such as provisioning of agricultural products.⁴ During this process, however, there may also be positive interactions – synergies

³ Ecosystem services in this context indicate the goods and services that ecosystems provide to society and may be categorized as provisioning, regulating, cultural, and supporting services (MA, 2005).

⁴ General Secretary of the Chinese Communist Party (CCP), Mr. Xi Jinping, visited Chengdu in February 2018 and suggested the development of a “Park City” (“*Gong Yuan Cheng Shi*” in Chinese), a concept similar to Howard’s “Garden City”. Shortly afterwards, a program called “Park City Construction” (“*Gong Yuan Cheng Shi Jian She*” in Chinese) was initiated by the Chengdu government with the main aim of increasing green

– between multiple services, such as wild flower patches in rural landscapes or city parks, which can increase pollination and the yield of crops or fruit trees (Bennett et al., 2009). Understanding the structure and functioning of a rural landscape and the complicated interactions between the ecosystem services within it is thus crucial for landscape preservation and planning to promote multi-functionality (Bennett et al., 2009).

With the rapid process of urbanization in China, many traditional rural landscapes have shrunk or even disappeared (Cai, 2019). Both the physical and cultural situations of rural areas are experiencing tremendous changes, and the traditional landscape is facing unprecedented challenges.

Over-commercialization and rapid modernization have become key issues for landscape preservation, and one of the most serious consequences is that the characteristic integrity and continuity of rural landscapes is being lost, followed by the disappearance of traditional culture. The ecological dependency of humans on biophysical landscapes in traditional agrarian society and the socio-economic connectivity between rural areas and urban centers through hierarchical rural markets have been profoundly changed (Skinner, 1965; Du and Zhang, 1986; Huang et al., 2020). Although many efforts so far have been put into landscape planning and preservation in China, most of them in fact only focus on how to use these landscapes as a kind of resource for development purposes (in particular for rural tourism), or on how to protect individual historic buildings physically rather than preserving the whole landscape or its holistic functions (Sun et al., 2008; Wang et al., 2009). The preservation of traditional cultural landscapes is very important for maintaining the specific societal structure and local environment of rural areas (Teresa, 2000). However, the multi-functionality of rural landscapes is consistently neglected by planners and decision makers (Wilson, 2007; Liu et al., 2005; Prändl-Zika, 2008; Vaarst et al., 2018).

Like many cultural landscapes, the *linpan* landscape in the Chengdu Plain is a fine-grained mosaic in which physiographic structures (spatial units characterized by relatively homogeneous abiotic factors) are traditionally well defined and utilized in different ways for agriculture, agro-forestry or forestry. The mosaic features of the *linpan* landscape have been shaped over generations by a strongly interlinked set of practices and production activities that have been adapted and transformed to maintain and improve the community's well-being while absorbing shocks to the system. Consequently, harmonious human actions within the social-ecological system that have formed the *linpan* landscape have generated areas characterized by high level of resilience (Abramson, 2019). Historically, at least since the middle of the Qing Dynasty, the co-evolutionary processes of the rural society and its environment have been favorable to, or synergistic with, landscape preservation, and still persist in farmlands, wetlands, and

space and ecological infrastructure in both urban and rural areas.

forests in the Chengdu Plain. The value of traditional knowledge and practices for environment conservation and sustainable development in this plain, however, is often overlooked by scholars and policymakers (Fang, 2013; Yuan, 2018; Li et al., 2018). With the accelerating loss of *linpan* landscapes, there is an increasing need to broaden the recognition of the values of this landscape for preservation as well as for human well-being (Tippins, 2014).

Urbanization and industrialization could result in population congestion in towns or cities, expansion or occurrence of newly centralized villages or townships, followed by the widespread disappearance of small farmers' settlements, and finally by changes in the structure and functions of rural landscapes (Ruda, 1998). In the Chengdu Plain, population migration (especially of young people) from rural to urban areas has led to a drastic decline of rural labor in the last two decades, associated with the abandonment of settlements and fields. Consequently, forests have expanded to a certain extent, indicating the shift in the ecosystem services delivered by the rural landscape (Peng et al., 2015; Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020). Ill-planned urbanization and infrastructural expansion in rural lands has also led to the fragmentation of *linpan* landscapes, turning it into many small "islands" separated by modern infrastructure such as highways and power lines, and urban construction. Traditional rural market towns have been urbanized and replaced by modern commercial centers (Huang et al., 2020). A vigorous and productive cultural landscape has partly lost its traditional functions. Generally, the relevant processes of change in *linpan* landscapes are mostly determined by socioeconomic and political issues. Thus, an understanding of the resilience of this landscape in facing past or on-going crises must be based on a thorough analysis of its structure, functions, and major nodes, as well as relationships with anthropogenic drivers (demographic, socio-economic, and political), to identify whether it can maintain the same capacity to absorb and adapt to the pressures associated with unprecedented rates of changes. Preservation and restoration of natural and built environments, especially long-settled landscapes, are crucial for rural revitalization. The harmonious dwelling of humans within a social-ecological system will be reflected by local features of the spatial patterns of rural landscapes and settlement architecture, which is the entry point of this study.

Urbanization in the Chengdu Plain has led to a restructuring of the urban population and the reshaping of the rural landscape as mentioned above. As early as 2003, Chengdu Municipality piloted a rural-urban integration development initiative, which then was promoted in 2007 as a national urban-rural comprehensive reform model (Li and Yang, 2011; Peng et al., 2015). The traditional scattered residential *linpan* clusters on the rural Chengdu Plain were or are being progressively replaced by centralized settlements according to the Construction of New Rural Villages ("*Xin Nong Cun Jian She*" in Chinese) movement (Ahlers and Schubert, 2009). This urbanizing process was accelerated by the disaster recovery after the Wenchuan earthquake in 2008 (Li, 2009; Abramson and Qi, 2011) and the

so-called “Three concentration policy” (“*San Ji Zhong Zheng Ce*” in Chinese).⁵ A shift came in 2017, when the Chengdu government put forward the “Western control policy” to limit the westward expansion of Chengdu’s built area in order to protect water sources, which shows a shift from focusing on large construction to environmental protection.⁶ Later, national strategies such as “Rural Revitalization” (“*Xiang Cun Zhen Xing*” in Chinese) emphasized the significance of agricultural development, environmental protection and livelihood improvement simultaneously, which are beneficial to both rural development and landscape preservation (Lin, 2011; Liu et al., 2017).⁷ Recently, the metropolitan government of Chengdu proposed a new program called “Park City Construction” with the main aim of increasing green space and ecological infrastructure in both urban and rural areas.

The change of the rural landscape in the Chengdu Plain has attracted a lot of researchers to study its challenges and opportunities. Much attention has been paid to its trend of development and its influence on land use and land cover changes (Li and Yang, 2011; Peng et al., 2015), urban growth and land-use outcomes (Schneider et al., 2005), and their implications for socio-ecological and aesthetic values (Yang et al., 2011), urbanism theory and urbanization influence (Webster et al., 2004; Liu, 2014). Shu et al. (2013) analyzed the impacts of land consolidation on traditional rural settlements in the Chengdu Plain

⁵ The “Three Concentration Policy”, including concentration of farming fields, concentration of settlements, and concentration of industry, aims at constructing a “new socialist countryside” through consolidating rural farm plots, resettling farmers in rural towns and locating factories in industrial zones, which was proposed by Chengdu metropolitan government in 2003. During that period, a few concentrated houses were built for the relocated farmers.

⁶ Because Pidu district is located inside of this proposed region with the most fertile farming lands and valuable drinking water source for the whole plain, the government no longer supported any kind of concentrated housing for farmers. Instead, a flexible policy encouraging small-scale living forms was put forward. Considering ecological protection, ecological corridors (protected belts) with 200 m wide were constructed along the Baitiao and Xuyan rivers. Two tributaries of the Dujiangyan Irrigation System with buffer zones 500 m wide were also required, prohibiting new construction. In summer of 2017, 10% of the farmers interviewed in my case-studying site of Paotong village have been relocated outside of the protected belts and buffer zones, and in 2018 all of the rest were moved out.

⁷ “Rural Revitalization” is a national strategy in China, which was proposed by the central government in 2017. It has seven goals, including (1) restructuring urban-rural relationship for an integrated development approach; (2) consolidating and improving rural fundamental management for a common prosperity approach; (3) deepening agricultural reform on the supply side for a high-quality agriculture approach; (4) insisting on harmonious coexistence of humans and nature for a greening rural development approach; (5) preserving, developing and promoting agricultural civilization for a prosperous rural culture approach; (6) innovating rural governance for a well-governed rural area approach; (7) continuing targeted poverty alleviation for a Chinese characteristics approach.

and tried to explore an approach to integrating traditional architectural elements into new planning and design. Later, Tippins (2014) evaluated the resilience of *linpan* landscapes under redevelopment alternatives, focusing specifically on landscape structure (spatial patterns) as a variable in agro-ecosystem resilience. With the increasing acknowledgement of the importance of *linpan* landscapes, the local government of Pidu District proposed to nominate this cultural landscape as a site of the Globally Important Agricultural Heritage Systems (GIAHS) in 2016.⁸ Recently, after a comprehensive study of traditional *linpan* in the Chengdu Plain, a group of experts suggested some typical *linpan* (units) for preservation and sustainable use (Li et al., 2018). Generally speaking, however, an integrated study articulating the mechanisms that link biophysical and socioeconomic drivers to the resilience of this socio-ecological system is still lacking, which may undermine preservation efforts in this cultural landscape.

1.2 Selection of the Study Area

1.2.1 Chengdu Plain

Located in the Sichuan Basin of southwest China, the Chengdu Plain has traditionally been the most important agricultural region on the upper reaches of the Yangtze River. Whiting et al. (2019) stated that this region has long been a leading food exporter in China, only recently starting to import food from outside due to the shrinkage of farmlands. Meanwhile, unlike other high-density agricultural areas of China, such as the Yangtze River Delta and the Pearl River Delta, the Chengdu Plain is characterized by not only its high agricultural productivity but also by its spatially dispersed pattern of rural settlements (traditionally used by local peasants) on the landscape (Fang, 2013; Whiting et al., 2019). This spatial pattern of settlements is called “*linpan*” in literature, and “*linpan*” has been used widely as a local slang on the Chengdu Plain for hundreds of years (Fang, 2013; Chen, 2011; Tao et al., 2016; Li et al., 2018). Generally speaking, the *linpan* landscape, composed of hundreds and thousands of *linpan* units or wooded lots (small settlement clusters), is found in the Chengdu Plain, an alluvial basin located between 103° -104° 42' E longitude and 29° 31' -31° 50' N latitude, about 110 km long from north to south and 80 km wide from west to east with an area about 9,000 square kilometers (Fang, 2013; Chen, 2011) (Figure 1.1).

⁸ According to the FAO's definition, a “*GIAHS is a living, evolving system of human communities in an intricate relationship with their territory, cultural or agricultural landscape or biophysical and wider social environment*”. This means a GIAHS site is not only a static monument but a productive system still used by local people today.

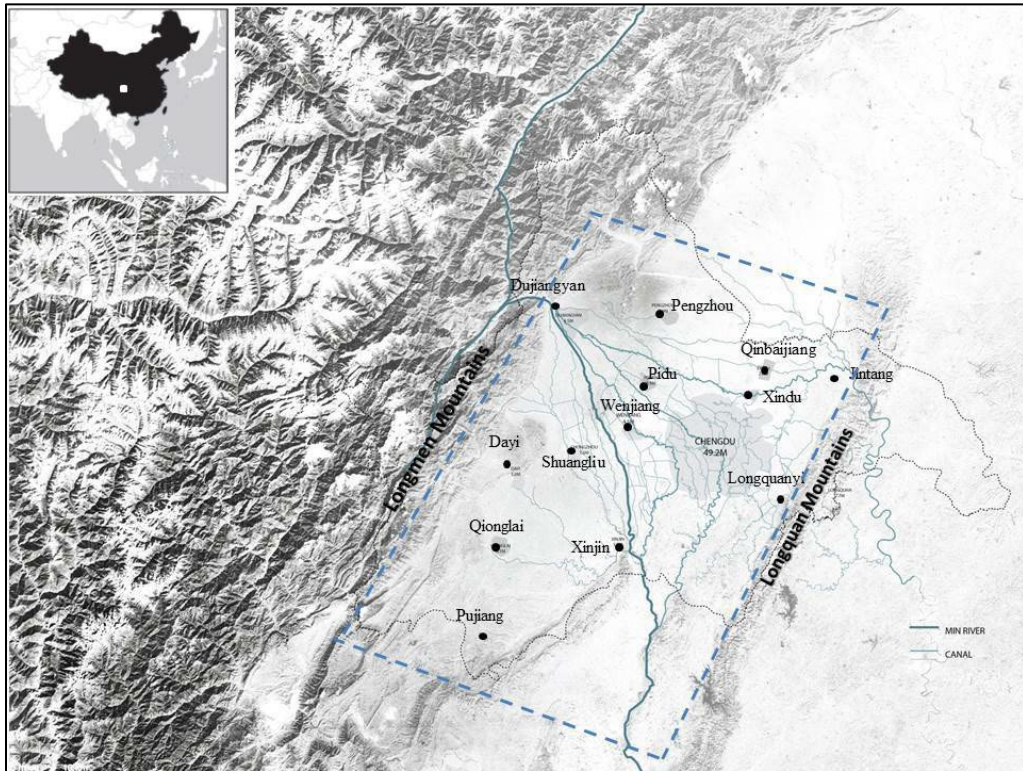


Figure 1.1 Location map of the Chengdu Plain

Note: This map shows the location of the Chengdu Plain (roughly inside of the blue dash lines), the watershed of the Dujiangyan Irrigation System, the location of counties/districts of Chengdu metropolitan area and the reach of the Longmen Mountains and the Longquan Mountains⁹

Source: Mapped by author

The Chengdu Plain is the “bottom” of the Sichuan Basin, extending between the Longmen Mountains in the west and Longquan Mountains in the east with a very flat and partly hilly topography. The great Min River and Tuo River, two large tributaries of the Yangtze River, together with their own tributaries, run across this plain, forming an expansive watershed. With an elevation of about 400-700 meters above sea level, the climate of this plain is typically subtropical with a mild temperature (annual mean temperature: 15.2–16.6 C) and rich rainfall (annual mean precipitation: 899-1284 mm) almost all year round, which provides ideal conditions for grain crops (rice, wheat, and maize) and vegetable cultivation, subtropical fruit plantation and raising domesticated animals such as cattle, pigs, poultry,

⁹ Longquan Mountains (called “*long quan shan*” in Chinese), located at the eastern fringe of the Chengdu Basin, is the division of Min River watershed and Tuo River watershed in Sichuan. With the north-south length of 200 km and the east-west width of 10 km, the height of main peak is 1051 m a.s.l but the relatively vertical difference is about 500 m from the bottom of the basin (Source: Baidu encyclopedia). Thus, it can be translated into Longquan Hills as well.

and freshwater fish (Editorial Committee of Chengdu Gazetteer, 2000). Even in winter the temperature is almost always above zero (the mean temperature in January being 6.2 C) with occasional frosts, but the highest monthly mean temperature is around 26 C in August, which supports two harvests of crops in this agricultural region (Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020).¹⁰ Abundant rainfall occurring in growing season (about 60 percent of the total falls from June to August) is beneficial to the development of wet-rice agriculture. Watered by the ancient Dujiangyan Irrigation System, the Chengdu Plain has become one of the world's most densely populated and richly productive agricultural regions (Yuan, 2018).¹¹ It is known as the "Land of Abundance" or "Heavenly Kingdom" (*tian fu zhi guo* in Chinese) in China

Administratively, except for five districts within the urban center of Chengdu city, fifteen rural counties or districts currently belong to Chengdu Municipality, including Longquanyi, Pidu (Pixian), Wenjiang, Shuangliu, Xindu, Qingbaijiang, Dayi, Xinjin, Jintang, Pujiang, Dujiangyan, Pengzhou, Chongzhou, Qionglai and Jianyang.¹² According to the survey report of the Chengdu Committee of Urban Rural Construction in 2007, typical *linpan* landscapes may be found in these rural counties or districts (except for Jianyang). In this study, I selected these fourteen areas as my target for further analysis (Table 1.1). Statistics show that the average population density of the six counties/districts bordering the urban center (called the "inner circle" in this study), including Longquanyi, Qingbaijiang, Xindu, Pidu, Wenjiang and Shuangliu, is 1342.17 persons/km², higher than the other eight counties/districts (called the "outer circle" in this study) located farther from the city (only 596.25 person/km²). The farm field area per capita in the "inner circle" is much lower, being only 0.468 mu/person, than the "outer circle" where the average area is 0.882 mu/person, illustrating a more intensive management of farming fields near the urban center.¹³

¹⁰ Just as Skinner's fieldnotes, in the Chengdu Plain there are two crop seasons, i.e. *dachun* (big spring) in late spring and summer and *xiaochun* (little spring) in winter and early spring (Skinner, 2017).

¹¹ Dujiangyan Irrigation System was constructed 2,400 years ago (completed in 256 B.C.) by Li Bin and his son (Li Er-lang) in the Qin Dynasty. As a world heritage site, it is still functioning today and irrigates 0.67 million hectare farming fields, over 40 counties in Chengdu Plain and beyond. Within the territory of the Chengdu Municipality, about 70% of arable land (about 0.4 million hectare) falls into the irrigated area (Editorial Committee of Sichuan Local Gazetteer, 1993; Editorial Committee of Chengdu Gazetteer, 2000).

¹² Considering that Jianyang was assigned administratively to Chengdu City after 2019 and is located to the east of Longquan Mountain, it is not included in the following discussion of *linpan* landscape.

¹³ The term "mu" is an area unit traditionally used in China for farming field. One hectare is equal to 15 *mu*.

Table 1.1 Basic conditions of rural counties/districts in Chengdu metropolitan area (2017)

County or district	Rural administrative hierarchy		Area (km ²)	Total population (1,000)	Population density (km ⁻²)	Cultivated area (1,000 <i>mu</i>)	Field per capita (<i>mu</i>)
	<i>Xiang</i> or <i>Zhen</i>	Cun					
Longquanyi*	8	76	556	684.8	1231	118.9	0.174
Qingbaijiang*	9	92	379	430	1134	285.2	0.663
Xindu*	10	127	496	771.5	1555	385	0.499
Wenjiang*	6	35	276	455.1	1649	201.9	0.444
Shuangliu*	18	116	1068	1185.2	1109	612.8	0.517
Pidu*	13	129	437	600.9	1375	308.3	0.513
Jintang**	20	164	1156	903	781	681.6	0.754
Dayi**	19	142	1284	511.5	398	401.4	0.785
Pujiang**	11	104	580	267.8	462	356.1	1.33
Xinjin**	11	64	329	317.2	964	226.3	0.692
Dujiangyan**	14	187	1208	622.6	515	400.5	0.643
Pengzhou**	19	251	1421	803	565	762.1	0.949
Qionglai**	22	200	1377	655	476	665.6	1.016
Chongzhou**	24	188	1089	663.6	609	586.1	0.883

Note: 1. “Cun”, sometimes translated as village, here indicates “*xing zhen cun*,” called “*cun min wei yuan hui*” (villager committee) in official publications.

2. * indicating those in “inner circle”; ** indicating those in “outer circle”

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2018.

1.2.2 Case study sites

Instead of forming large villages, peasants in the Chengdu Plain prefer to live in a dispersed mode and maintain a certain spatial interval from each other. Typically, 2-3 households or more live in one *linpan* unit which forms a relatively independent settlement cluster surrounded with woodlands and farm fields, appearing as wooded lots. These *linpan* units linked by canals and ditches well match the provision of water resources and the availability of traffic condition, characterized by a “dense-but dispersed spatial pattern” (Tippins, 2014) or “decentralized mode of village structure” (Shu et al., 2013). Sufficient space between these settlements guarantees that the 'niches' will not overlap and residents can avoid direct conflicts over natural resources (Wu, 2020). However, the structure and spatial pattern of the *linpan* landscape is varied at different locations, pursuant to natural and socio-economic conditions.

Considering the differences of geomorphological features (flat or gently hilly), hydraulic conditions

(historically or newly irrigated by the Dujiangyan Irrigation System) and associated land-use practices, two case-study sites were selected for detailed investigation and comparative study: Paotong Cun (village) in Pidu District (Pi County before 2017), about 26 km to the northwest of the urban center, and Dantu Cun (village) in Shuangliu District (Shuangliu County before 2019), about 30 km to the south (Figure 1.2). Both of these sites are “*xing zeng cun*” (literately “administrative village”) or are simply called “*cun*” in the rural administrative hierarchy, where they occupy the lowest level of the government system.¹⁴

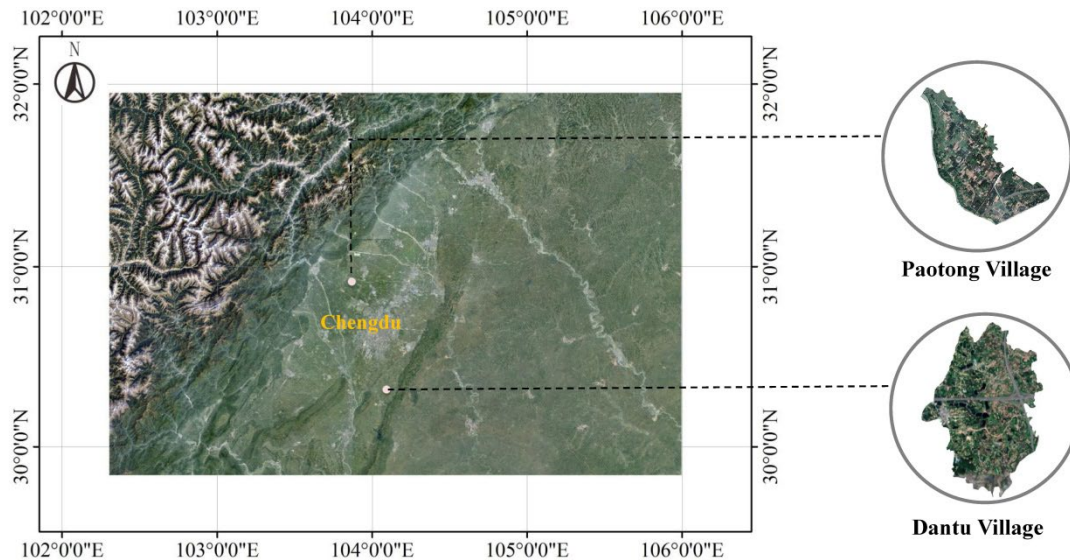


Figure 1.2 Location of case study sites in the Chengdu Plain

Source: modified from Google Earth by author

Paotong Cun, with an area of 1.87 km² and a population of 2,290 over 728 households in 2018, is a typical farming area where local people traditionally engage in grain, oilseed, and vegetable cultivation and occasionally in horticulture (mainly garden flowers or decorative plants). This administrative village includes eight villager groups and one farmer’s association (called “*nong min he zuo she*” in Chinese), mainly for the production of Chinese chives.¹⁵ Based on geo-spatial analysis (visual interpretation using ArcGIS and images drawn from the Google Earth) and field surveys, it was found that farms dominate land use, making up 69.29%, followed by forests (13.53%), built lands (11.87%, including human settlements and roads) and freshwater bodies (5.31%, including canals and ponds) (Figure 1.3a; Table

¹⁴ Below “*xing zheng cun*” there is “*cun min xiao zu*” (literately “villager group”) which is simply called “*xiao zu*” (group), but it is not an administrative level in the government system.

¹⁵ In 2020 Paotong Cun and Babuqiao Cun were combined as Babuqiao Shequ (Babuqiao Community), including nine (villager) groups, which belongs to Sandaoyan *Jiedao* (i.e. Sandaoyan *Zhen* before 2020) administratively.

1.2). This area with very flat topography and fertile soil belongs to the area irrigated in the Qing period by the Dujiangyan Irrigation System. Rice paddies are interspersed with many woodlots (*linpan* units), forming a typical *linpan* landscape. Because there is no rural market based on this *cun*, local villagers must go to the neighboring market town, Sandaoyan, or occasionally to further towns such as Tangyuan and Xinmin for their trading activities, all of which are located within a distance of 5-6 kilometers.

Table 1.2 Basic situations of two case-study sites, Paotong and Dantu

Situations	Paotong Cun	Dantu Cun
Area (km²)	1.87	6.45
Population	2,290	3,457
Population density (km⁻²)	1224.6	535.97
Households	728	1,072
Household size (persons/household)	3.15	3.23
Villager groups	8	3
Farmlands	69.29%	59.54%
Forests	13.53%	14.91%
Freshwater bodies	5.31%	10.16%
Built-up lands (settlements and roads)	11.87%	15.39%

Source: personal survey

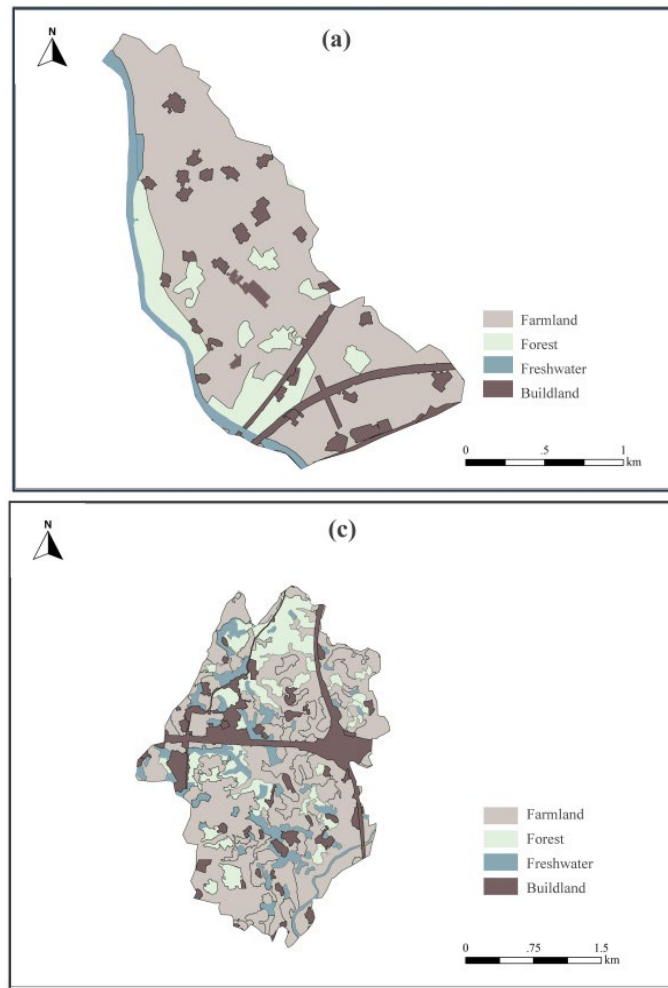


Figure 1.3 Land use of Paotong Cun (top) and Dantu Cun (bottom)

Source: Mapped by author

Dantu Cun is composed of nine groups, with an area of 6.45 km² and a rural population of 3,457 across 1,072 households in 2018.¹⁶ The landscape of Dantu Cun mainly consists of farmland (59.54%) and built-up land (15.39%), followed by forests (14.91%) and freshwater bodies (10.16%) (Figure 1.3b; Table 1.1), showing a more diverse land-use pattern than Paotong Cun. At an elevation of 500-550 m, the topography of Dantu Cun is gently hilly. Forests, including both native woodlands and plantations, are found on the 'up-slopes' of gentle hills, and freshwater bodies (mainly water ponds) are distributed on low-lying lands, neighboring the farming fields. Fish ponds and agro-forestry with fruit trees and crops are part of the local agricultural production. The irrigation system connecting to the Dujiangyan Irrigation System was constructed in the 1960s, thus belonging to a relatively new irrigated area in the

¹⁶ In 2014 three villages (*cun*), i.e. Dantu, Wudong and Huanglong, were combined as Dantu Cun, including nine (villager) groups. In 2020 these groups were further readjusted as six groups, and Dantu Cun was renamed *Dantu Shequ* (Dantu Community) under *Yongxing Jiedao* (i.e. *Yongxing Zhen* before 2020) administratively.

Chengdu Plain (Editorial Committee of Shuangliu County Gazetteer, 1992). Therefore, many ponds can be found in this area, the traditional method of water storage. Unlike Paotong Cun, Dantu has a periodic rural market, forming a small market town at the center, which provides an ideal sample for studying the functions of rural markets in linking *linpan* societies socio-economically and culturally.

1.3 Applicability of General Theories

1.3.1 Landscape ecology theory

Lately, scholars have recognized the importance of explicitly linking socio-economic and ecological processes in studying the dynamics of landscapes. From its beginnings in Europe, landscape ecology was conceived as an approach for understanding landscapes that drew upon both cultural and ecological knowledge (Nassauer, 1997). Applying a landscape approach in a socio-ecological system has become a widely acceptable method (Cumming, 2011a). In order to uncover the complex mechanisms of the urban-rural continuum, integrated studies have applied to study these socio-ecological systems that are not the methodology of either social or natural scientists who study sociopolitical and natural systems separately (Alberti, 2009). Landscape ecology, the branch of ecology dealing most directly with socio-ecological systems, is a useful discipline for understanding the configuration and tangible pattern of the studied landscape, followed by an understanding of the intangible parts (culture and supporting functions) (Leitao et al., 2006; Cumming, 2011a). Concepts from landscape ecology, such as metrics, patches, spatial patterns, connectivity, fragmentation and ecosystem services, have provided us with useful tools to understand a cultural landscape from a more quantitative angle (Alberti, 2005; Borgström et al., 2006; Haase et al., 2014).

The spatial pattern of a landscape is composed of many patches of different sizes, which may be considered as a spatial structure at a macroscopic level. Even corridors may be considered as a special kind of patchy habitats (Goekyer, 2013).¹⁷ The distribution of patches in a landscape interacting with landscape dynamic processes such as material and energy flow, determines the functions or service flows of a socio-ecological system. Through analyzing the spatial pattern of the *linpan* landscape, it is possible to understand the inextricable connectivity between patches such as woodlots, settlements or market towns, to trace the dynamic process, and then to identify the drivers behind them. Connectivity is a landscape property that nicely illustrates the relationship between landscape patches (structures) and their functions, a concept of great relevance to urban planning and management (Alberti, 2009). In addition to the tangible connectivity (e.g. ecological corridors, irrigation canals and roads), intangible networks such as economic and social linkages (e.g. trading routes, marketing range or socio-cultural

¹⁷ A special type of patch linking other patches in the matrix. Typically, a corridor is linear or elongated in shape, such as a stream corridor (Goekyer, 2013).

relationship) also contribute to the spatial features of cultural landscapes (Yuan, 2018). Fragmentation is also an important process that affects connectivity, which can be both ecological and social. In traditional landscape studies, fragmentation concepts have been used to discuss the flow and migration of biological species, but very little attention has been paid to its socio-economic or cultural effects (e.g. social centralization and decentralization, informal networks or economic restructure) on landscape connectivity (Cumming, 2011a).

The processes and functioning of various ecosystems within a landscape play fundamental roles in sustaining and fulfilling human life and livelihoods, which is reflected in the goods and services they deliver. Ecosystem services are considered to be a key factor for a healthy and prosperous life, and they are significant for the sustainability of human society (MA, 2005).¹⁸ The structure or pattern of a landscape can affect the ecosystem's functionality (its ability to deliver services) through the composition and configuration of landscape elements (Antrop, 2000; Willemsen et al., 2008), and through the indirect delivery of goods and services (Lee et al., 2014). It is thus implied that ecosystem services are expected to fulfill many landscape functions according to their structures. This concept of ecosystem services has become significant among researchers and practitioners in landscape planning and management (De Groot et al., 2010; Lee et al., 2014). Individual *linpan* and *linpan* landscapes as a whole in Chengdu Plain are very important for human wellbeing and the sustainable prosperity of Chengdu Municipality, which may be clearly seen from the changes in the supply of goods and services. Just as in other ecosystems, the services provided by *linpan*, either individually or collectively, could be grouped into four primary categories: provisioning services, supporting services, regulating services and cultural services (MA, 2005).¹⁹

1.3.2 Resilience theory

In cultural landscapes, both ecosystems and socio-economic systems are dynamic and inextricably linked, together sustaining people's lives and livelihoods. Since most ecosystems are managed by people, the term "ecosystem resilience" is increasingly being replaced by the term "socio-ecological resilience," meaning the capacity of linked social and ecological systems to absorb or adapt to disturbance while retaining essentially the same function, structure and identity (Folke et al., 2010). The resilience of this kind of system depends a great deal on the interactions between human and environmental components, in which humans adapt to the environment on the one hand and change the

¹⁸ The term "ecosystem services" refers to the benefits gained from the complex interactions between the human environment and the functions of an ecosystem (Costanza and Daly, 1992; Fisher et al., 2009).

¹⁹ Supporting services were not included in national or international assessments because they are basic but relevant to all other three categories (MA, 2005; IPBES, 2019).

environment in the process on the other, which can be seen as a prerequisite for sustainable development (Folke, 2006). Social-ecological resilience provides people with a kind of “insurance” against reaching a non-desired state (Maeler, 2008). A high insurance value corresponds to a high level of resilience. Protecting a resilient landscape such as the *linpan* landscape can thus maintain the delivery of multiple co-benefits (ecosystem services and goods) and help avoid maladaptation of local communities to external threats. This perspective has particularly influenced studies in landscape ecology focusing on cultural landscapes.

Social and economic disadvantages are important factors that increase vulnerability and reduce social-ecological resilience, further undermining the sustainability of the whole landscape. When resilience of landscapes is lost, vulnerability increases, and the socio-ecological system is not able to exert its functions in the face of disturbances. For a rural landscape such as *linpan*, it should be emphasized that resilience is the principle that connects both the production function of agricultural systems, and the regulating and cultural functions needed to sustain human wellbeing not only today but also in the future. Regarding sustainable development of the Chengdu Plain, it is important to recognize the direct use-values of *linpan* landscapes as well as to capture the associated and very significant “non-use” values.

Although the resilience approach applied to cultural landscapes provides a conceptual foundation for sustainable development, one area in which the resilience theory is critically underdeveloped is in metrics (Bergamini et al., 2013). Cumming et al. (2005) stated that resilience is difficult to operationalize because of its abstract and multi-dimensional nature. Various approaches to measuring resilience have been proposed, but they are always context-dependent for different landscapes (e.g., Bennett et al., 2005; Carpenter et al., 2001; Carpenter et al., 2006). In short, the concept needs to be ‘localized’ to and critically assessed for each specific context of landscape. More recently, instead of estimating resilience directly, scholars have preferred to monitor proxy attributes of the systems that are related to the resilience but are easily measurable (Bergamini et al., 2013; Tippins, 2014).

1.3.3 Preservation theory

Efforts towards the preservation of cultural landscapes started in Western Europe and North America. Beginning in the 1960s, inquiries into political tensions and social equity have brought new rationale into the preservation field. Modern western concepts such as authenticity, sense of place, civic dialogue and public participation began to dominate preservation practice and scholarship (Xu et al., 2005; Mason, 2008; Han, 2012; Verdini et al., 2017). More recently, the field of preservation has changed from purely “brick and mortar” to a more culturally based idea of “preserving information.” In the US, National Heritage Areas are defined as places where historic, cultural, and natural resources combine to form cohesive, nationally important landscapes (NPS, 2019). Unlike national parks, National Heritage

Areas are largely lived-in landscapes. Similarly, in addition to the world cultural heritage sites under the umbrella of UNESCO, Globally Important Agricultural Heritage Systems (GIAHS) identified by the FAO (Food and Agricultural Organization of the United Nations) mainly aim at the management and preservation of agricultural landscapes. A GIAHS site is a living and productive system rather than a static monument in the traditional preservation field, and its scale is much wider and broader compared to historic buildings (FAO, 2019).

The recent identification of the *linpan* landscape as an important agricultural heritage system (nominated by Pidu District and approved by the Agriculture Ministry of China in 2019) has raised awareness of preservation and triggered an excellent opportunity for deeply understanding the way in which local communities or civic societies can sustain the productivity and cultural values of this landscape in the long run. Some historic buildings in *linpan* settlements or market towns have fortunately maintained their traditional features, and provide good examples for studying their architectural functions as living environments, public spaces, and even “platforms” where original cultural practices continue. For those counties or districts which hope to preserve the *linpan* landscape well enough to meet the GIAHS criteria, it is very important to understand the functional services of *linpan* systems, to identify the historic features of remaining settlements, and to probe into how specific attributes at different scales have enabled the whole system to adapt and persist at particular moments of historical intervention. Lately it has been widely acknowledged that keeping a cultural landscape alive and performing its original functions may be the best way to preserve it, and the people living there certainly play a very important role in the process (Sayer et al., 2012; Appler and Rumbach, 2016; Helmer, 2017). Thus, the preservation of *linpan* landscapes requires a comprehensive perspective, because this system is not an isolated island but an interdependent system of people, social structures, and associated ecosystems.

Preservation has long been viewed as a “gatekeeper” for substantiality. Avrami (2016) in her article talked about the gap between preservation and sustainability, arguing that many current practices in the historic preservation field fail to help achieve the goal of sustainability. Although Avrami (2016) mostly discusses historic buildings, current issues facing cultural landscape management illustrate that it is time for us to integrate resilience theory into preservation and development efforts. Cultural landscapes, like a ball in a basin (see Figure 1.8), are constantly moving, and the basin itself is not static either, but is continuously moved by human action (Gunderson and Holling, 2002; Whiting et al., 2019; also see following Section 1.5.3). Therefore, traditional, static theories of historic preservation are inadequate for these circumstances. Rottle (2008) emphasized the inclusiveness of the ‘present’ in cultural landscape preservation. She noted that preservation sounds like preserving the past, but the present may be more important than any historical period when a landscape or monument was in use. In a sense, landscape preservation should be a long-term process, continually adapting to the activities of human society. This

resonates with resilience theory, which addresses dynamic processes and emphasizes adaptation of cultural landscapes (Rottle, 2008). Mason (2015) also demonstrated that historic preservation canonically has focused far more on achieving stasis and arresting decay than on allowing change, though the pendulum is shifting.

1.3.4 Human geography theory

Humans have influenced most of the Earth's ecosystems and shaped or created landscapes through activities that profoundly affect ecological processes and functions. In many landscapes, people and other species have co-evolved over centuries or millennia, creating unique bio-cultural systems. Some of the historical human-nature interactions and co-evolutionary processes have been favorable to or synergistic with landscape preservation and still persist in some agricultural systems around the world (The Satoyama Initiative, 2019). Considering the role of humans in their environments, a number of scientific fields have paid increasing attention to "coupled human and natural systems" (Redman et al., 2004; Folke et al., 2010). For instance, regarding the matter from the angle of cultural ecology, co-evolution in traditional agriculture implies that all socio-cultural sub-systems as well as biological systems in the landscape are involved in a continuous process of adaptation in optimize fitness in the face of selective pressures generated and maintained by the long tenure of traditional agricultural activity (Cuijpers et al., 2013). Thus, cultural landscapes such as *linpan* landscapes are an intrinsic feature of the local environment and a kind of human culture derived from the effective means of human livelihood. Local people improve their own condition with culture, and the level of cultural development also indicates the human condition in nature (Bergamini et al., 2013). Cultural landscapes by default are complex and hard to preserve in a practical way, and how best to utilize the dynamic view learning from human geography and apply the findings to the management of cultural landscape, is still under discussion (Mason, 2008).

Another important theory that needs to be addressed in this study is "Central Place Theory", a theory usually credited to Walter Christaller (1933), a German geographer. Based on the principles of centralization, the range of a good, and the nature of complementary regions, this theory is concerned mainly with the arrangements of cities or towns providing wholesale, retail, service, and administrative functions to a population as well as the hierarchical arrangement of these centers (Larkin and Peters, 1983). Following Christaller, several authors made empirical studies of central place systems; many of these studies were nicely summarized and extended by Berry (1967). One example of an empirical study of central places in a non-Western cultural region is Skinner (1964), who studied rural markets of the Chengdu Plain in 1949-50, and proposed the classic model of the hierarchical arrangement of market towns in the Chengdu Plain (Skinner, 1964; 1965a; 1965b). From this perspective, it can be asserted that rural markets function as 'central places,' providing goods and services to surrounding areas, and drive

the clustering distribution of *linpan* settlements for the purpose of easy trade, social communication or bureaucratic services. The different trading routes connecting market towns in hierarchical systems could be considered as ‘corridors’ in the landscape which provide channels for the flow of agricultural products and other goods for production and daily life (Wang, 2018). From this perspective, the general issues currently challenging the functions of market towns can be studied through comparison with previous studies on rural markets in Chengdu (e.g. Skinner, 1964; 1965a; 1965b; Du and Zhang, 1986; Du and Zhang, 1987), which would be helpful for better understanding the socio-ecological resilience of the whole landscape as well as its dynamic process.

Geographically, an individual *linpan* group may have a relatively clear boundary, but looking at the landscape as a whole, it becomes difficult to draw any boundaries. *Linpan* landscapes are dynamic, fluid, and in constant interaction with humans, and so could be viewed as ‘relative spaces.’²⁰ Additionally, the area of a *linpan* landscape is always changing spatially due to the effects of different drivers, which means that boundaries, even if they can be delineated, are also changeable. While studying *linpan* landscapes, an important concept of human geography that needs to be addressed is “place” or “sense of place.” “Place” refers to the attributes and values we associate with a location, and the “sense of place” is a subjective feeling for and/or attachment to a particular place (Larkin and Peters, 1983). As Tuan (1977) stated, “place” has more substance than the word “location” suggests. We can see that the sense of place derives not only from a place’s characteristics, but also from the ways in which various individuals and groups perceive and act in places. Therefore, when we talk about someone belonging to a place, normally we refer to its social identities or belongings. As Cresswell (1996) illustrated with phrases such as 'know your place' and 'a place for everything and everything in its place', some things and some people are determined to belong in one place and not in another, depending on their relationship to others.²¹ Therefore, a *linpan* landscape “exists” not only because of its physical features - forests, farmlands and houses - but also because of the invisible social and cultural relationships. Regardless of the sense of place, we cannot truly understand the integrity of a cultural landscape, and so it is difficult to find the appropriate proxy for comprehensively measuring or evaluating the resilience of *linpan* landscapes.

²⁰ As defined by the Encyclopedia of Geography, “in contrast to absolute space, which is fixed, asocial, and timeless, relative or relational space reflects the wide varieties of ways in which distance is measured and conquered, that is, space as socially made and remade over time. Relative space thus portrays geographies as fluid, mutable, and ever-changing” (Warf, 2010).

²¹ These viewpoints share the same idea as a popular slogan in the Rural Revitalization strategy in China “keep your nostalgia,” which expresses the idea that a person is not only physically bound to a place but also culturally.

Perception is an important component in studies of sense of place, mainly because experiences of both places and people are so diverse. Place becomes meaningful and tangible through experience (Tuan, 1975). Thus, one way to ensure people know their place is through the creation of cultural norms and identifiable social spaces, to socialize people into 'knowing their place' through cultural practice and to teach how to read cultural landscapes (Kitchin, 1999). In the case of *linpan* landscapes, rural markets have provided local people with a space to recognize themselves. It is not only for goods or everyday demands, but for spiritual and cultural purposes. Periodically visiting teahouses or restaurants in market towns has become a cultural norm for *linpan* dwellers (Skinner 2017, Wang, 2008). Keeping markets alive can be seen as continuity of a vivid and active space. Therefore, though there are now modern supermarkets, shopping malls or e-businesses, the functions of traditional rural markets cannot be fully replaced. Newly reconstructed *linpan* settlements for purposes of tourism may retain the physical features, but lack the social-cultural identities, and thus are also considered to be un-authentic in preservation. After the 1980s, the concept of sense of place found its way into planning practices (Larkin and Peters, 1983). In a modern context, it should still be emphasized that place and its influence on the way people think and act must be considered in urban and rural planning as well as preservation.

Graph theory is also a useful theory, which originated from math and computer science. It was introduced and discussed by Urban and Keitt in their publication on the ecological connectivity of landscapes (Urban and Keitt, 2001). Graph theory analyses connectivity through links and nodes (graphs) and can inform us about how different habitats are connected and the degree of connectivity in this landscape. It can also illustrate which node of connection is more important, and finds strong or weak ties in this system. Meanwhile, it has profound implications for epidemic disease control. Just as Urban & Keitt (2001) mentioned in their article, a certain distance is maintained in nature to prevent disease spread among species, but at the same time species are distributed near enough to each other that biological components (e.g. genes and viruses) can flow smoothly within the system. This finding has a broad impact on human ecology as human beings interact in many ways and share many things in common with nature. In this study I use graph theory to analyze how rural markets play an important role in connecting or networking dispersed *linpan* settlements, and to understand how this connectivity maintain the integrity of *linpan* landscape as a holistic socio-ecological system.

1.4 Scope and Approach of the Study

1.4.1 Scope of the study

Recent studies illustrate that a *linpan's* functions, residential, agricultural, socio-ecological and even cultural (Chen, 2011; Whiting et al., 2019), are based on its structure and dynamics through the intervention of human activities (Wu et al., 2020). With recent climate and non-climate changes in the Chengdu Plain, especially rapid urbanization, this landscape is under threat and is in fact progressively

disappearing (Shu et al., 2013; Peng et al., 2015), although local people have used it for centuries (Yang, 2011; Yuan, 2018; Chengdu Committee of Urban Rural Construction, 2007). Recently, UN-Habitat (2017) published a report titled "Implementing the New Urban Agenda by Strengthening Urban-Rural Linkages", which addressed the significance of the urban-rural continuum as a continuous space, for comprehensive urban-rural planning and designing. Among the Sustainable Development Goals of the United Nations (SDGs), one target (SDG 21) is to "*support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning*" (United Nations, 2015). *Linpan* landscapes, without a doubt, are embedded in this kind of continuum and forms an urban-rural coexistence from the built environment in the urban core to semi-natural and natural environment in rural areas. Though a large number of studies exist on natural ecosystems and urban areas, studies on rural landscapes are relatively few (Haase et al., 2014), creating a knowledge gap in comprehensively understanding on the integrity of the urban-rural continuum as a whole. Considering the *linpan* landscape as a special rural landscape in the world (Whiting et al., 2019), the scope of this study aims at elaborating: (1) the configuration and spatial pattern of *linpan* landscapes and market towns in the Chengdu Plain; (2) their functioning roles in delivering goods and services to both rural and urban people; (3) the socio-economic connection of the *linpan* landscapes through hierarchical market towns; and (4) the resilient features of the rural societies of the Chengdu Plain and the adaptive capacity of local communities in coping with socio-ecological disturbance. The landscape analysis applied metrics for studying the configuration (structure and spatial patterns), function (ecosystem services) and dynamic process (resilience and change). Four major components of *linpan* landscape – forest (woodland), agriculture (farmland), freshwater (wetland) and the built environment - were identified for elaborating the ecosystem services obtained by local people. In order to understand the functional role of rural markets in networking *linpan* landscapes, I studied the public spaces of market towns and their architectural structures in detail. Finally, in order to verify whether the *linpan* landscape is resilient in the face of external shocks, I established a set of indicators based on published statistical data and verified them using the COVID-19 pandemic as a test case. All of these will, I hope, provide knowledge for use in landscape preservation that better takes into account social and ecological dynamics, and will identify critical scales in landscape management for the wellbeing of both rural and urban population and consolidate a nature-based solution for sustainable development of the Chengdu Plain in the future.

1.4.2 Approaches of the study

Landscape ecology is a scientific branch of ecology, which makes contributions related to complexity studies (physical, biological, and ecological) of ecosystems. Focusing on spatial pattern and ecological responses to human disturbance, it leads to a new set of principles, distinct from the principles of

traditional ecology at finer scales (Turner et al., 2007; Alberti, 2008). With the development of technologies, it has incorporated remote sensing, geographical information systems (GIS) and geo-statistical tools to study spatial patterns over large areas and to track their change through time. In this study, I used remote sensing and GIS with powerful computer aided software (such as Arcgis/Qgis transferring tools) to uncover spatial patterns of *linpan* landscapes and compare their changes over time. After vectorizing local maps and images, I extracted a set of attributes about land use and land cover change, such as buildings, roads, water system (rivers, canals, and reservoirs), forests, and farmlands. Combined with field surveys it is possible to calculate landscape metrics (e.g. patch density, average size) using the FRAGSTATS tool and identifying individual *linpan*, small settlement clusters, and rural markets. On the visual outputs, individual *linpan* units and rural markets may be seen as various patches distributed on the maps. Their spatial patterns can be calculated with aggregation indexes, such as contagion indexes and negative binomial distribution models (Zhao and Li, 2001). Furthermore, by comparing the change in these metrics in the past 30 years, I tried to trace the dynamic processes of the landscape and analyze their possible drivers.

In considering the important role of rural markets, this study intends to explore whether these rural markets are nexuses of economic, social, and cultural connections. Following central place theory, I assert that rural markets function as “central places,” providing goods and services to surrounding areas, and thus drive the clustering distribution of *linpan* settlements for the purpose of easy trade, social communication or bureaucratic services. In the Chengdu Plain rural markets occur at standard market town, intermediate market town, or even county town levels, forming a hierarchy of central places. Such a system at any one level is connected with those at the next higher level through a complex network (Skinner, 1964; Skinner, 1965a). Thus, the conceptual framework of the central place theory was used to illustrate how the network of rural markets shapes and re-organizes *linpan* landscape.

Through analyzing the architectural space, especially public space in market town, I then hoped to elaborate the importance of rural markets for local communities and understand the resilience of *linpan* landscapes from the perspective of socio-economic functions (Zhong, 2002; Lue, 2012; Liu, 2014). In this study, architectural approaches, including sociological approaches and field survey methods used in historic preservation, are applied to study historic social fabrics, traditional ways of life, changes of residential settlements, and humans’ adaptation to changes. The development process of rural markets in the Chengdu Plain was from open-air markets to settled markets at specific locations, a turning point occurring with the introduction of permanent buildings (Ji, 2000). The buildings in a market town serve not only as private residences but also to host public activities. A study of how morphological attributes of historic markets especially designed for trading or socio-cultural purposes could thus provide a possible way to understand the role of market towns in *linpan* landscapes and their changes at particular

moments of historical intervention and/or environmental influence (Lue, 2012; Sun and Zhou, 2015; Huang, 2017). In a marketplace, buildings housing various shops that provide different services, such as groceries, teahouses or restaurants, have thus been designed or modified in their structures by inhabitants (Sun and Zhou, 2015). Additionally, various services are clustered in different sections of the market street (e.g. products for sale or cultural performances), which also reflects the diverse functions a market place has (Zhong, 2002). The diversification of architectural styles and functional sections in market towns indicates their socio-economic and cultural importance for the surrounding agrarian societies.

With the rapid development in China and great improvements in transportation, the traditional livelihood of local people has been changed accordingly. The out-migration of the rural population to urban areas (mostly young people) has influenced population structure and traditional livelihoods, which ultimately has led to the decline of agricultural production and rural markets. The change of policies, institutions and governance systems has greatly influenced landscape preservation, including both natural and cultural heritages. All of these should be studied carefully before they disappear, and the generated results will surely contribute to the conservation of *linpan* as a GIAHS site. In this study, a sociological approach is used to investigate the influence of direct (e.g. climate change, land use change) and indirect drivers (e.g. demographic, socio-cultural and economic changes) on the dynamic processes of landscapes and rural markets. Using empirical data from case studies as well as various data-sets, I analyze what constitutes the adaptive capacity of local communities, what might be seen as a ‘state of the art’ approach to adaptation, and how it contributes to socio-ecological resilience. Lastly, to measure resilience in *linpan* landscapes, which encompasses all the complexities a socio-ecological system can possibly have, I extract available data from official statistics and sociological surveys to develop an assessment framework including a set of associated indicators. These indicators are designed to capture the different properties (e.g. health-care, economic, governance, and environmental) that may be essential for sustaining a resilient landscape. Finally, viewing the COVID-19 pandemic as an external shock and economic recovery in post-pandemic period as a resilient response, a resilience index with eleven indicators was verified in fourteen rural counties or districts of the Chengdu Plain. Hopefully, such an approach will provide a strong foundation upon which to recognize trends and potential opportunities for further strengthening resilience.

1.5 Definition of Concepts

1.5.1 Culture landscape and “*linpan*”

In the last two decades, the concept of the cultural landscape has attracted increasing interdisciplinary attention and been applied in urbanization studies, land management, cultural heritage preservation, and human adaptation to environmental changes because it is so intimately intertwined with modern human

societies (Moreira et al., 2001; Barthel et al., 2005; Sun et al., 2008; Wang et al., 2009; Turner et al., 2014). Generally, **cultural landscape** in this study is defined as a landscape created intentionally by people to satisfy some of their needs, making use of materials in the environment. Within a cultural landscape, human disturbance in history create a unique assemblage of patterns, species, and processes (Farina, 1998). Cultural landscapes thus reflect the long-term interactions between people and their natural environment (Moreira et al., 2001). Temporal changes in landscape patterns can be attributed to a combination of natural and human derived disturbances (Forman, 1997).

In line with this definition, the *linpan* landscape in the Chengdu Plain is a kind of cultural landscape which has been modified by local people over hundreds or thousands of years for agricultural production as well as residential purposes. In a narrow sense, a single "*linpan unit*," often simply called "*linpan*" in this study refers to a patch of settlement clusters distributed in the rural Chengdu Plain, which normally consists of a few farmers' houses or courtyards surrounded with trees or bamboo groves (Duan and Liu, 2004; Fang, 2013; Liu et al., 2017) (Figure 1.4). Literally, "*linpan*" is composed of two Chinese words, "*lin*" (forest) and "*pan*" (plate), indicating a "woodlot" with a round shape. Regarding the structure of a *linpan*, four components are essential, dwellings with courtyards in the center, trees or groves surrounding the houses and courtyards, farming fields and irrigation canals extending nearby.

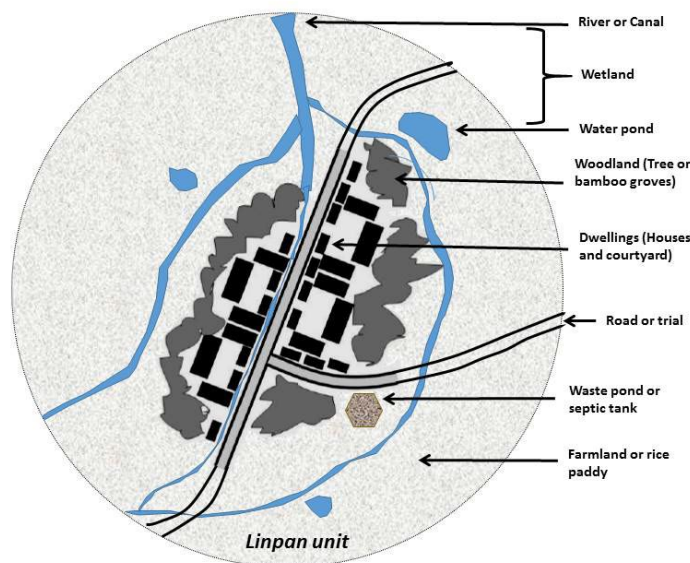


Figure 1.4 A schematic *linpan* unit showing major components

Source: Wu et al., 2020

Viewed from a macroscopic level, countless *linpan* units are scattered like stars on the Chengdu Plain from peri-urban to remote rural areas, forming a cultural landscape, referred to as the “*linpan* **landscape**”. It is a socio-ecological system, formed by human exploitation of natural resources in the Chengdu Plain and long-term adaptation to the Dujiangyan irrigation system. Extending sparsely over vast farmlands (mostly rice paddy), dispersed *linpan* units are physically interlinked by hydraulic systems (rivers, ditches, and canals) and roads (highways, paths and trails), and socio-economically linked by hierarchical market towns (Abramson, 2019; Wu et al., 2020) (Figure 1.5). The rural landscape of the Chengdu Plain thus can be presented with its patches (woodlots, settlements and marketplaces), corridors (ecological infrastructure, roads and irrigation canals), and matrixes (farming fields and forests) (Chen, 2011; Yang et al., 2011; Lu, 2012; Zhou, 2012). As a socio-ecological system, a *linpan* landscape integrating multiple functions supports agricultural production, human residence, daily life, and cultural transmission (Chen et al., 2011; Lin, 2011). It expresses a long and intimate relationship between people and their natural environment in the Chengdu Plain, representing the “combination of natural and man-made elements that comprises, at any given time, the essential character of a place” (Tuan, 1977).



Figure 1.5 Drone photography showing individual *linpan* (top) and the *linpan* landscape (bottom) in the Chengdu Plain

Source: Photo by author, 2019

Recently scholars have proposed many definitions for *linpan* (see review by Liu et al., 2017), but no one has been widely accepted. Li (2009) defined *linpan* from the perspective of landscape pattern and ecological structures as a kind of rural residence style, settlements with surrounding woodlands, streams and farmlands integrating with the natural environment and forming a green “island” embedded in the vast agricultural landscape. However, Duan and Liu (2004) describe *linpan* in a very romantic way:

“Walking on the Chengdu Plain, if you see a cluster of woods and bamboos with streams flowing inside, following the path you can find a farmhouse, and this is the location of linpan.”

From a socio-cultural perspective, Chen (2011) describes *linpan*, closely integrated with the Dujiangyan irrigation system, as a continuation of traditional agricultural activities and family relationships, and as a living space that represents certain ecological values and cultural features in rural west Sichuan. The concept proposed by Zhang (2008) emphasized the ecological features of *linpan*, describing it as a

“*linpan* community” (being analogous to a biological community), which indicates a settlement system distributed on semi-natural wetlands (rice paddies) in the Dujiangyan watershed. Generally, disagreement results from the divergence between an individual *linpan* unit and a collective *linpan* system, with some viewpoints only addressing the specific or one-sided functions of this system. No matter what definition is used, there is an implication that the *linpan* landscape is not a static object, but a living and productive socio-ecological system with livable and natural context (Yuan, 2018).

1.5.2 Rural markets and “*chang*”

Traditionally, Sichuan was a typical region with prosperous rural markets in China (Wang, 2018). The designation of **rural market** indicates the marketplace is located in a rural area and is a market mainly serving a peasant society and connecting them with urban markets. It is a settled location for periodical goods exchange, thus its other general appellation of “market town” (Skinner, 1964). In a traditional agrarian society, the economic significance of a rural market is dependent on: (1) its provision of goods and services to the particular region where the market is located; (2) its functional role as a central place in trading influxes and socio-economic connectivity; and (3) its location in the transportation network (Wang, 2018). In the Chengdu Plain almost all market towns may function in all three of these dimensions, but their impacts vary according to their size and location.

Generally, rural markets in the Chengdu Plain developed from temporary markets (called “*cao shi*”, meaning “grass market” literally) or roadside stores (called “*yao dian zi*” locally), to periodic rural markets, and then central markets based at county towns or cities (Figure 1.6). In this context, only a periodic rural market is called “*chang*.”

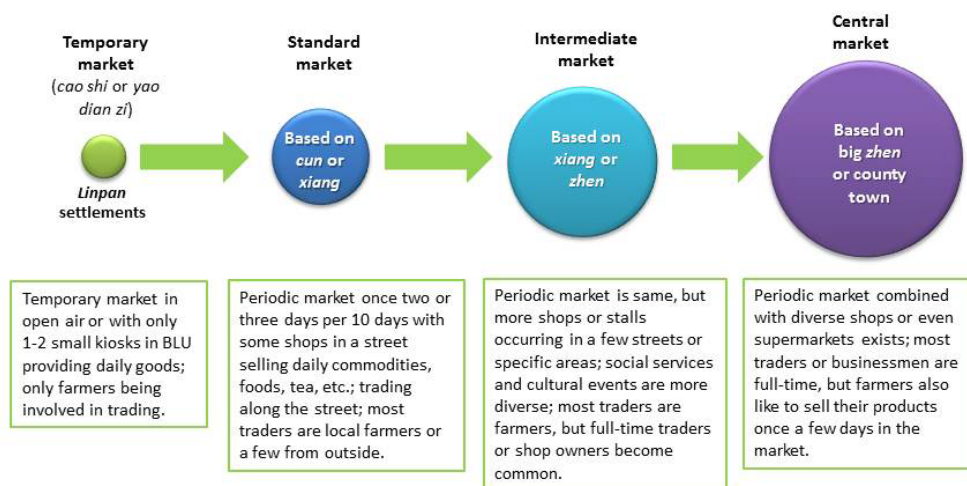


Figure 1.6 Evolutionary routes of rural markets with the increase of services and built areas

Source: Design by author

As markets developed, traders in rural markets varied from temporary (peasants engaging part-time in trading activities) to full-time business people who have permanent shops at the marketplaces. The “*cao shi*” specialized in the horizontal exchange of peasant produced goods such as green vegetables or fresh fruits, which was thought of as an incipient “*chang*” due to its negligible importance as an entry point for locally produced goods into the larger marketing system (Skinner, 1964). Literately, “*yao*” may mean “small”, “youngest” or “last” in the Sichuan language; thus “*yao dian zi*” indicates a few small stores, which were usually located in between courier stations (“*yi zhan*”) in ancient times (Wang, 1991). A “*yao dian zi*” may be nothing more than the little store itself, selling candy, cigarettes, and some food items. The establishment of “*yao dian zi*” might cause a cluster of buildings to occur around it, forming a larger settlement or “store community” and attracting local peasants and dealers gathering together periodically for goods exchange (Dong, 2004; Skinner, 2017).

Normally, periodic rural markets (“*chang*”) include standard markets and intermediate markets according to Skinner’s definition (Skinner, 1964). The “standard market” defined by Skinner (1964) is the lowest level of the hierarchical system of economic centers. Since the 1950s, standard markets have generally been based at the seat of *cun* or *xiang* headquarters, but intermediate markets are only found at *xiang* or *zhen* level.²² When establishing an administrative unit, such as *cun*, *xiang* or *zhen*, the size of the traditional market town and its marketing area was considered. Thus, almost every “*xiang*” or “*zhen*” in the Chengdu Plain now has its “*chang*,” but only a few “*chang*” can be found at *cun* level. At the county town level, the “central market” with more designed facilities always has an important wholesaling function receiving imported items and distributing them to other central markets or higher-level urban centers, but this “central market” normally operates every day.²³ Regardless at which level a “*chang*” occurs, it should be a town-like settlement with numerous permanent buildings and at least one main street for trading purposes. Thus Liu (2014) thought that the occurrence of architectural structures or designed facilities for commercial purposes and socio-cultural service provision was the turning point in the change from temporary market to periodic market (i.e. “*chang*”).

By the end of the 1980s, there were over 400 periodic rural markets at different levels on the Chengdu Plain, forming a hierarchy of central places (Wang, 2018). These rural markets connect through a

²² The term “*cun*”, meaning “village” literately, was introduced into Sichuan at the beginning of the 1950s and was used until 1958. After the Great Culture Revolution, it has been widely used again as the basic unit of administrative hierarchy in rural area.

²³ According to the investigation by Skinner (1964), every county town (*xian cheng*) supports at least one market and can be classed as a given central-place type in accordance with position in a marketing system, but occasionally one central market town would not be the county (*xian*) seat.

complex network, in which one center might be oriented to one, two, or three centers at the next higher level, and then to central markets in county-towns or Chengdu City. The economic function of a market town is consistently associated with its position in marketing systems (Skinner, 1964a). Thus, the conceptual framework of the central place theory proposed by Walter Christaller (1968) still seems useful in some sense to illustrate how the network of rural markets shapes and re-organizes the economic landscape of the Chengdu Plain (Figure 1.7), which will be analyzed in this study.

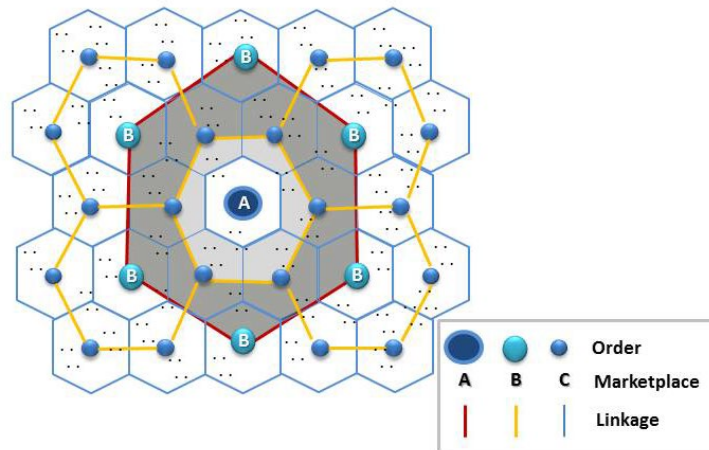


Figure 1.7 Central Place Theory Model showing the influence and inter-linkage of different orders of market areas

Notes: A market area at one of the orders (A, B, C) only provides goods or services within a specific range, i.e., the maximum distance consumers are prepared to travel to acquire goods. A significant feature of the overall structure is that marketing areas at each higher level overlap a number of marketing areas at the next lower level and completely envelop several areas of the level below that. In this figure, if order A was considered as a central market, order B and order C could be regarded as intermediate market and standard market respectively. The black points in each hexagon indicate *linpan* units distributed within the serving range of rural markets.

Source: Modified by author from Christaller, 1998

1.5.3 Adaptation and resilience

The term “**adaptation**” was defined by Smit and Wandel (2006) as:

“A process, action or outcome in a system (household, community, group, sector or country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity.”

This definition indicates changes of systems in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with actual or expected stimuli including both climatic and non-climatic changes (Burton and Challenger, 2007). The extent to which ecosystems and associated services are vulnerable depends both on their exposures to change and on the ability of the impacted system to adapt. In human systems, adaptation is undertaken by private decision makers and by public agencies or governments. Currently, in various contexts related to global change science the concepts of adaptation, adaptive capacity, vulnerability, and resilience are closely interrelated and widely applied in socio-ecological system or cultural landscape (Smit and Wandel, 2006).

Holling (1973) characterized stability as persistence of a system near or close to an equilibrium state. By contrast, **resilience** was introduced to indicate behavior of dynamic systems far from equilibrium, by defining resilience as the amount of disturbance that a system can absorb without changing state (Gunderson, 2000). This means a resilient system should have adaptive capacity, defined as the potential capacity of a system to cope with external threats (Figure 1.8). Following this principle, a resilient society or cultural landscape is one that has taken measures to adapt to threats or withstand shocks without shifting to a qualitatively different state. The response of a cultural landscape (such as the *linpan* landscape) may be automatic based on its structure and function, but adaptation involves humans' adjustments to enhance the viability of socio-economic development and to reduce its vulnerability to external threats, including natural (e.g. climate change) and anthropogenic (e.g. urbanization) events. Adaptive capacity is thus defined by how people experience and survive the exposure to pressures, risks or even hazards such as extreme weather, social unrest, or public health event (e.g. COVID-19 pandemic). For *linpan* landscape, it refers to the natural, economic, cultural and political ability of rural societies to make the required changes needed to survive the adverse effects of threats.

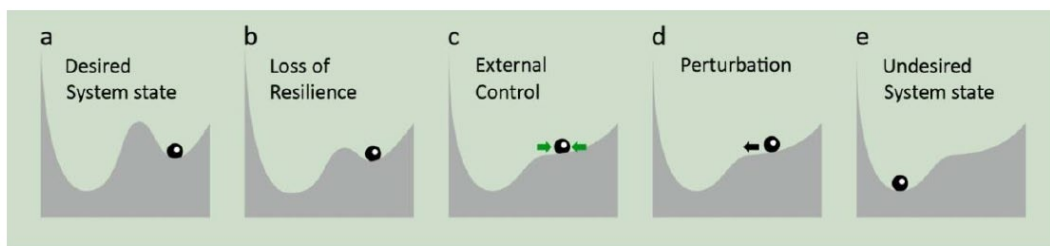


Figure 1.8 Resilience landscapes, showing the gradual loss of resilience in agricultural system

Notes: In ecosystems, multiple equilibrium states exist. (a) highly resilient, biodiverse agro-ecosystem; (b) gradual loss of resilience through narrowing crop rotations and loss of associated biodiversity; (c) complete loss of resilience: high amount of external control needed to keep the desired system state; (d) sudden perturbation, e.g. the invasion of a crop-borne pathogen;

(e) flip over to an undesired alternative system state, with diseased plants and lower production levels.

Source: Cuijpers et al., 2013.

1.6 Materials and Methods

I collected most of the data and literature used in this study during two field surveys in the Chengdu Plain and during several investigations with students from collaborative institutions such as the University of Washington, Sichuan University and the Chengdu Institute of Biology, Chinese Academy of Sciences. Due to the interruption of the COVID-19 pandemic, investigation *in-situ* became unfeasible, and students from the Chengdu Institute of Biology collected some supplementary data in 2020 and 2021 according to the author's requirements. Altogether, I spent about eight months in the case-study sites, Paotong Cun of Pidu District and Dantu Cun of Shuangliu District, both of which are located in the rural area of Chengdu City. The principal aim of these two trips was to collect primary data on *linpan* landscapes, rural markets, traditional and modern management of agriculture, and external pressures (including both climatic and non-climatic) impacting the agrarian society, people's adaptation to changes, and landscape resilience. The archive work carried out in both China and the US made it possible to examine a large amount of literature on *linpan* landscapes, rural markets, and modernization processes in the Chengdu Plain, and the socio-ecological resilience of the urban-rural continuum in other countries or regions. Through communication and exchange with experts in the University of Washington and the Chinese Academy of Sciences, it was helpful for the author to learn from various studies conducted previously in the Chengdu Plain which were relevant to this study.

1.6.1 Reconnaissance survey and scoping study

The purpose of the reconnaissance survey was to identify the representative *linpan* landscapes and traditional rural market in the Chengdu Plain. In this regard a few studies concerning the location of typical *linpan* and rural market were consulted by the author. Before drawing up the case-study site, I made about 40 tours in the summer of 2017 and 2018 throughout the Chengdu Plain, such as in the representative counties or districts, Wenjiang, Pidu, Xindu, Dayi, Chongzhou, Pengzhou, Shuangliu, and Dujiangyan. Mainly on the basis of visual observation, information from local officials or experts and analysis of published data or reports, I then identified typical *linpan* landscapes and rural markets. Finally, two case-study sites, Dantu Cun and Paotong Cun, were selected after considering their representation, traffic availability and field-work feasibility (practically speaking, the hospitality of local people).

A scoping study of current theories and arguments about *linpan* landscapes, rural markets and socio-ecological resilience was carried out to clarify a few vague concepts and highlight key messages.

The developmental history of rural markets in the Chengdu Plain (expanding to the entire Sichuan Basin), the relationship between *linpan* and the Dujiangyan Irrigation System, and the impacts of climate change and urbanization were analyzed by the author according to a review of historical achieves, records and open-accessible data. Climatic data (1978-2018 rainfall and temperature) were taken from the Chengdu Meteorological Bureau, and data on the urbanization process such as urbanization rates, Gross Domestic Product (GDP) per capita, agricultural products, and recreation consumption were extracted from Chengdu Statistical Yearbook (Statistics Bureau of Chengdu and NBS Survey Office in Chengdu, 2020).

1.6.2 Observer participation and interviews

In-depth interviews, participant observation, and sample surveys are the basic research tools used in this study for the analysis of landscape metrics, access to rural markets, trading or socio-cultural activities, people's perceptions, and impacts of socio-economic changes (see Appendices). The interviews were semi-structured around key topics to explore the knowledge, practices and perceptions related to the sense of importance and level of dependency on ecosystem services of *linpan* system and rural markets. Using the interview method, I investigated the perceptions and opinions related to the sense of climate and non-climate changes and people's adaptation. About 10 open discussions with knowledgeable elders and *cun* leaders were held to learn the local governance systems, social institutions, marketing activities and police implementation related to this study. I took notes when interviewing them, and if they allowed, I recorded the conversation as a back up. After going back to Chengdu, I transcribed my notes into word document without using qualitative software. I applied to the University of Washington IRB and received a waiver for this study (Human subjects Division Study #00014441).

The anthropological method of observer participation was used when the author stayed with local people who were reluctant or had difficulty in providing details such as average earnings from product trading or with whom they chatted in teashops. As the peasants were given to both under- and overstatement, answers to the questionnaire were subjected, such as those about their incomes or properties, whenever possible, to repeated checking with *in-situ* observations. In 2019, I spent three weeks in Dantu market with my team members, including one doctoral student Zhong Bo who was studying ecology in the Chengdu Institute of Biology, Chinese Academy of Sciences, and three undergraduated students from the Sichuan Cultural Industry College who were studying design, all of whom also participated in the 2019 Sichuan University Immersion Program before the field survey and learned basic theory and methods of rural community and landscape idea of *linpan* and *linpan* landscape. We observed how a rural market operated and how local people were involved, took photographs, did measurements of buildings and produced measured drawings. Every night after dinner we stayed together at the guesthouse of Dantu village and transcribed all our notes together, and then discussed the scope for the

next day's work. I also read all the notes taken from my assistants as a process of quality control. After the pandemic happened, the *in-situ* work became difficult. I then relied on my collaborator, doctoral student Zhong Bo along with his cohorts from his lab to carry out field work according to my requirements. In this way I filled the data gaps which I missed in previous survey. I used my funding to pay both their logistics (lodging and car rental) for carrying out interviews. My collaborator Zhong Bo is very familiar with the study topic and the area because we started to cooperate together since 2018, thus I could rely on him to lead the local group. Normally, I gave them my interview guide beforehand and also hold Wechat meetings before their field survey. In this way, I can ensure the quality of surveyed results. Unless otherwise stated, secondary sources such as statistics data were collected from local administrative departments, or from official publications such as yearbooks, gazetteers, or reports.

1.6.3 Online survey

Questionnaire Star (“*Wen Juan Xing*” in Chinese) is an online survey tool that is now widely used in China. After the emergence of COVID-19 and following the restriction of international travel in 2020, I administered 59 questionnaires (see Appendix 2) related to external shock (pandemic disturbance) and people's perceptions using the questionnaire tool, all of which came in through WeChat, a smart phone-based APP. I sent the questionnaire to the village leader whom I am familiar with and asked them to help me send it out to the villagers. My collaborator in Chengdu would also contact with them and ensure the follow-up survey. After the participants completed the questionnaire, a data report with data visualizations could be automatically generated in the App. In this report some useful information could be also collected, such as the time the respondents took to submit their questionnaire and the location of the IP address (only displaying the city name, but hiding the specific address). These data can help filter information further. For example, if the time taken to fill out the questionnaire was too short (<1min), it perhaps indicates that the respondent might not have answered the questions carefully, and such a questionnaire might not be reliable. Of course, there is no guarantee that the questionnaire is reliable if it takes the respondent a long time to fill out, because the user might have stayed on one webpage for a while without moving forward. This must be analyzed case by case based on the actual content of the questionnaire. According to the first-step result, it was found that most of the 59 respondents were young people, most of them younger than 30 years old. Therefore, in order to overcome the drawback of age imbalance for sampling, additional questionnaires were used for face-to-face interviews with the help of student assistants in Chengdu. More middle aged (> 30 years old) people and elders were selected intentionally for balancing the age and gender of respondents. Finally, the total sample size is 86 respondents, as shown in the following table (Table 1.3).

Table 1.3 Respondent structure of online survey

Age (years old)	Person No.	Percentage (%)
<20	17	19.77
21-30	36	41.86
31-40	4	4.65
41-50	11	12.79
51-60	7	8.14
>60	11	12.79

1.6.4 Mapping

Mapping was used to record all typical instances of *linpan* structure, public space of rural markets and building architecture. Satellite images were used to capture the major features of land use, settlement morphology and landscape patterns in the Chengdu Plain. The images in 2013 were extracted from Landsat8 OLI (<https://earthexplorer.usgs.gov/>) and those in 2018 from the Sentinel data of Copernicus (<https://scihub.copernicus.eu/dhus/#/home>). The data of the Digital Elevation Model (DEM) with the spatial solution of 30 m were got from the Geo-spatial Data Cloud (<https://www.gscloud.cn/>). The data of land-cover and socio-economic change from 2000 to 2018 were extracted from the Data Center of Chinese Academy of Sciences (<https://www.resdc.cn/>) and the published statistical yearbooks of Chengdu (<http://www.cdstats.chengdu.gov.cn/>). Landsat uses strip and line number to indicate locations and Sentinel uses a series of letters and numbers to indicate the location.

Table 1.4 Data sources of remote sensing image of the Chengdu Plain

	Strip Number	Line number	Date
	129	39	2013.04.20
2013	130	38	2013.08.17
Landsat8 OLI	130	39	2013.08.17
	20181101T034901_N0206_R104_T48RUU		
2018	20181103T033909_N0206_R061_T48RVU		
Sentinel data	20181216T035149_N0211_R104_T48RUV		
	20181108T033941_N0207_R061_T48RVV		

The images downloaded from the websites were treated by the software of ENVI 5.2. The tool of the Radiometric Calibration of the Radiometric Correction Mode was used to treat the radiation calibration

of images; the tool of the Image to Image of the Registration Mode was used for geometry correction and projection conversion; and the tool of the Quick Atmospheric Correction was used for atmospheric correction.

In order to capture the morphological features of *linpan* settlements and their spatial patterns, drone photography was applied in the summer of 2019 in case-study areas to substantiate the useful information. I also identified some small roads and *linpan* units in case-study sites by visual acquisition. Considering the general working radius of 500 m of *linpan* dwellers (Fang, 2013), which was proposed as the boundaries of *linpan* settlements, ArcGIS 10.2 was used to extract individual *linpan* on the images. The landscape metrics include the size of *linpan* settlements, their distribution, vegetation coverage and shape index (see Chapter 2). In combination with field survey in case-study sites and visual interpretation of the images of the Google Earth, the morphological features of *linpan* units were identified.

The software FRAGSTATS 4.2 was used to analyze landscape configuration, including density, distance to roads and canals, distance between *linpan* units and between market towns. Using the images of the Google Earth in 2018, the spatial connection between market towns around Dantu Cun was also mapped (see Chapter 3). The population of these market towns and the distances between them were verified by personal interviews and local records. The architectural features of rural market, historic buildings, and *linpan* settlements were drawn according to my survey on the ground.

1.6.5 Modeling

The classic model of central place theory was used to illustrate the hierarchical relationship between rural markets (Christaller 1998). After identifying the location of market towns near Dantu market and the distances between them on the images of the Google Earth, the data were verified by personal interview. The connectivity was calculated based on the gravity model, which indicates that the gravity of an area is positive to its size, but negative to its distance to the area (see Chapter 3).

In order to analyze the relationship between market towns and the *linpan* landscapes, I used the approach of graphy theory (Urban and Keitt, 2001; Minor and Urban, 2008). The hypothesis is that one “node” (a market) is missed or closed, other "redundant" nodes (markets) in this network can sustain the function of the whole system. However, if the network of rural markets becomes fragmented, it could be assumed that the active functions of *linpan* landscapes (patches) would be disrupted or even lost. Finally, a theoretical model showing holistic functions of *linpan* landscape was established, which figuratively illustrate the “entity” of the whole landscape in the Chengdu Plain (see Chapter 3).

The spatial pattern of Dantu market including buildings and streets was mapped with the images of the Google Earth in 2018 first, and then identified by my interview with local people. For better

understanding the functions of long-porch, which is the representative public space in market town, I used an architectural model to illustrate the change of spatial feeling from private to public space, and calculated the ratio value to measure the objective space (see Chapter 3).

In Chapter 4 a model for assessing socio-ecological resilience with a set of indicators, including 4 indexes and 11 indicators, was established for examining the economic recovery of rural counties or districts after the COVID-19 pandemic shocked the Chengdu Plain. For purposes of comparison, I collected relative data from the published yearbooks except for the Shannon-Wiener Diversity Index (SHDI), and are converted into average values per capita in a given county or district. Then, I used the percentage of anomaly (distance to mean value, DTM) to express the relative significance of a given resource in a county or district in comparison with the average level of the entire region (see Chapter 4). Some tools of mathematical statistics, such as regression analysis and correlation analysis of SPSS 26.0, were also used in data treatments.

Chapter 2 Spatial Pattern, Architecture and Ecosystem Services of *Linpan*

Considering the *linpan* landscape as a localized cultural landscape in the world, this chapter aims at elaborating: (1) the spatial pattern of *linpan* landscapes in the Chengdu Plain; (2) the typical spatial configuration of a *linpan* settlement with examples at Dantu Cun; and (3) the functioning role of the *linpan* landscape in delivering ecosystem services to both local residents and urban citizens. To consolidate the features of the *linpan* system, this chapter dissects *linpan* from a macro to a meso-scale, and then to a micro-scale. With these analyses I hope to improve our understanding of the current status of the cultural landscape as well as to benefit the preservation and sustainable management of the landscape in the future.

2.1 Spatial pattern of the *linpan* landscape

2.1.1 Distribution of *linpan* landscapes

A *linpan* landscape is a kind of agricultural or cultural landscape which has been localized through the long-term interaction between human society and the environment in the Chengdu Plain (Fang, 2013; Lin, 2011; Wang and Chen, 2013; Pu et al., 2016). For many centuries, the Dujiangyan Irrigation System has nourished this landscape and linked abundant individual *linpan* units as an integrated network (Yang et al., 2011; Shu et al., 2013), which ultimately contributed to the layout (morphology) of the *linpan* landscape in the Chengdu Plain (Chen, 2011; Fang and Li, 2011; Fu and Deng, 2014). As the overall terrain of the Chengdu Plain descends gently from northwest to southeast, water from upstream naturally irrigates vast farming fields in the watershed. Local people can access water sources conveniently for their agricultural production or daily use. While people have adapted to the water environment and agricultural conditions in the last over 2,000 years (the length of the history of the Dujiangyan Irrigation System), the landscape was localized and accordingly became an ingenious and finely tuned system (Figure 2.1).



Figure 2.1 Birds-eye view of a *linpan* unit in the Chengdu Plain

Note: A *linpan* settlement composed of a few farmhouses in the center and tree/bamboo groves on the periphery, surrounded by farming fields or paddies, and linked with other settlement clusters through roads and/or canals

Source: Photo with drone by author, 2019

According to data provided by the Chengdu Committee of Urban Rural Construction (2007), there were about 201,600 *linpan* units distributed in 2007 across the whole Chengdu Plain, among which 141,100 units were located in the administrative territory of the Chengdu metropolitan area. However, another data source, based on remote sensing, showed that the number of *linpan* units in the Chengdu metropolitan area was 132,367 in 2000, 102,251 in 2010 and 98,745 in 2018.²⁴ In the last few years, many scholars have tried to identify the distribution of *linpan* units in Chengdu (or its districts) with geospatial tools (Duan and Liu, 2004; Wang, 2019; Guo, 2017). Although the number of *linpan* units assessed with different methods has varied greatly, the general trend is similar, i.e. presenting a decline change in last 20 years (Figure 2.2). The population living in these *linpan* settlements also decreased during the same period. By the end of 2010, there were around 4.49 million people living in *linpan* farmhouses, amounting to 77.09% of the total rural population of the Chengdu metropolitan area (Chengdu Committee of Urban Rural Construction, 2007; Fang, 2013). By 2017 the number of *linpan* inhabitants was estimated at 4.15 million, about 66.29% of the rural population (Statistics Bureau of Sichuan Province, 2017).

²⁴ Data analyzed in collaboration with Mr. Zhong Bo, which was identified with software ArcGIS 10.2 based on imagines of Landsat 8 OLI and Sentinel data.

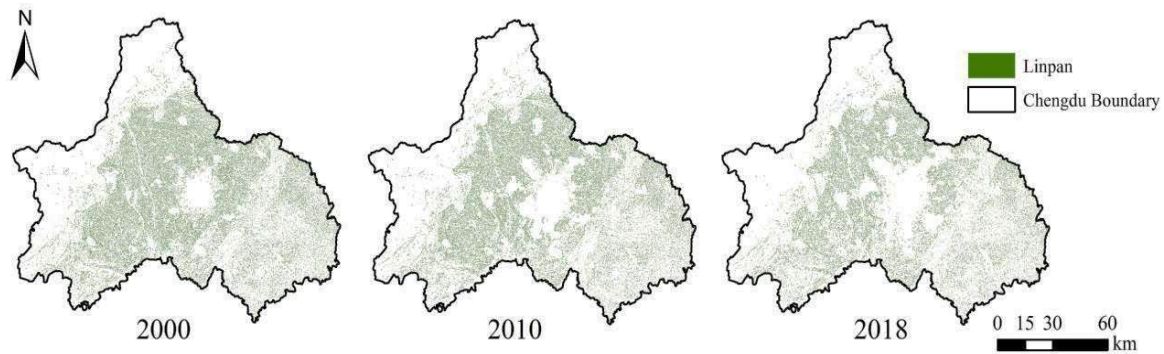


Figure 2.2 Spatial distribution of *linpan* units in the Chengdu Metropolitan Area

Source: Data analyzed in collaboration with Zhong Bo and mapped with the images from Landsat 8 OLI and Sentinel data

In order to understand landscape dynamics or functions, it is important to begin with an analysis of the landscape morphology. However, it is difficult to get accurate statistics on *linpan* settlements (both number and size). Many ways have been tested throughout the years by different groups of researchers including ourselves, including manual tracing of *linpan* settlements by humans, and the use of machine learning techniques. However, the definition of *linpan* used by each group is different and it is difficult to get a consistent measurement. Although the author and her colleagues have visualized the distribution of *linpan*, the accuracy for individual *linpan* units is still somewhat unsatisfactory. For example, using images from Landsat 8 OLI and Sentinel data, the visual identification of *linpan* units in 2018 was 68,238, much less than the above estimation. The reason for this difference is due to the weakness of machine-based object detection in identifying small-size *linpan* units. In this study I thus adopt the data from the report of the Chengdu Committee of Urban Rural Construction in 2007 as a baseline for further comparison, because it is officially accumulated data. However, this data only gives us the total number of *linpan* units in different counties or districts, and there is no geospatial data that can show the location and boundary of each *linpan*. Therefore, I used a few examples at case-study sites to illustrate the size, structure and distribution of *linpan* units with a method combining field survey and machine-based object detection.

2.1.2 Density of *linpan* units

Geospatial analysis indicates that the average distance between *linpan* settlements is usually less than 300 m and the radius of farming activities (working radius) of a *linpan*'s inhabitant is around 0.5-1 km (Liu and Mu, 2012) or even smaller (Tao et al., 2016). For some large (over ten households) and medium-sized (five to ten households) *linpan*, the interval distance may be about 1 km, and sometimes more (Fang, 2013). A too-short distance between *linpan* (residential clusters) and a highly dense pattern implies high pressure on land and water resources. Tippins (2014) finds this is a considerable radius of

human intervention, indicating that the daily life and farming activities of local people would not disturb biotic and non-biotic factors beyond the resilience threshold of the ecosystem. Too wide a space between units, on the contrary, indicates relative inconvenience for peasants to either manage their farmlands (Shu et al., 2013) or maintain social relationships with neighbors (Chen, 2011).

According to the data abstracted from the survey report of the Chengdu Committee of Urban Rural Construction (2007), the high densities of *linpan* units occur in Xindu (33.9 units/km²), Wenjiang (29.69 units/km²), Qingbaijiang (27.98 units/km²) and Pidu (22.19 units/km²), all of which, with flat topography, belong to areas traditionally irrigated by the ancient Dujiangyan Irrigation System (Figure 2.3). Most of the counties or districts with highly dense *linpan* (>13.16 units/km²) are bordered by Chengdu City (the urban center) except for Pengzhou and Dayi. Low densities are found in Qionglai (4.63 units/km²) and Pujiang (4.6 units/km²), where most parts of the land are hilly due to uplift from the Longmen Mountains. Generally speaking, the density of *linpan* units presents a progressive decline spatially from the east to the west. In addition, the average density of six counties/districts distributed closely nearby urban center (called the “inner circle”), including Longquanyi, Qingbaijiang, Xindu, Pidu, Wenjiang and Shuangliu, is higher (25.15 units/km²) than that of the other eight counties (11.83 units/km²) located in the “outer circle”, being only 47.03% of the former.

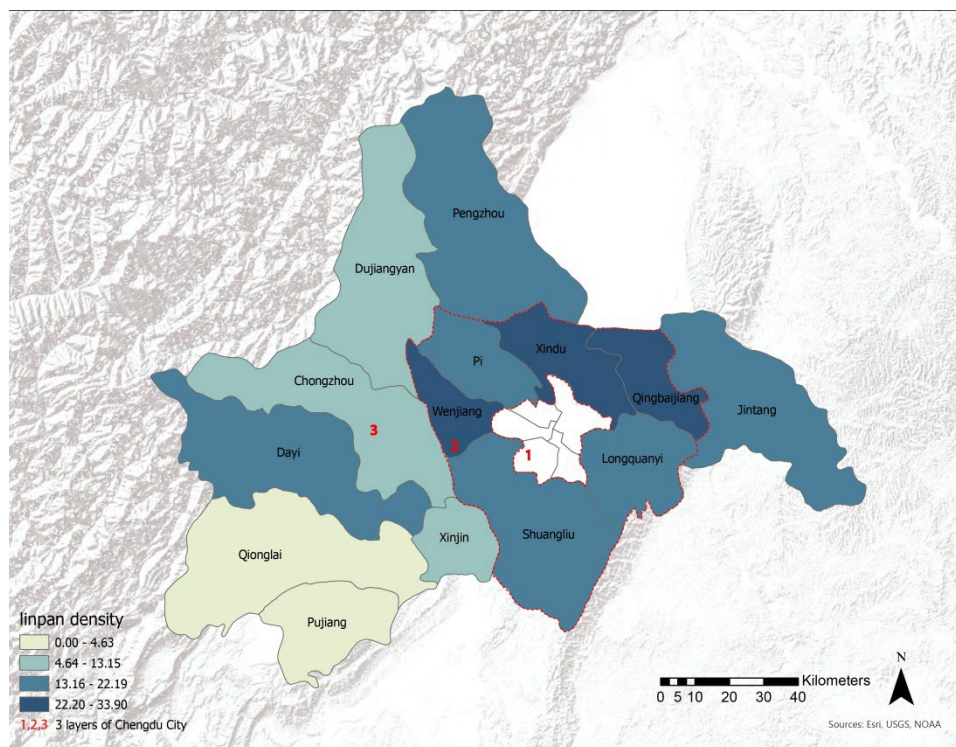


Figure 2.3 Density of *linpan* in different counties/districts of Chengdu

Notes: "1" indicates the “urban center”; "2" is the “inner circle”; and "3" is the “outer circle”.

Source: Chengdu Committee of Urban Rural Construction, 2007; mapped by author

The difference of *linpan* density shows the carrying capacity of the land changing with environmental and socio-economic conditions (e.g., water resources, soil fertility, market accessibility, etc.). In 2008, the average population density in the “inner circle” was 1,121 persons/km², but that of other counties or districts in the “outer circle” was only 585.13 persons/km², only about 52.2% of the former (Statistics Bureau of Chengdu, 2009). Thus, a high density of *linpan* corresponds well to a high density of (rural) population. In 2019 the average population density in the six districts of the “inner circle” rose to 1410.93 persons/km², about a 25.86% increase, but the density of the “outer circle” decreased to 560.48 persons/km² (Statistics Bureau of Chengdu and NBS Survey Office in Chengdu, 2020), showing a population shift orienting to the urban center.

Based on calculations made with FRAGSTATS software, the average interval distance between two neighboring *linpan* is around 300-500 m at the two case-study sites (Figure 2.4). The distribution of *linpan* and their densities is related closely to local topography, population density, availability of water supply and accessibility to traffic roads or market places (Chen et al., 2011; Guo, 2017). In Paotong Cun, for instance, where flat fields have been irrigated by the Dujiangyan Irrigation System for hundreds years and the population density is as high as 1,224.60 persons/km², the *linpan* density is 17.9 units/km² (Table 2.1). On the contrary, in Dantu Cun, a gently hilly area, the *linpan* density is 26 units/km², accounting to 45.25% higher than Paotong Cun, but its population density is only 497.98 persons/km², about 40.66% of Paotong’s population density. The negative correlations between *linpan* density and population density at the two case-study sites indicate that *linpan* settlements in plain areas support more residents and show greater size (in terms of households) than those in hilly areas. In Paotong Cun, for instance, one *linpan* can support an average of 68.41 persons, but in Dantu Cun the average is only 19.15 persons (see Table 2.1).

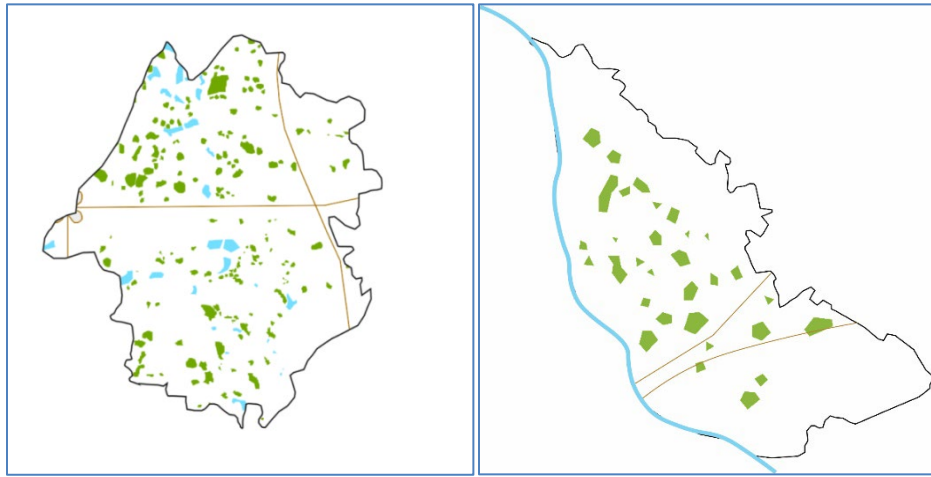


Figure 2.4 Spatial distribution of *linpan* (green) with roads (brown) and water system (blue) in case-study sites

Note: Dantu Cun (left) and Paotong Cun (right), traced from Google Earth (2018).

Source: Wu et al., 2020; mapped by author

Table 2.1 Metrics of *linpan* landscape in two case-study sites

Metrics	Paotong Cun	Dantu Cun
Land area (km ²)	1.87	6.45
Population density (persons/km ²)	1,224.60	497.98
Mean area of <i>linpan</i> unit (m ²)	8,342	3,000
Average interval distance (m)	273.98	395.50
<i>Linpan</i> density (units/km ²)	17.90	26.00
Carrying capacity of <i>linpan</i> unit (person/unit)	68.41	19.15

Note: carrying capacity of *linpan* unit = population density/*linpan* density.

Source: original table published in Chinese; please see “Wu S., 2020”.

2.1.3 Size of *linpan* units

The size of a *linpan* also varies with environmental and socio-economic conditions. In terms of households living inside a *linpan*, there are around 10,300 large *linpan* (over 10 households) within the territory of the Chengdu metropolitan area, making up only 7.3% of the total amount (Fang, 2013; Cai, 2009), but these provide livable spaces for a population of 1.08 million, i.e. 24.13% of the total rural people. These large-sized *linpan* settlements have a total land-surface area of 14,800 hectares, about 21.86% of the total area of the *linpan*'s occupation. In the Chengdu Plain, large *linpan* are normally located near central places (e.g. rural market towns) or at traffic hubs with good transportation,

accessible markets, and an available water-supply. On the contrary, small (<5 households) and medium-sized (5-9 households) *linpan* are the major types of *linpan*, which in total make up over 90% of all *linpan* units but house about 75% of the *linpan* population.

Given the spatial distribution of large *linpan*, high densities occur in Dayi (2.42 units/km²), Jintang (2.26 units/km²), Pidū (2.24 units/km²) and Xindu (2.04 units/km²). Still, low densities are found in Shuangliu (0.15 units/km²), Wenjiang (0.26 units/km²), Dujiangyan (0.33 units/km²), and Chongzhou (0.42 units/km²), where small *linpan* dominate the landscape. The density of large *linpan* in the “inner circle” is 1.24 units/km² on average, slightly higher than that of the “outer circle” at 1.07 units/km² (Figure 2.5). However, considering the concentration of dwellers in these large *linpan*, the counties or districts in the “outer circle” support more of the rural population, such as in Chongzhou and Dayi where 51.28% and 46.63% respectively of the rural population lived in large-sized *linpan*, contrasting to only 2.91% in Shuangliu and 3.16% in Wenjiang.

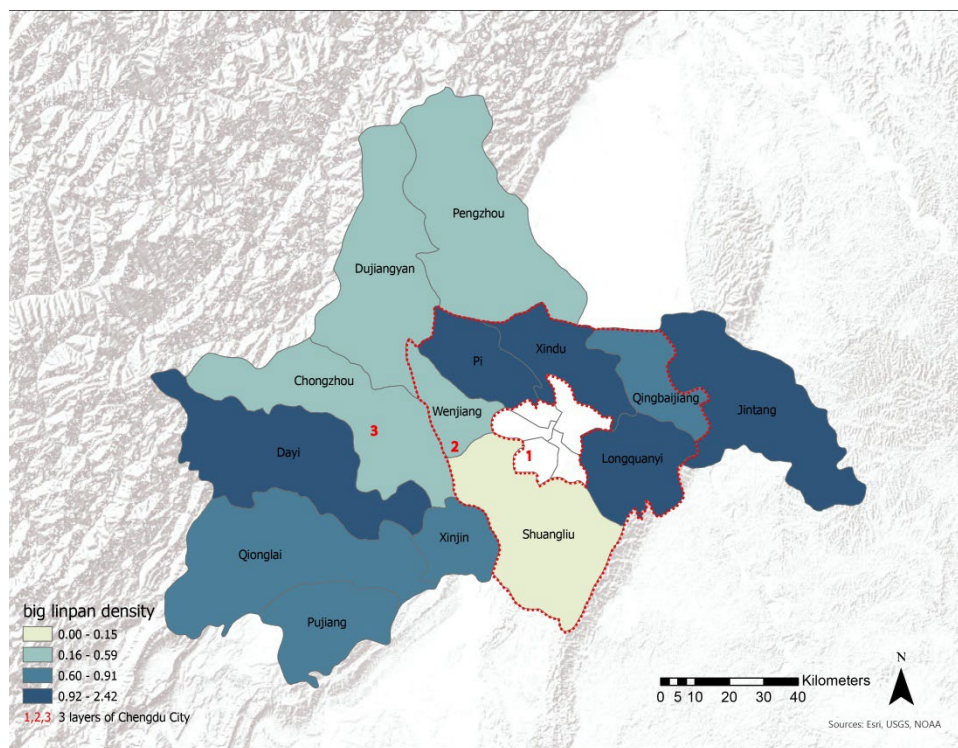


Figure 2.5 Density of large *linpan* (>10 households) in different counties/districts of Chengdu

Notes: Map produced in ArcGIS Pro by author; "1" indicates the urban center; "2" is the “inner circle”; and "3" is the “outer circle”.

Source: Mapped by author

In Dantu Cun, it is common for one household to live in one individual *linpan*. While 2 or 3 households may co-inhabit one *linpan*, these households are generally composed of brothers who have divided their

households after marriage. The relatively greater spaces in hilly areas enable them to live apart and develop their own independent *linpan* settlements. In the plain areas, due to the high population density and the associated limited space, brothers are unable to live apart even after marriage. Members of a large family (or clan) live in different houses of one *linpan* settlement even after two or three generations, a case common in Pidu District (e.g. Paotong Cun). Some scholars posit that the division of family property and living at a distance from family members after marriage, when the condition is available, is one of the reasons why the dispersed pattern presented by *linpan* in the Chengdu Plain (Fang, 2013; Wang, 2018).

The size of individual *linpan* units can also be measured by the surface area of occupied land. Generally, the shape of most *linpan* units appears circular or elliptical, and can thus be easily identified by the human eye and calculated based on GIS tools. Only a few *linpan* present long strip shapes, when they are constructed along main roads or waterways. The area of a *linpan* varies greatly at different locations. According to calculations made with FRAGSTAS, the average area of *linpan* units in the territory of the Chengdu metropolitan area is 0.54 hectares. This varies among the rural counties/districts from the highest, 0.99 hectares in Qionglai, to the lowest, 0.2 hectares in Wenjiang (Chengdu Committee of Urban Rural Construction, 2007) (Figure 2.6).

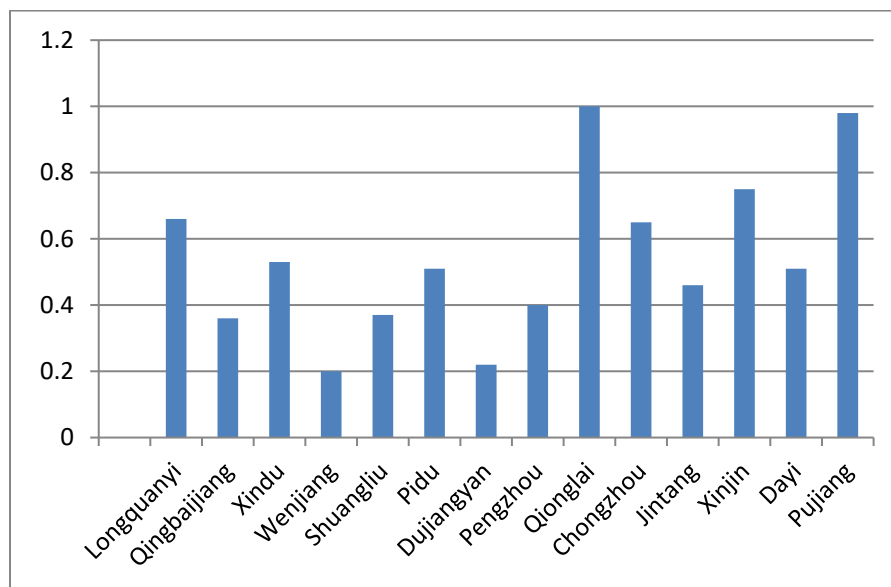


Figure 2.6 Average area of *linpan* unit (ha) in 14 counties/districts of Chengdu

Source: Calculated by author based on the report of Chengdu Committee of Urban Rural Construction, 2007

The average area of *linpan* in the “inner circle” is 0.44 hectares, contrasting to 0.62 hectares in the eight counties/districts located in the “outer circle”, indicating an increase of average *linpan* area from peri-urban to remote rural areas. The average area of a large *linpan* changes from 0.8 hectares in Jintang

to 7.75 hectares in Chongzhou, showing a similar trend of increase. In Chongzhou, for instance, there are 1,109 large *linpan* with a total area of 3,396.58 hectares, occupied by 51.28% of the total rural population of the county (Chengdu Committee of Urban Rural Construction, 2007). Understandably, in the remote rural counties, available land allows local peasants to develop their *linpan* as great size as possible. In hilly areas, such as Dantu Cun, local people plant trees or bamboo around their houses (for agro-forestry purposes), especially when the house is located on a gentle slope. More trees may enlarge the boundary of *linpan* when identifying them on satellite images. In contrast, in order to maintain sufficient area for farming, local people in the plains area (e.g. Paotong Cun) restrict the number of tree or bamboo groves around their houses, and agro-forestry is also relatively less developed.

As to the radius of *linpan* units, it was found that there were over 90% of *linpan* units with a radius less than 100 m, belonging to the category of small and medium-size units (Figure 2.7) (Fang, 2013). A *linpan* unit with a small size indicates that dwelling households have a relatively short working (farming) radius, meaning that peasants work the fields close to their settlements. In view of the whole territory of the Chengdu Plain, the farming radius (i.e., the distance from home to the field) is 146 m on average, but can be as high as 540 m for large *linpan*. When more households live in a large *linpan*, generally they also have more fields distributed around their settlements. Although the fields are relatively farther from the dwelling area, they are still convenient enough for agricultural activities. Generally, in the Chengdu Plain, the short distance from dwellings to fields is very accessible, allowing peasants to manage their farmlands frequently, but peasants in hilly areas must travel further.

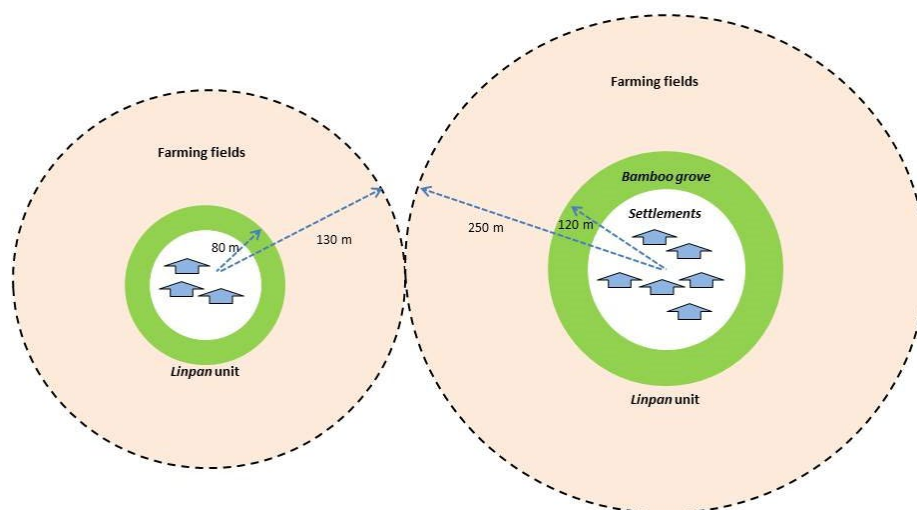


Figure 2.7 A schematic framework showing two neighboring *linpan* units with different radiuses of living and farming space

Source: designed by author

2.1.4 Environmental conditions determining spatial pattern

Generally speaking, *linpan* units (patches) present a dense pattern in the flat plain areas where farming fields are traditionally irrigated by the Dujiangyan Irrigation System. While going to the gently hilly regions, i.e., the areas closing to the Longmen Mountains or the Longquan Mountains, patches become sparsely distributed (see above). The reason for this may be relevant to the spatial variation of natural resources (e.g., water, soil, and topographic conditions), agricultural productivity, and the associated carrying capacity of the land. Within the Dujiangyan watershed, abundant tributaries or capillary canals are distributed, which can regulate water resources between flood and drought seasons and provide sufficient water for field irrigation all year round (Chen, 2011). Fertile soil (mostly paddy soil) is also rich enough to support intensive agriculture. According to the previous study, about 85.83% of the total *linpan* units were distributed in flat plains areas, inhabited by about 3.77 million people, i.e. 84% of the total rural population in the Chengdu metropolitan area in 2007 (Chengdu Committee of Urban Rural Construction, 2007; Table 2.2). Furthermore, about 87.4% large *linpan* units (>10 households) where almost one million people live are also found on the flat plain. Because there is no recent data about the distribution of *linpan* and the associated population, it is roughly estimated that the population of *linpan* settlements in the flat plain areas at present was about 3 million in 2017 (Statistics Bureau of Sichuan Province, 2017).

Table 2.2 *Linpan* units and dwellers in different natural regions in 2007

Topography	Flat plain	Gentle hilly	By waterway
No. of LU	121,100	20,000	42,800
% of total LU in Chengdu	85.83	14.17	30.33
No. of dweller in LU	3,771,800	673,900	1,257,300
% of total LU dweller in Chengdu	84.00	15.01	28.00
No. of BU	9,010	1,290	2,604
% of total BU in Chengdu	87.47	12.52	25.28
% of total LU in this area	7.44	6.45	6.08
No. of dweller in BU	936,490	146,910	261,400
% of total BU dweller in Chengdu	86.44	13.56	24.13
% of total LU dweller in this area	24.83	21.80	20.79

Notes: LU = *linpan* unit; BU = large *linpan* unit; The total numbers of *linpan* unit and large *linpan* unit are those distributed in the territory of Chengdu metropolitan area.

Source: Calculated by author based on Chengdu Committee of Urban Rural Construction, 2007

In contrast, the gently hilly areas, i.e. at the fringe of the basin, where the irrigation system was developed later (mostly after the 1950s) (Editorial Committee of Sichuan Local Gazetteer, 1993), peasants need more lands for sustenance and agricultural production, due to the declining productivity of farming fields. The low density of population in these areas makes it possible for local people to cultivate a larger space. The density of *linpan* units or the distance between them corresponds well to the availability of natural resources (water supply, soil fertility, and land conditions). According to the statistical analysis, the number of *linpan* units distributed in gently hilly areas was about 20 thousand, making up 14.17% of the total in the Chengdu metropolitan area, in which about 15.01% of total *linpan* dwellers lived in 2007 (Chengdu Committee of Urban Rural Construction, 2007; Table 2.2). Additionally, small and medium-size *linpan* dominate the landscape of hilly areas, accounting for 93.55% of the total *linpan* units in these areas. Additionally, the number of large *linpan* here was 1,290, occupied by 21.8% of regional dwellers. For the two case-study sites, the mean coverage of *linpan* unit was 8,342 m² in Paotong Cun, but 3,000 m² in Dantu Cun (see Table 2.1), representing a generally larger size of *linpan* in the plains area than in the hilly area.

In addition to topography, the distribution of *linpan* was thought to be related to the hydraulic system in the Chengdu Plain. The abundant tributaries of the Dujiangyan Irrigation System connecting with the Min River system in the south and Tuo River system in the north, include 38 arterial canals (“*gan qu*”), tens of main branches (“*zhi qu*” and “*dou qu*”), hundreds of sub-branches (“*mao qu*”) and thousands of ditches (“*nong qu*”), forming a crisscross pattern of irrigation network with the total irrigated area over 10 million *mu* or 667 thousand hectares (Editorial Committee of Sichuan Local Gazetteers, 1993).²⁵ In the Chengdu Plain the density of various canals is as high as 1.22 km/km² (Yuan 2018). Combined with thousands of water ponds spreading across the rural lands, there is a high ratio of water resources to inhabitants (about 3,000 m³ per capita) as well as sufficient water for the city (Editorial Committee of Chengdu Gazetteer, 2000).

Based on the survey report in 2007 (Chengdu Committee of Urban Rural Construction, 2007), there were 42,800 *linpan* units distributed along main canals (*gan qu*, *zhi qu* and *dou qu*), making up about 30.33% of the total *linpan* in the territory of the Chengdu metropolitan area, with 1.26 million inhabitants, i.e., about 28% of the total *linpan* dwellers in the Chengdu Plain (Table 2.2). The percentage of large *linpan* along waterways (main canals) was about 25.28% of the total large *linpan* in the Chengdu Plain. A more accurate assessment with ArcGIS based on imagines of Landsat 7 ETM+ and Landsat 8 OLI showed that in 2010 there were 80.53% of *linpan* units distributed at a distance of 3000

²⁵ The hierarchy of canals of the Dujiangyan Irrigation System (from top to bottom) includes *gan qu*, *zhi qu*, *dou qu*, *mao qu* and *nong qu*. Among these arterial canals (*gan qu*), five of them were constructed after the 1950s (Editorial Committee of Sichuan Local Gazetteer, 1993).

m to main canals, with 42.77% at a distance of 1000 m.²⁶ In the Chengdu Plain almost all of the farming fields are connected and irrigated by ditches (*mao qu* or *nong qu*). In average, the annual water supply for irrigating fields is 3,700 m³ per *mu* (Editorial Committee of Chengdu Gazetteers, 2000). Meanwhile, with the consideration of convenient water access, many *linpan* settlements are distributed along the branches of waterways (*dou qu* and *zhi qu*). Those *linpan* settlements located away from main canals may be connected by small ditches (e.g. *mao qu* or *nong qu*). The hair-like canals flow continually around *linpan* settlements and paddy fields, providing an ideal condition for peasants' living and production.

According to a recent survey in Pidu District (Huang et al., 2020), it was found that in the plains area there are no *linpan* settlements built on the riversides of arterial canals (*gan qu*). The majority were located near to medium-size water ways (e.g. *dou qu*, *zhi qu* and *mao qu*). Peasants are reluctant to build their houses on the banks of main river (Baitiao River in Paotong Cun) due to the risk of potentially damaging floods in summer. Huang et al. (2020) reported that about 80% of *linpan* in their case-study sites were distributed within a 200 -500 m wide belt on both sides of variously-sized canals. The density of *linpan* declined with the progressive distance from these waterways. The close distance to the hydraulic system reflects the good conditions for agricultural production in this area, which include convenient irrigation as well as fertile soil in this belt.

In the gently hilly areas, such as in Dantu Cun, the situation is slightly different. The arterial canal, *Dong Feng Qu* (literately “East Wind Arterial Canal”), connecting with the Dujiangyan Irrigation System, was constructed from 1956 to 1973 (Editorial Committee of Shuangliu County Gazetteers, 1992). Currently, the Dantu area is irrigated by *Shengli Dou Qu* (literately “Victory Main Canal”) which was built from 1965 to 1973, and is a main branch of *Dong Feng Qu*. Based on interviews, I learned that while local people need irrigation (mostly in spring), a few households together would require the administrative departments to release water to the *mao qu* and *nong qu* from which they could draw water. These households share the cost of electricity for pumping, but the water cost is paid by the local government (*xiang* or *cun*). Thus, in this area water ponds are used widely by local people for water storage, which is a traditional practice in hilly areas for coping with droughts in the spring. Findings based on geospatial analysis in Dantu Cun show a significant overlap of *linpan* density with water (pond) density and road density in three clusters (Figure 2.8).²⁷

²⁶ Data provided by Zhong Bo.

²⁷ Arcgis Online Calculate Density Tool. <https://doc.arcgis.com/en/arcgis-online/analyze/calculate-density-port-al-tool-reference.htm>. Accessed February 2022.

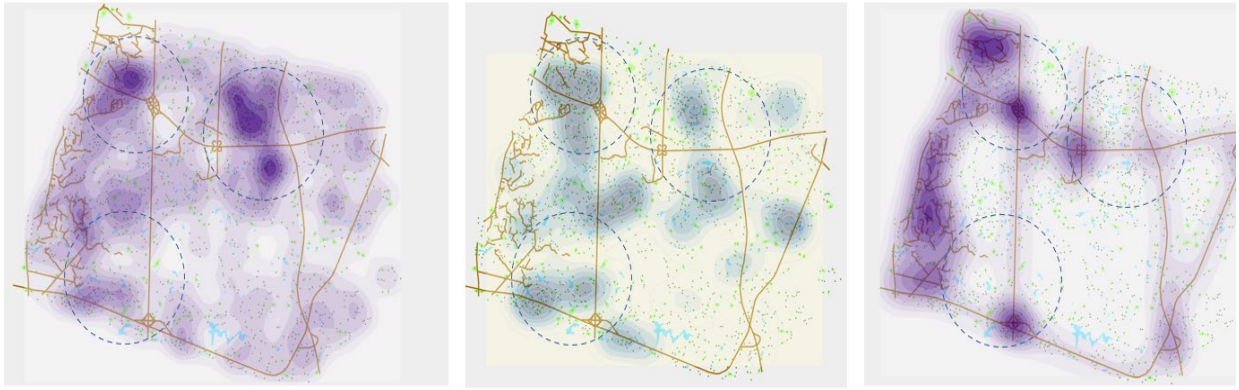


Figure 2.8 Agglomeration of *linpan* density (left), water/pond density (middle) and road density (right) in Dantu Cun

Note: Using Arcgis Online “Calculate Density Tool” to map the distribution.

Source: Mapped by author

This result indicates the distribution of *linpan* may correspond well to the distribution of water ponds and major traffic nodes. Generally, water ponds can be found near every *linpan* settlement, and the location of these settlements is generally not far from various roads. Considering the sustainability of land use, the fact that smaller *linpan* units were found predominately in Dantu Cun reflects a traditional practice which may lighten the population pressures on the relatively infertile lands through resource management (Figure 2.9).



Figure 2.9 Water ponds and hydraulic system in Dantu Cun

Note: **Top left:** A multi-functional water pond surrounded with rice paddy and trees, a local scene of the *linpan* landscape. **Bottom left:** A newly established fish farm based on water ponds, a new source of farmers' income. **Right:** A section of *Shengli Dou Qu*, the main irrigation canal for Dantu area.

Source: Photo by author, 2019

In this study, I also tested one hypothesis raised by my advisor Prof. Abramson: the size of *linpan* units within the landscape, and the distance between them, increases as they are farther from the historic core of the Irrigation District. In other words, the non-nucleated settlement pattern is associated with the age of the irrigated area, which also indicates some correspondence with the maintenance of the most densely ramified water channels and the best soil quality. As settlements occupy land that only more recently became part of the Irrigation District, they are more similar to the nucleated villages typical of other densely populated agrarian landscapes in China. To test this, I drew a line connecting Chengdu City and the Dujiangyan City, the head of the Dujiangyan Irrigation System, and then measured sample areas along a transect perpendicular to this line, expecting that the closer the *linpan* settlements are to the axis, historic core of the irrigation system, the smaller and denser the *linpan* would be; and the

farther away from the axis, the larger and sparser the *linapn* presented (Figure 2.10). These small and dense or large and sparse patterns would correspond well to the history of the irrigation system as well as the carrying capacity of the lands.

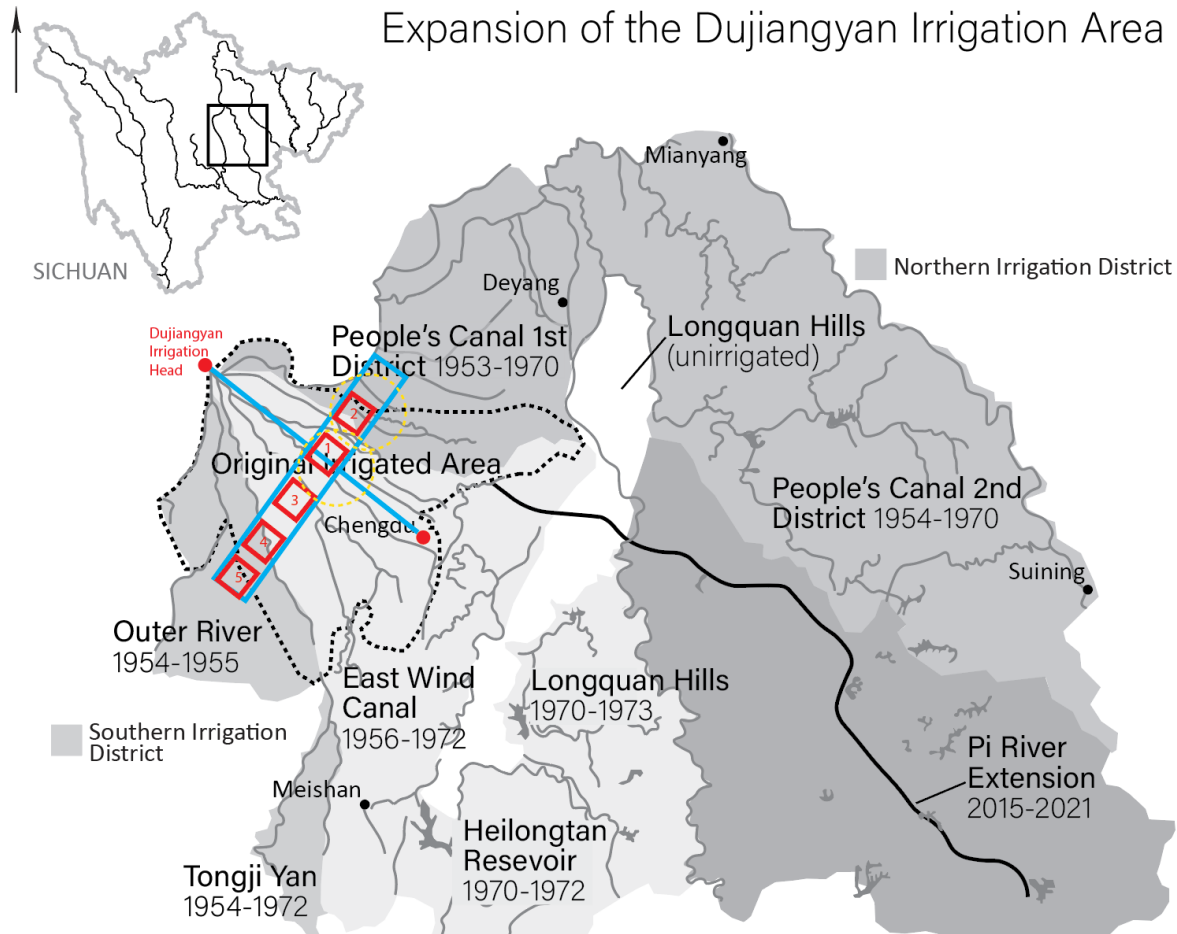


Figure 2.10 Five sample areas along the axis to test the hypothesis

Note: The size of sample area is 4km by 4 km

Source: Base map provided by Steve Harrell

I chosed five sample areas along the axis, each roughly 4 by 4 km, because this sample area is not too large to trace all the *linpan* features. I then calculated *linpan* density, average size of *linpan*, and the distance from the sample areas to the axis in ArcGIS. Finally, the calculated results correspond well to our hypothesis as shown below (Table 2.3).

Table 2.3 *Linpan* density, average size and distance to the axis in three sample areas

	Area 5	Area 2	Area 3
Distance to CD-DJY Axis (km)	38.5	9.6	12
<i>Linpan</i> density (unit/km ²)	9.2	17.9	22.3
Mean <i>linpan</i> size (m ²)	19376	8342	5959

The google earth images only dated back to 2000, when the urban expansion of Chengdu city began to transform the rural landscapes, but what did it look like before 2000? I then got some declassified corona images from the USGS and the Chinese dataset (<https://www.resdc.cn/>). The images are black and white, a little hard to detect *linpan*, but it is still possible (Figure 2.11). It will help fill the gap of the history before 2000 and enable us to trace the historical change of landscape. This part has not been fully done, but it will remain as a continuing project and a potential paper for the future.

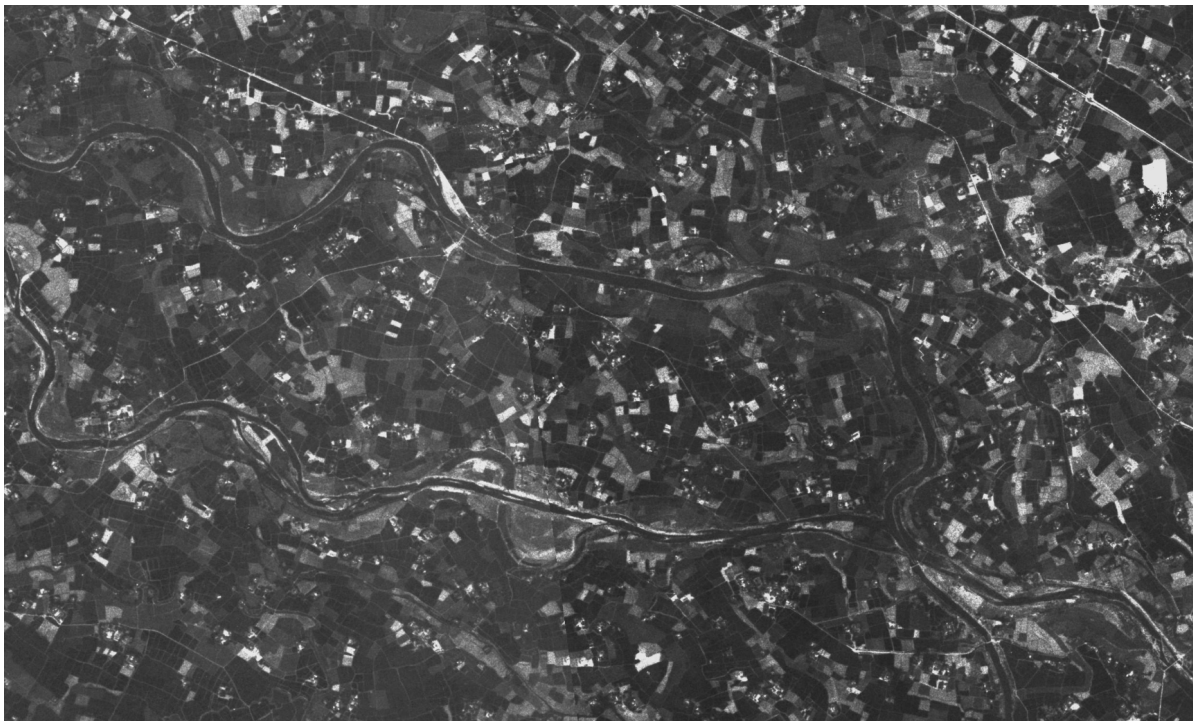


Figure 2.11 Corona images of Chengdu Plain (c.1960-1970s)

Source: USGS earth explorer <https://earthexplorer.usgs.gov/>

2.1.5 Governance of *linpan* landscape

2.1.5.1 Administrative institutions

The term “village” in this context means a “village community” as used by Skinner (1964), regardless of nucleated and dispersed types. Traditionally, in the Chengdu Plain farmers’ settlements (i.e. *linpan* units) are distributed separately and there are not typically nucleated villages. Before the 1950s, there were many *linpan* settlements gathered around a rural market (i.e. “*chang*”) which could be the seat of a local authority such as “*xiang*” (rural township) or “*zhen*” (urbanized township).²⁸ After 1958, with the establishment of the “people’s commune”, the rural governance hierarchy included three levels: “*ren min gong she*” (people’s commune), “*sheng chan da du*” (production brigade) and “*sheng chan xiao du*” (production team). This system was maintained until the beginning of the 1980s (Figure 2.12).

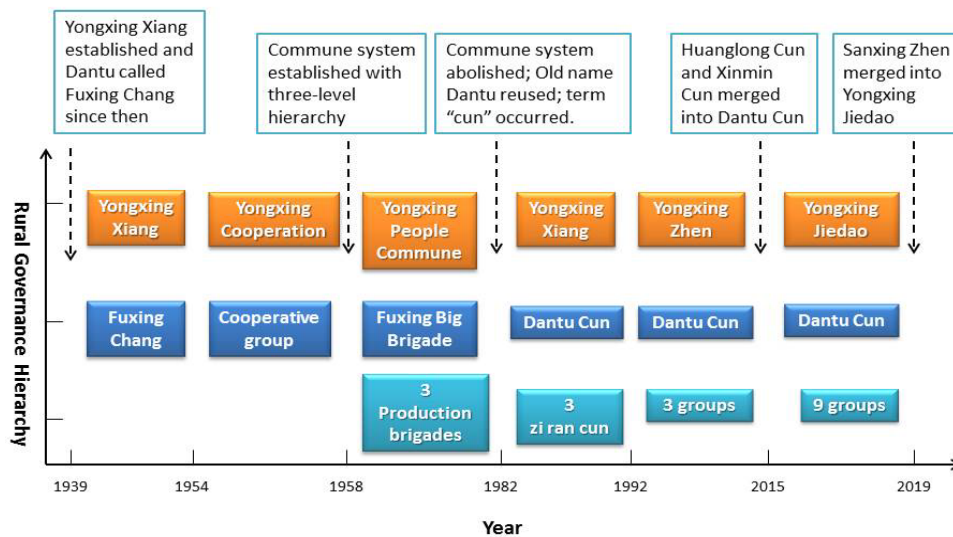


Figure 2.12 Changes in rural governance hierarchy in the Chengdu Plain, with cases of Yongxing and Dantu

Source: Editorial Committee of Shuangliu County Gazetteer, 1992; personal interview with local officials of Dantu Cun; designed by author

²⁸ During the Republic period (1911-1949) there were also three administrative levels in rural areas. In 1939 the central government required to establish “*bao*” and “*jia*” under *xiang* or *zhen* in Sichuan. There were normally 10 households included in a “*jia*”, which could range from 6 to 15 households, and 10 “*jia*” combined together as a “*bao*”, with 6 – 15 “*jia*” also allowable. The number of “*bao*” within a *xiang* (or *zhen*) territory was to be 6 to 15, but the traditional boundary of *xiang* (or *zhen*) was to be maintained. Thus, how many “*bao*” there were in a *xiang* (or *zhen*) was location dependent (Ran, 2005; see also Skinner’s field notes edited by Harrell and Lavelly in 2017).

In Shuangliu County, the “people’s commune” system was replaced by newly established hierarchy in 1982, i.e. “*xiang*” (rural township), “*xing zheng cun*” (administrative village), and “*zi ran cun*” (natural village). By then, the term “*cun*” was used as a basic level of local authority and was translated into “village”.²⁹ The term “*xing zheng cun*” indicates its administrative function within the government framework, but “*zi ran cun*” means the dispersed residential *linpan* forming themselves into natural groupings. Lately, the name of “*zi ran cun*” was changed into “*cun min xiao zu*” (villager group) or simply “*xiao zu*” (group). Thus, although the term “*cun*” (village) is still used, it has different meanings in different contexts.

Literately, “*xiang*” means a rural township, but “*zhen*” indicates an urbanized township. After 1992, with the process of urbanization, many “*xiang*” were renamed as “*zhen*” progressively, with Yongxing *Xiang* becoming Yongxing *Zhen* in my case-study area. Actually, the term “*xiang*” had been used since the 1930s as a traditional level of rural administrative hierarchy in Chengdu (see Skinner’s field-notes edited by Harrell and Lavelly in 2017), which was changed into “*ren min gong she*” (people’s commune) from 1958 to 1982 (the territory perhaps was not fully aligned with the previous boundary). With the economic reform in the 1980s, rural areas experienced a great change (e.g. the contracting of farming fields to peasants) which led to the restructuring of the associated institutional system, and the return of “*xiang*”. Traditionally, only the seat of county town or district town was called “*zhen*”, representing a small urbanized center. Recently, these “*xiang*” or “*zhen*” were renamed as “*jiedao*” (street community), a term which traditionally was only used in urban areas but now implied a more urbanized township. The newly established “*jiedao*” in previous rural areas usually combined 2 or 3 “*zhen*” or “*xiang*”, resulting in a larger territory, although the name could be maintained (see the case of Yongxing in Figure 2.10).

2.1.5.2 ICT-enabled governance

Effective governance systems play a critical role in societal responses to pressures by enhancing access to information and resources, as well as providing opportunities for adapting to changes (Agrawal and Perrin, 2008). In the last twenty years, the application of ICT combined with smartphones has become a powerful tool for natural resource conservation and environmental governance worldwide (Peng et al., 2017; Mol, 2009; Cox and Sseguya, 2015). In the mid-2000s local agencies in China began to gather geo-tagged data as part of an emerging “Grid Management System (GMS)” for the purposes of managing urban spaces and communities (Yan, 2006). In 2014, the GMS was proposed and then quickly

²⁹ The term “*cun*” was introduced into Chengdu at the beginning of the 1950s. It was widely used in northern China to indicate a village. But this term was only used for a short time in the 1950s in Sichuan and quickly replaced by “*he zuo she*” (farmer association) and “*sheng chan dui*” (production team) after 1956. After 1980, the term “*cun*” was reused in rural area as one of local governance institutions.

established in rural Chengdu including Paotong Cun and Dantu Cun, which provides opportunities to sustain and scale up the collection of data necessary to regulate management practices and enable local governance.

In order to understand how GMS function on the ground, we carried out an investigation in Paotong Cun from 2017 to 2020. The focus was on understanding how a newly emerging ICT-enabled governance practice presents an opportunity to correct what we see as a potentially maladaptive trend in the Chengdu Plain's development, i.e. how it might function as an adaptive innovation that strengthens feedback loops between different scales of decision making, informs the protection of important buffers against future disturbance, helps to resolve trade-offs, and achieves a balance between local choice and regional integration. In Paotong Cun an in-depth survey on GMS was carried out through face-to-face interviews with local officials (at villager group and township level) and *linpan* dwellers, and follow-up observations with grid managers (“*wang ge yuan*” in Chinese) during their regular patrols. We then try to use vignettes to depict the interwoven relationship between the grid managers, peasants, and entrepreneurs, and explore how ICT influences the resilience of a socio-ecological system.

In Pidu District there were 1,460 grid managers, including 589 full-time and 871 part-time, serving for the GMS of the District to which Paotong Cun belongs. In this system the territory of a county or district was divided into many small “grids” according to the administrative hierarchy from township, administrative village or community to villager group. At the top of this system, it has an information center or platform under the supervision of a county (or district) government, which was directly connected with a few regional nets (at township level) and indirectly with grids on the ground (at villager group level). The local governments hired local people (mostly educated young people) working as grid managers who were responsible for reporting on the ground. Generally, grid managers are required to fulfill some basic responsibilities, including:

- Collecting information about social conditions;
- Coordinating social services;
- Reporting and responding to emergencies;
- Mediating conflicts and disputes;
- Maintaining and safeguarding social order;
- Providing aid to vulnerable groups (e.g. elderly, disabled); and
- Promoting the implementation of policies and regulations.

The full-time grid managers were required to conduct at least two patrols per day in their own assigned grids, with the time of one patrol being no fewer than two hours (Figure 2.13). Their duties include visiting vulnerable groups (e.g., elders) and the mobile population (i.e., temporary inhabitants),

inspecting rental houses, monitoring environmental pollution (mainly water body, waste and garbage), fire prevention, and public security (including traffic safety and municipal facilities). They are to report what they find immediately to the higher levels of administrative departments through a specially designed mobile phone with GPS positioning (Figure 2.14). The information reported by these local managers is gathered and analyzed quickly by local nets or the county's information center. The functionalities of service platforms can then guide local grid managers at different levels to jointly carry out actions in responding to emerging issues or informing government departments of services needed by local communities. Local people are also encouraged to participate in this reporting effort by using their WeChat APPs, indicating a diversified source of information in-time collection.



Figure 2.13 A patrol map of a grid manager in Paotong Cun

Note: The map drawn by Mr. A (grid manager) is a perfect example to show bottom-up data generation that is very fine-grained, giving many details and interpretation of the place through his eyes.

Source: Drawn by the grid manager, modified by the author.



Figure 2.14 Grid manager main responsibilities and their smartphone interface

Source: Photo and designed by author, July 2018

Because of the application of ICT technology, messages from the grassroots level were collected and reported to higher administrative departments who might then respond as soon as possible, strengthening the smooth flow of information within the hierarchy of authorities and the agrarian society. By relying on this information platform, grid management service in the district operated through the two-way flow of information, i.e. bottom-up reporting and top-town intervention. The problems reported from local grid managers or villagers could be solved in a timely way through efficient actions. This system was supported by irregular monitoring and mass satisfaction assessment (by local people) on the grid managers and the staff working in the administrative departments of township and county governments.

2.2 Architecture in *linpan* settlement

Understanding the configuration of *linpan* settlement helps us to learn about the lives and livelihoods of local people, which may contribute to the preservation and sustainable use of *linpan* landscapes. From a bird’s-eye view, most *linpan* units present a round shape, but there are also a few, distributed along roads or canals, in belt form. Within a round *linpan*, one or a few houses are at the center. These houses with their courtyards are the living space for local peasants. Traditionally, most of the farmers’ houses in rural Chengdu were constructed with mud bricks (adobe) and thatched roofs. Skinner in his field-notes documented in detail about the replacement of a thatched roof house around 1949. After the 1980s, more and more houses were constructed with fired brick and tiles, replacing the traditional thatched cottages. In Paotong Cun, almost all of the houses were constructed after the 1980s, where brick and tile mixed buildings are dominant. On the contrary, in Dantu Cun many thatched cottages still remain, which are an excellent example for illustrating the traditional features of *linpan* settlements in this study. It should be noted that the whole set of architectural features were used together in most parts of the Chengdu Plain

only up until the 1990s; and that very few houses with all these characteristics now remain.

In Dantu Cun, the dominant type is a small-sized *linpan*, in which only one or two families live. The layouts of thatched cottage in Dantu Cun normally present a “line” shape, an “L” shape, a “U” shape (embracing a courtyard with three sides of buildings), and a “compound” shape (a courtyard surrounded by buildings on four sides), which is similar to the findings in other places of the Chengdu Plain (Zheng, 2010; Tao et al., 2016; Fu and Deng, 2014). These shapes follow an evolutionary process with the expansion of the inhabiting family (Figure 2.15), but “line” shape is rare, with the exception of some buildings located on roadsides. In Dantu Cun most of the cottages present “L” shape and “U” shape, and a “compound” shape could be considered as an expansion of these styles. In these settlements, the layout or plan is similar, i.e. the main room is located at the middle with two bedrooms on both sides, forming a “line” shaped main-building. The kitchen is normally connected with one bedroom on the left hand (southern side). As family members increase, one or two rooms are constructed on one side, being perpendicular to the main building, and forming the “L” shape. With further expansion new rooms are extended symmetrically on two wings, becoming the “U” shape. A pigpen may be located on two sides flexibly but always at the end of one or two wings, which depend on how many pigs the owners want to raise. While the “U” shape courtyard is fenced with walls, a “compound” shape settlement is formed. The rooms on both wings can be used as bedrooms (for more children), guestrooms or storage.

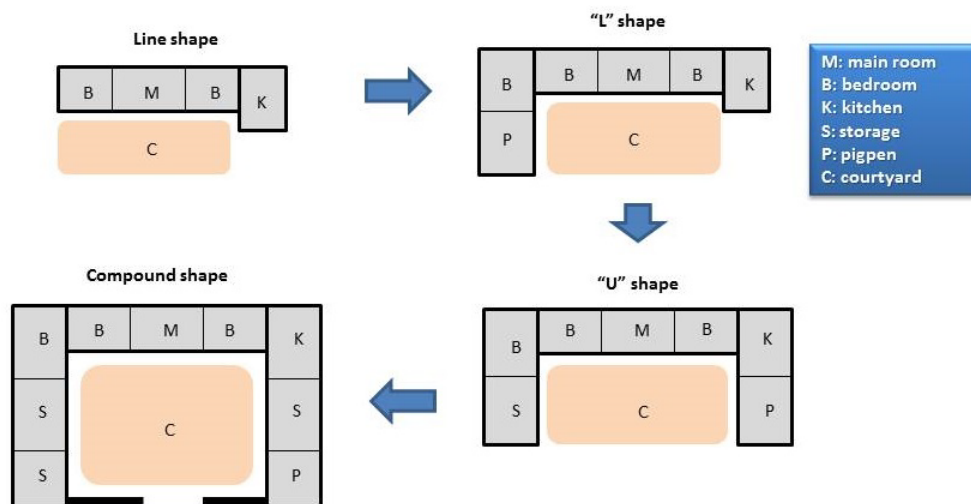


Figure 2.15 Evolutionary process of settlements with family expansion

Source: Designed by author

In Dantu Cun the orientation of most main buildings is west or southwest facing, but occasionally one is oriented differently according to the practical requirements of dwellers or topographical conditions. Generally, an individual *linpan* settlement is surrounded by trees or bamboo groves on its three sides

(rear, left and right hand), but its front side is an open space leaving access to farmlands or main roads. Topographically, the main-building always sits back against the hilly slopes (or relatively higher land) and faces down-sloping orchards or terraced fields in front of the courtyard. Water ponds located near the settlements are found everywhere, and are used for storing water during the rainy season and irrigating farmlands when drought comes. Although local people can use canal water nearby or pump water from the hydraulic system, they still prefer to store water in their own ponds, which is a traditional way for coping with occasional drought. Well water is the main drinking water in Dantu Cun, but now those people living in Dantu market and its surrounding area can use tap water. In the following sections, I will exemplify a few cases to illustrate the representative configuration of different farmers' settlements in detail.

2.2.1 “L” shape settlement

The “L” shape settlement is a common and basic style in Dantu Cun. One example is Mr. Zhu's old house, which is located at Group No. 1 (Figure 2.16). This house was built with mud brick and thatched roof in the 1970s by his parents and then reconstructed in 1983 when his son was born. His family lived here until 2008, when the Wenchuan earthquake struck this area. Although this house did not fall down, some large cracks occurred. Under the auspices of the government (partly financial support), his family moved into a new house in a nucleated settlement about 300 m away. A few years ago his son married and now is sells construction materials in Yongxing Zhen, the up-level market town of Dantu Cun. At present only Mr. Zhu and his wife stay at home. Because his field lot is located nearby this old house, every day he must travel back and forth for his field work. Therefore, he keeps his old house for storing tools, fertilizer, or other materials. He can also rest here while working the fields.



Figure 2.16 Environment and house in an “L” shaped settlement owned by Zhu’s family

Note: **Top left:** House located at the top of terraced lands surrounded by eucalyptus trees and bamboo groves; **Top right:** A lane through bamboo groves leading into the courtyard; **Bottom left:** Main building standing at the middle of *linpan* with the pigpen on the left-hand wing collapsed; **Bottom right:** Door of the main room and the porch under eaves; the thatched roof was covered with metal tiles.

Source: Photo by author, 2019

This house was constructed with mud bricks and a thatched roof. Since they moved to the new house, they no longer repair the old one. Some sections of the wall and a pigpen on the left-hand wing have fallen down. The thatched roof of this house was covered with metal tiles because the original roof leaked, but Mr. Zhu did not want to repair it in the traditional way. The surface of house wall used to be plastered with yellow mud mixed with straw, but in many areas the uncovered mud bricks have become exposed. Following Mr. Zhu’s explanation, the structure of this house (ichnography) was drawn up, which included one main room, two bedrooms, one storage room, one kitchen and one pigpen (Figure 2.17). A long porch under eaves, about 1.5 m wide, extends along the front belt of main building. A courtyard was used for drying grain and daily activities of family members.³⁰ Now there are a few

³⁰ In the Chengdu Plain the courtyard of *linpan* settlement is also called “*shai ba*”, meaning a place for drying grain under sunshine.

young trees growing up in previous courtyard. Mr. Zhu explained that the “L” shape settlement could be expanded in the event of an increase in family members, such as the birth of a child or the marriage of a son (before the married couple moves to their own home). Normally, one or two rooms on the left wing are constructed first, followed by one or two rooms on the right, if the family requires them. These added rooms could be used as bedrooms, guestrooms or storage. One or two pigpens are always put at the end of the wings.

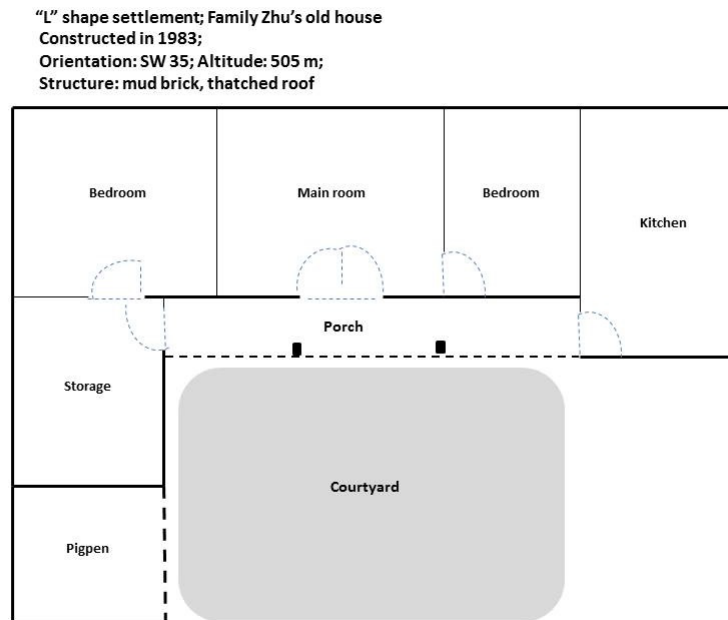


Figure 2.17 The ichnography of the “L” shape settlement owned by Zhu’s family

Note: Storage and pigpen on the left wing collapsed after 2008 and only remnants remain.

Source: Drawn by author, 2019

This independent *linpan* with one household is located at the top of gently terraced land, surrounded by eucalyptus trees and a few bamboo groves (Figure 2.18). On the second terrace, orange and tangerine trees were planted, forming small orchards intercropped with vegetables. There used to be a small round water pond in front of the courtyard, but it was not used after they moved away. A small lane through bamboo grove links the house with a driving road nearby, but another walkway extends to their farming fields. While irrigating the fields or orchards, Mr. Zhu can pump water from a big pond about 20 m away. Although this pond has been used for fish farming by another household, Mr. Zhu is allowed use of the water according to their traditional agreement. Vegetables are the major crops which he cultivates all year round, mainly for sale in the market town. He also plants oil rape in this field, intermittently and depending on market fluctuation. Since 2008 he has not cultivated grain crops such as rice and wheat due to high labor-cost, but maize is planted sometimes intercropping with soybeans.

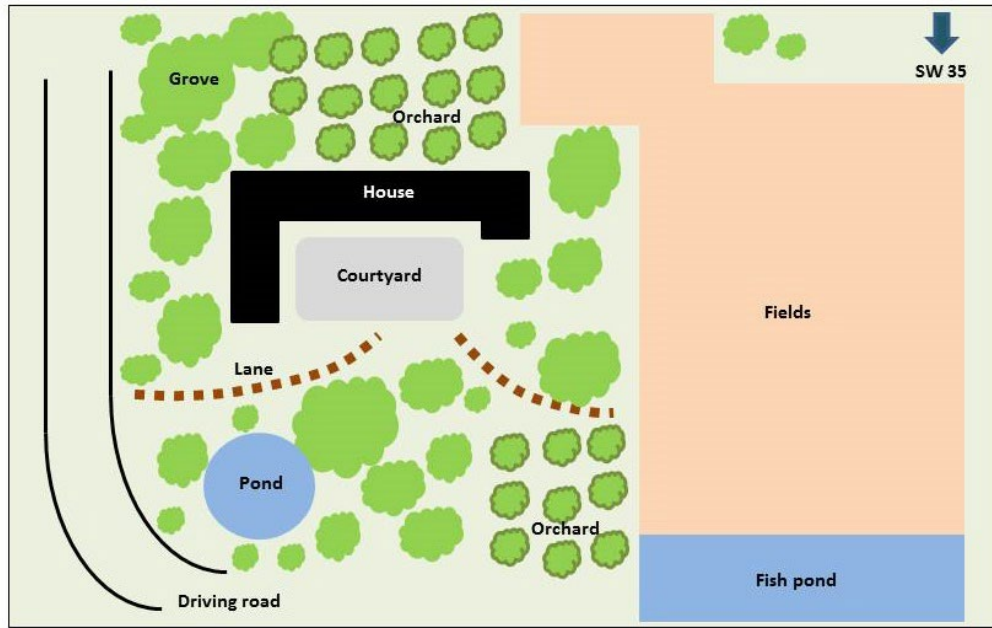


Figure 2.18 *Linpan* layout of the “L” shaped settlement owned by Zhu’s family

Source: Drawn by author, 2019

2.2.2 “U” shaped settlement

The “U” shaped settlement is developed from the “L” shape. Mr. Zhou’s house, located at Group No. 8, is an example in which five family members now live, including parents (Mr. Zhou and his wife), a son and his wife, and one granddaughter (Figure 2.19). This house was constructed at the beginning of the 1980s. In terms of ownership, two rooms on the left-hand wing belong to Mr. Zhou’s elder brother, but the brother left 20 years ago for educational reasons and now lives in Chengdu. This building therefore is used entirely by Mr. Zhu’s family. Though he engages in agriculture at home, Mr. Zhu has a part-time job as a security officer at a construction site. His son is in business and his son’s wife is a teacher in a local elementary school. Their granddaughter is studying in a secondary school in Jiancha Zhen. Daily they take her to Jiancha (about 6-7 km away) with their own motorcycle or on the public bus.



Figure 2.19 Environment and house of the “U” shaped settlement owned by Zhou’s family
Note: **Top left:** Farmhouse covered by tree and bamboo groves with water pond and farming fields nearby; **Top right:** A wide porch in the front of main building, with view of mud wall, thatched roof and wooden pillars; **Bottom left:** “U” shaped settlement with main building at the middle and two wings on both sides; thatched roof being covered with asbestos tiles; **Bottom right:** Door to main room, viewing porch as a public space

Source: Photo by author, 2019

According to information from Mr. Zhou, his parents had a house here, but it was reconstructed in 1985. After his elder brother graduated from school and left home, he and his family live in this house for over 35 years. His son married a woman from Mianyang City 14 years ago, but they still live in this house. Now they use four rooms as bedrooms with the main room (the middle room, called “*tang wu*” in Chinese) as a reception room (Figure 2.20). The restrooms on the left wing are maintained as storage rooms. On the right-hand wing, a room connecting with the kitchen is used as a washroom. Although there is a pigpen at the end of the right-hand wing, it has not been used for some years. Like other households in this area, they were not allowed to raise pigs at home to avoid epidemic disease (e.g. African swine fever). In rural areas, the pigpen is also used as a toilet at home. Thus a biogas well was constructed by the pigpen, which is common in many households. Mr. Zhu said he wants to reconstruct this house because it looks too old, but the local government did not approve his proposal. He was able to cover the thatched roof with asbestos tiles. He was told that this house was slated for demolition

because the area was part of a projected new development zone. He will be able to move to a new apartment or house provided by the government.

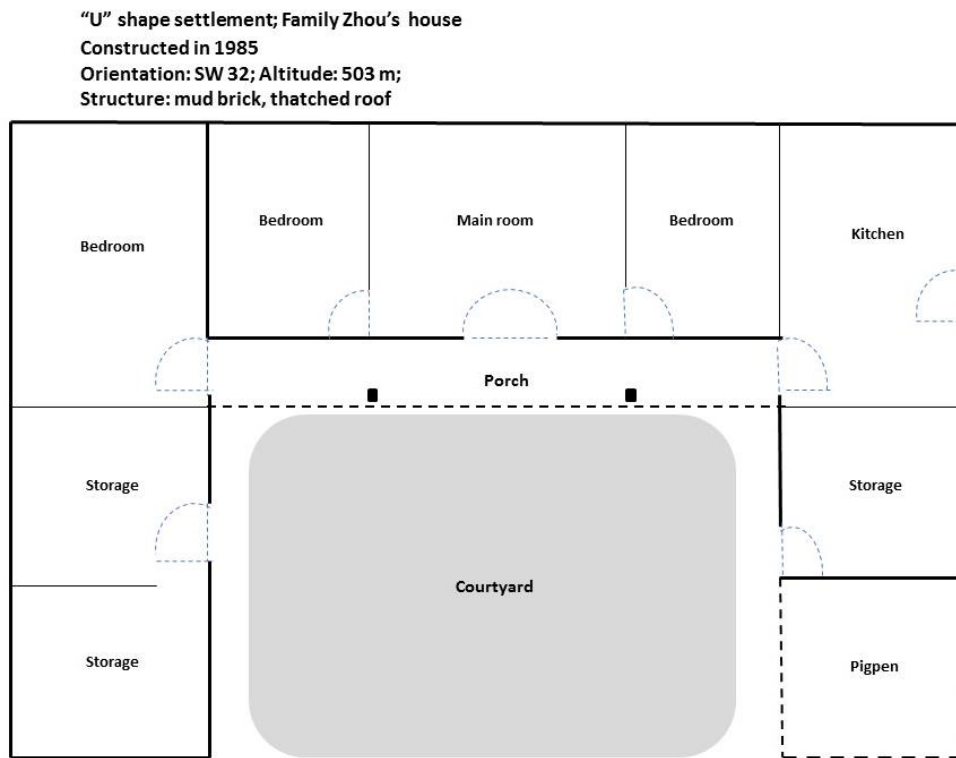


Figure 2.20 Ichnography of “U” shaped settlement owned by Zhou’s family

Notes: (1) Two storage rooms on the left-hand wing belong to Zhou’s brother, but now are used as storage or guest rooms; (2) Storage on the right-hand wing is used as a washroom.

Source: Drawn by author, 2019

The livelihood of this family is diverse. They cultivate vegetables and strawberries in fields, plant tangerines in orchards, raise fish in ponds, and even manage apiculture (Figure 2.21). Oriented facing southwest, farming lands stretch in the front, the main building has a very good visual field and the courtyard receives sufficient sunlight for drying grain. A canal flowing from the west irrigates the fields while he cultivates rice in summer. On the terraced fields, vegetables are planted under fruit trees, forming an agroforestry model. In winter almost all of these fields are cultivated with oil rape, from which the seed oil is the main product generating cash income. Mr. Zhou also raises fish in his small water pond. He and his family members are hard-working people, which is the reason why they can manage numerous kinds of livelihoods at the same time.

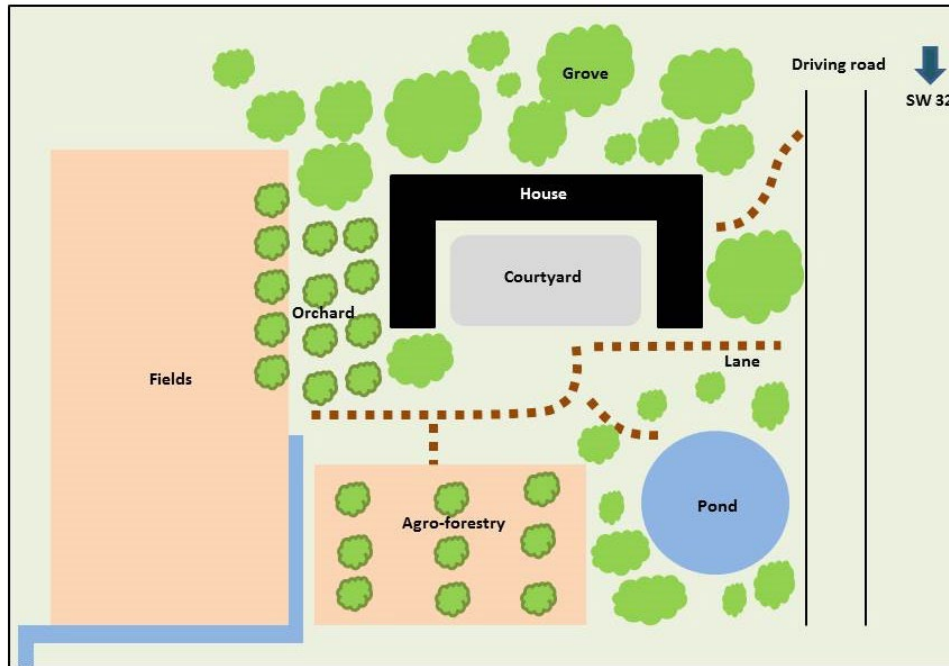


Figure 2.21 *Linpan* layout of “U” shaped settlement owned by Zhou’s family

Source: Designed by author, 2019

2.2.3 “Compound” shaped settlement

Close to the main road from Dantu Cun to Laolong Cun, a traffic line between two rural markets, Mr. Ye’s house is located in the middle of the *linpan* (Figure 2.22). This house shows a compound shape with a gate facing southwest. There are currently three family members living in this house, including Mr. Ye, his wife, and a grandson who is 13 years old and studying in a secondary school. After the Ye family moved out of their parents’ house, a thatched cottage about 50 m away, they were constructed this house in 2004 with fired bricks and tiles. Mr. Ye has two daughters, both of whom married some years ago. One daughter with her family is now working in Yunnan Province. Another is doing business with her husband, and leaves her son at home with her parents. Mr. Ye’s mother is still alive and lives in the old house, but she comes here to take lunch and dinner with her (elder) son’s family. One of Mr. Ye’s younger brothers is managing a restaurant at the crossroads of the traffic lines (from Dantu Cun to Laolong Cun), about 200 m away from this house. He has his own *linpan* settlement there. The other two younger brothers now work and live in the urban center. Because of the location of this house, similar distances to Dantu market and Laolong market, and the alternating market days of the two markets, Mr. Ye and his wife can easily visit one of the markets whenever they have available time.



Figure 2.22 Environment and house view of the “compound” shaped settlement owned by Ye’s family

Note: Top left: Settlement located in forest with farmlands and water pond at front of the compound;

Top right: Compound settlement under forest with a lane linking to the main road on the right hand;

Bottom left: View of main building and two wings from courtyard entrance; Mr. Ye standing at the center of courtyard to introduce his house, having just returned from the market town; **Bottom**

center: View of courtyard gate from main building; **Bottom right:** Long porch in the front belt of main building, viewing tiled eaves and concrete pillar.

Source: Photo by author, 2019

The layout of this settlement looks like a compound with buildings lined on three sides and a wall on the fourth side (Figure 2.23). Mr. Zhu and his wife live in the bedroom neighboring the reception room to the left, and the grandson lives in the bedroom in the right wing. The big bedroom at the right corner is for the married daughters when they visit. In line with traditional customs, the kitchen is still located at the northern end of the main building. Two pigpens at the end of each wing have not been used for many years, and are now storage. This compound could be considered as an altered form of the “U” shaped settlement, because the fourth side is a wall with a gate rather than rooms in the house. After visiting many “compound” shaped settlements in Dantu Cun and surrounding areas, it was found that this type of closed compound is very popular. The courtyard fenced with walls may give dwellers a safer feeling.

Compound shape settlement; Family Ye's house
 Constructed in 2004;
 Orientation: SW 23; Altitude: 515 m;
 Structure: brick, tiled roof

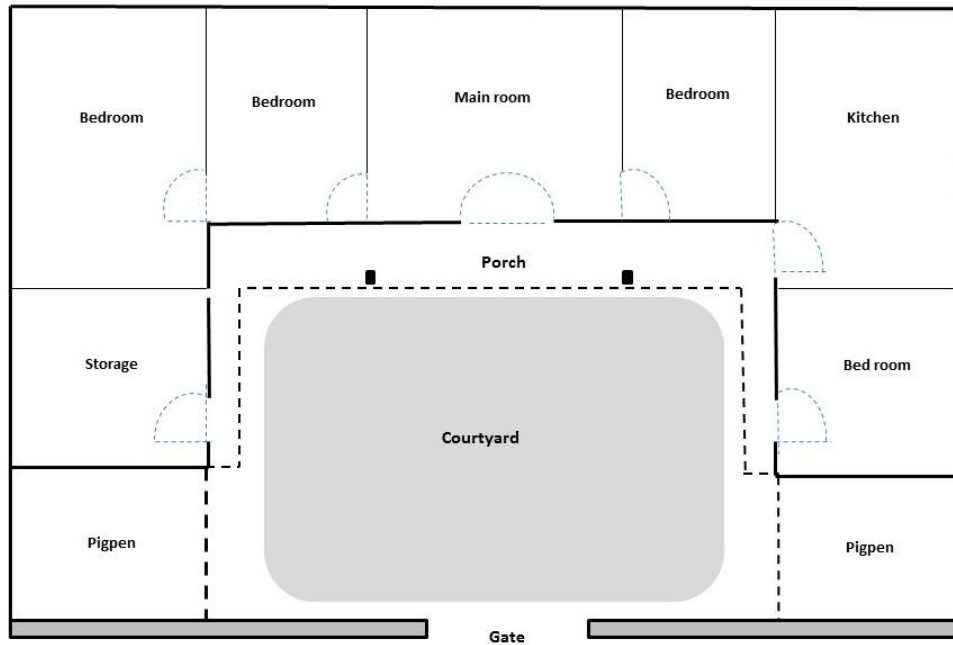


Figure 2.23 Ichnography of “compound” shaped settlement owned by Ye’s family

Source: Designed by author, 2019

The forests surrounding the house include eucalyptus, pine, and bamboo, forming a very harmonious settlement with the surrounding environment (Figure 2.24). This household has 2.5 *mu* (ca. 1.017 ha) farming fields and one water pond located in front of the courtyard. Now they lease 1 *mu* fields to a private company for operating rural tourism (“*nong jia le*” in Chinese), 1.5 *mu* fields to a tenant who cultivates cash crops, and the pond to a fish farm. Except for some fruit trees and common vegetables cultivated on a few plots, no one in this family is still engaged in agricultural production. Mr. Ye said that he and his wife like to visit the market towns (i.e. “*gan chang*”), not only for business but for relaxation or recreation also, because they have enough time now.

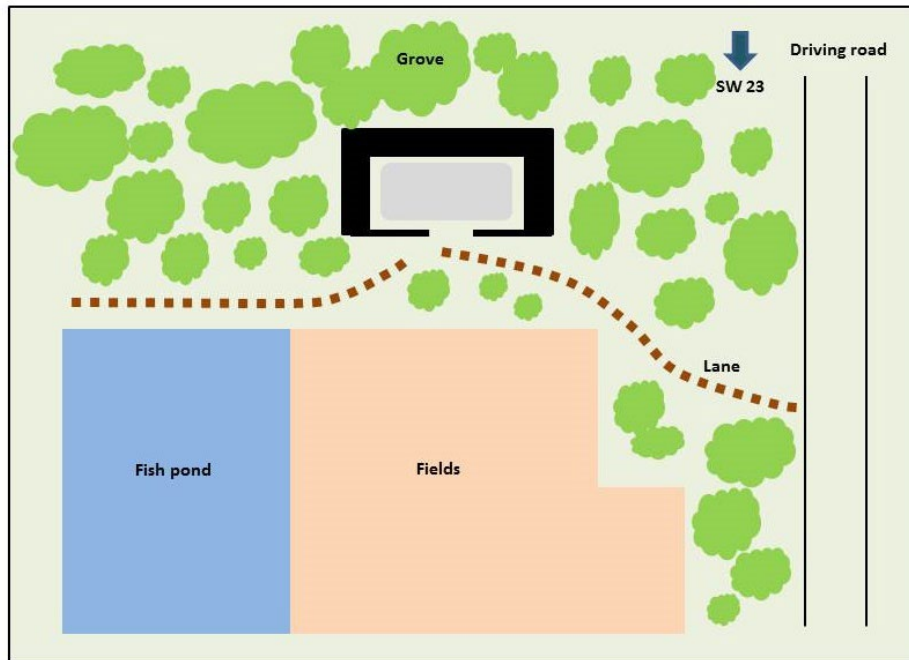


Figure 2.24 *Linpan* layout of “compound” shaped settlement owned by Ye’s family

Source: Designed by author, 2019

Another example of a compound settlement is Mr. Huang’s house at Group No. 6 of Dantu Cun (Figure 2.25). This compound is shared by two brothers and their families. At the end of 1970s, two brothers in Huang’s family divided this settlement into two parts. The younger brother’s family lives on the left hand (southern side), and the elder brother’s family on the right (northern side). The entrance of this compound is a gap (alleyway) between two buildings, which leads into the courtyard from the eastern side. Thus, unlike other settlements, the main rooms of this compound are not oriented to the west or southwest. The younger brother’s family has only two members living in this house now, Mr. Huang and his wife. Two of their children married many years ago and live in Yongxing Zhen. The elder brother died a few years ago, followed by his wife, so this part of the house is now inhabited by his son’s family, two parents and two children.



Figure 2.25 Environment and house view of “compound” shaped settlement owned by Huang’s family

Note: **Top left:** View of farming fields and bamboo groves from courtyard entrance; **Top right:** courtyard entrance (alleyway) between two buildings; **Bottom left:** View of the southern part (elder brother’s part) of compound; **Bottom right:** long porch in the front of the northern part (younger brother’s part) of compound, with view of tiles, concrete pillar and wooden frame.

Source: Photo by author, 2019

This house was built before the 1970s but reconstructed or redecorated many times thereafter (Figure 2.26). Originally the wall was constructed with mud bricks and plastered with lime. After the division of the two families, the thatched roof was replaced by tiles and some sections of wall by bricks. On the right hand side, the young couple has changed almost all of the walls and columns of the porches to fired bricks. On the younger brother’s side (the northern part), the older couple has not greatly changed the structure. Except for the tiled roof, almost all of the architectural structure has been maintained. The local government has informed them that this house is a ‘dangerous building’, which will be reconstructed or demolished in the near future. It is interesting to find that two parts of this compound are symmetrical, like a combination of two “U” shaped settlements. For example, the two kitchens are each located at the right hand of the main rooms (reception rooms). The main room with bedrooms on its two sides presents the same layout. To preserve uniformity, the two families constructed their storage rooms on the western side (above) and their pigpens on the eastern side (below). The long porch extends

from the northern side to the southern side through the western side, i.e. three sides of courtyard, easily connecting the two families during heavy rains or scorching sun. The pigpens have not been used for a long time, and now they are only used as toilets.

Compound shape settlement; family Huang's house
 Constructed in 1981 and reconstructed in 2003
 Orientation: SE 12; Altitude: 509 m;
 Structure: mud brick, tiled roof

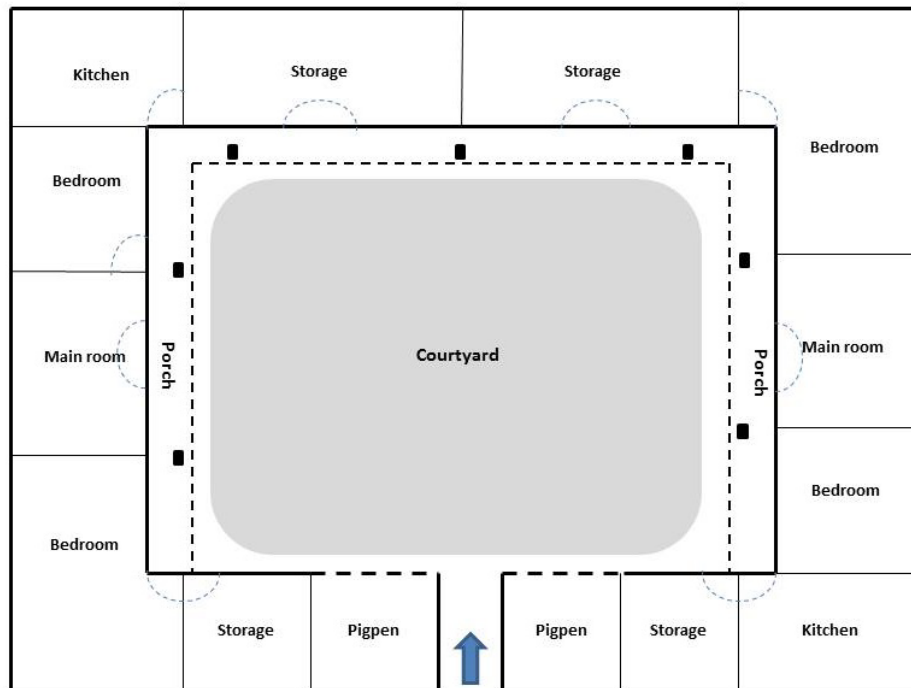


Figure 2.26 Ichnography of “compound” shaped settlement owned by Huang’s family

Note: A symmetrical settlement compound, the left half belonging to the younger brother’s family and the right half to the elder brother (now occupied by his son’s family)

Source: Designed by author, 2019

This big compound is located at the top of gently hilly topography with a very good view to their farming fields and the water pond on down slopes (Figure 2.27). From the roadside, a lane through a bamboo grove accesses the entrance of the courtyard. Poultry such as chickens and ducks are raised under bamboo or by the water pond. Tangerine or orange trees are planted in their orchard, which is located on terraced land. Along the low-lying lands, fertile paddy fields are distributed. These fields can be irrigated by canals while transplanting rice seedlings. Many beehives are put out in the courtyard or under the canopy of the fruit trees, with the hope that pollinators will be beneficial to the fruit harvest. The water pond was leased for fish farming, but the two households may still use water when they need it.

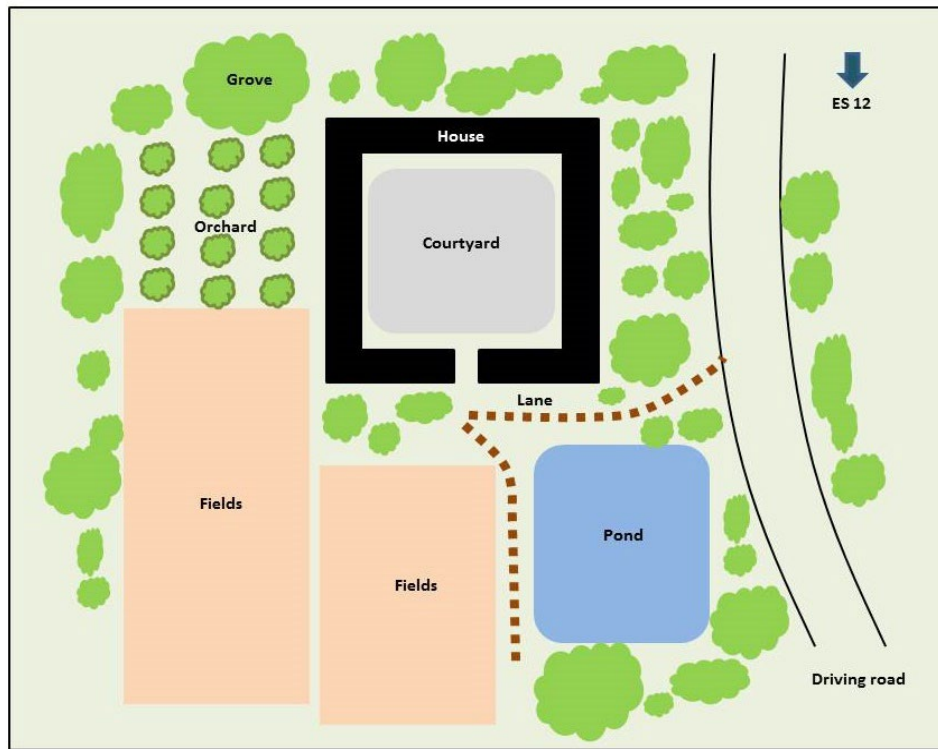


Figure 2.27 *Linpan* layout of “compound” shaped settlement owned by Huang’s family

Source: Designed by author, 2019

2.2.4 Constructing materials and structure

In most traditional settlements in Dantu Cun or its neighboring areas, farmhouse walls were constructed with mud bricks (a kind of unfired brick). Local people explained that there are two ways to make mud brick. One is to directly fetch bricks from paddy fields, which is done by flattening a paddy field with stone roller and then fetching bricks one by one according to the required size (see Figure 2.28). The fetched bricks are put out into the sun to dry. The second way is slightly more complicated but more popular. Mud bricks are extruded with a wooden mold in the shaping process. After dumping wet mud (always adding clayed red earth) into a wooden frame (mold), the surface of the mud is pounded with a big oversized mallet until compacted. The wooden frame consisted of four sides which fit together by grooves can be dismantled, so the shaped brick can be taken out easily. The shaped bricks are moved to the courtyard or flat place for drying. After at least one month, when the bricks are sufficiently dry, they can be used for house construction. Normally, the owner would invite a group of special artisans to make bricks and then construct a new house.

Mud bricks are laid on the foundation one by one and form the frame of a house. The house walls, both interior and exterior, are always plastered with ash mixed with straw (Figure 2.28), which finally becomes a strong finishing on the walls. The thickness of a wall is 25 cm, with 20 cm being the width of

mud bricks, with an additional 2.5 cm of finishing (on both sides). Sometimes a few households also use lime mortar to plaster interior walls, giving the dwelling a bright feeling. Not all of the rooms have windows; this depends on the owners' preference. When there are windows, they are only constructed on the interior sides (facing the courtyard).

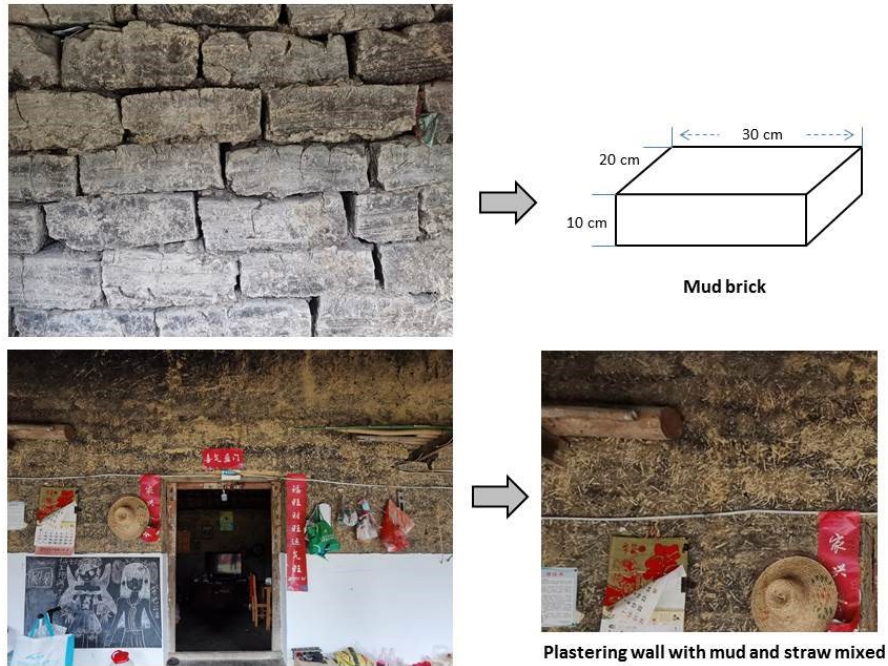


Figure 2.28 Mud brick and plastered wall of a traditional thatched cottage

Source: Photo and designed by author, 2019

The top of a traditional farmhouse is a thatched roof, supported by wooden beams and bamboo braces (Figure 2.29). In the Chengdu Plain, rice straw is preferred for roof material, followed by wheat stalks and grasses such as bulrush. Traditionally, thatched houses must be repaired every 10-20 years, especially the roof and bamboo braces, which must be replaced with new straw or bamboo (according to information from a local craftsman). However, due to the high labor cost and lack of materials, local people now cover the thatched roof with asbestos tiles or metal tiles, which function more effectively in waterproofing. Recently, metal tiles have replaced asbestos tiles, in consideration of the harmful effect of asbestos on human health.

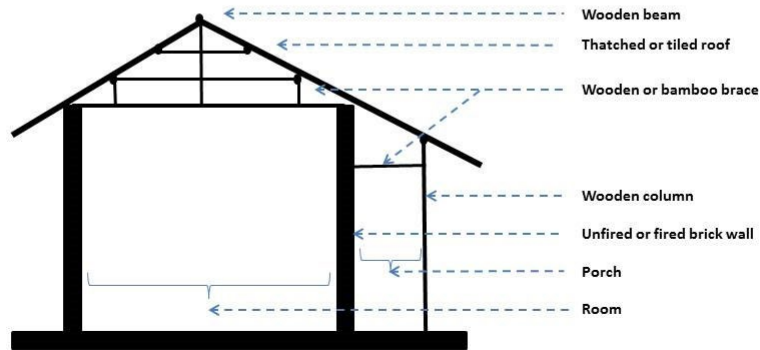


Figure 2.29 A farmhouse with traditional structure and material

Note: **Top left:** A “U” shape house located under grove with mud brick wall and (fired) tiles; **Top middle:** A typical gate of compound shape settlement with mud brick wall; **Top right:** Laborers replacing thatched roof of a traditional house with (fired) tiles; **Bottom:** Profile of a farmer’s house.

Source: Photo and designed by author, 2019

A long eave of thatched roof is normally extended over the courtyard side, forming a connective porch in front of doorways (with the exception of the pigpens). This long porch with a width of 1.5 – 2 m thus becomes an important public space for family members, who may work or take rest under the eaves regardless of rain or scorching sun (Figure 2.30).

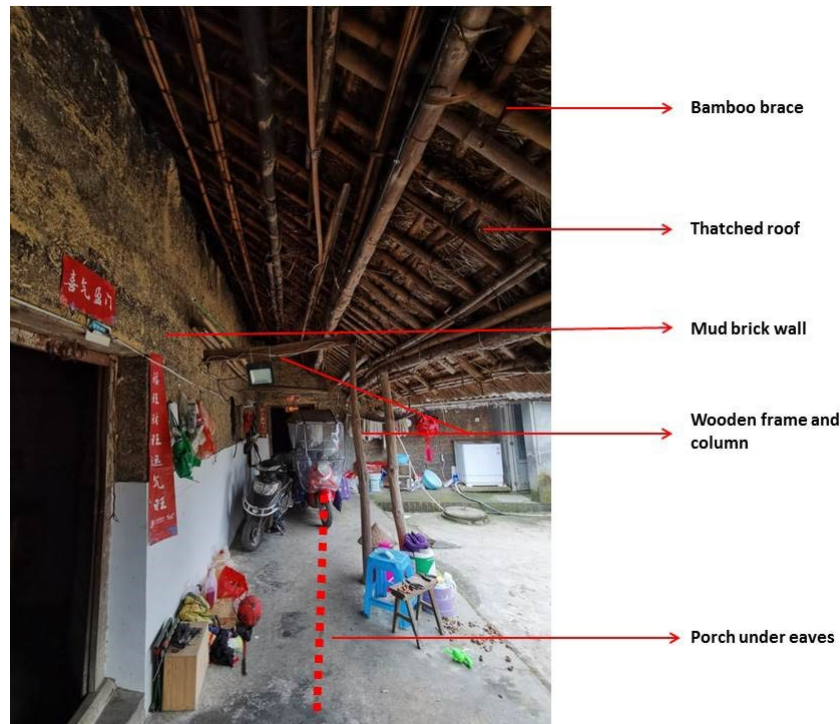


Figure 2.30 Material and structure of porch part of Zhou’s house

Source: Photo and designed by author, 2019

After the 1980s, more and more farmhouses were constructed with fired bricks and tiles. Some used fired bricks to replace partly unfired mud bricks when repairing their old houses. It is possible to find the two kinds of bricks mixed in one building. Today, even where the traditional style is maintained, the materials have been changed. Dantu Cun’s formerly numerous brick and tile factories have been closed, most of them disappearing between 1990 and 2000. During the field survey in Dantu in 2019, a local carpenter, Mr. Qiu, who lives about 12 km from Dantu Cun, informed me that rich families used to have very densely tiled roofs, about 120 tiles per square meter, because the higher the density is, the better the waterproofing is. For the columns supporting the porch eaves, pinewood is popularly used, followed by oak wood, but now many of these columns have been replaced by concrete pillars. When seeking strategies to maintain and restore these traditional buildings, the lack of traditional knowledge and skills has become a key issue. The disappearance of traditional artisans or craftsmen has posed a great threat to historic preservation.

2.3 Functioning role of the *linpan* landscape in delivering ecosystem services

Briefly speaking, an ecosystem can be defined as a complex system made up of living organisms, the physical environment, and their interrelationships in a particular unit of space (MA, 2003). This means an ecosystem can be of any size and may occur in a small (e.g. *linpan* unit) or large (e.g. *linpan* landscape) scale, within which the biotic and abiotic components interact through nutrient cycles and

energy flows. An ecosystem’s functioning, like any system, can be understood in terms of the processes, or changes, that occur in the system, the structure of the system, and key socio-ecological interactions. Thus, the supply of any specific ecosystem service from a locality can be described in terms of the ecosystem processes (e.g. water cycling, mineral cycle, and biological growth), structure (e.g. vegetation layers and soil cover) and key ecological interactions (e.g. decomposition, pollination and seed dispersal) for that service (Yi et al., 2017). In this context, the services provided by functioning *linpan* landscape, a socio-ecological system, are grouped into four primary categories according to the definitions of Millennium Ecosystem Assessment (MA, 2003; Figure 2.31). Because supporting services are the fundamental function of ecosystem and are necessary for the production of all other ecosystem services, including the transformation of energy, the cycling of water and nutrients, and soil formation and retention, which are not specific to *linpan* systems alone, they will not be elaborated in this study. In this section most of the contents have been updated with data after I published my article in 2020 (Wu et al., 2020). For further details about the four categories of ecosystem services of the *linpan* system, please find relevant contents in “What ecosystem services flowing from *linpan* system – A cultural landscape in Chengdu Plain, southwest China” (Wu et al., 2020).

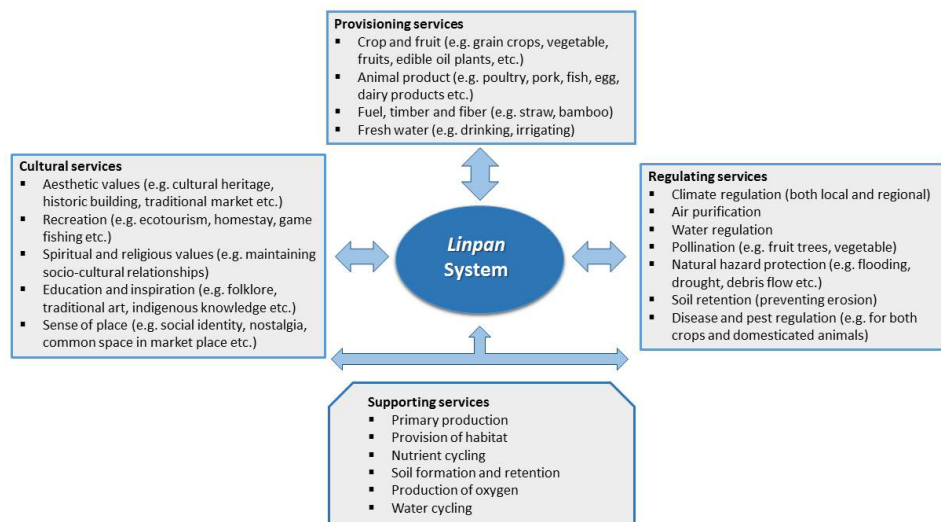


Figure 2.31 Four categories of ecosystem services delivered by the *linpan* landscape

Source: Wu et al., 2020.

The overall goal of this section is to improve our understanding of the *linpan* system and the many services that the system provides to local people. An extensive list of ecosystem services obtained and derived from these ecosystems has been documented based on the literature review. The interviews were semi-structured around key topics to explore the knowledge, practices, and perceptions related to the sense of importance and level of dependency on ecosystem services. A structured questionnaire was prepared to discover respondents’ perceptions about the importance of ecosystem services, including

provisioning services, regulating services, and cultural services. While conducting the surveys, the term ecosystem service was always referred to as “the benefits that ecosystems provide for life and livelihood” to make the term more understandable. In Paotong Cun and Dantu Cun, 40 and 50 in-depth interviews were carried out respectively with purposively selected smallholder farmers and key informants purposively selected with an eye to gender, age, and education balance. Their responses to the questionnaire about the importance of ecosystem services were calculated as the percentage of each service to illustrate their perceptions. Two group open discussions with village leaders including three current government officials (members of the village committee, young people, who did not participate in the questionnaire survey) and two retired members (old people, included in the questionnaire survey as key informants), were organized by authors separately in Dantu Cun and Paotong Cun to learn the implementation of policies and the governance system related to landscape conservation and socio-economic development. A number of field surveys were carried out for identifying environmental and socio-economic factors (e.g., climate, water resource, hydraulic system, transportation condition, and marketing activities, etc.), landscape heterogeneity, and biodiversity. Satellite images and drone photography were used to capture the major features in land use, settlement cluster morphology and landscape pattern in case-study areas to substantiate the information. Geospatial tools (i.e., ArcGIS) were used to analyze the landscape configuration and visualize the findings.

2.3.1 Provisioning services

As an important component of agricultural landscape in the Chengdu Plain, *linpan* provides multiple goods and services to lives and livelihood, among which the provisioning services are the most visible. The agricultural products, including numerous cereal crops, vegetables, cash crops and domesticated animals or fishes, are the main provisioning goods delivered to rural and urban people. Before the 1990s, on Chengdu Plain the grain crops were mainly rice, wheat and maize. Staple crops included potato and sweet potato. Vegetables were mainly grown for consumption by peasants themselves, in their homes and at market. Orchids or agro-forestry, combined with vegetables or cash crop cultivation, were popular in gently hilly areas. In the past two decades, the agricultural products delivered to the urban market have changed with the process of urbanization. In 2019, for instance, the area of farming fields for crop cultivation was 0.73 million hectares in the Chengdu metropolitan area (Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020). During the period from 1990 to 2019 the cultivated fields decreased about 26%, and the proportion for cereal crop cultivation declined from 70.9% in 1990 to 51.35% in 2019 due to the alteration of livelihoods in rural areas (Figure 2.32). On the contrary, the fields (sown areas) for vegetables and rape crop increased, obviously because of the continuous increase in market demand.

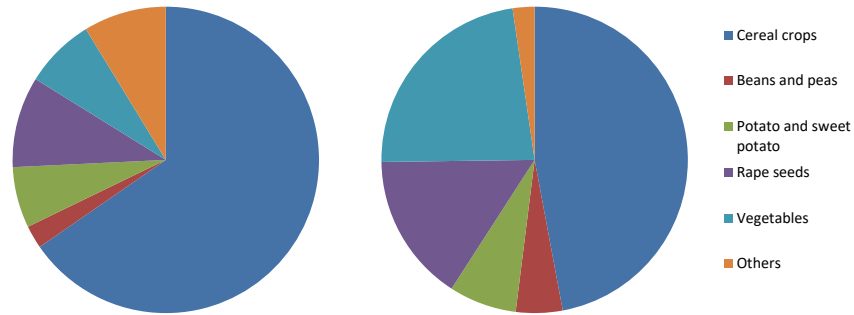


Figure 2.32 Comparison of farming fields for different crops in Chengdu in 1990 (left) and 2019 (right)

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020

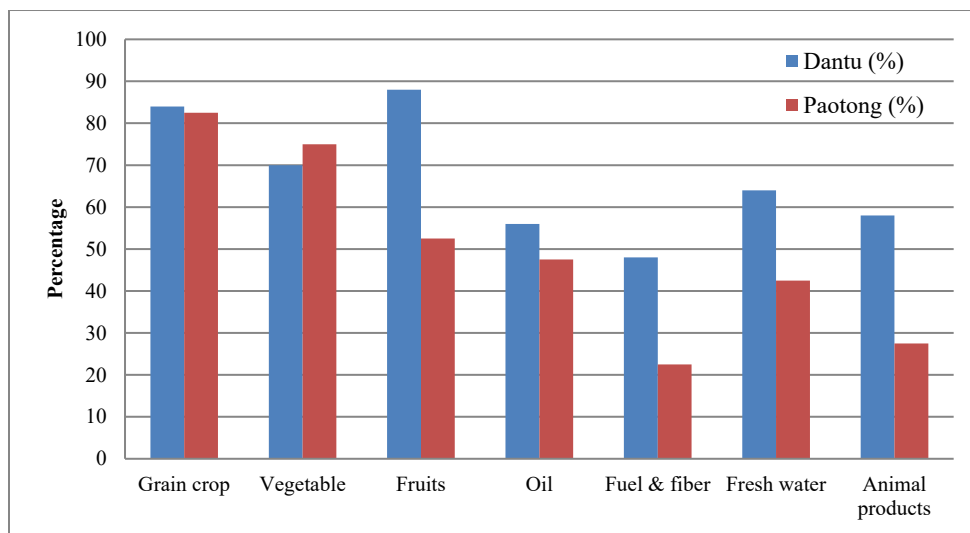


Figure 2.33 The importance of provisioning services perceived by respondents in Dantu Cun and Paotong Cun

Source: Wu et al., 2020

The local people living in *linpan* always manage multiple crops in their fields. In the two case-study sites, for instance, agriculture is mixed with cultivation of grain crops and staple crops (e.g. rice, wheat, maize, potato, sweet potato), vegetables (e.g. eggplant, chili pepper, pumpkin, cucumber, radish, cabbage, cauliflower etc.), and fresh fruits (e.g. mandarin, loquat, pear, peach, plum, shaddock, strawberry, cheery etc.). According to the survey, respondents ranked grain crop cultivation as the top provisioning service, at 84% in Dantu Cun and 82.5% in Paotong Cun (Figure 2.33). In Paotong Cun, where flat rice paddy is the main land use, the yield of rice makes up 70 - 80% of the annual grain production; in Dantu Cun, where soils are not so fertile and paddy field is limited, the annual yield of rice accounts for about 50-60% of grain yield, followed by maize (15%) and wheat (10%). In the Chengdu Plain, sweet potato is mainly found in gently hilly areas, such as Dantu Cun, where it is always cultivated by local people during seasonal droughts (Zhong et al., 2022).

A trend may be seen in the entire Chengdu Plain wherein the cultivation of wheat has been gradually replaced by rape crop and vegetables in winter³¹. In the last 40 years, the area of wheat fields declined from 29% of the total farming fields in 1978 to only 9.53% in 2019, but the fields for maize cultivation increased from 9.28% to 25.4% (Figure 2.34). According to the interviews and group discussions with local people, the preference for maize cultivation is mainly due to the increasing market demand on the one hand, as maize is mostly used for fodder processing and liquor production, and on the other hand for its better tolerance to weather extremes (e.g. drought and cold waves) and biological threats (e.g. disease and pest).

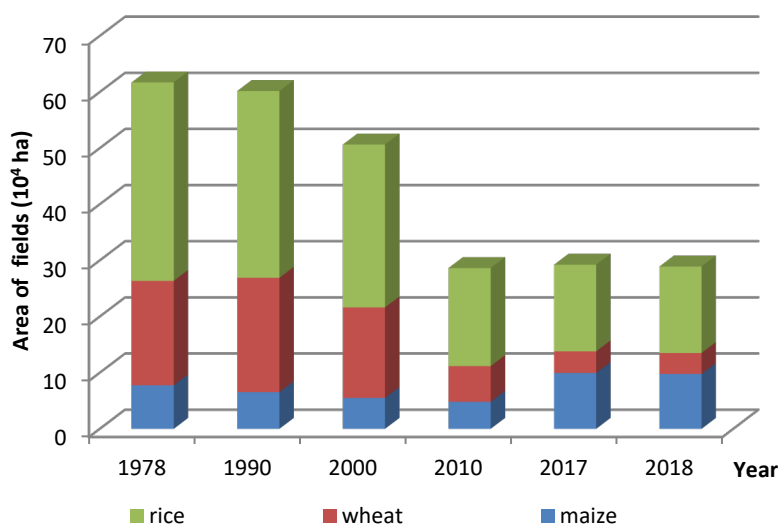


Figure 2.34 Cultivating fields for major grain crops in the Chengdu Plain since 1978

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020

According to the survey in Dantu Cun, local people complained that with increasingly frequent weather extremes (e.g. cold waves or heavy rain) in winter and spring, the yield of wheat was becoming more uncertain. For example, in the 1990s the average yield of wheat in Dantu Cun was 4.48 ton ha⁻¹ with the variation of 13.50%, while the average yields of rice and maize were 4.94 ton ha⁻¹ and 7.73 ton ha⁻¹, and their variations were less than 8.31% and 9.26%, respectively. In additions, the reasons for local preference for cultivation of the rape crop instead of wheat in winter are related to other factors, which may be summarized as follows:

- Frequent or increasing rainfall means that the wheat crop can be easily flattened and may even fall

³¹ Traditionally, in the Chengdu Plain there are two harvests in a year. Peasants cultivate wheat or rape crop (for edible oil) in October or November and harvest in April. Immediately then, they cultivate rice and harvest in September.

down;

- An increase in birdlife due to forest enrichment has led to the loss of wheat (as well as other grain crops)³²;
- Increasing diseases, especially stripe rust due to increasing rainfall and moisture, have significant impacts on wheat yield.³³

In the last few years, agricultural production has been diversified, as reflected in crop species and varieties. The proportion of vegetable sown area increased very quickly, changing from 8.06% of the total in 1990 to about 25% in 2019 (Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020). In Paotong Cun, there are 6 kinds of oil crops or beans and 24 kinds of vegetable (e.g., tomato, cabbage, chives, pepper, eggplant, chili pepper, pumpkin, cucumber, radish, cauliflower, etc.). In Dantu Cun, due to the heterogeneous environment, there are more diverse crops. For example, there are 2 varieties of potato (purple potato and jicama) and 3 varieties of vegetable (garlic, sweet pepper and okra) more than those of Paotong Cun (Zhong et al., 2022). Various seasonal vegetable, for self-consumption or sale, are traditionally cultivated in home gardens, orchards or farming fields near the *linpan*. However, newly occurring cultivation of vegetables on a large scale for commercial purpose may be found in both Paotong Cun and Dantu Cun. In Paotong Cun, for instance, cultivation of vegetables has replaced the traditional grain crops due to the increasing market demand in the urban area. Due to the plentiful water resources and convenient irrigation conditions, local people choose to cultivate vegetables with high water requirements, such as water spinach, chives, cucumber and tomatoes. For Group No. 1 of Paotong Cun, Chinese chives even became one of the most important products for generating cash (Figure 2.35).

³² Two main factors led to the enrichment of forests in rural Chengdu in the last twenty years, including (1) governments implemented reforestation programs and encouragement of local communities to protect their forests; and (2) depopulation in rural areas lightened pressures (demands) on community forests.

³³ It was reported that stripe rust is the most destructive disease in all winter-wheat growing regions of southern China, as well as in some spring-wheat growing areas of northern China (Chen et al., 2009; Zeng et al., 2014). The wheat yield losses of 6.0, 3.2 and 1.3 million tons were caused by the epidemics in 1950, 1964 and 2002 in China, respectively (Chen et al., 2009; Wan et al., 2007), showing an increasing trend. The Chengdu Plain is the most important “resort” for this fungal disease in winter, but in summer it can migrate to the high mountains of western Sichuan (Zhang et al. 2021). Cultivating the rape crop or other crops instead of wheat in the Chengdu Plain could thus reduce the epidemic spread of stripe rust in the region and the economic loss of local people.



Figure 2.35 Villagers washing dirt and chemicals off green chives in Paotong Cun

Source: Photo by author, 2018

Traditionally, the rape crop yields not only a kind of vegetable (the leaves) but also seeds used for producing edible oil in the Chengdu Plain. The total sown area for rape cultivation in the Chengdu Plain increased from 10.41% in 1990 to 17.09% in 2019 (Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020). In both Paotong Cun and Dantu Cun the rape crop has become the largest planted oil crop during winter time. Its yellow flowers, which color the landscape in spring time, offer one of most important attractions to urban tourists. Rape flowers, fruit flowers and even mature rice thus serve as a scenic landscape with multiple functions, delivering both provisioning services and cultural services (Figure 2.36).



Figure 2.36 Scenic landscapes in rural Chengdu Plain

Notes: **Top left:** Rape flowers blooming on gently-rolling hills in Dantu Cun; **Top right:** Water pond used for fish farm as well as tourism (e.g. angling) in Dantu Cun; **Bottom left:** Cultivating lotus in a pond for decorating the landscape of Farm Stay in Jiancha; **Bottom right:** Mature rice fields become a sightseeing point in Jiancha.

Source: Photo by author, 2018; 2019

Fruit trees intercropping with vegetable cultivation form a common model used by local peasants in managing their *linpan* landscapes. In Dantu Cun fruit production was the provisioning service perceived to be most important, being recognized by 88% of respondents, where fruit trees were planted in a large scale on sloping lands. In Paotong Cun, on the contrary, the importance of fruit production was relatively low, recognized by 52.5% of respondents. They prefer to plant ornament flowers or seedlings due to the increasing demands for greening urban and estate development (Figure 2.37). Meanwhile, the kinds of fruits cultivated have also increased very quickly. In Dantu Cun, for instance, strawberry, apricot and loquat have become alternatives in addition to oranges and tangerines, indicating a diversification of products. In terms of the entirety of rural Chengdu, the area of fruit orchards increased about 1.26 times from 1990 to 2019, and the cultivation area of ornamental flowers and seedlings

increased sharply about 80 times (Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020).



Figure 2.37 Agro-forestry and multi-operational farm in rural Chengdu Plain

Notes: **Top left:** Ornamental seedlings in the fields planted by local people in Paotong Cun; **Top right:** Traditional beekeeping in Dantu Cun, showing small beehives placed in an agro-forestry system; **Bottom left:** Chicken raised in a fenced lot under forests for “organic” food provision in Yongxing; **Bottom right:** Vegetables intercropping with orange trees in Dantu Cun.

Source: Photo by author, 2018; 2019

Linpan residents historically have raised animals in their homesteads, ponds or fields. Traditionally, pigs and poultry were raised mainly for self-consumption, marketing, and manure provision. Recently, due to changes in the urban market regarding animal products, fish farms have been developed in concert with private enterprises and farmers’ associations. In Dantu Cun, the fish ponds distributed on low-lying lands can store rain water during rainy seasons and can irrigate farming fields when drought comes, which enhances the adaptive capacity of local communities against drought or heat waves (Zhong et al., 2022). Traditionally, chicken and eggs are the main products for generating cash in rural market. With

the increase of demands for “organic food” or “native” chickens, local people now raise chickens in the fenced lots under *linpan* forests or orchards instead of the intensive chicken farms (Figure 2.37). Chicken raised “naturally” in this way command a good price.

Due to the serious influence of African swine fever in 2015 and 2016, local peasants are no longer allowed to raise pig at home, which is the reason of the empty piggens in all rural households in Dantu Cun. Currently all pork sold in rural markets is from large-scale pig breeding farms or henneries, which has led to a decrease in pig manure, a traditional fertilizer, used in farming fields. The biogas tank found in every rural household, for producing methane as fuel, also cannot be used. Efficient recycling of nutrients is essential for functioning agricultural system. In both Paotong Cun and Dantu Cun, local people make compost (with vegetable residues and animal manure) for accelerating nutrient activation. Since the ban on pig-raising at home was issued, the amount of available manure has decreased, leading to increasing costs as rural households must now purchase chemical fertilizer.

Besides those agricultural products, certain by-products are also important provisioning services provided by the *linpan* system. Straw, a byproduct of harvesting rice and wheat, was traditionally used for fuel, building material (for thatched roofs), or handmade crafts in rural Chengdu. Some straw was also burned in the fields for potash, which aids in fertilization. The enriched forests and diverse agroforestry around *linpan* provide many kinds of non-timber products to local communities. A number of medicinal herbs are collected from these forests or intentionally cultivated under the canopy. At Laolong Cun market, we identified over 50 species of medical herbs for sale, which are one of the important sources for local people practicing traditional medicine (see Chapter 3).

Additionally, beekeeping is a common activity in rural Chengdu, which provides not only an important source of income generation but also effective and stable crop pollination. In Dantu Cun, for example, local people like to keep a few beehives for honey production in their home gardens as well as in their fruit plantations (Figure 2.37). Recently, however, the increase of introduced bees has led to the decline of native species (Liu et al., 2019). Due to the loss of available habitats and the disappearance of home gardens in the Chengdu Plain, it was reported that the managed bees within the home gardens decreased by 62.05% and wild pollinators decline significantly (Liu et al., 2019). Finally, many genetic resources coming from these systems, such as spice and ornament plants, have supported local demands for over hundreds years and shaped the local cultural identities (Wu et al., 2020).

For an individual *linpan*, forests or bamboo groves around the settlement are very important for shaping its extrinsic features, separating the living space (settlement) from the working space (farming fields). Bamboo growing around *linpan* was once a very important material for building construction and handmade crafts. As mentioned above, a thatched cottage with bamboo wall daubed with plaster and

straw once formed the traditional scene in rural Chengdu as well as in Dantu Cun. Since the demand for bamboo has declined (replaced by new materials), many bamboo groves have been cut down. After the 1980s, eucalyptus and pine progressively replaced bamboo as the dominant trees in the rural landscape, as we found in Dantu Cun³⁴. Traditionally, local peasants preferred to plant specific trees in their home garden, such as locus trees (*Gleditsia sinensis*), the seeds of which are used as soap; cypress trees (*Cupressus funebris*) and *Camphora officinarum* trees whose leaves may be used as a spice, while the timber is used for making furniture and coffins; and walnut, ginkgo, and *Sophora japonica* trees, grown for food purposes. Although electronic appliances have been popularized in this area and the dependency on fire woods for cooking has decreased, local people still prefer to collect braches and leaves from the forests or orchards (e.g. tree pruning) for use as fuel, reducing the cost of electricity (Zhong et al., 2022).

2.3.2 Regulating services

As a socio-ecological system, *linpan* plays a very important role in regulating climate, air, and water in the Chengdu Plain. The *linpan* landscape as a whole influences the climate both locally and regionally and mitigates weather extremes such as flood and heat waves (Wu et al., 2020; Zhong et al., 2022). Through its regulating services, *linpan* works as a “buffer zone”, balancing the inside and outside temperatures of the settlement, purifying air through the woodlands surrounding the settlements, and mitigating the effect of the ‘Urban Heat Island’. At the local scale, interviewees identified the relative importance of various regulating services, among which climate regulation was perceived as the most important service by 76% of respondents in Dantu Cun and 80% in Paotong Cun (Figure 2.38). The participants admitted that trees and bamboo groves around their houses could function as a shelter for weather extremes, buffering the effects of strong wind, heat waves, and cold waves. In addition, 42% of respondents in Dantu Cun and 47.5% in Paotong Cun confirmed that air purification is one of the important functions of *linpan*.

³⁴ In Dantu Cun forests are mostly community-owned and secondary. Most of native forests were cut in the 1950s and 1960s, i.e. during the period of the Great Leap Forward and the Cultural Revolution. After the 1980s, forests were restored progressively with the support of the governments.

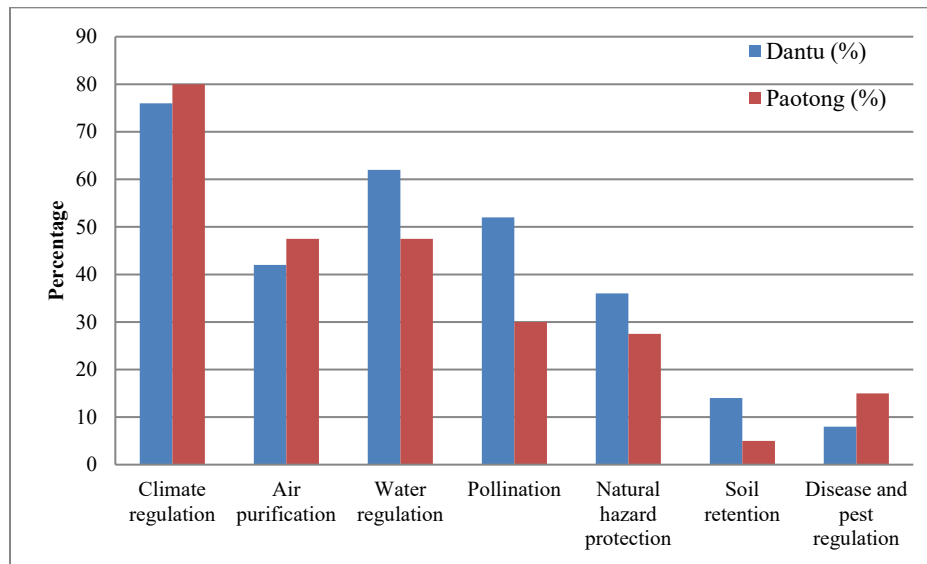


Figure 2.38 The importance of regulating services perceived by respondents in Dantu Cun and Paotong Cun

Source: Wu et al., 2020

The orientation of farmhouses always reflects the environmental design of the buildings with respect to climate variability and seasonality in the Chengdu Plain, which has hot and humid summers as well as cool and damp winters. According to a survey of architectural features in Dantu Cun (see case studies in Section 2.2), the main house of a settlement regardless of its shape, generally faces the sunniest direction (south facing, southwest facing or west facing), allowing heat absorption in winter and adequate ventilation in summer (Figure 2.39).³⁵ Previous studies found that *linpan* may regulate temperatures, cooling the air in summer and reducing wind speed in winter (Pu et al., 2016). The temperature difference between the outside and inside of a *linpan* decreases with an increasing base area, which means a suitable size of *linpan* is important for a comfortable micro-climate (Pu et al., 2016). In the farming fields around *linpan*, the micro-climate stays mild and humid throughout the year due to the regulating effects of the tree and bamboo groves (Zheng, 2010), which could be further beneficial to crop growth.

³⁵ According to *Feng Shui* (geomantic omen) Theory, buildings should face south or southwest orientation, i.e. so-called “*zuo bei chao nan*” (seating north and facing south). In rural areas of China, people always follow this principle traditionally for constructing their houses. Since it is warm and mostly cloudy in Chengdu Plain, the principle of south facing is not so strict (see examples in Section 2.2).

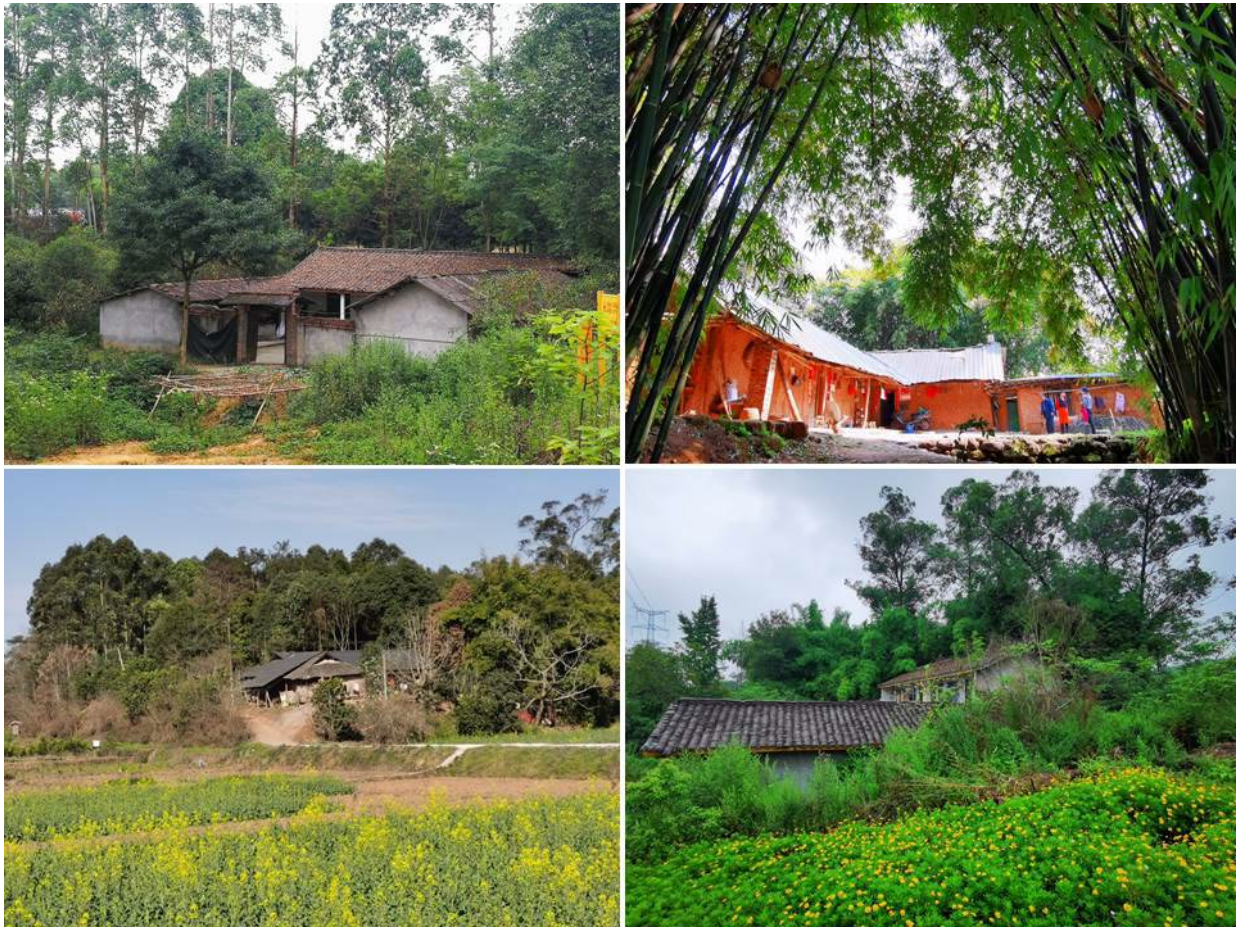


Figure 2.39 Typical *linpan* settlements surrounded with forests or bamboo groves in Dantu Cun
Source: Photo by author, 2019

The wetland system is one of the important components integrated into the *linpan* landscape, which has been overlooked in previous studies. Water canals or ditches flowing through or around *linpan* may not only provide water for daily life and agriculture but also transport fresh air for cooling temperatures in summer. Water ponds and forests in the *linpan* landscape have a huge capacity for storing water, regulating the timing and magnitude of runoff, flooding, and aquifer recharge (Wu et al., 2020). Due to the limited size of the water ponds, they are difficult to identify from satellite images while analyzing land use and land cover, accounting for this neglect in studies. In considering the total area, the *linpan* landscape may be considered as a type of important wetland, in which the capillary canals work together to regulate and purify water resources locally and regionally. In Dantu Cun, for example, around *linpan* seats there are always a number of ponds which may be used to collect rain water and runoff water for irrigating fields or to supply daily life, especially during the dry season (Figure 2.40). Many water ponds have been developed as fish ponds, which may explain why the recognition of the importance of water regulation of the *linpan* system was higher (62% of respondents) than in Paotong Cun (47.5%). Although the *linpan* system can be a source of impurities (e.g. daily waste) in fresh water, it also can

help to filter out and decompose organic wastes.



Figure 2.40 An integrative ecosystem complex showing water ponds located near fields and forests in Dantu Cun

Source: Photo by author, 2018; 2019

As mentioned above, the *linpan* landscape is a complicated ecosystem, composed of forests, farmlands and wetlands in one place and delivering diverse and integrated services. Because of the heterogeneity of environmental conditions in different locations, particularly topographical and irrigation conditions, the configuration and functioning of the agricultural landscape presents in various ways. Due to the gently hilly topography of its location in the foothills of the Longquan Mountains, conditions in Dantu Cun are ideal for forming a vertical agricultural model, integrating forests, farmlands and freshwater bodies (e.g. ponds) into a three-layer ecosystem complex (Figure 2.41). With this topography based vertical model, broad-leaved or pine forests distributed on the upper slopes or tops of gentle hills protect rice paddies or farming fields from rainwater-runoff and soil erosion. Groundwater stored in forest soil discharges slowly into water ponds down-slopes during heavy rains. Soil nutrients stored in the forests are also distributed to the rice terrace below by a finely-tuned drainage system of rain water or runoff,

which was called “hydrological fertilization” by Yang (2015) when he described the functions of the Hani Terraced Paddy in Yunnan Province. In case of drought or heat waves, local people can irrigate their farming fields or fruit plantations with stored water from the numerous ponds (including fish ponds) on low-lying lands. At the middle of the vertical topography, where human settlements and fruit orchards are located, people can manage their fields easily and mitigate the influence of heavy rainfalls or occasional floods in summer (Zhong et al., 2020).

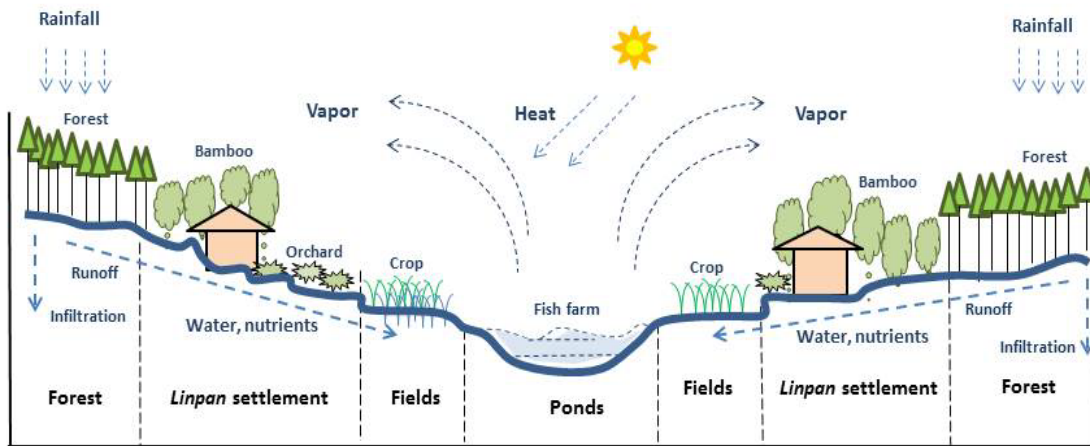


Figure 2.41 Conceptual modes of agricultural landscape and regulation services in Dantu Cun
Source: Modified from Zhong et al. 2022

2.3.3 Cultural services

Linpan landscape supports the interaction between humans and nature, and is a vital source of inspiration for culture and art. An individual *linpan* is a living space for interaction and communication between households, as well as a graveyard for families and clans, which provides a “sense of place” for local communities. Historically, the *linpan* landscape provides a rich source of inspiration for art, folklore, architecture, and advertising in Chengdu, which have become important components of local culture, such as the famous “*Shu* Culture” or “*Shu* Civilization”³⁶ in southwest China. The ancient “*Shu* Culture” due to a number of large-scale immigration and merging with various outside cultures (e.g. Hakka Culture), has been progressively refreshed and reformed (Fang, 2013). As an ancient trading nexus, situated on the southern Silk Road from China to south Asia and on the Tea-Horse Trading Road from the eastern farming territories to the western pastoral territories, the Chengdu Plain embraces diverse cultures, and has developed a specific local knowledge and cultural system (Yuan, 2018; Fang, 2013).

Generally, the *linpan* landscape lacks nucleated villages, and instead farmhouses are scattered among the

³⁶ “*Shu*” indicates Sichuan region in ancient time.

fields singly or in small clusters (Fang, 2013). Historically, such a social organization may take the form of customary laws and practices as well as ceremonial, religious and/or spiritual experiences. A man usually was not only born in a *linpan* but also entombed under the bamboo grove of the same *linpan*. Thus, the stability and capacity of *linpan* to provide goods and services critically depend upon rural communities having and sustaining diverse and complex forms of social organization (kinship, territoriality, settlement, etc.), culture (languages, values, rights, etc.), modes of production, and labor allocation. Additionally, the *linpan* landscape resulting from human adaptation of the natural environment has been developed into an ingenious and finely tuned socio-ecological system. Besides the tangible system of irrigation canals and roads, various individual *linpan* in the Chengdu Plain are also linked by intangible network, i.e., socio-economically and culturally by periodic rural markets, all of which together functioned well to support the long historical resilience of the *linpan* landscape (see Chapter 3).

In case-study sites, a number of cultural services were recognized by local respondents (Figure 2.42). Among these services, recreation was particularly noted, perceived as of the highest importance by 75% of respondents in Paotong Cun and 54% in Dantu Cun respectively. In both case-study sites, *linpan* based eco-tourism, including Farm Stay (“*nong jia le*” in Chinese), fishing game, fruit picking, and field hiking, has been developed recently. Urban people often choose to spend their leisure time based partly on the aesthetic value of rural landscapes. In order to meet the increasing demands of urban tourists, local people cultivate new varieties of vegetables and fresh fruits instead of the traditional crops, expand their chicken farms and guest rooms, and decorate new sightseeing points. Skill development in homestay management, cooking and hygiene knowledge has been offered to young people who want to operate Farm Stays. Colorful patches formed by rape flowers and ripening fruits create new opportunities for developing rural tourism. The recognition of recreation as well as aesthetic value has thus been enhanced by local communities in both Dantu Cun and Paotong Cun.

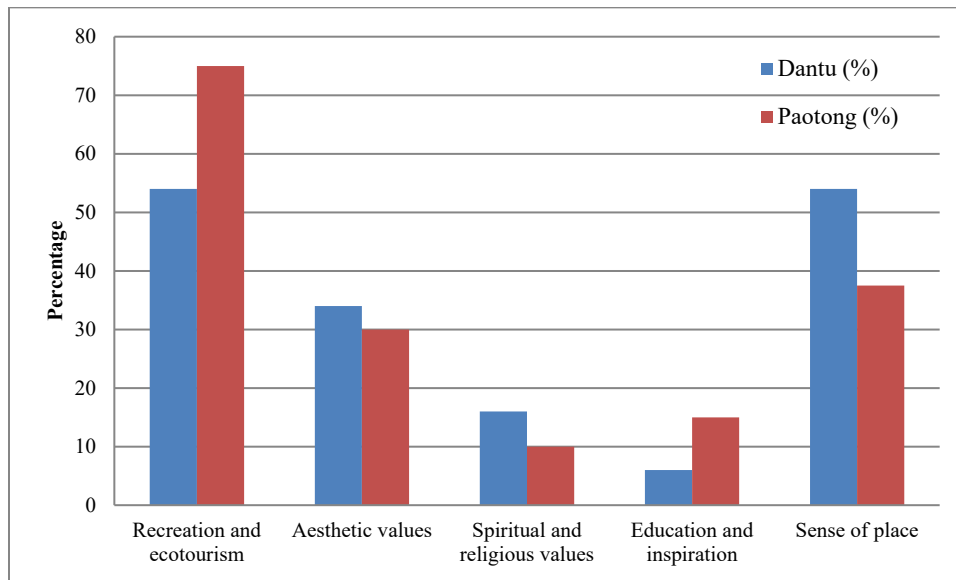


Figure 2.42 The importance of cultural services perceived by respondents in Dantu Cun and Paotong Cun

Source: Wu et al., 2020

In rural Chengdu local peasants always think of their own *linpan* as their “home” and numerous neighboring *linpan* units form a “village community” (Skinner, 1964). Even now, though young people have moved to urban areas for economic opportunities, they return for important events, such as weddings and traditional festivals like Chinese New Year (Figure 2.43). Thus, many of the cultural services of the *linpan* system are rooted in the traditional forms of the social/familial and cultural/nostalgic domains. Ancestral worship is a traditional culture in rural Chengdu and kinship plays an important role in maintaining the “integrity” of *linpan* society. Although *linpan* residents live in dispersed farmhouses, they are always networked culturally and spiritually, forming an integrative community and the localized “*linpan* culture” (Wang, 2018; Yuan, 2018).



Figure 2.43 The “Village Community” is not only “home” for local people but an attraction for urban tourists

Notes: **Top left:** A newly constructed gate showing “Historic Town” in Sandaoyan Zhen; **Top right:** A groom with his relatives and friends collect the bride from her “home” in Dantu Cun for a wedding ceremony with their kinsfolk, although the bride studied and is working in Chengdu; **Bottom left:** An ancestral temple nearby Dantu Cun serving the Xu family; **Bottom right:** Traditional pottery-making is one of several programs for tourism and education in *tong zhi long yao* (Tongzhi Kiln), Dantu Cun

Source: Photo provided by Tian Min, 2020; 2021

Those peasants living in *linpan* societies maintain their social relationship with other communities through market towns (see Chapter 3). For local people, social and cultural purposes form a major reason for periodic visits to rural markets, where they can participate in religious activities, cultural performances, and festival celebrations (Skinner, 1964). Thus, the cultural services of *linpan* landscape are linked by the functions of rural markets, which are one of the most important forms of social intercourses for local people (Fang, 2013). In Dantu Cun, for example, the development of the Farm Stay program is partly dependent on the historic market town. The *ming qing jie*, a market-street established in Ming Dynasty and Qing Dynasty (approximately 200-300 years), and the *tong zhi long*

yao, a Kiln constructed in Tongzhi Period of Qing Dynasty (about 150 years), have been preserved as a heritage site by the local government (Figure 2.43). Visiting historic market town and enjoying a leisurely lifestyle and local foods in the Farm Stay program has become an important activity for visitors.

As an integrated complex of ecosystems, agricultural systems, and residential clusters, the *linpan* landscape has characterized the Chengdu Plain socio-ecologically and culturally for many centuries, but now it is under threat, particularly from the rapid urbanization which has occurred since the 1990s. Although various services delivered by the *linpan* landscape (both material and non-material) were highly recognized, the perceived importance of services varied in accordance with socio-economic development, market fluctuation, and the awareness of the population. Therefore, when integrating the ecosystem services of the *linpan* system into landscape management and preservation, approaches and policies should be flexible enough to adapt smoothly to changes in environmental and socio-economic conditions.

Chapter 3 Development and Functions of Rural Markets

Local people living in the *linpan* landscape link their agricultural activities and daily lives with towns or urban areas through periodic rural markets. *Linpan* dwellers must go to market towns twice or three times in ten days for material purposes, such as selling agricultural products and purchasing commodities for daily life or seeds and fertilizers for production; social reasons including communication, meeting friends or seeing the doctor; and cultural purposes, such as religious activities, entertainment, or celebrating festivals. Without rural markets, the hundreds and thousands of dispersed *linpan* settlements risk becoming “isolated islands”. As Skinner emphasized (1964), marketing structures inevitably shaped local social organization and provided one of the crucial modes for integrating various peasant communities into a single social system, forming a holistic rural society. Even today, although the conditions of transportation and communication have changed, local peasants still rely on these markets to acquire economic, administrative, health, or cultural services. Those rural markets sparsely distributed in the *linpan* landscape still play a critical role in networking rural households (Figure 3.1).



Figure 3.1 Market day in Dantu, a standard market town in the south of Chengdu Plain

Source: Photo by author, 2019

3.1 Historic development of rural market

3.1.1 Development of rural markets in Sichuan

According to numerous archaeological findings, it is estimated that the rudimentary form of towns in Sichuan emerged between the late Neolithic Age and the beginning of the Xizhou (West Zhou Dynasty) period, about 4,500 to 2,875 BP (Meng, 1989). The relics of small towns formed before 4,000 BP were found in many places of the Chengdu Plain, such as Baodun Ruins in Xinjin County, Mangcheng Ruins in Dujiangyan County, Shuanghe Ruins in Chongzhou County, and Yufu Ruins in Wenjiang County, all of which together are referred to as the “Baodun Culture” (about 4,500-3,700 BP) by archaeologists, indicating the booming agglomeration of human settlements (Meng, 1989; Flad et al., 2013; Jiang, 2015). After 3,700 BP, “Baodun Culture” declined progressively and was replaced by “Sanxingdui Culture”, which includes Jinsha Relics and Shierqiao Relics in Chengdu city, forming the prosperous period of ancient “*Shu Culture*” (Duan, 2012). The fertile land, rich biodiversity, and ideal environmental conditions supported the gathering of ancient peoples and the subsequent occurrence of human settlements (Zhao and Li, 2004).

Until 316 BC, the *Shu* Kingdom (roughly equal to present-day Sichuan Province) was occupied by the Qin Kingdom from the north, and “*Shu Culture*” began to interact and mingle with the culture of northern China. During this period, the local governor, Li Bing, together with his son, constructed the famous Dujiangyan Irrigation System, which became one of the most important factors in the development of “*tian fu zhi guo*” (literally meaning “Heaven Land”) during the Han Dynasty (from 202 BCE to 220 CE) (Fang, 2013). The agricultural development in this period led to the increase of product exchange among local communities, and promoted the booming development of rural markets. With the succession of the Tang Dynasty (in 618-907 CE), more and more small-town based rural markets occurred, due to the politically stable situation and prospering agriculture and manufacture (Zhao and Li, 2004). Transportation development extended the traffic routes to previously remote rural areas and connected rural settlements with towns, which greatly contributed to commercial development. During the Tianbao Age (in 742 – 756 CE), the population in Chengdu increased to about 100,000 (Zhao and Li, 2004).

During the Song Dynasty (in 960 – 1279 CE), in addition to urban centers, rural markets in the Chengdu Plain and the entire territory of Sichuan Province developed very quickly (Ji, 2000). Both the “garrison town” and the “market town” occurred during this period, and their interdependence and interaction led to the prosperity of some market towns (Liu, 2014). Until 1,078 CE, there were 688 towns in Sichuan, which formed the framework of the hierarchical system of economic centers in the region and supported the co-development of agriculture, manufacture, and commerce in subsequent dynasties (Ji, 2000). At the end of Ming Dynasty (in 1368-1644 CE) and the beginning of Qing Dynasty (in 1636-1912 CE), the

population in Sichuan declined sharply and the economy was almost devastated by incessant civil wars. In order to promote economic recovery in Sichuan, the imperial government of the Qing Dynasty encouraged immigration from other provinces such as Hubei, Hunan, Guangxi and Guangdong provinces, the so-called “*hu guang tian Sichuan*”, meaning a large-scale movement of human population from central and/or southeastern China to Sichuan. The immigration brought different cultures, knowledge and practices into Sichuan, which catalyzed innovations in agriculture and manufacture, and diversified local culture, including the architectural style of the Chengdu Plain (Chen, 2009). During this period, “*cha zhan*”, a term for the immigrants’ practice of laying claim to a piece of land as their own property, was believed by various historians to play an important role in forming *linpan* patterns (Yuan, 2018). With the long-term and stable development of the rural economy, the number of rural markets increased and diversified. By the end of Qing Dynasty (the beginning of the 20th century), there were over 6,000 towns in Sichuan, among which there were about 3,000-4,000 market towns with stationary households over 100 (Ji, 2000). Many of these rural markets have functioned continuously since their founding to the present date.

Initially, when peasants living in dispersed *linpan* settlements wanted to sell their surplus agricultural products or by-products for cash, they gathered at a crossroads or an open-air square, in which a temporary market “*cao shi*” was established. The sporadic occurrence of the “*cao shi*” in rural areas has limited functions, and was thought as an incipient “*chang*” (periodic rural market) by Skinner (1964). The lower level of “*chang*” consists of the small clusters of shops, i.e. “*yao dian zi*”, on which peasants living in dispersed settlements are dependent. With the evolution of a rural market, teashops, little restaurants, and stores were established, as well as one or more temples. Many necessities were available, and social services or imports could be offered. In subsequent years the location and day of the market day were fixed, zones for trading different products or goods were specialized, some manufacture workshops for activities like food processing and blacksmithing were established, and specific public facilities for religious, entertaining or meeting purposes were built. Considering the convenience of trade and commercial opportunities, more and more people chose to live in or nearby the marketplaces. The size of a “*chang*” was thus expanded and its functions were diversified.

As one moves following the hierarchical typology from the standard market to the higher-level markets, such as intermediate markets and the central markets of county towns (Skinner, 1964), the number of households increases but the proportion of the labor force engaged in agriculture falls. Some inhabitants of the market towns changed their roles from part-time traders to full-time shopkeepers or itinerant dealers, showing an urbanizing process to a certain extent (Liu, 2014). Generally, a market town is a central place not only economically but also culturally and politically, because almost every town is the location of local administrative agencies, although their levels may vary. Thus, as one ascends the

market system hierarchy from small market towns to county towns, occupational differentiation, product specialization, and institutionalization steadily increase (Skinner, 1971).

At the beginning of the 1980s, the population in Sichuan was over 100 million, among which about 80% lived in the countryside, including the rural market towns. According to the estimation by Du and Zhang (1986), in 1983 there were 6,128 market towns in total in Sichuan, among which 5,853 were located in rural areas, mainly distributed at the seats of “*xiang*”, “*zhen*” or even lower-level towns. It was estimated that there were still over 3,000 market towns distributed in the territory of present Sichuan Province.³⁷ Currently, marketing activities (“*gan chang*”) have continued according to traditional schedules, but intensified market days have been adopted in most of these markets. The size of market towns has generally increased, but the total number of towns has decreased. Despite these changes, itinerant peddlers continue to make the circuit rural markets, and peasant producers are still able to sell their products directly to consumers during market days.

3.1.2 Periodicity of rural market

The Chinese term “*gan chang*” means to visit a rural market periodically.³⁸ As in most traditional agrarian societies, rural markets in the Chengdu Plain were convened every few days (Skinner, 1964). Until the first half of the 20th century, the market day of almost all rural markets in the Chengdu Plain occurred three times or five times every ten days (Skinner, 1964). In my case-study area before the 1950s, the specific day for “*gan chang*” was scheduled according to the Chinese lunar calendar with market days on the 1st, 4th and 7th, or 2nd, 5th and 8th, to fall once every three days (Table 3.1). The traditional way of scheduling market day was described in detail by Skinner in his classic publication (Skinner, 1964). By the end of the 1930s, there were seven market towns distributed around Dantu (called “*fu xing chang*”), forming an interactive network of service functions (Figure 3.2). Local products from this area were transported to Huayang Zhen and Chengdu city through specific trading routes with wheelbarrows (“*ji gong che*” in Chinese) and carts.

³⁷ In 1997 Chongqing separated from Sichuan Province and became the municipality directly under the Central Government, with which over 2,000 towns were allocated to Chongqing administratively.

³⁸ In Sichuan language, visiting rural market at a specific market day is called “*gan chang*”, but in northern China called “*gan ji*”.

Table 3.1 Market day of Dantu and its surrounding “*chang*” in 1939

Name of market town	Market day	Administrative region
Dantu (Fu Xing Chang)	3、6、9	Huayang County and Renshou County
Hongxiang (Hong Xiang Si)	1、4、7	Renshou County
Yongxing (Tu Di Miao)	1、4、7	Huayang County
Sanxing (Cheng Jia Gou)	3、6、9	Huayang County
Dalin (Da Lin Chang)	2、5、8	Huayang County and Renshou County
Xinglong (Lan Jia Dian)	3、6、10	Huayang County
Jiancha (Jian Cha Xi)	2、5、8	Renshou County
Jitian (Ji Tian Pu)	3、6、9	Renshou County

Source: Editorial Committee of Shuangliu Gazetteer, 1992

Note: The names in brackets are the old names of marketplaces (“*chang*”) used by local people. The number of “market days” means the end number of a day of the lunar month. Except for *Jitian* and *Xinglong* which were located relatively further from Dantu, only the market day of *Sanxing* overlapped with Dantu’s market.



Figure 3.2 Location of “chang” around Dantu and trading routes to Chengdu city

Note: The trading routes connecting Dantu with surrounding “chang” (in blue) and Chengdu city were drawn on an old map published in the 1940s (provided by Yang Xiande).

Source: The data were based on interviews with elder people in Dantu and records in Shuangliu Gazetteer (Editorial Committee of Shuangliu Gazetteer, 1992).

After the 1950s, the schedule of market days was changed in some places. For example, after 1954 the date of “gan chang” was arranged to occur twice in ten days in Shuangliu County according to the Gregorian calendar (Editorial Committee of Shuangliu Gazetteer, 1992), i.e. market day being fixed at days ending in numbers 5 and 10. This lasted until 1973 (the period of the Cultural Revolution), when the local government of Shuangliu County decided that the market day should be once a week, with the rural market convening only on Sunday (Editorial Committee of Shuangliu Gazetteer, 1992). This regulation led to the decline of rural markets, reducing the opportunity for agricultural product exchange. With rural reform began in China after the 1980s, the marketing economy was encouraged, and the market days scheduled once in three days were revitalized according to the Gregorian calendar (Table 3.2). In some big towns, such as Yongxing, Dalin, Jiancha and Jitian, the market day occurred once in two days. In the 1980s a new market, Liu Gong Chang based at Laolong Cun (thus also called Laolong Chang), occurred when a new *xiang* called Liugong was established.

Table 3.2 Market day of Dantu and its surrounding “*chang*” in 1985

Name of market town	Market day	Administrative region
Dantu (Fu Xing Chang)	2、5、8	Yong Xing Xiang, Shuangliu
Liugong (Lao Long Chang)	3、6、9	Liu Gong Xiang, Shuangliu
Hongxiang (Hong Xiang Si)	4、7、10	Jia Cha Xiang, Shuangliu
Yongxing (Tu Di Miao)	1、3、5、7、9	Yong Xing Xiang, Shuangliu
Sanxing (Chen Jia Gou)	3、6、9	San Xing Xiang, Shuangliu
Dalin	2、4、6、8、10	Da Lin Xiang, Shuangliu
Xinglong (Lan Jia Dian)	2、5、8	Xing Long Xiang, Shuangliu
Jiancha	2、4、6、8、10	Jian Cha Xiang, Shuangliu
Jitian	1、3、5、7、9	Ji Tian Zhen, Shuangliu

Note: The names in brackets are the old names of the places still used by local people in the 1980s. The number of “market days” means the end number of a day of the Gregorian month. The frequent dates indicated the revitalization of rural markets in the 1980s.

Source: Editorial Committee of Shuangliu Gazetteer, 1992

Since the 1990s the market day for all rural markets in the Chengdu Plain occurs once per two days, indicating prosperous and intensive trading activities in rural areas as well as the increased population within the market-dependent area. Generally, the adjacent markets have different schedules for their market days. For instance, the market day of one market is arranged on the odd-numbered days (e.g. 1, 3, 5, 7, 9), while that of a neighboring market might be on even-numbered days (e.g. 2, 4, 6, 8, 10). In this way, the peasants living in one region have the flexibility to attend different marketplaces if necessary. Skinner (1964) suggested that the market day of a lower-level or standard market was alternated with its economically higher-level market around which it must orient itself to avoid conflicting days. For example, the market day of Dantu, a standard market, is different from that of Yongxing, an intermediate market, because Dantu is located within the administrative compass of Yongxing (Table 3.3). Due to the near location and alternative date, the periodic market at Laolong (another standard market nearby) is visited frequently by the people from Dantu. In this way, local villagers have an open market within their reach almost every day and there is reduced competition between neighboring markets. Since the beginning of the 1990s, although Liu Gong Xiang was merged into Jian Cha Xiang, the market at Laolong Cun has been maintained to the present date.

Table 3.3 Market day of Dantu and its surrounding “*chang*” in 2019

Name of market town	Marketing date	Administrative region
Dantu	Even date (2、4、6、8、10)	Yong Xing Jiedao, Tian Fu District
Laolong	Odd date (1、3、5、7、9)	Jian Cha Jiedao, Tian Fu District
Hongxiang	Even date (2、4、6、8、10)	Jian Cha Jiedao, Tian Fu District
Yongxing	Odd date (1、3、5、7、9)	Yong Xing Jiedao, Tian Fu District
Sanxing	Odd date (1、3、5、7、9)	Yong Xing Jiedao, Tian Fu District
Dalin	Even date (2、4、6、8、10)	Da Lin Jiedao, Tian Fu District
Xinglong	Even date (2、4、6、8、10)	Xing Long Jiedao, Tian Fu District
Jiancha	Even date (2、4、6、8、10)	Jian Cha Jiedao, Tian Fu District
Jitian	Odd date (1、3、5、7、9)	Ji Tian Jiedao, Tian Fu District

Note: The number of “market days” means the end number of a day of the Gregorian month. Until the middle of 1990s, all market days were scheduled once every two days.

Source: Based on author’s survey

In 2013 the area where Dantu is located, including neighboring markets, was allocated to the administrative region of the newly established Tian Fu New District, directly under the administration of Chengdu Metropolitan Area. The name of “*xiang*” or “*zhen*” was changed into “*Jiedao*”. In 2020 the administrative territory of a “*Jiedao*” was expanded. Sanxing Zhen was merged into Yongxing Zhen, becoming a new administrative region called *Yongxing Jiedao* (meaning Yongxing Street Community literally), but their periodic markets have been continued. Although more and more shops or even supermarkets occur in these market towns, indicating a reduced economic dependency on periodic trade, the importance of “*chang*” for local people has not been reduced.

It should be noted that the level of transport is a crucial variable, regardless of the periodicity of traditional markets (Skinner, 1964). Before the 1980s, the traditional periodicity of markets reflects the relatively primitive state of transport, being based on the distance a man could reach on foot in one day. For those peasants living in dispersed settlements, the periodicity of markets could reduce the travel distance to obtain the required goods and services³⁹. Similarly, itinerant peddlers needed to carry their products or wares from one market to the next with the aid of a barrow wheel or a carrying pole (Figure

³⁹ Skinner (1964) argued that for a rural area with relatively sparse population, the number of households required to support a daily market would have meant marketing areas so large that villagers at the rim could not manage the trip to and from market in a single day.

3.3). The distance was of great importance for these individual “firms” as they moved between different markets, allowing them to make a sufficient profit. Based on a survey in Gaodianzi in 1949, Skinner concluded the periodicity as follows (Skinner, 1964:10):

“By repositioning himself at periodic intervals, the entrepreneur can tap the demand of several marketing areas and thereby attain the survival threshold. From the point of view of the itinerant entrepreneur, periodicity in marketing has the virtue of concentrating the demand for his product at restricted localities on certain specific days. When a group of related markets operates on coordinated periodic (as opposed to daily) schedules, he can arrange to be in each town in the circuit on its market day.”



Figure 3.3 “Gan Chang” at Gaodianzi in 1949 and Dantu in 2019, similar events in different eras

Note: **Top left:** An old woman pushing a wheelbarrow in Dantu on the way to market (Photo by author, 2019); **Top right:** Peasants pushing a wheelbarrow and carrying products in Gaodianzi on the way to market (Photo by Skinner, 2017); **Bottom left:** Local people shopping in Dantu market during a market day (Photo by author, 2019); **Bottom right:** Crowds trading in the street of Gaodianzi during a market day (Photo by Skinner, 2017).

Today, since the great improvement of transportation conditions, local people can sell their products or purchase daily goods in relatively remote markets (even directly in urban centers). Private vehicles have replaced carts and wheel barrows in long-distance transportation, although metal barrows are still popular in rural areas like Dantu. Public buses connect different market towns regularly, which provide a convenient way for local people to visit different markets frequently. Because a regular bus runs between Dantu and Yongxing, the market in Yongxing has become the most important alternative to Dantu due to its bigger size, more diverse products and higher-level administrative role.

3.2 Distribution and spatial pattern of rural market

The development of the rural market is a historical process driven by the development of the commercial economy in rural areas (Du and Zhang, 1986). These markets normally occur in relatively developed areas where consumption level is high. Most rural markets are located at the important transportation hubs, whether these are waterways or roads. The ease of access and the inexpensive logistics of a geographical crossroad contribute greatly to the development of market towns (Du and Zhang, 1986). A comprehensive analysis of the occurrence and formation of rural markets in the Chengdu Plain shows that their development and prosperity are dependent on the following conditions:

- Trading necessity: The trading requirements for agricultural products and commodities inspire the local society to establish a trading market at a geographically central place.
- Transportation accessibility: A market place is always selected at a traffic hub, whether the route is a road or a waterway, which provides access and low logistical costs for commercial exchange.
- Occupational concentration: The prosperity of a rural market is related to the volume of trade, the development of production and processing, and the wholesale level of specific local products. A marketplace with diverse occupations such as agricultural production (primary industry), handcraft (secondary industry), and services (tertiary industry) will better expand and develop.

3.2.1 Distribution of rural markets

A market town is not only a residential place but also a nexus for production, trade, and logistics. For this reason, most rural markets in Sichuan have been located at traffic hubs (Ji, 2000). Transportation is undoubtedly a crucial factor impacting the formation and development of rural markets. Historically, the hydraulic system in the Chengdu Plain influenced the location of rural markets, as the logistical cost of river transport was cheaper than roads. In Pidu District (formerly called Pi County), there were 11 rural markets located along the rivers, making up 61.11% of the total in 1947 (Huang et al., 2020). In 1970, this number declined to 7 (31.82%), and then to 6 (28.57%) in 1985, indicating the decreasing importance of river transport to the location of rural markets (Huang et al., 2020). Meanwhile, the dependence of rural markets on the road system increased, especially after the 1980s, when traffic

infrastructure was developed greatly in the Chengdu Plain. Almost all rural markets were connected with newly built highways, and driving roads were progressively constructed and extended to almost all big clusters of settlements. Road transportation became the main and sometimes only way to ship products or commodities, which inevitably reshaped the spatial pattern of rural markets in the Chengdu Plain. While discussing the distribution of rural markets in the Chengdu Plain, Wang (2018) mentioned:

“Located in western Sichuan, the Chengdu Plain is the region with the densest population, earliest developed, and best natural conditions on the upper Yangtze River. Every year a great amount of rice is exported from this plain and the production of other economic crops is also prosperous. Although the conditions for river transport in this region are less ideal, the road traffic is very convenient. Many main highways and roads are extended from this plain to the outside. The density of rural markets in this region is very high, about every 8-10 km a rural market may be found (compared to 15-20 km in other regions), which means the mean distance from linpan settlements to rural markets is shorter than 5 km. Thus, the commercial trade between rural areas and market towns is very prosperous in this region.” (Wang Di, 2018: 171; translated from Chinese text)

According to the records of local annuals, by the end of the 1980s, there were about 420 market towns (i.e. “*chang*”) in the Chengdu Plain, although this number varied in different counties/districts later due to the change of administrative territory and/or urbanization. The average density of “*chang*” in the Chengdu Plain was 4.45 per 100 square kilometer at the beginning of the 1990s (Figure 3.4). High densities occurred in flat plains areas such as Xinjin (8.81), Wenjiang (7.61), Xindu (6.17), Pidu (5.95) and Qingbaijiang (5.59), where both population density and agricultural productivity were very high. Due to the convenient transportation and close linkage with the urban center (Chengdu City), rural markets in these counties or districts were very developed. Traditionally, these counties or districts are also the areas irrigated by the historical Dujiangyan Irrigation System, called “*lao guan qu*” (old irrigation area) in Chengdu, meaning these areas have been irrigated since before the 1950s, where the hydraulic system has been developed for over hundreds of years.

In the counties or districts where mountainous or hilly topographies are found, the counties or districts located further away from Chengdu city, the density of market towns decline due to the relatively sparse population, inaccessible conditions and low agricultural productivity. Examples of this situation may be found in Dayi (2.18), Dujiangyan (2.32), and Qionglai (2.54) near the Longmen Mountain, and Longquanyi (2.52) in which the Longquan Mountain occupies almost half of the territory. In Pengzhou, Chongzhou, Pujiang and Jintang, the hilly topography also influences the density of market towns, within the range of 3.38-3.67 units per 100 square kilometers and showing a decreasing trend.

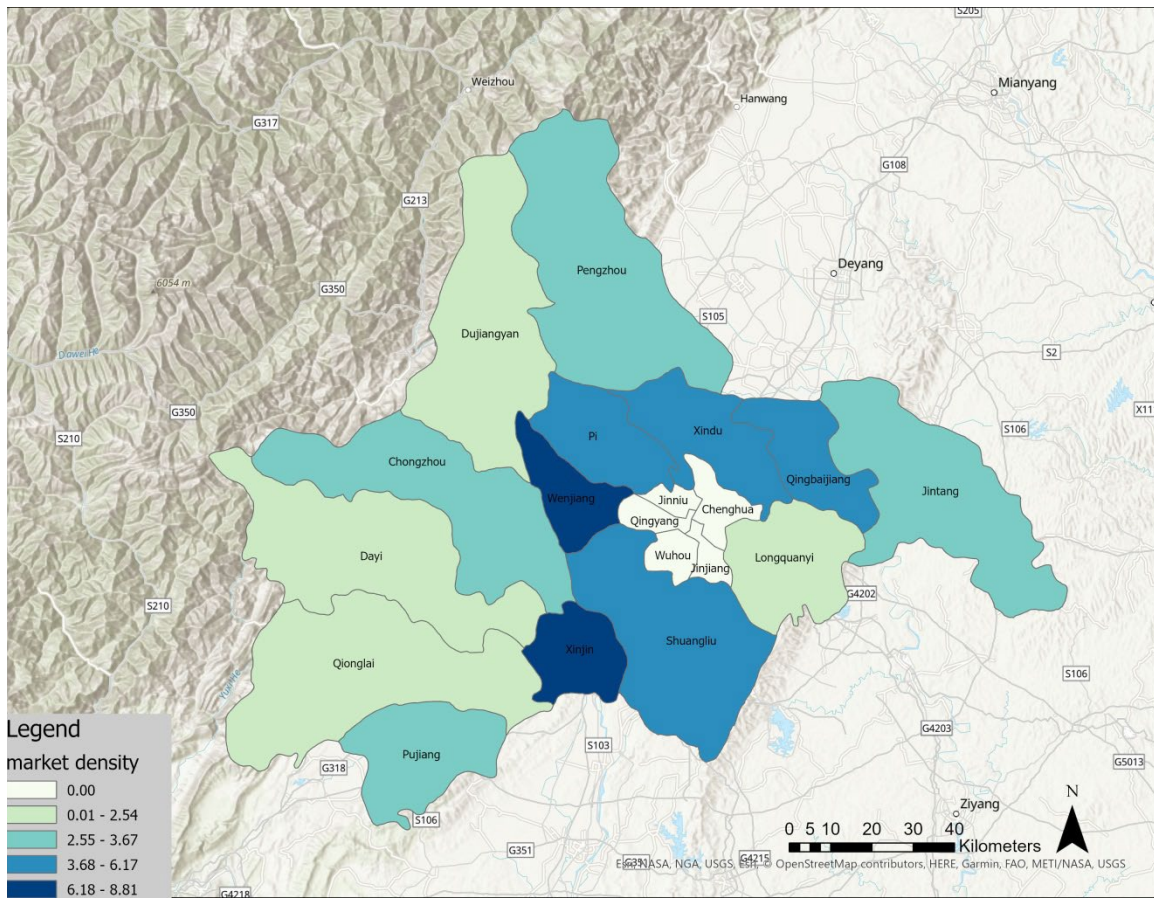


Figure 3.4 Density of market towns in different counties/districts of Chengdu at the beginning of the 1990s

Source: Basic data abstracted by author from local Gazetteer or archives of these counties or districts; Mapped by author

Generally, the size of a marketing area (i.e. the area served by a market town) varies inversely with the density of population. In hilly regions where the population is sparsely distributed, marketing areas are always large in order to encompass enough demand to support the market. On the contrary, in densely settled regions such as the flat plains areas, the marketing area is relatively smaller. The size of a marketing area in fact reflects the density of market towns in a given region, which are closely related to each other. In the Chengdu Plain the market density shows a significant correlation with the density of the rural population ($R^2 = 0.5963$), which may be illustrated with an exponential equation as follows (Figure 3.5):

$$y = 1.6173 e^{0.1472 x} \quad \dots(3.1)$$

Here, y is the market density, and x is the rural population density. At the beginning of the 1990s the high density of market towns occurred undoubtedly in those densely populated counties or districts.

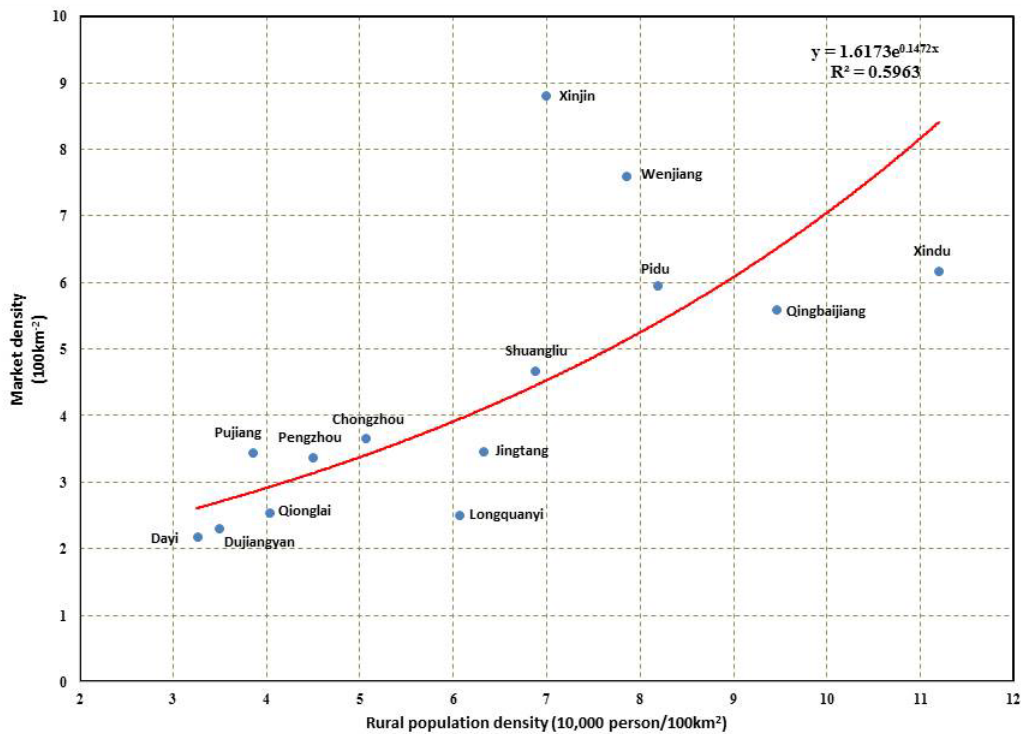


Figure 3.5 The relationship between market density and rural population density in the Chengdu Plain

Note: Each data point is a county/district in Chengdu Municipality.

Source: All data were extracted from local Gazetteer of counties or districts and standardized in 1990.

Modernization and urbanization in rural areas may lead to a change in the density dependence of rural markets. The modernization of a traditional marketing system always commences when economically efficient transport provides convenient conditions for linkage with outside systems of production (Skinner, 1965). After the 1990s, the rapid development of highway and railroad construction has changed the transport conditions in the Chengdu Plain, improving the connectivity between rural markets and the centers of industrial production. As roads are improved and mechanized transport is introduced within the city's trading area, these facilities radiate out from urban areas, extending eventually to the dependent rural markets. Thus, marketing systems at the rim of the city's trading area are progressively commercialized, leading to the expansion of higher-level marketing areas (intermediate markets and urban markets) but the decline of other small rural markets such as standard markets.

Table 3.4 Data of market towns in different counties or districts of Chengdu

County/District	Size of MT (km ²)	Serving radius (km)	Serving RP (x 10 ⁴ person)	Market density (100 km ⁻²)	RP density (km ⁻²)
Dayi	45.86	3.82	1.49	2.18	325.16
Dujiangyan	43.14	3.71	1.5	2.32	348.34
Longquanyi	39.71	3.56	2.41	2.52	606.65
Qionglai	39.34	3.54	1.58	2.54	402.76
Pengzhou	29.6	3.07	1.33	3.38	448.77
Pujiang	29	3.04	1.12	3.45	384.48
Jintang	28.9	3.03	1.82	3.46	631.31
Chongzhou	27.23	2.94	1.38	3.67	506.34
Shuangliu	21.36	2.61	1.47	4.68	687.17
Qingbaijiang	17.89	2.39	1.69	5.59	945.03
Pidu	16.81	2.31	1.37	5.95	817.85
Xindu	16.2	2.27	1.81	6.17	1119.75
Wenjiang	13.14	2.05	1.03	7.61	785.51
Xinjin	11.34	1.9	0.79	8.81	699.09
Mean	27.11	2.87	1.49	4.45	622.02

Note: The data from market towns were collected from local annuals or archives of every county/district at the beginning of the 1990s when urbanization has not yet led to the obvious change of rural landscape in the Chengdu Plain. In this table, the order of county or district follows the increase of market density. “MT” means market town; “RP” is rural population; and “serving radius” indicates the average serving range of market towns in each county/district.

In the Chengdu Plain the average size of a marketing area was 27.11 km² with the serving radius of 2.87 km (Table 3.4). This means that the majority of marketing areas are of a size which puts the most disadvantaged villager within easy walking distance to the town, around 2 to 4 kilometers. The long distances were found in those counties where mountainous and hilly topography was distributed, such as Dayi (3.82 km), Longquanyi (3.56 km), and Qionglai (3.54 km). In the flat plain areas the serving radius became short, as in Xinjin (1.90 km), Wenjiang (2.05 km), Xindu (2.27 km) and Pidū (2.31 km), all of which are located around the urban center (Chengdu City). According to this analysis, market towns in the Chengdu Plain are less than eight kilometers apart, and the maximum walking distance to the town is approximately 3.5 - 4.0 km, which corresponds to Skinner’s findings in 1949 (Skinner, 1964).

With a maximum average area of 45.86 km² in Dayi and the minimum of 11.34 km² in Xinjin, the rural population served by each market town on average is estimated at about 15,000, showing a much higher density than the data found by Skinner in 1949 (1964; 1965a), who reported that the average population of the standard marketing community was somewhat over 7,000. Generally, the average population of marketing communities increases along with population density. At the beginning of the 1990s the mean density of rural population was 622.02 persons per square kilometer with the maximum of 1,119.75 in Xindu and the minimum of 325.16 in Dayi. In Xinjin, however, although the market density was as high as 8.81 per 100 square kilometer, the rural population was only 699.09 persons per square kilometer, indicating a nonlinear relationship, suggesting that other factors may also influence the size of the marketing area.

As mentioned above, the improved roads resulting from urbanization connect market towns to urban areas and shorten the distance between *linpan* settlements and their rural markets. Due to the availability of public transit options like shuttle buses, villagers situated near the improved roads may find it feasible to market their products directly at the high-level markets, thereby taking advantage of the higher prices there. In Dantu, for example, elders over 70 ride the shuttle bus free of charge when they want to sell their products or purchase what they require in Yongxing or even as far away as Huayang Zhen or Chengdu City. The improved transport now makes it possible for even the least advantageously situated peasants to make the trip regularly to relatively remote markets in a reasonable amount of time. In the meantime, the high degree of specialization and differentiation of markets and favorable prices in high-level market towns attracts young people to do a large volume of trade there, enhancing business efficiency. As a result, marketing activity is shifted from low-level markets to high-level markets and then to modern trading centers in the course of modernization. As the number of participants decreases in one of these low-level markets, schedules of market days or the time for marketing activities are likely to be reduced, and finally the markets in the disadvantaged location shut down. With the closure of low-level markets, the size of other markets increases (Skinner, 1965). The markets at Laolong Cun and Hongxiang Cun, both of which were seats of *xiang* government before they were merged into Jiancha Zhen administratively after the 1980s, have declined. The marketing time (the time for “*gan chang*”) only lasts for 1 or at most 2 hours in the morning, although the schedules of market days have not been changed. At the same time, the more urbanized the market towns became, the more likely it is that the average size of the marketing area becomes abnormally large for its dense population. For instance, *Yongxing Jiedao* includes the territory of previous *Yongxing Zhen* and *Sanxing Zhen*, becoming a centralized urban center, which marketing area has been thus increased accordingly.

3.2.2 Theoretical model of spatial pattern

3.2.2.1 Rural market as central place

In the Chengdu Plain, a market town may be conceptualized as being located at the center of a circle (or a hexagon in the Skinner's theory model) with the radius range of 2-4 km (average 2.9 km). Within this serving range many *linpan* units are distributed, all of which would be dependent on the services provided by this market (Wang, 2018). A case study in Pidu showed that over 90% of *linpan* settlements were distributed around at least one rural marketplace within the radius of 3 kilometers, and this distance has been stable since the 1940s (Huang et al., 2020). The serving range of a market town varies with the cost or convenience of consumers' travel to acquire goods and services from the marketplace. In the flat plains areas the radius of the serving range is generally shorter than those in hilly areas. For example, in Xinjin and Wenjiang the radii are only 1.9 km and 2.05 km respectively, but in hilly counties such as Dayi and Dujiangyan the radii are 3.82 km and 3.71 km (Figure 3.6). Longer distances to marketplaces are common for those living in hilly areas or even mountains where local people must travel over 5 km to visit a market town.

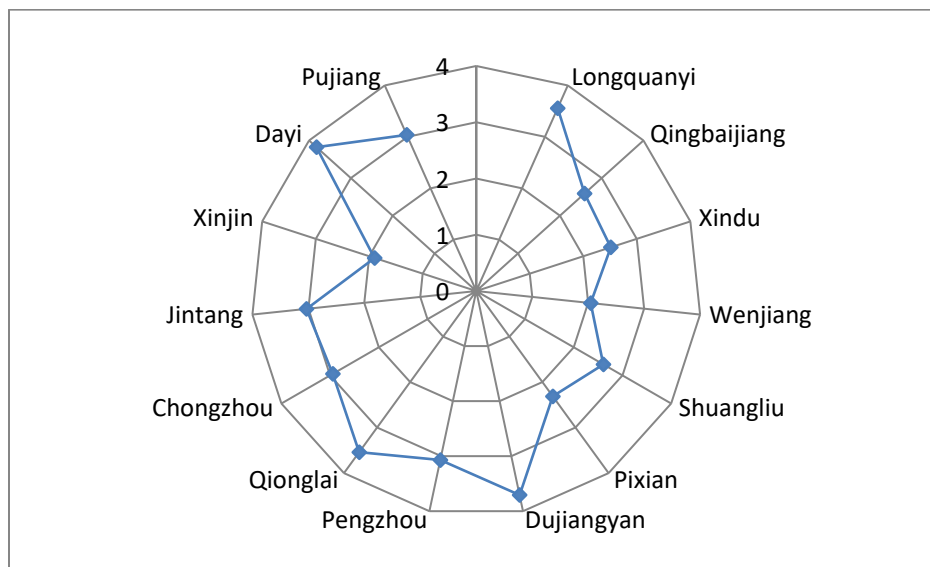


Figure 3.6 The average radius of serving range of market towns in each county/district of Chengdu at the beginning of the 1990s

Sources: Data were extracted from Gazetteer of each county/district

The serving ranges of neighboring markets are always overlapped so that *linpan* dwellers may easily visit one or another if it is necessary. Whether a trader visits a market nearby or another far away is dependent on demand for the type of products or commodities for sale or purchase, which is closely related to traffic costs. Normally, local people prefer to sell their agricultural products at the market town nearby, but acquire their social services at the high-level market town, which may be relatively

remote but will have comprehensive administrative authorities or cultural facilities. Dantu market, a standard market, mainly serves the people living in the territory of Dantu Villager Committee, including Dantu Cun, Huanglong Cun and Xinmin Cun, with a radius of less than 3 kilometers (blue circle in Figure 3.7). Traditionally, local people living here visit Dantu market once every two days, but go to other markets occasionally. Near Dantu market there are two other standard markets, Laolong and Hongxiang, both of which are about 3-4 kilometers away from Dantu market (yellow circle in Figure 3.7). Due to the alternative market day of Laolong (on odd days) with Dantu (on even days) (see Table 3.3), local people living in the blue circle also like to visit this market frequently, especially itinerant peddlers or small retailers who prefer to make a circuit of these two markets. The market day in Hongxiang conflicts with Dantu (both on even days), thus only a few people from Dantu frequent it.

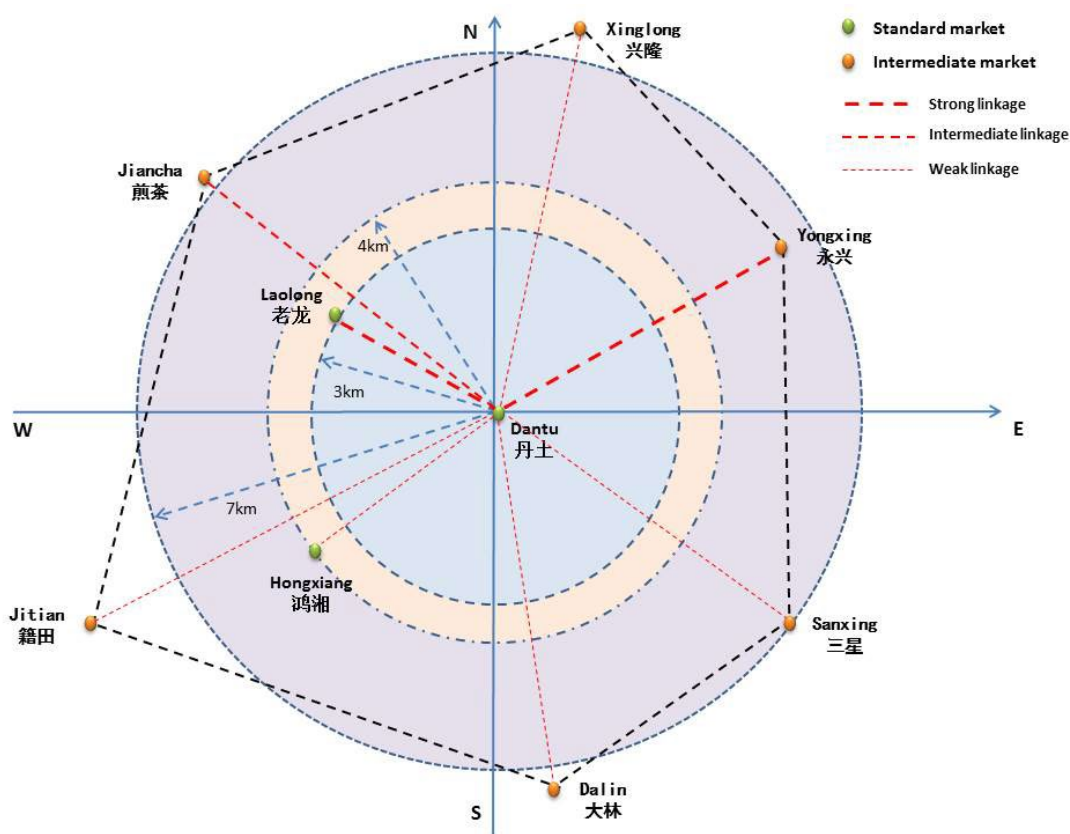


Figure 3.7 Serving ranges of rural markets around Dantu and their linkage

Note: The blue circle with the radius of 3 kilometers shows the serving range of Dantu market. Two standard markets, including Laolong and Hongxiang, are located in the yellow circle, with a radius of less than 4 kilometers. Some high-level markets (intermediate markets), such as Yongxing, Sanxing, Dalin, Jitian, Jiancha and Xinglong, are distributed within or near the purple circle with a serving radius of around 7 kilometers. Based on the frequency of “*gan chang*” of Dantu’s populace, Laolong and Yongxing have strong linkages with Dantu due to their alternative

market days. The linkage of Dantu with Jiancha is intermediate, but links with other markets are relatively weak, only occasionally visited by Dantu people.

Source: Designed by author based on field survey

When local people have greater demands for materials or services, they visit relatively remote markets with high-level authorities, markets based in the “*zhen*” or county town. For the people living in Dantu (in the blue circle of Figure 3.7), the priority is Yongxing market. Local people may deal with their social or administrative affairs at governmental agencies located in Yongxing, such as applying for social security, marriage registration, visiting hospitals or even simply watching a movie there. Other neighboring towns which they frequent include Sanxing, Dalin and Jiancha, all of which are located about 6 kilometers away from Dantu market. At these market towns, local people can make purchases which are out of the ordinary, or obtain services which peasants do not normally require. This type of intermediate market usually has two serving areas, a “primary area” including *linpan* settlements nearby (less than 3 km), and a “secondary area” encompassing settlements located relatively farther away but within the administrative territory where local inhabitants come occasionally for items or services hard to obtain in their own market. At present, children living in Dantu must go to the kindergartens or schools based at Yongxing because the primary school at Dantu market was closed ten years ago. This is one of reasons why adults must go to Yongxing more frequently than they did before. If these intermediate market towns could not meet their demands, local people would go to Chengdu city for both material and non-material purposes.

3.2.2.2 *Landscape connectivity between marketing areas*

Viewing the serving areas of market towns as “patches”, we may observe that these “patches” are connected or even overlapped, forming a landscape continuum. Although the serving range of a market town may differ from its administrative radius, in particular the range of the “primary area” as mentioned above, its impact, in terms of the “secondary area”, always corresponds to the administrative circle, inside of which local government or its agencies provide necessary services to the resident communities, though they may only serve as channels for providing administrative services. From the perspective of landscape ecology, the connectivity of socio-ecological systems between marketing areas “patches”, more simply called “socio-ecological connectivity,” is determined by distance, which is related to the traffic cost and accessibility of marketing activities (“*gan chang*”). Similarly, the size of a “patch” is closely related to the resident population inside. The more people there are, the larger its size tends to be. In this study, the population of an administrative region (i.e. *Cun*⁴⁰, *Xiang* or *Zhen*) where a

⁴⁰ Here, a “*cun*” means a “*xing zheng cun*” (literately “administrative village”), which has a clear administrative range and consolidated (resident) population.

market town was located was used to represent the population in a “patch”, including the dwellers living in the market town as well as surrounding *linpan* settlements. Thus, the connectivity coefficient (K) could be used to describe quantitatively the relationship or interaction between “patches”. Based on the gravity model ($F = G M_1 * M_2 / R_2$), which indicates that the gravity of an area is positive to its size (M_1 , M_2), but negative to its distance to the area, I customized the formula as follows:

$$K = P_1 * P_2 / D^2$$

Here, K is the connectivity coefficient; P_1 is the resident population in “patch” 1; P_2 is the resident population in “patch” 2; D^2 is the squared distance between marketplace 1 and marketplace 2. With this formula the connectivity coefficients between the serving area of Dantu market and other neighboring areas may be calculated (Table 3.5).

Table 3.5 Connectivity coefficients between marketing area of Dantu and surrounding “*chang*”

Name of market	Resident population (P) 1,000 person	Distance to Dantu market (D) km	Connectivity coefficient (K)
Dantu	3.5		
Laolong	3.1	3	1.21
Yongxing	21.8	6	2.12
Jiancha	30.7	7.7	1.81
Dalin	28.3	7.5	1.76
Sanxing	18.4	7.2	1.24
Xinglong	30.9	9.5	1.20
Jitian	35.1	13.3	0.69
Huayang	106.2	22	0.77
Chengdu	6,640	51	8.94

Note: The “resident population” means the total residents living in the administrative territory of a *cun*, a *xiang* or a *zhen* in 2018, including the population in market and *linpan* settlements.

It may be seen that there is a strong connectivity between the marketing area of Dantu and Yongxing ($K=2.12$), indicating a close linkage between these two markets, which corresponds to the results of our interviews (see Figure 3.7). The second is Jiancha ($K=1.81$), where there is dense population and a large-scale market. Because of the high quality of the high school in Jiancha, Dantu people prefer to send their children to study there. Historically, Dantu market was located on the border between Yongxing Xiang and Jiancha Xiang, which has also influenced the people’s preference of “*gan chang*”. Although the distances to Yongxing and Jiancha are similar, the higher K value of Yongxing is due to

not only the shorter distance but also its administrative impacts. On the contrary, although the K value of Laolong is not very high ($K=1.21$), which could not be matched with visiting frequency, its importance for Dantu people still should be emphasized due to its location a short distance away, and its alternative market day. In fact, as a standard market, Laolong is very attractive for itinerant peddlers, who may easily make the circuit of two markets every day.

The distances from Dantu market to Dalin market and Sanxing market are similar, but the resident population in the serving area of Dalin is relatively greater, which thus shows stronger attraction ($K=1.76$) than Sanxing ($K=1.24$) for visitors (Table 3.5). Historically, Dalin (literately meaning “big forest”) was famous for its bamboo products and fuel wood, most of which needed to be transported to Chengdu City. On the way from Dalin to Chengdu, Dantu is one of important stops for overnighting and repacking. Thus, there is a historic relationship between Dalin and Dantu, although this linkage has declined. The impact of Sanxing market is relatively weak. With Sanxing Zhen being merged into Yongxing Jiedao recently, and its role as local administrative center declining, the serving area of Sanxing market may shrink progressively. Recently, due to the new establishment of Tianfu District and huge investment in this area, the resident population in Xinglong is increasing very quickly. Many institutions or companies have been moved there. Some people from Dantu Cun also like to visit to sell their products, in particular vegetables and fresh fruits. Although the estimated profits impel those peddlers to move among different markets, the distance is still an important determining factor for traders. For example, because both Jitian Zhen and Huayang Zhen are located far away from Dantu, the connectivity coefficients (K value) are very low, being only 0.69 and 0.77 respectively, which is borne out by local people, who only very occasionally go to these two markets (excepting a very few wholesale traders).

The attraction and influence between markets are interdependent and interacting. Although there is no clear-cut line of demarcation, the serving range of a “*chang*” has a recognizable area, and people within certain areas are viewed as its primary customers. The socio-ecological connectivity reflects the interaction between marketing areas, the ecological linkage of “patches,” as well as the preference of local people to markets, which, in turn, are regarded by local people as their “*chang*”. High connectivity indicates a strong interaction or close linkage between two marketing areas. However, the importance of a given market for a specific community is not be simply decided by the connectivity coefficient, but is also impacted by other factors also such as social and cultural relationships. Further, with the development of transportation conditions and rapid urbanization, the serving ranges of market towns have thus been expanded, resulting in a corresponding change in connectivity. Owing to the popularity of private cars and motorcycles, many small retailers or itinerant peddlers can now move easily between

markets in one day. In this way, the connectivity between “patches” (marketing areas) seems uncertain to some degree.

3.3 Functions of rural market

3.3.1 General description

Going to a rural market ("*gan chang*") once every few days could be considered as an integral part of the peasants' life and livelihood, although urbanization has provided more choices for them to access the previously-remote markets in the urban center. Du and Zhang (1986) concluded that rural markets were regional centers, considering their political, economic and cultural importance. During market days, local people trade their products or buy daily necessities, seek medical support, and visit temples and friends (Wang, 2018). Whiting et al. (2019) notes:

"Local markets provide opportunities for farmer households to exchange what they do not need for what they do not produce and to sell surpluses to build up cash reserves against emergencies or important life-cycle events."

These rural market towns distributed in the *linpan* landscape are linked with urban centers on one side and rural society on the other. Rural markets have been considered essential, both as a source of necessary goods and services unavailable in rural community and as an outlet for local production (Skinner, 1964). Therefore, understanding the role and function of rural markets in networking individual *linpan* units is an entry point for deeply analyzing the mechanism or function by which the scattered *linpan* units operate as a holistic socio-ecological system.

Among the various functions of rural markets, trade of products and commodities is the priority, which is also the most important historical reason for the existence of any rural markets. In a traditional agrarian society, at least before the 1980s when large-scale urbanization or modernization had not yet occurred in the Chengdu Plain, local peasants produced many agricultural products or by-products from their farming fields, plantations, home gardens, or *linpan* forests, in other words, the full scale of the provision services of the *linpan* landscape (Wu et al., 2020). Processed goods might also be produced by small-scale workshops or cottage industries at market towns. Rural markets thus become the starting point for the flow of agricultural products and craft items into higher reaches of the marketing system, and were also the terminus of the downward flow of industrial commodities or necessities imported for local consumption (Skinner, 1964; Wang, 2018). The exchange of goods produced within the market's dependent area was the most important channel for local peasants to generate cash income. In addition, for those peasants engaging in cash crop cultivation, non-timber product collection (such as mushrooms or medicinal plants), poultry and fish farming, or sericulture, the location and size of a market town was an important consideration when determining the scale or volume of production and sale.

The rural people of the *linpan* landscape traditionally conduct certain types of business during their slack season. In Dantu Cun, for example, local people used to transport firewood or pottery to Chengdu for selling, and carried commodities back. This kind of long-distance transportation and trade increased the connectivity between marketing areas and expanded their social space. Although the primary function of rural markets is that of exchanging what the peasants produce for what they need, peasants also require the services of tool sharpeners, livestock castrators, medical practitioners, barbers, and myriad entertainers (Skinner, 1964; 1965a). While many of these services are not available, itinerants purveying all of them occasionally visit every market. For *linpan* residents “*gan chang*” was also an important channel for meeting their spiritual demands. Li et al. (2018) argue that maintaining “*gan chang*” would be an important approach for preserving traditional or local culture. Widely distributed in the *linpan* landscape, market towns provide a concentrated public space for the social and cultural activities of rural societies.

Across the rural landscape of the Chengdu Plain, where human settlements (*linpan* units) were scattered sparsely but commercial activities were relatively active, rural markets played an important role in maintaining the social relationship (Wang, 2018). Local peasants living in a certain area such as one “*xiang*” need a common space for their social and cultural events in order to meet their cultural and intellectual needs or to renew their spiritual life. According to the records of local Gazetteers, various events integrating trading activities and cultural performances were regularly held in market towns such as temple fairs during traditional festivals and worship services for various gods of different guilds (Editorial Committee of Shuangliu Gazetteer, 1992). In his field notes, Skinner (2017) described the details of the celebration ceremony of the Dong Yue Festival, a traditional event in rural Chengdu before the 1950s. At market towns many restaurants and teashops provided important public space for local people to gather together. *Linpan* dwellers shared their news, knowledge, and interests, and enjoyed various entertainments during “*gan chang*”. Marketing activities offered a window for local people to learn about the outside world. For this reason Skinner (1964) argued that the effective social field of the peasant was delimited not by the narrow horizons of his settlement but rather by the boundaries of his marketing area.

From a graph theory perspective, market towns in the Chengdu Plain functioned as “nodes” in the landscape, where information, energy, and trade flow between those market towns could be considered as “edges” (Urban and Keitt, 2001; Minor and Urban, 2008; Figure 3.8). If one “node” (a market) was missed or closed, other “redundant” nodes (markets) in this network could sustain the function of the whole system. However, if the network of rural markets became fragmented, it could be assumed that the active functions of *linpan* units (patches) would be disrupted or even lost. The diversity of “nodes” (rural markets at different levels) could enhance the stability of the socio-ecological system of the *linpan*

landscape, therefore decreasing the potential for catastrophic failure in the face of an external shock or threat. This diversity is very important to the socio-ecological resilience of a landscape. The *linpan* landscape is heterogeneous on the household or settlement scale, where one or a few households often engage in their own agricultural activities. At a macro-scale, however, the whole landscape is homogeneous, in that sparsely distributed *linpan* are connected through market towns as an “entity”.

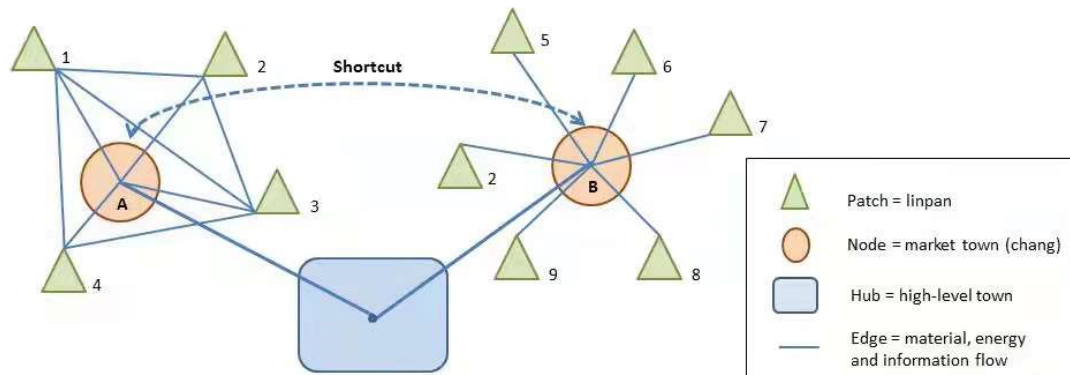


Figure 3.8 A theoretical model showing holistic functions of *linpan* landscape

Note: Market A (node A) connects four *linpan* (patches) as a group, with complicated interaction among patches; Market B (node B) connects six *linpan* as another group but all patches are simply linked to each other through the node. Both Market A and Market B orient to a high-level market town (hub highlighted in blue) where material, energy and information flows (edge) converge. Between node A and node B there is a shortcut for edge flowing but the linkage is weak.

Source: Designed by author

In last few decades, traditional rural markets have been changed greatly by various drivers, and have been especially eroded by ambitious urbanization plans (Ji, 2000; Li et al., 2018). Following the implementation of the policy of "concentration of living space" in Chengdu since 2013, urbanized towns have replaced many traditional rural markets. The historic buildings or blocks in traditional markets including many public spaces have been changed into modernized shopping centers or office buildings. Recently, a new regulation regarding administrative division has been initiated, in which two or three “*xiang*” are first combined as a “*zhen*”, and then changed into “*jiedao*” (literately meaning “street community”), which has accelerated the urbanizing process in rural areas. The rapid growth of satellite towns around urban centers, coupled with increasing out-migration of the younger generation, has led to the rapid decline of traditional rural markets, especially in the socio-cultural domain. In some market towns, new market halls (called “*zong he mao yi shi chang*” or “*nong mao shi chang*”) were constructed, with canopies able to serve as awnings or rain-protections, but the socio-cultural function has been lost

to a certain extent, with only the commercial function remaining (Figure 3.9). The integrative functions of a rural market have been thus separated.



Figure 3.9 Marketing activities (“*gan chang*”) in a newly constructed market hall in Yongxing Zhen

Note: **Top left:** An entrance of “*nong mao shi chang*”, a large market hall similar to a bazaar, in Yongxing town; **Top right:** “Shopkeepers” renting stationary booths in the market hall, which can be used every two days; **Bottom left:** An old man pushing an old-style barrow wheel for his “*gan chang*”; **Bottom right:** Local peasants gathering temporarily around the market hall to sell their vegetables.

Source: Photo by author, 2019

3.3.2 Public space of rural market – explaining functions with a case-study

Public space is a kind of architectural space, and is the key point for understanding the functions pertaining to the vitality of a market town. As Skinner states (1964:17):

“Any attempt to comprehend the social or economic dimensions of marketing structures inevitably makes certain assumptions about their spatial characteristics.”

Exploring the features of public space thus has become the focus for many scholars studying the economic, social and cultural functions of market towns (Ji, 2000; Ji, 2008; Liu, 2014; Zhong, 2002; Sun and Zhou, 2015; Peng and Yang, 2018). “Public space” is defined as a type of socially architectural space providing for the gathering and communication of local communities, where humans are the protagonists. Human behavior, custom, and tradition decide the morphological and structural features of a market town. Therefore, as an agglomeration of human settlements, a market town always has its own public space, which is not only the commercial agora, but is the “epitome” of socio-economic development for a given agrarian society. The architectural structure of the public space reflects the regional culture and history, forming the identifying features differentiating it from other regions. Thus, when discussing the public space of a market town, the relationship between local inhabitants and their physical or cultural environments must be studied at the same time.

“Social communication” or “public exchange” is a basic requirement for human life and livelihood (Wang, 2018). The concept of collectivism formed by the gregarious life of ancient peoples has influenced the environments which humans have inhabited. Through the “public exchange”, humans are socialized and social relationships were established. These social relationships inevitably led to the occurrence of human settlements with unique spatial structures and functions. In his analysis of the motives of *linpan* dwellers for going to rural markets, Wang (2019) emphasized the importance of the public space of rural markets in providing a platform for the spiritual life and cultural communication. He found that public spaces such as restaurants and tea houses located in market towns served to maintain the socio-economic and cultural connectivity of *linpan* residents. In the book “Disappearance of Ancient Capital”, he said:

“In the Chengdu Plain peasants lived in a decentralized mode. Every household lived near their farming fields. There were no traditional nucleated villages as in other regions of China. In the Chengdu Plain individual or a few farmers’ houses surrounded by bamboo groves were distributed in the agricultural landscape, forming a semi-natural landscape. Owing to the lack of close neighboring relationships, these farmers would feel isolated. Thus, visiting rural markets or going to townships frequently became a necessary part of their daily life.” (Wang D., 2019: 295)

In this study the term “public space” indicates those places which support public communication or exchange, which are structural as well as functional. “Commonality” and “assemblage” are their basic features. Because many kinds of commercial, cultural, and social events are involved, public space thus becomes a center of collective activities. In the following text, for purposes of elaboration, the public space is divided into “street-based public space” and “courtyard-based public space”. Of course, in a market town the elements of public spaces are interactive and interwoven. Some public spaces are

transitional and their boundaries are blurred. The communication or exchange of traders or residents would not be limited to only one space and the functions of a given public space are also variable.

3.3.2.1 Street-based public space

In a traditional market town there is normally a main street or “market street,” along which two arrays of buildings are located on both sides. With the development of market towns, one or a few small lanes or side-streets occur, which are normally perpendicular to the main street. As more and more lanes or side-streets are formed, the market town begins to take shape. The main street of a market town is not always straight but can be changeable with undulating topography, in particular in hilly areas or along the winding shape of river ways. Generally, the number of streets or lanes in a market town indicates its developmental history and size. A standard market normally has only one or two streets but an intermediate market may have numerous streets or side-streets, illustrating a much more urbanized market town.

(1) Market street

In a market town the main street is a comprehensive space with multiple functions. It serves as a walk way, a space for commercial activity and cultural performance, and as the living space of local inhabitants. Other public spaces in a market town are always oriented to the main street, all of which may be understood as the extension and specialization of the main street’s functions (Zhong, 2002). In Dantu market, for instance, the main street extends from north to south, to which a side-street is perpendicular, forming a cross-shaped traffic framework. Almost all of traditional buildings are located along the both sides of streets (Figure 3.10). Outside of this cross-shaped market town, there are also some newly built houses, most of which were constructed after the destructive Wenchuan earthquake in 2008. Now, there are 41 households living on the market streets.



Figure 3.10 Street based public spaces in Dantu market in 2019

Source: Mapped by author based on field survey in 2019

The length of the main street in Dantu market is 240 m, almost extending along the contour with the northern-end being about 3 m higher than the southern. The 3.5 m wide surface is paved with flagstones. From the northern-end to the crossroads, where most of the shops are distributed, the length is about 180 m. From the crossroads to the southern end, the length is about 110 m, in which only a few shops (a sauce and pickle shop, a liquor store, a sewing shop and a barbershop), restaurants and tea houses are found. In addition to the 3.5 m wide street-surface, there are two 2-3 m wide long-porches extending along the both sides of the main street. Thus, the total width between building faces of street sides is about 8-9 m. This linear space is used by local people during market days for their walking and trading purposes. Most of the buildings along the main street are courtyard-style, detached each other and perpendicular to the main street. The doors of the courtyards face the street but the private living spaces are located behind.

The side-street extending from east to west is relatively short, about 140 m long, including an eastern section (about 60 m) and a western section (about 80 m), both of which began separately from the crossroad. In the western section there once was a primary school and a *tu di miao* (an earth-god shrine). There are no long-porches on the side-streets, which thus are mainly used for bypass flow during market days. Generally speaking, the larger a market town is, the more side-streets there are. A small rural

market like Dantu, has only one side-street. While reviewing the architectural features of market towns in Sichuan, Liu (2014) found that the existence of lanes or side-streets led to the spatial variability of the marketplace and the expansion of living space of local people.

Reducing the pressure of crowds and traffic during market day is important for the architectural planning of a market town. On market days, the number of pedestrians and vehicles in the street increases enormously (becoming incredibly crowded). Many shops and trading stands have been laid linearly along the main street, but side-passages must be considered for easing traffic flow. At Dantu market, for instance, the crossroad located at the center is a traffic knot, as four directions of walk-ways release the pressure of their moving masses. In addition, a narrow lane has been placed at the northern section of the main street, which is only about 1 m wide and is called the “fire lane” (“*huo xiang*” in Chinese) by local people (Figure 3.10; Figure 3.11). This lane may be used in case any emergency occurs, such as fire or crowd congestion.

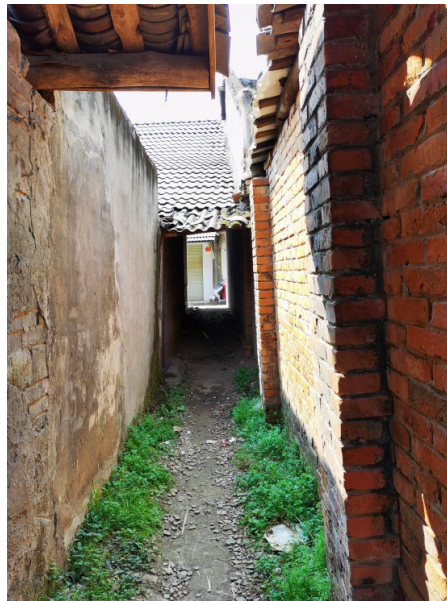


Figure 3.11 The entrance of a “fire lane” at Dantu market

Source: Photo by author, 2019

The public space of the market-street, shaped by the horizontal street surface and vertical building facades on both sides, is a linear space for public activities. In terms of the social life of the local inhabitants, the market street plays a number of practical roles. Social activities are always pursued outside of the courtyards, in the street. Locals enjoy sitting at side of the streets or by the doors, chatting, drinking tea, eating meals, or just relaxing. Thus, the street functions as their “parlor”, or “reception room”, providing a flexible space for their public life. In the street, building faces are traditionally an array of wooden door planks, which can be opened one by one during market days but closed partly at

normal times. Restaurants and tea houses become relatively more penetrable are totally opened during market days. Therefore, the street-based public space varies with the open or closes doors of the shops, increasing the spatial resilience of the marketplace as the moving mass ebbs and flows every two days.

(2) Town gate

Unlike county towns or cities in the Chengdu Plain, there are no city walls or city gates in rural market towns. Normally, market towns, particularly small towns (e.g. standard markets) were partially walled by connected buildings, with the town gates, called “*zha men*”, located at street ends, becoming the only entrances. The town gate itself was not a public space but it could shape a space for public activity. At night or during emergencies such as bandit attacks, the town gate could be closed easily and that the enclosed “market town” became a “fortress”. Town gates were popular in traditional rural markets because they could be constructed easily with local materials such as wood and stone (Figure 3.12).



Figure 3.12 A traditional town gate with wooden framework in Xianshi Town, Sichuan

Source: Photo by author, 2019

Interviews with local people have verified that before the 1950s there were five town gates in Dantu market, located at the four street-ends and the entrance of the “fire lane” (Figure 3.13). The wooden columns were put on stone bases (Figure 3.14), and a small cabin was built on the upper side of the gate where a guard could live at night. This guard was responsible for opening or closing the gate, as well as sounding the night watches⁴¹. The opened town gate was an icon of entrance into a public space for

⁴¹ The night watch is called “*da geng*” in rural Chengdu. The watchman must mark every two hours during the night by sounding a gong or clapper.

visitors, but the closed gate implied a closed “world,” giving local inhabitants greater feeling of security. For a market town like Dantu, town gates formed a special space for local residents, within which neighbor relationships and cultural traditions were consolidated, highlighting the ‘sense of place’.

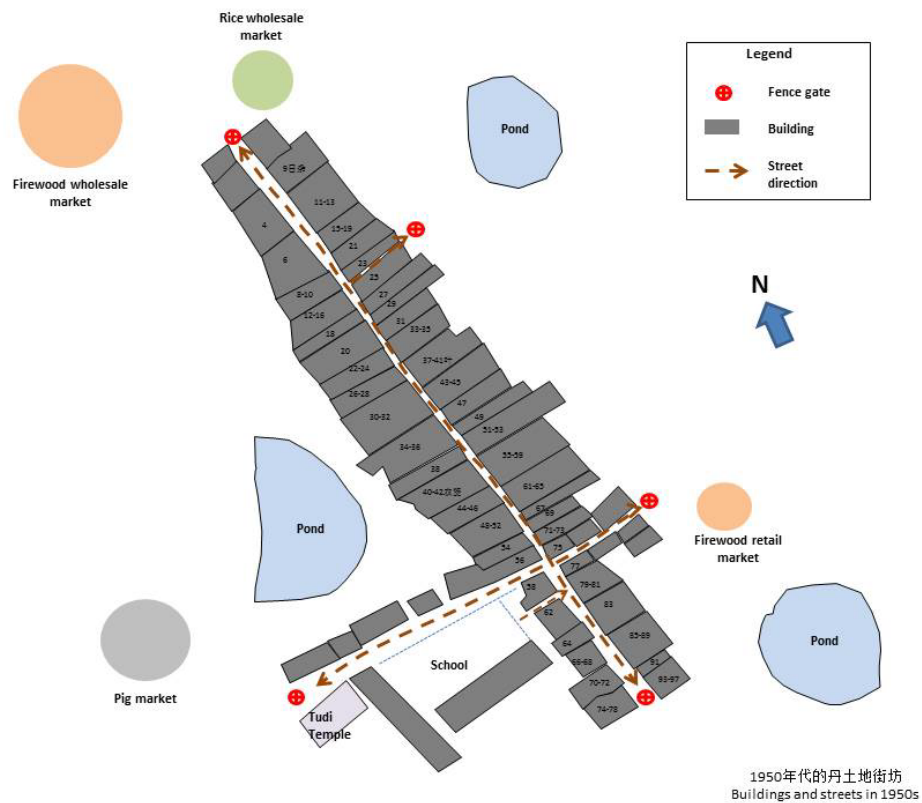


Figure 3.13 Location of town gates in Dantu market before the 1950s

Source: Designed by author based on personal interview with local people in 2019



Figure 3.14 A remnant of supporting stone of town gate in Dantu market

Note: Red stone (remnant) at right below, located at the eastern end of side-street

Source: Photo by author, 2019

(3) Long-porch

As mentioned above, in a market town many courtyards with shops in the front and living space in the rear are lined one by one along the market street. Due to humid and frequently rainy weather in the Chengdu Plain, the eaves of the buildings are elongated to the street, and form a porch on the street side. All of these porches connect with each other to form a special architectural structure, “long-porch” (“*chang lang*”), a local feature in architecture (Lve, 2012), also called “wind-rain porch” (“*feng yu lang*”) by local people, as it protects people from the influence of wind, rain and strong sunshine (Figure 3.15). Similar structures can be seen widely in the southeastern provinces of China such as Fujian and Guangdong, as well as in southeastern Asia. Thus, it is believed that this architectural design was introduced by immigrants from southeastern China at the beginning of the Qing Dynasty (Ji, 2000).



Figure 3.15 Long-porches along both sides of main-street in Dantu market

Note: **Top left:** A quiet long-porch extending along main street on a non-market day; **Top right:** Neighbors like to sit under the long-porch at their courtyard doors, resting, chatting, or doing their homework. The long-porch becomes a public place for the social communication of the local community; **Bottom left:** Empty teashop tables after “*gan chang*”, during which the long-porch becomes an external part of the shop; **Bottom right:** The long-porch, filled with different stands, becomes an important marketing space during market day.

Source: Photo provided by Tian Min, 2020

At Dantu market there are many types of porches, most of which have a wooden framework and present different types of structures (Figure 3.16). Recently, reconstructed houses have had their wooden columns replaced by reinforced concrete. According to a survey of traditional porches in 2019, the basic structures of porches in this marketplace include the “two-step eave style” found on Houses No. 12, 20, 59 and 73, and the “three-step eave style,” which is occasionally found (as in House No. 39). Traditionally, in order to reduce the impacts of humidity and wood rot, the wooden columns are erected on stone bases (called “*zhu chu*”, literally meaning “column base”).

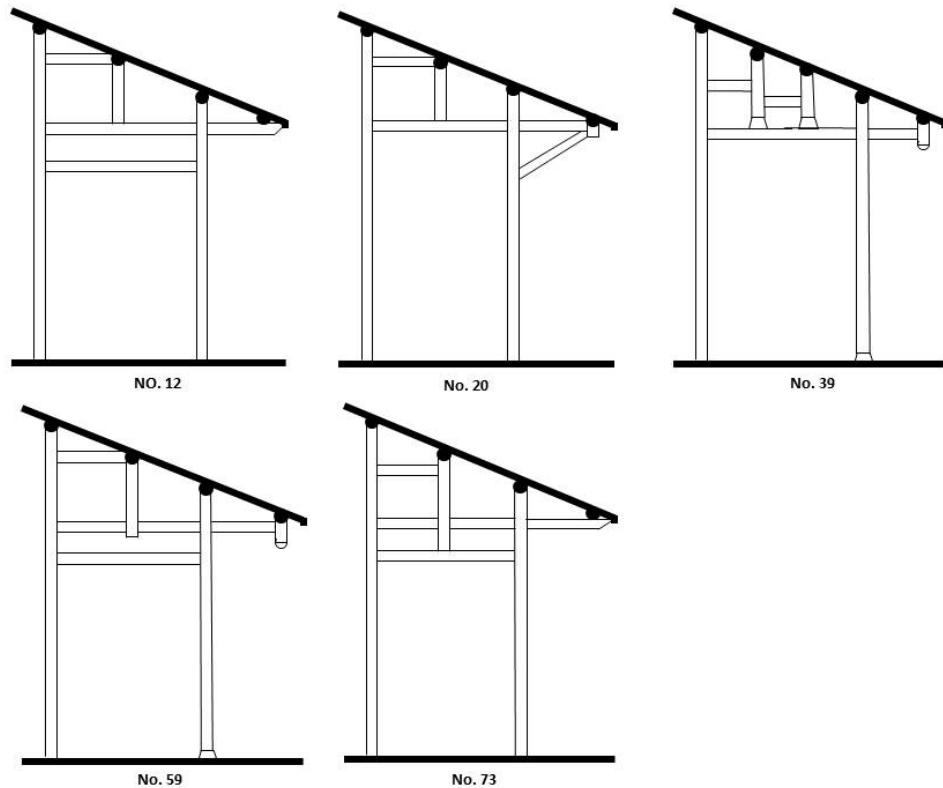


Figure 3.16 Main styles of traditional porch framework in Dantu market

Note: House numbers of surveyed cases are shown; drawn by author in 2019

The traditional “long-porch” lined up in two arrays has been maintained well in the northern section of the main street, where the width of porch is about 2 – 2.5 m. The maximum width is 3.26 m, found at House No. 57, while the minimum width of 1.3 m is at House No. 29. In the side-street from east to west, there is no porch structure. In the southern section of the main street, only a few porches remain after a disastrous fire many years ago (as reported in interviews). Generally, the long-porch presents its widest part at the middle section of the market street, but becomes narrow at the two ends, forming a “boat shape” (Zhao and Zhong, 2009; Lve, 2012; Sun and Zhou, 2015). This architectural structure was thought to be beneficial to not only trading activities during market days, with the wider middle section able to accommodate the teeming public while the narrow street-ends made the town defensible, being easily closed by the town gates during emergencies (Ji, 2000).

The “long-porch” belongs to the semi-public space, a transitional belt between the closed private living space of the courtyards and the open-air public space of the street, and is referred to as “grey space” (Ji, 2008). It is an architectural symbol which divides the space into areas for “guest” and “host,” for shopkeepers and customers respectively. After the rush of market day, the “long-porches” quiet down and become the main space for children frolicking, students reading, women knitting, or men chatting.

Under the eaves local residents discuss their interests with their neighbors, which further enhance the “sense of identity” of a community. During market days, the “long-porch” becomes the platform of traders or itinerant peddlers. Many temporary stalls are established under the eaves. Some peasants take a rest at the courtyard doors after they sell out their products for the day or have finished buying necessities (Figure 3.17). The street sides thus function as a public space for the communication between “hosts” and “guests”. This kind of communication occasioned by the “long-porch” meets the spiritual and social demands of local people, which is the reason why “long-porch” was called “architectural media” by Ji (2000).



Figure 3.17 A courtyard door (House No. 20) opening during a marketing day

Note: Two women from Yongxing Zhen rest under the porch after their “*gan chang*”. Although they are strangers, the porch provides them a temporary place for the communication between “host” (waking outside of the door) and “guest”.

Source: Photo by author, 2019

From an architectural perspective, the ratio between the height of the eave fringe and the width of street can be used to describe the division of space quantitatively. The “width” includes two dimensions, i.e. the width of street surface (W_1), and the width between building faces (courtyard walls) on street sides (W_2) (seeing Figure 3.18). It should be mentioned that the “width” is also subjective, and depends on the assessment of individuals on the street. People prefer to feel the “width” of a street depending on their demands or where they stand. While they walk on the street, for instance, their feeling of W_1 may be the stronger one, but standing under the eave, W_2 might dominate their spatial feeling (Lve, 2012). In this study, however, I used the ratio value (R) to measure the objective space. The higher the R value, the

wider the public space of the section of street. A wide space generally feels more comfortable. The formula of R value is as follows:

$$R_1 = W_1/H \quad \dots(3.3)$$

$$R_2 = W_2/H \quad \dots(3.4)$$

Here, W_1 is the width of street surface; W_2 is the width between building faces; H is the height of eave fringe; R_1 and R_2 are the ratio values of public space.

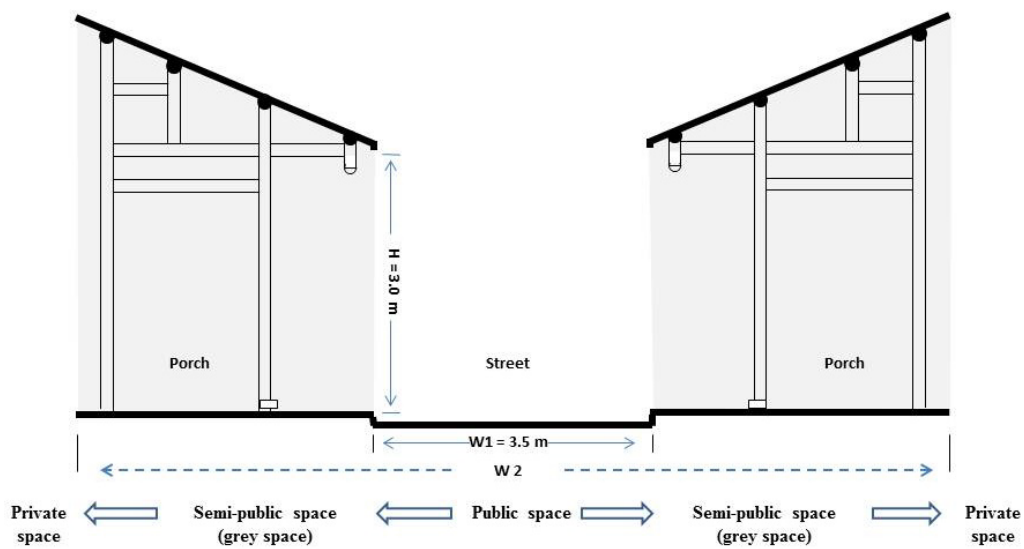


Figure 3.18 Profile of main-street in Dantu market illustrating the change of spatial feeling from private to public space

Source: Drawn by author based on field survey, 2019

In Dantu market, the width of the street surface (white space) is relatively stable, about 3.25 – 3.50 m wide, but the width of porches (grey space) varies between 1.3 – 3.26 m. The height of the eave fringe is the same as about 3.0 m. Thus R values are:

$$R_1 = 1.08 \sim 1.17$$

$$R_2 = 1.95 \sim 3.34$$

It was reported that the R_1 of other traditional market towns was about 1 (Lve, 2012). When the street surface is too wide and the porch is too narrow, it creates a lack of the feeling of separation in the outer

interface of the long-porch. A porch with a wide enough space can provide a unique place for trading activities, which differ from the street surface, where people mainly walk through. Thus, the outer interface of the long-porch, an imagined boundary (like a screen) from the eave fringes to the ground, divides the street into two functional spaces, white space and grey space (Figure 3.18). Generally, the R_2 in Dantu market varies between 2 and 3.3, which means a much wider space of porch, or grey space, than street surface or white space. Generalizing the findings in Dantu market and other market towns (Ji, 2000), the functions of “long-porch” may be summarized as follows:

- It is a marketing space during all kinds of weather, as the elongated eaves protect the market from both rain and sun. The semi-public grey space thus increases the comfortable feeling or ‘sense of security’ of both “hosts” and “guests”.
- It can divert the flow of marketers during peak times on market days and reduce the congestion of crowds in the street due to its widened space.
- It can divide the market street into different functional zones, including public space for walking and semi-public space for peddlers’ trading or resting.
- It can serve as a “bridge” for connecting neighbors in a small society, where neighbors or visitors can communicate with each other easily and frequently, enjoying a harmoniously social relationship.

3.3.2.2 Courtyard-based public space

In the Chengdu Plain the settlements located at a market town are generally a complex of courtyards, connected to each other as two arrays along the street. In a market town a larger public space generally means a larger market. This means more space for public use (Peng, 1994). Although courtyards are privately owned, the front parts are usually used as shops, which then may be considered as public space (or at least semi-public space). A typical courtyard normally includes three parts: Shops in the front, a “sky-well” (called “*Tian Jing*,” a central drainage area) with kitchen and dining hall on both sides located at the middle, and living rooms in the rear (Figure 3.19; Figure 3.20; Figure 3.21). These three parts may be penetrable, normally without clear lines of demarcation (Liu, 2014).

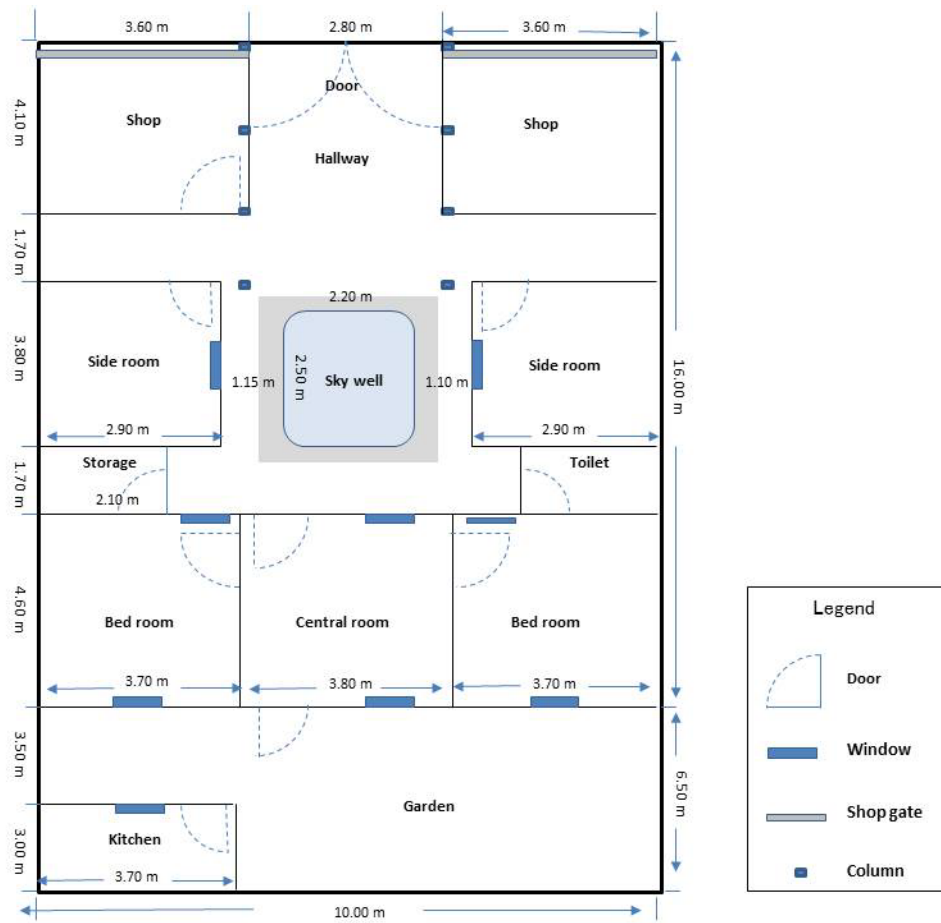


Figure 3.19 Plan of courtyard houses (No. 37-39) in Dantu market

Note: Two shops are located in the front, along with a living space in the rear and a “sky well” surrounded by porches at the middle

Source: Surveyed and drawn by author, 2019



Figure 3.20 Front architecture of Courtyard No. 37-39

Note: **Top left:** Courtyard No. 37-39 belonging to the Ye family, located in the middle section of the main street. The porch has four wooden columns, forming three spans with a 2.5 m wide porch at the front face; **Top right:** Wooden framework for supporting eaves; **Bottom left:** Front porch of the courtyard; **Bottom center:** A “*zhu chu*”, the stone base of the wooden column; **Bottom right:** The central door of the courtyard used by the host.

Source: Photo by author, 2019



Figure 3.21 A view of “sky wells” for rain water discharge and air exchange in Dantu market

Note: **Left:** Numerous “sky wells” indicating many courtyards connected in a line; **Right:** A “sky well” showing the inside structure of the courtyard.

Source: Photo by author, 2019

(1) Tea houses

Tea houses (“*cha pu*” or “*cha guan*” in Chinese) are among the most important public spaces in traditional market towns. They are not only a place for chatting, relaxing, and entertainment, but also a space for negotiating business and cultural performances (Wang, 2008). For those peasants or peddlers coming into the marketplace during market days, tea houses are the most favored places for communicating and involvement in various social activities. Tea houses provide an affordable means of public engagement. While discussing the traditional tea houses in Chengdu, Wang (2010) mentioned:

“There was no public space like the tea house which could connect with the daily life of local people so closely. What happened in a teahouse every day was a true picture of the life style of this city and its citizens. In fact, the tea house was like a microcosm, refracting the diversity and variability of this world.” (Wang D., 2010: 11; translated from Chinese text)

In Dantu market there are five teahouses, located evenly along the main street from north to south. Considering that 41 households currently live in the market streets, every eight households have one

teahouse on average. Tea houses not only serve local dwellers, but visitors on market days also. A long-time owner of tea house, Mr. Liu, recalled that there used to be 17 tea houses during the flourishing period of the Dantu market (in the 1940s and 1950s). The number of teahouse in a market town illustrates the importance of a market in a given region and reflects its prosperity.

It should be noted that “*gan chang*” is seldom a day-long activity, but generally last only a few hours in the morning. The pulsations of marketing activity which occur as both mobile firms and consumers converge at a market town define one of the basic life rhythms in agrarian societies (Skinner, 1964). In Dantu market, for instance, tea houses as well as many other shops are normally opened from the early morning (as early as 6:00 am) to 12:00 pm. In the summer they may close even earlier. If a tea house also provides the service of Majiang (Mahjong), it may be open until the afternoon.

According to a survey of Dantu market, the frequenters of tea houses are mainly elder men, who account for more than 70% of customers. Women are seldom found in teahouses, but they occasionally sit down to play Mahjong also. Long-time customers are very faithful to their tea house, drinking tea in the same house every time, as they meet their old friends or acquaintances there. Tea houses are also important temporary working places, where local people can discuss their business during market days, as described by Skinner (2017) in his field notes. The low cost is one reason for the continued gathering of local people in tea houses. At present, the price for one cup of tea in Dantu market is still two Yuan RMB, but in Chengdu City it costs at least ten Yuan RMB. While studying rural market and social structure in the Chengdu Plain, Skinner (1964) also proposed that tea houses and restaurants in traditional market towns play a similar function, providing public facilities and services to customers:

“He socialized in the teahouses with fellow peasants from village communities far removed from his own. Nor was the peasant alone in this, (for rural market) there was a teahouse for everyone, and few persons who went to market failed to spend at least an hour in one or two. Codes of hospitality and sociability operated to bring any community member who entered the door quickly to a table as somebody’s guest. Inevitably an hour in the teahouse enlarged a man’s circle of acquaintances and deepened his social knowledge of other parts of the community.” (Skinner, 1964:35).

In the Chengdu Plain, benefiting from the finely-tuned irrigation system, agriculture is well developed. Local peasants do not need to work in fields all year round. They have enough time to do business or entertainment, and can also spend their time in teahouses (Wang, 2010). Communication among customers in teahouses helps the smooth flow of information, connecting those residents scattered on *linpan* landscapes as an integrated community, which thus enhance societal resilience. Peasants living in dispersed settlements may not have opportunities for visiting their neighbors frequently, but they can often meet at the same tea house during market days. News and knowledge can be gained or

disseminated as they drink tea together (Figure 3.22). People may also arrange for cooperation and coordination in irrigation, wholesale business, or house construction. A free and cordial atmosphere thus becomes one of main reasons for the tea house's important role in social integration (Wang, 2008; Liu, 2014).



Figure 3.22 Seniors gathering in tea houses during market day in Dantu market

Note: **Top left:** Old friends meet together in teahouse, an important purpose of their “*gan chang*” (in 2020); **Top right:** A man sits in a teahouse and does business (selling bamboo crafts) at the same time (in 2020); **Bottom left:** Customers may bring their own tea cups and add hot water in the teahouse, but most of them like to order a cup of tea again (in 2020); **Bottom right:** The teahouse is not only for drinking tea but also for recreation, such as playing mahjong or cards. Here four men are playing a local card game, called “*chuan pai*”, literally meaning “Sichuan card” (in 2021)

Source: Photo by Tian Min, 2020; 2021

(2) Restaurants

In Dantu market there are five restaurants located on the main street, including two at the north-end, one at the middle of northern section, one at the crossroad, and one at the south-end. These restaurants are

courtyard-based, facing the main street with the front and middle parts of the courtyard being used as dining halls. Except for the Peng Ji Restaurant at the southern-end, which is the biggest, all of these restaurants are only opened during market days (even for a half day). Peng Ji Restaurant is opened almost every day, because it is an important facility in this market town for local people to celebrate their important events such as weddings, birthdays, and even bereavement.⁴² When hosting a large banquet, the hosts book the whole restaurant for themselves and invite their friends, neighbors and relatives to take meals together (Figure 3.23). This kind of large party, called “*bao xi*” (wholly using all tables) traditionally in the Chengdu Plain, is an important social activity in rural areas. This kind of restaurant has a social function similar to that of a teahouse, as a social forum.



Figure 3.23 “*Bao Xi*”, an important activity in rural areas for social networking

Note: **Top left:** Peng Ji Restaurant, the biggest restaurant in Dantu market located at the southern end of the main street (in 2020); **Top right:** A waiter prepares a table for “*bao xi*” (in 2019); **Bottom left:** A waitress prepares “*dou hua*” (fresh tofu), a very popular food in rural Chengdu, for customers

⁴² The name of the Peng Ji Restaurant tells us that the family name of the owner is Peng. In rural Chengdu local peasants call weddings “*hong xi*” (red happiness), but the death of senior citizens over 70 years old is called “*bai xi*” (white happiness). After the funeral rites, the family invites the participants to take lunch together.

(in 2021); **Bottom right:** Guests enjoy “*bao xi*,” an occasion for many relatives, kinsfolk and friends to meet (in 2021)

Source: Photo by Tian Min, 2020; 2021

Other small restaurants provide customers with simple home-style cooking during market days, opening from early morning to middle day. These foods are inexpensive for local people and easily prepared by cooks, who always act as the hosts of their courtyards. In addition, some local people also make snack foods for sale in the market or at the street side (in front of their courtyard doors) (Figure 3.24). Equally characteristic of rural markets are the wandering “cooks”, who carry their “food stores” to different markets every day, selling snack foods (Figure 3.25).



Figure 3.24 Restaurants and snack-food stands are indispensable for visitors during market days or temple fairs

Source: Photo by Tian Min, 2020; 2021



Figure 3.25 Itinerant “cooks” following the flow of alternative market days

Note: Top left: A tricycle cart offers various preparations of snake, including fritters and pancakes at Dantu market (Photo by author, 2019); **Top right:** A decorated mini-van provides cooked ducks at Sanxing market (Photo by Tian Min, 2020); **Bottom left:** Itinerant cooks bring their equipment with them to offer cuisine in the market hall of Yongxing town (Photo by author, 2019); **Bottom right:** A woman cooks fried pancakes on the streets of Yongxing town (Photo by Tian Min, 2021)

(3) Clinics

Visiting the doctor or buying medicine is one of important reasons for the “*gan chang*” of local people, as health-care services and medical treatment are provided by market towns. In Dantu market there are three clinics at present. One is state-owned, called “Health Office of Dantu Cun” (Figure 3.26), which is administrated by the governmental hospital based at Yongxing Zhen. In this “health office” one young doctor dispenses medical advice to local patients and treats common ailments. If the patients need further medical examination, they are directed to the upper level hospital, Yongxing Hospital. In rural Chengdu, local governments have now established this kind of “health office” in almost all seats of administrative villages (i.e. *xing zheng cun*), which are networked with upper level hospitals located at the seats of *xiang*, *zhen*, *jiedao* or even county towns.



Figure 3.26 A governmental clinic (health office) in Dantu Cun

Source: Photo by author, 2019

In addition to this state-owned clinic, there are two private drugstores where local people purchase medicines and get medical advice. The owner of “Sichuan Kang Bei Drugstore” (“*Sichuan kang bei da yao fang*”), Mr. Xu, is a retired doctor from a governmental hospital. He uses the front part of his inherited courtyard as a drugstore, selling medicines as well as treating some common diseases. According to Mr. Xu’s introduction, there are 30-50 customers (or patients) on average during market days, but only about 10 on non-market days. The patients include local villagers as well as those from neighboring *cun* or *zhen*. Another drugstore is called “Bai Xin Pharmacy Store” (“*bai xin yao ye*”), which is operated by a local man who gathered his knowledge of traditional Chinese medicine from his grandfather. This store mainly offers herbal medicines or Chinese patent drugs for local people (Figure 3.27). The owner reports that his business has declined as young people increasingly prefer western medicine to traditional medicine, so he is looking for other opportunities to generate more income.



Figure 3.27 Two private drugstores in Dantu market provide medicines and medical service
Note: **Top left:** A customer sits at the door of “Bai Xing Pharmacy Store” (House No. 33); **Top right:** Traditional furniture for selling herbal medicine in “Bai Xing Pharmacy Store”; **Bottom left:** Store front of “Sichuan Kang Bei Drugstore”; **Bottom right:** A few customers (or patients) wait for Doctor Xu’s services in “Sichuan Kang Bei Drugstore”
Source: Photo by author, 2019

In market towns these kinds of drugstores or clinics serve the local people, and some also provide traditional treatments such as acupuncture, chiropractic therapy or manipulation, and are very popular due to their convenience and low cost. According to our survey in Dantu market, one of the main reasons that local people continue to frequent private “doctors” more properly called “medical practitioners” is the ease of communication. The medical-practitioner shopkeepers are local people also. The patients and the medical practitioners have known each other for many years, making a trip to the “doctor” during market days feel like a trip to visit a friend. The social relationship is thus the determining factor for local people choosing a local “doctor” rather than visiting a hospital at a higher-level market town. Of course, there are also “itinerant doctors” or “tooth artists” in rural areas, who provide services to villagers with herbal medicines, acupuncture and dental treatments (Figure

3.28). Some traders selling medicinal plants at the market also give medical advice, recommending particular herbs to treat what particular diseases (Figure 3.29).



Figure 3.28 A “tooth artist” treats a customer during market day in Dantu market

Source: Photo by author, 2019



Figure 3.29 Herbal medicines, including collected plants and prepared medicines, for sale at the market

Note: **Top left:** A trader explains his collection to interviewers at Laolong market. He was a “bare-foot doctor” in the 1970s (Photo by Tian Min, 2019); **Top right:** An itinerant shopkeeper shows his traditional medicines to customers on the street of Yongxing market (Photo by author, 2019); **Bottom left:** A booth in the market hall offers medicines as well as vegetables (Photo by author, 2019); **Bottom right:** Local peasants sell fresh and dry herbs collected by themselves at Yongxing market (Photo by author, 2019).

(4) Barber shops

Peasants (mainly males) living in *linpan* units generally go to the market town for haircuts. Traditionally, some itinerant barbers also circulated in rural areas to provide haircut services. However, this kind of service has declined since transportation conditions in rural areas have improved. Barbers generally occupy a fixed plot at the corner of a market or rent a room from which they serve customers on market days. In Dantu market, there are two barber shops located at the northern section (House No. 47) and the southern section (House No. 85) of the main street, both of which are only open during market days (and only in the morning). Barber shops are another kind of public space where local people meet. News and information is passed around among visitors in barber shops. Traditionally, local

people like to cut their hair before festivals or important events such as weddings or birthdays. After the spring festival (Chinese New Year), for example, haircuts must be given to all little boys at the beginning of lunar February, which is called “*long tai tou*” (literately meaning ‘dragon raising head’), indicating good luck in the new year (Figure 3.30).



Figure 3.30 Barber shops at Dantu market

Note: Left (top and bottom): A barber shop located at House No. 47 of the main street. Mr. Mao, from Sanxing Zhen, cuts a boy’s hair to celebrate his “*long tai tou*” (raising dragon head); **Right:** A ‘modern’ barber shop located at House No. 85. The young hairdresser, Mr. Chen, is from Xinglong Zhen

Source: Photo by Tian Min, 2020

Unlike the owners of tea houses and restaurants, however, in Dantu market the barbers are not local residents, but outsiders who rent shops (generally one room in the front part of a courtyard) to provide their services during market days. A possible reason for this is that barbering is a special skill which cannot be done by simply anyone. The barber working in House No. 47, Mr. Mao, is from Sanxing Zhen. He rents two shops, one in Dantu market and one in Laolong market. In this way he circulates every other day between the two markets on their alternating market days. The barber shop mainly serves men and boys, and the price is very low (6 Yuan RMB/person). Mr. Mao only works at one shop

for a half day (during morning market), Leaving him time to manage his farming fields at home in the afternoon. The barber shop based at House No. 85 seems modern (Figure 3.30), and is preferred by young people, but the price is slightly higher (10-30 Yuan RMB/person). The hairdresser is a young man from Yongxing Zhen. Hairdressing is a part-time job for him as well, otherwise he works as a guard at a construction site. Because he can dress hair in various modern styles, some young women now come to have their hair dressed in this shop.

Although barber shops do not attract as many customers as tea houses or restaurants, they still provide an important public space in market town, at least for men. It is interesting to find that barbers are always itinerants while shopkeepers of tea houses and restaurants are local residents. While the first barber, Mr. Mao, has two barber shops in Dantu and Laolong, the second, Mr. Chen, holds two jobs, barbering on market day, and otherwise working as a security guard. In essence, this demonstrates that the total amount of demand encompassed by the marketing area of any single rural market is insufficient to provide a profit level which enables a barber to live well. Periodicity in marketing has the virtue of concentrating the demand for the itinerant barber's services at restricted localities on certain specific days, which is also the case for other kinds of itinerant peddlers (Skinner, 1964). Benefiting from the coordinated periodic schedules of the market day, barbers can arrange to be in one of selected towns in the circuit on its market day or work flexibly in other jobs (Figure 3.31).



Figure 3.31 Itinerant barbers and their booths at market towns

Note: Top (left and right): A “barber booth”, where an itinerant barber serves customers at the street side (left) or the corner of market hall (right) with mobile facilities; **Bottom (left and right):** A “barber shop”, two stationary barber shops based in the front part of a settlement, serving customers only on market day

Source: Photo by Tian Min, 2020; 2021

(5) Shops and marketing spaces

Commercial activities are the pillar of market existence. The prosperity of commercial exchange decides the size and the maturity of a rural market. At a market town, shops are independent of each other, owned by different shopkeepers, who do their business according to their own preferences. When customers enter the market-street, they can walk along the street or through the long porch to visit these shops one by one. The shopkeepers may be the owners of the courtyards or tenants. During market days, the products and goods carried into the market town are displayed in the shops or stalls on both sides of the market-street, presenting a dazzling array of diverse goods and commodities (Figure 3.32). Listed by type of commodity, the shops or stalls in the streets of Dantu market include the following: (1) Necessities for daily life necessity, such as cigarettes, candy, soy sauce, vinegar, and cleaning products;

(2) Necessities for production, such as farming tools, fertilizers, pesticides, fodder, and seeds; (3) Home wares, such as tableware, kitchen ware, and home appliances; (4) Food, including butchered meat, alcohol, grain, and table oil; (5) Clothes, such as shoes, sock, hats, cloth and dresses; (6) Other, such as mobile phone stores or ritual and religious goods.



Figure 3.32 Shops or shopping booths in Dantu market during market day

Note: **Top left:** A clothing booth under the long-porch of the main street; **Top right:** A butcher shop located at the crossroad of the market street; **Bottom left:** A courtyard owner sells necessities for production, such as vegetable seeds, fertilizers, and pesticides, on a market day; **Bottom right:** A small restaurant open for customers.

Source: Photo by author, 2019

According to local elderly people, in the 1950s there were four butcher shops, two grain shops, five breweries for distilled spirits (liquor shops), seven tea shops, one inn, and two shops for ritual and religious goods in Dantu market. There were also a few small workshops, including a fabric dyer, blacksmiths, and a vermicelli shop. At that time, the market day was once every three days. Due to the prosperous wholesale markets for pottery and firewood, many traders gathered here periodically, which promoted the development of the rural market. Before the 1950s firewood was the main energy source for daily life in Chengdu city, and was mainly imported from the hills and mountains near Chengdu city,

such as the Longquan Mountains (Wang, 2019). While traders transported firewood from Dalin to Chengdu city, Dantu market offered a logistically convenient overnight stop. A wholesale market for firewood was thus located to the north of the market town. Pottery products such as pickle jars made in the Dantu area were an important and traditional bulk item, as Sichuanese pickle was the traditional home-made food in almost every local household. All of these wholesale markets were located outside of the market town, which was intended to ease the flow of visitors during market days.

Every market town provides a particular place for fresh products such as vegetables, fruits, live poultry, eggs, live fish, and grain (particularly newly-produced rice). At Dantu market, a market hall (like a bazaar) has been constructed, called “*nong mao shi chang*.” Here, stalls of fresh products or perishable products can be gathered and sold together. At some high-level market towns, such as Yongxing and Jiancha, the newly constructed market halls are more comprehensive and larger in size, and include all kinds of goods or commodities (Figure 3.33). In market halls, shopkeepers may rent a stationary stall to sell their goods during market days and local peasants temporarily exhibit their products such as vegetables, fruits or eggs at the sides of market halls. A few services can also be found in market halls such as itinerant barbers, sewing services, and snack food vendors, but most of the social or cultural facilities are allocated outside of market halls.



Figure 3.33 Marketing activities (“*gan chang*”) in newly constructed market halls
Note: **Top left:** Local people selling vegetables in market hall of Dantu (Photo by Tian Min, 2020); **Top right:** Stands of dry foods in the market hall of Yongxing (Photo by author, 2019); **Bottom left:** In addition to food, daily necessities are common in the market hall of Yongxing (Photo by author, 2019); **Bottom right:** Sewing service during market day in Yongxing (Photo by Tian Min, 2021).

If local people require items not on offer in this market, they must go to upper level marketplaces, such as Yongxing, Jiancha or even Chengdu city. In addition, many sellers at rural market towns are likely to be itinerant, who provide various goods as well as services (Figure 3.34). Rural market towns normally support a number of craftsmen, including (most typically) blacksmiths, carpenters, and makers of paper effigies for burning in religious rites. A few crude workshops to process local products may also be located in market towns. However, these market-based handicraft industries are progressively declining and even disappearing in most market towns.



Figure 3.34 Itinerant peddlers at rural markets

Note: **Top left:** A peddler sells prepared meat in Dantu market (Photo by author, 2019); **Top middle:** A cook prepares corn cake with mobile facilities, Yongxing market (Photo by Tian Min, 2021); **Top right:** A peddler sells prepared pickles (salted vegetables) from his mobile stand, Sanxing market (Photo by author, 2019); **Bottom left:** A craftsman makes bamboo knickknack during market day, Yongxing market (Photo by author, 2019); **Bottom middle:** Many traders drive their automobiles and circulate between markets, Sanxing market (Photo by author, 2019); **Bottom right:** A barber serves a customer at the corner of market hall, Yongxing market (Photo by Tian Min, 2021).

(6) Cultural space

The importance of a market town is based not only on its socio-economic services but on its cultural services. Local peasants visit the marketplace frequently because of these diverse functions. A traditional market town offered many facilities, buildings, and infrastructure for cultural purposes such as temples, schools, arenas, and playgrounds. In Dantu market there used to be a primary school located at the western section of the side-street. As young people increasingly migrated to urban areas, the number of school children decreased. Now all children must go to the schools based at *zhen* (e.g. Yongxing or Jiancha) for their primary and secondary education (Figure 3.35). There are no longer any

primary schools based at the *cun* level in rural Chengdu. The previous primary schools were combined and moved to *zhen* or *Jiedao*



Figure 3.35 A newly established kindergarten at Yongxing Zhen

Note: A kindergarten attended by most children from Dantu Cun

Source: Photo by author, 2019

In rural Chengdu before the 1950s, local people worshiped different gods in different traditional festivals. The activities of traditional believers formed the elements of local culture. In addition to worship at home, public worship was held with ceremonial celebrations, which evolved into festivals. For those people living in dispersed *linpan* settlements, a celebration held at a market town was undoubtedly a great social event. The streets or squares of market towns thus became a public space for spiritual expression. The cultural performance of festival celebrations in the public street was a part of temple fairs, which formed the main cultural life of local people. Performances presented by wandering artisans, myriad entertainers, boxers, magicians or theatrical troupes during the celebration ceremony reflected strongly the local culture and could be an important channel for social harmony and integration. Durkheim (1895) found that people’s norms, beliefs, and values make up a collective consciousness, or a shared way of understanding and behaving in the world. The collective consciousness binds individuals together and creates social integration.

In Dantu market there were once two temples. One was “*tu di miao*” (literately “earth-god shrine” or “earth-god temple”) located at the western end of the side-street. It is believed that earth-god worship can be traced back to the Ming Dynasty in Han Chinese society (Baidu encyclopedia, 2021). The Earth-god temple or shrine was always built by local people themselves, with a simple architectural

structure, in temple style or shrine style, often located on the roadside or under a big tree (Figure 3.36). There were also finely-designed, complex buildings, normally found in cities (Baidu encyclopedia, 2021). Before 1949 “*tu di miao*” could be found in every market town of rural Chengdu. The worship of the earth god is important for peasants because the earth indicates harvest and prosperity. For Han Chinese, particularly those people in rural areas, every person at birth has his or her own “*tu di miao*,” to which he or she belongs for life, a concept linked to a sense of native place or origin (Baidu encyclopedia, 2021). Thus, the shrine of the earth god was considered as the central place when the dispersed *linpan* households formed themselves into natural groupings. The sphere of worship of one “*tu di miao*” actually indicates the range of a village community, reflecting a “sense of place”.



Figure 3.36 Earth-god shrines in a market town, Huanglongxi, Shuangliu

Note: **Left:** An earth-god shrine under a big tree at a Buddhist temple; **Top right:** An earth-god statue at the street-side; **Bottom right:** An earth-god statue in the shrine under a big tree at a Buddhist temple.

Source: Photo by Tian Min, 2021

The other temple at Dantu market was called Old Temple (“*lao miao zi*” in Chinese) by locals and was located about 200 m to the south of the town. This temple was mainly devoted to Da Yu (Yu King), a legendary ancient king and the patron deity of pottery-makers. At the beginning of the 1950s there were seven pottery kilns in the Dantu area. Pottery products (in particular pickle jars) made in Dantu, which

were a bulk commodity for exporting, were very famous in the Chengdu market. This Old Temple was constructed in the middle of the Qing Dynasty, about 200 years ago, and expanded later with the development of the pottery industry in the Dantu area. Every spring (at the beginning of lunar February), craftsmen working in these kilns would gather in Old Temple to worship their ancestor, Yu King. The sacrifice rite and the public celebration were combined, and could last for seven days. During this festival, local people liked to gather in the market town for the “temple fair” (“*miao hui*” in Chinese), a specific marketing activity.

At Dantu market, the celebration ceremony was organized by a committee which included leading shopkeepers, owners of pottery kilns, and the most powerful or knowledgeable members of the local community. A number of pottery kilns would sponsor the celebratory events, including cultural performances and lion-dance parades. For rural people the temple fair and ancestor worship were vital in relieving the tedium of a lifestyle which could be notably devoid of such cultural events. As Skinner notes (1964), while market day brought relief from the tedium of rural life through the provision of recreational opportunities, the temple fair afforded the high point of the villagers’ recreational year. When combined with commodity trading, cultural performances, and local food exhibitions, temple fairs or other celebratory events played a very important role in providing an annual reaffirmation of the community’s territorial extent and a symbolic reinforcement of its town-centered structure (Skinner, 1965a). The performance of traditional Sichuan opera at the market town was also important for spiritual cohesiveness, dissemination of traditional knowledge, and moral education in a rural society where, at the time, most peasants were illiterate.

Ancestor worship (called “*qing ming hui*”) was rooted in the rural society of the Chengdu Plain, and was held by different families or clans in spring (during the Qing Ming Festival which is normally at the beginning of April). In some places large families or clans have their own ancestral temple or clan hall (Figure 3.37). When the Qing Ming Festival approaches, all members of a big family (patrilineally related) or a clan (localized lineage of the same family name) living in the area or the surrounding *xiang* (or even from remote areas) gather to hold a memorial ceremony. Because many of peasants in the Chengdu Plain were immigrated from central or southeastern provinces during the early Qing Dynasty (about 300 years ago), the households distributed in numerous settlements constitute in effect an offshoot of the lineage localized in their place of origin, often not far away. Through segmentation of this kind over a period of centuries, certain portions of the rural landscape have come to support a number of localized lineages of the same family name, all historically related by virtue of descent from a common ancestor. Therefore, the memorial ceremony every spring undoubtedly consolidated the social relationship of these households situated in different *xiang* or market towns, and ideally it strengthened their capacity to cope collaboratively with external pressures or shocks.

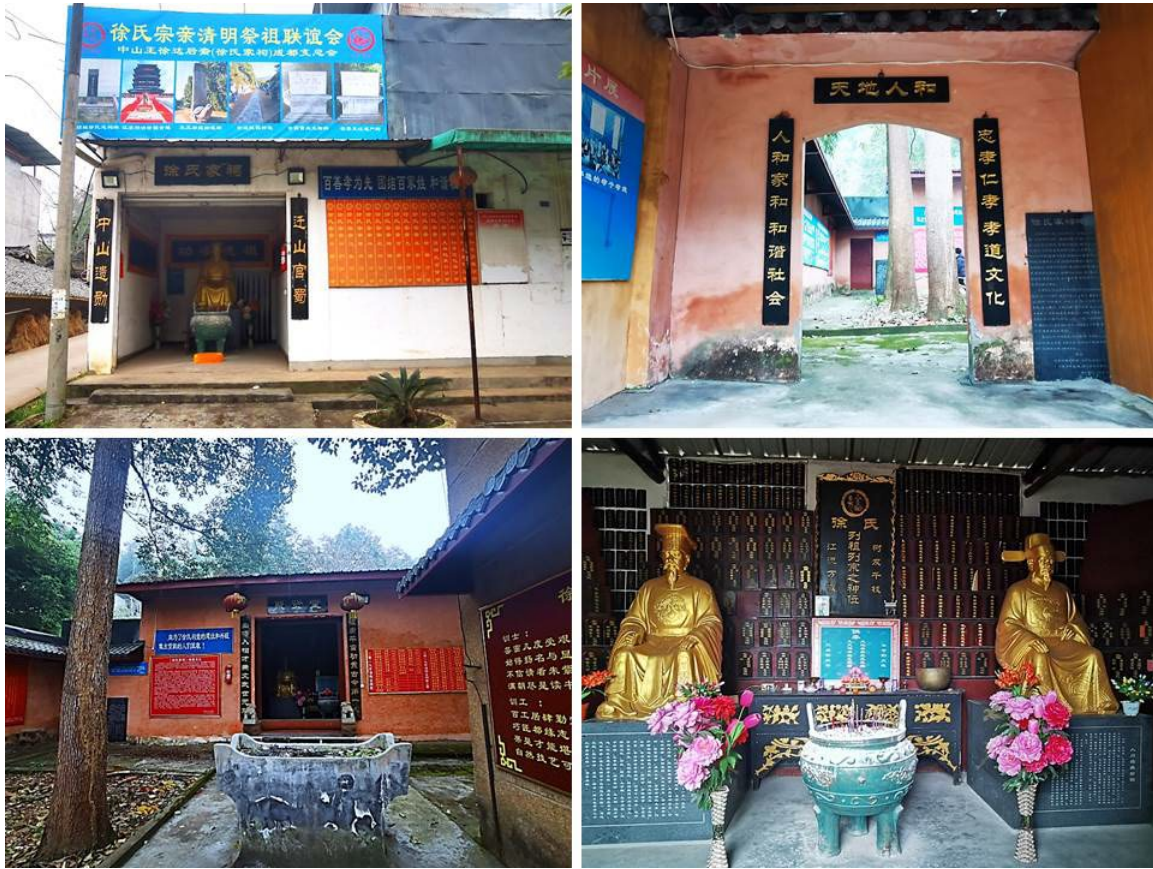


Figure 3.37 A clan hall (Family Xu) located near Dantu market

Note: Every spring (on or before Qing Min Festival) members of the Xu’s clan gather here together to worship their ancestor, Xu Da, a famous general of the Ming Dynasty

Source: Photo by author, 2019

With the progress of socio-economic development, the traditions of ancestral worship have begun to fade in the younger generation. The spiritual space of market towns has been transformed into numerous new styles. In the market towns close to Dantu, there are now three Buddhist temples, which have been maintained or rebuilt after the Cultural Revolution (Figure 3.38). When important festivals approach, such as Chinese New Year (Spring Festival), local people often attend one of these temples for worship (called “*shao xiang*”). Following the development of rural tourism, these temples have become sight-seeing spots for visitors.



Figure 3.38 Three Buddhist temples located close to Dantu Market

Note: **Top left:** Dalin Temple (*da lin si*), the biggest temple in this area, located at Dalin Zhen (Photo by author, 2019); **Top right:** Ming Shui Temple (*ming shui si*), a famous temple in the Qing Dynasty due to the visit of the Royal Prince, located at Yongxing Zhen (Photo by Tian Min, 2020); **Bottom left:** Wo Yun Temple (*wo yun si*), a very old nunnery which dates dated back to the Tang Dynasty, located at Yongxing Zhen (Photo by author, 2019); **Bottom right:** the historic building of Wo Yun Temple (Photo by author, 2019).

In Dantu market, a small museum was also established in the old courtyards (Figure 3.39). The owner's collections which include as outdated books, journals, paintings and furniture, are mostly related to the history of Chengdu, Yongxing or Dantu. Local participation in the tourism is important and raises the awareness of historic preservation in the local community. The historic site of a pottery kiln and the entire market street in Dantu have been preserved, parts of which required repairs or maintenance, and are used as sight-seeing spots.



Figure 3.39 Historic buildings preserved as cultural heritage sites as well as tourist attractions

Note: **Top left:** A stele erected at the entrance of market street in Dantu, naming it as a cultural relic protection site, “Street of Ming and Qing Dynasty”; **Top right:** A small museum called “*de juan shu yuan*” (literately “Dejuan College”) located in an old courtyard, House No. 57-59, in Dantu market; **Bottom left:** One of the important tourist attractions in Dantu market, “*tong zhi long yao*”, where pottery making is performed for visitors; **Bottom right:** a label standing in front of the historic site of the pottery kiln

Source: Photo by author, 2019

In conclusion, the spatial features of a market town, in particular its public spaces revealed the relationship of the traditional marketing area to the society. With the advance of socio-economic development, in particular the rapid urbanization of the Chengdu Plain, the fate of rural markets in a modernizing landscape is essentially dependent on the spatial patterns and temporal sequence of transportation modernization (Skinner, 1965b). When marketing structures in a given area have been completely modernized, rural markets will be changed into modern trading centers. Daily markets, as a designated trading system, would replace periodic markets.

This study emphasizes the issue that preservation efforts should not only focus the architectural features of a market town, but the way in which traditional marketing activities shaped the peasants’ way of life-

not just the physical space, but the collective experience of everyday life and the traditional knowledge embedded in their life. This idea is essential in cultural landscape preservation but always has its question mark about how to implement it. Preserving a building in a static mode or even freeze it as a museum is feasible but it will never be possible to do this with an evolving and productive cultural landscape. The key here, I think, is how to preserve the information, the knowledge of adaptation to the environment and being resilient.

Now, the combination of a number of “*xiang*” as one urbanized “*zhen*” which then becomes a “*Jiedao*” is leading to a transformative expansion of social horizons, which is likely to involve a contraction of social community or a structural change in society. During my fieldwork, I found a few markets in villages were abandoned because a few villages nearby were combined into a bigger “*cun*”. This led to the result that some disadvantaged villagers cannot go to the nearest market and get their services within a reasonable walking distance. This generated many challenges as we witnessed during the pandemic, because speaking from a systematic point of view, diversity and redundancy enhance the system resilience in many ways. Actually, many cities in the world are trying to establish living circles in cities, e.g. the 15-20 min living circle during and after the pandemic for the convenience of the citizens, which is what the rural Chengdu Plain and the *linpan* landscape has already evolved for hundreds of years.

Chapter 4 Resilience of the *Linpan* Landscape to Disturbance

The stability of a socio-ecological system was characterized by Holling (1973) as the persistence of the system near or close to an equilibrium state. By contrast, resilience describes the behavior of dynamic systems far from equilibrium, is defined as the amount of disturbance that a system can absorb without changing state (Gunderson, 2000). This means a resilient system should have absorbing capacity, i.e. the potential capacity of a system to cope with external threats. Following this principle, a resilient society or cultural landscape is one that has taken measures to adapt and respond to threats or disturbances. The response of a cultural landscape may be automatic based on its structure and function, but adaptation involves human adjustments to enhance the viability of socio-economic development and to reduce its vulnerability to external threats, including natural (as in climate change) and anthropogenic (as in urbanization) events.

Many previous assessments of resilience have focused on coping with global climate change or major natural disasters such as earthquakes and tsunamis (Bergamini et al., 2013). Research on socio-ecological resilience to public health events has been relatively lacking. Additionally, the resilience assessment of suburbs and distant rural areas is often overlooked in favor of urban areas. This neglect is not only reflected in data gaps, but also inequality among social groups and insufficient attention to rural society (Cuijpers et al., 2013). Due to the weak infrastructure and relatively poor medical care in rural areas, there is a general belief that these socio-ecological systems would easily collapse if hit by external disturbances such as epidemic diseases. Unlike urban centers, rural areas are not only easily affected by human infectious diseases, but also by infectious animal pathogens, such as avian flu and swine fever. With this consideration, the COVID-19 pandemic provides an excellent example for analyzing the resilience of rural societies in responding to this sudden disturbance.

The COVID-19 pandemic occurred worldwide beginning in 2020, and undoubtedly provides us with a real-world example for observing the resilience of rural areas from different angles. The impacts of this external disturbance may exhibit in all aspects of socio-ecological systems, including not only human health, but also economic, social and even political domains (ICIMOD, 2020; Jo and Chang, 2020; FAO, 2021). Previous studies on epidemic effects showed that underdeveloped areas are vulnerable to disease-related disasters (Rasul, 2020). At the same time, local culture and the customs of human communities also affect responses to major public health events (Goldman, 2020; Provenzi and Barello, 2020). While facing the shock of the COVID-19 pandemic, the recovery period may reflect the resilience of a given system, or how a system, as it moves from one state to another, may or may not

regain equilibrium. Landscape ecology has discussed the idea that human community has long existed in a "meta-stable state", and posits that this type of state is the basis for the stable existence of human society (Alberti, 2008). Although the new equilibrium state perhaps consists of a set of new conditions, the regrowth of the economy is always the most obvious and notable indicator. A recovered society restarts its economic development following a sustainable trajectory.

As a sudden risk, epidemic diseases such as COVID-19 pandemic seriously impacted the health-care system, as well as the socio-economic system, which resulted in long-term impacts on the whole of human society. When this kind of disturbance arrives, the resilience of a socio-ecological system becomes very important for maintaining a society's integrity and functions. However, the shifts in socio-ecological stability domains are also chronicled as natural or socio-economic resource crisis (Gunderson, 2000). Understanding how to allocate and regulate resources thus becomes the key to promote the systemic return to equilibrium or a steady-state following a disturbance, or in other words, managing its resilience. The capacities of resilience management differ with variances in the natural, economic, and political resources of a region, which inevitably leads to different trajectories of post-pandemic recovery. Based on the official statistical data, combined with sociological and ethnographical surveys, this study aims at establishing a set of indicators which will illustrate the resilience (in term of economic recovery after the Pandemic) of different rural districts of Chengdu.

4.1 Rationales of indicator selection

In this study I select a few categories of indicators which may reflect the resilience of rural Chengdu in the face of the COVID-19 pandemic, and verify the effectiveness of these indicators with the actual economic recovery during the post-pandemic period. In the case of a rapidly spreading disturbance such as a public health event, the resilience of a system is usually determined by a number of factors, which should differ from long-term impacts such as climate change. For measuring the resilience of socio-ecological production landscapes (SELPs), a set of inclusive indicators was used (Bergamini et al., 2013), including: (1) ecosystem protection and the maintenance of biodiversity; (2) agricultural biodiversity; (3) knowledge, learning and innovation; and (4) social equity and infrastructure. This approach is enlightening in following resilience assessment (Cuijpers et al., 2013; Tippins, 2014). However, when considering the difference between disturbances and impacted systems, the indicators and the combination of categories for assessment must be different. Some specific indicators related to the resilience capacity of the system under specific pressure (as in the COVID-19 pandemic) should be considered.

The feasibility of indicators and the availability of data for assessment should also be taken into consideration. As mentioned above, in rural areas there are many data gaps and it is difficult to give a

rapid assessment after a disturbance. In order to provide a comprehensive assessment of potential resilience in the Chengdu Plain, I have mainly used official statistics (extracting data from published yearbooks) combined with questionnaire surveys, for a combination of top-down and bottom-up approaches. The advantage of official census data is that it is published every year and is accessible to planners, and decision makers as well as scholars, but their variable settings may not completely match our study objectives. Therefore, a targeted questionnaire provides complementary information for specific purposes such as indicator weighting.

In view of published data in official statistical annuals, four categories of indicators were developed to assess the resilience of rural districts of Chengdu in this study, including: **Health-care Index, Economy Index, Governance Index and Landscape Index**. Since the resilience of a system is determined not only by conditions (such as facilities and infrastructure), but also various subjective factors, such as the leadership of local governors and the publics' willingness to cooperate, the assessment based on statistical data could only indicate the potentiality of the systemic resilience, rather than an actual portrait of a recovered system. Considering that the COVID-19 pandemic is ongoing, further verification of the true state of recovery will need to await future study.

4.1.1 Indicators of health-care index

The medical and health-care conditions of a county or district are undoubtedly the basis for preventing and controlling the occurrence and spread of epidemic diseases, and provide substantial support in the recovery of the public health situation. The Chengdu Statistics Yearbook (2020) offers three kinds of indicator data which are relevant to the category of the health-care index at the county or district level, including: (1) the number of health-care institutions (e.g. hospitals and clinics); (2) the number of sickbeds in hospitals and clinics; and (3) the number of professional staff in health-care institutions (surgeons, physicians, pharmacists, etc.). The hypothesis is that the more medical and health resources there are, the stronger the resilience capacity of a county or district will be, coupled with a greater ability to control epidemic diseases and to mitigate negative impacts. This in turn should lead to a more rapid recovery of the socio-economic situation after the disturbance.⁴³

⁴³ It should be noted that certain conditions, such as the effectiveness of medical institutions and the expertise of professional staff, cannot be assessed based these statistics. These three kinds of indicator data should be considered as the “hardware” of the medical system, which must be combined with the “software” for the whole system to operate efficiently.

4.1.2 Indicators of economy index

The ability of a county or district to control the influence of the pandemic and to promote post-disaster recovery is closely related to its fundamental economic conditions. The hypothesis is that the more developed a county or district is, the stronger ability for prevention and control it will have. The economic basis is also crucial to the speed of recovery. In rural areas in the Chengdu Plain, agriculture is fundamental to the livelihood of local communities, but was barely impacted by the COVID-19 pandemic due to the sparsely populated conditions of the region (Wu, 2020).⁴⁴ Considering the lockdown or administrative restrictions during the pandemic period, enough disposable cash of rural households is beneficial to maintaining their daily lives and to the post-pandemic recovery. In developed districts, although the spread of epidemic disease may cause a high infection rate due to the flow of the larger population and both economic and cultural activities, superior economic conditions, including capital accumulation, sustainable investment, and employment opportunities, are hypothesized to enable a smooth revival of industrial production and commercial activities in the post-pandemic period. According to the statistical data in the Chengdu Statistics Yearbook (Statistics Bureau of Chengdu and NBS Survey Office in Chengdu, 2020), the available indicators for assessing the economic capacity in rural Chengdu include: (1) the gross domestic product (GDP), indicating the overall economic condition of a county or district; (2) the gross output value of agriculture (including farming, forestry, plantation, animal husbandry and fishery) at the county or district level, representing the agricultural situation of rural areas; and (3) the disposable income of rural residents per capita of a county or district, which can directly reflect the real income of the rural population.

4.1.3 Indicators of governance index

As discussed earlier, governance issues often involve policy formulation and implementation and can be very subjective, making it difficult to extrapolate useful information in this area from statistical data. However, focusing on the number of governmental agencies in the administrative system assists us in analyzing the factors that may affect governance capacity. In rural areas, the number of townships (“*xiang*” or “*zhen*”) per capita and the number of administrative village (*xing zheng cun*) per capita indicates the degree of "centralization" or "decentralization" of the governance system in a county or district. It may be generally hypothesized that the smaller the population of an administrative territory is (e.g. one *xiang* or one *cun*), the more decentralized the system is, and the more attentive the government and bureaucratic institutions are to the needs of the populace. If one *xiang* or *cun* only managed a small number of households during the COVID-19 pandemic, it would have been relatively easy to monitor

⁴⁴ The agricultural system is extremely vulnerable to crop and livestock diseases, but that is not the topic of this study.

the situation of each household, and to provide necessary assistance. Conversely, if one *xiang* or *cun* was too large and overpopulated, it would have been difficult for government staff to take into account the necessary aspects of pandemic control, such as the distribution of facial masks or other materials and the monitoring of the necessary "social distancing" in public spaces. Because the administrative units have been changed frequently in the last decade, in this study I follow only two level of governmental institutions in rural areas, *xiang* (including "zhen" and "jiedao") and *cun* (including "administrative village", "inhabitant committee" and "villager committee"). The data at the end of 2019 (Statistics Bureau of Chengdu and NBS Survey Office in Chengdu, 2020) was collated in reference to data from the end of the 2000s (Statistics Bureau of Sichuan Province, 2009; Statistics Bureau of Sichuan Province, 2017) when the names of administrative units had not been changed.

4.1.4 Indicators of landscape index

The landscape index is a set of environmental indicators derived from density-related data, including population density and tillage area per capita. Using data on the area of available land (Statistics Bureau of Chengdu and NBS Survey Office in Chengdu, 2020), we may easily calculate how much land resource one person has in a given county or district. From the perspective of the spreading of epidemic diseases, densely populated places are more likely to see a rapid spread and infection. Thus, the population density in a place is related to the prevention and control of epidemic diseases. Because the population of a region is concentrated in urban areas, I also use the area of farming field per capita to describe the intensity of agricultural land use. It is hypothesized that the less tillage one rural person has, the denser the rural population will be, and the more intensive the land use.

In the rural landscape of the Chengdu Plain there are diverse ecosystems, such as farmlands, forests and wetlands. The ecosystem diversity or landscape heterogeneity may reflect the environmental conditions in a given area, which are fundamental to the resilience of the rural landscape (Alberti, 2008). In this study I use **Shannon-Weiner Diversity Index (SHDI)** to calculate the diversity of the ecosystems in rural Chengdu. The hypothesis is that the high diversity of ecosystems, usually including diversified economic activities and land use, is beneficial to survival during the pandemic disturbance and to recovery following the pandemic. Based on satellite images from 2018, the following types of land covers were identified with the software FRAGSTATS: paddy, dry farmland, forested land, shrub land, woodland, bamboo groves, grasslands, rivers, canals, lakes, reservoirs, built-up lands (including farmhouses) and barren land (e.g. rocks).⁴⁵ These represent the main types of ecosystem in rural

⁴⁵ Data source: Resource and Environment Science and Data Center, China;
<https://www.resdc.cn/data.aspx?DATAID=347>

Chengdu (Wu et al., 2020). The formula of SHDI was used to calculate the diversity of ecosystems, i.e. the heterogeneity of landscape, as follows:

$$H = - \sum_{i=1}^S (P_i \log_2 P_i) \quad \dots(4.1)$$

Here, S is the number of patches; P_i is the proportion between the number of patch i and the total number of patches. For a landscape, if only one kind of patch covers the land surface, SHDI is 0. The higher the SHDI is, the more land cover types there are or the more evenly these patches are distributed. Given that a high SHDI value may result from landscape fragmentation, the implications of SHDI values must be analyzed further in combination with practical situations in a given place. SHDI does not simply represent whether the environmental condition is good or not, but may reflect the diversity of land uses and the potential diversification of livelihoods in rural areas.

4.2 Calculation of indicators

4.2.1 Standardizing data

For purposes of comparison, these collected data are converted into average values per capita in a given county or district except for the Shannon-Wiener Diversity Index (SHDI). Generally speaking, when people in a county or district have more resources, including health-care, economic, administrative and environmental resources, it may be hypothesized that they have a better capacity to cope with external disturbance such as the COVID-19 pandemic, and the local socio-economic situation may be recovered or restored quickly. After standardizing the data mentioned above, a total of 11 indicators within four categories were selected for resilience assessment (Table 4.1).

In order to compare the capacities of different counties or districts, in terms of the resources owned by one person, the absolute data were then converted into the relative value. I used the percentage of anomaly (distance to mean value, DTM) to express the relative significance of a given resource in a county or district in comparison with the average level of the entire region (the entirety of rural Chengdu, including 14 counties or districts). If the DTM value of a given resource in a district is over 100% (the mean value of rural Chengdu), it indicates that a resource owned by one person in this district is higher than the regional average level. A DTM value below 100% represents that the resource per capita is less than the regional mean. In this way, all indicators may be illustrated as percentages, which are feasible for further comparison. For each county or district, the average value of the indicators in each category was calculated, forming a matrix of four indexes in a given county or district, including H values, E values, G values and L values.

Table 4.1 Summary of indexes and indicators of resilience assessment and their abbreviations

Categories	Data	Average value (mean per capita)	Indicators (standardized value in %)	Index values
Health-care index (H)	No. of health-care institutions	HI-mean	DTM-HI (H1)	$H = (H1 + H2 + H3)/3$
	No. of beds	HB-mean	DTM-HB (H2)	
	No. of professional staff	HP-mean	DTM-HP (H3)	
Economy index (E)	Gross domestic production (GDP)	EG-mean	DTM-EG (E1)	$E = (E1 + E2 + E3)/3$
	Gross output of agriculture (GOA)	EA-mean	DTM-EA (E2)	
	Disposable income of rural residents (DIR)	ED-mean	DTM-ED (E3)	
Governance index (G)	No. of township (<i>xiang</i>)	GT-mean	DTM-GT (G1)	$G = (G1 + G2)/2$
	No. of villager committee (<i>cun</i>)	GV-mean	DTM-GV (G2)	
Landscape index (L)	Land area (km ²)	LA-mean	DTM-LA (L1)	$L = (L1 + L2 + L3)/3$
	Tillage field area (ha)	LF-mean	DTM-LF (L2)	
	Shannon-Wiener Diversity Index (SHDI)	LS	DTM-LS (L3)	

Note: (1) The Shannon-Wiener Diversity Index (SHDI) is not converted into the average value per capita. (2) Standardized value is the Distance to Mean (DTM) and each DTM value is used as an indicator.

4.2.2 Weighting data

For a comprehensive assessment of system resiliency, it is important to know the relative contributions of four types of resources or indexes. Considering the role that each index plays in coping with disturbance and post-pandemic recovery, it is necessary to assign a weight to each. In this study I combined the methods of expert assessment with a sociological survey in case-study sites to first identify the partial contribution of each index. They were then weighted using a scale of respective percentages. Finally, the average value of the weighted indexes in a county or district was used to represent its comprehensive resilience.

At first, the weights were determined by iterated surveys with local people in case-study sites. Due to the COVID-19 pandemic in 2020, the interviews were carried out over the online platform “*Wen Juan Xing*” (see Section 1.6.3). After that, a team of student assistants interviewed villagers, village leaders

and local knowledgeable persons with prepared questionnaires (also using “*Wen Juan Xing*”) for adjusting indicator weights. It was found that local people, most of whom are farmers, recognized that the indicators of governance index should be ranked first, followed by the health-care index, the landscape index and the economic index. 60% of the local people felt that an efficient governance system and strong leadership in local government (including *xiang* and *cun*) would be very important for coping with the pandemic influence, and could ensure the effective implementation of mitigating measures. The indicators in the health-care index were also thought to be important to control the epidemic spread. The in-time provision of medical materials (particularly facial masks and disinfectant) and health-care services (vaccinations and nucleic acid tests) was heavily dependent on the health-care resources in a county or district. A sufficient number of health-care institutions and professional staff were undoubtedly the preconditions for success in this area.

Five experts from Sichuan University and Chinese Academy of Sciences (their expertise areas include ecology, environment, urban and rural planning, and geography), all of whom have good experience working in rural areas or *linpan* landscapes, believed that the health-care index should take priority, because medical conditions are very important not only for current mitigation (in 2020) but also for post-pandemic recovery. As there was no large-scale outbreak of COVID-19 in the countryside, the role of health-care indicators may perhaps have been underestimated by local people. At the same time, economic conditions were also perceived as important indicators by experts, particularly for economic recovery after the pandemic. Without a good economic base, they believed it would be impossible to restart and sustain the socio-economic development in a county or district.

The experts ranked the landscape index as the third priority, which matched the farmers’ perception. All of them believed that good environmental conditions, sufficient natural resources, and opening living spaces were necessary for preventing the epidemic spread and facilitating post-pandemic recovery. The governance index was ranked fourth by the experts, because of the difficulty in using statistical data to directly or objectively describe the efficiency and effectiveness of the governance system. Many factors might affect the local governance, leading to many uncertainties. The perception of the leadership of local government as discussed by local farmers, was variable and subjective. To a certain extent, the level of local governance was dependent on personal capacity, mutual collaboration and comprehensive coordination rather than the number of institutions or staff.

In summarizing the viewpoints of both sides, I accepted the suggestions of the experts and readjusted the weighting value of each index. I explained the results to the interviewees from villager committees again and got their agreement. Ultimately, each of the indexes was given a weighting on a scale of percentage as follows: 30% for health-care, 30% for economy, 20% for governance, and 20% for landscape, thus

totaling 100%. The average value of the four weighted indexes was used to indicate the level of comprehensive resilience (R value), with a formula as follows:

$$R_i = (30\%H_i + 30\%E_i + 20\%G_i + 20\%L_i)/4 \quad \dots(4.2)$$

Here, R_i is the value of the resilience index in district i ; H is the value of the health-care index in district i ; E is the value of the economic index in district i ; G is the value of the governance index in district i ; and L is the value of the landscape index in district i .

4.3 Description of indexes with the cases of rural Chengdu

4.3.1 Health-care index

According to the analysis of statistical data in 2019, the health index (H value) varied greatly in the fourteen rural counties or districts of Chengdu (Table 4.2), indicating the difference of medical and health-care conditions. The H values above 120%, i.e. 20% higher than the regional mean, occur in Wenjiang and Xinjin, with H values of 151.15% and 133.26% respectively. There are two districts with an H value obviously below the regional mean, Shuangliu (59.60%) and Jintang (70.72%). In the other ten counties or districts, H values fluctuate around the regional mean within the range of 20%, indicating that their medical and health-care conditions are roughly balanced. A low H value in a district is often caused by a large population. The populations of Shuangliu and Jintang rank first and second among the fourteen districts. However, Pujiang with the lowest population has a relatively low H value, at only 87.25%. Thus, population is not the only determinant of the H value. Economic conditions, for example, may also impact investment in the health-care infrastructure. In the last few years, some sectors (*xiang* or *zhen*) of Shuangliu (especially those bordering with urban center of Chengdu City) have been allocated to the administration of Tianfu New District, a newly established development zone, leading to the loss of some health-care resources (e.g. hospitals and clinics), which influenced the H value of Shuangliu to a certain extent.





In terms of the spatial distribution of medical or health-care resources, there is no significant difference between the districts neighboring the urban center (the inner circle) and those located remotely (the outer circle). Distant counties or districts, such as Dayi and Dujiangyan, in fact possess better medical or health-care resources than many neighboring districts, and the conditions in Qionglai, Pengzhou, and Chongzhou, all of which are located in the outer circle, are also close to the regional level. In terms of specific resources, Wenjiang has the highest value of professional staff ($H3$), about 71.94% higher than the regional mean, as well as institutions ($H1$) at 47.89% above the average. Xinjin has the most hospital beds per capita, with the $H2$ as high as 226.26%, over double the average. It is not the case that the closer a district is located to the urban center, the more health-care resources it will have. For example,

the H values of Qingbaijiang, Jintang, and Shuangliu are much lower than the regional mean, although they are developed and share borders with the urban center.

Table 4.2 Health-care index and its indicators for 14 counties or districts in Chengdu

County	Population	Institution	HI-mean	H1	Bed	HB-mean	H2	Staff	HP-mean	H3	H value	Color marks
Longquanyi	714400	516	0.000722	101.50%	4603	0.006443	68.98%	6813	0.009537	112.40%	94.29%	
Qingbaijiang	422000	243	0.000576	80.97%	3440	0.008152	87.28%	3230	0.007654	90.21%	86.15%	
Xindu	799400	710	0.000888	124.83%	6509	0.008142	87.17%	8529	0.010669	125.74%	112.58%	
Wenjiang	487700	513	0.001052	147.89%	6086	0.012479	133.61%	7115	0.014589	171.94%	151.15%	
Shuangliu	1316600	584	0.000444	62.42%	7029	0.005339	57.16%	6614	0.005024	59.21%	59.60%	
Pidu	632900	566	0.000894	125.68%	4605	0.007276	77.90%	6405	0.01012	119.27%	107.62%	
Dujiangyan	622200	465	0.000747	105.01%	7272	0.011688	125.14%	6711	0.010786	127.12%	119.09%	
Pengzhou	802400	539	0.000672	94.47%	6916	0.008619	92.28%	5621	0.007005	82.56%	89.77%	
Qionglai	654700	426	0.000651	91.52%	6299	0.009621	103.01%	3916	0.005981	70.49%	88.34%	
Chongzhou	662800	507	0.000765	107.54%	4908	0.007405	79.28%	5522	0.008331	98.19%	95.00%	
Jintang	902700	476	0.000527	74.08%	6346	0.00703	75.27%	4810	0.005328	62.79%	70.72%	
Xinjin	318900	171	0.000536	75.35%	6739	0.021132	226.26%	2656	0.008329	98.16%	133.26%	
Dayi	510000	436	0.000855	120.19%	4766	0.009345	100.06%	4124	0.008086	95.30%	105.18%	
Pujiang	268200	169	0.00063	88.56%	2169	0.008087	86.59%	1971	0.007349	86.61%	87.25%	

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020.

Legend: H value	Class	Color
>120	very high	
100-120	high	
80-100	low	
<80	very low	

The low value of the H index implies that these districts might have fewer resources for disease detection and treatment. For example, nucleic acid testing during the COVID-19 pandemic requires technicians and professional institutions, which only those districts which possessed sufficient resources could provide quickly. Of course, a relative lack of resources in one district could be augmented by regional cooperation under an efficient coordination system, but such a response inevitably has a time lag. Due to the short distance between Shuangliu and Chengdu City, for instance, the inhabitants in Shuangliu were in fact able to take advantage of the services provided by hospitals in the urban center. On the other hand, Wenjiang has been focusing on building health-care infrastructure recently so that its medical institutions have been developed greatly. Thus, when discussing the contribution of health-care resource to resilience, practical conditions must be considered comprehensively.

4.3.2 Economy index

Whether a district or county was able to control the spread of the epidemic effectively and efficiently recover, is closely related to its economic level. Among the fourteen rural counties or districts of Chengdu, the E values of Longquanyi and Piddu are 132.98% and 127.55%, ranking at the top, much higher than the regional mean (Table 4.3). The economic features of these two districts are reflected in their high GDP per capita (E1) and high disposable income of rural people (E3), although their output value of agriculture (E2) are relatively low. The E values of four other counties or districts including Qingbaijiang (100.69%), Wenjiang (105.96%), Xinjin (111.78%) and Pujiang (102.30%) are also higher

than the regional average. There are eight counties or districts with an E value below the mean value of 100%, but none is “very low”, i.e. less than 80%, indicating the relative balance of economic development among these rural counties or districts.





The E value is a comprehensive index. It is related to GDP per capita, but they are not equivalent. For example, Shuangliu has a “very low” E2 (only 24.95%) but a “high” E1 (118.78%) and E3 (115.37%), which finally result in a “low” E index (Table 4.3). The high GDP per capita (E1), contrasted with the low agricultural output (E2), reflects the industrialized but unbalanced structure of the local economy. Spatially speaking, except for Pujiang, all of the counties or districts with E value over the regional mean (>100%) are close to the urban center, indicating the role of the urban center in driving economic development. The level of disposable income of rural residents per capita (E3) presents a similar trend. A “high” E3 occurs in areas neighboring the urban center, including Longquanyi (119.08%), Xindu (106.67%), Wenjiang (118.03%), Shuangliu (115.37%) and Pidu (111.85%). This phenomenon make sense, given that the farmers living in suburbs have more diversified livelihoods and more convenient channels for generating income than those in distant districts (or counties). Rapid urbanization has promoted the expansion of infrastructure and has brought huge investments as well as job opportunities, all of which have been beneficial to the local economy of rural districts, but the benefits are not equally distributed to everyone. Thus, the reason for the spatial variation of E values among the fourteen rural districts or counties is clear.

Table 4.3 Economy index with three indicators for 14 counties or districts in Chengdu

County	Population	GDP	EG-mean	E1	GOA	EA-mean	E2	DIR	E3	E value	Color marks
Longquanyi	714400	13188773	18.461328	189.39%	620494	0.868553	90.46%	30405	119.08%	132.98%	
Qingbaijiang	422000	5258910	12.461872	127.85%	309169	0.732628	76.31%	25004	97.93%	100.69%	
Xindu	799400	8248003	10.317742	105.85%	549021	0.686791	71.53%	27237	106.67%	94.68%	
Wenjiang	487700	5955681	12.211772	125.28%	349192	0.715998	74.58%	30138	118.03%	105.96%	
Shuangliu	1316600	15243393	11.577847	118.78%	315330	0.239503	24.95%	29458	115.37%	86.36%	
Pidu	632900	11882051	18.773979	192.60%	475113	0.750692	78.19%	28559	111.85%	127.55%	
Dujiangyan	622200	4245125	6.822766	69.99%	550223	0.884319	92.11%	23861	93.45%	85.18%	
Pengzhou	802400	5254836	6.548898	67.18%	995940	1.241201	129.28%	23504	92.05%	96.17%	
Qionglai	654700	3307307	5.051637	51.82%	793459	1.211943	126.23%	22499	88.12%	88.72%	
Chongzhou	662800	3811099	5.749998	58.99%	717831	1.083028	112.80%	23625	92.53%	88.11%	
Jintang	902700	4404358	4.879094	50.05%	949533	1.051881	109.56%	21305	83.44%	81.02%	
Xinjin	318900	3747197	11.750383	120.55%	365724	1.14683	119.45%	24345	95.35%	111.78%	
Dayi	510000	2856878	5.601722	57.47%	710157	1.392465	145.03%	23737	92.97%	98.49%	
Pujiang	268200	1678220	6.257345	64.19%	385036	1.43563	149.53%	23788	93.16%	102.30%	

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020.

Notes: GDP = Gross domestic production; GOV = Gross output value of agriculture; DIR = Disposable income of rural residents
The DIR data extracted from the statistics are the average value per capita which do not need to be converted again.

Legend:	E value	Class	Color
	>120	very high	
	100-120	high	
	80-100	low	
	<80	very low	





4.3.3 Governance index

As derived from a comprehensive analysis of the percentage of anomalies between the number of townships (*xiang* or *zhen*) per capita and the number of villager committees (*cun*) per capita, the G indexes of Pujiang (151.82%) and Dayi (120.13%) are “very high”, and another five counties or districts including Xinjin (114.18%), Chongzhou (116.20%), Qionglai (115.60%), Pengzhou (106.52%) and Dujiangyan (107.27%) are higher than the regional average value (Table 4.4). It is interesting that all of these counties or districts except for Xinjin are located in the “outer circle” and share no direct borders with Chengdu City. The farther away from the urban center, the smaller the size of the administrative institution is. Counties or districts neighboring the urban center have G indexes below the regional mean, showing “low” or “very low” in Table 4.4. “Very low” G indexes occur in Shuangliu (69.78%), Longquanyi (69.05%) and Xindu (75.44%), all of which belong to the early urbanized and/or industrialized districts.

Table 4.4 Governance index with two indicators for 14 counties or districts in Chengdu

County	Population	Township	GT-mean	G1	Village	GV-mean	G2	G value	Color marks
Longquanyi	714400	10	0.000014	73.68%	158	0.000221	64.42%	69.05%	
Qingbaijiang	422000	7	0.000017	89.47%	124	0.000294	85.70%	87.59%	
Xindu	799400	9	0.000011	57.89%	255	0.000319	92.98%	75.44%	
Wenjiang	487700	9	0.000018	94.74%	121	0.000248	72.29%	83.51%	
Shuangliu	1316600	19	0.000014	73.68%	298	0.000226	65.88%	69.78%	
Pidu	632900	12	0.000019	100.00%	209	0.00033	96.19%	98.09%	
Dujiangyan	622200	11	0.000018	94.74%	256	0.000411	119.80%	107.27%	
Pengzhou	802400	13	0.000016	84.21%	355	0.000442	128.84%	106.52%	
Qionglai	654700	14	0.000021	110.53%	271	0.000414	120.67%	115.60%	
Chongzhou	662800	15	0.000023	121.05%	253	0.000382	111.35%	116.20%	
Jintang	902700	16	0.000018	94.74%	232	0.000257	74.91%	84.82%	
Xinjin	318900	8	0.000025	131.58%	106	0.000332	96.77%	114.18%	
Dayi	510000	11	0.000022	115.79%	218	0.000427	124.46%	120.13%	
Pujiang	268200	8	0.00003	157.89%	134	0.0005	145.74%	151.82%	

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020.

Legend: G value	Class	Color
>120	very high	
100-120	high	
80-100	low	
<80	very low	

In remote rural areas, population density is always low, but the proportion of agriculture-based *cun* and market towns increases. Because of this, grassroots organizations, such as villager committees or farmers’ associations, can often have close relationships and interactions with local residents. As mentioned in Chapter 3, in the Chengdu Plain every township (“*Xiang*” or “*Zhen*”) has at least one rural market. Thus, the number of townships largely represents the number of rural markets. Market towns, with their multiple functions, play important roles not only in the local socio-economy but in the also

local administration. A high density of market towns means a small but efficiently governed area. In the districts or counties bordering the urban center, administrative institutions have been readjusted many times in the last few years. The combined townships (some now called “*Jiedao*”) and villager committees (some now called “*Shequ*”) are often larger than they had been⁴⁶. The enlarged territory and population suggest that the delivery of administrative and social services to local people could suffer in the face of a sudden disruption such as the COVID-19. However, the urbanized township and *cun* generally have good infrastructure and economic conditions, offsetting the effects of the overstraining of administrative and governance sectors.

Regarding the “precise” and “accurate” management of townships and *cun*, the recently emerging **Grid Management System (GMS)** in rural Chengdu has been studied extensively by scholars and decision makers (see Chapter Two). This system uses ICT-based technologies (including geographic information system, real-time information pushes, mobile APPs, etc.) to improve the efficiency and effectiveness of rural governance, but its details are not included in statistical data. In February 2020, when the COVID-19 pandemic struck the Chengdu Plain, the grid managers were required to be responsible for regularly surveying the conditions of epidemic prevention. This included real-time reporting of local demands for various materials like face masks and disinfectant, disseminating information about hygiene and sanitation, insuring the necessary “social distancing”, monitoring the health conditions of local inhabitants, and assisting vulnerable groups to acquire food and daily necessities. Under the guidance of the GMS platform, many volunteers were involved in pandemic control through direct provision of necessary assistance to vulnerable groups. Moreover, while governments enforced lockdowns, the digital platforms became a very important channel to disseminate information about the pandemic situation, effectively communicating and stimulating community collaboration to response to external shock. Therefore, it may be concluded that the combination of traditional practices with emerging technologies has enabled local governance to consolidate and adapt, which benefits to the resiliency of the *linpan* landscape (Wu, Abramson and Zhong, 2022, under review).

4.3.4 Landscape index

Four counties or districts located in the “outer circle,” far from the urban center, show a “very high” L index, including Pujiang (151.38%), Dayi (132.85%), Qionglai (136.57%) and Pengzhou (130.42%). Sparse population and diverse landscape contribute to the good environmental conditions in these areas (Table 4.5). Three counties or districts with a “high” L index have similar conditions, except for Jintang (105.01%), which borders the urban center but has the Longquan Mountain in its territory. Those

⁴⁶ The hypothesis here is that the combination of administrative institutions was followed up with the combination of previous staff. Thus, the average number of staff per capita serving for local people has not been changed.





counties or districts located in the “inner circle”, bordering the urban center, such as Longquanyi (63.88%), Xindu (66.68%), Wenjiang (56.74%), Shuangliu (77.75%) and Pid u (64.21%), have “very low” L indexes. In these “very low” areas, the dense population often increases the pressure on epidemic prevention and control. Although the level of economic development in these counties or districts is relatively high, the need for more financial and human investment in epidemic prevention and control may weaken their economic base and postpone economic recovery in the post-pandemic period.

Table 4.5 Landscape index with three indicators for 14 counties or districts in Chengdu

County	Population	Land (km ²)	LA-mean	L1	Field (ha)	LF-mean	L2	SHDI	L3	L value	Color marks
Longquanyi	714400	556	0.000778	57.89%	7880	0.01103	23.12%	1.7554	110.63%	63.88%	
Qingbaijiang	422000	379	0.000898	66.82%	18884	0.044749	93.80%	1.6685	105.15%	88.59%	
Xindu	799400	496	0.00062	46.13%	25632	0.032064	67.21%	1.3755	86.69%	66.68%	
Wenjiang	487700	276	0.000566	42.12%	13165	0.026994	56.59%	1.1349	71.52%	56.74%	
Shuangliu	1316600	1068	0.000811	60.35%	39806	0.030234	63.38%	1.7378	109.52%	77.75%	
Pidu	632900	437	0.00069	51.34%	20485	0.032367	67.85%	1.1653	73.44%	64.21%	
Dujiangyan	622200	1208	0.001941	144.43%	26712	0.042932	90.00%	1.9304	121.66%	118.69%	
Pengzhou	802400	1421	0.001771	131.78%	50703	0.063189	132.46%	2.0154	127.01%	130.42%	
Qionglai	654700	1377	0.002103	156.48%	44310	0.06768	141.87%	1.767	111.36%	136.57%	
Chongzhou	662800	1089	0.001643	122.25%	39124	0.059028	123.74%	1.4071	88.68%	111.56%	
Jintang	902700	1156	0.001281	95.32%	56500	0.06259	131.20%	1.4046	88.52%	105.01%	
Xinjin	318900	329	0.001032	76.79%	15226	0.047745	100.09%	1.7475	110.13%	95.67%	
Dayi	510000	1284	0.002518	187.36%	29638	0.058114	121.82%	1.4181	89.37%	132.85%	
Pujiang	268200	580	0.002163	160.95%	23909	0.089146	186.87%	1.6869	106.31%	151.38%	

Source: Statistic Bureau of Chengdu and NBS Survey Office in Chengdu, 2020.
Resource and Environment Science and Data Center, China. <https://www.resdc.cn/data.aspx?DATAID=347>

Notes: SHDI = Shannon-Wiener Diversity Index
The SHDI data do not need to be converted into per capita values.

Legend:	L value	Class	Color
	>120	very high	
	100-120	high	
	80-100	low	
	<80	very low	

In terms of SHDI, the “very high” values (L3) occur in the northwestern part of the Chengdu Plain, including Dujiangyan (121.66%) and Pengzhou (127.01%), where a famous biodiversity hotspot, Longmen Mountain, is found (Figure 4.1). Longquanyi (110.63%), Qingbaijiang (105.15%), and Shuangliu (109.52%), where the Longquan Mountains stretch, the L3 values are also higher than the regional mean. However, the diversity (SHDI) in Wenjiang and Pid u are “very low”, with the L3 being 71.52% and 73.44% respectively. These locations belong to the traditional farming areas irrigated by the ancient Dujiangyan Irrigation System, and their land cover has been homogenized under the long-term impact of agricultural activities.

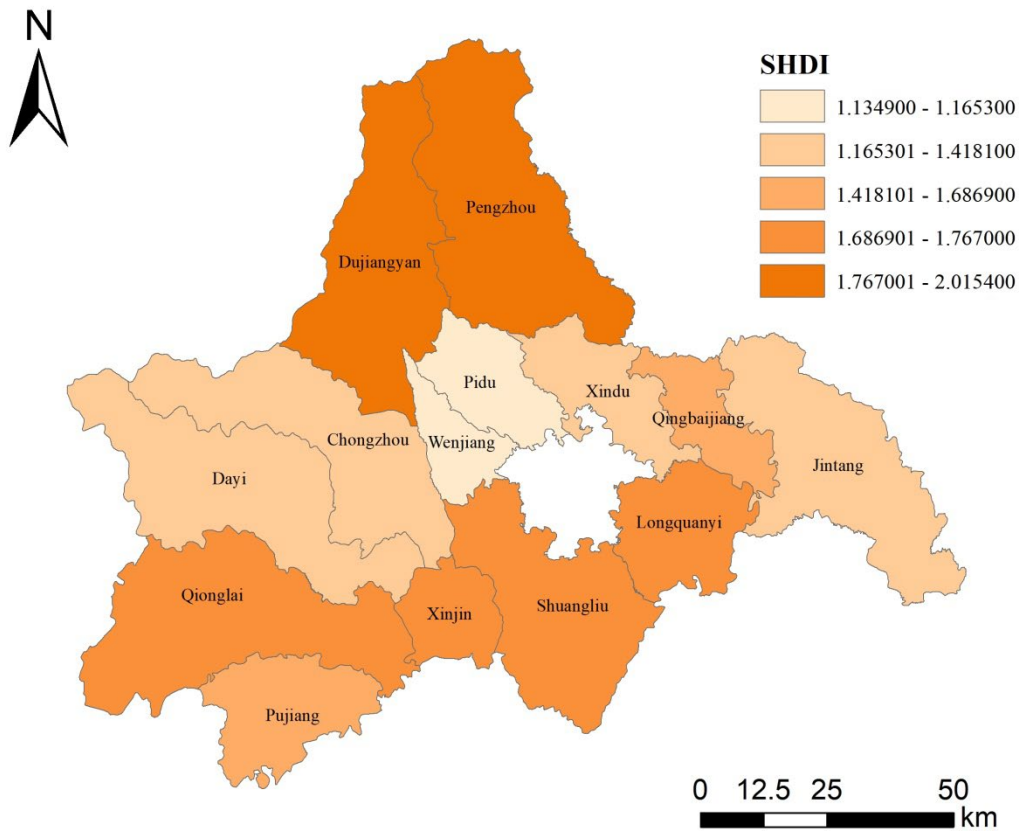


Figure 4.1 Shannon-Wiener Diversity Index of Chengdu Metropolitan Area in 2018

Source: Mapped by author





4.3.5 Comprehensive assessment of resilience

As mentioned above, the resilience of a given county or district should be assessed using all of the factors comprehensively. Among the fourteen counties or districts there are nine with an *R* value above the regional mean, but none is “very high” (Table 4.6). The resilience indexes in Pujiang (117.51%), Dayi (111.70%) and Xinjin (115.48%) are relatively higher, more than 10% over the regional average. Wenjiang’s *L* value is “very low”, but its advantages in health-care conditions (*H* value) and economic strength (*E* value) raise its resilience capacity, showing a “high” *R* index (105.18%). The other five counties or districts, excepting Shuangliu (73.29%), have *R* values which are “low.” The resilience of these counties or districts is similar to the situation in the Chengdu Plain in terms of pandemic control and economic recovery, and is not significantly unbalanced. The situation of Shuangliu is special, perhaps due to the allocation of some townships to Tianfu New District, data for which were not recorded in the statistics yearbook in 2019. Shuangliu is an early industrialized district and has a good economic base, but its population is very large. The reallocation of some developed townships alleviates its advantage of economic resources and increases the administrative burdens of other townships.

Table 4.6 Resilience assessment (*R* value) for 14 counties or districts in Chengdu

County	H value	E value	G value	L value	R	DTM-R	Color marks
Longquanyi	94.29%	132.98%	69.05%	63.88%	23.69%	94.77%	
Qingbaijiang	86.15%	100.69%	87.59%	88.59%	22.82%	91.29%	
Xindu	112.58%	94.68%	75.44%	66.68%	22.65%	90.60%	
Wenjiang	151.15%	105.96%	83.51%	56.74%	26.30%	105.18%	
Shuangliu	59.60%	86.36%	69.78%	77.75%	18.32%	73.29%	
Pidu	107.62%	127.55%	98.09%	64.21%	25.75%	103.01%	
Dujiangyan	119.09%	85.18%	107.27%	118.69%	26.62%	106.47%	
Pengzhou	89.77%	96.17%	106.52%	130.42%	25.79%	103.17%	
Qionglai	88.34%	88.72%	115.60%	136.57%	25.89%	103.55%	
Chongzhou	95.00%	88.11%	116.20%	111.56%	25.12%	100.49%	
Jintang	70.72%	81.02%	84.82%	105.01%	20.87%	83.49%	
Xinjin	133.26%	111.78%	114.18%	95.67%	28.87%	115.48%	
Dayi	105.18%	98.49%	120.13%	132.85%	27.92%	111.70%	
Pujiang	87.25%	102.30%	151.82%	151.38%	0.293763	117.51%	

Note: The value of DTM-R is the distance to regional mean in percentage.

Legend:	R value	Class	Color
	>120	very high	
	100-120	high	
	80-100	low	
	<80	very low	

If the strength of resilience is classified into different groups based on the *R* value at a scale of 10%, there are four groups as follows:

- Very strong (>110%): Pujiang, Dayi and Xinjin;
- Strong (100-110%): Chongzhou, Qionglai, Pengzhou, Dujiangyan, Piddu and Wenjiang;
- Weak (90-100%): Xindu, Qingbaijiang and Longquanyi;
- Very weak (<90%): Jintang and Shuangliu;

4.4 Validation with economic recovery in 2020

The COVID-19 pandemic has developed from a health crisis to a “systemic global risk,” bringing unprecedented challenges to societies and threatening global resilience (ICIMOD, 2020). Following January of 2020, the pandemic swept across countries and affected all continents, neglecting administrative borders and permeating every aspect of human life and well-being (Rasul, 2020). In Chengdu, people were in lockdown from January to March of 2020. All enterprises, offices, public entertainment venues and even shops were shut down, while many of the means of communication moved online. At the end of March 2020, certain enterprises, factories, and office buildings were opened progressively, partly starting an economic recovery of primary and secondary industries. After the end of June 2020, the service sector, a tertiary industry, began slowly to return to normality. This study thus identifies three phases in the process of the post-pandemic recovery in 2020. In the first quarter, economic development was stagnant except for agriculture (a primary industry); the second quarter saw

a partial recovery of the economy, in particular of secondary industry; and by the third quarter, most economic sectors showed recovery. It is hypothesized that the economic recovery in a given county or district is related to the strength of its socio-ecological resilience.

The first indicator of economic growth is the GDP per capita, which is easily accessible from official statistics and even public media. Comparing regrowth of fourteen counties or districts from the first quarter to the third quarter, half of them presented a faster recovery than the regional average level, with Dayi (139.01%) being at the top (Table 4.7). Other counties or districts such as Pujiang (118.60%), Jintang (119.06%), Pengzhou (117.42%) and Qionglai (110.48%) also had a good performance. A relative stagnation of economic regrowth was present in Longquanyi (75.83%), Xindu (75.51%) and Wenjiang (67.41%). The difference between the maximum and the minimum is 71.60%, indicating no significance among these counties or districts.

Table 4.7 Regrowth of GDP per capita of 14 counties or districts from the 1st quarter to 3rd quarter of year 2020

County	GDP in 1 st Q.	GDP in 2 nd Q.	GDP increase (1-2)	DTM-1	GDP in 3 rd Q.	GDP increase (1-3)	DTM-2	Color marks
Longquanyi	0.040789	0.047424	16.27%	95.76%	0.049314	20.90%	75.83%	
Qingbaijiang	0.027962	0.032915	17.71%	104.28%	0.034858	24.66%	89.47%	
Xindu	0.023618	0.026845	13.66%	80.43%	0.028534	20.81%	75.51%	
Wenjiang	0.02803	0.032992	17.70%	104.21%	0.033238	18.58%	67.41%	
Shuangliu	0.015213	0.017082	12.29%	72.32%	0.019383	27.41%	99.45%	
Pidu	0.022452	0.025739	14.64%	86.18%	0.028061	24.98%	90.63%	
Dujiangyan	0.014561	0.017567	20.64%	121.53%	0.01829	25.61%	92.91%	
Pengzhou	0.01336	0.014806	10.82%	63.72%	0.017684	32.37%	117.42%	
Qionglai	0.010784	0.012907	19.69%	115.89%	0.014068	30.45%	110.48%	
Chongzhou	0.012779	0.014952	17.00%	100.10%	0.016355	27.98%	101.52%	
Jintang	0.010668	0.012418	16.40%	96.57%	0.014169	32.82%	119.06%	
Xinjin	0.025368	0.031295	23.36%	137.54%	0.032549	28.31%	102.70%	
Dayi	0.011922	0.013765	15.46%	91.00%	0.01649	38.32%	139.01%	
Pujiang	0.01346	0.016443	22.16%	130.46%	0.01786	32.69%	118.60%	

Source: Statistic Bureau of Chengdu, 2020

Notes: (1) The value of GDP is the per capita data at the end of the 1st quarter, the 2nd quarter and the 3rd quarter of the year 2020.

(2) The percentage of GDP increase is the comparison between the 2nd quarter and the 1st quarter, and between the 3rd quarter and the 1st quarter.

(3) DTM = distance to mean; >100% means above the regional average value; <100% means below the regional average value.

(4) The unit of GDP is million RMB Yuan

Among the seven counties or districts with rapid recovery (DTM>100%) at the end of the third quarter, six of them are listed in the “high” group, showing an *R* value higher than the regional mean (except for Jintang, see Table 4.6). Among the three counties or districts with “very slow” regrowth, two of them (Longquanyi and Xindu) are marked with “low” resilience (except for Wenjiang; see Table 4.6). These results validated the theory that the recovery of GDP per capita in a given county or district is relevant to its resilience (*R* value). The exception is Shuangliu, where recovery was similar to the regional average

at 99.45%, but which showed the lowest *R* value (see Table 4.6). The reason may be its close proximity to Chengdu City, which offers availability of supplementary economic and health-care resources. A similar phenomenon may be found in Jintang, which has a relatively low *R* value (83.49%, see Table 4.6), but an index of economic recovery higher than the regional mean (119.06%, see Table 4.7).

The process of economic recovery is varied in different districts and different economic sectors. In the rural districts, agriculture functioned as a stabilizer for the local economy during the height of the spread of COVID-19 in the first quarter. When most people in urban were in lockdown, farmers were nearly the only workers still active in their fields. Agriculture was never shut down, even at the beginning of the COVID-19 pandemic sweeping across China. Thereafter, agriculture regrew stably in every county or district, as the delivery of food to urban markets was no longer restricted. In an analysis of the regrowth process of primary industries from the first quarter to the third quarter, all of counties and districts showed a stable and balanced development (Table 4.8). The difference between the maximum and the minimum of DTM-2 is only 38.83%, with no “very high” or “very low” cases. This result verifies the importance of agriculture in maintaining regional resilience, even in the face of sudden disruptions.

Table 4.8 Regrowth of primary industry of 14 counties or districts from the 1st quarter to 3rd quarter of year 2020

County	PI in 1 st Q.	PI in 2 nd Q.	PI increase (1-2)	DTM-1	PI in 3 rd Q.	PI increase (1-3)	DTM-2	Color marks
Longquanyi	0.000728	0.001008	38.46%	106.97%	0.002254	209.62%	99.01%	
Qingbaijiang	0.000664	0.000948	42.77%	118.96%	0.001991	199.85%	94.40%	
Xindu	0.000663	0.000888	33.94%	94.39%	0.002164	226.40%	106.94%	
Wenjiang	0.000697	0.000943	35.29%	98.16%	0.002461	253.08%	119.55%	
Shuangliu	0.000213	0.000289	35.68%	99.24%	0.000577	170.89%	80.72%	
Pidu	0.000679	0.000932	37.26%	103.63%	0.002101	209.43%	98.92%	
Dujiangyan	0.00082	0.001125	37.20%	103.45%	0.002507	205.73%	97.18%	
Pengzhou	0.001196	0.001558	30.27%	84.18%	0.003951	230.35%	108.81%	
Qionglai	0.001084	0.001451	33.86%	94.16%	0.003513	224.08%	105.85%	
Chongzhou	0.001011	0.001343	32.84%	91.33%	0.00347	243.22%	114.89%	
Jintang	0.000986	0.001296	31.44%	87.44%	0.003013	205.58%	97.11%	
Xinjin	0.001003	0.001411	40.68%	113.14%	0.002854	184.55%	87.17%	
Dayi	0.001235	0.001686	36.52%	101.57%	0.003824	209.64%	99.02%	
Pujiang	0.001305	0.00179	37.16%	103.37%	0.003803	191.42%	90.42%	

Source: Statistic Bureau of Chengdu, 2020

Notes: (1) The value of primary industry (PI) is the per capita data at the end of the 1st quarter, the 2nd quarter and the 3rd quarter of the year 2020.

(2) The percentage of PI increase is the comparison between the 2nd quarter and the 1st quarter, and between the 3rd quarter and the 1st quarter.

(3) DTM = distance to mean; >100% means above the regional average value; <100% means below the regional average value;

(4) The unit of output value of primary industry is million RMB Yuan.

After the first quarter, secondary-industry employees in industrial production and construction progressively restarted work, but the rate of reintroduction varied in different sectors. Infrastructure construction was reopened first, while factories (especially those with assembly lines) were delayed. At

the end of the second quarter, only Wenjiang, Pidū, Dujiangyan and Pujiang showed a “very high” growth trend (DTM-1>120%, see Table 4.9). At the end of the third quarter, a “very high” performance was displayed by Xindu, Pidū and Dayi with the DTM-2 values of 139.07%, 194.98% and 160.50% respectively. Only Pidū maintained its “very high” second quarter regrowth. In a few counties or districts, such as Dujiangyan and Qionglai, the secondary industry increased very quickly in the second quarter but fell down sharply by the end of the third quarter, perhaps due to industrial particularities or administrative restrictions on personnel gatherings (to avoid the risk of contamination by any traveller with a positive nucleic acid test). For those counties or districts in which secondary industry recovered quickly, the strength of resilience could be enhanced by increasing investment and employment opportunities. However, Table 4.9 shows that the difference between the maximum and the minimum of DTM-2 is as high as 163.6%, indicating a great variation among these counties or districts. Generally, the recovery of secondary industry is related to what type and structure of industry exists. The contribution from industrial production can make up a heavy proportion of the local economy and provide an important base for economic resilience, but may also show a high uncertainty during the regrowth process.

Table 4.9 Regrowth of secondary industry in 14 counties or districts from the 1st quarter to 3rd quarter of year 2020

County	SI in 1 st Q.	SI in 2 nd Q.	SI increase (1-2)	DTM-1	SI in 3 rd Q.	SI increase (1-3)	DTM-2	Color marks
Longquanyi	0.024566	0.030263	23.19%	79.48%	0.030473	24.05%	103.61%	
Qingbaijiang	0.008412	0.010829	28.73%	98.48%	0.010403	23.67%	101.99%	
Xindu	0.007055	0.009207	30.50%	104.54%	0.009332	32.27%	139.07%	
Wenjiang	0.009596	0.013102	36.54%	125.22%	0.012221	27.36%	117.87%	
Shuangliu	0.005089	0.006297	23.74%	81.36%	0.006167	21.18%	91.27%	
Pidū	0.006842	0.009638	40.87%	140.06%	0.009938	45.25%	194.98%	
Dujiangyan	0.004822	0.006525	35.32%	121.04%	0.005432	12.65%	54.51%	
Pengzhou	0.007129	0.007665	7.52%	25.77%	0.007926	11.18%	48.17%	
Qionglai	0.004613	0.006064	31.45%	107.80%	0.004949	7.28%	31.38%	
Chongzhou	0.00596	0.007468	25.30%	86.72%	0.00691	15.94%	68.68%	
Jintang	0.004176	0.005395	29.19%	100.04%	0.00524	25.48%	109.79%	
Xinjin	0.010693	0.013829	29.33%	100.51%	0.0127	18.77%	80.87%	
Dayi	0.004529	0.005765	27.29%	93.53%	0.006216	37.25%	160.50%	
Pujiang	0.004623	0.00645	39.52%	135.45%	0.005667	22.58%	97.31%	

Source: Statistic Bureau of Chengdu, 2020

Notes: (1) The value of secondary industry (SI) is the per capita data at the end of the 1st quarter, the 2nd quarter and the 3rd quarter of the year 2020.

(2) The percentage of SI increase is the comparison between the 2nd quarter and the 1st quarter, and between the 3rd quarter and the 1st quarter.

(3) DTM = distance to mean; >100% means above the regional average value; <100% means below the regional average value;

(4) The unit of output value of secondary industry is million RMB Yuan.

The impacts of COVID-19 on the tertiary or service-sector industry are the most serious, leading to a general stagnation. Entertainment venues, restaurants, cafés, teahouses and other public places were shut

down again and again upon discovery of anybody in a building who tested positive. The subsequent two week lockdown inevitably led to the loss of the owners' income. A great variation in recovery is present among the fourteen counties or districts (Table 4.10). Five of them presented a “very high” DTM-2 value (>120%), i.e. very strong regrowth in the tertiary industry, with the highest being 232.73% in Shuangliu. On the contrary, seven rural districts showed a “very low” trend with a DTM-2 value below 80%. This result illustrates that the service sector is the most vulnerable to pandemic disturbances.

Table 4.10 Regrowth of the tertiary industry in 14 counties or districts from the 1st quarter to 3rd quarter of year 2020

County	TI in 1 st Q.	TI in 2 nd Q.	TI increase (1-2)	DTM-1	TI in 3 rd Q.	TI increase (1-3)	DTM-2	Color marks
Longquanyi	0.015496	0.016139	4.15%	55.81%	0.016601	7.13%	60.17%	
Qingbaijiang	0.018863	0.021161	12.18%	163.85%	0.022464	19.09%	161.07%	
Xindu	0.015899	0.01675	5.35%	71.99%	0.017038	7.16%	60.45%	
Wenjiang	0.017736	0.018926	6.71%	90.24%	0.018577	4.74%	40.01%	
Shuangliu	0.009912	0.010497	5.90%	79.38%	0.012646	27.58%	232.73%	
Pidu	0.014931	0.015168	1.59%	21.35%	0.016021	7.30%	61.60%	
Dujiangyan	0.00892	0.009932	11.35%	152.59%	0.01035	16.03%	135.26%	
Pengzhou	0.005035	0.005583	10.88%	146.38%	0.005808	15.35%	129.54%	
Qionglai	0.005071	0.005407	6.63%	89.11%	0.005621	10.85%	91.51%	
Chongzhou	0.005809	0.006141	5.72%	76.87%	0.005975	2.86%	24.11%	
Jintang	0.005517	0.005716	3.61%	48.51%	0.005916	7.23%	61.02%	
Xinjin	0.013641	0.016087	17.93%	241.16%	0.016996	24.59%	207.52%	
Dayi	0.006137	0.006333	3.19%	42.95%	0.006451	5.12%	43.17%	
Pujiang	0.007532	0.008203	8.91%	119.82%	0.008352	10.89%	91.86%	

Source: Statistic Bureau of Chengdu, 2020

Notes: (1) The value of tertiary industry (TI) is the per capita data at the end of the 1st quarter, the 2nd quarter and the 3rd quarter of the year 2020.

(2) The percentage of TI increase is the comparison between the 2nd quarter and the 1st quarter, and between the 3rd quarter and the 1st quarter.

(3) DTM = distance to mean; >100% means above the regional average value; <100% means below the regional average value;

(4) The unit of output value of tertiary industry is million RMB Yuan.

The results above analyzed show a close relationship between resilience index and post-pandemic economic recovery in Chengdu, but they are not simply equivalent. A few local particularities may also be found in specific districts or sectors. Based on the correlation analysis with SPSS software (Table 4.11), it was found that the L index is very significantly related to the regrowth of GDP per capita ($p = 0.827$, $R^2 = 0.684$), which means landscape domain contributes most to the economic recovery (Figure 4.2). The second contributor is the G index ($p = 0.633$, $R^2 = 0.400$), the governance domain, which also has a significant correlation with economic regrowth during the post-pandemic period, but is not as stable as the contribution of the L index. This result indicates that good conditions in landscape and governance are beneficial to economic recovery. Although a high value for the H index may enhance the resilience (R value) in a county or district, showing a significant correlation ($p = 0.596$, $R^2 = 0.355$), its importance in economic recovery is not as high as previously perceived.

Table 4.11 Correlation analysis of economic regrowth with resilience indexes

	Regrowth	R index	H index	E index	G index	L index
Regrowth	1					
R index	0.261	1				
H index	-0.433	.596*	1			
E index	-0.388	0.289	0.344	1		
G index	.633*	.798**	0.079	-0.127	1	
L index	.827**	0.471	-0.293	-0.475	.827**	1

Note: * Correlation is significant at 0.05 level; ** Correlation is very significant at 0.01 level.

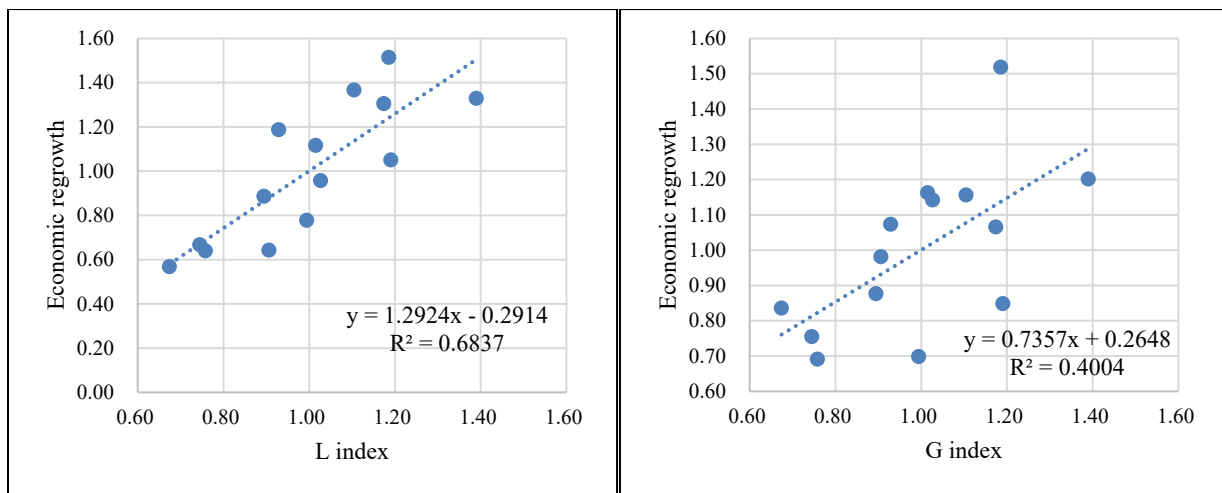


Figure 4.2 Correlation analysis with regression model between economic regrowth and L index (left) and G index (right)

For a given county or district, a good basis of economy and health-care infrastructure did not lead naturally to an effective regrowth of the local economy. The hypothesis that the more developed a region was, the quicker regrowth it would have, has not been proved by this study. Economic regrowth depends on not only a quantitative basis (the total GDP) but also on qualitative characteristics such as economic structure. Furthermore, economic and medical resources are mostly mobile, which may be regulated through regional coordination in cases of emergency, but landscape resources, environmental conditions, and governance are much more stable and localized. Although the administrative hierarchy in every county or district is similar, the size of each administrative institution (or unit) is different. Generally, a decentralized system of the distant counties and districts, composed of many small units, is beneficial to socio-ecological resilience as well as post-pandemic recovery. The large-scale industrialization and intensive administration in some districts, most of which border the urban center, has not enhanced their resilience (*R* index) and has contributed greatly to economic regrowth.

The 2020 COVID-19 pandemic crisis hit China vary rapidly, but fortunately the entire society was able to bounce back to relative normality after a few months of quarantine. Therefore, the COVID-19 pandemic provides an excellent example to analyze how the studied area responded to this disturbance through comparing statistical data before and after the pandemic. The UN report explicitly says that the pandemic functioned like an x-ray, reflecting the weakest part of society just as the virus hits the weakest part of a body (FAO, 2021). Many scholars define resilience as the time required for a system to return to an equilibrium or steady-state following a disturbance (Gunderson, 2000). In the Chengdu Plain, three quarters' worth of data could not fully reflect the economic recovery; a longer period is required for further verification. Even now the pandemic persists. Occasional lockdowns or administrative restrictions still occur from time to time in parts of the city. Thus, the full recovery to normality, particularly in the economic sector, has a long way to go.

4.5 Rethinking resilience assessment

The interconnected nature of the COVID-19 pandemic crisis demands an integrated approach and coordinated action, which further complicates decision making. Identifying the best set of approaches and instruments to address COVID-19 challenges, and aligning them with broader social goals, will be critically important for sustainable recovery from the disturbance of the COVID-19 pandemic (Rasul, 2020; ICIMOD, 2020). In rural Chengdu, controlling the epidemic spread and recovering the economy from the threat of COVID-19 is dependent not only on the economic basis but on many other prerequisites, including health-care facilities, human capital, and government capacity. In the statistical data we find some evidence to assess systemic resiliency to the pandemic threat, but both resilience and recovery are also dependent on certain subjective factors, which cannot be verified using the published statistics. For example, leadership is critically important for effectively dealing with public health-care crises, and for engaging and coordinating diverse actions and stakeholders in achieving broader social goals (Mei, 2020). Effectiveness of leadership, however, is a function of the personal features of the leaders and the efficiency of administrative agencies, which together determine the quality of a governance system. At the same time, local culture and the customs of human communities also affect responses to external pressures or risks in different ways (Rasul, 2020). Thus, a resilience index based solely on statistical data cannot fully correspond with the realities of economic recovery, although it should be still considered as a very important reference for decision making.

Resilience cannot be measured until a disturbance has actually occurred and the system has recovered. It is “knowable for certain only in retrospect.”⁴⁷ Because of this, the use of indicators to quantify resilience in socio-ecological systems is always a challenge. Most systems are still evolving and are not

⁴⁷ Personal communication with Steven Harrell by email

at a stable stage. Moreover, neither socio-economic nor ecological processes can be understood in isolation, and “resilience to what?” is always the first question to ask. While discussing the resilience of a given area or sector, it should be understood that resilience is often determined by different factors in the system, for different goals, on different time scales. Further, a system may move from one state to another and achieve an equilibrium, which is different from its original state (Gunderson, 2000). In terms of the economic sector, for instance, recovery is not only regrowth in the post-pandemic period but also structural change, meaning both qualitative and quantitative changes, which will not be reflected in published statistical data.

The COVID-19 pandemic provides an opportunity to take a broad look at factoring economic, social, and environmental sustainability into resilience assessment in order to create more sustainable societies. The more resources a society has, the stronger its resilience. This also requires strategic and comprehensive thinking on policy options in both short-term and long-term strategies adopted by local governments. The strategies for long-term investment in post-pandemic recovery should ensure that the short-term actions result in long-term benefits (Rasul, 2020). In rural Chengdu, for instance, short-term support for agriculture could stabilize the food market, which would be beneficial to the whole society, especially during the period of the highest pandemic spread or at the beginning of recovery. On the other hand, a long-term investment in constructing dispersed farmhouses in line with the traditional style of *linpan* settlements would be important for future maintenance of social distancing in rural areas. This study has once again proven that a heterogeneous and high-quality rural landscape (yielding high values of the L index) could be beneficial to human health, economic stability and social resilience.

In contrast to the previous assessments of socio-ecological resilience, the framework and its indicators provided by this study could enable decision makers to develop a coherent and integrated set of policy decisions in the volatile situation of the COVID-19 pandemic. Identifying the best set of instruments and approaches for addressing pandemic challenges and aligning them with broader social goals will be critically important for sustainable recovery and a resilient society. Poorly understanding socio-ecological resilience, including its status, trend and drivers, is likely to be ineffective in addressing the health, economic, social, and environmental challenges and harnessing the potential long-term economic and environmental benefits. Last but not least, in designing the detailed strategies and pathways for post-pandemic recovery, cultural values, leadership, coordination of local governments, and the participation of local communities should also be considered. Only in this way can a resilient and sustainable society be achieved.

Chapter 5 Conclusion and Way Forward

5.1 Conclusion

In the last 50 years we have witnessed the most rapid transformation of the biosphere ever to occur in human history. Intensive land use and overexploitation of natural resources have become the largest drivers of environmental change as we have shaped the landscapes to fulfill our demands and aspirations for food, water, shelter and transportation. Along with environmental factors such as climate change, various anthropogenic factors have altered ecosystems, creating different cultural landscapes and sometimes disturbing their structures and even functions. Among the globe's very diverse landscapes, urban centers combined with their outlying rural areas are highly human-dominated environments, creating a new set of ecological conditions by changing landscape dynamics, which have become complex coupled systems intertwining humanity and nature. It has become evident that earth's landscapes are increasingly influenced by the pace and patterns of the urbanization process, which have brought about impacts on the local environment and beyond.

With the rapid process of urbanization in China, many traditional rural landscapes have shrunk or even disappeared. Both the physical and spiritual situations of rural areas are experiencing tremendous changes, and these rural landscapes are facing unprecedented challenges. Apart from on-going physical expansion, urban land-use change is predominantly characterized by peri-urbanization where rural lands, both close to and distance from urban centers, have been enveloped by, or transformed into, extended metropolitan regions. Even previously entirely agrarian societies have seen large sectors become involved in planned development programs and the urbanization process. This produces a complex mosaic of traditional and modern land uses or land covers and associated socio-economic and governance systems. The ecological dependency of humanity on nature in traditional agrarian society and the socio-economic connectivity between rural areas and urban centers have been profoundly changed. Although many efforts so far have been put into landscape planning and preservation, most of them in fact only focus on how to use these landscapes as a kind of resource for development purposes, rather than preserving the whole landscape for its multi-functionality and integrity.

- 1. The *linpan* landscape is a special rural landscape distributed in the Chengdu Plain, which has supported the long-term resilience of socio-ecological systems as well as the regional prosperity, but now is being modified by the unprecedented urbanization..**

As a special rural landscape in the world, the *linpan* landscape in the Chengdu Plain is a fine-grained mosaic in which physiographic structures are traditionally well defined and utilized in different ways for agriculture, agro-forestry or forestry. The mosaic features of *linpan* landscapes have been shaped over generations by a strongly interlinked set of traditional practices and production activities that have been adapted and transformed to maintain and improve human well-being while absorbing disturbances to the system. Some of the historical human and nature interactions and co-evolutionary processes have been favorable to or synergistic with landscape preservation and still persist in agricultural environments in the Chengdu Plain. With the accelerating loss of *linpan* landscapes due to urbanization, there is an increasing need to broaden the recognition of the value of this landscape for preservation as well as for human well-being.

Unlike other high-density agricultural areas of China, the Chengdu Plain is characterized not only by its high agricultural productivity but also by its spatially dispersed pattern of rural *linpan* settlements. As the overall terrain of the Chengdu Plain descends gently from northwest to southeast, water from upstream naturally irrigates vast farming fields in the watershed. Local people can access water sources conveniently for their agricultural production or daily use. While people have adapted to the water environment in the last many centuries, the landscape was localized and thus became an ingenious and finely tuned system. In 2007, it was estimated that about 141,100 *linpan* settlements were located in the administrative territory of the Chengdu metropolitan area, comprising 77.09% of the total rural population, although this number has declined around 25.4% from 2000 to 2018 due to continuous urbanization.

2. The structure and spatial pattern of the *linpan* landscapes vary by location, following both natural and anthropogenic conditions, and reflecting human's adaptation to environmental changes.

The spatial pattern and densities of *linpan* are related closely to local topography, population density, availability of water supply, and accessibility to traffic roads or market places. In the Chengdu Plain, the high densities of *linpan* units occur in flat areas, but the low densities are found in the northwestern hills formed by the lift of the Longmen Mountain. The reason for this may be relevant to the spatial variation of natural resources (water, soil, and topographic conditions), agricultural productivity, and associated carrying capacity of the land. In addition to topography, the distribution of *linpan* is also relevant to the hydraulic system of the Dujiangyan Irrigation System. This study estimated that in 2010 about 80.53% of *linpan* units were distributed 3,000 m from the hydraulic system, and 42.77% in a distance of 1,000 m. The hair-like canals always flow around settlements and paddy fields, providing an ideal condition for peasants' living and production.

From a bird's eye view, most of the *linpan* units present a round shape. The size of a *linpan* also varies with environmental and socio-economic conditions. Large *linpan* (over 10 households) only make up 7.3% of the total amount, and provide livable spaces for 24.13% of the total rural population. Small (<5 households) and medium (5-9 households) *linpan* are dominant in terms of size, supporting 75% of the *linpan* population. The average distance between *linpan* settlements is usually less than 300 m and the working radius of farming activities of *linpan* dwellers is around 1 km or even smaller. A too-short distance between *linpan* residential clusters implies high population pressure on land and water resources, but the too wide space inbetween, on the contrary, indicates relative inconvenience for farmers either in managing their farmlands or maintaining social relationships.

The layouts of traditional cottages normally present a “line” shape, an “L” shape, a “U” shape, and a “compound” shape. These shapes follow an evolutionary process, tracking the expansion of the family. The orientation of the main building of a settlement normally faces the sun (southwest or west), but occasionally changes are made according to practical requirements of dwellers or due to the topographical conditions. Because of the heterogeneity of environmental conditions in different locations, the configuration and spatial pattern of *linpan* landscapes present various types. In the gently hilly areas such as Dantu Cun, a vertical model of *linpan* landscape was created by local people, which integrates forests, farmlands and freshwater bodies into a three-layer ecosystem complex. The forests distributed on the upper slopes protect fields from rainwater-runoff and soil erosion, and slowly discharge groundwater and nutrients stored in forest soil into down-slope terraces and water ponds. This “hydrological fertilization” approach reflects the ecosystem-based adaptation of local people, which finally enhances the resilience of *linpan* landscapes.

3. The *linpan* landscapes not only provide multiple agricultural products to both rural and urban people, but also play a very important role in regulating climate and water, and are a vital source of inspiration for culture and art.

As an important component of the rural landscape in the Chengdu Plain, *linpan* systems provide multiple goods and services to local lives and livelihoods. The agricultural products, including numerous cereal crops, vegetables, cash crops, and domesticated animals or fishes are the main goods delivered to both rural and urban people. In the past two decades, the agricultural products have changed with the process of urbanization. With the decline of cereal crop cultivation, vegetables and rape seed increased because of the continuous increase of market demand. Fruit trees intercropped with vegetable cultivation forms an agro-forestry model widely used by local peasants. Traditionally, pig and poultry were raised in the homesteads mainly for self-consumption, marketing, and manure provision. Recently, fish farms have also been developed under the auspices of private enterprise or farmer associations. Besides those

agricultural products, some by-products or non-timber products (such as mushrooms and medicinal herbs) are also important provisioning services of *linpan* landscapes.

The *linpan* systems play a very important role in regulating air and water in the Chengdu Plain, which as a whole influence the climate both locally and regionally. Through its regulating function, *linpan* settlements work as “buffer zones,” balancing the inside and outside temperatures of settlements, purifying air through the tree or bamboo groves surrounding settlements, and further mitigating the effects of the ‘Urban Heat Island’. Farming fields around the *linpan* have mild and humid micro-climates throughout the year, which may be further beneficial to crop growth. Water canals or ditches flowing through or around *linpan* settlements may not only provide water for daily life and agriculture but also transport fresh air for cooling temperatures in summer. Water ponds and forests in *linpan* landscapes have a huge capacity for storing water, regulating the timing and magnitude of runoff, flooding, and aquifer recharge, which thus can mitigate weather extremes such as floods and heat waves.

The *linpan* landscapes support the interaction between humans and nature, and are a vital source of inspiration for culture and art. Individual *linpan* are living spaces for the interaction and communication of local communities, grave-yards for families and clans, and touchstones for the “sense of place” of local people. Thus, the stability and capacity of *linpan* landscapes to provide goods and services critically depends upon rural communities having and sustaining diverse and complex forms of social organization such as kinship and territoriality, culture (languages, values, and nostalgia), modes of production, and labor allocation. Besides the tangible system of irrigation canals and roads, various individual *linpan* in the Chengdu Plain are also linked by an intangible cultural and spiritual network, forming an integrative “village community” and the localized “*linpan* culture”, all of which together have historically worked to support the resilience of the *linpan* landscape.

4. Rural markets are undividable parts of the rural landscape in the Chengdu Plain, which occurrence and distribution depend on three conditions including trading necessity, transportation accessibility and occupation concentration.

The development of rural markets is a historical process which is driven by a robust commercial economy and exchange of goods in rural areas. Considering the geographical location, most rural markets are located at important confluences of transportation, regardless of waterways or roads. Easy accessibility and cheap logistics at a geographical crossroad contributes greatly to the development of market towns. Before the 1980s, the service range of a rural market reflected the relatively primitive state of transport, i.e. the distance a man could reach on foot in one day. For those peasants living in dispersed settlements, the alternative periodicity of neighboring markets could reduce the distance they must travel to obtain the required goods and services. Since the great modern improvement of

transportation conditions, local people now can sell their products or purchase daily goods in relatively remote markets.

At the beginning of the 1990s, there were about 420 market towns (“*chang*”) in the Chengdu Plain. The average density of a *chang* was 4.45 per 100 square kilometer. The high densities occurred in flat areas, where both population density and agricultural productivity were very high. In counties or districts where hilly topographies are found, the densities of market towns decline due to the relatively low population and inaccessible conditions. In the Chengdu Plain the average size of a marketing area was 27.11 km² with a service radius of 2.87 km. This means that the majority of marketing areas are of a size which puts the most disadvantaged villagers within easy walking distance to a market town. Meanwhile, the serving ranges of neighboring markets are always overlapped so that local people may easily visit one another if it is necessary. Local people living in the *linpan* settlements have been integrated into an agrarian society through these periodic rural markets, and these market towns also become the undividable parts of the rural landscape. Even now, although the conditions of transportation and communication have changed already, local people still rely on these markets to acquire economic, administrative, health, or cultural services, indicating that the socio-cultural importance of “*chang*” for local people has remained relatively static.

5. Public spaces in market towns provide local people an area for socializing themselves through public exchange, which are important venues for social harmonization and the “epitome” of rural development.

Public space in market towns is a type of architectural space which provides local people an area for gathering and communication. Human behaviors, customs, and traditions determine the morphological and structural features of a market town. Therefore, as an agglomeration of human settlements, a market town always has its own public spaces, which are not only the commercial agoras, but the “epitome” of socio-economic development for a given agrarian society. In public spaces people socialized through public exchange. This kind of social relationship finally led to the occurrence of human settlements with specific functions and architectural features.

In a traditional market town there is normally a main street or ‘market street’, along which two arrays of buildings are located on both sides. This main street is a comprehensive space with multiple functions including a walk way, a venue for commercial activity and cultural performances, and living space. Thus, the street functions as a “parlor” or “reception room,” providing a flexible space for public life. Along the main street, the eaves of buildings are elongated to the street, forming a long porch. This architectural structure can protect market-goers from heavy rain and blazing sun, eased population flow during market days, and provided a “grey space” (semi-public space) for the social communication

of local inhabitants. In addition to many shops, local people prefer to visit other public spaces during the market days, among which tea shops, restaurants, barber shops and clinics are most important. During traditional festivals, celebrations and ‘temple fairs’ held at market towns are undoubtedly great events in rural areas. Thus, the public spaces of market towns are important venues for the social harmonization of *linpan* society, which can further consolidate the resilience capacity of the whole system through the integration of rural and urban people.

6. The economic recovery in post-pandemic period is closely related to the strength of socio-ecological resilience. Agriculture functions as a stabilizer for the local economy in the face of the COVID-19. Among the four categories of indexes, landscape domain contributes most to the economic recovery.

The COVID-19 pandemic in 2020 provides us with a good case for observing the resilience of the rural societies, which may reflect in the post-recovery of economy from the pandemic. In this study, four categories of indexes, including health, economic, governance and landscape domains, with 11 indicators were selected to assess the resilience of the rural Chengdu. This study found that the health index (H value) varied greatly in the fourteen rural districts of Chengdu, indicating the difference of medical and health-care conditions. The low value of the H index always implies the possible difficulty in disease detection and treatment. The ability of a district to prevent and control the epidemic is closely related to its economic basis. Spatially speaking, almost all of the counties or districts with a high economic index (E index) over the regional mean (>100%) neighbors the urban center, indicating that urban areas are important in driving the economic development of suburbs and rural areas. On the contrary, almost all of the counties or districts with a high value (>100%) of governance index (G index) and the “very high” landscape index (L index) are those belonging to remote rural districts, where sparse population, dispersed settlements and diverse landscapes can be found. According to the comprehensive analysis of the resilience index (R value) among the fourteen rural districts, there are nine with an R value above the regional mean (>100%), but none is “very high.” The resilience of these districts shows a similar situation in terms of their epidemic control and economic recovery.

In this study, three phases were identified in the process of post-pandemic recovery in 2020. In the first phase, economic development was stagnant with the exception of agriculture; in the second phase, a partial recovery of the economy occurred, in particular of secondary industries; and in the third phase, most economic sectors had recovered. It is assumed that the economic recovery in a given county or district is related to its strength of socio-ecological resilience. Comparing the economic regrowth from the first to the third phase, half of these districts presented a more rapid recovery than the regional average level. Among the seven districts with rapid recovery, six of them have “high” or “very high” R values, meaning strong or very strong resilience. Conversely, the three districts with slow regrowth were

all noted to have a low R value. These results validated the hypothesis that the recovery of GDP per capita would reflect the resilience.

The process of economic recovery varies in different districts and different economic sectors. Agriculture functions as a stabilizer for the local economy when the disturbance occurs. Agriculture never shut down, even in the first quarter of 2020. In the second phase, industrial production and construction recovered progressively, but this varied greatly in different sectors. The contribution of secondary industries always makes up a heavy proportion of a local economy, but its uncertainty is very high during the period of economic recovery. The impact of the pandemic on the service sector was most serious, leading to a general stagnation in the first and second phases. Even in the third phase, a great variation in recovery was found among the fourteen districts, with five presenting a “very strong” regrowth and seven showing “very weak”. These results validated the close relationship between the resilience index and post-pandemic recovery in rural Chengdu, but they are not simply equivalent. Finally, this study shows that the L index is very significantly related to the regrowth of GDP per capita, which means that landscape domain contributes most to the economic recovery.

5.2 The way forward

1. For identifying the geographic patterns of *linpan* patches more accurately and more efficiently, the methods using deep learning model should be developed in the future.

Because of the complexity of socio-ecological systems, this study was not able to address all aspects of the *linpan* landscape in the preceding chapters, and many gaps remain to be filled in the future. As regards data gathering of the geographic patterns of *linpan* patches, some tests were done using deep learning for extracting the features in Arcgis Pro, and using ENVI supervised classification. However, the results were not conclusive enough to use. The deep learning model combined with ENVI supervised classification can detect around 70% of *linpan* patches, but the rest of them still require human eyes for detection. When the author cooperated with the team from the Chengdu Institute of Biology, Chinese Academy of Sciences, we tried to develop a tool based on ArcGIS 10.2 and ENVI 5.2 to identify the boundary of individual *linpan* with images from Landsat 8 and Sentinel data. Although the result of identification for the *linpan* in the plains area were about 80%, the accuracy is still unsatisfactory for those distributed in hilly regions. The reasons are mainly these: 1) One patch of *linpan* consists of houses (built areas) and forests, presenting a mosaic of land-use. On the images it is difficult for machines to identify whether a given patch is a *linpan* unit or forested land. Some *linpan* patches are hard to classify even with the human eye, especially in hilly areas with a complex distribution of natural forests and plantations. 2) Testing a small area sample is very well, but a large quantity of satellite imagery for deep learning process requires more advanced machines and more complicated computation

methods, which are beyond the capacity of this study; 3) The image quality in different parts of the Chengdu Plain differs, and image quality for some years is better than others. Therefore, it is hard to generate a consistent model to apply to all images for comparison purposes. 4) Because the current images only date back to 2000, it is difficult to detect information about the *linpan* landscape from earlier eras. Although the pictures from the USGS earth explorer around the 1960-70s have high resolutions, it is hard to confirm their exact location and to compare them with new satellite images. This is a potential avenue for deep learning in the future.

2. The COVID-19 pandemic has triggered the innovation and application of ICT-based technologies, promoting the effective communication and enabling people to cope with the sudden disturbance, but the challenges of these new technologies for vulnerable groups should be considered in the future.

Because of the pandemic, face to face interviews became impossible during some periods of this study, and therefore I used the online survey platform “*Wenjuan Xing*”. This method, combining online and face to face surveys, shows a great potential for sociological studies in the future, particularly for large-scale surveys which normally require a huge investment of manpower and time. The COVID-19 pandemic has not only tested the resilience of socio-ecological systems, but also triggered innovation in current research methodologies, which may benefit both social sciences and natural sciences in the future.

During the COVID-19 pandemic, the newly emerging Information Communication Technology (ICT) has also been applied in landscape management and rural governance. Grid managers of the Grid Management System (GMS) played an important role in reporting the epidemic spread and the coordination of social services while people were locked down. The digital platforms became a very important way to effectively communicate and stimulate rural communities (in particular those of dispersed *linpan* communities) to cope with the sudden disturbance. However, it was also found that some vulnerable groups, such as the elderly, may have not smartphones and do not know how to use applications. Some female farmers were also reluctant to use applications to report their current or future activities. Acceptance of a new technology is still a process. Care should be taken when imposing any technology on any given group, as the tool can only be useful when it is carefully examined within the local situation. Whether or not the GMS will enable rural governance in the long term will be an interesting topic, to which I will pay close attention in the future. Another interesting geography topic to discover is how digital technology is adding a new “sense of place” to the rural community - another “space” which coexist with the current physical world.

3. The post-pandemic recovery in rural Chengdu is related to the resilience of *linpan* landscapes, but the resilience is dependent on multiple factors in various domains, which are beyond the four indexes and eleven indicators of this study.

Rural Chengdu's resilience is dependent on multiple factors in various domains. Even the economic recovery after the threat of COVID-19 is determined by many prerequisites such as health-care facilities, human capital, and government capacity, rather than a simple economic basis. Urban-rural areas that include substantial agro-biodiverse production, responsive governance at many scales, and locally and robustly connected social and cultural life are more likely to recover quickly from external shocks. Indirect factors, such as environmental condition and governance, play a more important role in the contribution to economic regrowth, although both experts and farmers overlooked their roles when I discussed with them about the weight of indexes. However, in this study only one diversity indicator (the Shannon-Wiener Diversity Index) of the landscape was considered in the resilience assessment, which perhaps may not reflect the overall situation of landscape quality. There are also other diversity index apart from this one, also some concepts related to entropy may be useful in enriching the indexes. Importantly, the local culture and customs of human communities also affect responses to external disturbances in different ways. Many factors of governance are subjective rather than objective, which cannot be reflected in statistical data. For example, the control of COVID-19 is not only determined by how many beds or doctors are there in the region but also people's willingness to cooperate and their self-autonomy. Apart from objective vs subjective factors, the census data at county/district level was not able to capture everything at a finer scale, i.e. village or street level. For example, I met some village doctors ("*chi jiao yi sheng*") in Dantu Cun but they are not documented in the statistical yearbook. However, they are playing a critical role in medical assistance in rural areas. Finally, the fundamental philosophical question between qualitative vs quantitative methods, what can and cannot be measured, is worth thinking when we want to assess socio-ecological resilience. What I have been trying here is to balance the two methods and integrate them into the resilience assessment model by incorporating index selections and weight adjustments with interviews and focus groups. So, this approach has two advantages: 1) the census data is official and can be repeated by other researchers in the future, with a potential to apply in another geographic area; 2) the qualitative method makes this model more suitable for the specific case and in this context. It can be seen as an innovative approach but is not the only approach for this question. All of these considerations require more attention in the assessment framework of socio-ecological systems in the future.

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Appendix I: Glossary

Babuqiao Cun 八步桥村 Babuqiao Village, a *xing zheng cun* belonging to Sandaoyan Zhen, now called Babuqiao Shequ, including Paotong Cun

Bai xi 白喜 “White happiness,” a term for the death of people over the age of 70

Bao 保 A rural administrative unit used from 1939 to 1959 in Chengdu, consisting of ten (6-15) *jia*

Bao xi 包席 The practice of wholly using all tables in a restaurant for a reception banquet

Cao shi 草市 Literally “grass market,” indicating a primary, temporary and open-air rural market

Cha pu 茶铺 A tea shop or tea house

Cha Zhan 插占 Meaning to claim a piece of land as property

Chang 场 A rural market or market town

Chang lang 长廊 A long porch

Chi jiao yi sheng 赤脚医生 Literally “barefoot doctor,” a term for the person who is a local farmer but has been trained to provide medical service in villages

Chongzhou 崇州 A county-level city (*shi*) of Chengdu

Chuan pai 川牌 Literally “Sichuan card”, a traditional card game in Sichuan

Cun 村 A village, an abbreviation of *xing zheng cun*

Cun min wei yuan hui 村民委员会 A villager committee

Cun min xiao zu 村民小组 A villager group, a basic (first level) unit of the administrative system in rural areas

Da geng 打更 “Night watch”, a practice where a night-watchman sounds a gong or clapper every two hours during the night

Dalin 大林 A township belonging to Shuangliu (now Tianfu New District). Its former name was *Da Lin Chang* (大林场)

Da lin si 大林寺 Dalin Temple, a Buddhist temple located at Dalin

Dantu Cun 丹土村 or 丹土地 Dantu Village, a *xing zheng cun* belonging to Yongxing Zhen (now Yongxing Jiedao). Its former name was *Dantu Di* (丹土地).

Dayi 大邑 A county (*xian*) of Chengdu

De juan shu yuan 得卷书院 Literally “Dejuan College”, a small museum in Dantu market, exhibiting historical documents and a private collection showcasing Chengdu history

Dong Feng Qu 东风渠 Literally “East Wind Canal”, an arterial canal which was constructed from 1956 to 1973, connecting with the Dujiangyan Irrigation System and irrigating the eastern part of Chengdu Plain

Dong Yue Jie 东岳节 Literally “Dongyue Festival”, a traditional festival in the Chengdu Plain

Dou hua 豆花 Fresh tofu, a popular food made of soybeans in rural Chengdu

Dou qu 斗渠 A main canal, the third level of the hydraulic system (below *zhi qu*)

Dujiangyan 都江堰 A county-level city (*shi*) of Chengdu, called *Guan Xian* (灌县) before 1988; also used as the abbreviation of the Dujiangyan Irrigation System

Fan guan 饭馆 Restaurant

Feng Shui 风水 A system by which one’s space is arranged according to geomantic omens

Feng yu lang 风雨廊 Literally “wind-rain porch”, an architectural structure with elongated and connected eaves along the street, which protects market-goers from the influence of wind, rain and sun

Fu Xing Chang 复兴场 Literally “Fu Xing market”, old name of Dantu market

Gan chang 赶场 The practice of periodically visiting a market town

Gan ji 赶集 A synonym for *gan chang* usually used in northern China

Gan qu 干渠 Arterial canal, the highest level of irrigation branch of the hydraulic system

Gong yuan cheng shi 公园城市 Literally “park city”

Gong yuan cheng shi jian she 公园城市建设 Literally “park city construction”, a program initiated by the Chengdu government

He zuo she 合作社 Farmer’s association, a rural administrative unit was used from 1952 to 1958. Now this term is used for groups of farmers who produce the same agricultural products, such as vegetables, fruits or fish.

Hong xi 红喜 Literally “Red happiness,” indicating a wedding

Hongxiang 鸿湘 A *xing zheng cun* belonging to Jiacha Zhen, old name *Hong Xiang Si* (鸿湘寺)

Huayang 华阳 A township (*zhen*) belonging to Shuangliu (now Tianfu New District), which used to be the seat of Huayang County before 1966, formerly named *Zhong Xing Chang* (中兴场)

Hu guang tian Sichuan 湖广填四川 Meaning a large-scale migration from central, eastern and southeastern China to Sichuan in the 17th Century

Huo xiang 火巷 Literally “Fire lane,” used in cases of emergency such as fire or crowd congestion in a market town

Jia 甲 A term for a rural administrative unit used from 1939 to 1959 in Chengdu, consisting of ten households, but flexible from 6 to 15 households

Jiancha 煎茶 A township belonging to Shuangliu (now Tianfu New District), formerly named *Jian Cha Xi* (煎茶溪)

Jiedao 街道 Literally “Street community,” an administrative unit, which has replaced *xiang* or *zhen* in some urbanized areas

Ji gong che 鸡公车 A wheelbarrow used for carrying freight or a passenger

Jintang 金堂 A county (*xian*) of Chengdu

Jitian 籍田 A township belonging to Shuangliu (now Tianfu New District), formerly named *Ji Tian Pu* (籍田铺)

Laolong chang 老龙场 Laolong Market, see *Liugong chang* 刘公场

Lin 林 A forest or woodland, indicating the composition of *linpan*

Linpan 林盘 A wooded lot, a settlement surrounded by forest or bamboo groves in rural Chengdu

Liu gong chang 刘公场 Liugong Market, a rural market based at *Laolong Cun* of *Liugong Xiang*, thus also called *Laolong chang* 老龙场

Longquanyi 龙泉驿 A township (*zhen*) in Chengdu, also used as the name of a district

Long tai tou 龙抬头 Literally meaning “dragon raising head,” a day at the beginning of lunar February

Mao qu 毛渠 A hairline canal, the fourth level of the hydraulic system (below *dou qu*)

Miao hui 庙会 Temple fair, a specific marketing activity during traditional festivals

Ming Qing Jie 明清街 Literally “Ming and Qing Street,” a market-street in Dantu market, established during the Ming and Qing Dynasties, about 200-300 years ago

Ming shui si 明水寺 Mingshui Temple, a Buddhist temple which became famous in the Qing Dynasty due to the visit of the Royal Prince in the 18th Century, located at Yongxing Zhen

Nong jia le 农家乐 Farm-stay, a kind of rural tourism based on *linpan* settlements, providing food, tea, recreation and even home-stay services

Nong mao shi chang 农贸市场 An agricultural product trade market

Nong qu 农渠 Farming canal, the fifth level of the hydraulic system (below *mao qu*)

Pan 盘 Literally “plate,” indicating the shape of *linpan*

Paotong Cun 泡桐村 or 泡桐树村 Paotong Village, a *xing zheng cun* belonging to Sandaoyan Zhen (now Sandaoyan Jiedao)

Pengzhou 彭州 A county-level city (*shi*) of Chengdu, called *Peng Xian* (彭县) before 1993

Pidu 郫都 Also called *Pixian* (郫县) before 2016, a district (*qu*) of Chengdu, where a case-study site, Paotong Cun, is located

Pujiang 蒲江 A county (*xian*) of Chengdu

Qingbaijiang 青白江 A district (*qu*) of Chengdu

Qing ming hui 清明会 Ancestor worship, which is held by different families or clans during the Qing Ming Festival (at the beginning of April)

Qionglai 邛崃 A county-level city (*shi*) of Chengdu

Qu 区 District, an administrative unit below Chengdu (equal to *xian*) but above *xiang* or *zhen* or *jiedao*

Ren min gong se 人民公社 People's commune, the third level unit of the administrative system in rural areas from 1958 to 1978 (above *sheng chan da dui*)

Sandaoyan Zhen 三道堰镇 A township belonging to Piddu District (*qu*), now called *Sandaoyan Jiedao*

San Ji Zhong Zheng Ce 三集中政策 Literally “Three concentration policy”, a policy proposed by the Chengdu government

Sanxing 三星 A township belonging to Shuangliu (now Tianfu New District), formerly named *Cheng Jia Gou* (陈家沟), now combined with Yongxing as *Yongxing Jiedao*

Shai ba 晒坝 A place for drying grain in the sun in a courtyard

Shao xiang 烧香 To burn incense for worship

Sheng 省 Province

Sheng chan da dui 生产大队 Production brigade, the second-level unit of the administrative system in rural areas from 1958 to 1978 (above *sheng chan xiao dui*)

Sheng chan xiao dui 生产小队 Production team, a basic (first level) unit of the administrative system in rural areas from 1958 to 1978

Shengli qu 胜利渠 Literally “Victory Canal,” a main canal (*dou qu*) built from 1965 to 1973, connecting with *Dong Feng Qu* and irrigating the fields in Yongxing Zhen including Dantu Cun

Shequ 社区 Community, now used as an administrative unit to replace *xing zheng cun* in rural areas

Shi 市 City or municipality, an administrative unit below province (*sheng*) but above *xian* or *qu* or county-level *shi*

Shu 蜀 A term for the Sichuan region in ancient times

Shuangliu 双流 A district (*qu*) of Chengdu where the case-study site of Dantu Cun is located

Tang wu 堂屋 The main room or reception room of a rural house

Tian fu xin qu 天府新区 Tianfu New District, a newly established district of Chengdu, most of its territory previously part of Shuangliu

Tian fu zhi guo 天府之国 Land of Abundance or Heaven Land, indicating the area of Chengdu Plain

Tian jing 天井 Literally “Sky-well,” an architectural structure of a courtyard, meaning a central drainage area

Tongzhi Longyao 同治龙窑 Tongzhi Kiln, a dragon shaped kiln for pottery making in Dantu Cun, established during the period of Tongzhi Emperor in Qing Dynasty

Tu di miao 土地庙 Earth-god shrine or earth-god temple

Wang ge yuan 网格员 Grid manager, an employee of the “grid management system”, a newly emerging ICT-enabled governance system

Wei xin 微信 WeChat, a smart phone based APP for personal communication and networking

Wenjiang 温江 A district (*qu*) of Chengdu

Wen juan xing 问卷星 Questionnaire Star, an online survey tool

Wo yun si 卧云寺 Woyun Temple, a very old nunnery dating to the Tang Dynasty, located at Yongxing Zhen

Xi Kong Zheng Ce 西控政策 Literally “Western control policy”, a policy proposed by the Chengdu government

Xiang cun zhen xing 乡村振兴 Rural revitalization, a national strategy

Xing zheng cun 行政村 Administrative village, the second level of administrative unit in rural areas (below *xiang* but above *zi ran cun* or *cun min xiao zu*)

Xinjin 新津 A district (*qu*) of Chengdu

Xin Nong Cun Jian She 新农村建设 Literally “Construction of New Rural Villages”, a national movement

Xian 县 County, an administrative unit below city (*shi*) but above *xiang* or *zhen*, equal to *qu* but more rural

Xian cheng 县城 County town

Xiang 乡 Rural township, the third level of administrative unit in a rural area (above *xing zheng cun*)

Xiang Cun Zhen Xing 乡村振兴 Literally “Rural Revitalization”, a national movement

Xiao zu 小组 Group, abbreviation of *cun min xiao zu* (villager group)

Xindu 新都 A district (*qu*) of Chengdu

Xinglong 兴隆 A township belonging to Shuangliu (now Tianfu New District), formerly named *Lan Jia Dian* (蓝家店)

Yao dian zi 幺店子 Roadside store (or a few shops), a primary but not periodic market

Yao pu 药铺 Medicine shop or pharmacy, providing medicines and medical services

Yi zhan 驿站 Courier stations in ancient times

Yongxing 永兴 A township belonging to Shuangliu (now Tianfu New District), formerly named *Tu Di Miao* (土地庙), where the case-study site Paotong Cun is located

Za huo pu 杂货铺 A miscellaneous goods store

Zha men 栅门 Town gates, located at the ends of market town streets

Zhen 镇 Urbanized township, the third level of administrative units in rural areas, equal to *xiang* and *jiedao*

Zhi qu 支渠 Branch canal, the second level of the hydraulic system (below *gan qu*)

Zhu chu 柱础 The columnar base of a building

Zi ran cun 自然村 Literally “natural village,” a basic (first level) unit of administrative system in rural area, equal to *cun min xiao zu*

Zong he mao yi shi chang 综合贸易市场 A comprehensive trade market

Zuo bei chao nan 坐北朝南 Literally “seated north and facing south,” indicating that a rural house should be built with a sunny orientation according to the theory of *Feng Shui*, i.e. facing south or southwest in Chengdu

Appendix II: Questionnaire for an Assessment of Ecosystem Services

An Assessment of Ecosystem Services: Household Survey Questionnaire

We are conducting Ecosystem Services Assessment survey in your community. The purpose is to assess the status of *linpan* ecosystems and their services and we request you to take part in the Household survey. If you agree to take part in the survey, we would like to ask you some questions. The questions that you answer are completely your views and perception; there is no any right or wrong answers as such. The information, opinion and knowledge you provide will be helpful for us to come up with the detail assessment of the ecosystem services of *linpan* landscapes in rural Chengdu. We ensure your responses will completely remain anonymous and only the aggregated results will be published in the report and in papers.⁴⁸

1. Basic Information

a	Date (dd/mm/yy):		g	Name of respondent:	
b	Name of interviewer:		h	Sex	1 <input type="checkbox"/> Male 2 <input type="checkbox"/> Female
c	District/Zhen or Xiang		i	Age:	
d	Village:		j	Group:	
e	Mobile No.:		k	WeChat:	

2. Demographic Information

Please use the following codes: * 0= Male; 1= Female ** Marital status: 0= Never married; 1= Married; 2= Divorced/ Widowed *** 0= No; 1= Yes **** 1 = Farming; 2 = Household activity; 3 = Wage labour; 4 = Petty business (specify); 5 = Salaried employee; 6 = Studying; 7 = Remittances; 8= Infant; 0 = Other (specify)

N	Name of	Age	Se	Marital	Can read	Level of education	Occupation / Main activity****
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⁴⁸ This questionnaire was developed to assess the ecosystem services of *linpan* system in 2018 and 2019.

o.	HHs members	(years)	x*	status**	and write***	(years of schooling)	1 st	2 nd
1								
2								
3								
4								
5								
6								
7								
8								

Note: Start with the household head first, then spouse and then other members in the order

3. Land information

Does your family live in a *linpan* settlement? 0 No 1 Yes

3.1. If yes, provide the following information.

Linpan type*	Land use					Radius		Remarks
	Farmland (mu)**	Orchid (mu)	Bamboo or tree grove (mu)	Pond (mu)	Fish farm (mu)	Linpan radius (m)	Farming radius (m)	

Please use the following codes: * 0=small (<5 households); 1= medium (5-9 households); 3=large (>10 households) ** Farmland: 0= rice paddy (tian); 1= irrigated land (di)

4. What are the major crops grown, area under cultivation, input cost of cultivation and gross return?

Major crops	Area under crop (in mu)	Cost of cultivation*	Gross return (Home consumption and sale)	Quantity produced	Unit price **
1.					
2.					
3.					
4.					
5.					
6.					

*Cost of cultivation: Labor man days and other cost (seed, fertilizer, pesticides etc.)

** Get the unit price from market survey

5. Does your household have any livestock and poultry? 0 No 1 Yes

5.1. If yes, please give details (Please use given codes: *1= grain, 2= crop residues, 3=grass, 4=compound feed, 5=others; **1=live, 2=slaughtered, 3=egg, 4=by-products)

Type	Present number	Number in the past 5 years	Feedstuff*	Animal or products deliver to market**	Average income from marketing per annum	Remarks

6. Households' gross annual income. Please tick one of the following.

- a. Less than 50,000
- b. Between 51,000-99,000
- c. Between 100,000-199,000
- d. More than 200,000

7. State of ecosystems and ecosystem services

What are the major ecosystems and their services your household depend on? Even if your household does not depend on these ecosystem services, do you feel that these ecosystem services are important?

Major ecosystems	Rank in terms of the household's dependency on the services	Rank in terms of their importance to provide services	Remarks/Reasons

(Please use given codes: 4= very important, 3= important, 2= moderately important, 1= less important, 0 = not important)

4= highly dependent, 3= dependent, 2= moderately dependent, 1= less dependent, 0 = not dependent)

8. Is there any change in these ecosystems in terms of their area over the last 10 years?

Major ecosystems	Change*	Reasons for change
Forests and bamboo groves		
Farmlands		
Orchards		
Freshwater bodies		
Others (built lands)		

(*Please use given codes: 0= No change; 1= Increasing; 2= Decreasing, 3= Do not know)

9. Information on ecosystems services, sources and their status

What kind of provisioning ecosystem services you use for your livelihood?

(Please use the following code: 0= No; 1= Yes)

Ecosystem services (Provisioning)	Major ecosystems					Remarks
	Forest	Farmland	Wetland	Orchard	Others	

10. In your opinion, what are the major regulating ecosystems services provided by these ecosystems?

(Please use the following code: 0= No; 1= Yes)

Ecosystem Services (Regulating)	Major ecosystems					Remarks
	Forest	Farmland	Freshwater	Orchard	Others	
Carbon sequestration						
Climate regulation						
Erosion control						
Flood control						
Pest regulation						
Pollination						
Seed dispersal						
Water purification						
Water retention						
Other (specify)						

11. In your opinion, what are the major supporting ecosystems services provided by these ecosystems?

(Please use the following code: 0= No; 1= Yes)

Ecosystem services (Supporting)	Major ecosystems					Remarks
	Forest	Farmland	Freshwater	Orchard	Others	
Ecosystem resilience						
Habitat for species						
Hydrologic cycle						
Soil formation						
Ground water recharge						

14. General

14.1. Has the livelihood of your household improved through ecosystem management compared to the situation 10 years ago? 0 No 1 Yes

14.2. What would be most helpful to improve the livelihood of your household?

Thank you for valuable your time!

Appendix III: Questionnaire for Farmer's Response to COVID-19

我是一名研究农村人居环境的学生，想了解一下疫情期间您和家庭的应对情况，受到了哪些影响？哪些因素你们觉得对于应对疫情很重要？同时还了解一下你们家庭的生活和生产情况。信息将仅用于学生报告。

此卷为调查疫情前后农村农民生产生活韧性调查

This questionnaire is deigned to learn the resilience of agricultural production and daily life of local farmers under the impacts of the COVID-19.⁴⁹

1-8 为基本信息题

1-8 are about the basic information

1. 问卷编号 [填空题] * Survey ID number

_____DT001_____

2. 请选择日期： [填空题] * Survey Date

3. 您的姓名 [填空题] * Subject's Name

4. 您的性别 [填空题] * Gender

⁴⁹ This questionnaire was also used in the online survey of *wen juan xing* in 2020.

5. 出生年月 [填空题] * Date of birth

6. 联系方式 [填空题] * Contact info

7. 教育程度 [单选题] * Education level

未受教育 0 not educated

小学 1 primary school

中学 2 middle school

大学 3 college level

大学以上 4 above college level

8. 你属于哪个村第几组? [填空题] *

Which group do you belong to?

9-10 为房屋情况

9-10 are about houses

9. 采访者住在传统林盘还是新型农村? [单选题] *

Are you living in dispersed *linpan* or newly constructed villages?

传统林盘 traditional *linpan* (dispersed type)

○新型农村 newly constructed village (concentrated type)

9-2. 您觉得疫情期间住在分散的林盘会提升你的安全感吗? [单选题] *

Do you feel safer living in dispersed *linpan* under the pandemic?

○Yes

○No

为什么? Why?

10. 你们家有几间房: _____ 土坯房还是砖瓦房? _____ 有茅草顶吗?

是自己修的, 还是政府统一修的? _____ 哪一年修的? _____

如果自己修的, 政府有补贴吗? _____ 是用自己的土地吗? _____ [填空题] *

How many rooms do you have? Adobe or Brick? Thatched roof? Do you build by yourself or is it a government project? Which year did you build it? If it is constructed on your own, do you have a subsidy from the government? Is it your house built upon your own land?

11-22 为个人及家庭收入情况

11-22 are about personal and family income

11. 您的家庭成员有 () 位? [单选题] *

How many members are there in your family?

○2 two

○3 three

○4 four

○5 five

○其他 _____ other

12. 您家庭收入来源主要有： [多选题] *

What is your primary source of income?

土地收入 agriculture

外出务工 work as migrant labor

副业 subsidiary business

其他 _____ other

13. 你家庭的主要收入来源（疫情期间）是？ [填空题] *

What is your primary source of income during COVID-19?

14. 您家土地大约有多少亩？ [填空题]

How many *mu* of land do you have?

15. 您家从事劳动农业人数是几个人？ [填空题] *

How many persons of your family engaged in agriculture are there?

16. 您家土地种植作物有： [多选题] *

What kind of crops/fruits do you grow?

水果/蔬菜 vegetables and fruits

粮食作物，如水稻，小麦等 grain crops (rice, wheat)

经济作物，如油菜，烟草等 Economic crops (such as rape, tobacco, etc.)

其他 _____ other

17. 您未选择外出务工的原因是？ [多选题] *

Why don't you choose to go to work in cities?

家中务农可以满足日常生活消费 Farming at home can satisfy daily consumption

大城市生活压力大 Life in big cities is under pressure

缺少一定的技术本领 Lack of certain technical skills

老人小孩 Elderly and children

疫情影响 The impact of the pandemic

其他 _____ other

18. 您在 2019 年的下半年与 2020 年上半年外出务工情况如何？ [单选题] *

How do you describe your income level in the early year of 2020 compared to the late of 2019?

都成功外出务工并拿到应得的工资

All successfully went out to work and got their due wages

都成功外出务工但由于疫情等原因一部分工资并未拿到

All successfully went out to work, but due to the epidemic and other reasons, some of the wages were not received.

2020 年上半年因为疫情未能外出务工

Failed to go out to work due to the epidemic in the first half of 2020

19. 您家外出务工人数为？ _____ 在什么地方： _____

How many family members go out to work as migrant workers? Where?

对家里的主要贡献为（列入汇款，孩子上学）： _____

What are their contributions to this family, such as remittance and children education?

疫情后他们是否回原地上班了 [填空题] *

Do they go back to work after the Covid-19 terminated?

20. 您家外出务工人员所从事的行业是？ [填空题] *

What is the occupation of the family member who engages in non-agricultural work?

21. 您所从事的行业？ [多选题] * What is your occupation?

工业（例如木材加工、塑料加工、金属制品等） Industry (such as wood processing, plastic processing, metal products, etc.)

商业（例如商品超市、摊点零售、餐饮酒店等） Business (such as commodity supermarkets, retail stalls, restaurants and hotels, etc.)

建筑建材业（例如建筑行业、建材贩卖、装修装饰等） Building materials industry (such as construction industry, building materials sales, decoration and decoration, etc.)

农业与农村服务业（例如养殖业、果蔬种养等） Agriculture and rural service industries (such as breeding, fruit and vegetable cultivation, etc.)

运输业（例如公交、载客出租运营等） Transportation industry (such as public transportation, passenger rental operation, etc.)

服务业（例如快递、餐饮、外卖送家、家政服务等） Service industry (such as express delivery, catering, takeaway delivery, housekeeping services, etc.)

其他 _____ Other

22. 您家庭最大支出的两项为？ [排序题，请在中括号内依次填入数字] *

What are the two major categories of spending in your family?

- 老人赡养 Elderly support
- 生活费用 Cost of living
- 生产费用 Production cost
- 孩子教育费用 Child Education Expenses
- 医疗费用 Medical expense
- 其他 Other

23-38 为疫情前后对家庭影响的测评题

23-39 are about the percetions to the COVID-19

23. 您认为疫情对您家庭生活的影响大吗？ [单选题] *

How do you describe the impact of COVID-19 upon your families?

- 大，收入减少较多 Large, more income reduction
- 一般，没什么区别 Moderate, no difference
- 小，收入有所增加 Little, income has increased

24. 您认为您收入减少的主要原因是？ [多选题] *

What are the major reasons leading to the decrease of your income?

- 疫情阻止外出务工，或在外地受到歧视，不好揽活 Epidemic prevent from going out to work, or are discriminated against in other places, it is not easy to get jobs
- 由于封锁，农产品等卖不出去 Due to the blockade, agricultural products cannot be sold
- 其他 _____ * Other

25. 疫情期间村里的信息主要由谁通知？ [多选题] *

Where do you get Covid-19 related information?

村委 village committee

网格员 grid manager

手机或电视 cell phone or TV

医疗人员 medical staff

亲友邻里告知 neighbors or relatives

26. 防疫信息传递的及时程度？ [单选题] *

How do you rate the efficiency of information passing related to COVID-19 in your village?

很不满意 1 2 3 4 5 很满意

1 as very unsatisfied, and 5 as very satisfied

27. 您认为村里的医疗资源是否足够？ [单选题] *

Is the amount of health facilities in your village enough for local people?

很不足 1 2 3 4 5 很充足

1 as not enough and 5 as enough

28. 如何评价您的家庭对于 COVID-19 的应对能力？ [单选题] *

How do you rate your family responsive capacity to COVID-19?

很不足 1 2 3 4 5 很充足

1 as the lowest rate and 5 as the highest rate

29. 请对于 28 题做出各项打分[矩阵量表题] *

Please rate the following categories according to your family situation. 1 as the lowest and 5 as the highest score.

	1	2	3	4	5
医疗储备 Health care	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
食物储备 Food storage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
资金储备 Money storage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
邻里互助 Neighbor help	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
其他（请说明） Others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

30. 您觉得您家，或者是整个社区，对于猪流感禽流感等的应对能力？ [单选题] *

How do you rate your community's responsive capacity to pig flu or chicken flu?

弱 1 2 3 4 5 强

1 as the lowest and 5 as the highest.

基于上面打分，谈谈为什么打分高或低？ [填空题]

Please explain why you rate this.

31. 您认为农村与城市相比疫情控制更易或更难？ [单选题] *

Do you think rural areas are easier or more difficult to control under pandemic?

易 easy

难 difficult

32. 以下衡量地区抗疫韧性的条件，1 为不重要，5 为很重要，请打分[矩阵量表题]

Please rate the following index importance under pandemic in you region* 1 as the lowest and 5 as the highest importance.

	1	2	3	4	5
环境条件 Environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
经济基础 Economy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
治理水平 Governance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
医疗条件 Medical	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

在调查时向对象说明这四类条件包括哪些方面。

Explaining what means of these indexes when interview local people.

33. 除了以上指标，您认为哪些因素会影响疫情防御？ [填空题] *

What other factors do you think will impact pandemic control?

34. 疫情期间您家的农业生产受到影响了吗？

Have you stopped the agricultural activities of your family during the pandemic?

- 没有 no
- 短暂 short time
- 长期 long time

35. 疫情期间你们的赶场受到影响了吗？

Have you stopped your gan chang activities during the pandemic?

- 没有 no
- 短暂 short time
- 长时间 long time

36. 您认为哪些因素影响疫情后的生产生活恢复能力？（1为不同意，5为非常同意）[矩阵量表题] *

What factors do you think will influence the recovering capacity after the pandemic? 1 as strongly disagree and 5 as strongly agree.

	1	2	3	4	5
家庭经济实力 Economic	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
个人能力 Personal capacity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
政府扶持 Governmental aid	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
大家相互帮助 Neighbor's help	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
销售渠道畅通 Efficient marketing channel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
交通与通讯 Transportation and communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
其它 Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

37. 您觉得疫情过后您的家庭可以多久恢复到以往情况？ [单选题] *
How long do you think your family will recover from this shock?

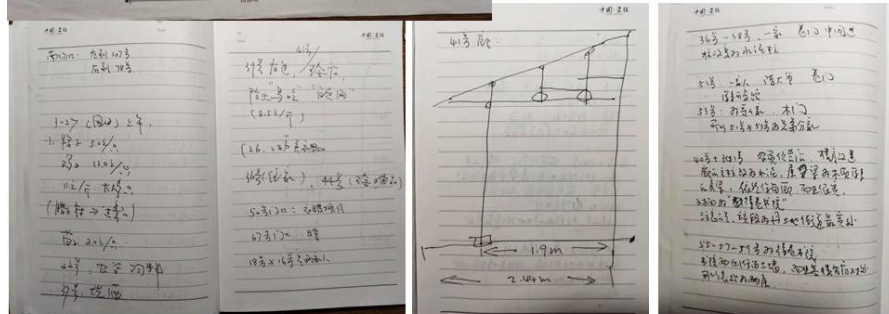
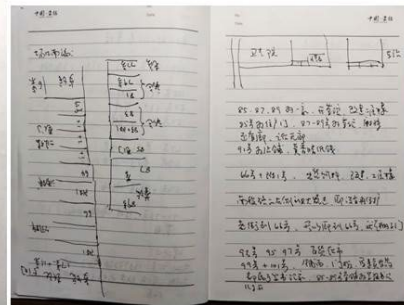
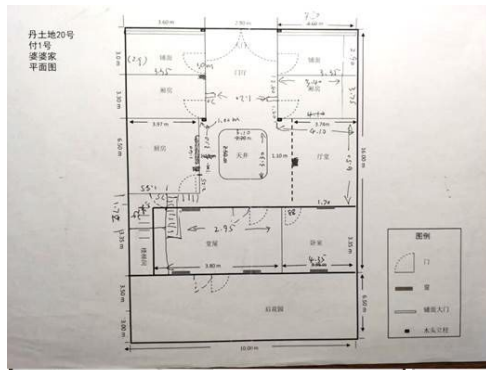
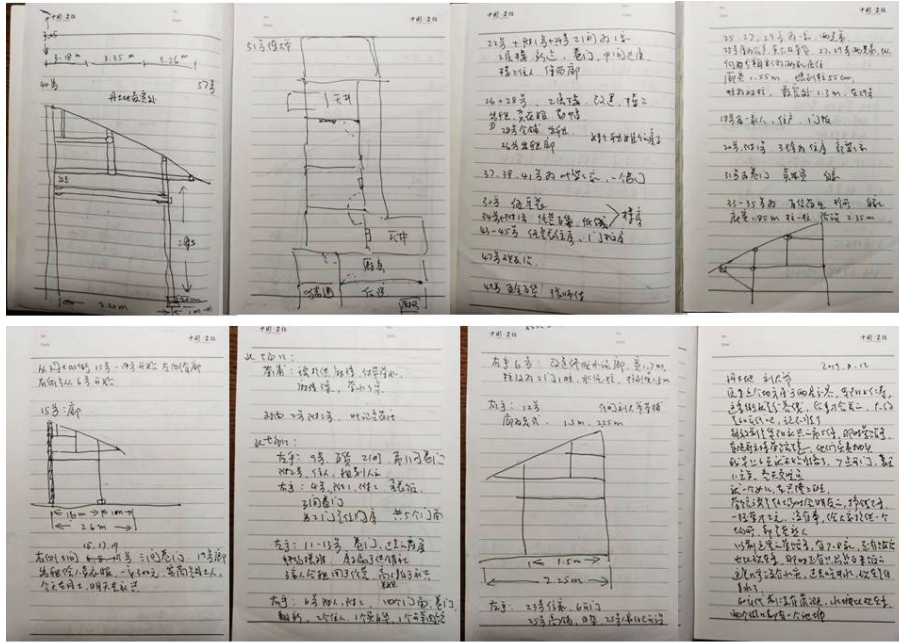
- 1-6 个月 1-6 months
- 6-12 个月 6-12 months
- 大于 12 个月 more than 12 months

38. 公交车不开期间，您怎么买菜？ [填空题] *
How do you buy food when transportation is closed during COVID-19?

39. 疫情期间网络对你的日常生活有帮助吗？表现在哪方面？
Can the internet help your daily life during the COVID-19? In which aspects does it reflect?

APPENDIX IV

Parts of field notes



VITA

Shuang Wu, was born in Chengdu, China. From 2009 to 2013, she studied in the College of Architecture and Urban Planning, Tongji University, Shanghai, and graduated with the Bachelor of Engineering in Architecture and Conservation. From 2013 to 2016, she studied in the School of Design, University of Pennsylvania, Philadelphia, and graduated with the Master of Science in Historic Preservation. In 2017 she started her PhD study in the College of Built Environment, University of Washington, Seattle under the supervision of Prof. Daniel Abramson. Her research interests mainly include cultural landscape, socio-ecological resilience, historic preservation and spatial data science. During her study in universities, she used to work as research associate at the University of Pennsylvania, intern architect in Berlin, and teaching assistant at the University of Washington. She has published several interdisciplinary articles in peer-reviewed journals and also participated in a number of international conferences or symposiums and presented paper or posters.