Whose rules? Whose land? Whose water?

–Water rights, equity and justice in Dujiangyan water conservation area

Water of Dujiangyan.
Source: Yichiquqqujing. (2019).

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Water justice in Dujiangyan Irrigation District
--The intervention framework of water equity in Dujiangyan water conservation area

Abstract

With the explosive growing population in Chengdu, the demand for urban drinking water is increasing, and the application of water conservation regulations is becoming more and more stringent. However, with the delineation of water source protection zones, villages and small towns in the upper reaches of Chengdu have been affected a lot.

The upstream of Chengdu, which is part of the Dujiangyan irrigation area, is the typical western Sichuan style village with its vernacular wisdom of living with water (Xu, 2014). But now they are expected to leave and move into a collective community with fixed reimbursement due to the water source protection policy. Local small industries and livestock raising are no longer allowed, and agricultural production is also restricted due to the risk of water pollution. Besides the economic loss, the authentic lifestyle that carries water culture has also suffered the loss. Metropolis gain priority on water and the indigenous people are sacrificed. And this water injustice issue is even exacerbated when the new modernized neighbourhood came since the informal development is intolerant by the government (Abramson, 2019).

Therefore, this research will explain the conceptualization of water justice and the key elements in this specific local urbanization context. Through the analysis of the impact by water extraction, the tangible water value, the virtual value of water, and the cultural preservation, mearing the expulsion of this water project and the livelihood of the locals. Then clarifying the multiple-layer influence of the water conservation interventions in this irrigation area and emphasizing the importance of water justice especially for the indigenous people with the social survey, literature review, and comparison of other villages. And scenario testing of different possible new development in the perspective of different priorities to find a balanced solution for both sides.

This research is aiming to engage flexible water conservation policies with the methods of ecological compensation and local empowerment, explore a win-win way of both water use cities and water source districts. And for this specific case, find out a sustainable development way with a comprehensive consideration for vulnerable groups which allows them to keep their positive way of living while doing the water conservancy.

Key words: Water conservation, Dujiangyan irrigation area, water justice, sustainable development



Fig 1.1 Village in Dujiangyan irrigation area
Source: Wang, D. (2018)

Motivation

For drinking water source conservation, regulations are getting stricter which is good for the health and sanitation of the water supply.

In one of the villages of Dujiangyan irrigation area, which is located completely in the water conservation area, no housing construction is allowed in the village. Livestock is not allowed neither are pesticides and fertilizers. They lost almost half of their income so that to the extent that the young generations are forced to go to work in towns.

The government builds a new community on the edge of the town but not all of the villagers can afford to live there because the water, gas, electricity in the urban area is much more expensive. In the meantime, they are far away from their agriculture land. The current one-size-fits-all policy is to reset all villagers in new residential areas and provide a certain amount of subsidies, ignoring the plight of some villagers who cannot afford to live there.

The water conservation forced them to change their self-sufficient lifestyle which had lasted for centuries.

Safe drinking water supply is crucial, but the life of the indigenous people there also needs to be taken into account.

1 Introduction

The West Sichuan Plain, called 'West Sichuan Bazi' in the Sichuan dialect, mainly refers to the alluvial plains of the Min River and Tuo River. Because Chengdu is located in the centre of the plain formed by the two rivers, it is also called the Chengdu Plain. The Chengdu Plain is developed on a fan-shaped alluvial plain from northwest to southeast. It is formed by the alluvial soil of the Min River, Tuo River and its tributaries while overlapping each other. The soil is fertile and is conducive to cultivation.

Both the Min River and the Tuo River are the upper tributaries of the Yangtze River, which merge into the Yangtze River in Yibin City and Luzhou City respectively. The human settlement on the Chengdu Plain rose due to this water system. Agriculture and villages developed rapidly since the built of Dujiang Weir in the Qin Dynasty (221 - 206 BC). In addition to the development of agriculture, cities and towns also flourished along with water. Several important cities were distributed along the mid-ridge line of the alluvial plain (Yan, Xiang, & Yuan, 2005), from Dujiangyan City to Pixian County (now Pidu District) and then to Chengdu. The plain where water is drawn from Dujiangyan, goes through the canal, and irrigates the field is called Dujiangyan Irrigation District.

Since the 1930s, modern water conservancy technology has brought about tremendous changes to the entire Chengdu Plain (Yan, Xiang, & Yuan, 2005). Rigid river embankments and sluices have increased the utilization rate of rivers in the West Sichuan Plain. Modern transportation technology has also enabled the development of cities to rely on land transportation, and the water system has begun to be separated from the city. These destroyed the original water use method that was symbiosis with natural conditions, and water resources began to be regarded as a kind of merely used resources.

As a megacity in the southwest region, the urbanization process accelerated in Chengdu since 2000 and its population has grown rapidly. It is predicted that the population in 2030 will be more than double the population in 2005 (He & Li, 2007). The rapid growth of the population has put pressure on urban infrastructure. The increase in urban water use and the increase in water source protection requirements have caused the unfair use of water resources in Chengdu, Pidu District, and Dujiangyan City. Metropolis has obtained priority in the competition for water resources. The development of water source cities, water source villages, and upstream water conservation areas have been affected.

This project is aiming to analyze the form and degree of unfair use of water resources, summarize the elements of water resources that need to be paid attention to in the regional development justice, and propose a framework and specific strategies and interventions to achieve water equity.

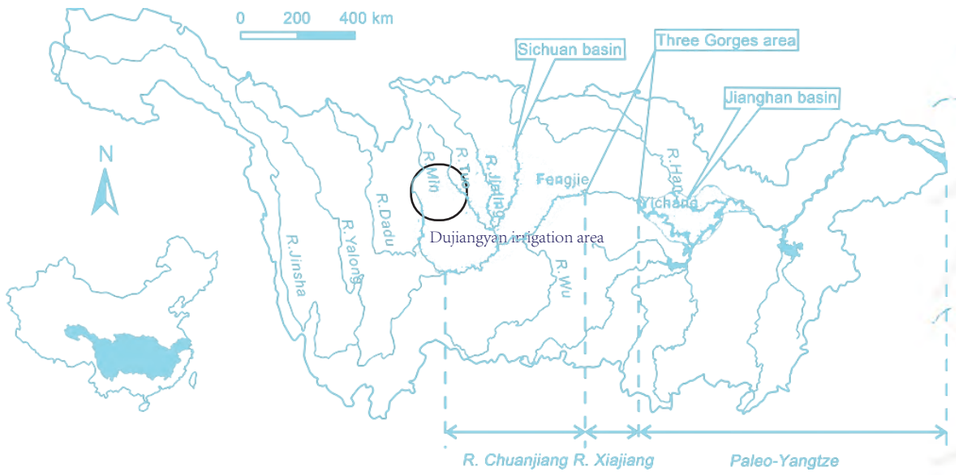


Fig 1.2: Dujiangyan irrigation area in Yangtze River Basin
Source: Author, adapted from Hu, Tan, and Xu (2019).



Fig 1.3: River system in Chengdu Plain
Source: Author, adapted from Snazzy Maps(n.d.)

The sichuan basin

Sichuan basin with a total area of about 260000 square kilometres, is located in south-central Asia, Sichuan province in southwestern China. It is surrounded by the Qinghai-Tibet plateau, Dabashan mountain, Huaying Mountain and Yunnan-Guizhou plateau with a 1000 metres to 3000 metres altitude. The middle area is low-lying with an altitude of 250 metres to 750 metres (Wikipedia contributors, 2020).

Min River Basin

The Min River originates from Garena, northwest of Songpan, at an altitude of 3860 metres, finally reaches Dujiangyan at only 770 metres (Fang, 2012). From the birthplace of the Min River to Dujiangyan, the water flow is 350 kilometres, with a drop of about 3,000 metres. Before entering the plain of western Sichuan, the current is turbulent. Once it arrived at Dujiangyan and entered the vast plain, the water flow slowed down and the carried sediment accumulated in the plain of western Sichuan to form an alluvial fan, and formed the mid-ridge line of Dujiangyan-Pixian-Chengdu.

Dujiangyan Irrigation District

Compared with other areas, the water system in Dujiangyan irrigated area is obviously dense and marked by artificial build rather than natural rivers.

The West Sichuan Plain is mainly composed of the Min River and Tuo River alluvial plain. The terrain is flat and slightly slopes from northwest to southeast with an average slope of only 3 ~ 10‰, which is conducive to the development of artesian irrigation. The relative elevation difference of the surface is generally no more than 20 metres, and there are vast plains fertile fields (Fang, 2012).

The maximum thickness of the sedimentary layer in the West Sichuan Plain is 541.2 metres, and the thickness of the sedimentary layer at the edge of the plain becomes thinner (Thorp, 1935).

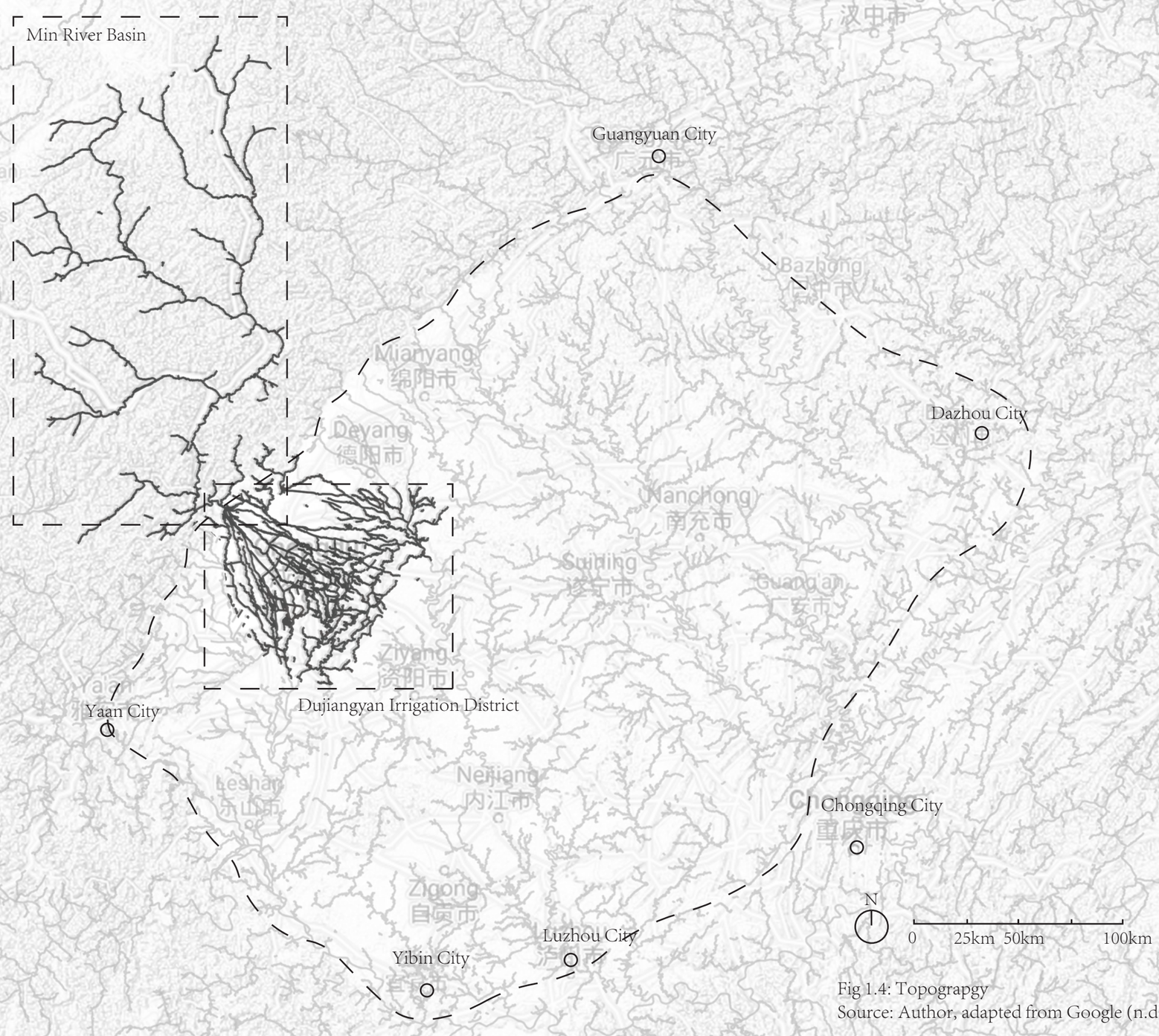


Fig 1.4: Topograpgy
Source: Author, adapted from Google (n.d.).

1.2 Context

The water system of the Dujiangyan Irrigation District is constantly developing. Starting from the natural water system, more and more water conservancy projects and canals have been dug artificially, and the density is getting higher and higher, eventually forming an irrigation system with dense water systems that leads to every inch of land.

(Embryonic stage 5000 to 256 BC)

After Min River flows to Dujiangyan, due to the slow terrain, it is divided into four rivers, one flowing into the Tuo River, and the other eventually flowing back into the Min River system. The plain area between the Longmen Mountains and the Longquan Mountains, through which the Min River system passes, is the Dujiangyan Irrigation District and the Chengdu Plain. The water systems at this time are all natural water systems, with fewer tributaries and larger water flow.

Primitive human settlements developed from the fishing and hunting civilization to the farming civilization. People migrated from the upper reaches of the Min River to the alluvial fan of the West Sichuan Plain, and because of the risk of flooding in the mainstream of the Min River, they gradually settled in the relatively high-lying mid-ridge area. Due to the impact of natural floods in alluvial plains, a small and scattered 'habitation by water' settlement spatial structure has formed (Yan, Xiang, & Yuan, 2005).

(Formation period 256 BC to 266 AD)

Since the construction of the Dujiangyan water conservancy project, the flooding of the Chengdu Plain has been effectively controlled, the agricultural and handicraft industry has been greatly developed. The main canal water conservancy system was completed along with Dujiangyan at this time. The patterns of Jian River (Zuma River), Du River (Batiao River), and Jian River (Puyang River) in the inner river basin of the Min River System have been preliminarily formed. These are all hydraulic systems that were excavated manually during the Han Dynasty (202 BC - 220 AD). The water system of the Chengdu Plain at this time mainly started from Dujiangyan and expanded to the east, showing a radial shape.

During the Qin Dynasty (221 - 206 BC), Chengdu was first built as a city. When Li Bing, the governor of Shu County, built the Dujiangyan water project, he led two rivers (Pijiang and Liujiang) around Chengdu (Liu, 2004).

(Improving period 266 to 1271 AD)

During the Sui and Tang Dynasties (581 - 907AD), the country was prosperous and water conservancy construction projects were frequent. The water system of the Chengdu Plain expanded from the centre of the plain to the edge of the plain, and the Min River and Tuo River gradually connected. The main canal system is basically formed, very close to modern times, and the density of the water network is also increasing.

Dujiangyan has been destroyed and rebuilt many times due to war. The main water conservancy system has not changed much after each reconstruction. The main construction is a multi-level water network and terminal irrigation system. Almost homogeneous irrigation conditions have been formed in the Dujiangyan Irrigation District, with small but numerous rural settlements distributed along smaller canals.

(Developed stage 1271 to 1912 AD)

During the Yuan, Ming and Qing Dynasties (1271 - 1912AD), the inner and outer river basins of the Chengdu Plain were stable, and the structure of the main canals became mature (Yang, 2015). In addition to the main canal, the most rapid development at this stage is the small irrigation canal at the end, called the 'bucket canal' and 'mao canal'.

At this time, the Chengdu Plain water system formed a grid-like distribution, with the end canals leading to every inch of the field, and the Chengdu Plain pattern with crisscross water networks reached its peak.

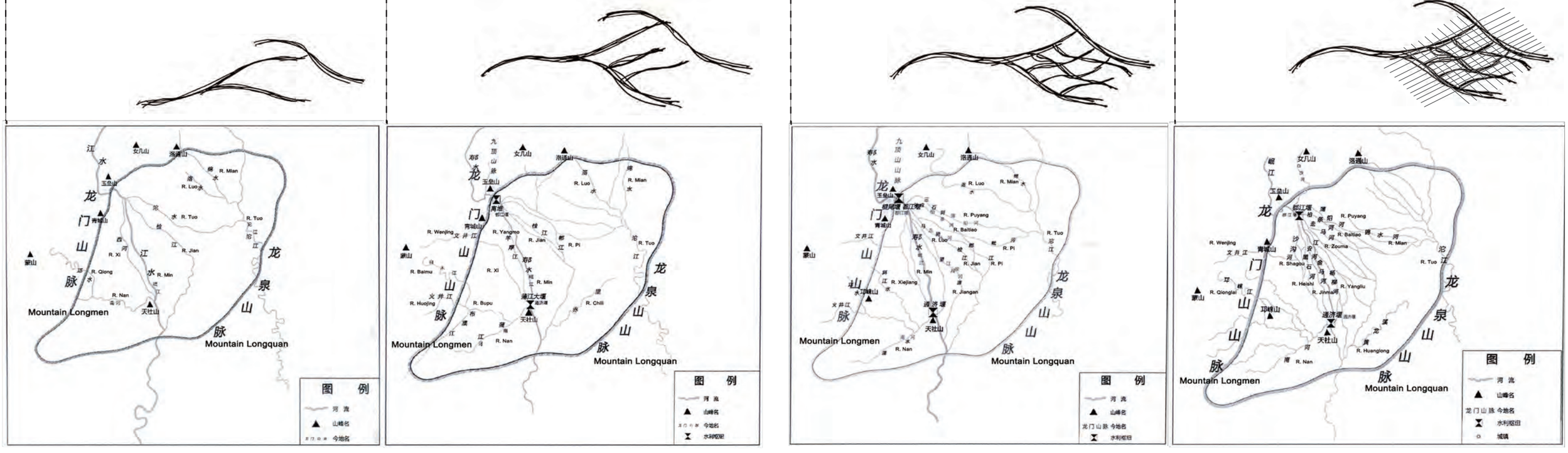


Fig 1.5: River system development in Chengdu Plain
Source: Author, adapted from Yang (2015).

1.3 Problem Field

1.3.1 Leaving the water

After 1930, modern water conservancy technology had a huge impact on the Dujiangyan Project and the entire Dujiangyan Irrigation District. An earthquake in the upper reaches of Dujiangyan in 1933 caused a burst of the barrier lake. In 1936, the Min River flood destroyed the Dujiangyan Project. Therefore, in the 1936 Dujiangyan Project plan, it is expected that the internal non-dam water diversion system will be replaced by a large modern water conservancy project (Yan, Xian & Yuan, 2005). Although the plan was not implemented, it reflects the trend of using new technologies. The traditional materials in the project were completely replaced by modern reinforced concrete, and a modern sluice was built inside the project. Then in Dujiangyan, all the Min River water is lead into the irrigation area during the dry season, and the mainstream of the Min River will be cut off during that period. Through the construction of the water control gate, the area of Chengdu Plain's current irrigation area has been expanded four times compared with the 1940s (Yan, Xian & Yuan, 2005). In 2006, the Zipingpu Reservoir (Fig 1.6) was built 9km upstream of the Dujiangyan Project to further control the runoff of the Min River. In addition to large-scale water conservancy projects, a large number of small sluices have been built, and the control of irrigation water depends entirely on these modern projects now.

Human settlements in the Dujiangyan Irrigation District have gone through four main stages: 1.living by the water, 2.city-build along the water, 3.improving the water, and 4.leaving the water. These are forming the spatial structure of human settlements (Yan, Xiang, & Yuan, 2005).

In this period of engineering technology guided, water was merely regarded as a resource, and the structure of the human settlement in the West Sichuan Plain that traditionally lived by water changed rapidly. The emergence of new water diversion irrigation technology makes the end capillary canal of rural irrigation in a state of water cut during non-irrigation. The urbanization process oriented by the development of transportation has separated the residential space from the water. The water-related lifestyle is fading. The water system has only the role of the landscape for the city, and the role in the village is gradually becoming simplified in the modernization process. The plain of western Sichuan has begun to leave the water.



Fig 1.6: Zipingpu water conservancy project in upper Dujiangyan
Source: Laofei (2019)

Chengdu has always been a famous water city in history. There are two rivers surrounding the city, namely the Fu River and Nan River. The two rivers converge in the southeast of the city named Funan River. The confluence of the two rivers is the most important water terminal in Chengdu. Commercial trade in the West Sichuan Plain departs from here to enter the Yangtze River. Fig1.7 is the bustling people and boats at Jin River Wharf in Qing Dynasty (1644 - 1912). Fig 1.8 is citizens playing in the Funan River in the 1940s. At this time, the river was not seriously polluted and was the source of drinking water in Chengdu (Wang, 2003). Cities and water systems are closely connected. Rivers are not only for recreation but also a source of water for commerce, transportation, and daily life.

In 1998, the Funan River was renovated and the river banks were paved (Fig1.9), which won the UN-Habitat Award. The function of the urban river is only the function of landscape viewing nowadays. The water system is far away from human life.



Fig 1.7: Jin River Wharf in Qing Dynasty (1644-1912)
Source: Yuan (2010)



Fig 1.8: Citicens playing in Funan River in the 1940s
Source: Sichuan Mobile News (2019)



Fig 1.9: Paved water bank: leaving the water
Source: Toutiao (n.d.)

1.3 Problem Field

1.3.2 Growing water demand in Chengdu

Growing population and water demand

Chengdu is a central city in southwestern China. The Tianfu New District plan was approved in 2014, with the goal of 'create another Chengdu' (The People's Government of Sichuan Province, 2015). As shown in Figure 1.10, the population of Chengdu is growing rapidly, approaching 16 million people in 2016. Together with the population growth is the total water consumption of urban residents, which was close to 1.3 billion cubic metres in 2016.

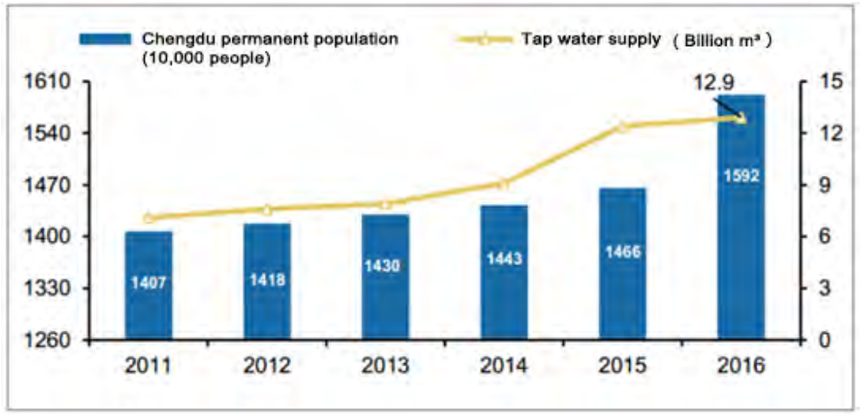


Fig 1.10: Population and water supply of Chengdu Plain
Source: China Industry Information. (2018).

Although Chengdu is located between the two large rivers Min River and Tuo River, the water network is densely distributed, but the actual per capita water resources are not sufficient. The per capita possession was only 800 cubic metres in 2000-2005 (Ren, Wang, Zou, & Wu, 2007). The per capita water resources can reach about 2800 cubic metres when including the transit water (Li and Liu, 2002). According to the four-level assessment standard of water resources proposed by the World Water Resources Institute, Chengdu belongs to water-deficient areas (Ren, Wang, Zou, & Wu, 2007). According to calculations by Li, Ding, and Wang (2003), with a water guarantee rate of 50%, the actual water shortage in Chengdu in 2010 exceeded 1.6 billion cubic metres. To achieve the guarantee rate of 95%, the water shortage is almost 30 Billion cubic metres and around 18% of the total demand. In addition, it can be seen from these data that the water resources of the Chengdu Plain are mainly surface water, and more than 90% of the water resources come from the Min River water system (Chen, 2010). Therefore, the Min River water supply system is the lifeline of water in Chengdu. The water volume, water quality and seasonal water supply changes of the Min River all affect the production and domestic water consumption in Chengdu.

The calculation table of water supply and demand balance in Chengdu in 2010 (Billion m³)

Guarantee rate /%	Agriculture	Industry	Water demand		Other	Total	Available water	Waste	Shortage	Shortage rate /%
			Urban	Rural						
50	35 44	100 32	12 54	3 41	0 18	151 89	135 83	86 53	16 06	10 57
75	40 96	100 32	12 54	3 41	0 18	157 41	132 14	61 13	25 27	16 05
95	48 89	100 32	12 54	3 41	0 18	165 34	135 54	51 33	29 80	18 02

Fig 1.11: Water shortage in Chengdu
Source: Li, Ding, and Wang (2003)

Measuring water stress

A common measure of water stress in a region is the ratio of total annual water withdrawal to average annual available freshwater resources (both surface and groundwater). It has been widely used by international organisations such as the FAO (G20 Green Finance Study Group) and the World Bank 68 in comparing water management between different countries. It is also the SDG indicator 6.4.2 (Hu, Tan, & Xu, 2019).

Judging from the distribution of water pressure in the world, the Chengdu Plain is in an area with lower average pressure, and only itself is facing greater water pressure in this area. According to the forecast in 2030, the overall water pressure in the world is decreasing and concentrated, but the water pressure on the Chengdu Plain will increase significantly in 2030. The reason is, on the one hand, the runoff of the Min River system has decreased, and on the other hand, it is the population pressure caused by the urbanization process of Chengdu.

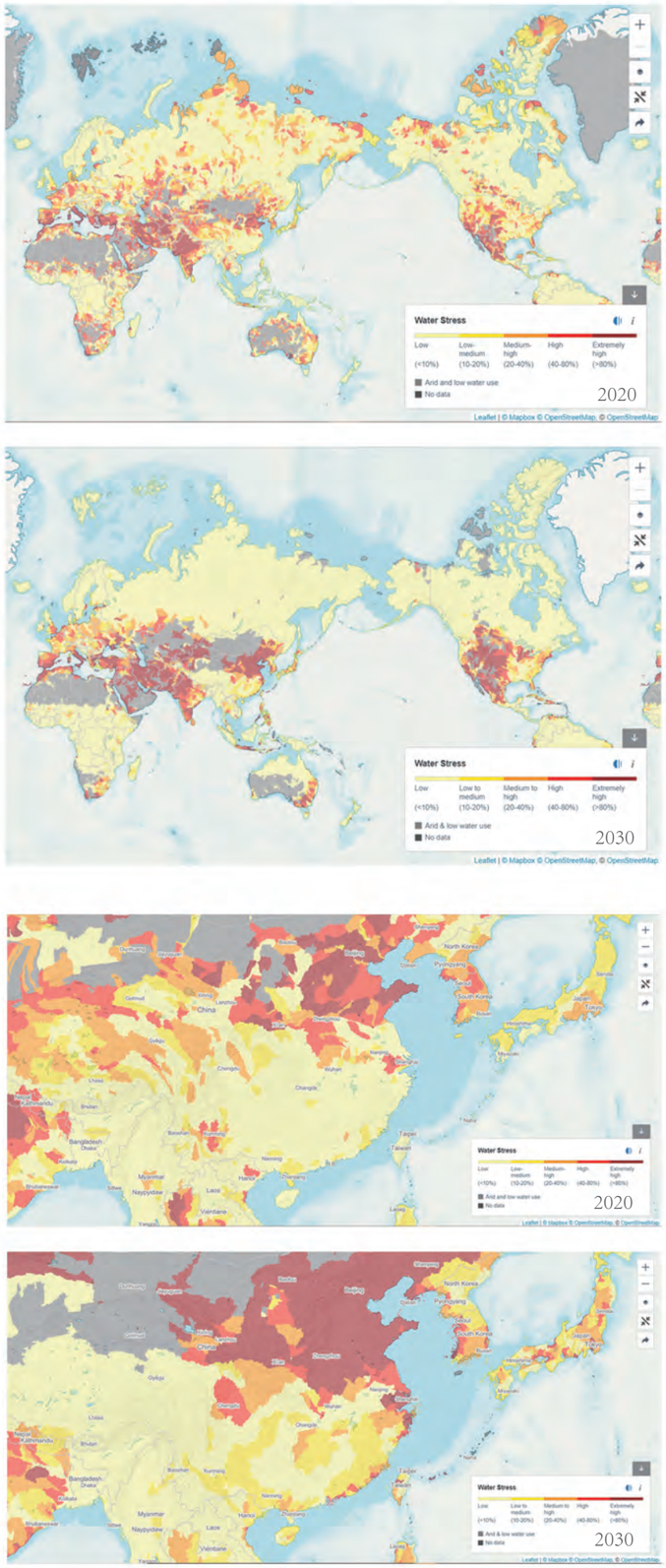


Fig 1.12: Water stress of Chengdu Plain
Source: Aqueduct water risk atlas. (n.d.).

1.3.3 Water source protection policy

The main sources of drinking water in the urban area of Chengdu are the Xuyan River and the Baitiao River. The water intakes are located in Sandaoyan Town, Pidu District, Chengdu, which is the water source for the Sixth Tap Water Plant in Chengdu (Zhou, Lv, Wang, Gao, & Liang, 2016).

In the secondary protection zone for surface water and drinking water sources, it is forbidden to build, rebuild, or expand construction projects that discharge pollutants; those that have been completed must be demolished or closed; the use of pesticides and the use of chemical fertilizers are prohibited; poultry breeding and fish farming are prohibited. In the first-level protection zone for surface water and drinking water sources, it is forbidden to build, rebuild, or expand construction projects that have nothing to do with water supply facilities and protection of water sources; those that have been completed must be demolished or closed; the use of chemical fertilizers, livestock and poultry breeding, swimming, fishing, and tourism are prohibited. (Regulations of Sichuan Province on the Protection and Management of Drinking Water Sources, 2019).

This means that for villages or counties in protected areas of water sources, local industry and breeding are not allowed, and agricultural production is restricted. In the first-level water source protection area, tourism and other industries are also prohibited, and residents living in it even need to move out of their place of residence.

Protection policy of drinking water sources in Chengdu

First-class protection zone: the water area between the downstream sluice of the Xuyan River intake (including the diversion channel of the power station) to the 2000 metres upstream of the intake of the Xuyan River. The water boundary of the first-level protection zone extends to the land area with a horizontal distance of 200 metres from both sides of the strait. The water area between the downstream gate of the Baitiao River's intake to the 2000 metres upstream of it. The water boundary of the first-level protection zone extends to the land area with a horizontal distance of 200 metres from both sides of the strait. The Baimu River extends 800 metres upstream from the point where it joins the Xuyan River, and the water area between the two banks of the embankment. The water boundary of the first-level protection zone extends to the land area with a horizontal distance of 200 metres from both sides of the strait.

Secondary protection zone: The downstream sluice of the Xuyan River intake extends 12.3 kilometres upstream to the lower boundary of the secondary protection zone for drinking water sources of The 7th tap water plant (including the diversion channel of the power station). The water boundary of the first and second protection areas extends 1,000 metres to both sides of the bank. The downstream gate of the Baitiao River intake extends 12 kilometres upstream to the lower boundary of the secondary protection zone for the drinking water source of The 7th tap water plant. The water boundary of the first and second protection areas extends 1,000 metres to both sides of the bank. The upstream boundary of the first-level protection zone extends 2,000 metres upstream along the Baimu River and the water area between the two banks of the embankment (The People's Government of Sichuan Province, 2017).

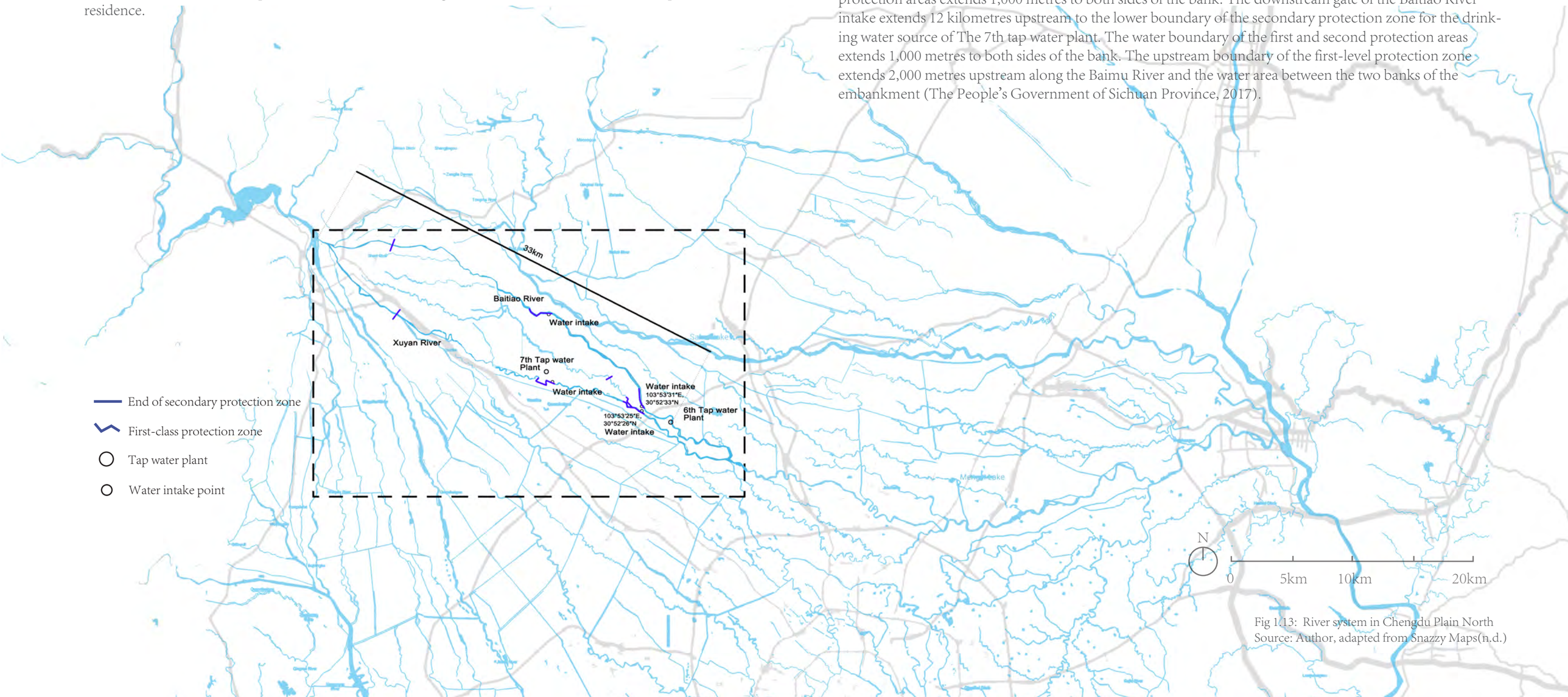


Fig 1.13: River system in Chengdu Plain North
Source: Author, adapted from Snazzy Maps(n.d.)

1.3.4 Urbanization in Rural Area

In the 1980s, the Chinese government set China's urbanization directive as 'strictly controlling the scale of large cities, developing moderate and small cities' (Chen and Gao, 2011), which was called 'the small city strategy' (Chen, 2006). It restricts the size of large cities through artificial means such as the household registration system, leading to the excessive development of small towns. However, due to the limited scale of small towns and lack of population and industrial agglomeration benefits, it is impossible to narrow the urban-rural gap through local urbanization (Rawski, 2003). Therefore, urbanization after 2002 began to focus on the coordinated development of urban and rural areas, paying more attention to economic efficiency, market promotion and human rights. The population movement between urban and rural areas has become a free behaviour driven by market factors. In fact, this policy not only alleviates many restrictions on entering big cities but also brings urban development and urban life into the countryside.

The new coordinated development plan has three priorities for rural development. The first is to realize the centralized resettlement of rural residents, which may occur in large cities, small towns, or villages. The second is to try to concentrate the land and realize the scale economy of agriculture. The third is to realize the agglomeration effect of rural industries.

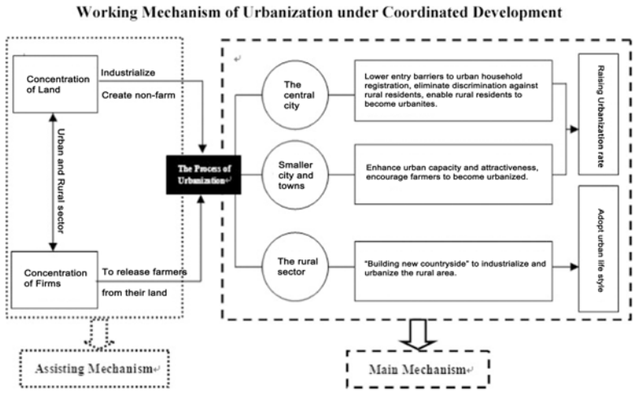


Fig 1.14: Coordinated Development
Source: Chen and Gao (2011)

The urbanization of Chengdu's rural areas basically followed the same line of thinking, persuading farmers to voluntarily move away from the original scattered rural living mode, and move to more concentrated and land-saving multi-family courtyards or apartment buildings. New communities usually have the same standard of infrastructure as towns. Due to the strict control of agricultural land, centralized resettlement has become an important means of obtaining land for urban development. Through concentrated living in the rural fringe, a certain quota of construction land will be released and converted into construction land at the urban fringe (Zeuthen, 2018). The income generated by this process is used for resettlement community construction and subsidies to villagers. Therefore, in the demolition and resettlement of water source protection areas, centralized resettlement has become an easy solution. However, due to strict construction restrictions, local industrial or tourism development cannot be achieved. The replacement land construction quotas can only be sold, and the benefits are limited. In addition, the urbanization of living methods keeps farmers away from cultivated land, and at the same time, the cost of living has risen sharply, especially in villages located on the edge of the county.

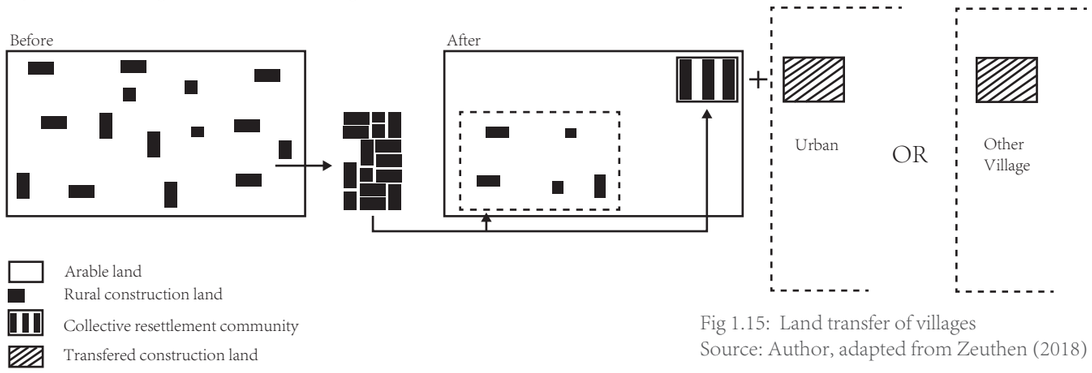
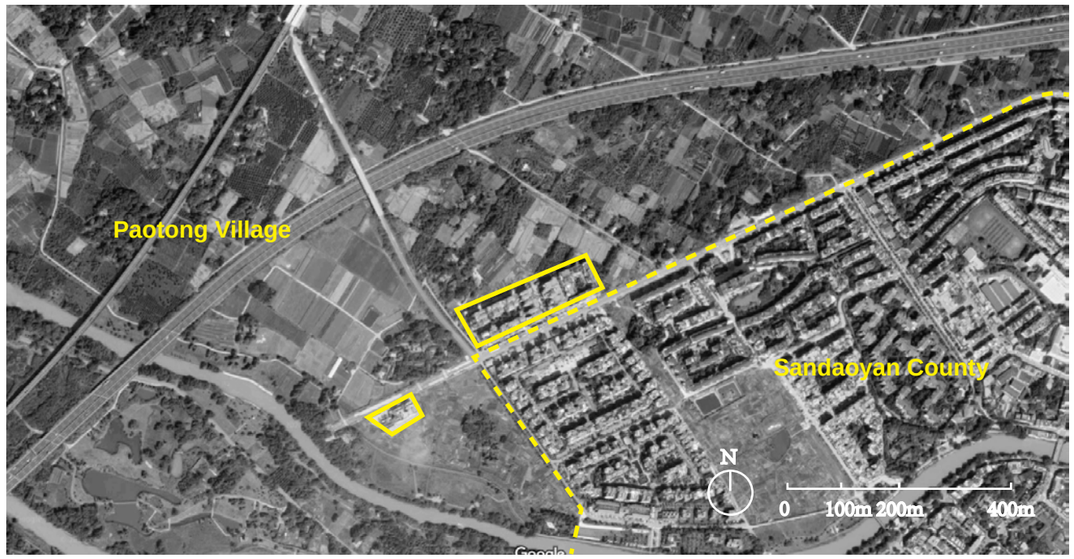
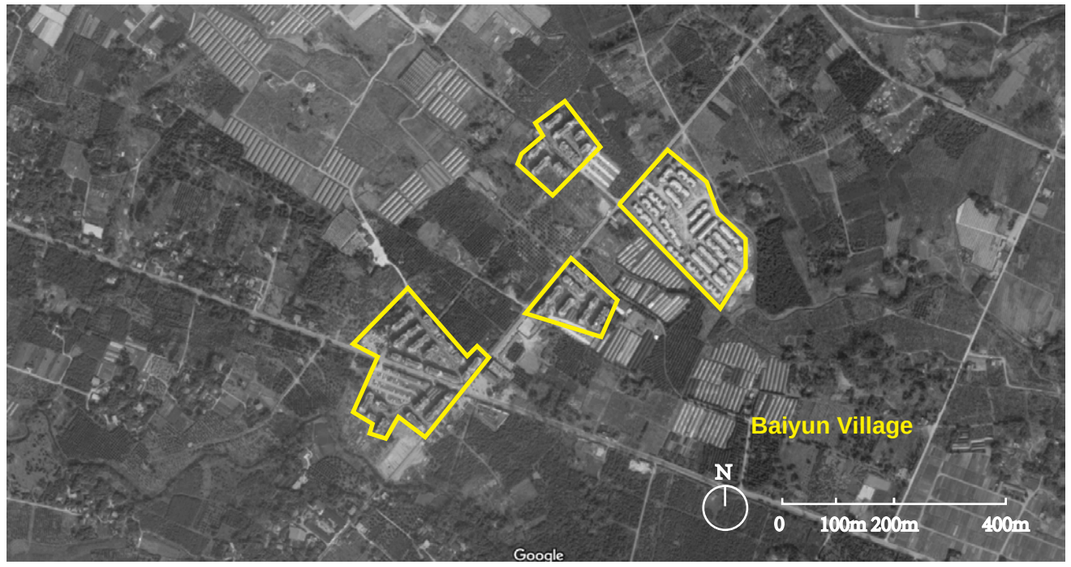


Fig 1.15: Land transfer of villages
Source: Author, adapted from Zeuthen (2018)



A kind of urbanization occurred in villages next to the county, modern collective communities were built on the edge of the city (the land belonged to the countryside), and the residents of the communities work in agricultural production or work in the city or do both.



One is local urbanization as well. Villages build modern collective communities on collective land close to roads, which facilitate the laying of infrastructures such as tap water, electricity, and the internet.

Fig 1.16: Urbanization of Villages
Source: Author, adapted from Google (n.d.).

1.3 Problem Field

1.3.5 Upstream cities and towns



‘Dujiangyan: Build an ecological barrier in the upper reaches of Chengdu’
‘Dujiangyan: Build an ecological barrier in the upper reaches of Yangzte River’
‘Build an ecological barrier like Dujiangyan for Chaohu Lake’
‘Build an ecological barrier like Dujiangyan for Dunhuang’

Fig 1.17: Ecological barrier Dujiangyan
Source: Author, adapted from People.cn (2020), Dujiangyan News (2019), Economic Information Daily (2016) & China Environment News (2013).

According to China Environment News (2013), Dujiangyan local government invested CN¥ 630 million to complete the construction of the emergency water source project. As of 2012, Dujiangyan City has invested more than CN¥ 9 billion to implement nearly 60 projects related to water conservation and ecological protection. In addition to directly investing in ecological projects, Dujiangyan City gave up a series of major industrial development opportunities and rejected investment from more than 10 enterprises, totaling CN¥ 15 billion. From 2009 to 2013, Dujiangyan City closed many polluting enterprises with outdated technology and moved other enterprises into centralized management industrial parks.

Pidu District has also built a higher standard sewage treatment network and banned some heavy pollution industrial enterprises. The counties and towns of the water source protection area build related infrastructure, provide land policy support for the construction of water plants, and refuse to keep or build any polluting enterprises in the area. Before the water source protection land policy, these local enterprises were legal and also met the discharge standards. These cities are sacrificed on the new water source protection requirements.

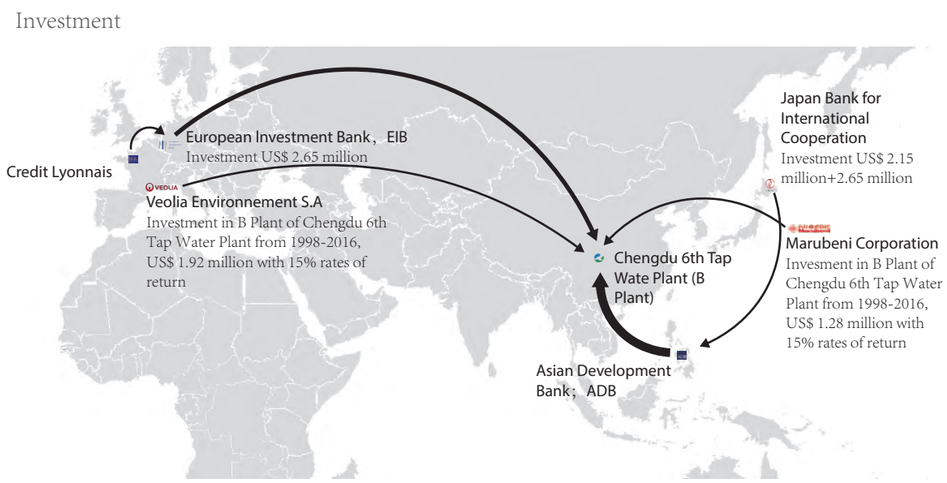
Regarding ecological environment protection and construction as the primary task of Dujiangyan City, protecting water sources as a political responsibility and historical mission, and building a green ecological barrier. (China Environment News, 2013)



Fig 1.18: River and Water Plant in Saodaoyan County
Source: Author, adapted from Zuo Ke (2018).

Investment model

The B Plant of the Sixth Water Plant in Chengdu has an international investment. Plant B adopts the BOT (Build-Operate-Transfer) model. It is invested by French and Japanese investment banks and built by French and Japanese companies. After a certain period of operation, it will be transferred to a locally operating company, namely the Chengdu Water Supply Company, for free. In the operating period of international enterprises, a fixed rate of return will be achieved through fixed water purchases and prices.



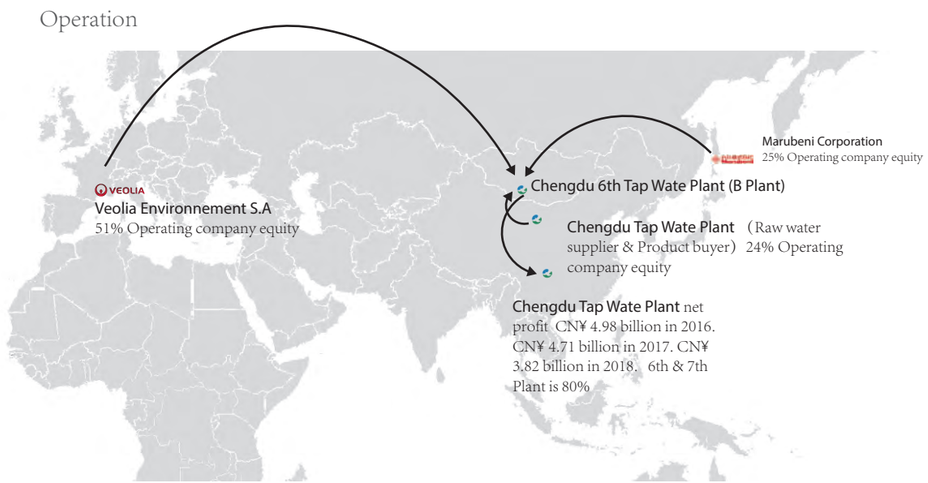


Fig 1.19: Ecological barrier Dujiangyan
Source: Author, adapted from XieXie-Bang(2019); Haileyfeng(2011) & Gyula Kozma(2019).

Income Distribution

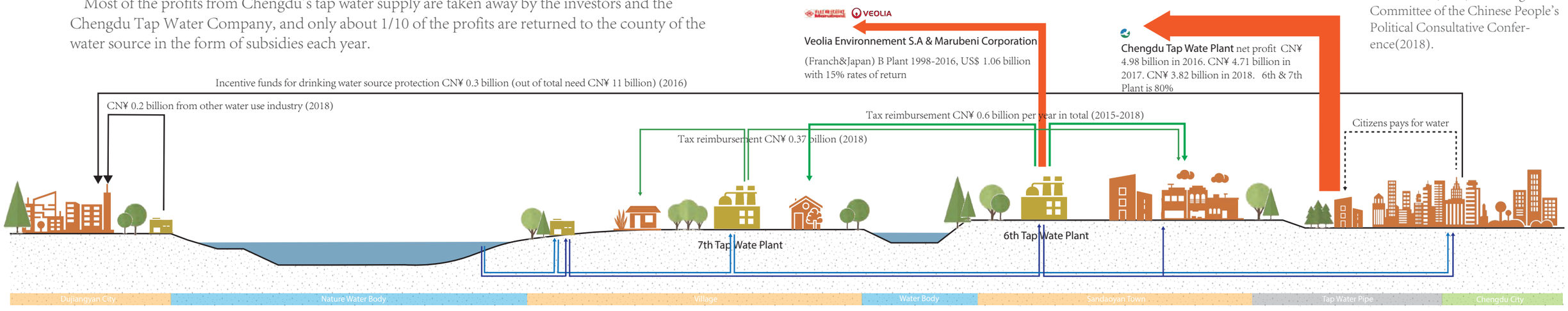
For Veolia Environment S.A. and Marubeni Corporation from France and Japan, they owned the B plant for 18 years and gain around CN¥ 1.11 billion (about US$ 0.16 billion) per year (School of Government and Management, Peking University, 2015; Waitanshen, 2011). After the plant transferred to the Chengdu Tap Water company, the net profit of both the 6th and 7th water plants is around CN¥ 4.5 billion (about US$ 0.64 billion) per year (Qiu, Y. Huang, H. & Zhao, T, 2018; Chengdu Xingrong Environment Co., Ltd, 2016; Yin, S., & Hao, W, 2010). However, the tax reimbursement for the water source towns and villages is only about CN¥ 0.6 billion from the 6th plant and CN¥ 0.37 billion from the 7th plant per year (Chengdu Committee of the Chinese People's Political Consultative Conference, 2018). For upstream cities, Dujiangyan city only gains incentive water protection funds of CN¥ 0.3 billion per year. And because of strict regulation on industry, their economic losses are dozens of times more than financial subsidies.

Most of the profits from Chengdu's tap water supply are taken away by the investors and the Chengdu Tap Water Company, and only about 1/10 of the profits are returned to the county of the water source in the form of subsidies each year.

Therefore, two questions are raised here:

1. How much of the water tax subsidy reaches the villages in the water conservation area?
2. How much tax subsidies do the cities in the upstream of water source protection zones receive for water extraction proceeds?

Fig 1.20: Profit and reimbursement
Source: Author, data from Chengdu Xingrong Environment Co., Ltd(2016); Qiu, Y. Huang, H. & Zhao, T(2018); Yin, S., & Hao, W(2010), Peking University(2015); Waitanshen(2011); & Chengdu Committee of the Chinese People's Political Consultative Conference(2018).



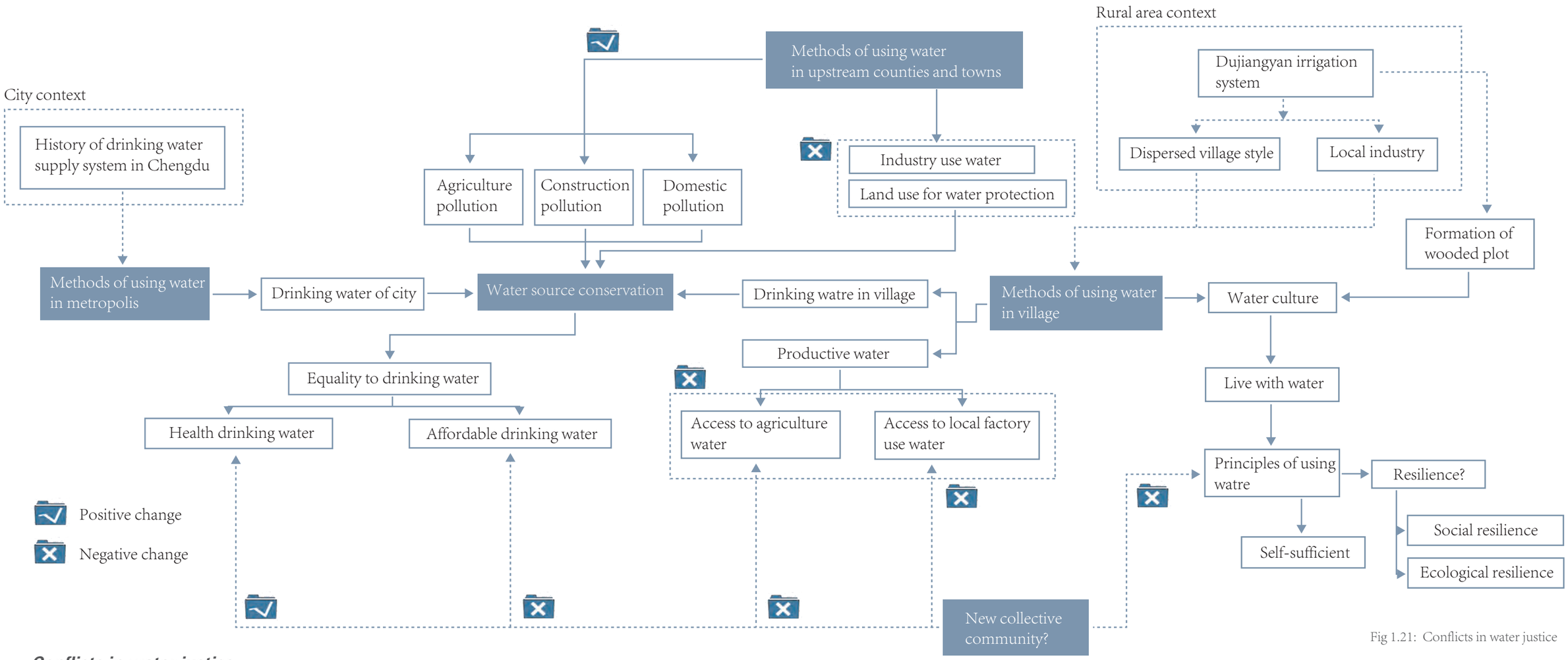


Fig 1.21: Conflicts in water justice

Conflicts in water justice

With the explosive growth of Chengdu's population and the increase in standards for safe drinking water, the amount of water extraction is getting larger and water conservation regulation is getting stricter. Therefore, the indigenous people living in the conservation district are forced to move out of the preserved zone and into a socialist new village which is a collective settlement at the edge of the county. However, not all of the villagers can afford to live in an urbanized way because the reimbursements are fixed and sometimes not enough, and the new living cost gets higher. At the same time, in order to prevent pollution, some husbandry and agriculture and local industries are unable to carry out. They lost their traditional village organization and water culture of the Dujiangyan Irrigation District in this process as well. Moreover, the development of small upstream cities is also restricted to a certain extent because of the need to ensure the safety of drinking water in Chengdu.

In the water conservation program, the water rights between the water source site and water use city are injustice and indigenous people suffered lost the most. Metropolitan gets priority on water rights and the 'one size fits all' compensatory intervention even exacerbates these conflicts. In the commercial process of the drinking water industry, the interests of vulnerable groups are sacrificed. Therefore, a new fairway of using water and facing up to the value of water in multiple dimensions is required and an inclusive decision-making process is emergent.

Problem statement

With the explosive growth population in Chengdu and increasing water stress in the Dujiangyan irrigation area, stricter water conservation is necessary. However, the indigenous people and upstream cities suffered economical loss and cultural loss in this water-preserve-oriented program. Justice in water rights from economic, cultural, and governance perspectives needs to be taken more seriously.

2 THEORETICAL UNDERPINNING

- Water justice framework
- Water justice theories



Fig 2 Waterflow of Dujiangyan
Source: Ming Zhang (2013)

Water justice framework

Water justice lies not only in ensuring that everyone enjoys a healthy environment and the basic requirements necessary to sustain life but also in the satisfaction of fair water distribution in addition to basic needs. In practice, the issue of water justice is usually complex and is affected by socio-economic and political background. Even if the research is focused on a specific area, the process of realizing water justice is also very complicated. In this process, many stakeholders are involved. The different processes of different participants require different propositions about justice, which is the purpose of this framework.

Lukasiewicz, Bowmer, Syme, & Davidson (2013) proposed a social justice framework (SJF). This framework includes a variety of principles describing justice in the distribution of environmental resources. It can help make the best balance between various interests and be applied to the allocation of natural water resource. This decision-making model includes three aspects of justice, namely, distributive justice, procedural justice, and interactive justice.

Distributive justice

Distributive justice mainly includes two theories. The first one is the theory of Deutsch (1975) based on need, equality, and equity, emphasizing the dominant position of justice in social relations. Need refers to the priority of emergency water use under socially recognized values. In an area with fragile ecosystems, ecological water demand may be the priority of water resource allocation. In an area where urban domestic water is in short supply, citizens' water demand will be given priority. Equality and equity refer to the relationship status between different groups of people in water distribution and the sustainable development between generations.

The second one is Wilke's (1991) greed, efficiency, and fairness (GEF) hypothesis, assuming that everyone who uses water is greedy, but constrained by the two motives of water efficiency and fairness. The efficiency principle is closely related to the distribution of market-oriented water, and it is a principle that managers tend to choose under water shortage conditions (Movik, 2014).

Procedural justice

The rules in the decision-making process include consistency, ethicality, impartiality, accuracy, and error correction capabilities. Consistency is reflected in the rules of different regions, as well as between generations. Ethicality and impartiality are concerned with the recognition of the decision-making process itself, emphasizing the choices made by participants with complete understanding. Accuracy and error correction capabilities pay more attention to the expression in regulations and policies and the dynamic adjustment ability.

Procedural justice

Interactive justice also pays attention to the fairness of the water distribution process, but it concentrates on the social relations in this decision-making process rather than the power structure (Cropanzano et al., 2002). It highlights each participant's dignity, respect, trust, and effective transmission of information. Interactive justice also involves respect and recognition of different views and values.

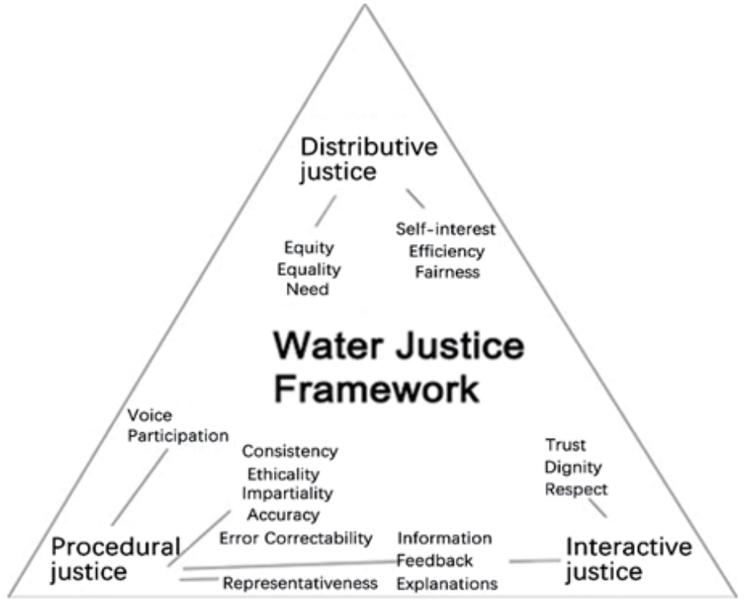


Figure 2.1: Water Justice Framework
(Source: Lukasiewicz, Bowmer, Syme, & Davidson, 2013)

The Practical Principles of Distributive Justice

There are two types of water equity. The first is the equity within the same water use method where the social relationship is most important, such as the equity of drinking water of all the residents in the same river basin. The fairness within the use can be simply explained as a group of farmers or residents or enterprises are able to obtain the same amount of water, which is the principle of egalitarianism. The second is the fairness between different water uses, such as the fairness between agricultural and industrial. The fairness between uses focuses on functional comparison rather than quantitative comparison with a develop-oriented objective, reflecting the principle of efficiency raised by Wilke (1991).

The Practical Principles of Procedural Justice

Procedural justice is the justice of the decision-making process and methods. The question to be discussed is: Who will decide the way of water distribution? Who has the right to participate in the preparation of water regulation and policy? Whose opinions and norms should be accepted? Whose definition, priority and interest prevail? These questions can be summed up as three powers in practical procedural justice regarding water: the right of recognition, the right to participate, and the right to redistribute (Zwarteveen & Boelens, 2014).

The Practical Principles of interactive justice

Interaction justice is especially important in the peri-urban context because big cities usually have priority. In the Dujiangyan Irrigation District, Chengdu is a metropolis in the region. It has priority in economics and politics and represents the most efficient use of water resources. The villages and towns in the water conservation area are small in size. The asymmetry of the relationship needs more emphasis on respect, dignity, and trust of interactive justice (Lukasiewicz et al., 2013).

Water justice theories

The theoretical framework illustrates the theories related to the issue of water justice, including the special context of peri-urban conditions and multiple levels. And the concepts in the justice topics, global expulsion, water governance research, and virtual value measurement are involved as well. This chapter will introduce the theories used in both the analysis of the problems and the proposal of the interventions, including the main body of the theories and their suitability in this special peri-urban context. The detailed implementation will be delivered in the following analysis and strategy chapters.

Conceptualization of water justice

Water justice consists of three dimensions, which are distributive justice, procedural justice, and interaction justice (Lukasiewicz et al., 2013). This theory and its implementation in this project is mentioned on the former page and detailed discussed in the theory paper in the appendix.

Expulsion on water

Expulsion is a path of the current global economy and a form of economic expansion (Sassen, 2014). Taking water in the upper reaches of Chengdu to serve the city's domestic water at the cost of expelling local farmers and traditional economic forms is in line with this concept. The aborigines were forced to change their way of life, left their original place of residence, and lost their land. The transfer of land ownership, control, or use rights is one of the typical forms.

Because of the strict drinking water protection regulations, the villagers living in that zone are forced to move out and go into a resettlement community, and they have to change their way of agriculture in the Dujiangyan irrigation area. Some villagers no longer engage in agricultural labour and instead work in the county, which is the labour and resource requirement of the urban economy.

Expulsion not only occurs at the local and regional levels but also at the global level. Sassen (2014) cites the example of Nestle, they are extracting water at a place where the local people are not familiar with negotiating with multinational companies, especially in small rural areas. Since local people are in a disadvantaged position in terms of financial resources, political and legal assistance, they are difficult to have full voice and decision-making rights.

There are also large multinational companies in the peri-urban area in the upper reaches of Chengdu. The Coca-Cola company has a water extraction plant here, and the water company is invested and built by French and Japanese companies as well. International capital has made a lot of profits, and locals have only received limited compensation.

Small businesses such as local food processing plants have also been pushed out of the global capital mainstream system, falling on the other side of being expelled (Sassen, 2014). This stems from the pursuit and confidence in modern technology and production efficiency (Sneddon & Fox, 2007), which means the resources should be used in more efficient industries instead of small businesses.

This expulsion is a deep-level systemic change, a new stage of global capitalism that is the widespread global destruction (Sassen, 2014). Expulsion occurs on people who are excluded from the system. It is an exploiting mode of operation and the destruction of the local economic structure, which always have a negative impact on the life of indigenous people. Therefore, understanding the status quo from the perspective of expulsion gives a view to exam the related stakeholders in this process and it is of great significance to future systematic intervention.

Theoretical framework

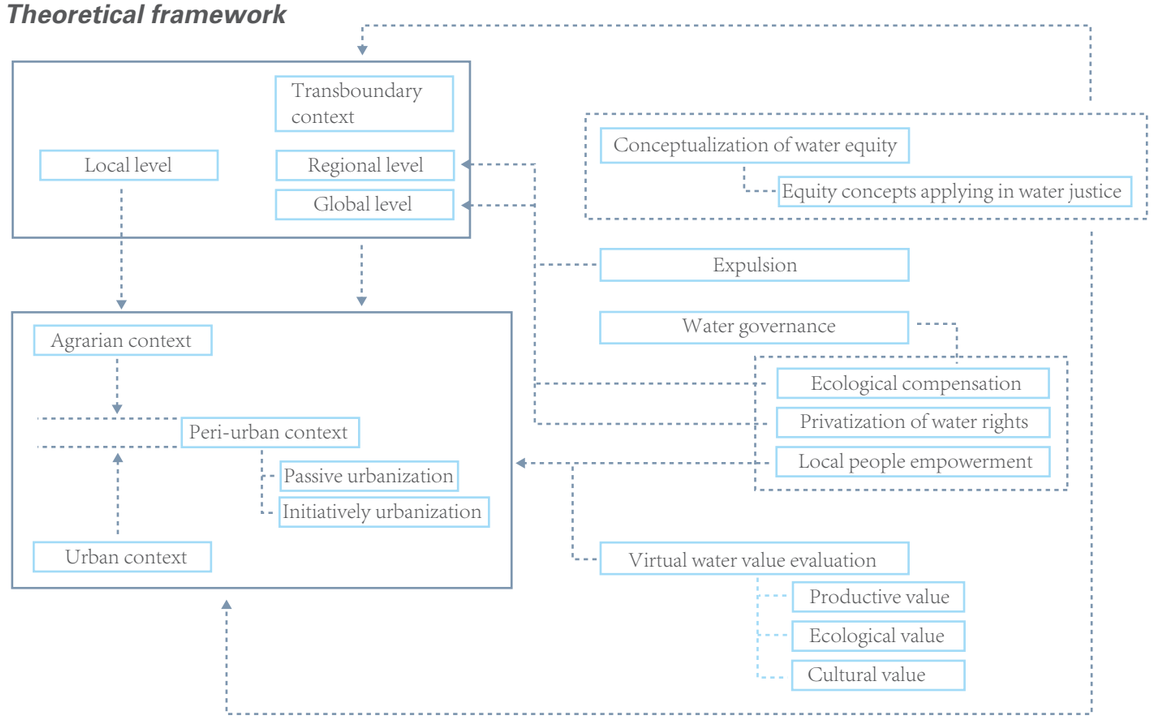


Fig 2.2 Theoretical framework

Water governance

The 'water crisis' is mainly a governance crisis (Castro, 2007). In water policy, document governance is usually understood as a means to achieve certain goals. This is a strategic strategy, not a democratic dialogue, negotiation, and the complex process of citizen participation (Dryzek, 1997). From the point of view of water power, water governance is the balance between 'state', 'market' and 'civil society' (Picciotto, 1997). The core of governance is to determine the goals and values that should be selected and the way to pursue these goals and values. Therefore, governance is not a strategy, nor an ideal interaction plan between ideal participants, but a political process. Water management is a part of procedural justice. The right of recognition, participation, and redistribution of stakeholders (Zwarteveen & Boelens, 2014) is the core of water management.

In addition to rules, regulations, and systems, water governance also includes value-related issues such as responsibility, accountability, transparency, justice, and equity. Since water is an indispensable part of the entire development process, the planning and implementation of the water sector must rely on other economic and production sectors. The governance of the water sector must take into account the continuous changes within and outside the water sector (Tortajada. 2010). Water problems are actually reflected in water-related industries. For example, water justice in the Dujiangyan District is about drinking water supply, agricultural production water, and industrial water issues. In fact, they are all industrial issues, economic issues and development issues. The value of water culture also takes water as the carrier, and human activities are the core value of water.

Water justice theories

In terms of just and implementable water governance practices, each country or city must develop its own specific strategies based on its special conditions, requirements, expectations, and capabilities (Biswas & Tortajada, 2010). People in the peri-urban area of Dujiangyan Irrigation District are at a specific stage of development, and jobs are provided by a mixture of agriculture, agricultural and sideline products, and urban industry. They have their own unique problems. To develop new pollution-free industries or to enter the urban industrial system requires a transitional stage. Protecting the interests of indigenous people during the transition period is an important issue in the practice of water management.

Ecological compensation

Ecological compensation originally referred to the self-buffering effect of the ecosystem. Jiang (1990) proposed a punitive ecological compensation to compensate for development and pollution. Yu and Ren (2007) believe that ecological compensation is a kind of benefit distribution, a kind of institutional and policy means.

Basin ecological compensation is a legal system for the distribution of benefits between beneficiaries and protectors under certain market laws. It is an ecological benefit. Various forms of compensation are used to encourage ecological protectors to protect the ecological environment, so as to achieve sustainable economic and social development in the basin (Wang, Zhang & Gao, 2014).

At present, ecological compensation has a variety of calculation methods based on cost, ecological service value, and compensation willingness to determine the specific compensation amount. Compensation methods mainly include fiscal transfer payments, ecological compensation funds, policy compensation, water rights trading, and enclave development (Wang, 2018). However, there is less consideration of water rights structure, social relations, and new comprehensive compensation systems.

Su and Shang (2013) found that farmers who dominate agricultural production tend to choose two types of ecological compensation: technical support and material support, while those who dominate non-agricultural operations prefer two types of compensation: financial support and policy support. Therefore, in the Dujiangyan Irrigation District, some villagers are engaged in agricultural production, and some farmers work in cities, and their expected compensation forms are also different. Technology, policies, funds, even urban rights, education and training support are all possible compensation methods.

Privatization of water rights

Water privatization stems from the reform of public enterprises. The liberalization of the water sector in the global south enables the private sector and external technical assistance to step into the water business (Bakker, 2013).

Since 1990, private water supply companies have gradually increased their investment in China and focused on areas with higher profits and lower risks. This mode of privatization has paid increasing attention to urban areas at the expense of suburban and rural areas. This is exactly what happens in southwest China. Individual water sources and small rural collective water sources have been gradually canceled due to water quality control issues. Large-scale collective drinking water supply is controlled by large-scale enterprises. They draw water from the peri-urban area and supply water to the big cities. They have made huge profits, but little is given back to the local area.

Privatization is believed to increase the efficiency of water supply and sanitation services (Nyangena, 2008). But large companies can completely dominate the game and a profit-oriented process would cause injustice for the vulnerable people (Trawick, 2003). Therefore, the distribution of benefits between the privatized water company and the local people in the water drawing area requires more justice. The privatization alternatives, including state and community-led water supply plans, combined with private capital may be the 'post-neoliberal futures' (Bakker, 2013).

Local people empowerment

At present, the success of many rural development projects only focuses on the difference between before and after technology application. As a result, due to the low level of empowerment of local people, it is impossible to achieve further sustainable development (Sianipar et al., 2013). Local empowerment is the next shape of sustainable development.

In addition, the right of recognition, the right to participate, and the right to redistribute of indigenous people is an important part of water procedure justice (Zwarteveen & Boelens, 2014). Local empowerment is legitimizing local knowledge. This kind of 'indigenous' knowledge of rural society is the potential basis for sustainable agricultural development in the world (Thrupp, 1989).

The agricultural production and village living style in the Chengdu Plain has a long history, and they are resilient and sustainable. The backbone of this production and lifestyle is a process of villagers' autonomy in water management. This kind of traditional knowledge may be of reference value in the new transition to environmental protection and ecology.

Virtual water value

Virtual water trade is an instrument to achieve water security and efficient water use. It also focuses on making the link between water consumption and the wider impacts (Hoekstra, 2003). Virtual water value is water productivity and its variation in space and time (Renault, 2003).

The measurement of virtual water value should focus on production methods and water efficiency, and the water consumption of intermediate products (Hoekstra, 2003). In addition to production value, water value also includes ecological benefits, which is the foundation of an ecosystem that sustains life and provides various goods and services (Zhou et al., 2011), and the cultural benefits which is a part of the cultural heritage (Jackson, 2006).

When proposing the scenarios of the new water management and local communities, virtual water value would be an important indicator for the proposals. Water cost in construction, agriculture, industry, and culture of several scenarios differs and a proper intervention could be select in certain value orientation and conditions.

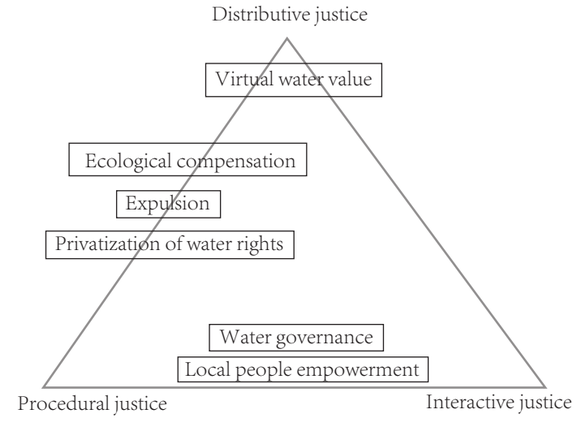


Fig 2.3 The position of theory in the justice framework

3 METHODOLOGY

- Research Aim
- Research Question
- Conceptual Framework
- Research Approach

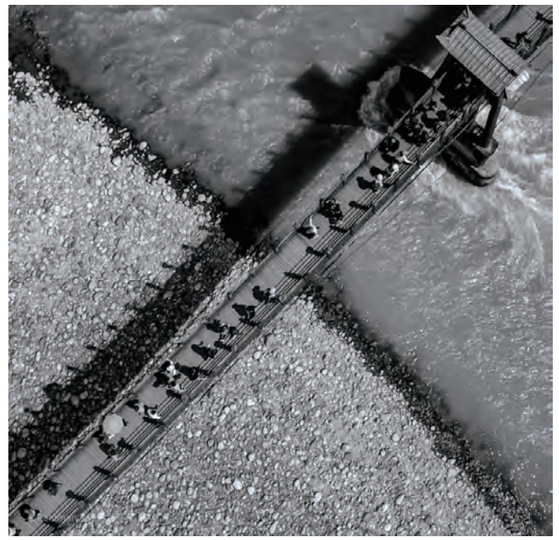


Fig 3 Bridge of Dujiangyan
Source: Rainman Wong (2019)

METHODOLOGY

Road Map

This chapter introduces the methodology used for the research on the water justice issue in the Dujiangyan irrigation area. It sets out a research framework and related methods that are used to figure out the research questions. The methodology is included to have a scientific way of doing analysis and strategic interventions. The conceptual and theoretical framework supports research with concepts and relevant literature. The timeline and expected outcomes describe how the research will proceed.

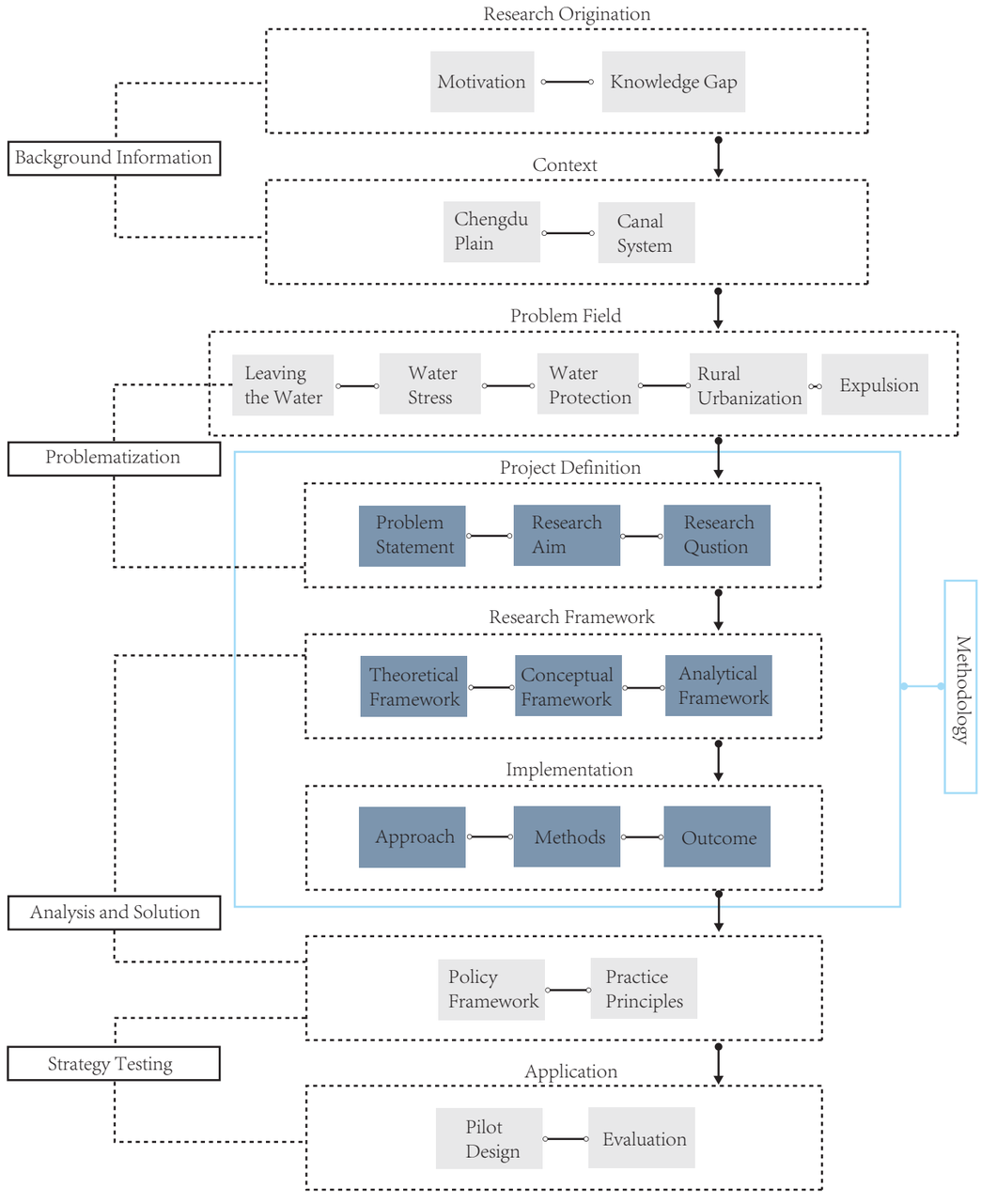


Fig 3.1 Methodology road map

METHODOLOGY

Research Aim



Fig 3.2: Chengdu Plain under Dujiangyan's Watch
Source: Sunset-Island(2020)

Research aim

The main aim of the research is to explore a framework of various elements to achieve water justice in the water conservation districts next to the metropolis. The research objective is to fill the knowledge gap in the upstream water protection development in the southwest of China, evaluate the current policies and strategies to build flexible water governance on both local and transboundary levels.

Theoretical

- A framework of how to evaluate both the physical and virtual value of water

- The emphasis on different forms of water culture

- A flexible governance system could adapt to different situations

Local

- Evaluation of both physical and virtual value of water in the Dujinagyan irrigation area

- Discover, refine and protect the local water culture

- Strategies of sustainable economic development with water conservancy in upstream villages

- Strategies of flexible living condition improvement

- A flexible governance system, fair compensation, and local empowerment

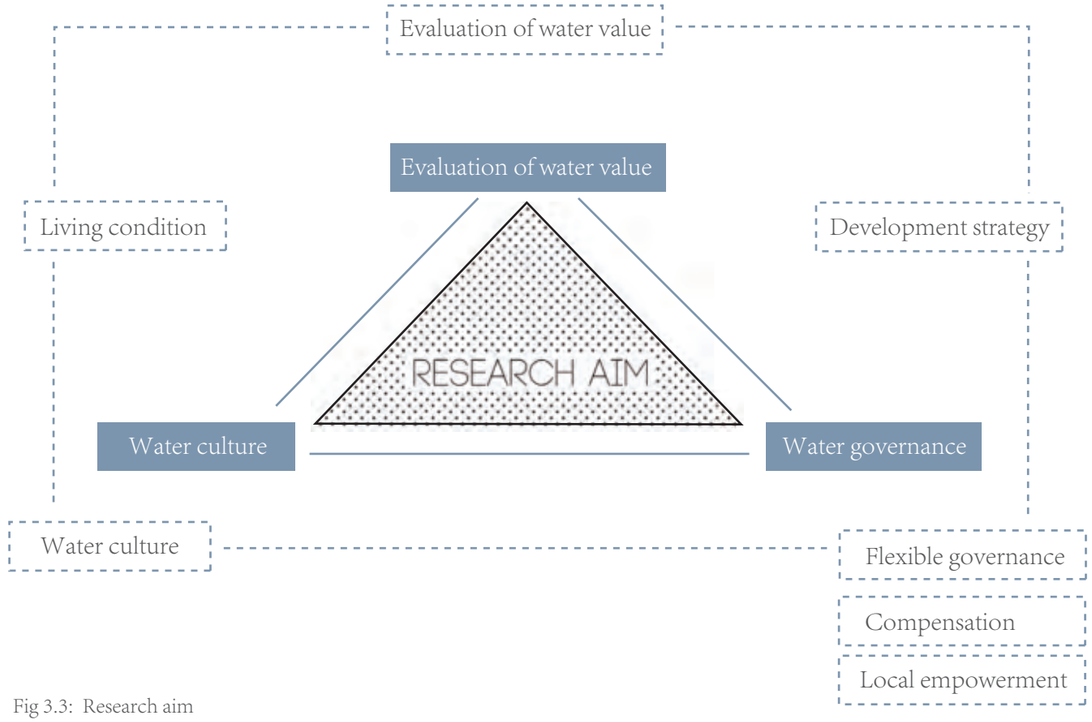


Fig 3.3: Research aim

METHODOLOGY

Research Question

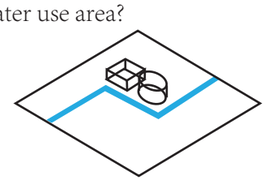
How can a strategic and policy framework based on fair use of water and respect for local cultural knowledge lead to sustainable and inclusive development of water conservation area in the Dujiangyan Irrigation District?

Sub-questions

1.How to make the water allocation process justice between water source area and water use area and prevent pollution?

--How to supply healthy and affordable water for both the water source area and water use area?

--How to make water supply and sewage system efficient and eco-friendly?

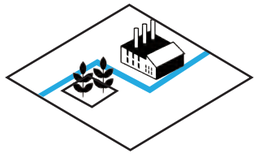


2.What virtual value of water need to be considered while making a sustainable and inclusive development of water conservation area?

--How to reimburse the value of a water ecology system?

--How to reimburse the potential economic value of the water system?

--How to measure the virtual value of a water system in the new development?



3.How can traditional aspects of village practices and environments be preserved and adapted as part of a strategy of the new development?

--How can the local village be empowered through the traditional water culture?

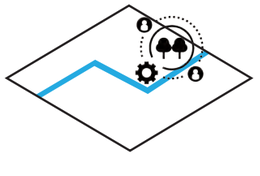
--How can the local village maintain their culture of living with water in the new development?



4.How can the strategy and policy be justice and flexible at the water governance level?

--How to make an institutional system that allows disadvantaged groups to speak out?

--How to establish an institutional system to achieve fair ecological compensation?



METHODOLOGY

Research Approach

SCALES-CROSS RESEARCH

Starting from the situation of one village, the water justice issue is naturally linked to the whole river basin. Upstream water conservancy development, soil erosion, and pollution issues will affect the water quality and quantity of the water source protection area. The water problem of the downstream big cities must be guaranteed by the upstream water source. In addition, the realization of water justice also includes compensation for other rights and interests other than water power, which is the expansion of the social structure and power system. There are international investments, and the participation of multinational companies as well. This kind of issue is multi-layered and scale-crossing, a single perspective cannot fully cover the question and limited the solutions. Based on the scale-cross research, a deeper understanding of the problem and wisely solution can be developed and the final policy strategies and design test will be more convincing and practical.

COMBINATION OF QUALITATIVE AND QUANTITATIVE RESEARCH

This research conducts a combination of both qualitative and quantitative methods, which will be used in different topics and analysis. Qualitative methods focus on the governance and water power structure, aiming to build a feasible compensation framework. Quantitative methods focus on the wishes of indigenous people and downstream citizens. A combined method gives a better connection between policies and people's ideas.

SCENARIO TESTING

Scenario test is a method that focuses on special oriented directions of the program and helps to compare and optimize the interventions. This method brings a more comprehensive understanding obtained by experimenting with a design principle and comparing it from different orientations. It helps to develop a comprehensive strategy and design framework.

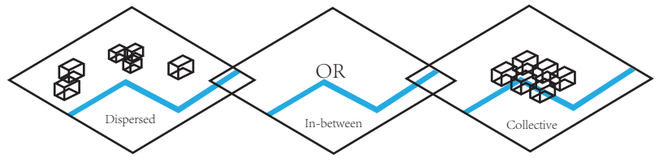


Fig 3.4 New development model of water conservation area

METHODOLOGY

Research Scale and Hypothesis

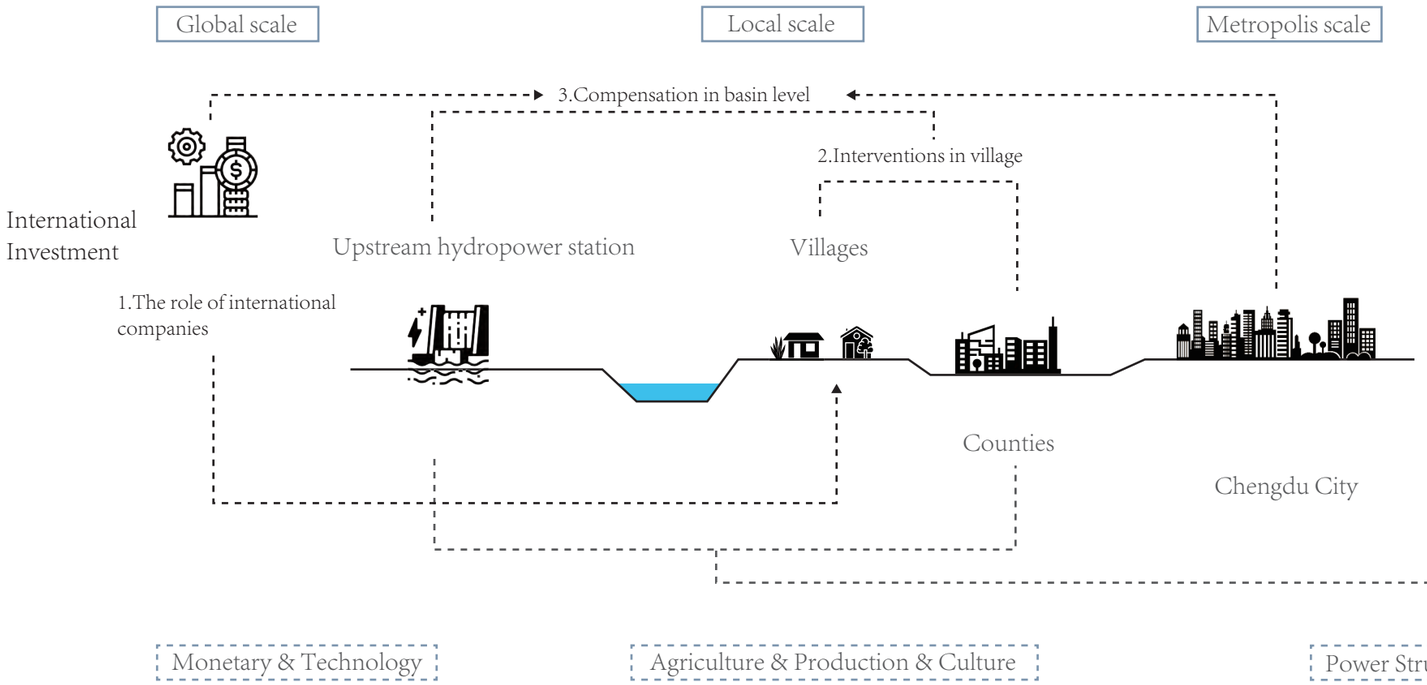
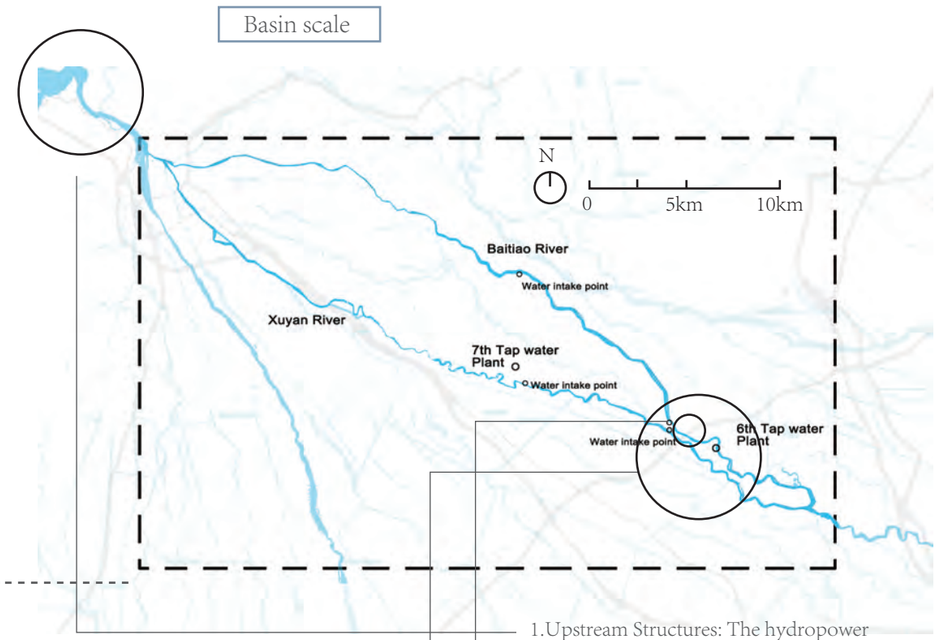


Fig 3.5: Research scales

The research is mainly conducted on four scales. The first is the global level, focusing on the role of multinational investment and international companies. They can bring monetary compensation and technical input to improve the use of local water resources. Metropolis scale is similar, it can propose more reasonable ecological compensation and more diversified compensation methods. Basin-scale includes the cooperation and coordinated development of villages and towns in water source protection areas. Local-scale refers to the landing intervention in the spatial form of a specific village.

The final location for the pilot project will be the Paotong village in water conservation areas which would be an example of a specific village design, including residential areas, industrial structures, and ecological measures.

Research locations



1.Upstream Structures: The hydropower stations in the upper reaches are affecting the water source area.

2.Pidu District: Fringe area of Chengdu, whose development limited by the water conservation system.

3.Paotong Village: First class protection area and second ring road limitation district, strict limitation on its own local industry and agriculture.

Fig 3.6: Possible locations

METHODOLOGY

Research Framework

The purpose of this scheme is to explain the research progress from the problem field to the final conclusion and clarify the alignment of research methods and research questions.

The problematic analysis starts from two aspects of the city context and agrarian context, which are the two main actors in this water justice issue. The increasing demand for water from the city pushes the publication of water conservation policies, and then the pressure transferred to the local village of the protection area. From there, the problem statement addressed. To achieve water justice, four important aspects should be taken into consideration, which are Physical Water, Virtual Water, Water Culture and Governance. Through the related theoretical review and implementation of these concepts, a deep understanding of both conceptual level and specific site level is gained. After the design approach, which is scenario testing and comparison, the final interventions would include both spatial strategies and government policymaking.

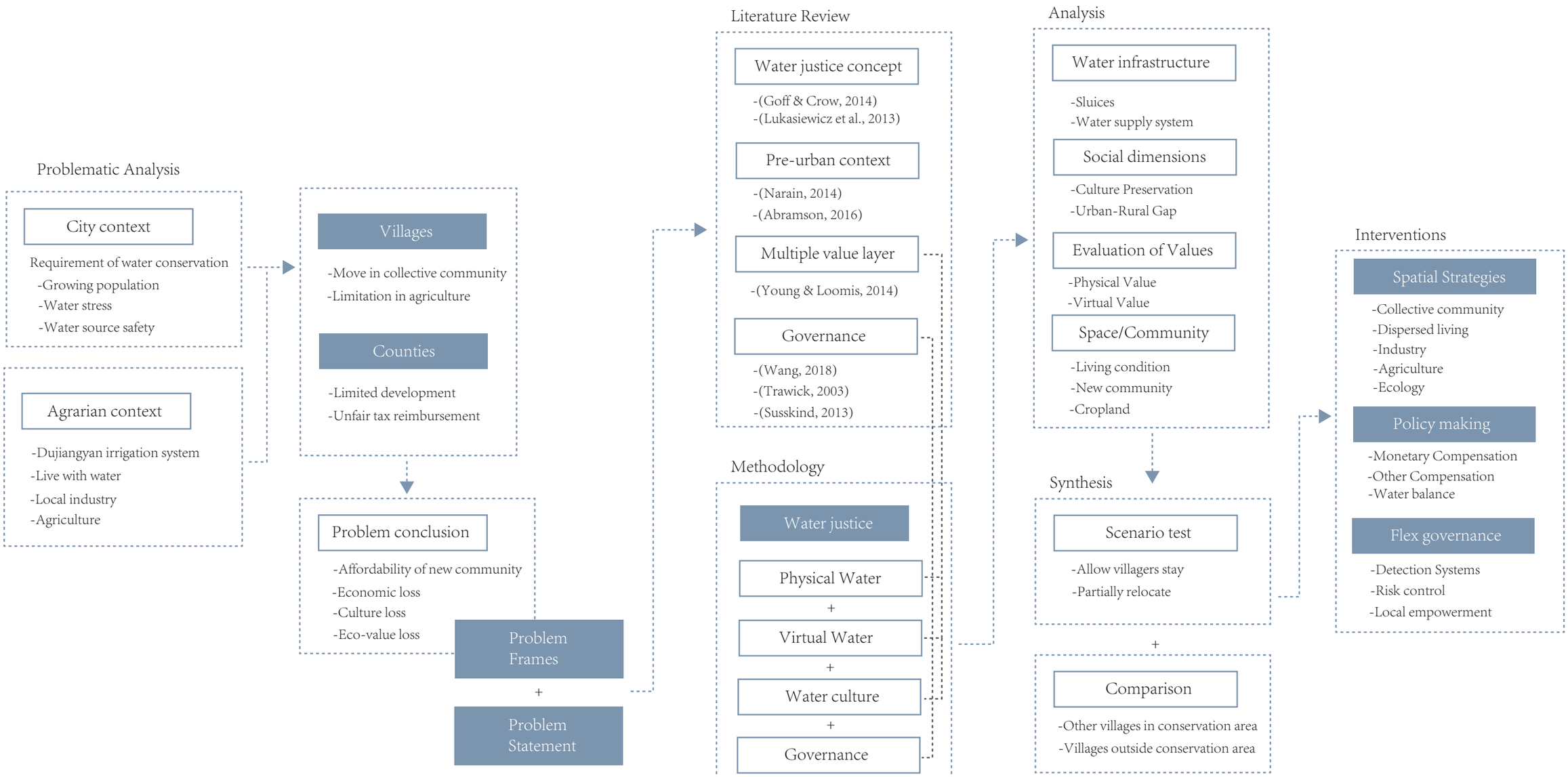


Fig 3.7: Research framework

METHODOLOGY

Conceptual Framework

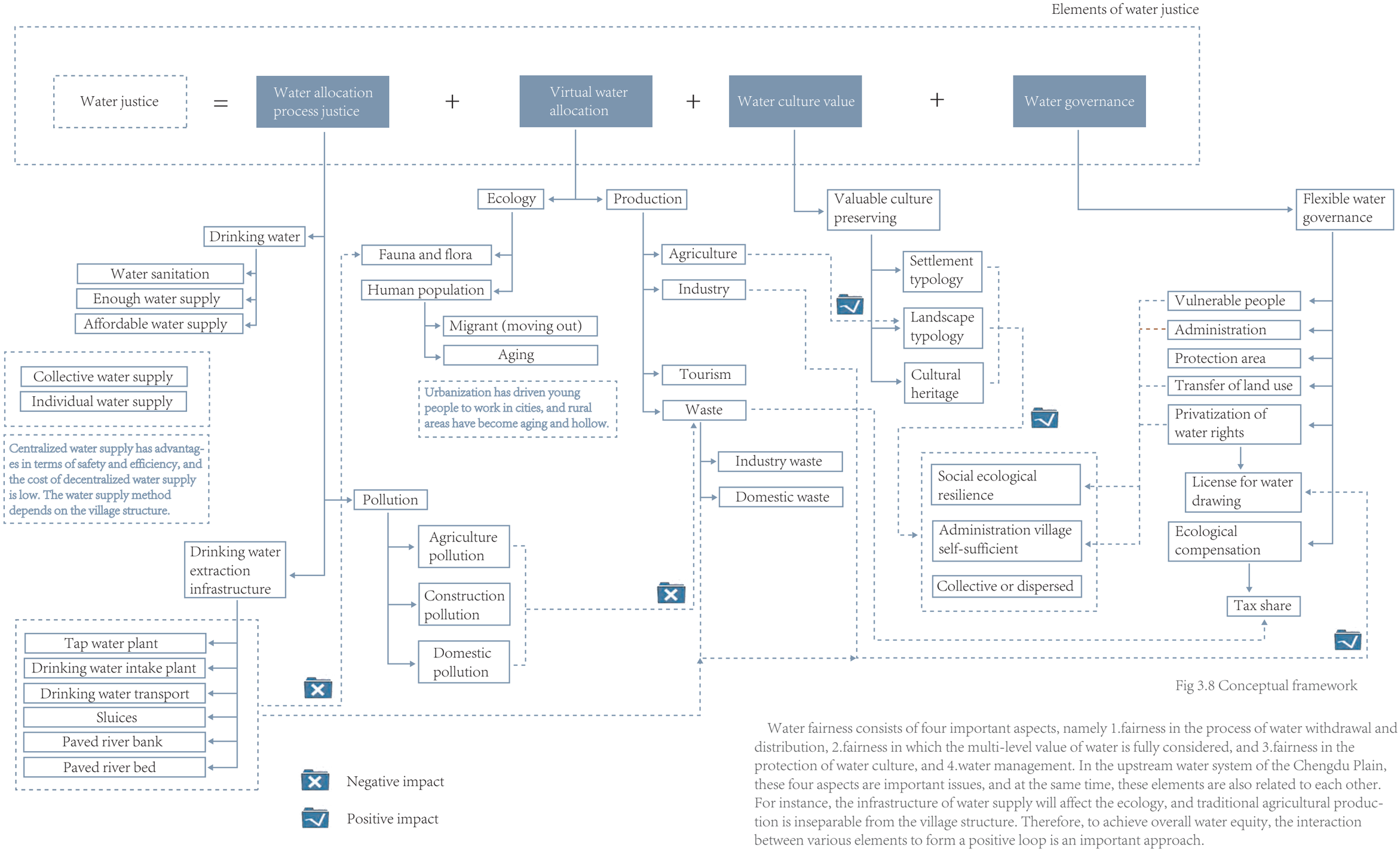


Fig 3.8 Conceptual framework

Water fairness consists of four important aspects, namely 1.fairness in the process of water withdrawal and distribution, 2.fairness in which the multi-level value of water is fully considered, and 3.fairness in the protection of water culture, and 4.water management. In the upstream water system of the Chengdu Plain, these four aspects are important issues, and at the same time, these elements are also related to each other. For instance, the infrastructure of water supply will affect the ecology, and traditional agricultural production is inseparable from the village structure. Therefore, to achieve overall water equity, the interaction between various elements to form a positive loop is an important approach.

METHODOLOGY

Methods and outcomes

M-1 Literature Review
M-2 Document/policy Analysis
M-3 Fieldwork/Interview
M-4 Multi-scale Mapping
M-5 Power Structure Analysis
M-6 Case Study
M-7 Scenario Testing

METHODS AND OUTCOMES

Sub-questions	*Scale*	*Methods*	*Outcome*
1.How to make the water allocation process justice between water source area and water use area and prevent pollution? --How to supply healthy and affordable water for both the water source area and water use area? --How to make water supply and sewage system efficient and eco-friendly?	Metropolis Local	M-6 Case Study - Other examples about how to deal with the pollution and make eco-friendly water infrastructure. M-3 Income survey - Villagers' financial situation and thier ideas about the water supply system M-4 Mappping - Mapping the drinking water supply and sewage, irrigation infrastructure and their ecological impact	A new suggestion of water supply system or a new way for indigenous people to get water The approach of making the water infrastructure ecologically friendly
2.What virtual value of water need to be considered while making a sustainable and inclusive development of water conservation area? --How to reimburse the value of a water ecology system? --How to reimburse the potential economic value of the water system? --How to measure the virtual value of a water system in the new development?	Metropolis & Global Metropolis & Global Local	M-3 M-4 Fieldwork and mapping of the ecology conditions. M-1 Literature review - The virtual ecology value of the water system; the potential economic value of water system. M-1 Literature review - The reimbursement of the water value. M-6 Case study - The other villages in the same area with green and sustainable development.	Seize the opportunity for local industrial and agricultural development. A framework of preserving virtual ecology and productive value of water system. The system of how to make reasonable compensation of the water value. The approaches that can be applied in the research site to protect the water ecological system.
3.How can traditional aspects of village practices and environments be preserved and adapted as part of a strategy of the new development? --How can the local village be empowered through the traditional water culture? --How can the local village maintain their culture of living with water in the new development?	Basin & Local Basin & Local	M-5 Power structure - Understanding the current practice in local empowerment. M-6 Comparison - The other villages in other parts of China to conclude the cultural value of this special format. M-3 Survey and history reserch - Special water culture and related society structure. M-7 Scenario testing - Possible new development with different priorities.	The way of feasible local empowerment. A historical story of how the formation of this culture and their special value today and how to protect this culture. Comparison of different scenarios in water consumption aspect.
4.How can the strategy and policy be justice and flexible at the water governance level? --How to make an institutional system that allows disadvantaged groups to speak out? --How to establish an institutional system to achieve fair ecological compensation?	Metropolis & Local Metropolis & Basin	M-1 Literature review - Theories on flexible water government practices. M-5 Stakeholders analysis - Different stakeholders in the water supply process. M-2 Policy Analysis - The local participation programme and fair finance and taxation system	The critical position of existing stakeholders' structure and their power and roles. A new policy framework of water management and public surveillance system.

Fig 3.9 Methods and outcomes

METHODOLOGY

Flowchart

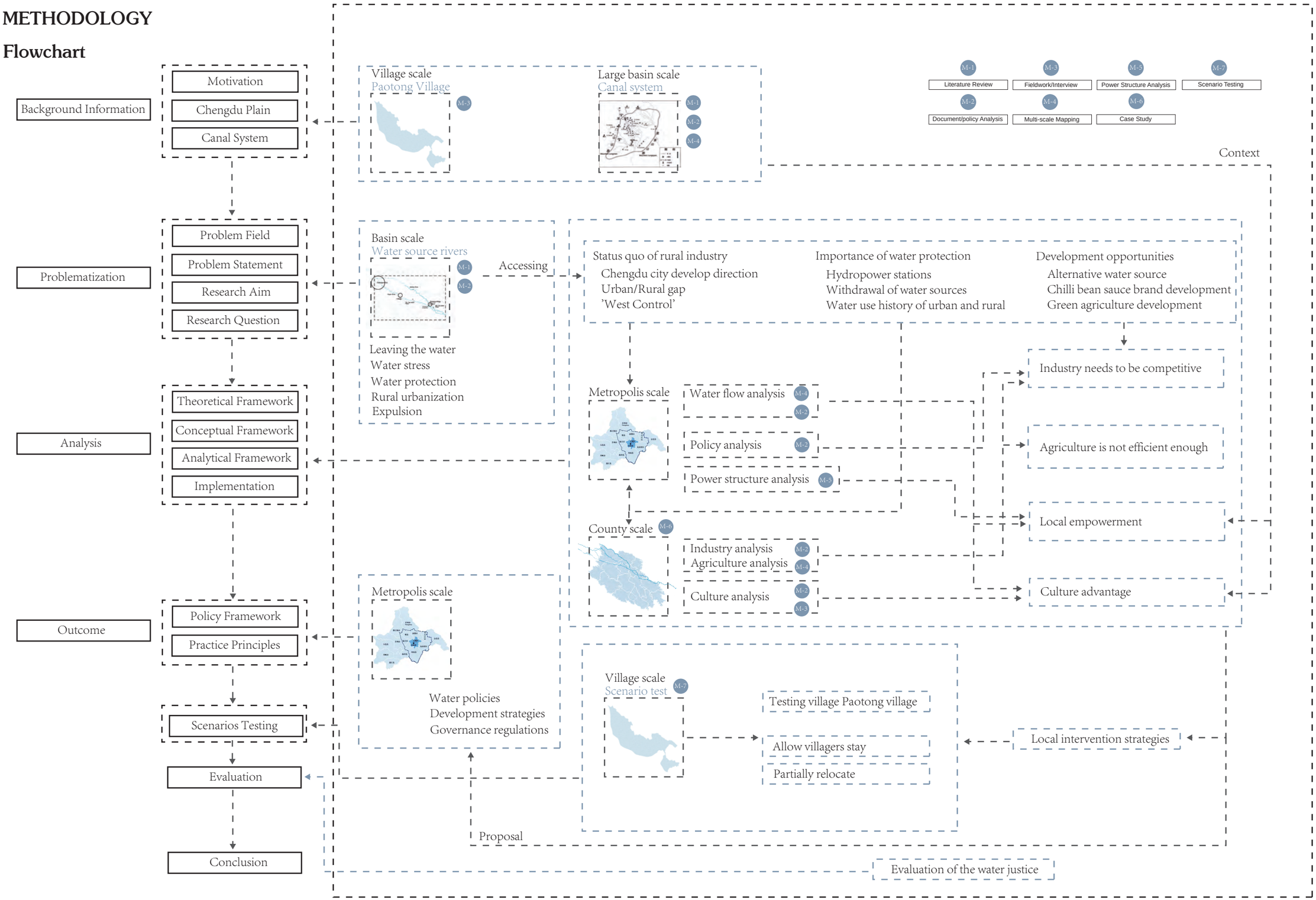


Fig 3.10 Methodology flowchart

METHODOLOGY

Intervention framework and timeline

Intervention framework

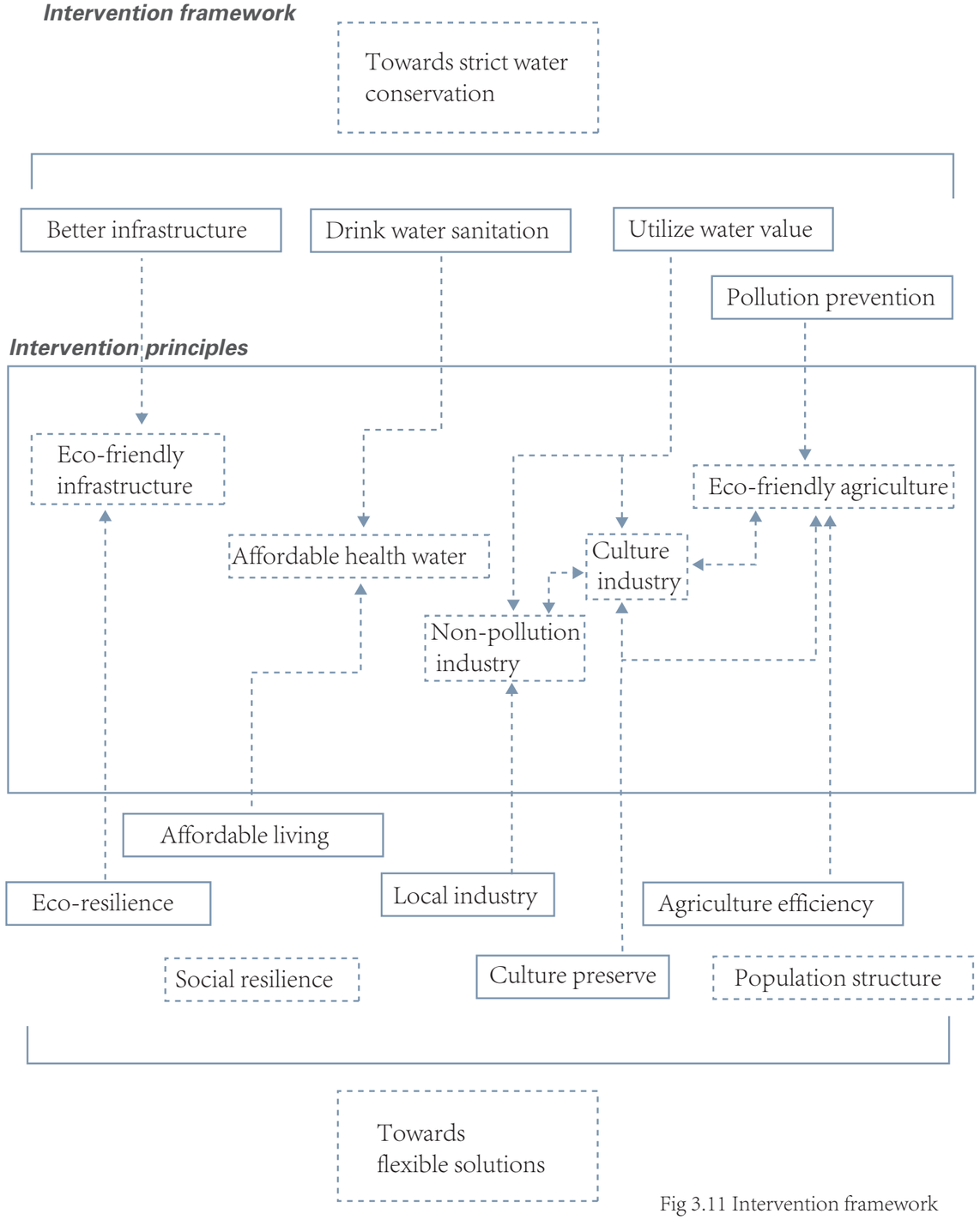


Fig 3.11 Intervention framework

Project Time–Line

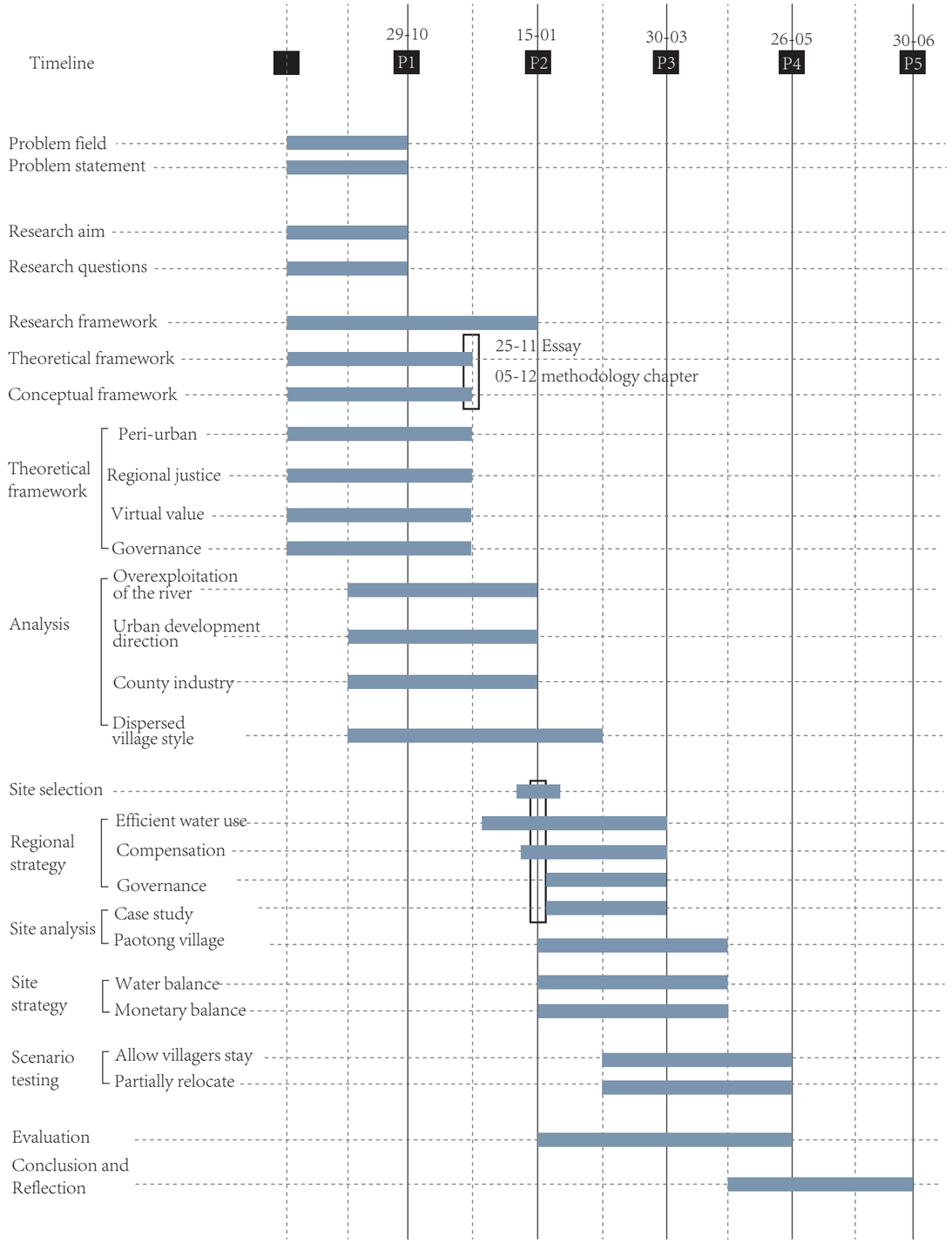


Fig 3.12 Project timeline

4 REGIONAL ANALYSIS

4.1 Define the Analysis Scales

4.2 Water Stopping Upstream sluices

4.3 Increasing water use in core urban areas

4.4 Industry structure of Pidu District

4.1 Define the Analysis Scales

Analysis scales

Water flow, economy, regulations, social relations and power structure are cross-scale.



Fig 4.1.1 Upper Yangtze River Map
Source: Yao, Chen, Hu & Li (2016)

Upper Yangtze River

Dujiangyan irrigation area is located between the Min and Tuo River systems, which are tributaries of the upper reaches of the Yangtze River. The main drinking water source is the Min River basin. This scale mainly analyzes the impact of engineering interventions in the water system on the watershed of the water source protection area.



Fig 4.1.2 Chengdu Map
Source: Chengdu Urban Planning Bureau. (2017)

Chengdu area

Dujiangyan water conservation area is a peri-urban district of Chengdu. In the scale of Chengdu city, this analysis starts from the change of water use in the urban area which is the main reason for the conflict and describes the unbalanced status between the city and this peri-urban area.



Fig 4.1.3 Pidu District Map
Source: Chengdu Urban Planning Bureau. (2017)

Pidu District

The Xuanyan River and Baitiao River is the main drinking water source of the Chengdu region. In this scale, the essential focus is the spatial impact of the water protection regulations and the river water volume issues.

4.2 Water Stopping Upstream sluices

Disorganized development of small hydropower stations

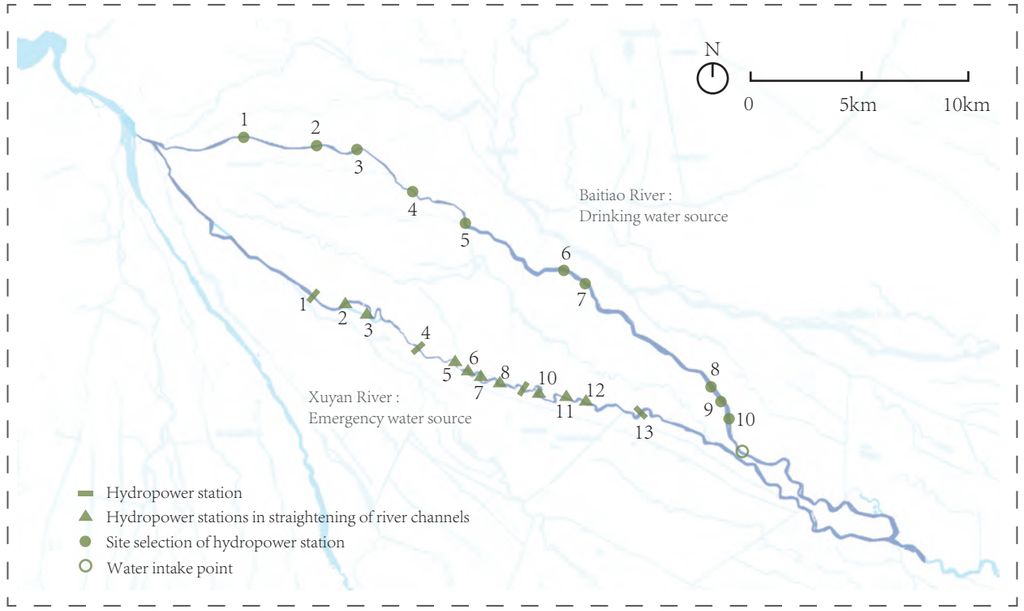


Fig 4.2.1 Hydropower stations in water source rivers

In the upper reaches of the water source protection area, which is the upper reaches of the Min River, hydropower stations are scattered across the main-stream and tributaries. They cut off the river and affected the water volume in the drinking water source area. These hydroelectric stations built in mountainous areas are also affecting the local environment, and have adverse effects on ecology, soil and water (Wang & Peng, 2008). Even among the two rivers in the water source area, the emergency water source Xuyan River has constructed 13 sluices, the conventional water source Baitiao River have also tried to develop cascade hydropower, and more than 10 sites have been hardened.

Large-scale projects such as hydroelectricity affect the protection of drinking water sources, but due to a lack of ecological awareness and chaotic manage-ment, these projects have been unimpeded.

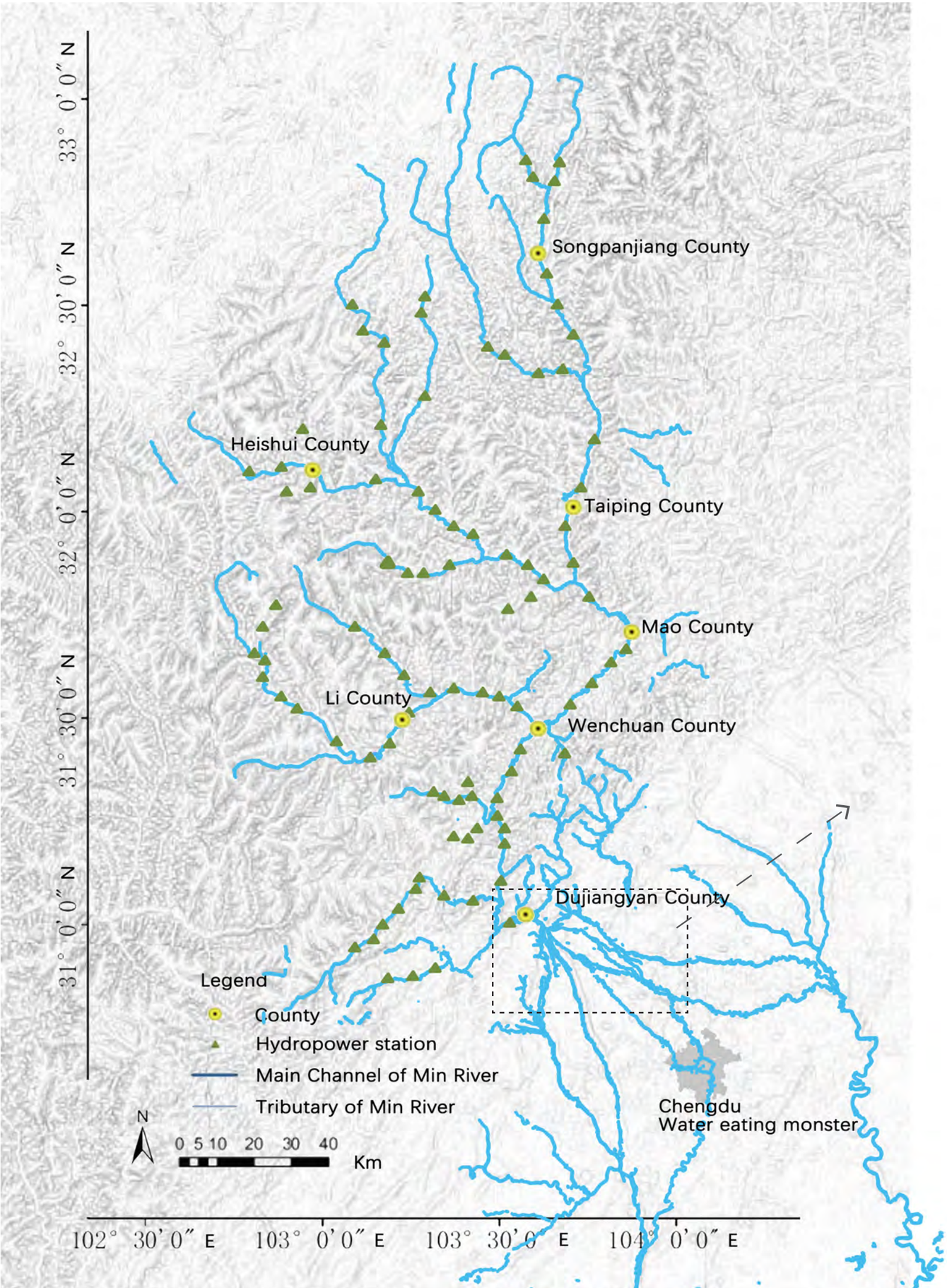


Fig 4.2.2 Upstream hydropower stations of Min River
Source: Adapted from Li (2014)

The Approval of Hydropower in the Upper Yangtze River

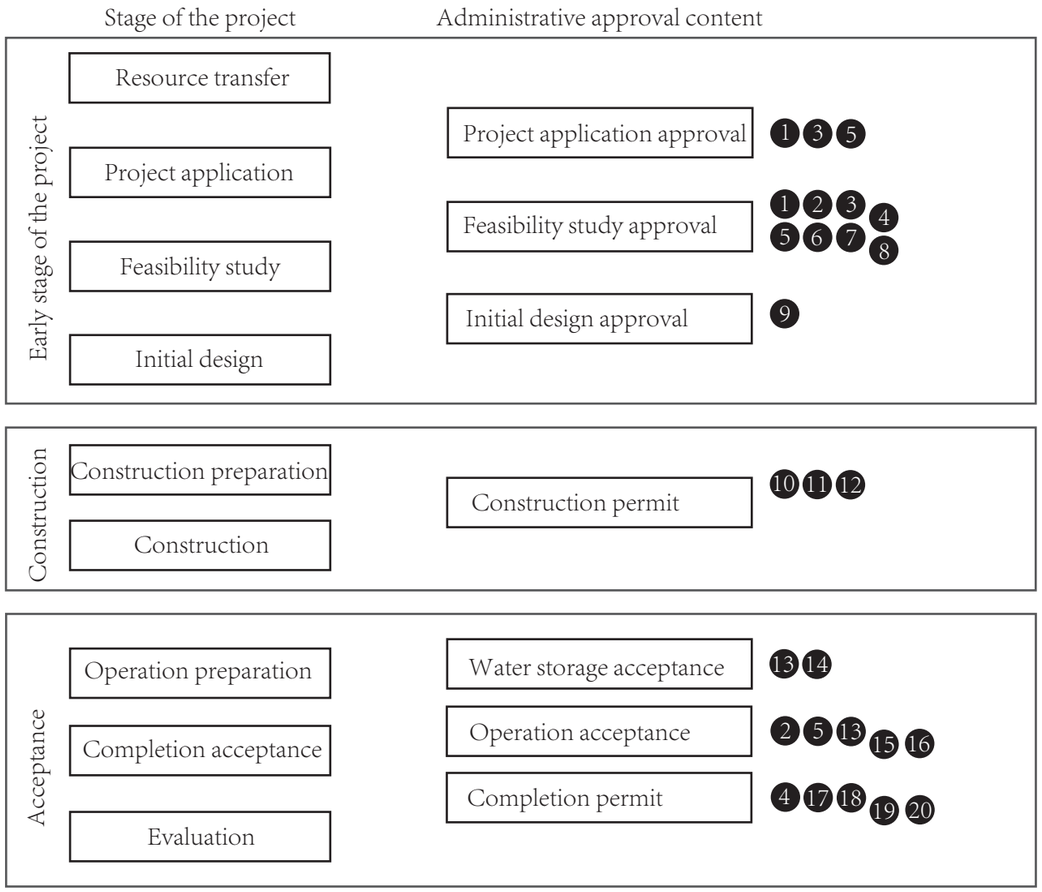


Fig 4.2.3 Approval of rural hydropower stations

In the approval of specific hydropower projects, at present, in addition to the National Development and Reform Commission, the provincial and municipal water conservancy departments, economic and trade commissions, and development and reform commissions also have the right to approve, and even the prefecture and city levels have the right to approve.

Due to the administrative level, the environmental protection department is subordinate to the local governments, and the financial and human resource management are not independent, so they are vulnerable to pressure from the local government and interest groups. For remote small hydropower projects, the environmental protection department is very inconvenient for daily supervision; large hydropower stations are invested by state-owned enterprises. As a county-level environmental protection supervision department, it is even difficult to enter the construction site to implement environmental protection supervision.

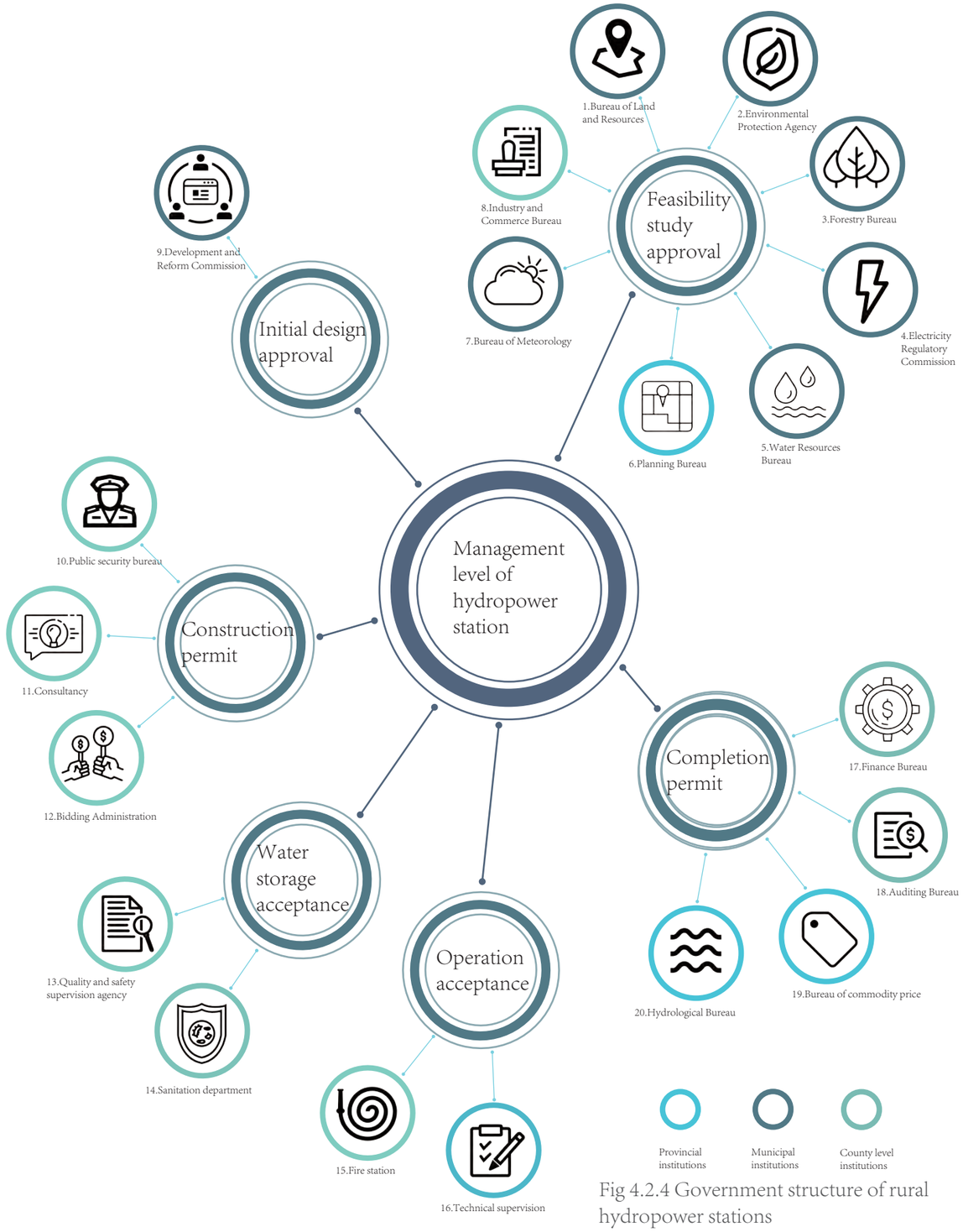


Fig 4.2.4 Government structure of rural hydropower stations

The construction of a hydropower station project requires very few provincial-level approvals. Most of the supervision takes place at the municipal or county level, and the overall consideration of the basin is almost non-existent.

Disorganized development of small hydropower stations

Since the 1940s, the amount of water from the upper reaches of the Min River to the Dujiangyan Irrigation District has been decreasing year by year, which coincides with the year when the Min River began to build hydropower stations. The second reduction in water flow since the 1960s was also related to the construction of small rural reservoirs in the same period. The multi-faceted impact caused by hydropower stations is a factor in the decrease in the water flow of the Min River (Liu, Su, Xu, & Zhang, 2006).

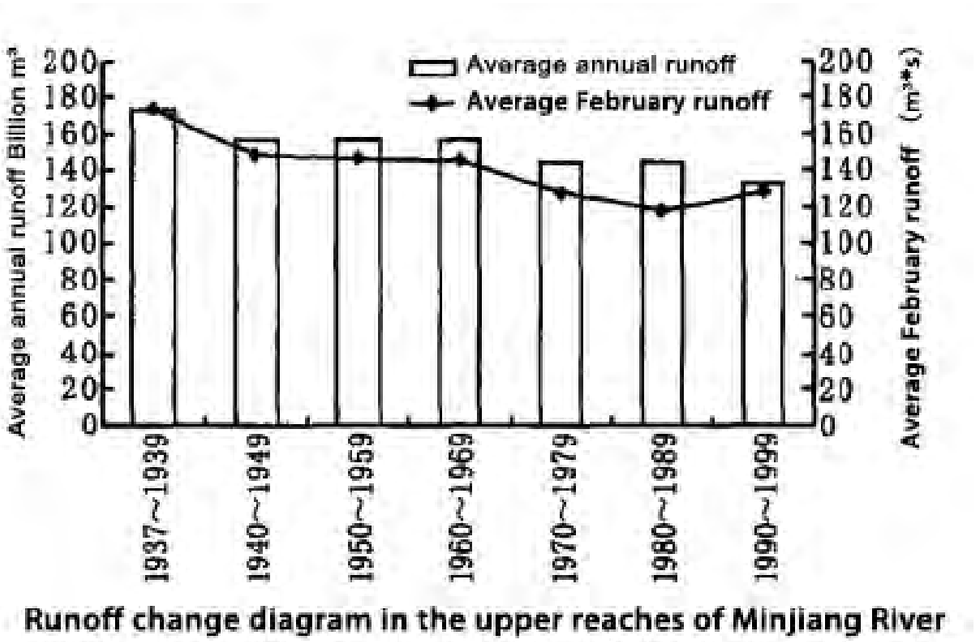


Fig 4.2.5 Water runoff decreasing in the upper reaches of Min River.
Source: Liu, Su, Xu, & Zhang. (2006).

	Indicators	Before con-struction	Under con-struction	Running	Affected groups
River ecosystem services	Hydropower (electricity)	None	None	High	Enterprise, local government, power user
	Fresh water	High	Low	Middle	Residents in and downstream of the basin
	Aquatic products	High	Low	Low	Residents along the river
	Gene bank (biodiversity)	High	Low	Low	All residents
	Purifying water quality	High	Low	Low	Residents in and downstream of the basin
	Shipping	Low	None	None	Residents in the basin
	Flood control	Middle	Low	Low	Residents in and downstream of the basin
	Culture aesthetics tourism	High	Low	Low	Residents in the basin
Environmental pollution		Low	High	Middle	Residents near the hydropower station

Social & economy issue	Phase
Simple social relations economic backwardness	Before construc-tion
Complex social relations Investment-oriented economy	Under construc-tion
Complex social relations The economy has grown substantially but the beneficiaries have changed	Running

Fig 4.2.6 Impact of hydropower stations.
Source: Wang & Peng (2008).

Long term effect

1.Ecological blockage, the river's self-purification ability is affected
2.Water cut off for power generation, downstream water volume is affected
3.The upstream ecology is affected, causing soil erosion, and total water volume reduction
(It is destroying landscape continuity, and the groundwater level and nearby soil quality changes.)
4.Dam construction polluted water (especially small dams) (Wang & Peng, 2008).

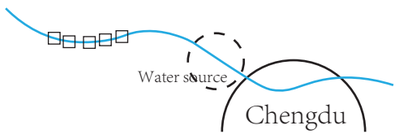
Hydropower development has caused ecological damage. Small hydropower or disorganized hydropower development has caused water volume reduction, but the downstream water source protection area has to pay for it (Liu, 2002).

The Hydropower stations in the Upper Yangtze River

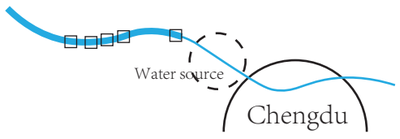
Conclusion on the upstream water flows

Challenge The disordered hydropower development affects the water of the protection area

How does upstream hydropower development compensate downstream affected areas?

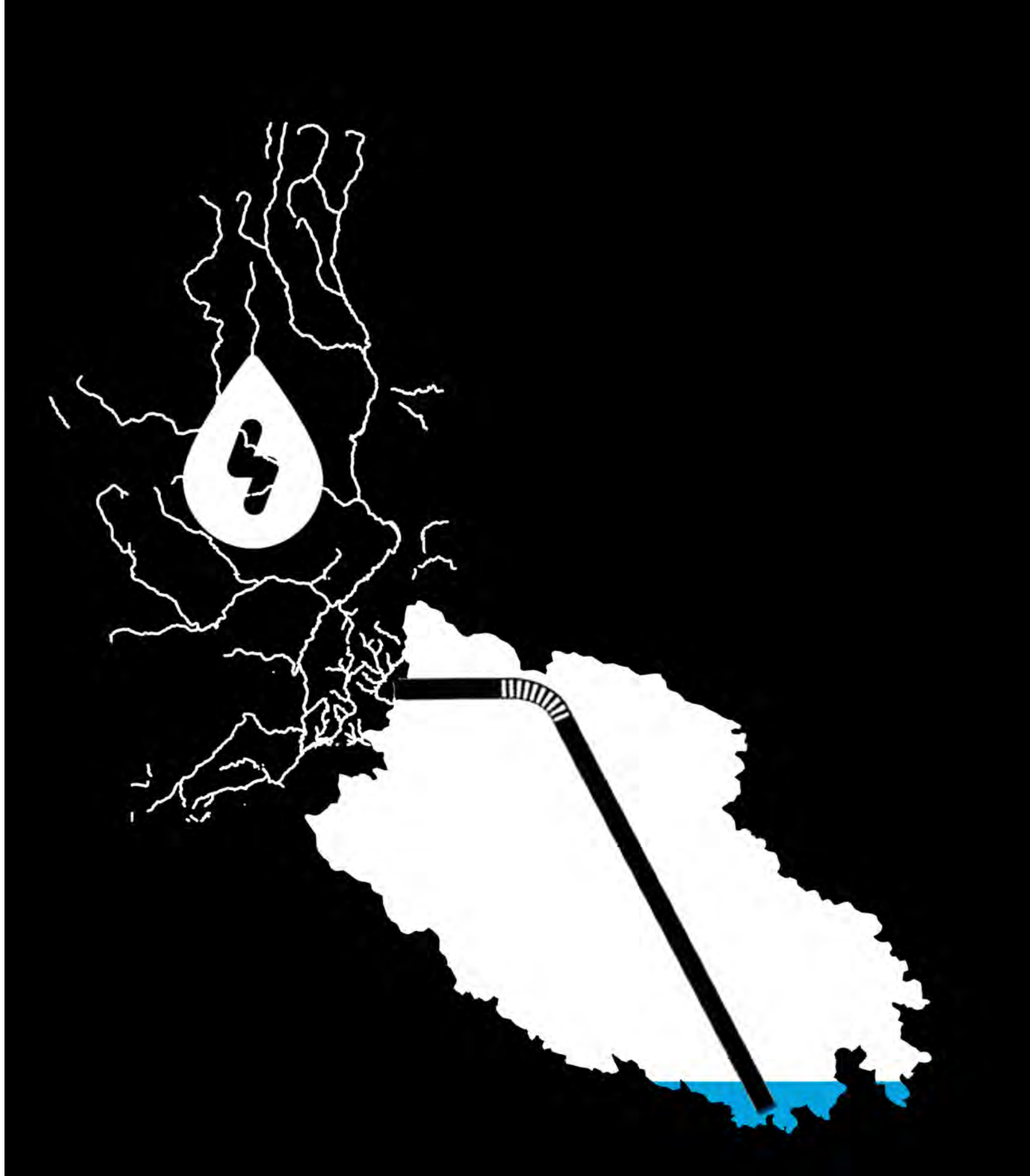


Large and small reservoirs and sluices built upstream, especially in rural areas, are poorly managed and excessively dense.



The impact of upstream hydropower stations on the local ecology is ultimately reflected in the amount and quality of the water supplies in the protection zone.

Fig 4.2.7 Conclusion of chanllenge



4.2 Water Stopping Upstream Sluices

Fig 4.2.8 Conclusion of hydropower stations
Source: Made by author based on GAZETA.PL (n.d.)

4.3 Increasing water use in core urban areas

4.3.1 The population of migrants and their water rights

To obtain natural resources like water is a part of the right to the city (Phillips and Gilbert, 2005). It is, in many instances, a part of the socio-economic right in the city. Matilla (2005) believes that the right to the city is the right to a communal good, such as the basic resources needed. Lefebvre (1991) defines the right to the city most simply as a 'transformed and renewed right to urban life', basic life needs are part of urban life. Scholars ascribe the right to the city to all manner of groups (Attoh, 2011). For instance, migrants have the right to the city (Dikeç, 2005). Marc Purcell (2005) believes that the right to the city belongs to the people who live in the city and have made contributions to life experience and living space, which certainly includes the increase of migrants from Chengdu.

Chengdu's inflow population, no matter where they come from, has the same water rights as all inhabitants in the city.

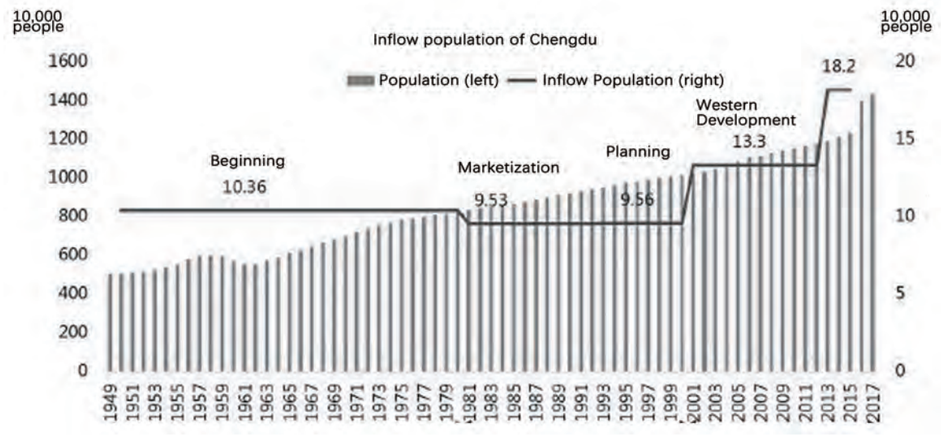


Fig 4.3.1.1 Population growth in the core of Chengdu
Source: Adapted from FCW (2018)



Fig 4.3.1.2 The crowd at the train station of Chengdu
Source: Dreamstime (2018)

4.3.2 Ecological Condition and 'Control West'

A more ecological upstream area

Terrain and Landform

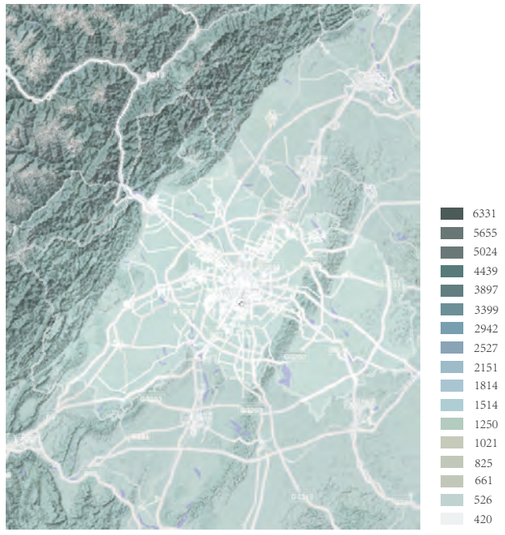


Fig 4.3.2.1 Source: Topograficmap (n.d.)

Ecological zone

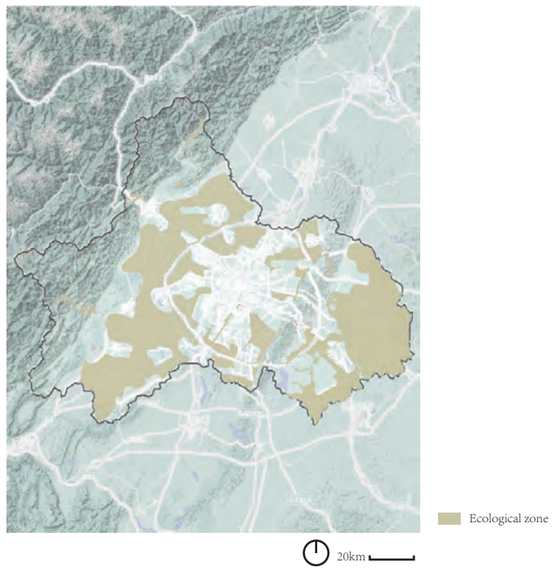


Fig 4.3.2.2 Source: Adapted from Chengdu Planning and Natural Resources Bureau (2016)

3D Terrain model simulation of Sichuan Basin

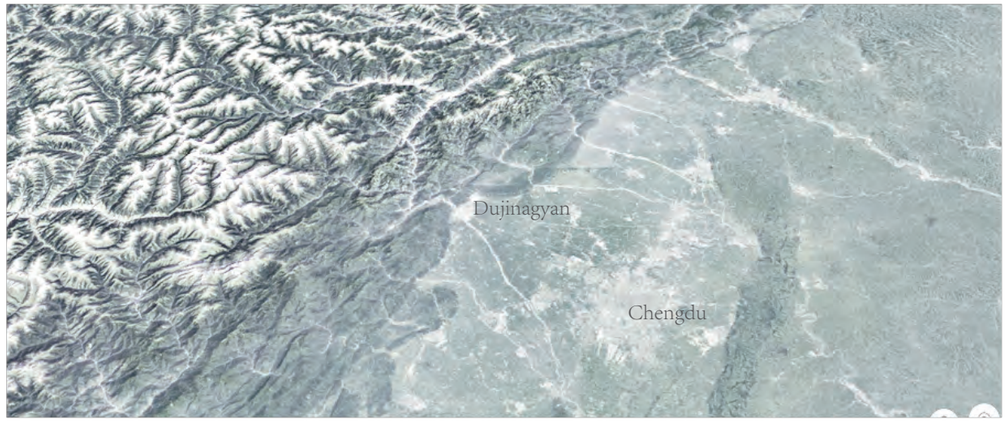


Fig 4.3.2.3 Source: Google earth (n.d.)

4.3.2.1 What is 'Control West' strategy?

The Chengdu Plain is part of the Chengdu Basin on a larger scale and is surrounded by mountains. Minshan Mountains in the west of Chengdu is the starting point of the Qinghai-Tibet Plateau. Therefore, this district has a low development level and excellent environmental conditions. In 2017, Chengdu proposed a planning strategy for urban development, 'North Reform', 'Middle Optimization', 'East Expansion', 'South Extension', and ' Control West'. The 'Control West' strategy is to focus on improving ecological functions in the west of Chengdu, strictly abide by the ecological control red line and urban development boundaries, control development intensity, and create featured towns and rural communities. In terms of industry, it requires to develop green and pollution-free industries, control industrial scale, and develop green ecological agriculture. It also emphasizes the use of cultural resources to build a global tourism industry service chain, but the scale must be strictly controlled.

4.3.2.2 What is 'Control West' means to the upstream cities and towns?

According to the report of the Sichuan Provincial People's Government in 2020, through the densification strategy, the urban land in the west has been reduced by 30 square kilometres. In terms of industrial structure, Pidu District, Dujiangyan City, and Dayi County have closed down 3,509 high-polluting local small businesses.

Western Chengdu chose to be livable, and it would not be able to develop businesses such as heavy industry and manufacturing. These industries must be transformed and upgraded. The green industry needs relatively high investment and a long return period. For a local township and village, it means that the local industry that originally brought great income is not feasible, and agricultural production has also entered the process of transitioning to ecological agriculture. Changing the current production method has brought economic losses.

Therefore, although the western region has been labelled as having a good ecological environment and being livable, industrial development has indeed been greatly restricted. Livability is only one aspect, the development of the industry actually determines the whereabouts of people. Although the environment in the west is good, its economic competitiveness is obviously insufficient.

In the villages and towns of the water source protection area, due to the urban development strategy, the development of industries that can be selected is limited. Besides, it is difficult for relocated residents to change their original lifestyles and enter the ecological industry. So the dependence on compensation there is relatively high.

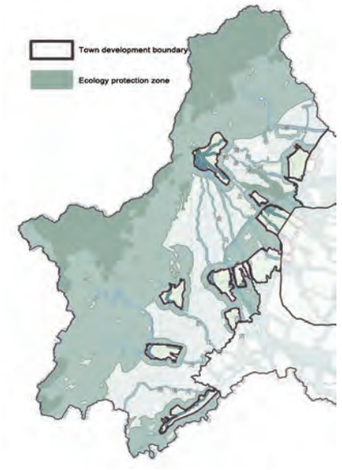


Fig 4.3.2.4 Control West
Source: Zhitianfu (2019)

4.3.3 Conclusion on domestic water

Domestic Water Consumption of Three Layers

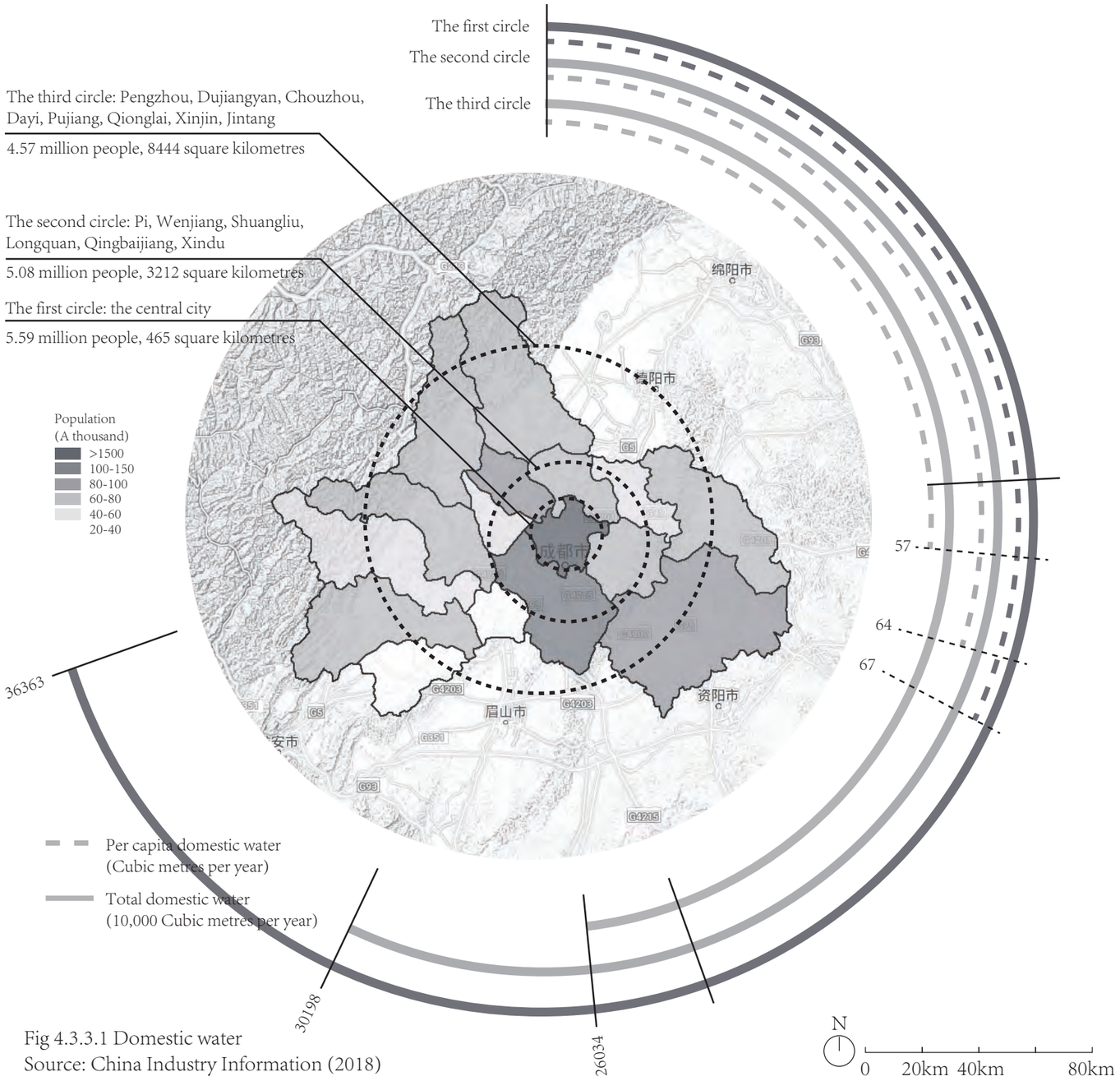


Fig 4.3.3.1 Domestic water
Source: China Industry Information (2018)

4.3.3
The water consumption gap between central city and counties in Chengdu

The Chengdu area can be divided into three circles. The first layer is the core area of the city, including five districts. The second layer is the middle layer, including four fringe districts and two counties. The third layer is the outer circle layer, including four county-level cities and four counties.

These three circles are the geographical sequence of Chengdu from urban to rural, and the population from dense to scattered. The core area of Chengdu, the first circle, has the largest population. Although the population of the second and third circles has decreased compared with the first circle, the reduction ratio is within 20%. In terms of the domestic water consumption of the three circles, the annual domestic water consumption of the first circle is the largest, reaching 36,000 cubic metres. The total water consumption of the second and third circles is reduced, but the reduction ratio of the adjacent circles is 25 %, which is higher than the proportion of population reduction. This can also be reflected in the per capita domestic water consumption.

The annual domestic water consumption per capita in the first circle is 67 cubic metres, the second circle is 64 cubic metres, and the third circle is only 57 cubic metres. The annual domestic water consumption per capita of the Pidu District where the water source protection zone located is only 61 cubic metres, even less than the average of the second circle. Besides, considering that the main direction of Chengdu's development to the south and southeast, the construction of infrastructure, including urban water supply, will be inclined to the priority development area, so the water source protection area in the northwest has no advantage in the domestic water supply. Not to mention the gap between urban built-up areas and rural areas.

In the distribution of drinking water, the principle of achieving fairness is that everyone should be able to get the same amount of qualified drinking water. One of the issues that need to be resolved is the urban-rural gap in drinking water.

Conclusion on industry/ecology water supply

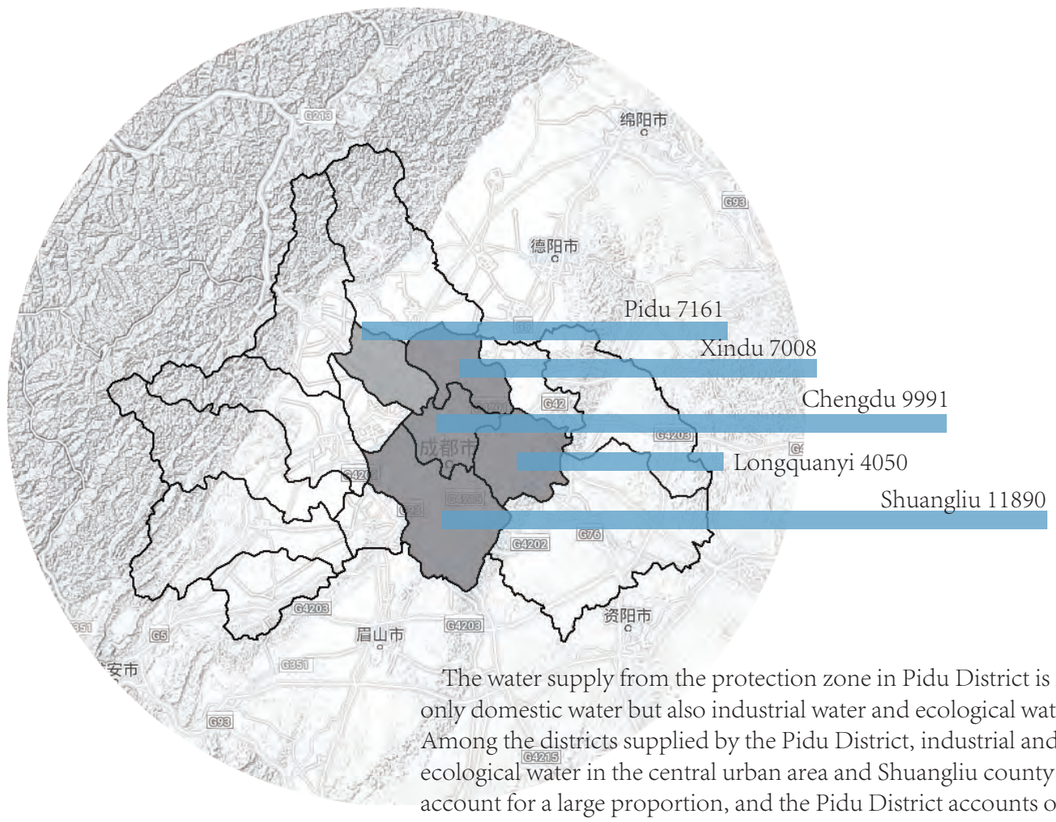
Source of water and consumption districts

Districts	Industry	Ecology	Total
Central city	6443	648	7091
Tianfu new district	710	2190	2900
Longquanyi district	3446	604	4050
Xindu district	6510	498	7008
Shuangliu district	10720	1170	11890
Pidu district	6148	1013	7161

Unit: Ten thousand cubic metres

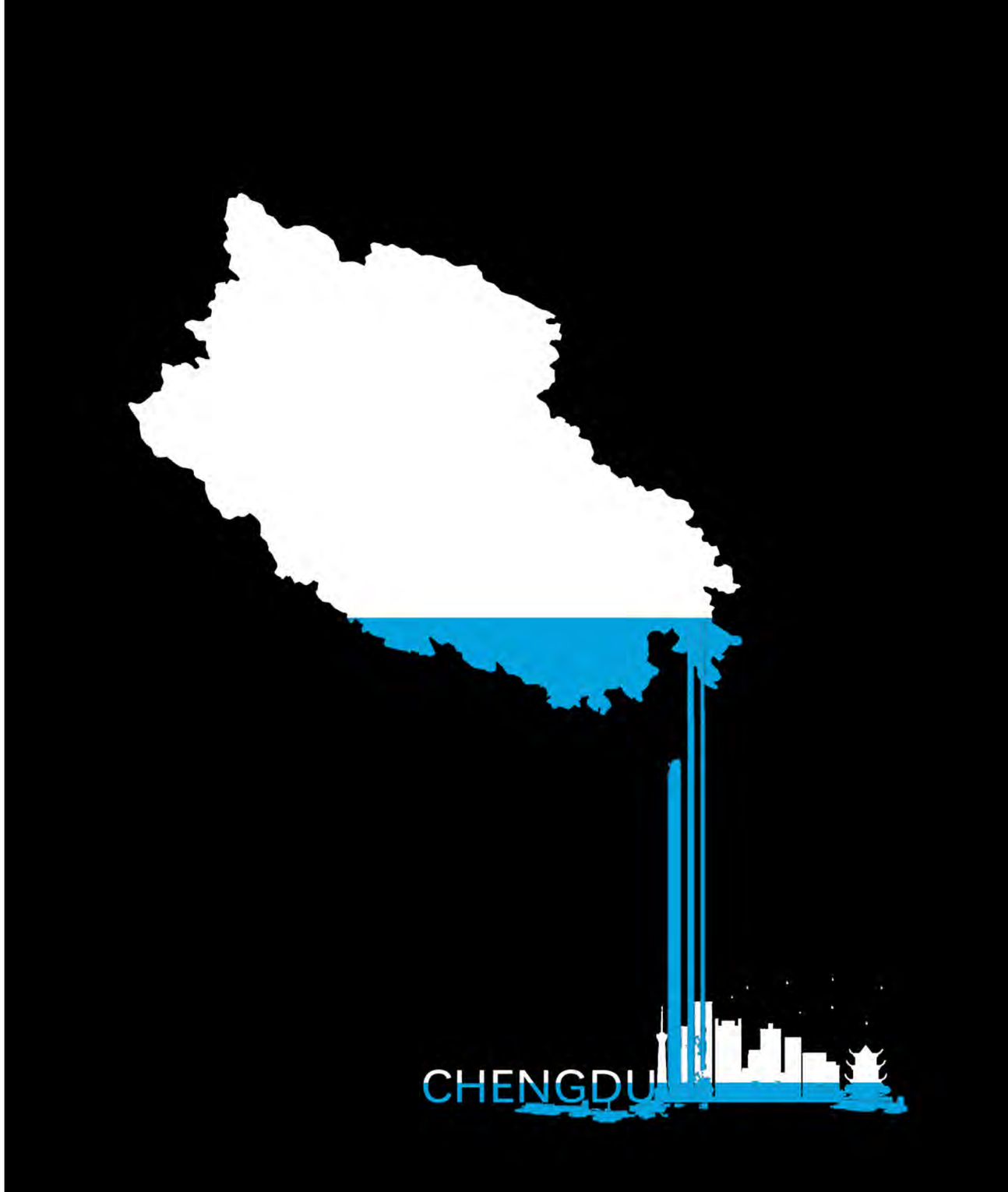
- Tianfu New District is directly managed by Chengdu City and is part of the core urban area.
- Ecological water use refers to ecological water use outside the river.
- Pidu District is the location of the water source protection area, and several other areas are the water supply areas of Pidu District.

Fig 4.3.3.2 The districts that water supplied by Pidu District
Source: Chengdu Water Resources Bulletin (2018)



The water supply from the protection zone in Pidu District is not only domestic water but also industrial water and ecological water. Among the districts supplied by the Pidu District, industrial and ecological water in the central urban area and Shuangliu county account for a large proportion, and the Pidu District accounts only for 18% of the total. The Pidu District is providing water support for the industrial and ecological water use of other districts.

Fig 4.3.3.3 The amount of water supplied by Pidu District
Source: Chengdu Water Resources Bulletin (2018)
& New Times Securities (2018)



4.3 Water Consuming Downstream City

Fig 4.3.3.4 Conclusion of metropolis level

4.4 Industry structure of Pidu District

Pidu District

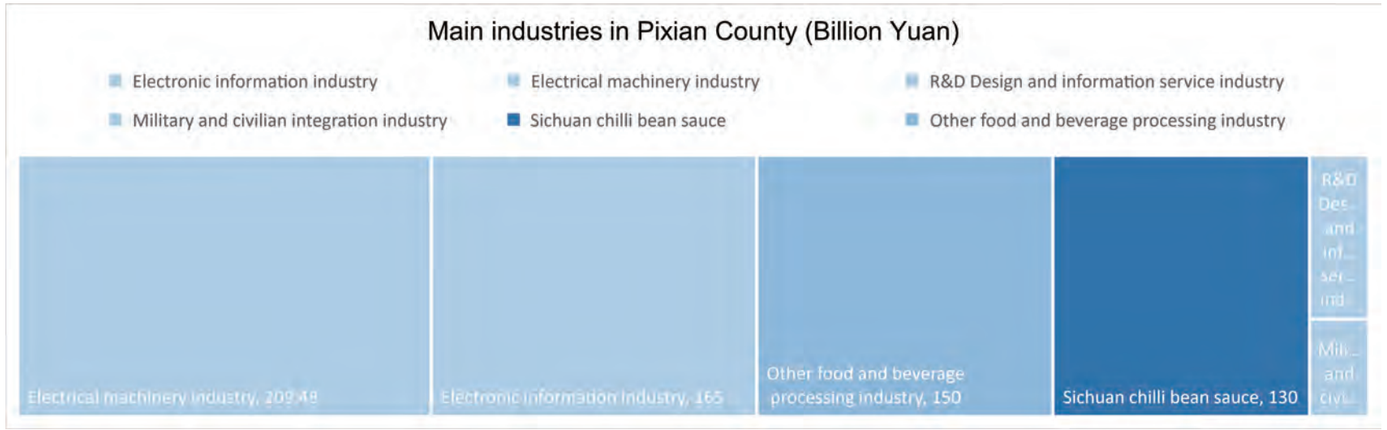
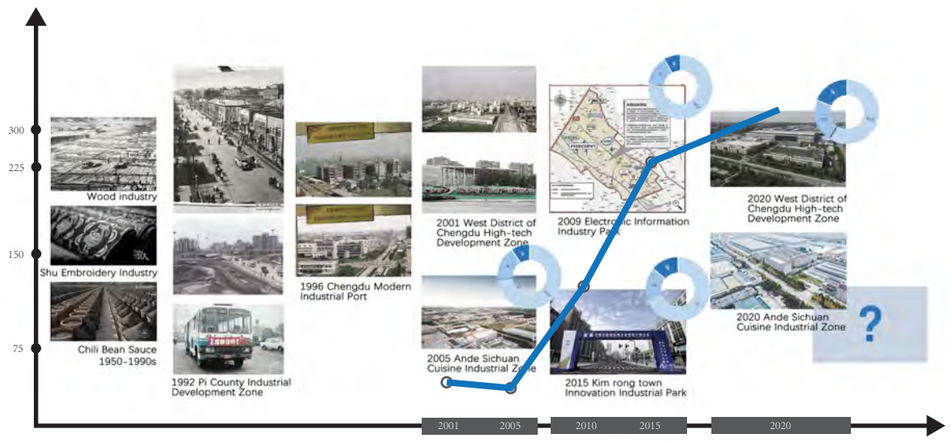


Fig 4.4.1 Main industry in Pidu District
Source: Chengdu Statistical Yearbook (2019)

In addition to the main urban area, Chengdu also has jurisdiction over 15 counties. Pi County is one of them and was renamed Pidu District in 2016. According to the Statistics Yearbook (2019), the output value of the primary industry in Pidu District is limited, and more than half of the output value comes from manufactory production.

Specifically, nearly half of the output value of the secondary industry in Pidu District comes from the food processing industry, which is consistent with the traditional agricultural production area of Dujiangyan Irrigation District in Pidu District. In the food industry, nearly half comes from chilli bean sauce, which is rapidly increasing since 2005 when the cuisine industry park established.



Industrial structure diagram: 2005/2009 is the total sales volume of the industry and 2015/2020 is the total output of the industrial industry

Fig 4.4.2 Industrial development history
Source: Aijinniu (2018) & Qingjujin Official City (2019) & Pengpai news (2020) & JK51 (1992) & Chengdu High-tech Zone Rong Media Centre (2020) & Chengdu High-tech Zone News Centre (2018) & Kuaibao (2018) & Newsweek (2018) & Chengdu Office Information Network (n.d.) & Shenbi Wenchuang (2020) & Daily Economic News (2019) & Chengdu Daily (2020)

4.4.1 Pidu District industrial district distribution



Pidu District industrial district started in 2005



Water conservation policies were tightened in 2012

In 2005, the industrial park in Pidu District began to take shape, forming a certain cluster scale. Part of it is within the third ring road of Chengdu city and the other part of the industry park is outside but next to the third ring road. It mainly relies on the development of the industrial foundation in Chengdu. In the northwest of Pidu District, a large area is still in the stage of local small industrial workshops.

In 2012, Chengdu's water protection zone policy was revised for the third time, requiring the demolition of all buildings in secondary and primary water protection zones that may affect water sources. Small businesses in the water source district began to move, but the industrial park near the city's main urban area was not affected. Meanwhile, the Sichuan-cuisine industrial park began to develop in the northwest of Pidu District, where the scale industry finally entered the rural area.

In 2017, the 'Control West' strategy was implemented. Although part of the industrial park in Pidu District was not within the scope of the transformation area, the industrial park is transforming into an electronic information industry with less and controlled pollution. However, the vast area on the west side of Pidu District is restricted in local industrial development for ecological protection. According to Chengdu Environmental Protection Bureau (2017), there are a total of 40 industrial enterprises in the Pidu District water source protection zone, and 85 tourist restaurants have been closed or relocated, which are small-scale rural industries.

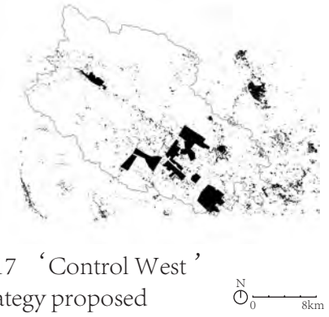


Fig 4.4.1.1 Industrial distribution history
Source: Google map (n.d.)

4.4.2 Large Scale Industry in Pidu District

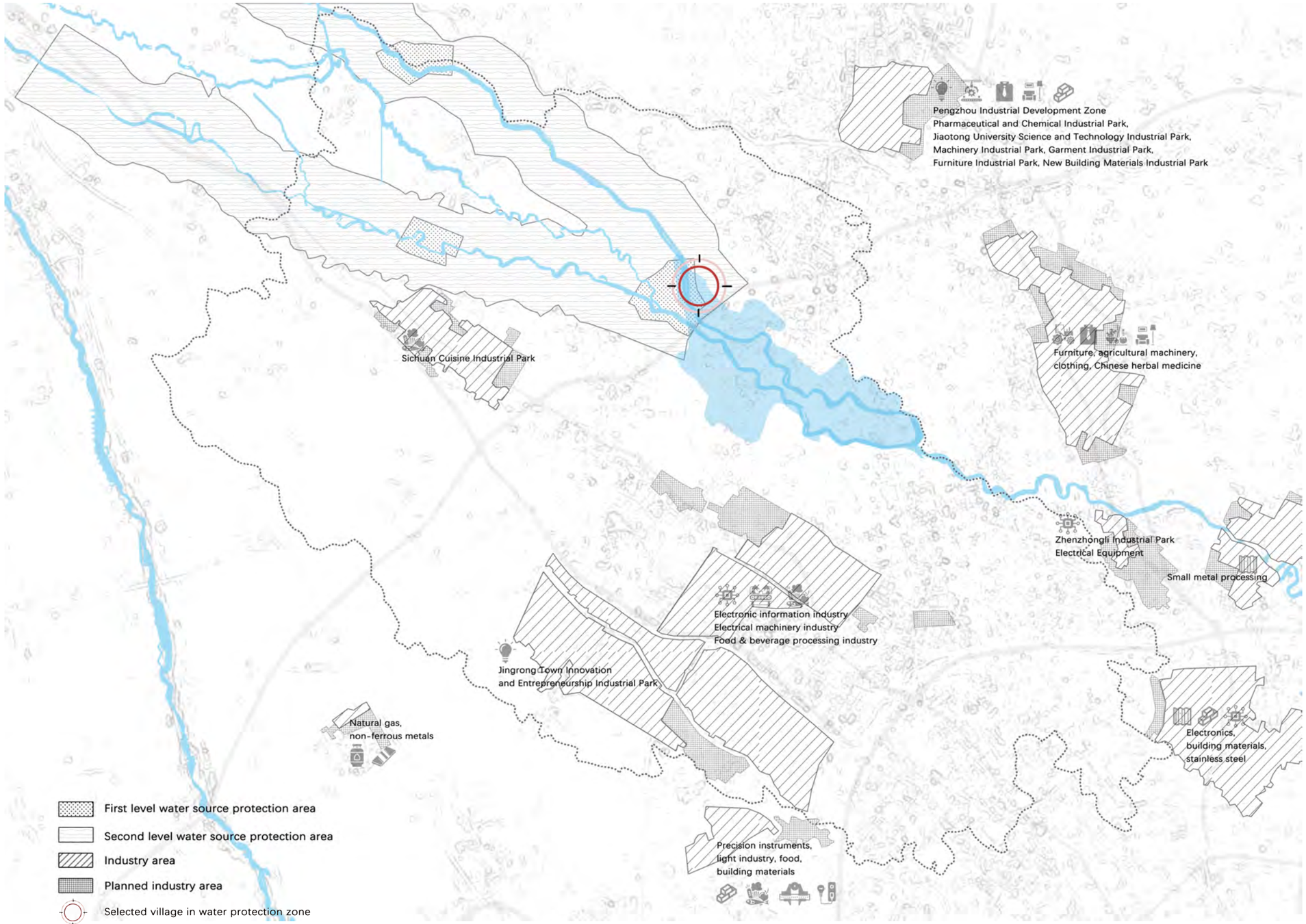


Fig 4.4.2.1 Large scale industry in Pidu District
Source: Google Map (n.d.)

1. Chengdu Modern Industrial Port

The large-scale industry in the Pidu District is mainly composed of two industrial parks. The first is the Chengdu Modern Industrial Port, namely the High-tech West Zone, which is an industrial park directly managed by the central city, with the total industrial output value accounting for half of the total in the district. The leading industry of this industrial park is the electronic information industry, which is a labour-intensive industry and undertakes the outward transfer of the manufacturing industry in Chengdu. It is located around the third ring road of Chengdu. Under the new strategy of 'Control West', the company there will transform into a high-end manufacturing industry, which will need the improvement of a highly skilled workforce.

2. Ande Sichuan Cuisine Industrial Park

Another industrial park is the Ande Sichuan Cuisine Industrial Park, which began to develop in 2005. This industrial park is located in the western region of Pidu District, near the water source protection area. Mainly relying on the well-known chilli bean sauce industry in Pidu District, it strives to promote the development of the agricultural product processing industry in Pidu District, which is also an opportunity for the development of high-quality agricultural products.

The industrial development focus of Pidu District is concentrated in the southeast region, relying on the geographical advantages close to the main urban area of Chengdu. Chengdu Modern Industrial Port is also the first industrial park that uses water from the water extraction plant. Therefore, the industrial park should give compensation to the water source zone. By providing jobs or vocational training, this industrial park can provide diversified compensation methods by utilizing its position advantage. As a food industry developing in accordance with its historical advantages, Sichuan Cuisine Industrial Park has its own uniqueness and can provide new opportunities for the development of agriculture in the Pidu District.

4.4.3 Combination of agriculture and manufacturing

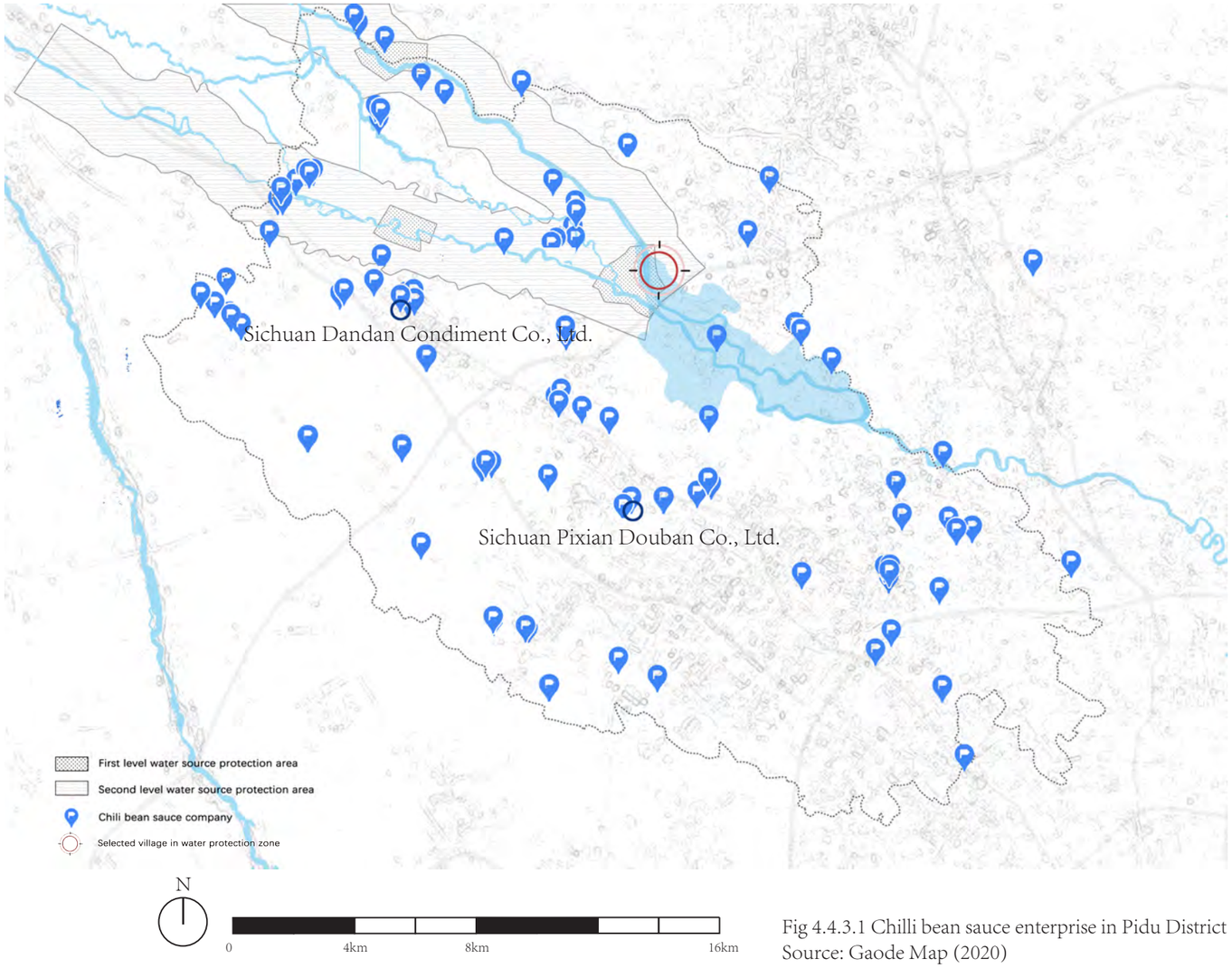


Fig 4.4.3.1 Chilli bean sauce enterprise in Pidu District
Source: Gaode Map (2020)

Chilli bean sauce has a high status in Sichuan cuisine, and is called the 'soul of Sichuan cuisine'. The origin of chilli bean sauce is Pidu District where is also the best place for the development of chilli bean sauce industry. As a very popular sauce, almost every family in Pidu District makes it at home, and small bean sauce factories are also spread all over the district. Due to the limitation of water source protection, 21 small-scale chilli bean sauce factories will close and stop production.

Except for the two larger chilli bean sauce factories, Sichuan Dandan Condiment Co., Ltd. and Sichuan Pixian Douban Co., Ltd., the rest of the bean sauce factories basically only serve the local area and need to integrate the brand to coordinate development.

Chilli bean sauce raw material source

Take Sichuan Dandan Condiment Co., Ltd., the largest bean paste manufacturer in Pidu District, as an example. Except for some chilli and pepper produced locally, the other raw materials come from all over the country. The company bears the freight for national transportation for better quality raw materials.

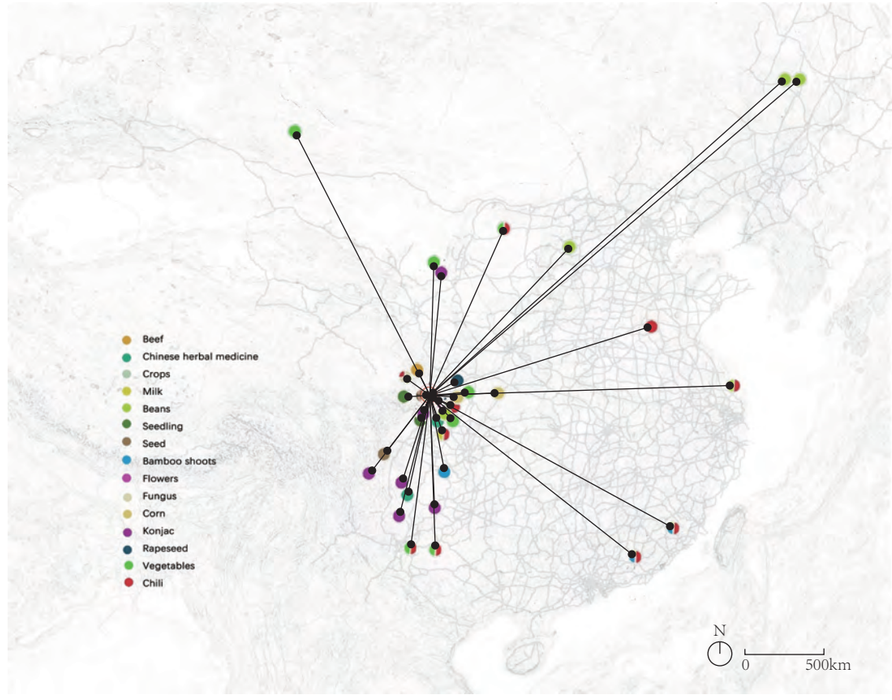
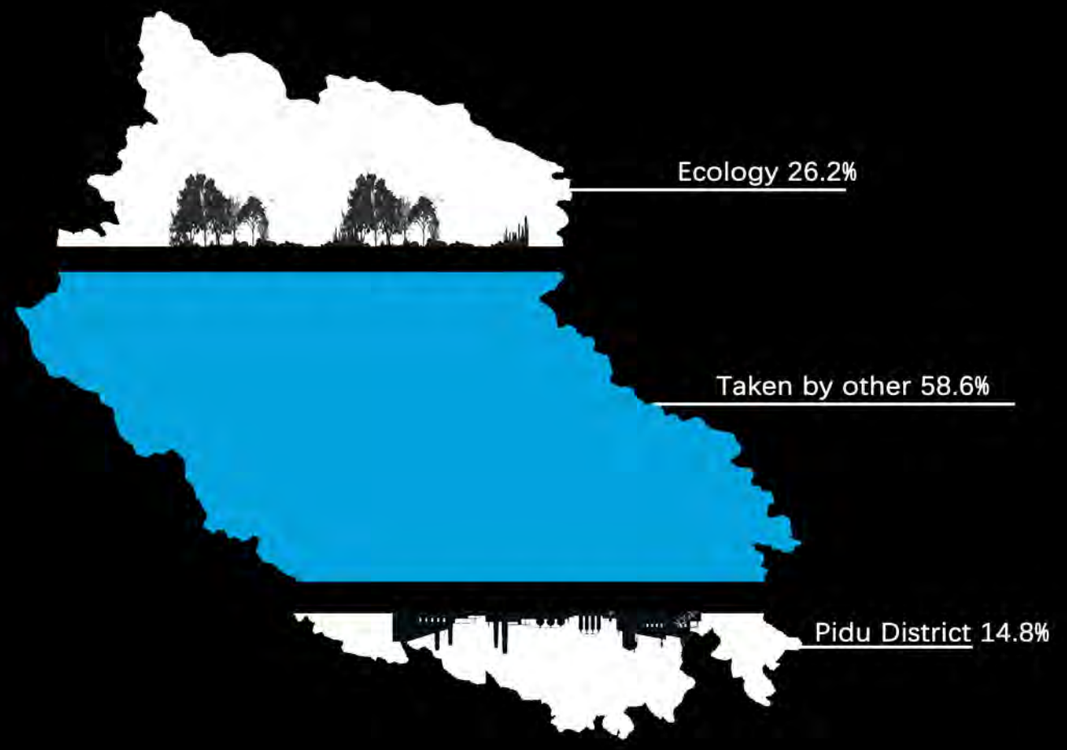


Fig 4.4.3.2 Chilli bean sauce raw material source
Source: China County Economic Research Centre (2018)

From the perspective of brand integration, chilli bean sauce production companies in Pidu District need a unified geographic brand, merge small processing plants, and enhance the brand benefits of their products. Because the production of bean sauce is a natural fermentation process, the pollution produced is limited, so strict supervised sauce plants in the water source protection area are also possible for development. Besides, the development of agriculture in the water source protection zone could shift to refined planting, which can provide raw materials for the bean sauce industry by planting on-demand. Local high-quality agricultural products save transportation costs and also enable win-win cooperation between agriculture and food processing industries.



The use of river water resources should not exceed 40% (Li & Zheng, 1999; Yan, Xiang & Yuan, 2017).
The total utilization of water in Pidu District accounts for 73.4% of the total water resources

Fig 4.4.4.1 Water utilization in Pidu District
Source: Chengdu Water Resources Bulletin (2018)

4.4.4 Conclusion on the water utilization in Pidu District

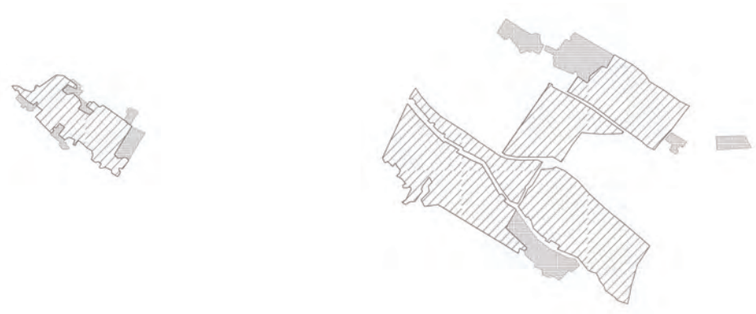
Challenges

Affected industries and agriculture in the water source zone need compensation.



Opportunities

Electronic Information Industrial Park and Sichuan Cuisine Industrial Park are opportunities



Sichuan Cuisine Industry Park

Electronic Information Industrial Park

Fig 4.4.4.2 Conclusion of water use in Pidu District

5 LOCAL LEVEL ANALYSIS

- Water culture
- Local empowerment
- Drinking water history of villages



Fig 5 Dujiangyan on the World Heritage List
Source: Ace Miles (2018)



Yangtze River Delta agriculture settlements



Pearl River Delta agriculture settlements



West Sichuan Plain agriculture settlements



Fig 5.1.1 Styles of Chinese villages
Source: Google Map (n.d.)

5.1 Water culture of the Dujiangyan Irrigation District

For farming, it is not necessary for many people to live together. Because farming has not developed a specialized division of labour, it is unnecessary for many people to live together in the same place. Generally speaking, Chinese farmers live grouped together in villages for the following reasons: (1) The piece of land that each family cultivates is invariably small. This is a petty agricultural economy; people live together in the same place so that they can be close to their fields. (2) Where irrigation is required, people must work together as a group, so living together is quite convenient. (3) Living together as a group also greatly contributes to everyone's security. (Fei et al., 1992).

From the satellite image, it could be seen that the settlements in the Yangtze River Delta and Pearl River Delta are larger and clear, but the settlements in the West Sichuan Plain is dispersed and almost invisible.



Fig 5.1.2 Villages and farmland of Chengdu Plain
Source: Chengdu CPPCC (2019)



Fig 5.1.3 Villages of Chengdu Plain
Source: Fang (2012)

(1) Farming in China has not developed a specialized division of labour, A farmer can complete the whole process from planting to harvesting by himself, so cooperative production is of little significance. Therefore, for agricultural production, scattered living will make the residential land and cultivated land closely integrated, which is convenient for field management, labour, and transportation. This has the highest productivity for a small peasant economy dominated by human and animal power (Fei et al., 1992).

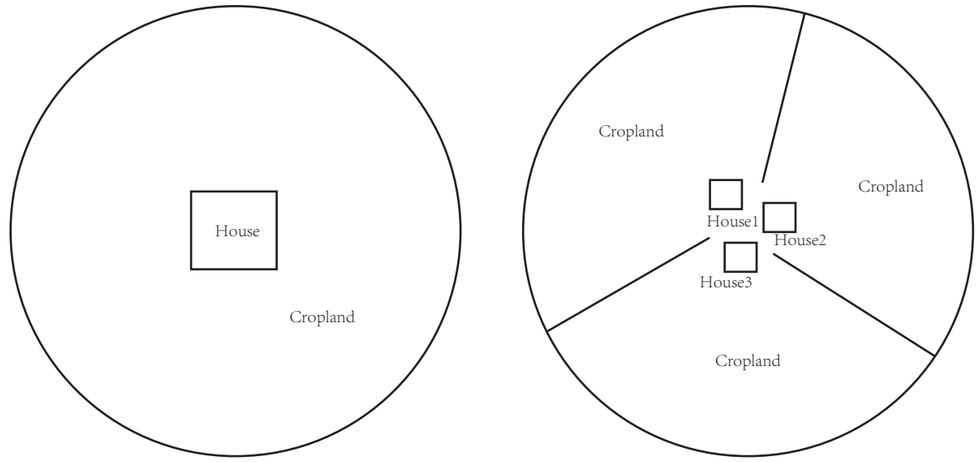


Fig 5.1.4 Formation of a Chinese village

Therefore, for a farmer, the most economical form of living is to live in the centre of the farmland that is cultivated by oneself, so as to realize the shortest transportation distance from living to the farmland. Or a new settlement has several families arriving at the same time, forming a small settlement, each of which is relatively close to its own field, which is the most productive form of living.

The rural form of the Dujiangyan Irrigation District is that one or several households form a small settlement, surrounded by woods and other vegetation, and then outside is the field of each household. This special form of residence represents the rural culture of the West Sichuan Plain, with the most typical ones in the northwestern area of Pidu District (Sun, 2011).

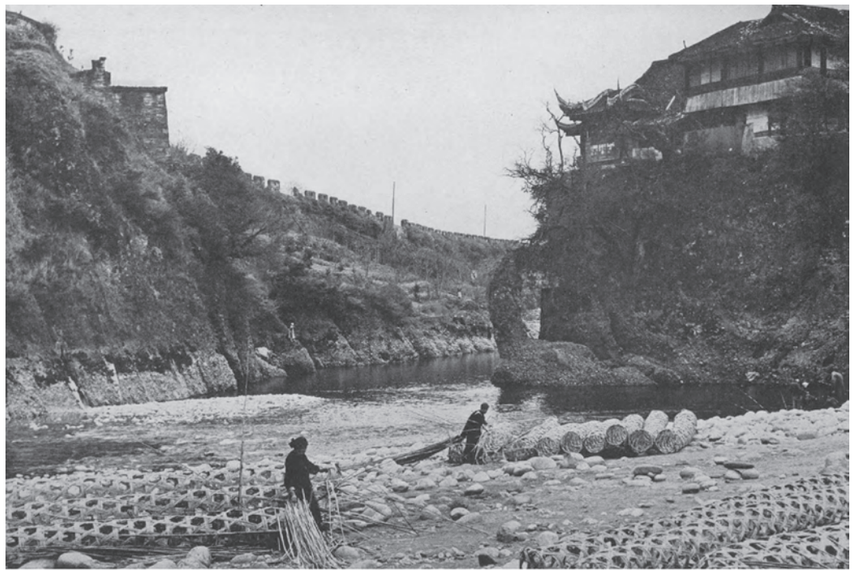


Fig 5.1.5 Villagers working at Fly Sand Weir
Source: Jones (1954)



Fig 5.1.6 Slogan at Dujiang Weir
Source: Cheney Tseng (2009)

(2) Where irrigation is required, people must work together as a group, so living together is quite convenient (Fei et al., 1992).

The Dujiangyan was built in the Qin Dynasty (221 to 206 BC), and the irrigation network was formed in the Han Dynasty (202 BC – 220 AD). This is the foundation of Dujiangyan irrigation culture.

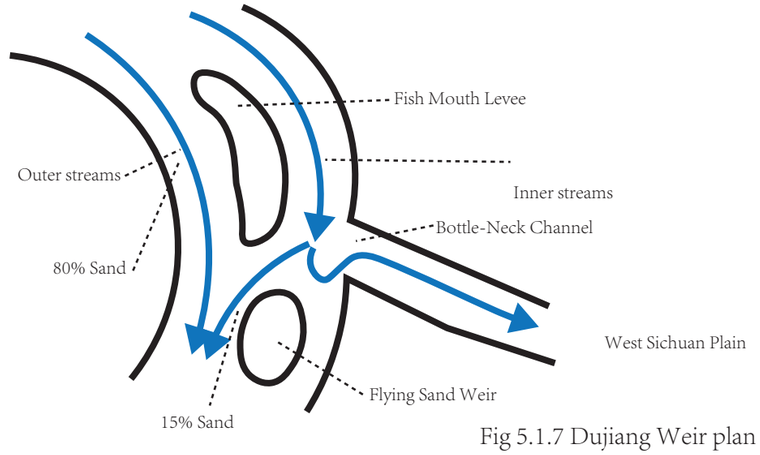


Fig 5.1.7 Dujiang Weir plan

This ensures against flooding by allowing the natural swirling flow of the water to drain out excess water from the inner to the outer stream. The swirl also drains out silt and sediment that failed to go into the outer stream (Wikipedia, n.d.).

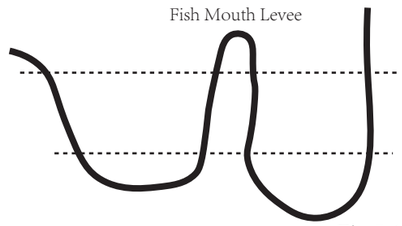


Fig 5.1.8 Dujiang Weir section

The inner stream carries approximately 60% of the river's flow into the irrigation system during the dry season. While during the flood season, this amount decreases to 40% to protect the people from flooding (Wikipedia, n.d.).

Different from modern water conservancy facilities, the Dujiangyan water conservancy system embodies the social norms of making equal water rights in the river basin. If all water diversion projects in a river basin adopt the 4/6 division principle, the final total water consumption may be restricted to between 40% and 50% of the total runoff in the basin. This figure is exactly the same as the current widely accepted international river water carrying capacity (Wentao, Y., Weining, X., & Lin, Y., 2017).

The formation of the irrigation system

The Dujiangyan Water Conservancy Project divides the Min River into the outer river and the inner river. The inner river is continuously bifurcated step by step through the water-distributing fish mouths, forming an artesian irrigation network consisting of five-level channels of the main canal, branch canal, bucket canal, agricultural canal and mao canal from Song Dynasty to Qing Dynasties (960-1820 AD) (Wentao, Y., Weining, X., & Lin, Y., 2017). After the transformation of the canal system in the 1970s, the main canal, branch canal, and bucket canal were perennial water delivery channels, and the agricultural canal and mao canal were temporary water channels, and water was used for irrigation. The Dujiangyan water conservancy construction project is very large and requires a lot of funds and manpower to build and maintain it. The farmers cooperate with each other under the regional government, jointly undertake the construction and maintenance of the head canals and irrigation canals, pay water conservancy fees, and share the right to irrigation. Therefore, under a unified water conservancy system, farmers in irrigation areas do not have to live in groups for irrigation problems.

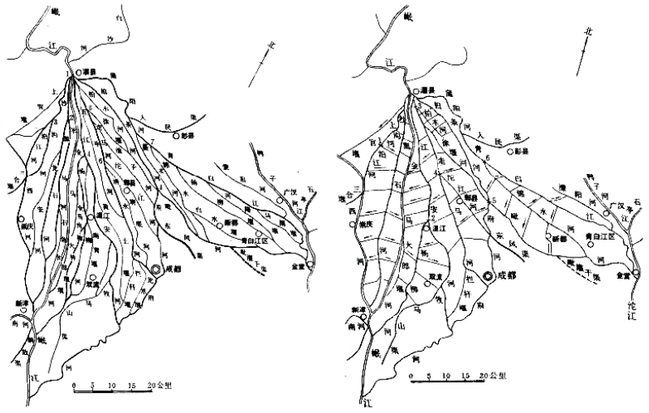


Fig 5.1.9 Canal system in Dujiangyan irrigation area
Source: Adapted from Yang (2015)

This capillary irrigation system, together with Dujiangyan with functions of shipping, irrigation, and flood control, creates an overall regional water conservancy system with resilience and regulation functions and provides a foundation for the development of human settlements in the entire Dujiangyan area.



Mao canal, photo by Chamberlin Thomas Chrowder (1909)



Agriculture canal, Photo by Robert Ferris Fitch (1917)



Branch canal, photo by Sidney David Gamble (1917)



Agriculture canal, Photo by Robert Ferris Fitch (1917)

Fig 5.1.10 Canals in Dujiangyan irrigation area
Source: Daily Dujiangyan (2018)

Local empowerment in the management of the irrigation system

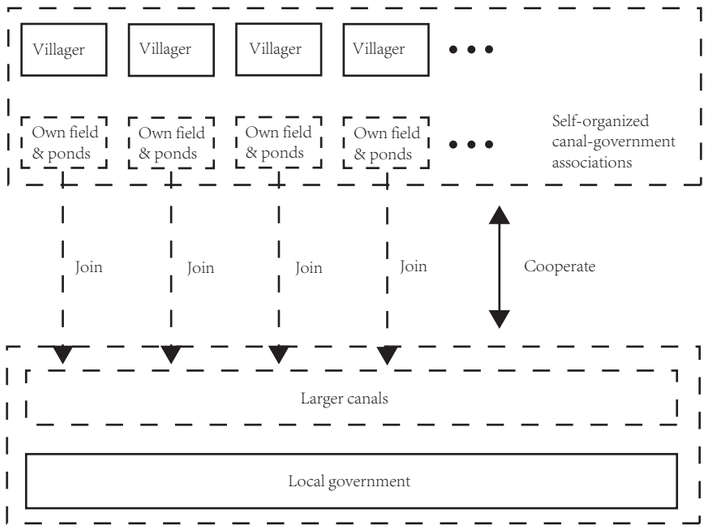


Fig 5.1.11Canal management system

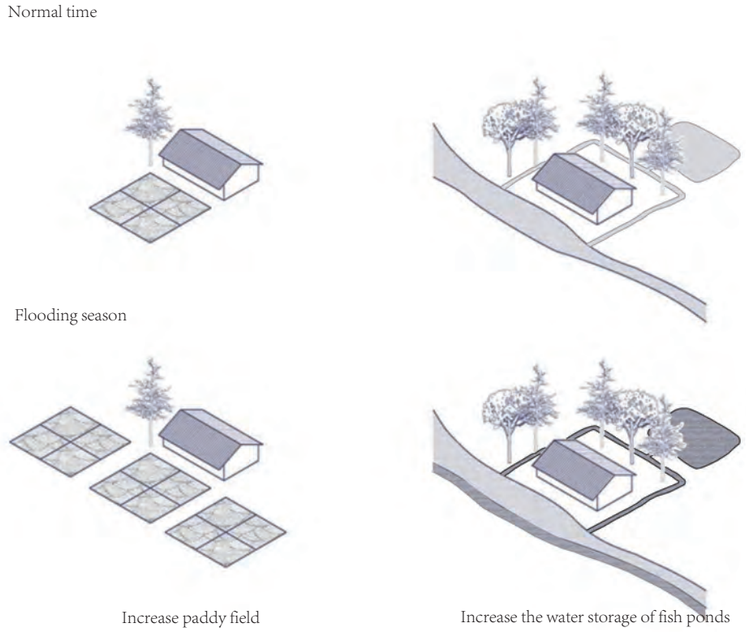


Fig 5.1.12 Participatory flood management

The water volume in the Dujiangyan Irrigation District changes frequently in different seasons. The management of small tributaries at the end of the irrigation system requires the independent participation of water farmers to achieve flexible adjustments. Therefore, an autonomous rural social organization has formed a way to manage the terminal water system. 'Civil canal' managers generally have an electoral system and a rotation system. In order to coordinate the water disputes between the 'Offical canal' and 'Civil canal', the upstream and downstream, and the inner and outer rivers, a 'Weir committee' was also established. The discussion mechanism of the 'Weir committee' is created to coordinate water use between the government and the people and between different regions (Wentao, Y., Weining, X., & Lin, Y., 2017).

(3) Living together as a group also greatly contributes to everyone's security (Fei et al., 1992).

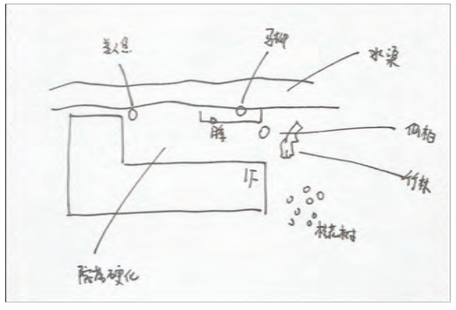


The current industry, washing leeks



Leek planting base

Fig 5.1.13 Important water for leeks
Source: Photo by author



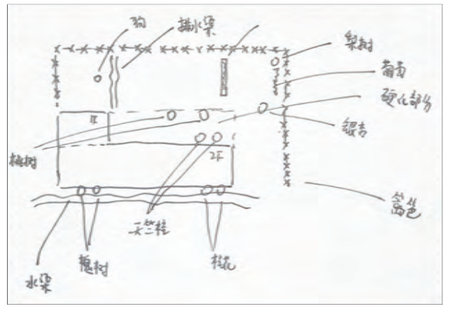


Fig 5.1.14: Biodiversity of the human settlements
Source: Manuscript by author

The Chengdu Plain has a complex ecological structure and strong ecological diversity, so it has a strong natural buffer against natural disasters (He, 2012). The plains are fertile, so farmers' lives are easier to recover (Huang, 1985). Therefore, there are no calamities that need to be collectively dealt with here. For farmers in the Western Sichuan Plain, security refers to the need to enrich sources of nutrition, production of other daily necessities and participate in small business transactions.

The need for self-sufficiency

Traffic is blocked in the Sichuan Basin, and the upper Yangtze River is an easy out but difficult in. Therefore, self-sufficiency in this basin production is very important. Regional self-sufficiency requirements are reflected in the production of each household. The form of decentralized living also puts forward higher demand for the self-sufficiency of each household, so certain sideline jobs must be carried out around the place of residence. Therefore, it is very important to live by the water. For example, bamboo weaving, handicraft manufacturing of daily necessities, aquaculture and small-scale fruit and vegetable planting, the water system near the residence will provide water, which is suitable for the growth of bamboo trees.

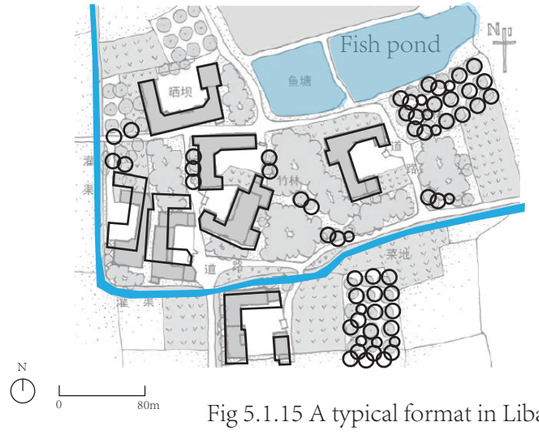


Fig 5.1.15 A typical format in Libai village
Source: Adapted from Fang (2012)

Another important productive activity is aquaculture. Farmers grow lotus to raise fish or keep waterfowl, etc. The ponds connected to the irrigation canals have good water quality due to the flow of water. The cultivated land is limited, so aquatic products need intensive cultivation and better to be dug near the residential area.

The need for transportation

Another reason for living on the water is that the road system is underdeveloped due to the dense water network in the West Sichuan Plain. Waterways are very important as a transportation system linked to small-scale commercial transactions. In addition, the high groundwater level and high land reclamation rate in the West Sichuan Plain, slender and soft field ridges are not conducive to long-distance transportation by means of land transportation, causing people to live scattered in the fields with water as much as possible. Before the construction of the modern highway system, the water system was the main transportation in the area. In fact, at the beginning of the construction of Dujiang Weir, an important purpose of the First Emperor (Qin Shi Huang, 18 February 259 BC – 10 September 210 BC) was to transport soldiers to Chengdu through this water conservancy and water system to facilitate the attack on Shu (Tan, 2015).

5.2 Rural drinking water history

Before the 1940s, villagers in Dujiangyan Irrigation District had their main water source from the canal system. Later, the surface water was seriously polluted, and almost every family used underground water sources by drilling wells.

Until the 1970s, many farmers in the 'Upper Five Counties' in the Dujiangyan Irrigation District were still drinking river water, but later changed to drinking groundwater or tap water due to water pollution.

In 2018, the 'Village Connection Project' was implemented, and achieved the goal of realizing water supply in the whole area, extending the water pipe network to the boundaries of each administrative village (community). Gradually abolish the decentralized small water sources and incorporate the village water into the centralized water supply system.

The 'Household Connection Project' adopts the principle of voluntary contributions of farmers and government subsidies, and refers to the village-level democratic self-government method of the construction of village-level public service projects to connect the water pipe network to households.

Far away from large urban water plants, a township-level centralized water supply is gradually being established. At present, the city has delineated 141 centralized drinking water resource protection areas, including 22 centralized drinking water sources above the county seat and 119 centralized drinking water in towns.

Gap

The village connection project is completed by the government-funded from top to bottom, and the tap water into the household is decided by each villager voluntarily and need payment. Therefore, concentrated living will help reduce the construction cost of water supply infrastructure.

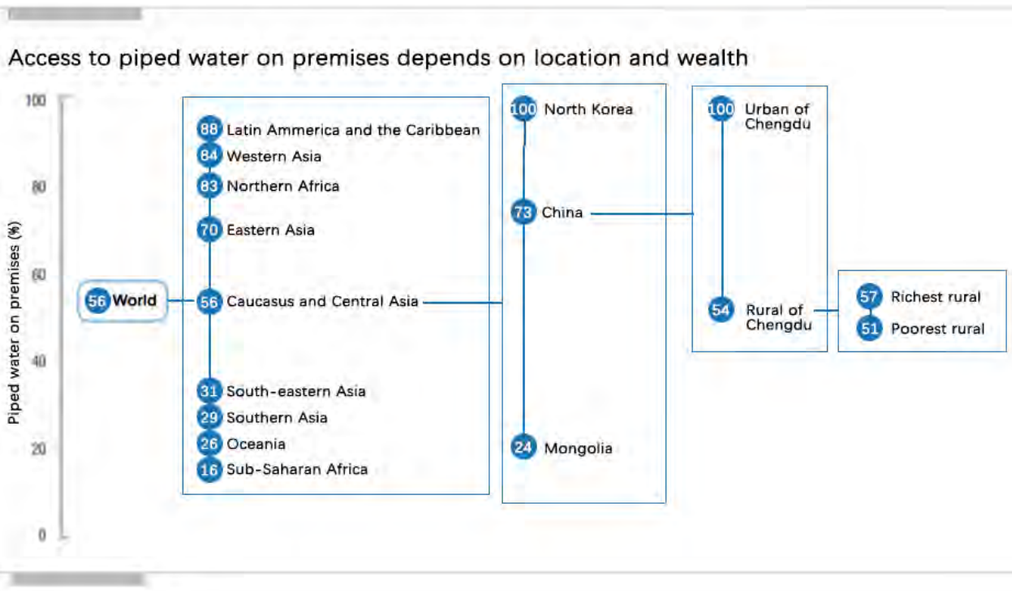


Fig 5.2.1 Piped water on premises in Chengdu
Source: Institute for health metrics and evaluation (2021) & WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme, & World Health Organization. (2015)

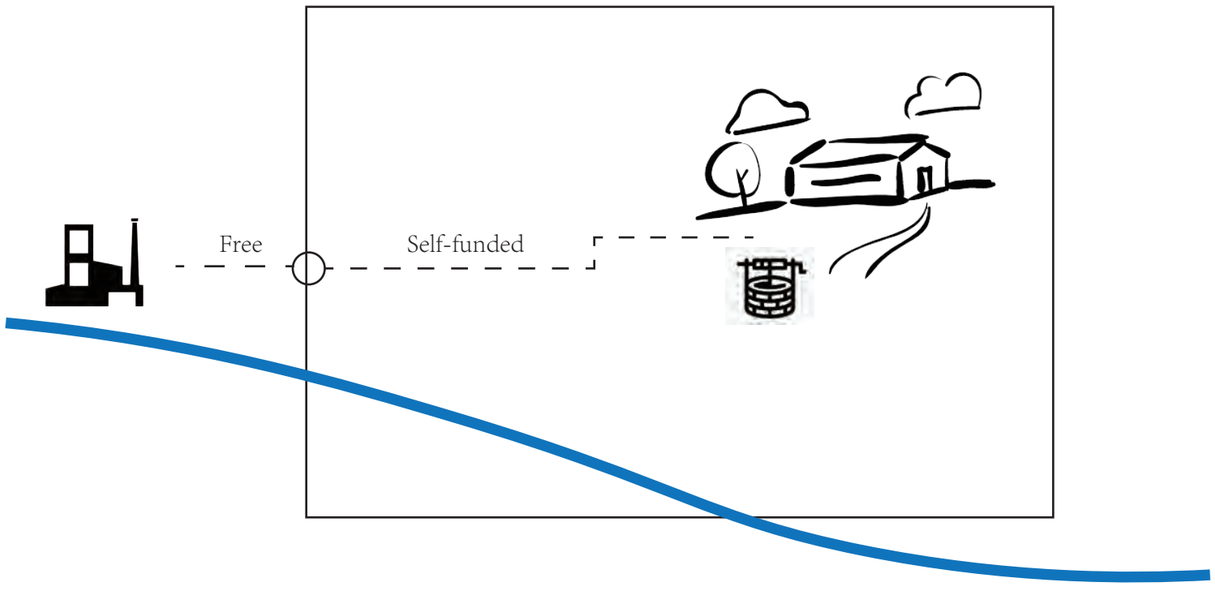


Fig 5.2.2 Rural drinking water history

6 STRATEGIES

- Rebalancing regional water supply
  - Separate water supply for different sectors
  - Alternate water resource
- Ecological compensation
  - Regenerating the production
  - Rising ecological security
  - Strengthening water-cultural infrastructure
- From goals to design principles



Fig 6 A village settlement in west Sichuan
Source: Sichuan Business News (2018)

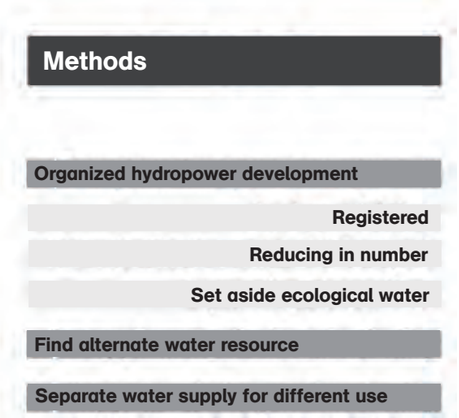
STRATEGIES

STRATEGY 1:
Rebalancing regional water supply

The first strategy is to balance the water supply in the regional budget, which is reducing the water stress of the Pidu District. The main method is to make upstream hydropower management organized, find alternate domestic water resource for urban area and separate water supply for different sectors.

By increasing upstream water conservation, decentralizing water intake locations, and adopting water-saving measures in industrial and agricultural fields, the goal is to control the proportion of water intake in Pidu District at 40%, which is a line of water safety (Li & Zheng, 1999; Yan, Xiang & Yuan, 2017).

First of all, there needs a unified effective water governance system, which should put the hydropower, conservation, productive use, ecological and domestic water in, and also negotiate with housing, industry and technology agriculture sectors. This system really gives higher priority to water management and achieves regional coordination through unified management.



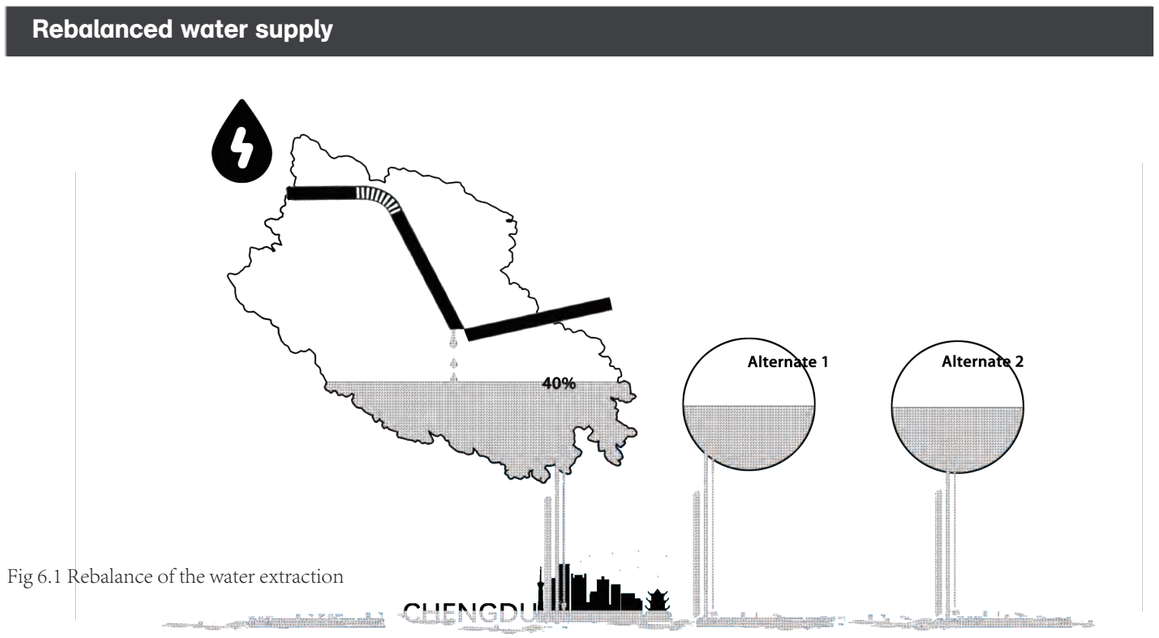


Fig 6.1 Rebalance of the water extraction

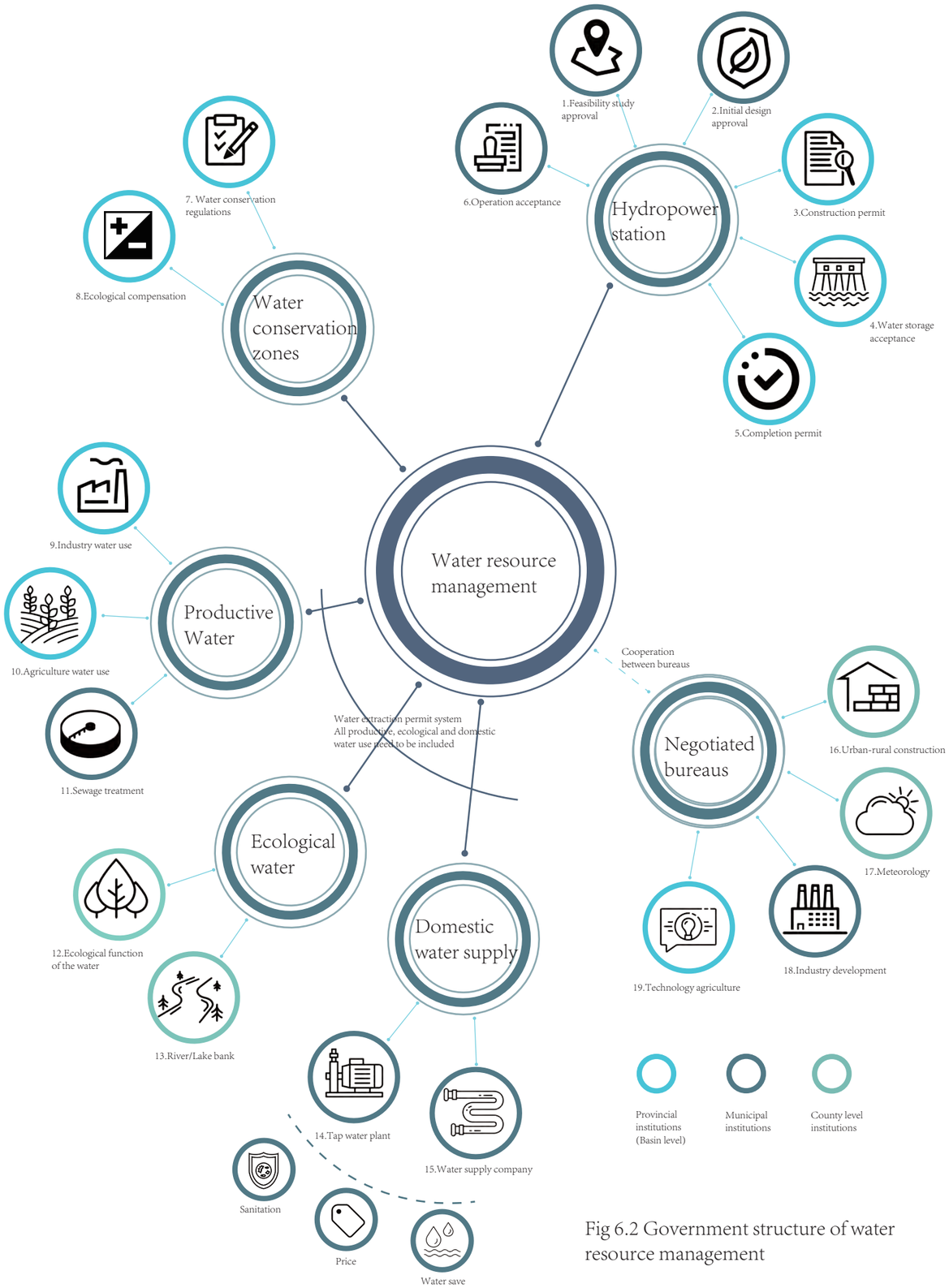


Fig 6.2 Government structure of water resource management

Methods
Separate water supply for different sectors

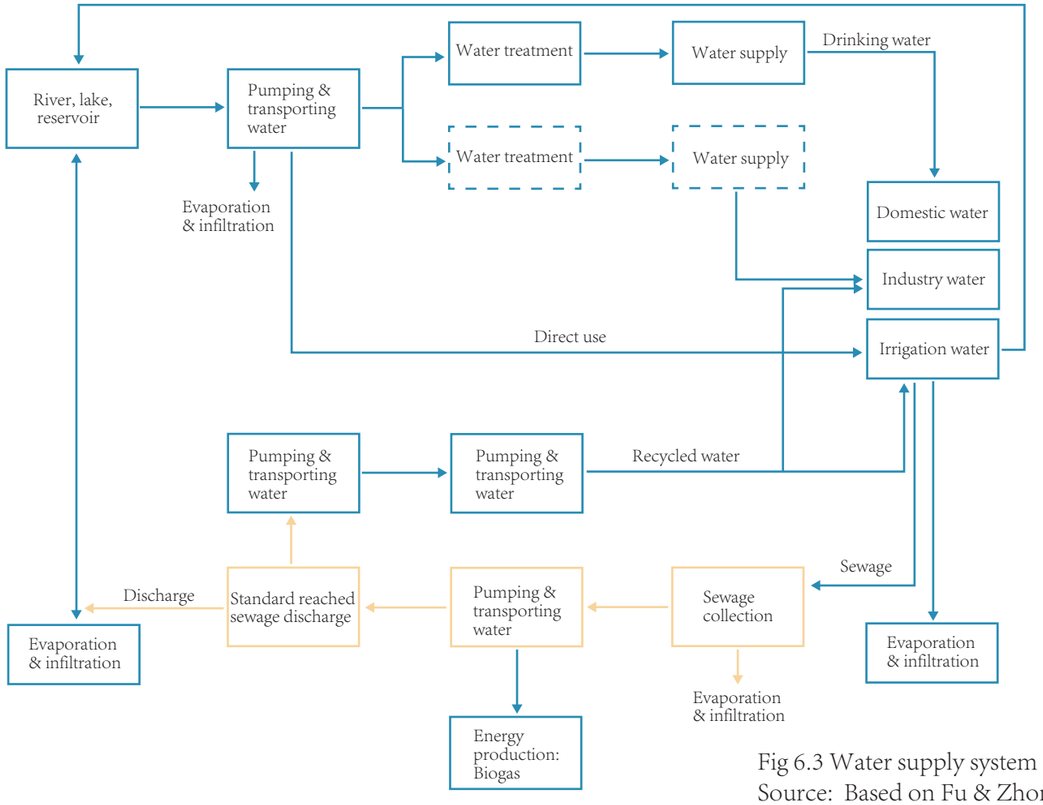


Fig 6.3 Water supply system
Source: Based on Fu & Zhong (2014)

Impact of separate water supply



Industry sector

●●●○○

Industrial sectors that do not require high water quality can simplify water quality treatment. These industries could develop near water sources and extract water themselves.



Agriculture sector

●○○○○

The irrigation water can directly use natural water and should be recycled to save water resources. The recycled water from the domestic sector could be used in irrigation.



Domestic sector

●●●○○

The drinking water sector could raise the treatment standard to reach direct drinking.
Water supply for different qualities can improve water efficiency and save water treatment costs.



Sewage sector

●●○○○

The separate water supply could directly lead to classified sewage, which will greatly save the cost in the sewage treatment process.

Methods
Alternate water resource (Lijiayan Reservoir)

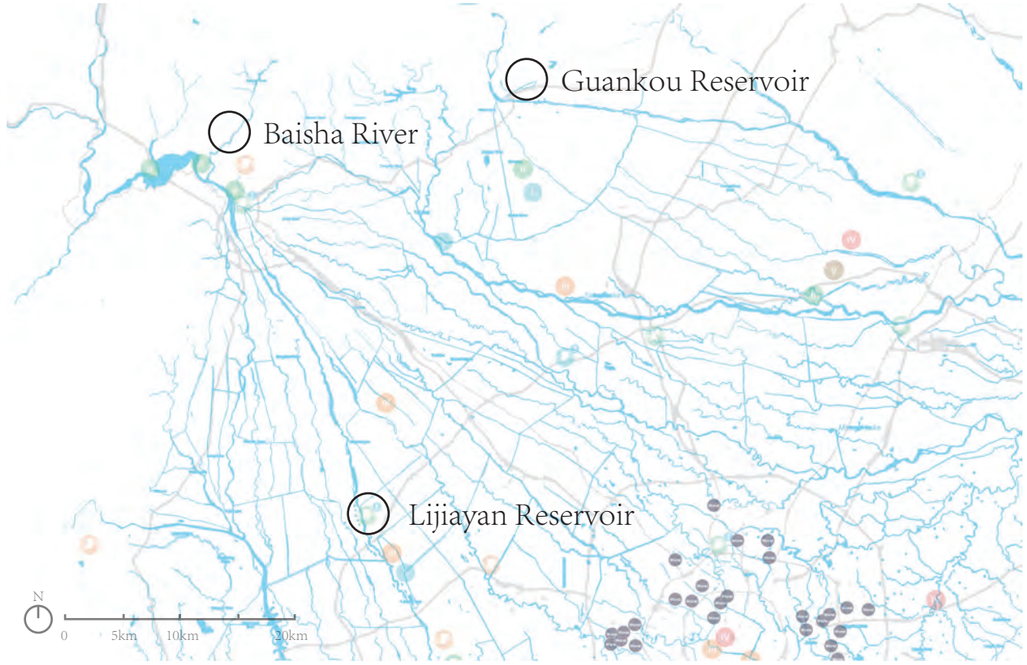


Fig 6.4 Alternate water source
Source: China News Network (2016)

Reducing water stress	
Domestic water extraction from the Pidu District	1,400,000 Cubic Metre * 365 = 511,000,000 Cubic Metre
Lijiayan Reservoir could provide	278,000,000 Cubic Metre / Year
Total water extraction	511,000,000 / 58.6% = 872,010,000 Cubic Metre / Year
Water stress released	511,000,000 - 278,000,000 = 233,000,000 Cubic Metre / Year
Water stress released (in percentage)	233,000,000 / 872,010,000 = 26.7 %
Water extraction level	26.7% + 14.8% = 41.5%

Chengdu's current water plant has an average daily water supply capacity of only 1.78 million tons, and the actual water consumption is close to 1.6 million tons. According to China News Network (2016) estimates, the Xuyan River system of the Baitiao River in Chengdu has basically reached the upper limit of its water supply capacity.

The alternate water sources being built is the Lijiayan reservoir which could provide 27.8 million cubic metres of water (Sohu, 2020). It reduces the water drawn from the water source of Pidu District and eases the water pressure of Pidu District. The water use in the district decreased by more than 30%, but it still exceeds 40%, which require no more water use increase in the local productive activities.

STRATEGIES

STRATEGY 2:
Ecological compensation

Ecological compensation is a method to adjust the regional economic environment. As a public product or public service, ecological resources have significant trans-regional characteristics and distinct regional attributes. Compensating the local ecological, social and economic impacts of natural resource acquisition is an effective way to achieve eco-justice.

For the water conservation zone, water intake activities affect the local production water, domestic water, ecological status, social culture, and development opportunities. Therefore, eco-compensation should also be diversified compensation for different losses.

For the aspects that can be quantified, monetary compensation is provided with a widely accepted standard.

For those that are difficult to quantify, other forms of compensation are provided for specific local development proposals.

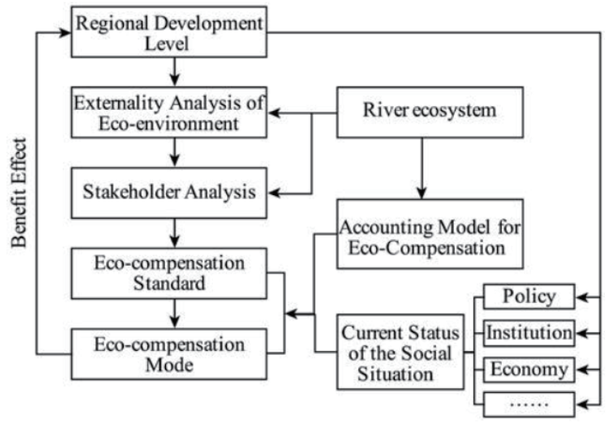


Fig 6.5 The basic framework of ecological compensation
Source: Han, Song & Deng (2017)

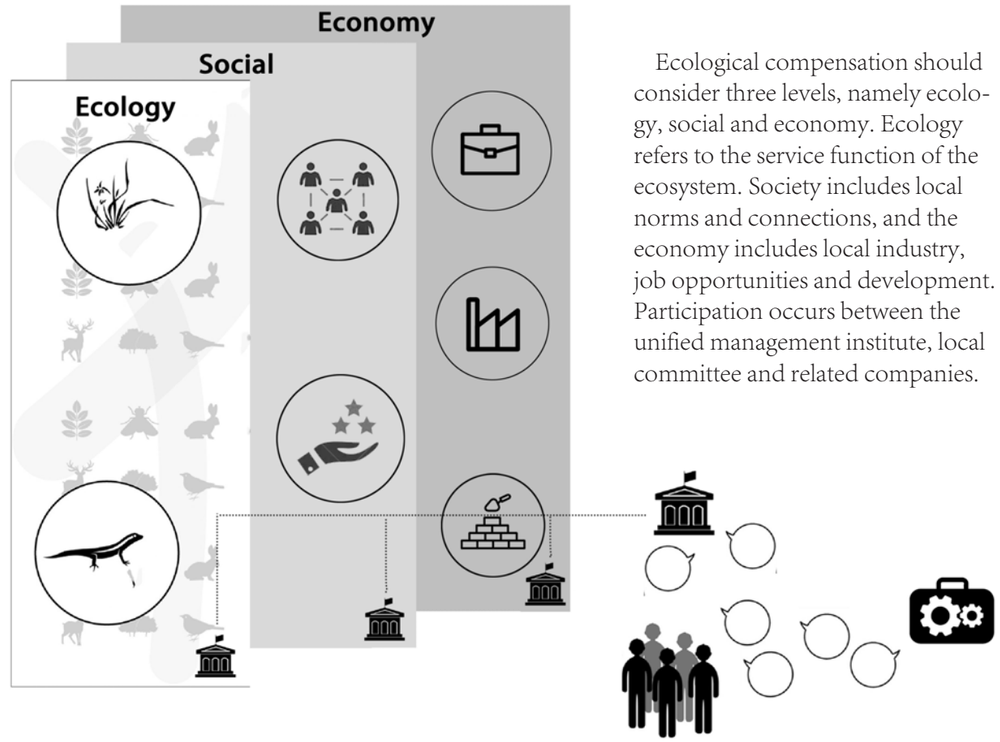
Current situation



Fig 6.6 Current status of compensation methods

According to an interview by Science and Technology Daily (2012), Chengdu compensates Pidu District by CN¥ 60 million every year. This is the result of discussion and negotiation, not calculation. Currently, Sichuan Province does not have a unified accounting standard for ecological compensation. Yuan Qingdan, deputy director of the Environmental and Economic Policy Research Centre of the Ministry of Environmental Protection, said, "If the compensation is based on the actual situation, the number is too large to make up."

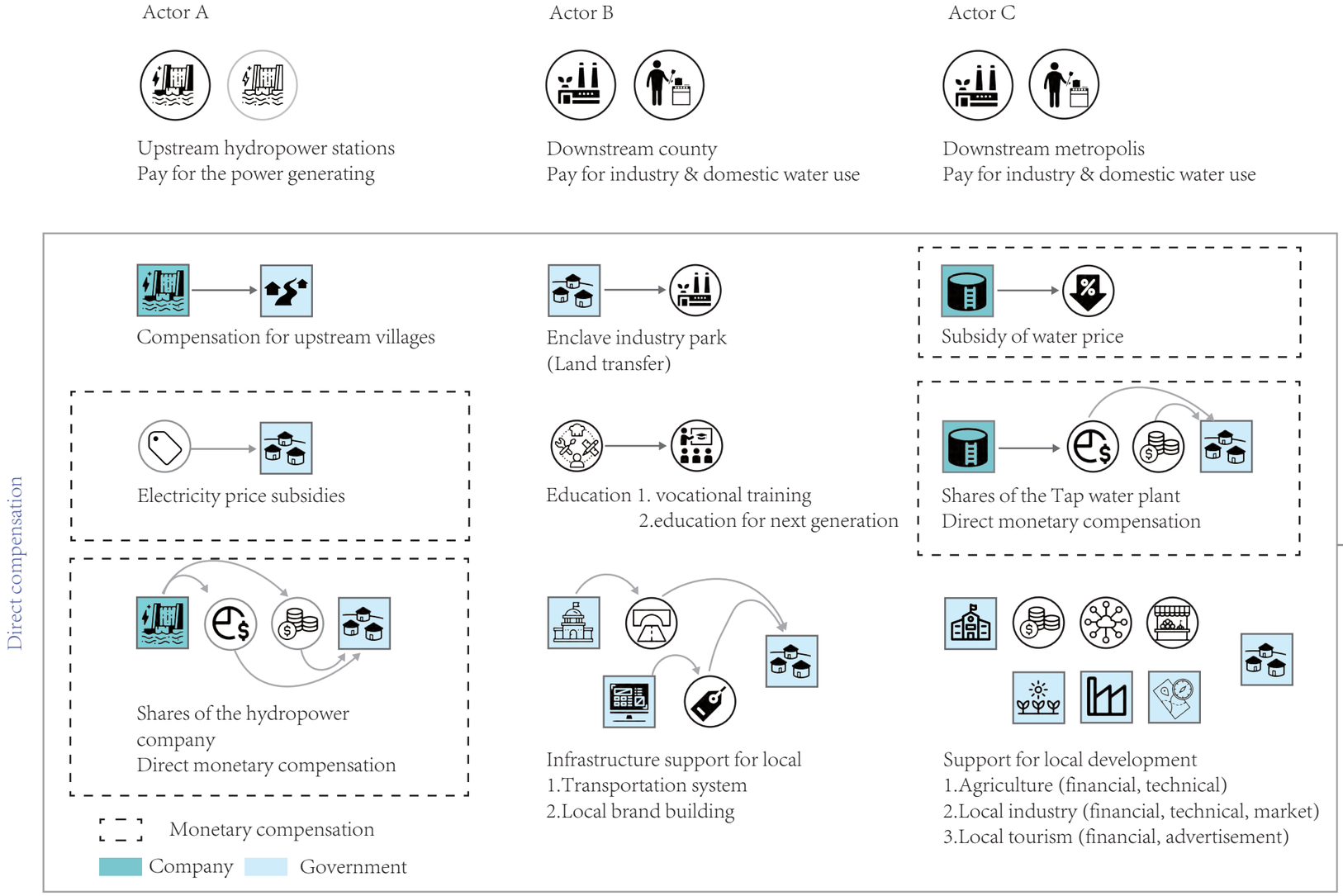
It is necessary to put forward an accounting proposal for the ecological compensation of the Dujiangyan Irrigation District, which comprehensively considers all aspects of ecology, culture, agriculture, and industry and emphasizes dialogue and public participation in the process.



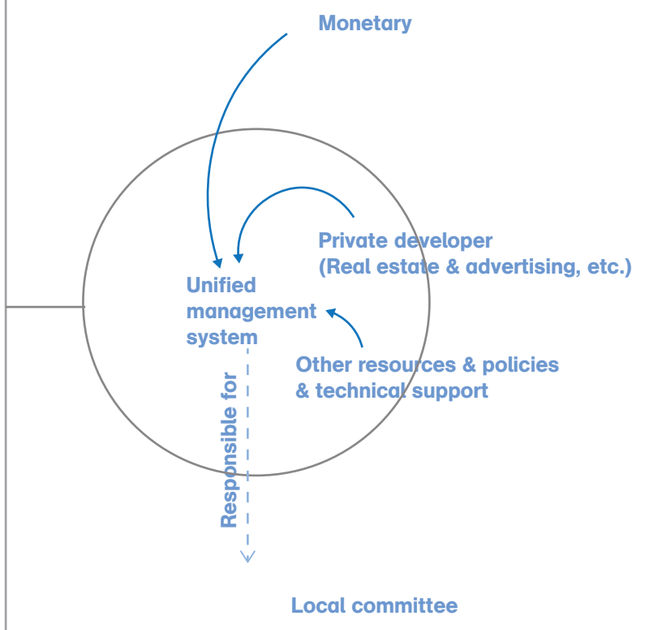
Ecological compensation should consider three levels, namely ecology, social and economy. Ecology refers to the service function of the ecosystem. Society includes local norms and connections, and the economy includes local industry, job opportunities and development. Participation occurs between the unified management institute, local committee and related companies.

Fig 6.7 Layers of ecological compensation
Source: Adapted from Vaissiere & Meinard (2021)

Eco-compensation
What does the beneficiary can provide



Since the ecological compensation requires diversified compensation methods, in the water power structure of the tap water plant, different actors can provide different compensation. The downstream county can assist in the enclave industrial park, educational resources, infrastructure and brand building because of the advantage of being geographically adjacent. Water plants can provide water price subsidies, especially for local vulnerable groups. Metropolis can help local industries and tourism development with its market advantages, and it can also improve agriculture and local factories through technical support.



Through a unified water governance system, in addition to monetary compensation, some private companies can be introduced, such as real estate, advertising planning, and agricultural technology companies.

Besides, there are some indirect methods, for example, the industries in county and metropolis try to realize the water cycle, looking for independent water resource, which is in line with the water balance strategy as well.

Fig 6.8 Available compensation methods

From goals to design principles

Requirement of the regional water supply & Goals of the compensation in the local community

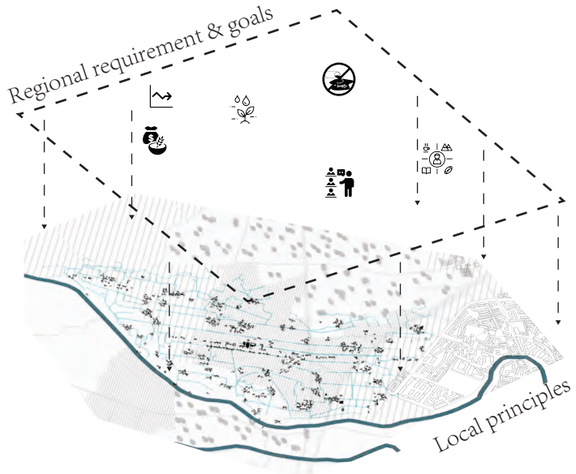


Fig 6.9 From regional goals to local design principles

Regional water rebalancing imposes requirements on local interventions. Ecological compensation provides a guiding framework for local development because ecological compensation is flexible, and how to compensate is actually based on the needs of the indigenous people.

To pursue justice, in addition to strategies at the regional level, methods at the local level are also needed. Cross-scale interaction will be a more effective approach. From the regional requirement and goals, the principles of the local level would be 1.Regenerating the production, which is water-proof agriculture and industry: 2.Rising ecological security, which is for increasing water safety: and 3. Strengthening the water culture, aiming for the social layer of the village community. And they are all connecting to each other with the spatial changes.

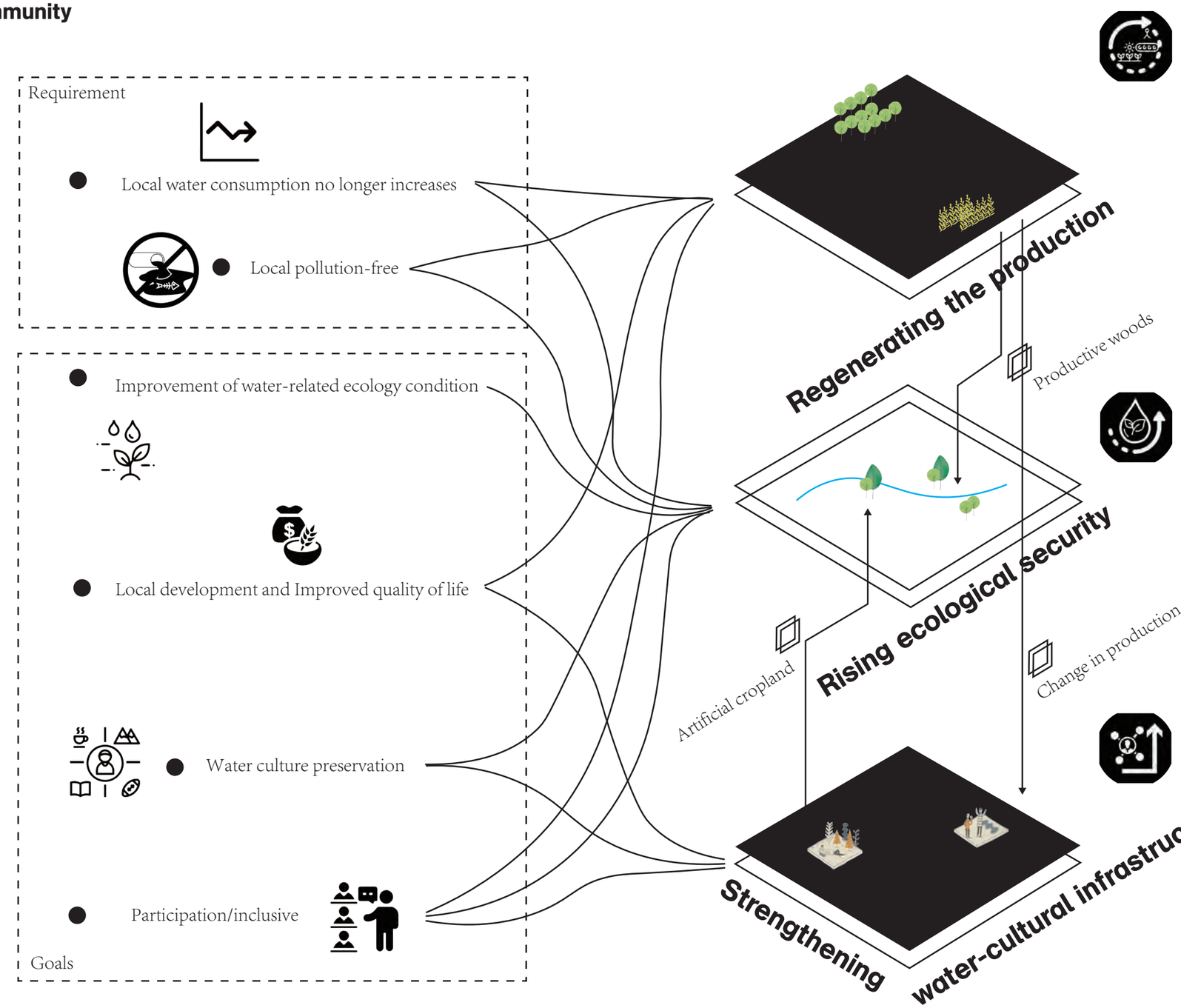


Fig 6.10 From goals to design principles

1. Regenerating the production

The first design approach is to regenerate the production of the village. As a village in a water source protection area, an important prerequisite is to realize pollution-free and to achieve water circularity as far as possible in the village and the household/plot level.

The second step is to realize the development of local industries, mainly in two aspects: agricultural production and local food processing industry. In the planting industry, in addition to scaled cropland, it is also great to develop high-value cash crops based on water quality advantages, such as organic vegetables and flowers. In addition, being a part of the food processing industry's supply chain can reduce risks and increase revenue. Local development of the initial processing of products can also increase the added value of agricultural products.

1.Zero eutrophication

2.Water circularity

3.Scaled agriculture

4.Intelligent agriculture

5.Industry convergence

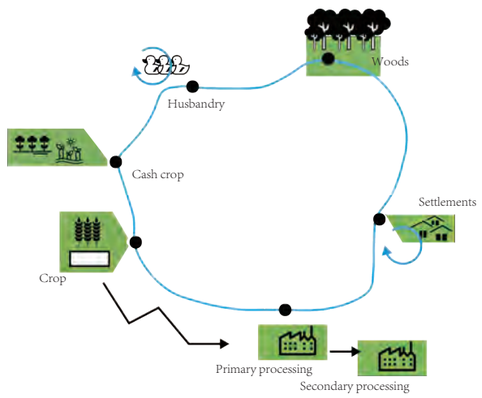
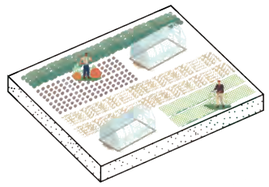


Fig 6.11 The production chain of the village



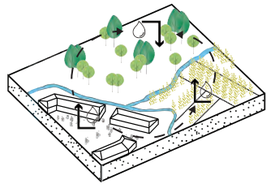
Fig 6.12 Production of the village

1a Organic farms



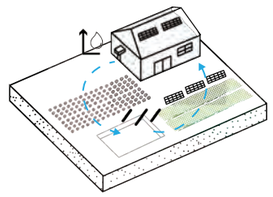
Zero eutrophication
Actors: Township, contractor, villagers

2a Water circularity in village



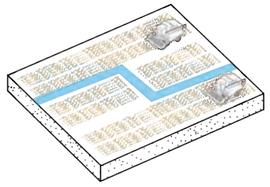
Water catchment equals consumption in the village scale
Actors: Metropolis, contractor, villagers

2b Water circularity per household



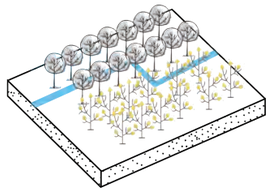
Strive to realize water circularity in plot-level after construction
Actors: Township, villagers

3a Scaled cropland



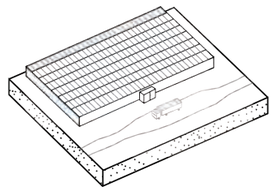
Scaled cropland, production groups act together to raise efficiency
Actors: Contractor, production groups

3b Scaled economic crop



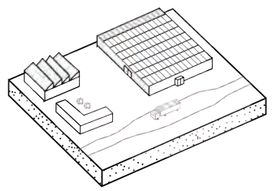
Production groups act together to improve efficiency
Actors: Township, contractor, villagers

4a Economic crop greenhouse



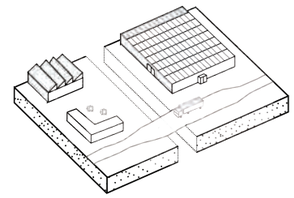
High-end vegetable/economic crop cultivation
Actors: Metropolis, township, contractor, villagers

4b Local primary food processing



Local food processing industry
Actors: Township, private developer, villagers

4c Suppliers of raw materials



Act as the primary supplier of crop
Actors: Metropolis, township, private developer, contractor, villagers, production groups

Fig 6.13 Regenerating the production strategies

2. Rising ecological security

To rise ecological security, the first step needs to do is to deal with the sewage system. The local and remote sewage treatment would be implemented together.

Then the naturalize of the canals, wetlands and flexible terminal adjustment would greatly increase the ecological conditions of the village. Besides, it is helpful to solve the flooding issue downstream by mitigating the river flow during the flood period.

The natural forest and biodiversity in the cropland are vital to the ecological resilience of the local community. It would help maintain the rainfall and provide a buffer against the extreme climate.

1.Zero domestic pollution

2.Naturalize canals

3.Thriving wetland

4.Diverse (non)-productive green

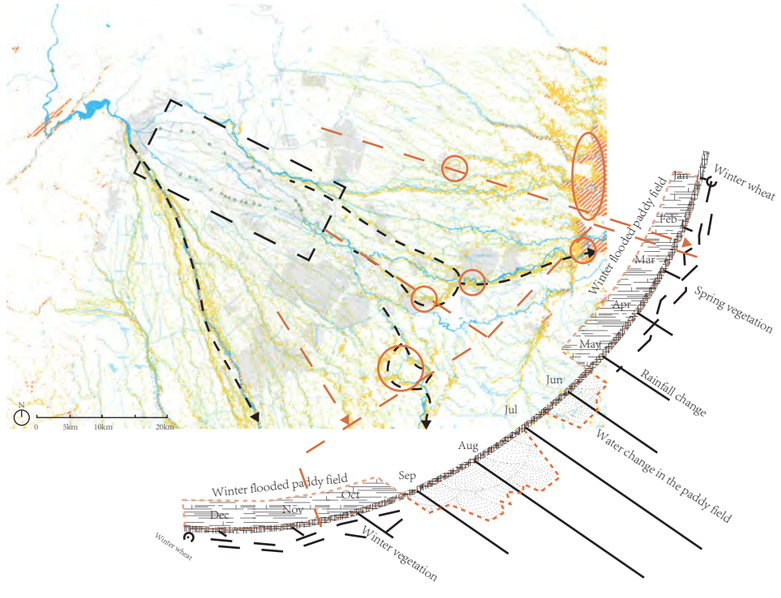


Fig 6.14 Flood inundation map of Chengdu Plain
Source: Adapted from GISwater (2018)

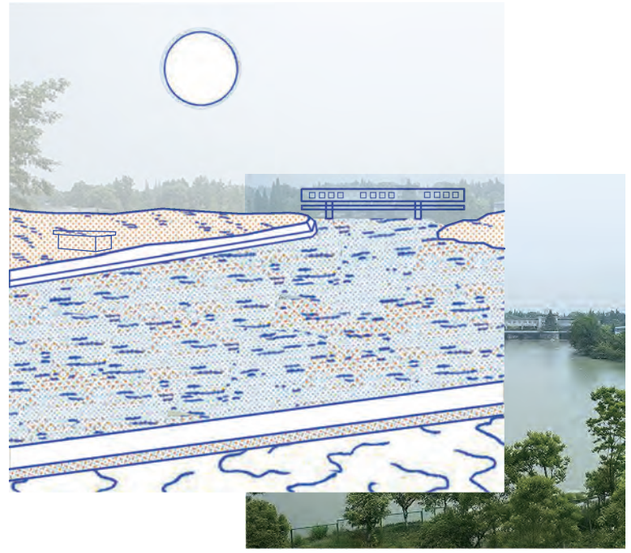


Fig 6.15 Half-paved river bank
Source: Based on Sina (2020)

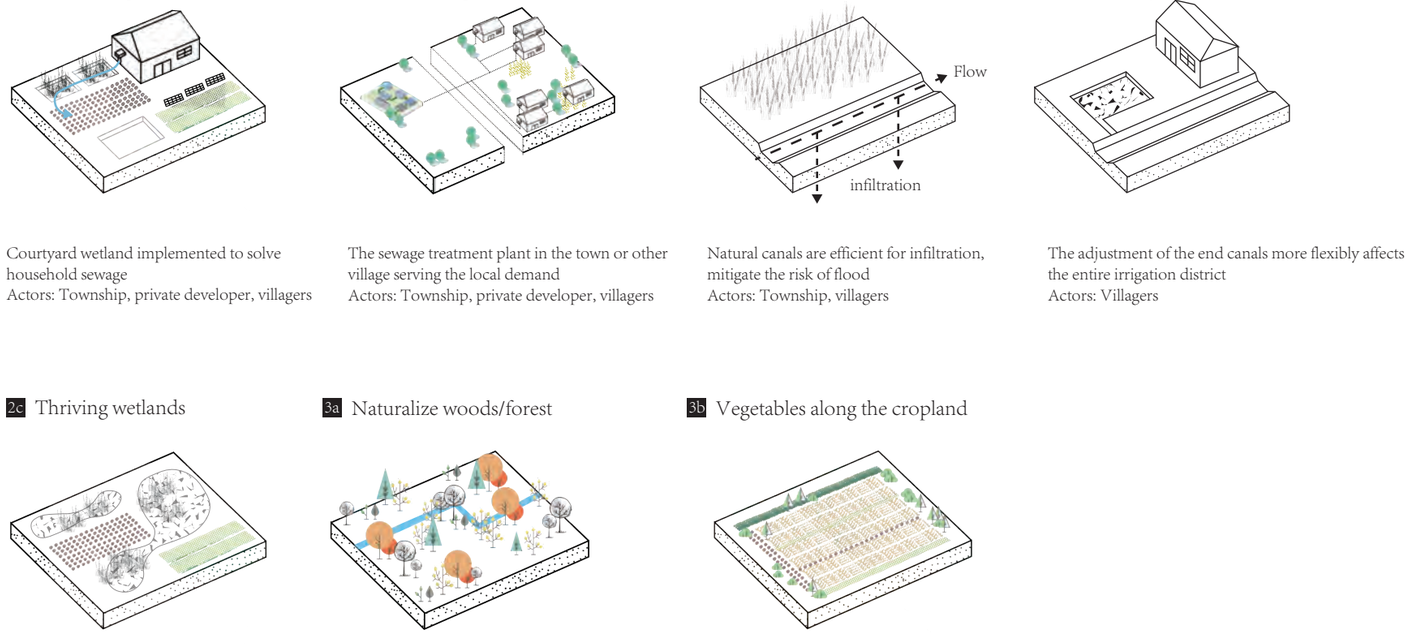


Fig 6.16 Rising ecological security strategies

3. Strengthening water-cultural infrastructure

To strengthen the water-culture infrastructure, the first step is to build a domestic water supply to make the villagers gain health and affordable water.

Besides, to preserve the water culture of the village, the way they live with water at the household level, plot level and village level would be retained. Water surrounding woods, public space and hydrophilic activities are important for village life.

In the future development, the local new constructions and renovation should also obey the water culture and respect the will of the villagers, which is essential for promoting the local social capital.


1.Equal domestic water supply


2.Culture preservation


3.Tighten social connections


4.Respect the wishes of residents

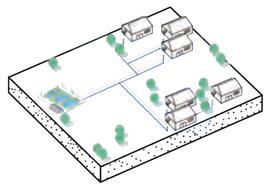


Fig 6.17 Social capital
Source: Dreamstime (n.d.)



Fig 6.18 Public space and village life

1a Domestic water supply



Piped water supply for every household
sanitation and affordable
Actors: Township, Tap water plant, villagers

2a Water surrounding household



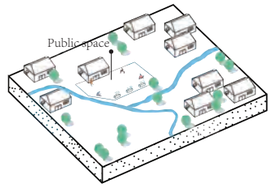
Preservation of the water living way,
planting trees, vegetables, fish pond surrounding
Actors: Villagers

2b Water connection in the plot



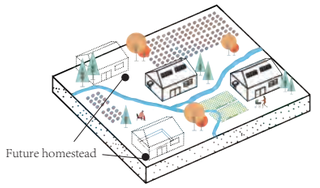
Improve the public space within the plot
Actors: Township, villagers

2c Water connection in the village



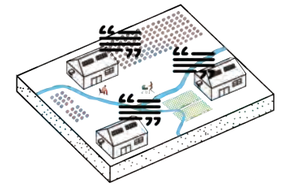
Keep the identity village public space
Actors: Township, contractor, villagers

3a Future construction in tradition



Allowing future construction aligns with the traditional way
Actors: Township, private developer, villagers

3b Respect the willingness



The development model based on the ideas of the villagers
Actors: Metropolis, township, private developer, contractor, villagers, production groups

Fig 6.19 Strengthening water-cultural infrastructure strategies

7 CURRENT STATUS OF TESTING VILLAGE

- A typical example of villages in the water conservation zone
- A village formulated by water
- Water flows between urban and rural
- Social connections and public space

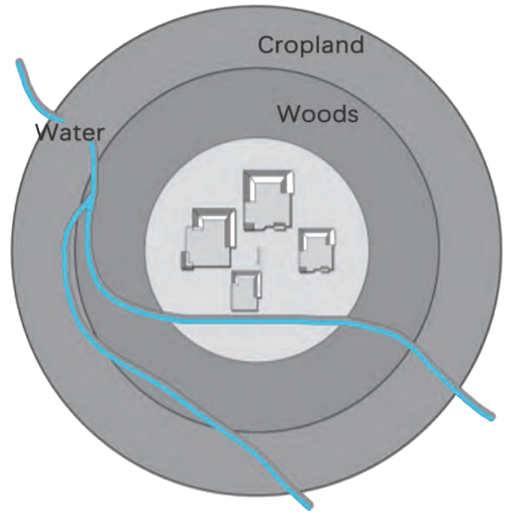


Fig 7 A typical village settlement in west Sichuan
Source: Rainman Wong (2019)

Paotong village in Sandaoyan town

Sandaoyan Town

Sandaoyan town where the Paotong village located in used to be a transit site for cargo transportation on the Baitiao River and a busy water transportation terminal. Although water transportation has almost disappeared, the rich historical resources have made Sandaoyan a town with tourism as the main development direction, mainly rely on the scenery of the water town and the dock culture. It can be seen from Fig 7.2 that the special architectural style, river landscape, rice field, canal, and water well are all important attractive elements.

Fig 7.1 shows that the transportation system in this area mainly crosses the built-up area in the north-south direction, and the bus station is set up on this line, because this is also the direction of traffic linking the county and Chengdu. In addition, the red area is the future development orientation of the township, extending to the southeast.

Testing example - Paotong Village

The Paotong Village is located in Sandaoyan Town in the northern part of Pidu District. It is used to test these local spatial interventions. Paotong Village is at the starting point of the water source protection area, and the tap water plant's water intake point is located on the bank of the river in the village. The entire village is in a water source protection area, of which 1/3 are in a first-level water source protection area.

In addition, because it is very close to the built-up area of Sandaoyan Town, the settlement community of the Paotong Village is built on the edge of the city. Therefore, infrastructure such as water supply and power supply is directly connected to the urban system, and the cost of living becomes very high.

In conclusion, the Paotong Village has more stringent water source protection measures, and the resettlement community also brings complex affordability issues. Therefore, the test scenarios here will provide a good example for other villages to show how to solve these limitations and promote sustainable and fair development with respect for local culture.

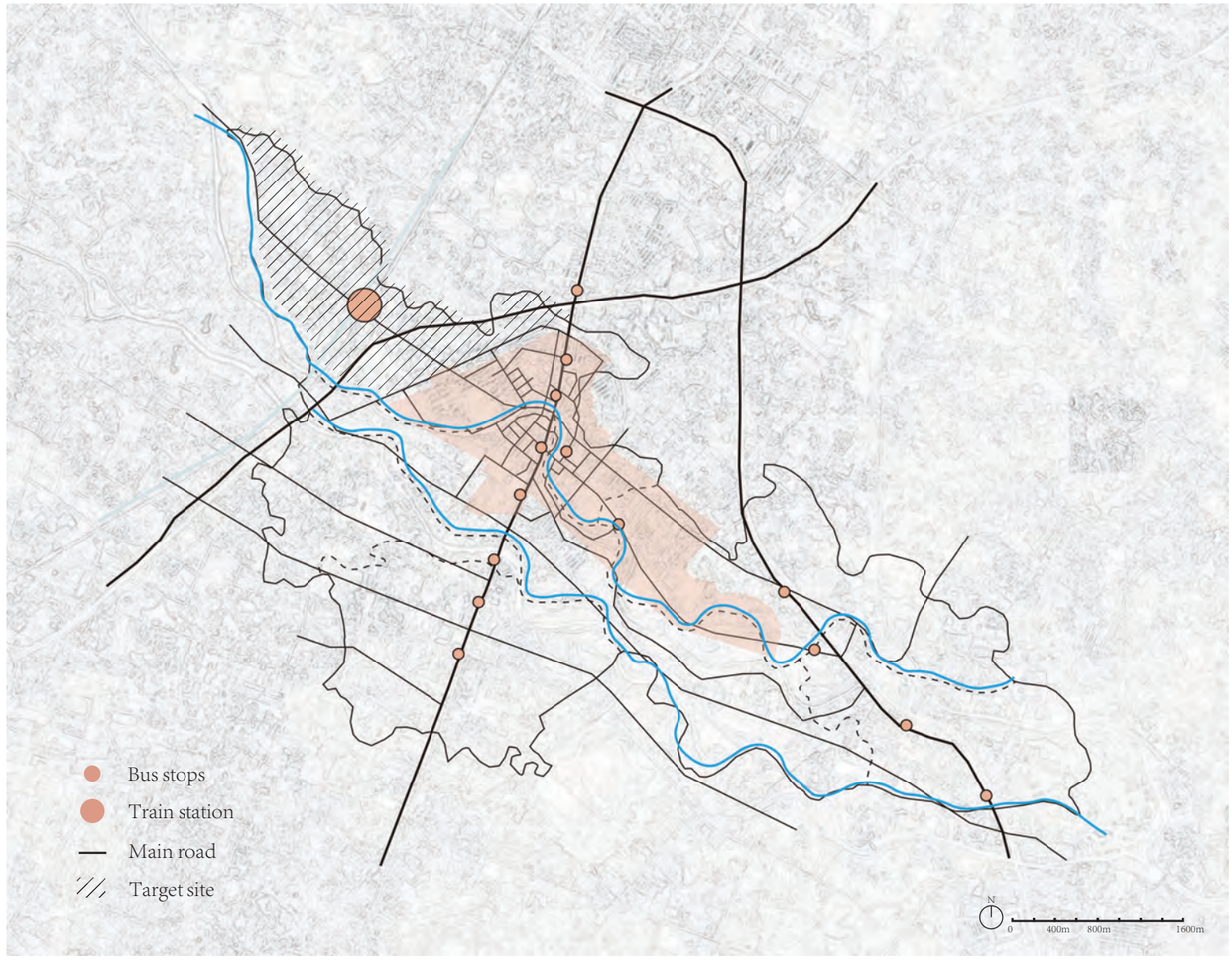


Fig 7.1 The transportation system of Sandaoyan town



Fig 7.2 Impression of the Paotong Village

Typical Chengdu Plain village

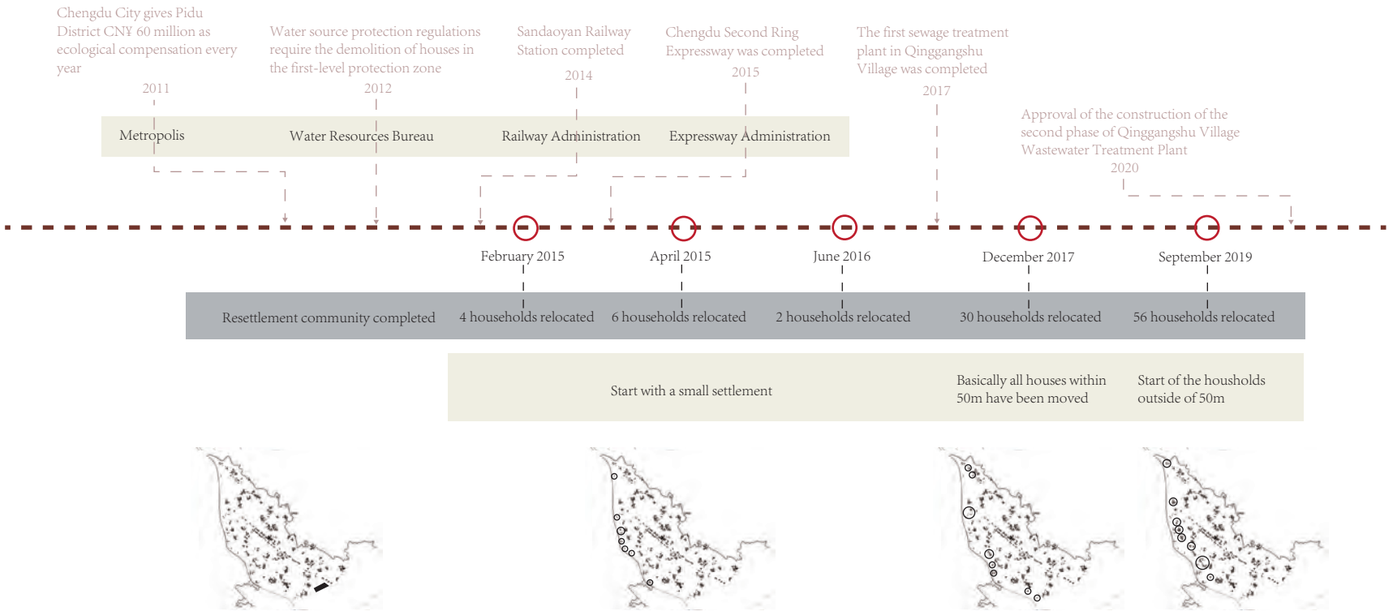


Fig 7.3 Relocation process of Paotong Village

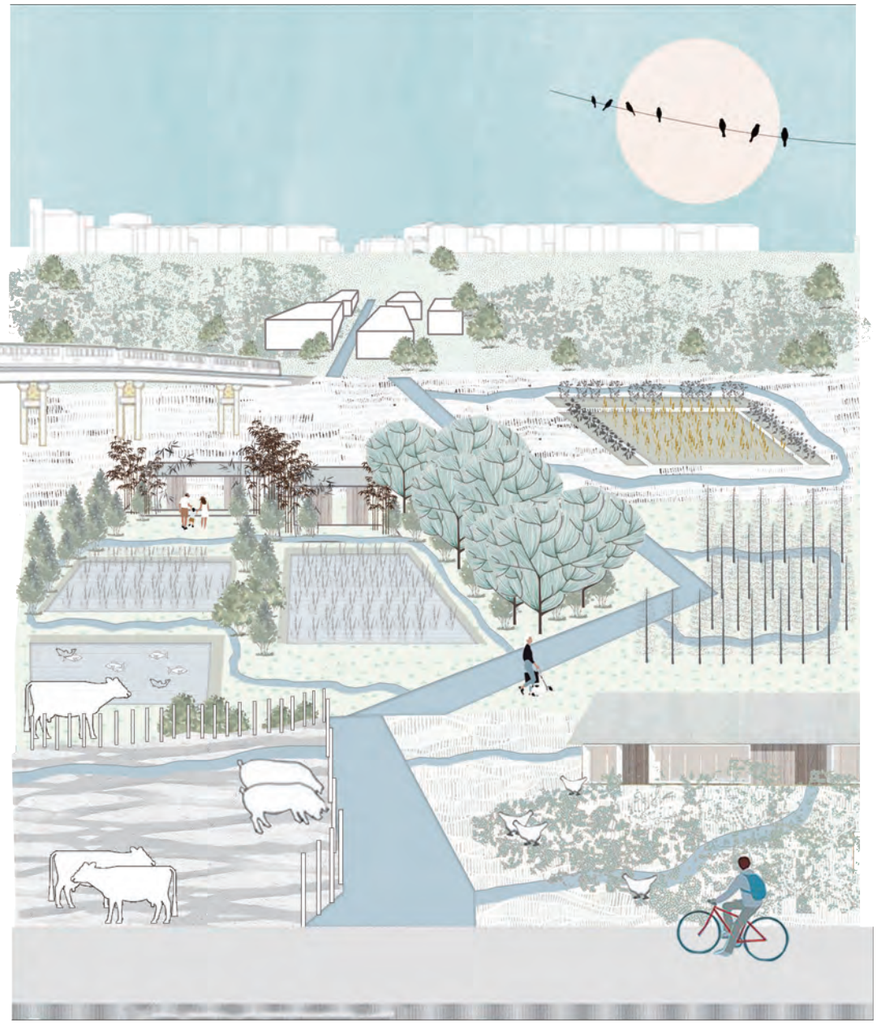


Fig 7.4 The typical countryside in the Chengdu Plain

The Paotong Village is a typical village organization on the Chengdu Plain, and the water system constitutes the base of the village. The village has cattle, sheep, chicken breeding, fish ponds and paddy fields. In addition, there are sapling trees and some natural tree areas, every household is surrounded by lush trees and bamboos.

The Paotong Village is also one of the first villages to start the relocation of water source protection. Since 2015, the villagers in the first-level protection area have been relocated, and in 2017, it has been extended to the second-level protection area. Although the provincial protection regulations only require the relocation of the first-level protected areas, the local government hopes to promote the relocation of the second-level protected areas. However, during this process, some villagers also encountered problems such as living costs, which need to be resolved urgently.

Formulated by water

For a self-sufficient agricultural community, the most important thing is the acquisition of irrigation water and domestic water, and the Paotong Village is no exception. Since the Chengdu Plain is high in the northwest and low in the southeast, although it is adjacent to the Baitiao River, except for a few water intake estuaries, irrigation water there mainly relies on the upstream canal system. The straight irrigation water system that was modified in the 1980s stops taking water directly from the Baitiao River.

This distribution of canal has also given room to the area along the river. Before the implementation of the water source protection area policy, the riverside was also covered by lush vegetation, mainly naturally growing plants. After the water canal was reconstructed, it was intentionally set aside for environmental protection.

The canals are divided into multiple parallel water systems from a starting point. The only exception is the 'Lanjia Burning House', the brewery in the village still retains the traditional curved water system. It also retains the most age-old traditional buildings in the village.

From the distribution of human settlements in the villages, except for the newer houses concentrated on both sides of the main road, the others are close to canals. The road system in the village is increased according to the layout of human settlements. In addition, two local factories are located at the intersection of the canal and path, which is conducive to water intake and transportation.

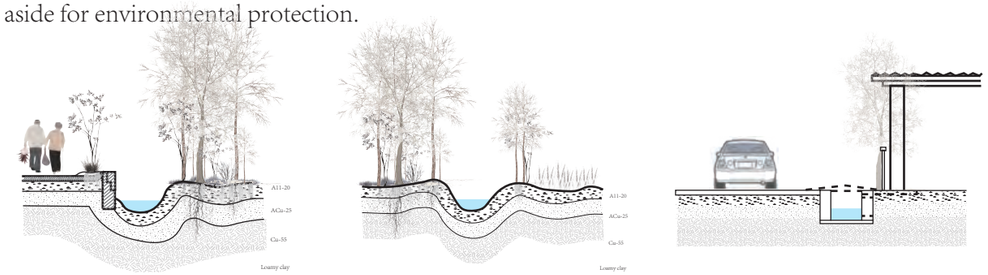
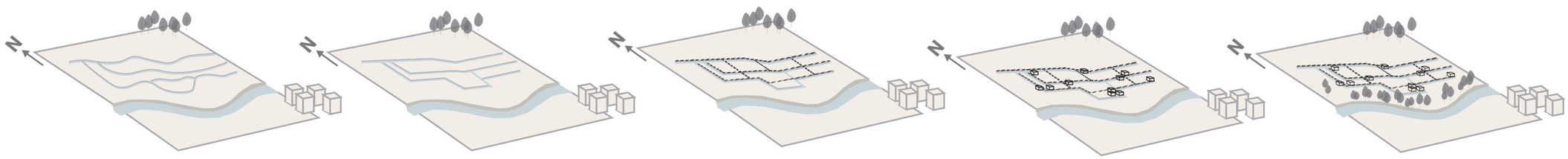


Fig 7.5 Canals & Path interaction



Fig 7.6 Water structure as the base



Natural canal before 1980 | Modified straight canal | Paved roads since 2002 | Canals > Path for households | A better ecology along the river

Fig 7.7 The process of village formation

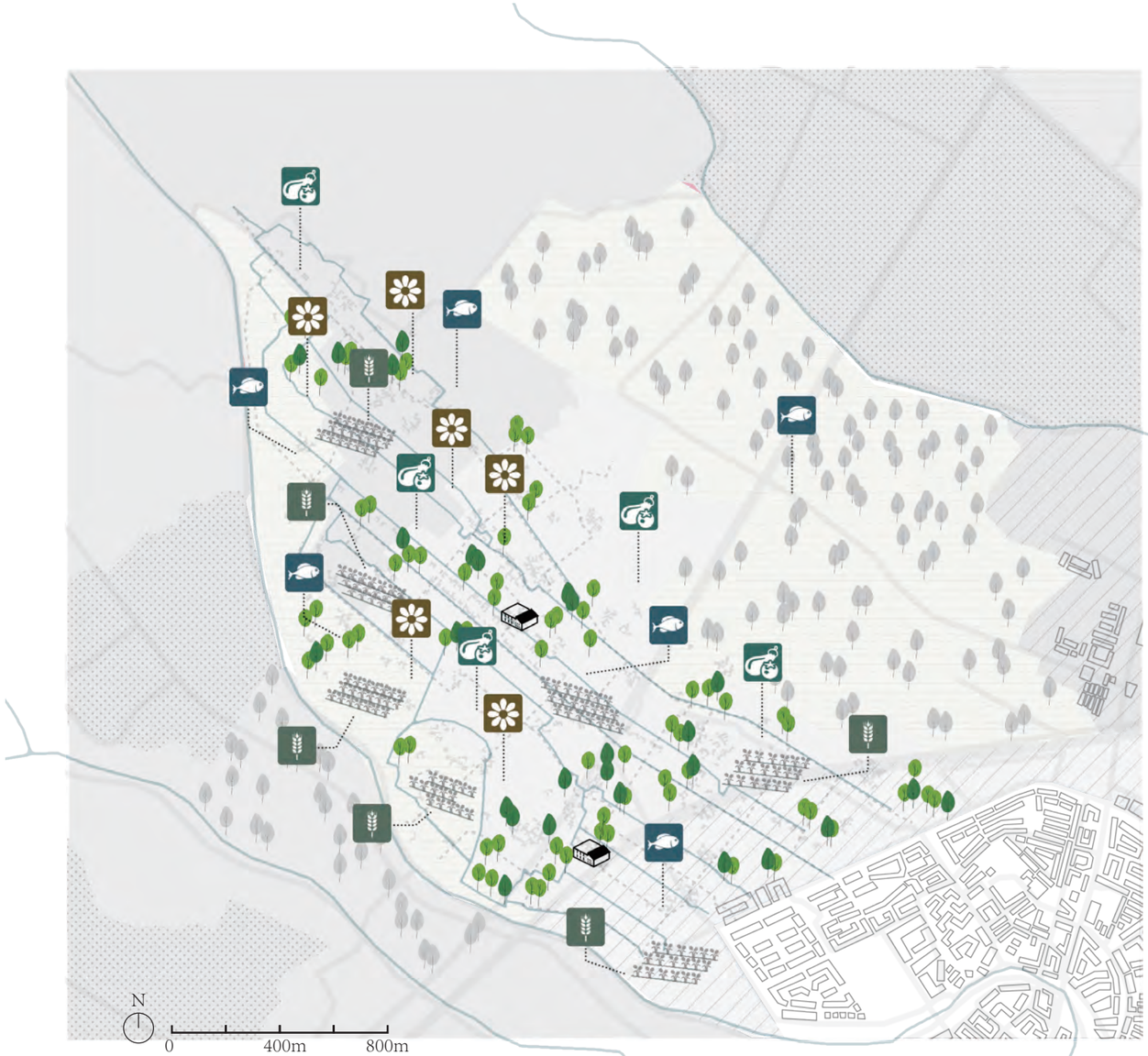


Fig 7.8 Production of the village

Production by water

For agricultural production, nothing is more important than water. In Paotong Village, apart from two small local food processing plants, the other industries are tree planting, flowers planting, fish farming, vegetables growing and rice planting.

Among them, flower planting is mainly distributed in the northwest, close to better water sources, and far away from urban and traffic pollution. The tree-planting industry is concentrated on the highways passing through the village and on both sides of the canals. This is a flood prevention measure and a continuation of history. Fish ponds are mainly distributed on the borders of villages, of which the land is used efficiently on irregular land. Vegetable greenhouses are far away from the Baitiao River, close to the interaction of main canals and traffic roads.

A special planting pattern in the West Sichuan Plain is to grow vegetables on strips of cropland to gain water from the end-canal easily. At the same time, this field also increases the diversity of the agricultural ecosystem.

In the future, trees planting will be declined, because the villagers believe that selling the trees will take away the fertile surface of the soil (Fig 7.9).

In conclusion, the distribution of the village water system affects the distribution of production, forming diverse productive zoning, and it would continuously changing over time.

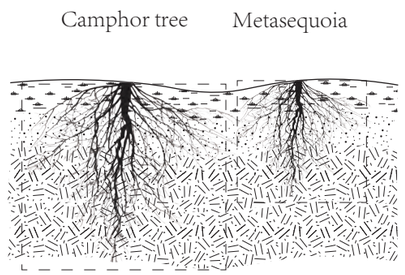
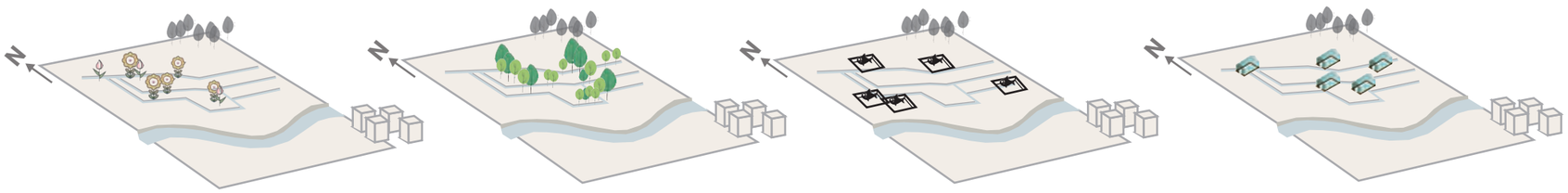


Fig 7.9 Tree roots and soil



Distribution of flowers　Distribution of trees　Distribution of fish ponds　Distribution of greenhouses

Fig 7.10 Distribution of productions

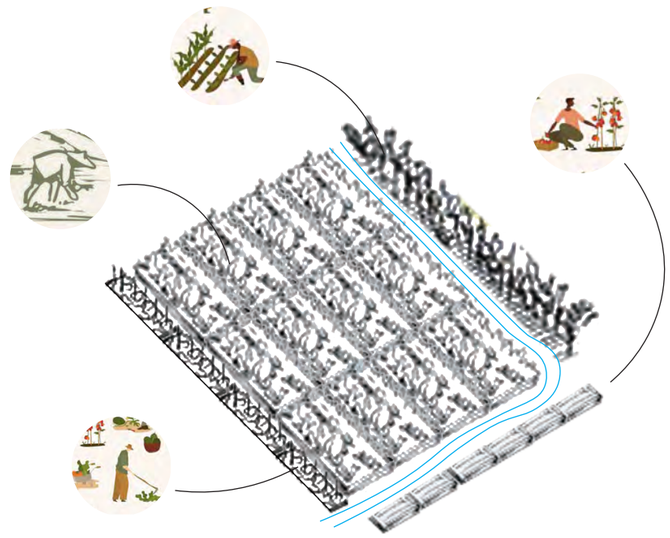


Fig 7.11 Biodiversity of the cropland

Water Flows

The physical water flow between urban and rural areas is mainly agricultural productive water and domestic water extraction. In addition, the rural ecosystem provides numerous products, food, wood, and local industrial products, which transfer virtual water to urban or township area. At the same time, rural area infrastructure, resettlement communities, agricultural supplies and other life industrial products are gaining virtual water for the village.

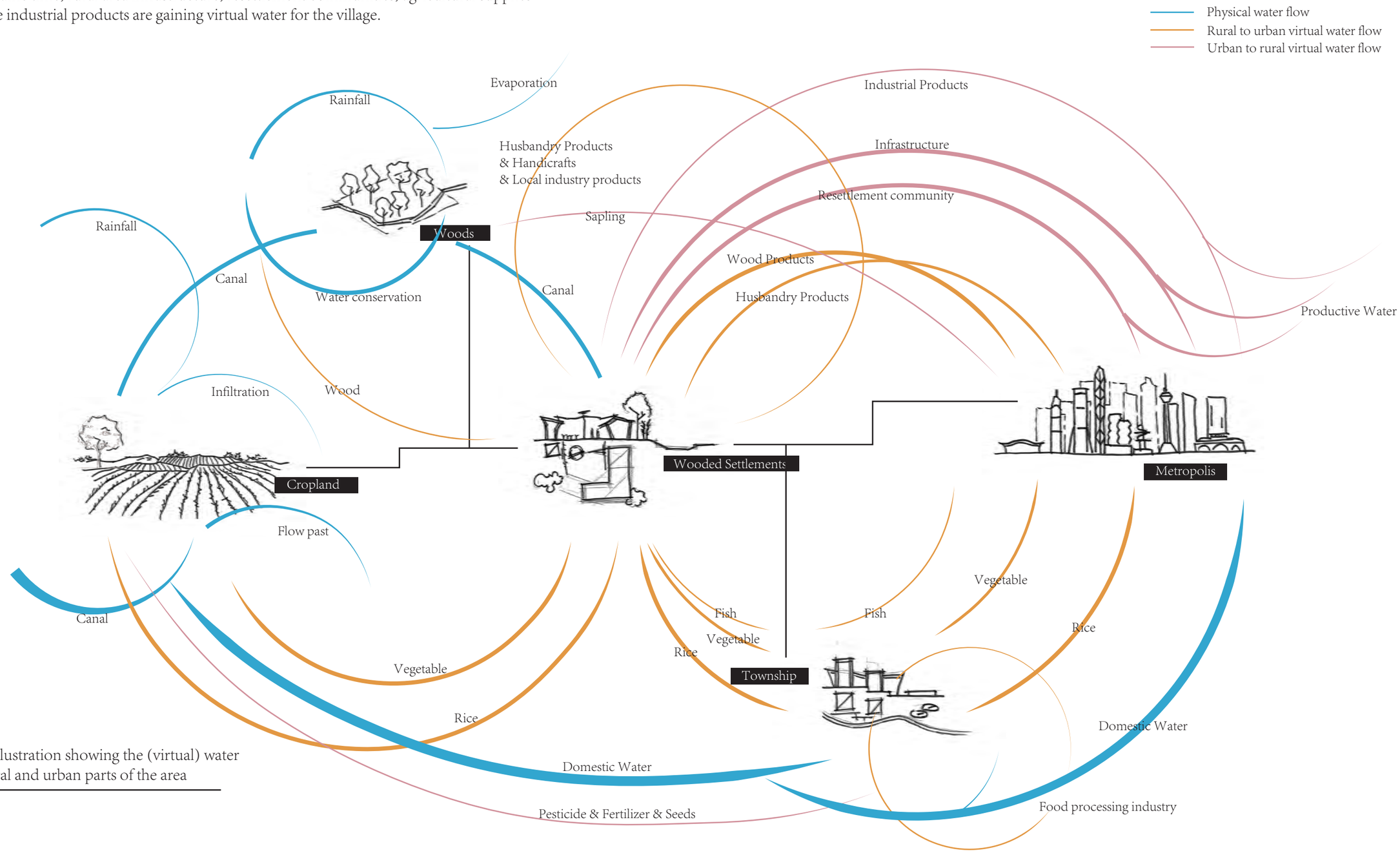


Fig 7.12: Illustration showing the (virtual) water flow in rural and urban parts of the area

Social connections

For the scattered villages in the West Sichuan Plain, social relations are more clearly reflected in the spatial structure.

At the administrative level, the villagers are divided into 8 production groups according to the spatial relationship, and each group has a close number of settlements and corresponding croplands of the villagers. The villagers in the same group are also the basic-level electoral units. Through their own organizations, they decide on common production methods, water distribution, land transfer contract, and so on. When encountering difficulties, this is also the geographic unit where the nearest neighbours help each other.

Another social relationship is made up of the canals system. Water resources are not only necessary for agricultural production, but also important elements within the settlement. On a large scale, the upstream and downstream of the same canal need to be coordinated. For example, if the upstream works on the preliminary cleaning of vegetables, the downstream will suffer short-term lower water quality. At the settlement level, daily activities such as washing, playing in the water, watering the flowers are also an important part of social relations.

The kin relationship is the most important social relationship in the villages of other regions. But it is relatively weak of the villages in the West Sichuan Plain, which is also reflected in the geographical distribution. There are relatively few large families (over two generations and five households) in the village, accounting for less than half. The houses of large families with relatively large populations are also relatively scattered, usually in several different settlements.

Although the residences of the villages are scattered geographically, the social connections are tightly based on productive activities and water connection.

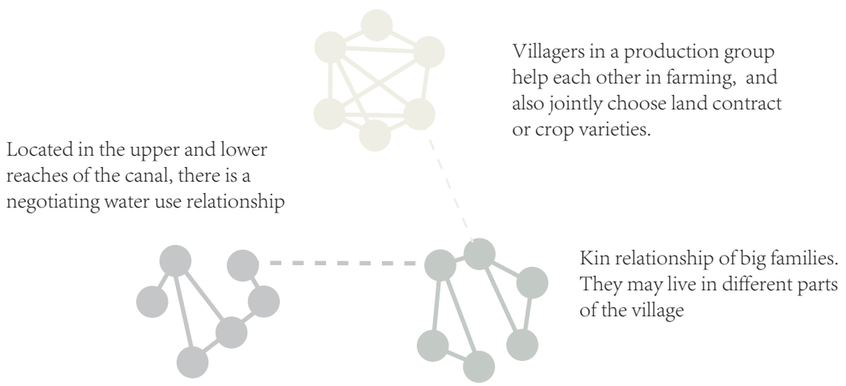


Fig 7.13 Social connections in the village

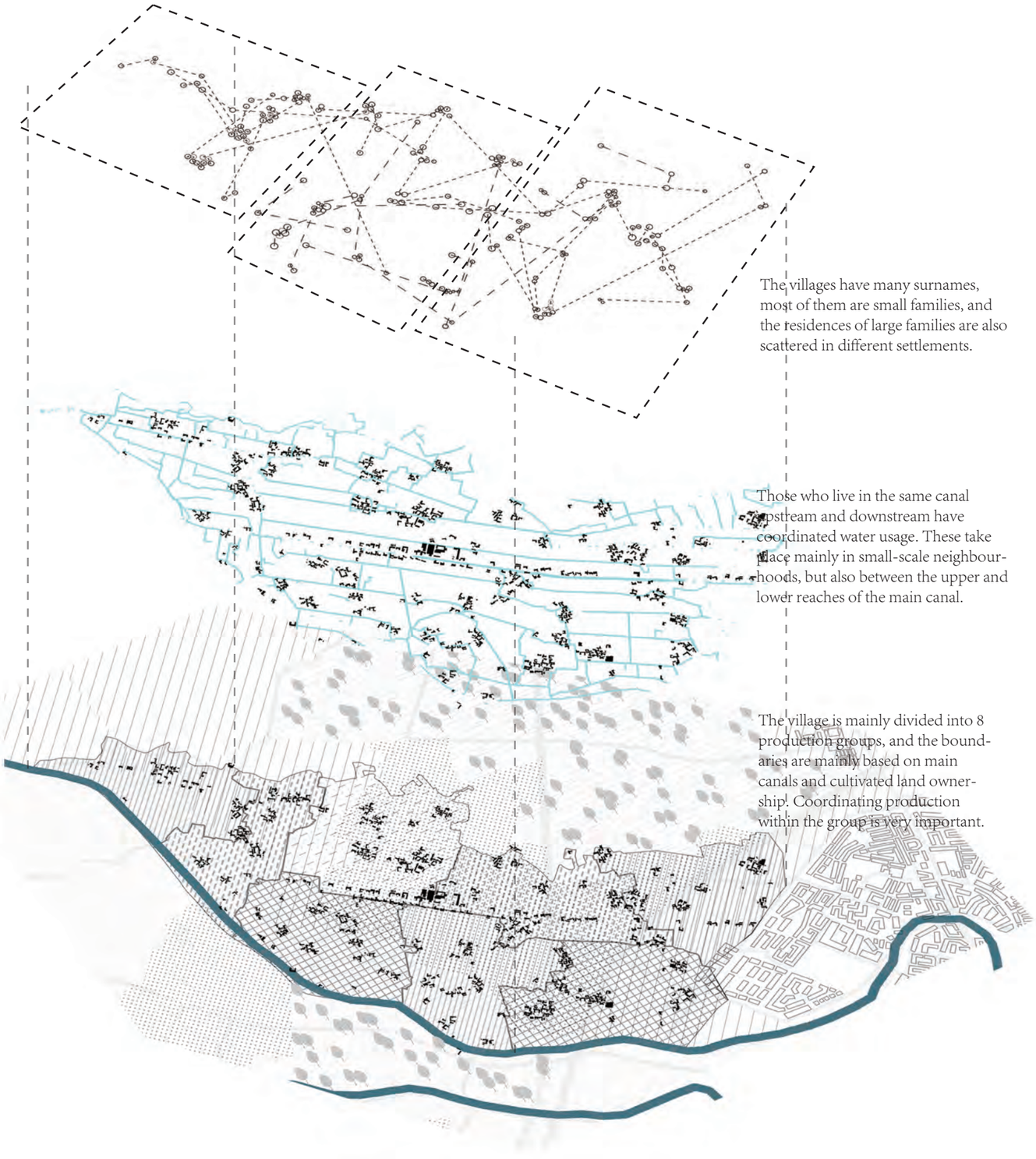


Fig 7.14 Social connections in the village

Village public spaces

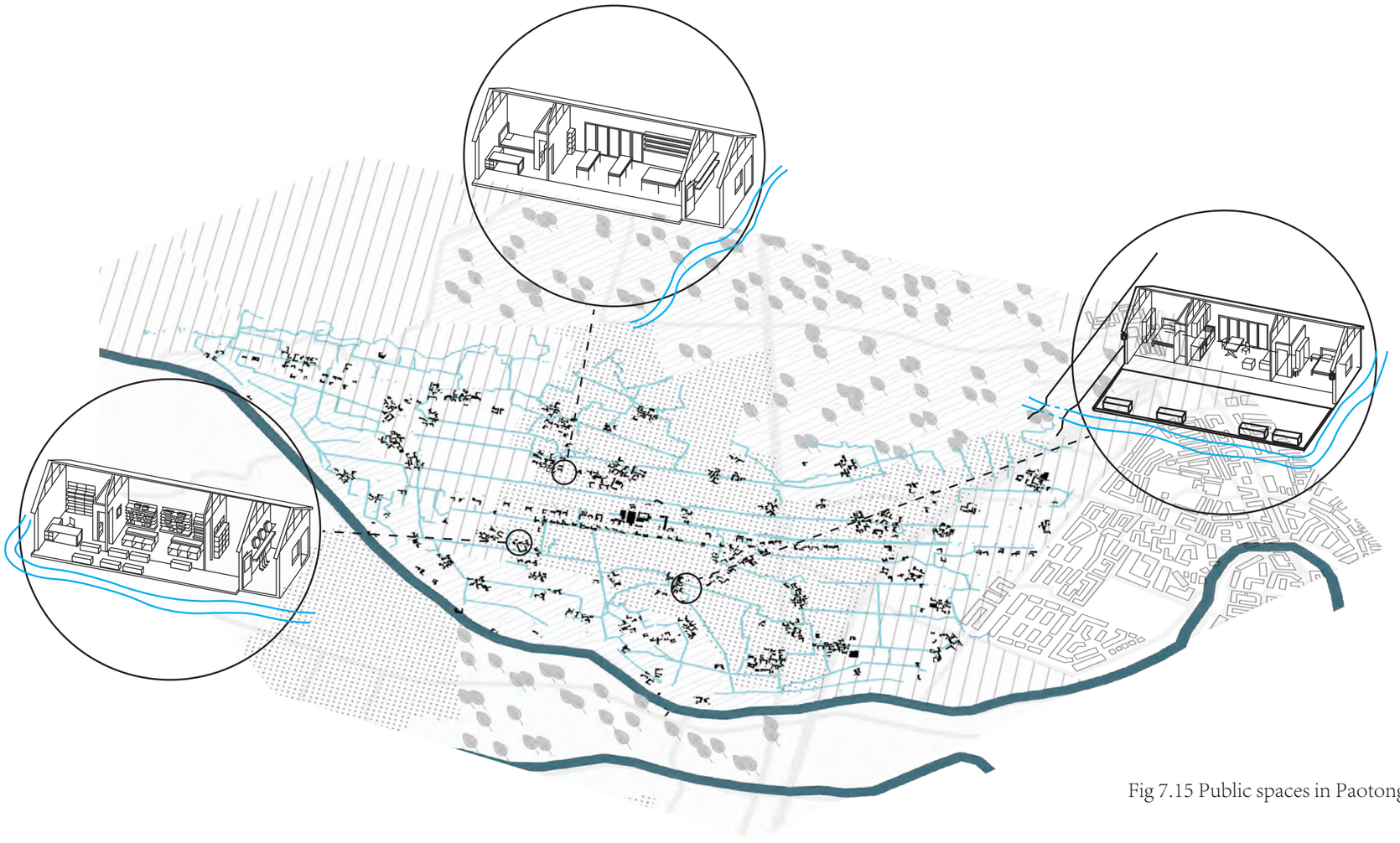


Fig 7.15 Public spaces in Paotong village

Because of the scattered living in the village, there is no central public space that the whole village will go to. Leisure activities in the village are mainly divided into three types, playing mahjong, drinking tea and going to the village committee. Among them, the village committee is the sphere of public activities at the village level, but the using frequency is relatively low, and it is directed to special activities such as voting. Chess and card rooms and tea houses are scattered in different areas of the village. They are a small regional centre that radiates several settlements in the surrounding area. These places are generally based on a villager's home, and at the same time are a local commercial place, and this family is usually the core organizer of the village's public life.

The spatial feature of these public spaces is that they have a large site, a canal and a beautiful natural environment, which also reflects the importance of water systems, bamboo forests, and trees to public life.

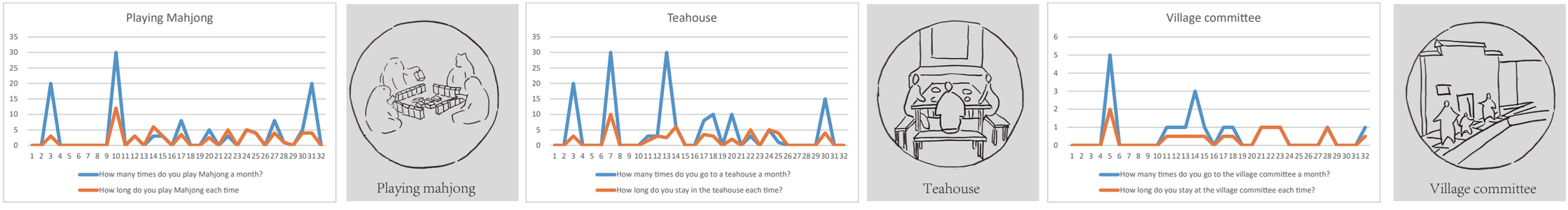


Fig 7.16 Usage of the public spaces

Wooded plot

The most basic unit of villages in the Chengdu Plain is the wooded household, which refers to villagers' houses surrounded by trees and water systems. All species form a basic micro-ecosystem here.

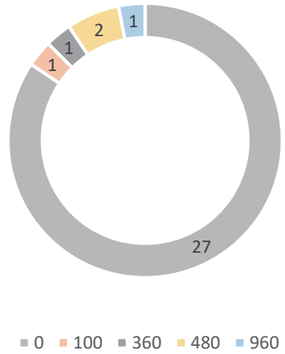
The houses are mainly made of local materials, mostly wood and clay. Villagers often raise chickens in their homes, pigs in a pig house, and cattle for farming. The house is surrounded by trees. There are fruit trees and flowers that directly produce fruits or provide landscapes, as well as camphor and bamboo forests. These species form a cycle of producing and consuming oxygen, as well as the cycle of maintaining water and water consumption.

In addition, there would be a canal flowing around the house to provide water for trees and poultry. At the same time, the wider canal is also a habitat for fish. The surrounding paddy field is a symbiosis field of ducks and rice. The ducks are useful for deworming, and the water in the field also provides a natural habitat. This is the second small cycle of water.

Harmonious symbiosis field, the way of water use and ecological function are the core of the function of wooded plot, and it worth being preserved.

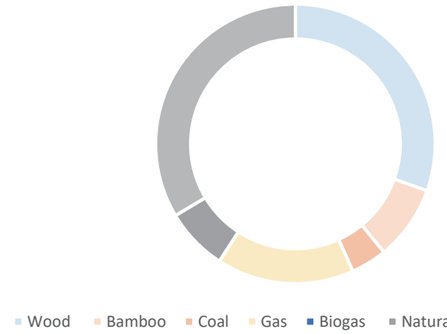
Moreover, in this living mode with nature, the water is almost free. In order to reduce the cost of living, the future new water supply system needs to consider providing subsidies. This model also provides basic energy for the villagers, such as using wood as an energy source, but in terms of emerging clean energy, it is possible to implant new energy structures in this lifestyle, such as biogas and natural gas.

Fig 7.17: Water cost per year (CN¥)

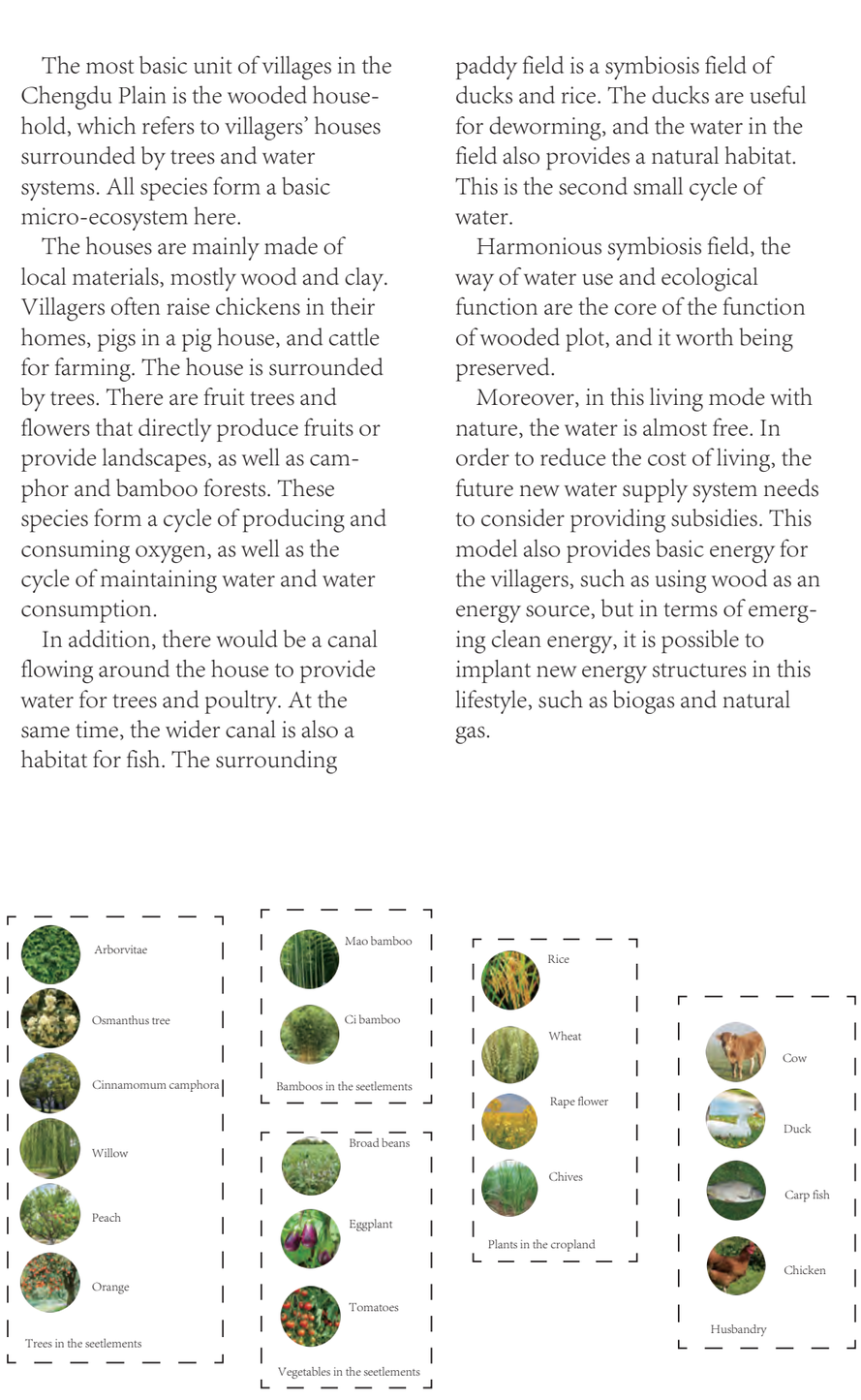


Because there is no centralized water supply, most people in the village have their own wells to gain free domestic water.

Fig 7.18: Energy use condition



The proportion of using wood and gas as energy is high, and the promotion of biogas and natural gas is poor.



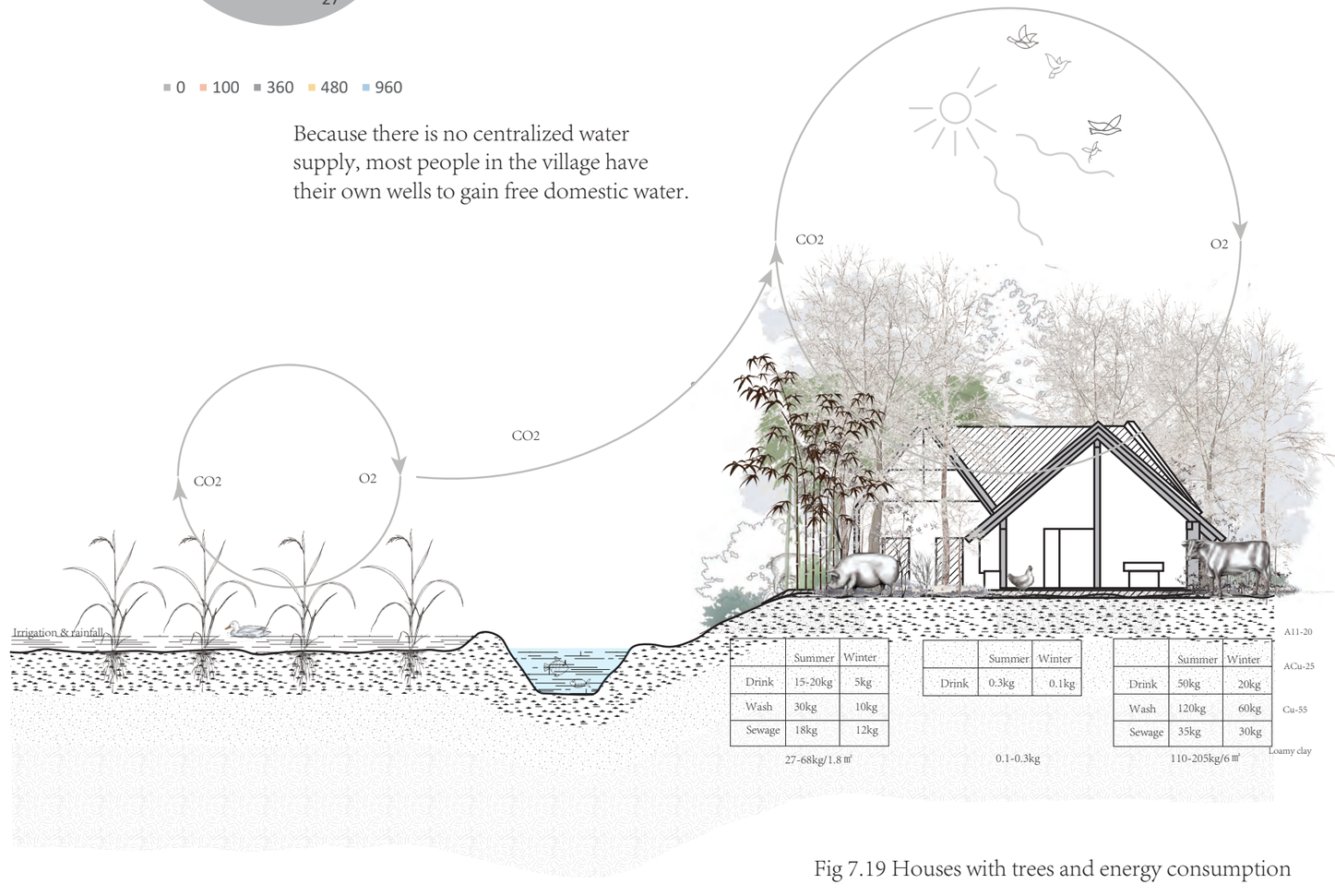


Fig 7.19 Houses with trees and energy consumption

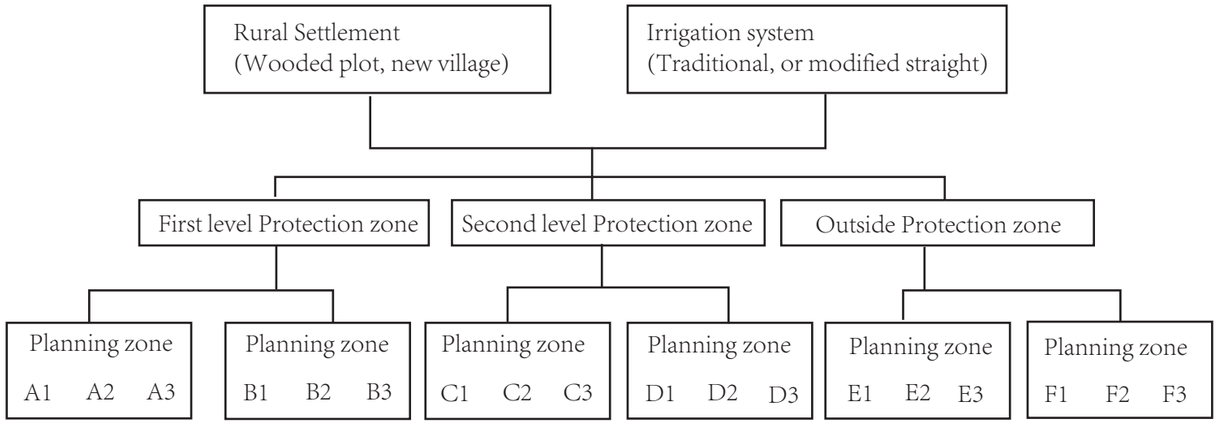
8 DEVELOPMENT ORIENTATION AND COMPENSATION MECHANISM

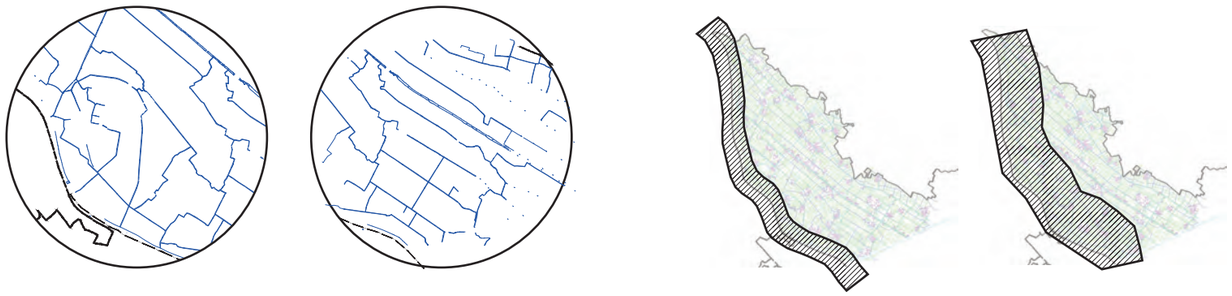
- Classification of settlements
- Monetary compensation mechanism
- Water balance mechanism



Fig 8 Traditional building in the Paotong village

8.1 Classification:
Possible development direction based on advantages of the plots





Wooded plot & resettlement community						Irrigation system		Zones		
	Traditional farming	Sightseeing-oriented	Special industry	Ecology style	New settlement	Traditional winding	Modified straight	First-protection	Second-protection	Non-protection
A1	●	●								
A2	●		●			●				
A3				●						
B1	●	●								
B2	●		●				●	●		
B3				●						
C1	●	●								
C2	●		●			●				
C3				●						
D1	●	●								
D2	●		●				●		●	
D3				●						

Fig 8.1.1 Plots classification principles

Planning zone type A1 is a combination of wooded plot located in the first protection zone and connected with a traditional winding canal. Among the traditional farming wooded plot of A1, some wooded plot that is close to the main traffic road, convenient for tourists and rich in tourism resources can be selected to develop into tourism-oriented. The planning zone type A2 is also a wooded plot located in the first protection zone and connected to the traditional winding canal. Among these A2 plots, some with better land conditions can be selected to develop Chinese herbal medicines, fruits, flowers, trees and other planting industries to improve the economic benefits of land use. The planning zone type A3 is the place that no one lives there and suitable for developing ecology functions because of its remaining greens. Large trees there are important objects of landscape protection. Plot C, D, E, F follows the same principles.

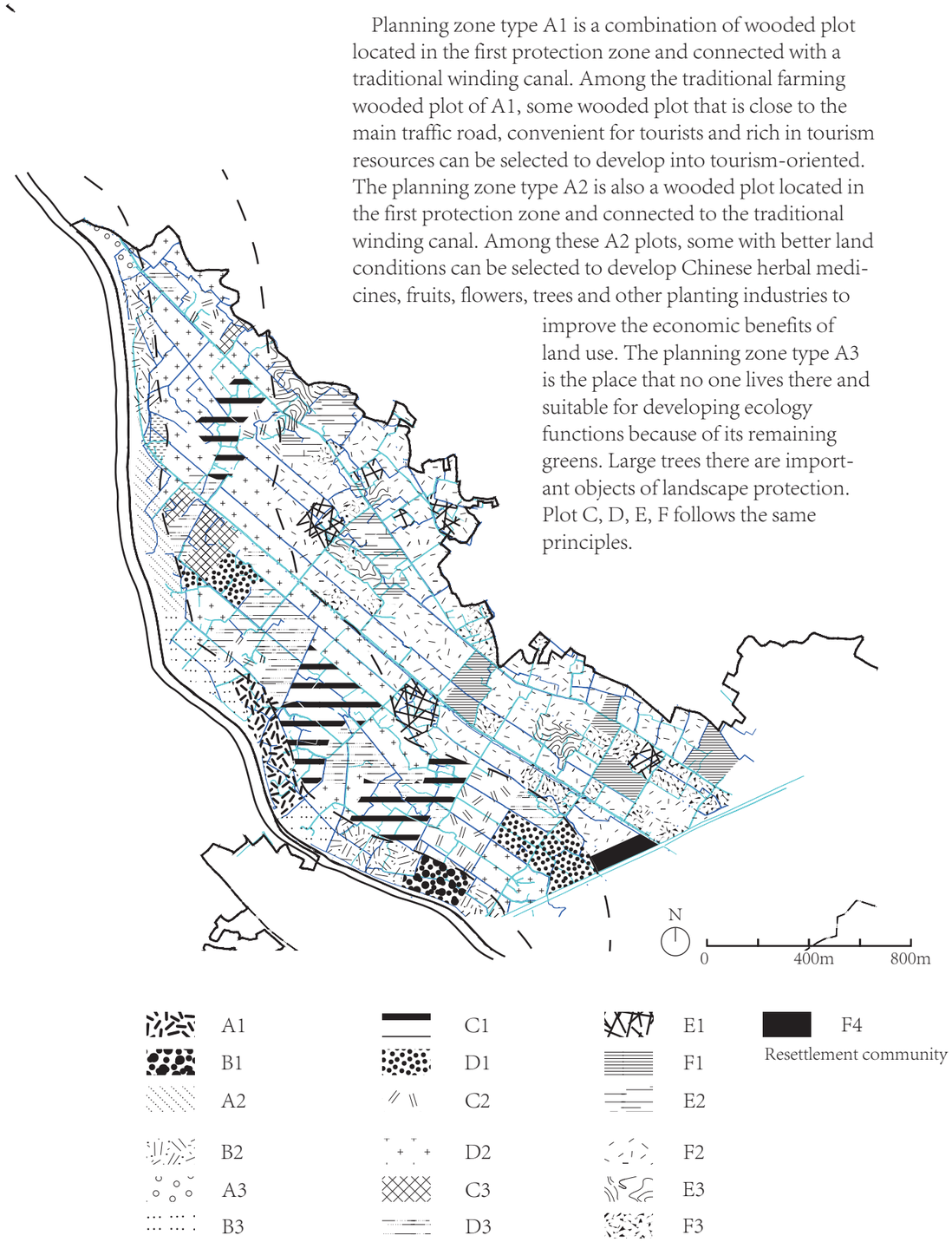


Fig 8.1.2 Plots classification of Paotong village

Sightseeing oriented plots

The Paotong Village has a wide distribution of settlements with rich tourism resources. Some have old-style houses, some are surrounded by flower fields, and some has a private environment. The water culture and rural experience carried by surrounding canals are outstanding tourist resources of these plots.

If there are limited settlements that can develop tourism, those with winding canals will be given priority.

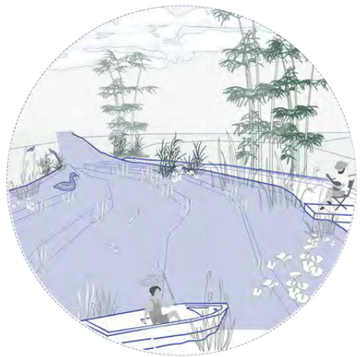




Fig 8.1.3 Sightseeing oriented plots
Source: Jiangyu Pan (n.d.)

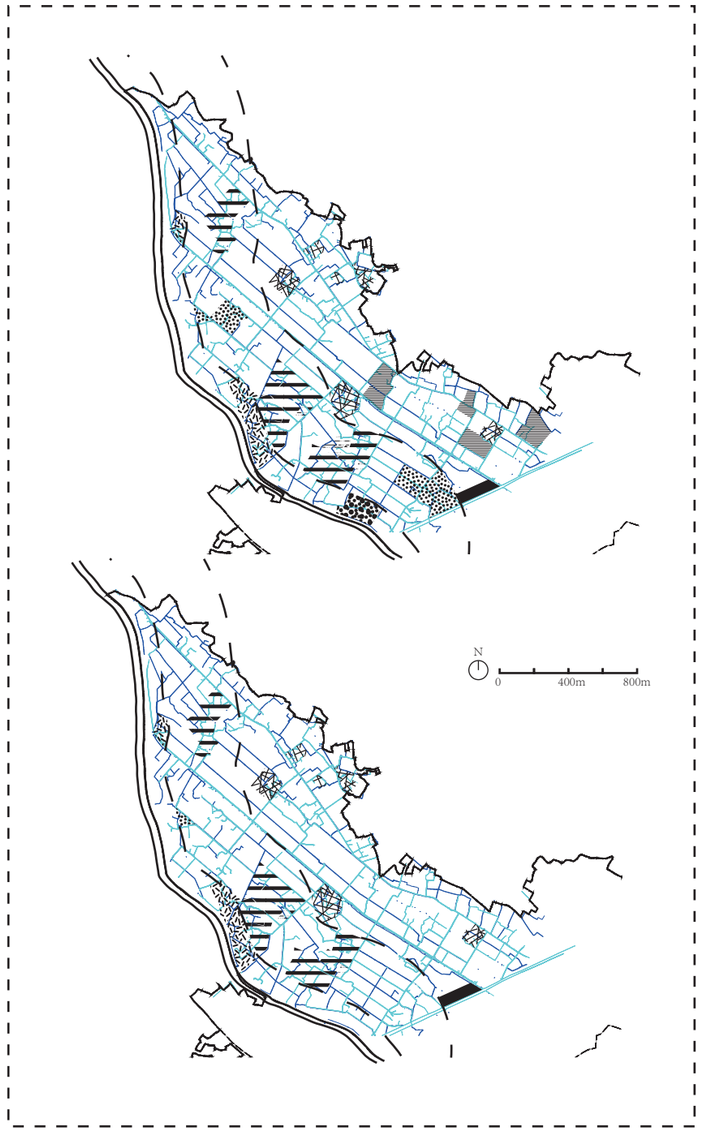


Fig 8.1.4 Sightseeing oriented plots of Paotong village

Production / Ecology oriented plots

Those surrounding plots with good agricultural development foundation and regular plots are suitable to develop new economic crops and green agriculture. The scaled economies and industrial chain will increase villagers' income.

The rest plots are able to be converted into ecological functions, which means that the surrounded cropland could be given back to nature to meet the ecology requirement.



Fig 8.1.5 Production oriented plots
Source: Jiangyu Pan (n.d.)

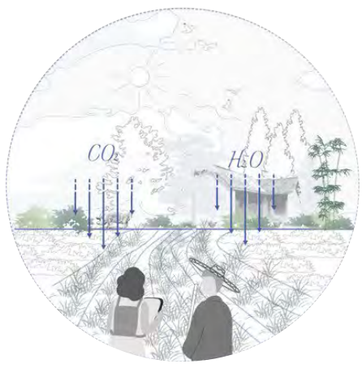


Fig 8.1.6 Ecology oriented plots
Source: Jiangyu Pan (n.d.)

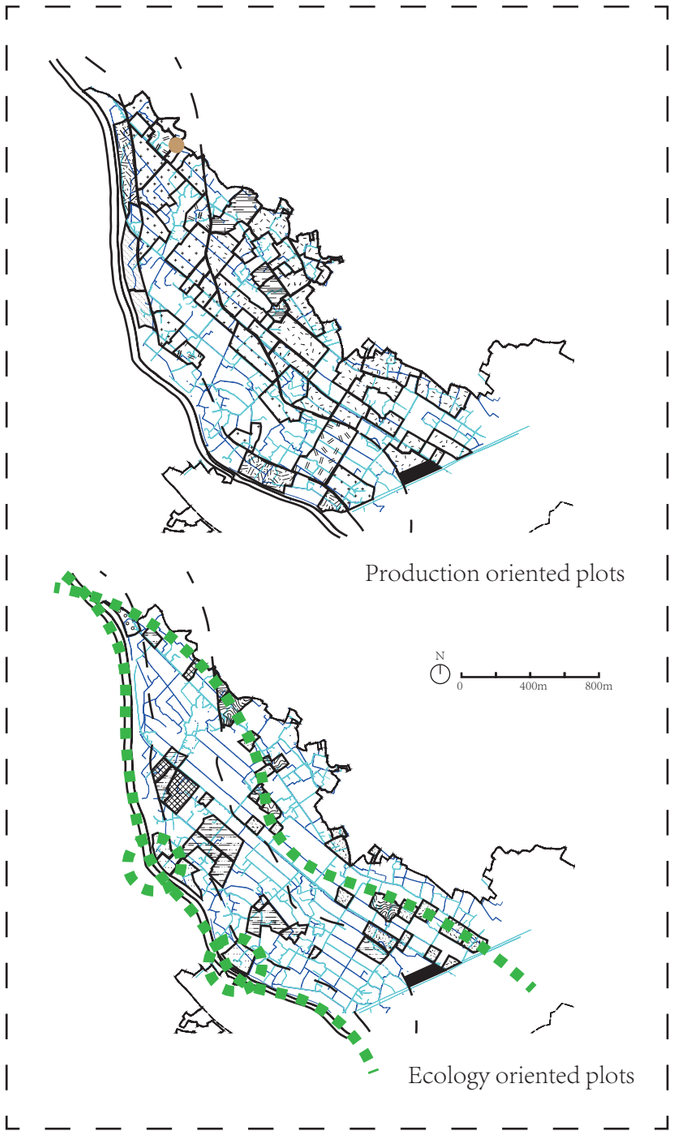


Fig 8.1.7 Production / Ecology oriented plots of Paotong village

8.2 Compensation balance

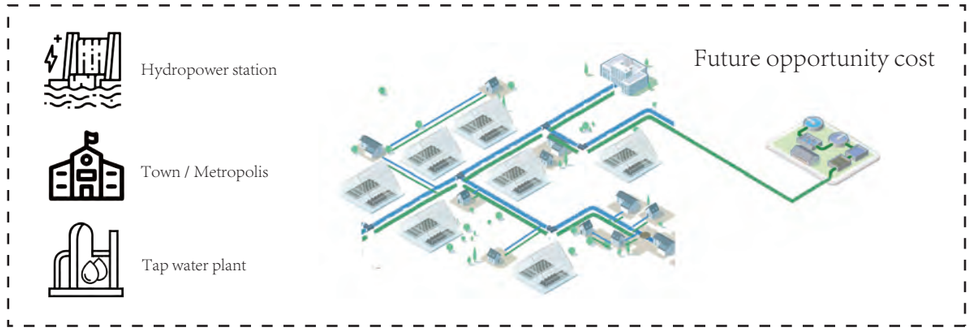
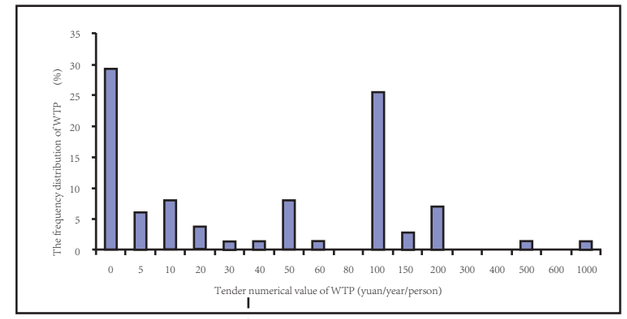


Fig 8.2.1 Paying for future development

The first balance that needs to achieve is the compensation balance. The ecological compensation consists of two parts (Hanemann, 1994; Kritrom, 1991). The first one is the Willingness To Pay (WTP), which means the downstream citizens who are the beneficiaries are paying for the mandatory cost of the upstream ecological protection. This includes the resettlement fees, sewage treatment and water supply cost, as well as the cost in converting woods and soil erosion prevention in this case.

The balance takes place in the relocation process since the cost of building resettlement communities is different from the cost of constructing sewage pipes, so the amount of compensation will determine how many villagers could stay in or they need to move out of the village.

Another part of the ecological compensation is future opportunity cost. This part will be paid by the upstream hydropower stations, tap water plant and local government, to cover the future development cost in the village, such as local industries, green vegetable and tourism renovation.



WTP mathematical expectation

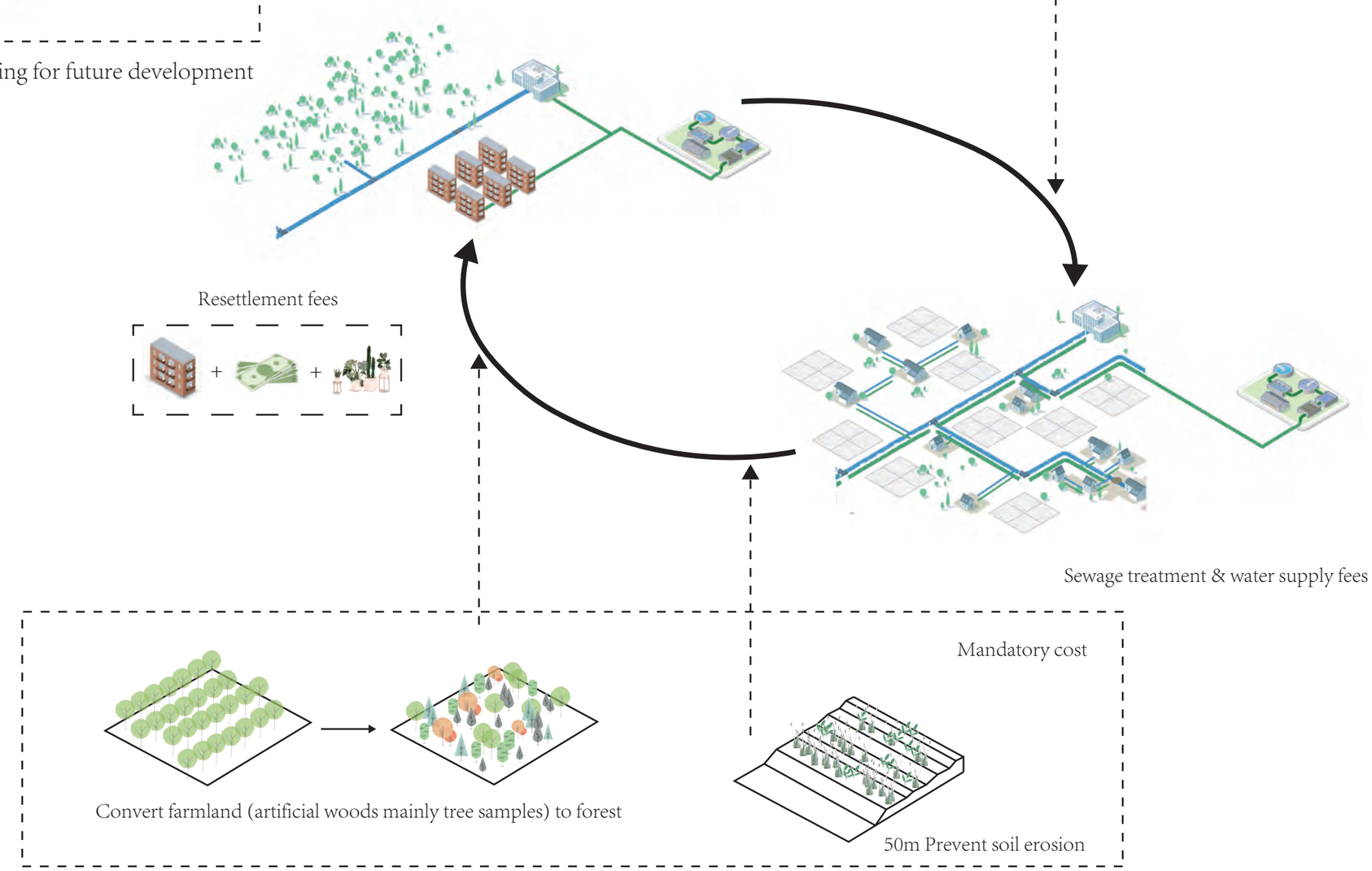


Fig 8.2.2 Monetary compensation balance

Table 8.1. Statistics of the Chengdu residents willingness to pay in Water Conservation Zone

Items	Options	Sample size (person)	Proportion (%)
Willingness to pay	Yes	168	70.89%
	No	69	29.11%
Reasons for not willing to pay	X1	42	60.87%
	X2	39	56.52%
	X3	24	34.78%
	X4	12	17.39%
	X5	6	8.7%
	X6	9	13.04%
	X7	3	4.35%
	X8	0	0%
The way of payment	X9	51	30.36%
	X10	60	35.71%
	X11	33	19.64%
	X12	75	44.64%
	X13	24	14.29%

X1-They think that funds should be raised by the government, X2-The ecology protection should be paid by the Tap Water Company, X3-Water consumption companies should take responsibility, X4-The upstream is responsible for ecological degradation, X5-Inability to pay, X6-Do not believe that the compensation will be used reasonably, X7-Not interested in drinking water source environment X8-The environment of the drinking water source has little effect on myself, X9-Donation, X10-Paying more for utilities, X11-Participating in voluntary labour, X12-Ecotax, X13-Buying environmental lottery

Table 8.2. Statistics of the frequency distribution of the Willingness to pay for

Willingness to pay (CN¥)	Frequency (person)	Positive frequency of the willingness to pay (%)	Positive cumulative frequency of the willingness to pay (%)	Total frequency of the willingness to pay (%)	Cumulative frequency (%)
0	69			29.11	29.11
5	15	8.93	8.93	6.33	35.44
10	21	12.5	21.43	8.86	44.3
20	9	5.36	26.79	3.80	48.10
30	3	1.79	28.58	1.27	49.37
40	3	1.79	30.37	1.27	50.64
50	21	12.5	42.87	8.86	59.5
60	3	1.79	44.66	1.27	60.77
80	0	0	44.66	0	60.77
100	63	37.5	82.16	26.58	87.35
150	6	3.57	85.73	2.53	89.88
200	18	10.71	96.44	7.59	97.47
300	0	0	96.44	0	97.47
400	0	0	96.44	0	97.47
500	3	1.79	98.23	1.27	98.74
600	0	0	98.23	0	98.74
＞1000	3	1.79	100.00	1.27	100.00
Total	237	100			

Estimation of monetary compensation
Willingness to pay of Chengdu residents

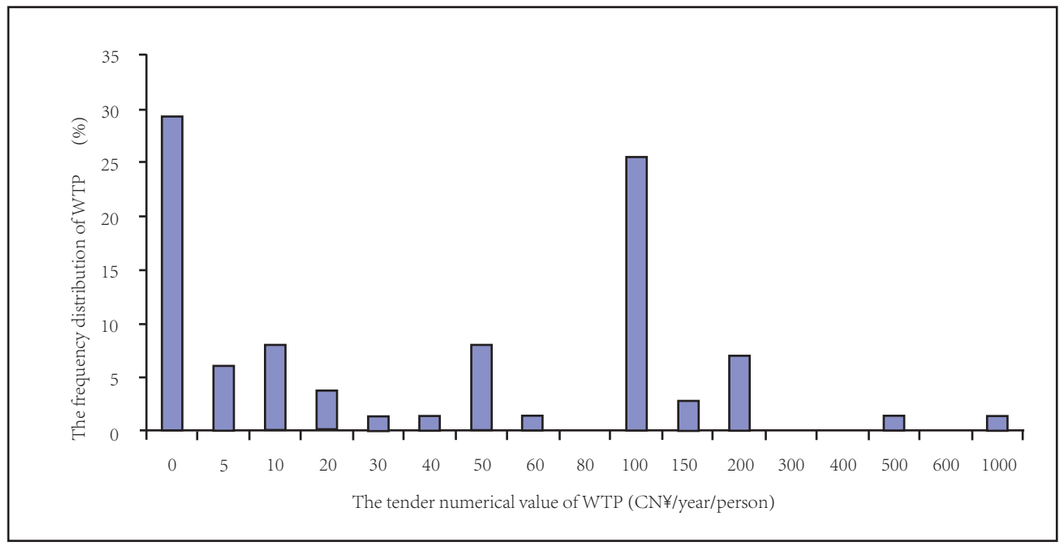


Fig 8.2.3. Frequency distribution of Willingness to pay

The frequency distribution was combined with Hanemann's WTP mathematical expectation formula adjusted by Spike's model; was used to obtain the average maximum willingness to pay of Chengdu residents (Hanemann, 1994; Kritrom, 1991). Therefore, the positive average willingness by using the mathematical expectation formula of the discrete variables:

$$E(WTP\rangle 0) = \sum_{i=1}^{n} A_i P_i$$

Where A_i is the tender numerical value of WTP, and P_i is the amount of probability respondents to select, and n is the number of alternative tender, and n=16, so E(WTP) positive is calculated as CN¥ 102.47 per person per year. The exact average willingness need to be adjusted by Spike model, because the WTP of 29.11% of the sample is zero.

$$E(WTP) = E(WTP\rangle 0) \cdot (1 - WTPR_0)$$

Where WTPR0 is the ratio of the people who do not want to pay. It is calculated that E(WTP) is CN¥ 72.64 per person per year for Chengdu residents for the value of the water conservation zone.

Therefore, the total amount of compensation from the residents in Chengdu to the Water Conservation Zone is:

E(WTP)*Population=CN¥ 654.28 million per year.

Since there are 70 villages involved in the Water conservation zone, each village can be allocated equally by CN¥ 9.22 million per year.



Fig 8.2.4 Villages in the water conservation zone
Source: Author, based on Snazzy Map (n.d.)

8.3 Water balance

Another important part is to achieve water balance. In the construction of resettlement community and the renovation of sightseeing oriented and production plots, there is virtual water consumption from materials, wastes and loss of greenery land. On the other hand, the increasing natural canals and biodiversity would bring more water maintenance capacity.

Since the local development should not use more water, the water balance in the village relocation and renovation process need to be gained. For the gap between the virtual water cost and water catch capacity, there are more sampling trees and cropland in the village converted into natural lush forest, which would increase the water maintenance capacity and finally gain the water balance.

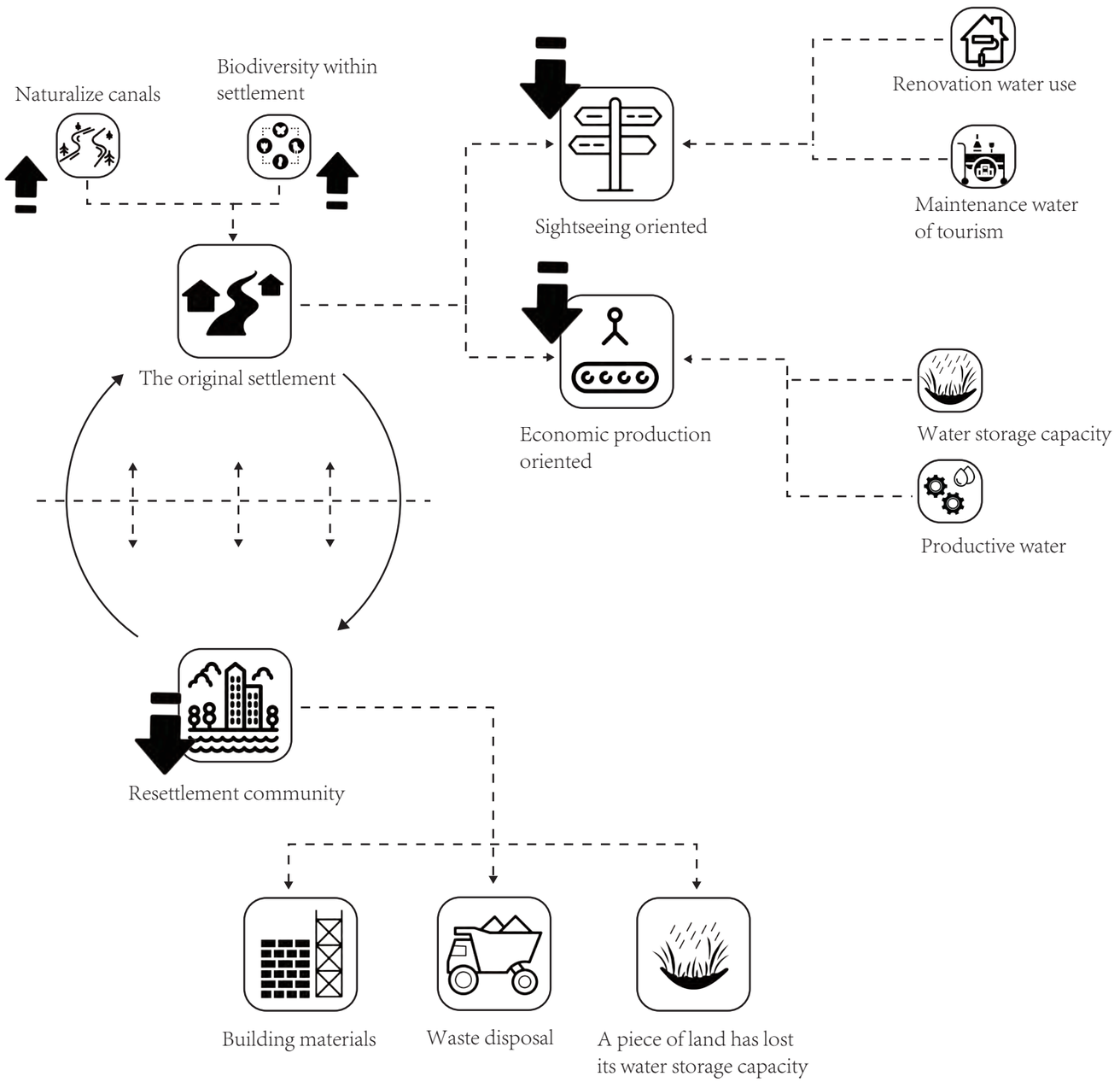


Fig 8.3.1 Water balance in the relocation process

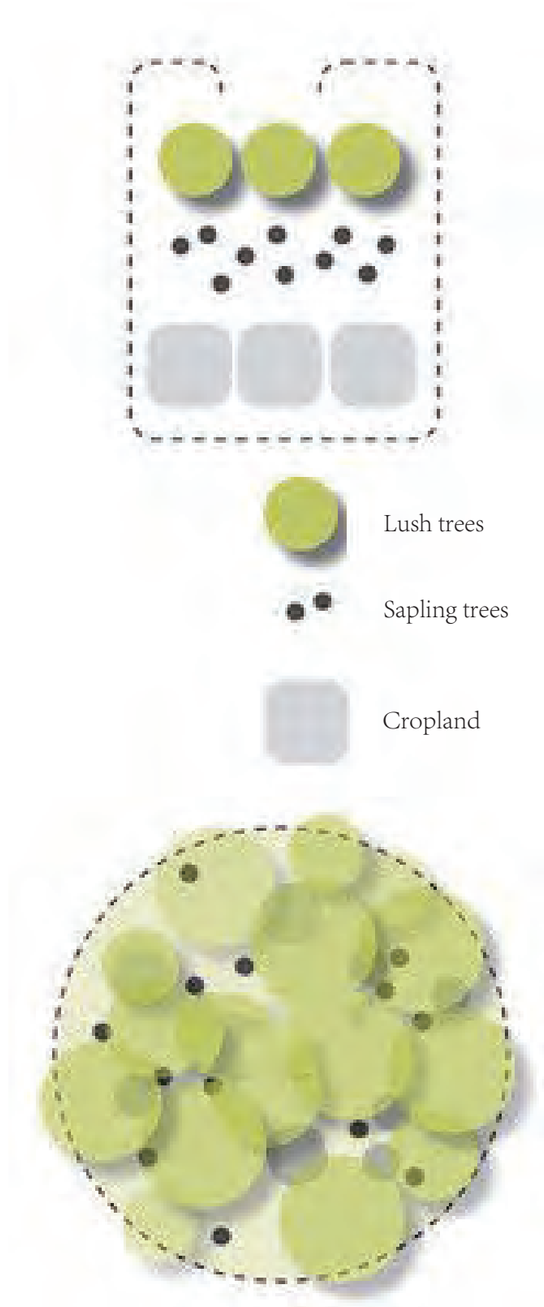


Fig 8.3.2 More natural woodland retains more water
Source: logon architecture (2010)

9 SCENARIOS TESTING IN PAOTONG VILLAGE

- Compensation and water balance in the scenario I & II
- Scenario I
- Scenario II



Fig 9 Traditional West Sichuan village
Source: Bashu Mingren (2020)

Projection scenario I & II

Local development model & Resettlement development model



Scenario I

Scenario II

Scenario I is aiming to allow as many people as possible to stay in the village and maintain the original landscape, lifestyle and social relations of the village.

Scenario II complies with the minimum water source protection regulation. Villagers within 50m need to move into the resettlement community and develop local industries based on this situation.

Fig 9.1.1 Scenario I & II

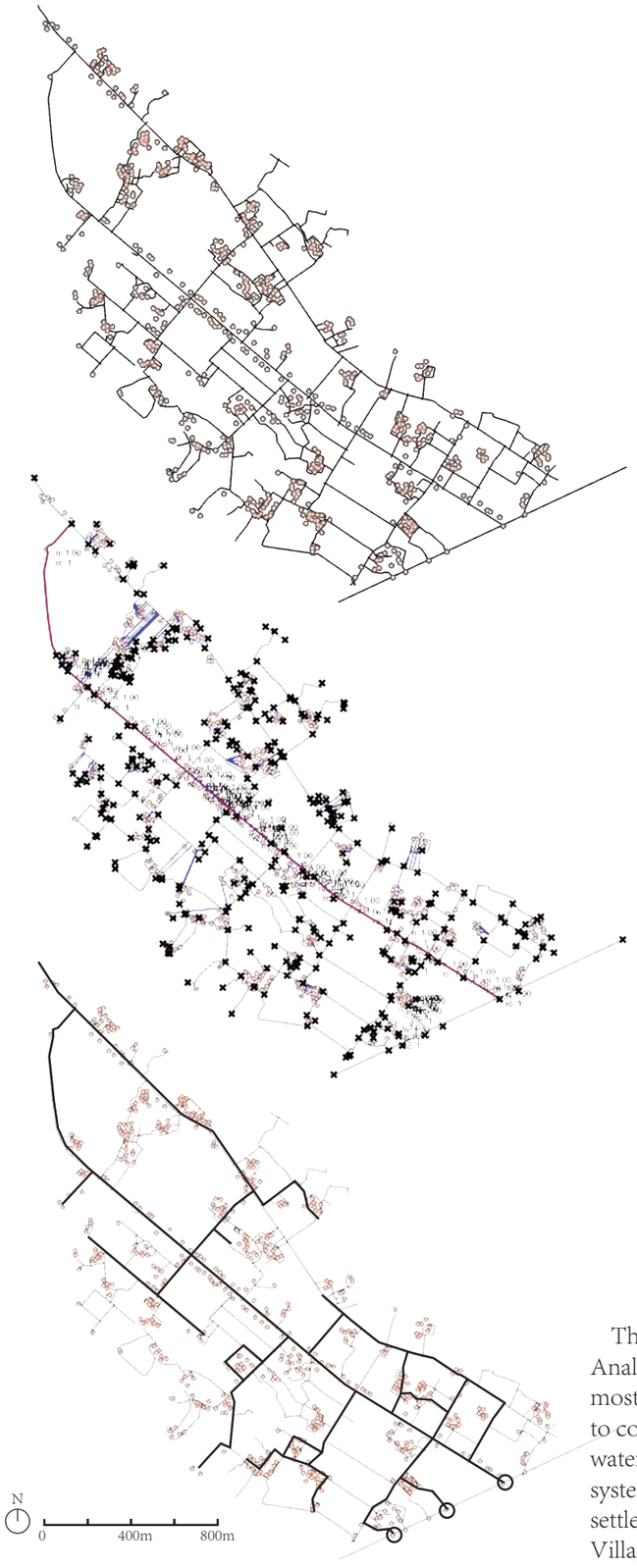


Fig 9.1.2 Domestic supply & sewage pipes

Through the Urban Analysis Toolbox, the most economical solution to construct a domestic water supply and sewage system covering all settlements in Paotong Village was calculated.

Compensation in scenario I&II

Pipes cost
The average cost per kilometre of tap water pipes (dn160) is CN¥ 165000
The average cost of sewage pipes (dn 600) per kilometre is CN¥ 300000
There are 728 households in Paotong Village, 47.34km pipes in total
Average pipe cost (include both domestic and sewage) is CN¥ 30200 per household

Source: Qingdao Water Affairs Administration (2016); zxnna201 (2014)

Resettlement fee
The average house price in Sandaoyan Town is CN¥ 5000 per square metre
The housing area is 120 ㎡ per household
The fixed compensation fee is CN¥ 30000
The average compensation for a relocated household is CN¥ 630000

Source: Anjuke (2021)



Fig 9.1.3 Woods to be converted

Converting farmland to forest fee
Compensation: The first three years CN¥ 2200 per mu, the following 5 years CN¥ 4300 per mu
There is 121.76 mu forest that need to be converted, CN¥ 3420000 cost
Prevent soil erosion is CN¥ 544 per mu with 256.95 mu, CN¥ 140000 cost
Compensation for ecology is CN¥ 3560000

Source: Compensation standards for forest land in Chengdu (2019); Jin, L., Zuo, W., Li, Y., Zhao, Y., & Zhang, Q. (2012)

34 (5 years) /80 (8 years) /111 (10 years) households could be relocated

There is 42 household in the first level protection zone
275 households in the second protection zone

If there are X households that need to be relocated
The resettlement fee is 63X
Pipes cost is (728-X)*3.02

If take 5 years WTP to pay for the cost,
63x+(728–x)*3.02=922*5–342–14
x=34

Because that build pipe is cheaper, the max household can relocate is 34
If take 8 years WTP to pay, the max household can relocate is 80

If the paying willingness increase (people more aware of the water protection policies), the resettlement households could be more
If the pipe needs a stricter building condition, like deeper or wider or better material, then the households that can move is lesser

Water balance in scenario I&II



Fig 9.1.4 Relocation and stay in the village

Virtual water consumption

New construction of resettlement community	Renovation of the tourism-oriented house
26.5 m3 water per square metre	26.5 m3 * (1-67.74%) = 8.55 m3 per square metre

Source: Han, et al. (2016)

Water holding capacity of forest

The young plantation forest	490.53 tons/ha
The natural fir forest	2520.02 tons/ha
The grassland	529 tons/ha
The average natural woods	1332.98 tons/ha
Mature plantation	1384.94 tons/ha

Source: Yang C., Dang K., & Liu J. (1997)

Young plantation converting to natural forest

490.53 tons/ha → 2520.02 tons/ha

Mature plantation converting to natural forest

1384.94 tons/ha → 2520.02 tons/ha

The grassland converting to a natural forest (Prevent soil erosion)

529 tons/ha → 1332.98 tons/ha

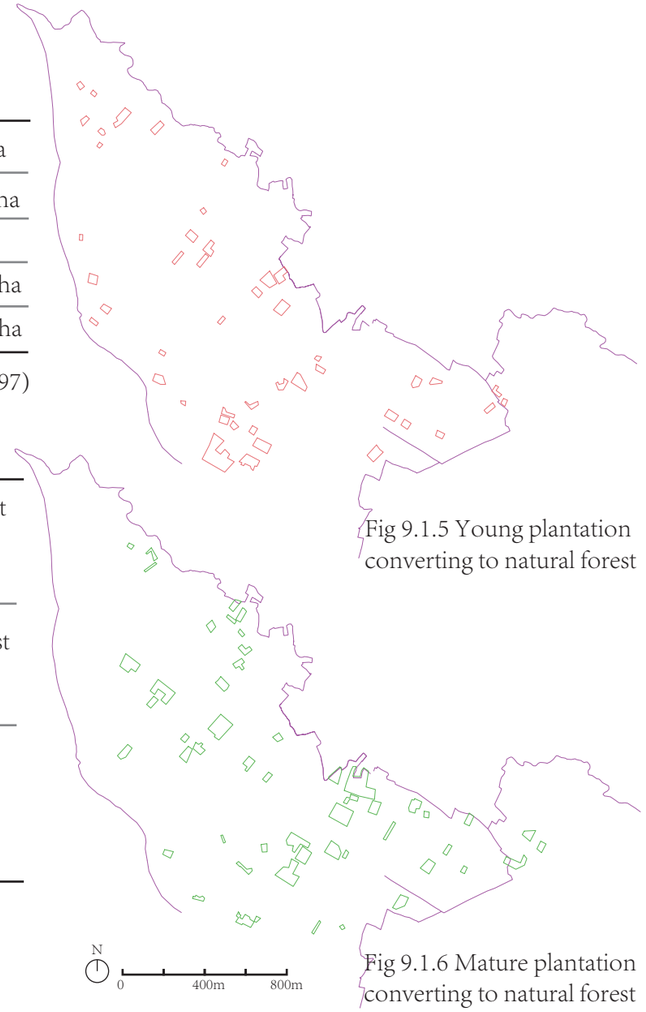


Fig 9.1.5 Young plantation converting to natural forest

Fig 9.1.6 Mature plantation converting to natural forest

Scenario I

Virtual water consumption

30 houses go for tourism 30*150 ㎡=4500 ㎡
The average area of tourism house is 150 ㎡
4500 ㎡ * 8.55 m3 per square metre = 38475m3= 38475ton

12 relocated
Average relocation flat is 120 ㎡
12*120m2 *26.5m3/m2 = 31800ton

Increasing water holding capacity

Young plantation converting to natural forest

In total 16474 ton per ha

The grassland converting to a natural forest (Prevent soil erosion)

In total 13772.18 ton per ha

3 years to achieve water circularity
38160+38475 ＞ 3*(16474+13772.18)

The water is enough from converting young plantation to natural forest

Scenario II

Virtual water consumption

30 houses go for tourism 30*150 ㎡=4500 ㎡
The average area of tourism house is 150 ㎡
4500 ㎡ * 8.55 m3 per square metre =38475 ton=38475 ton

62 relocated
Average relocation flat is 120 ㎡
62*120m2 *26.5m3/m2 = 197160 ton

Increasing water holding capacity

Young plantation converting to natural forest

The grassland converting to a natural forest (Prevent soil erosion)

Mature plantation converting to natural forest

In total 13598.26 ton per ha

5 years to achieve water circularity
Water gap 3280.15 ton

Another 4.1 ha cropland need to be converted to natural forest

There cannot be too many of the houses renovated into tourism building.
Otherwise more local material and traditional way of construction should be used

Projection scenario I

Local development model

Scenario I is aiming to allow as many people as possible to stay in the village and maintain the original landscape, lifestyle and social relations of the village.



Scenario I

Scenario II

Fig 9.2.1 Scenario I

Production

Agriculture based industry

Village

-Acting together by planting activity instead of a productive group

Farmers

-Owner of the cropland/facilities
-Working in his/her own land
-Shareholder of the processing industry

Local factory

-Chilli bean sauce production
The raw materials come from the village
-Packaging bio-production

Productive path

-Linking the productive plots
-Set up the primary processing & selling
-Using a tricycle, keep pollution out

Production

-Flower planting upstream
Sightseeing oriented combination with a winding canal
-Vegetables mid outside of river
Combining picking experience
-Vegetables in the northeast
-Crop/Fish near the river
-Saplings in the centre
Mix with fruit trees

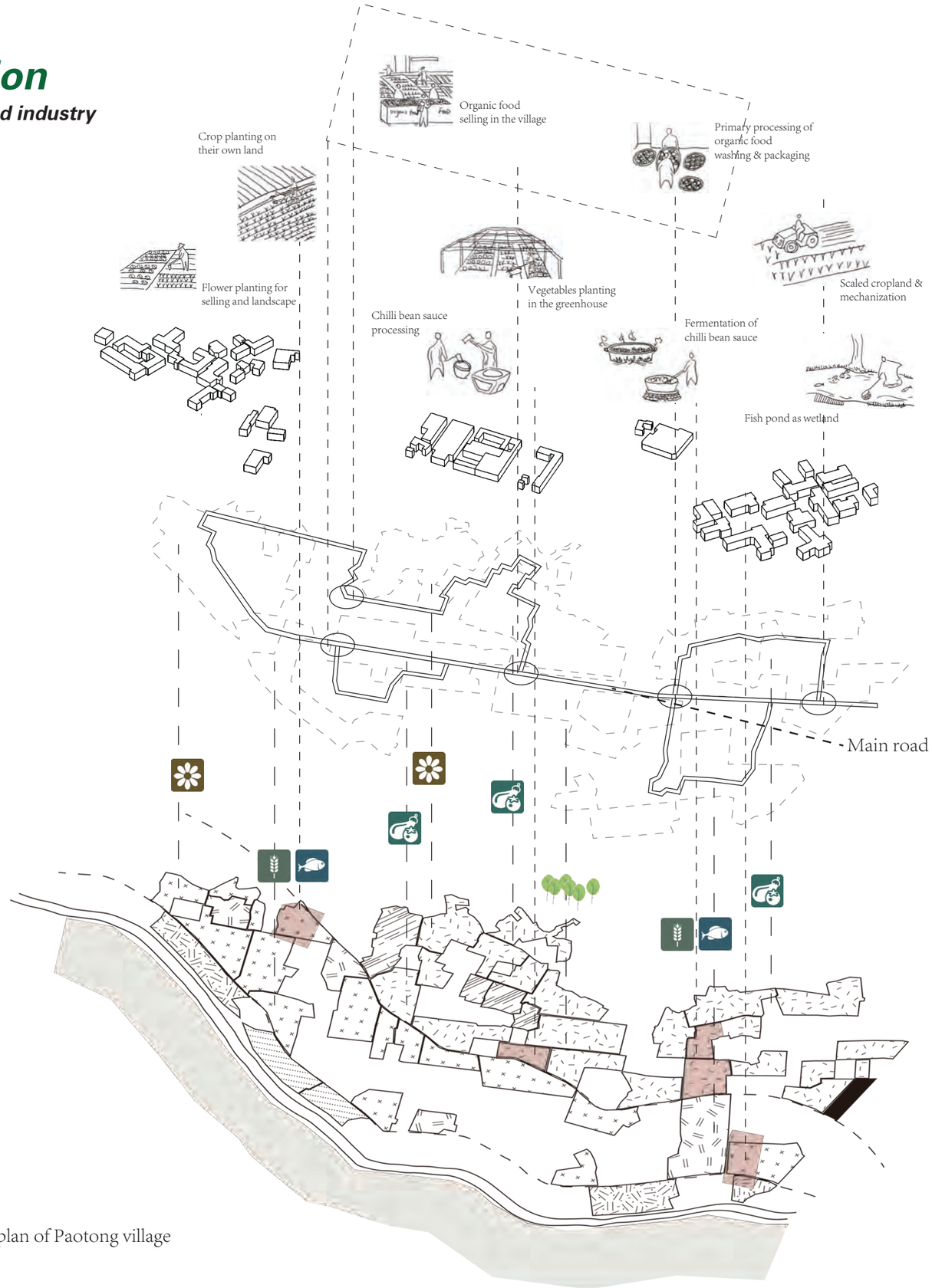


Fig 9.2.2 : Production cooperation plan of Paotong village

Who is planting

According to the crops planted, the villagers form a new cooperative group to jointly realize scaled planting. On this basis, the same group of villagers conduct primary processing and establish local brands to enhance the fame and added value of the products.
The choice of vegetable planting can rely on the needs of the food processing plants in the village and the Sichuan Vegetable Industrial Park to grow broad beans, peppers, etc.

Logistics route

The logistics lines cover the main agricultural crop production areas, relying on existing roads and food processing plants. The primary processing is set at the junction node.

Decide what to grow

In the productive plot, according to the original land planting situation, the integration was carried out, creating a more concentrated and scaled planting. For example, the riverside is still dominated by food and fish ponds, the upstream continues to grow flowers, and the vegetable base is established in a place with better ecological conditions.

This process is based on environmental conditions and villagers' wishes, and at the same time integrates to achieve large-scale production, forming the foundation for the food processing industry and the establishment of organic food brands.

The main road and canal

The important facilities of the production landscape in the village are inserted into the main roads and canals. The first production node near the entrance is the village level logistics distribution centre, which is responsible for the transportation of green agricultural products and processed products in the village. But it also has the function of displaying and selling products.

The two chilli bean sauce processing plants in the village will have the opportunity to keep and continue to produce, and become a semi-display place. The required raw materials are sourced locally and purchased from the village.

In addition, along this axis, there are other places where products are initially processed and packaged, which can be displayed and sold at the same time to increase the value of products.

Along the main canal, there are vegetable greenhouses, saplings, vegetable planting, rice planting and flower fields, forming a rich landscape.

This main axis is also the main route for one-day outings on weekends to attract tourists and promote local green agricultural products.

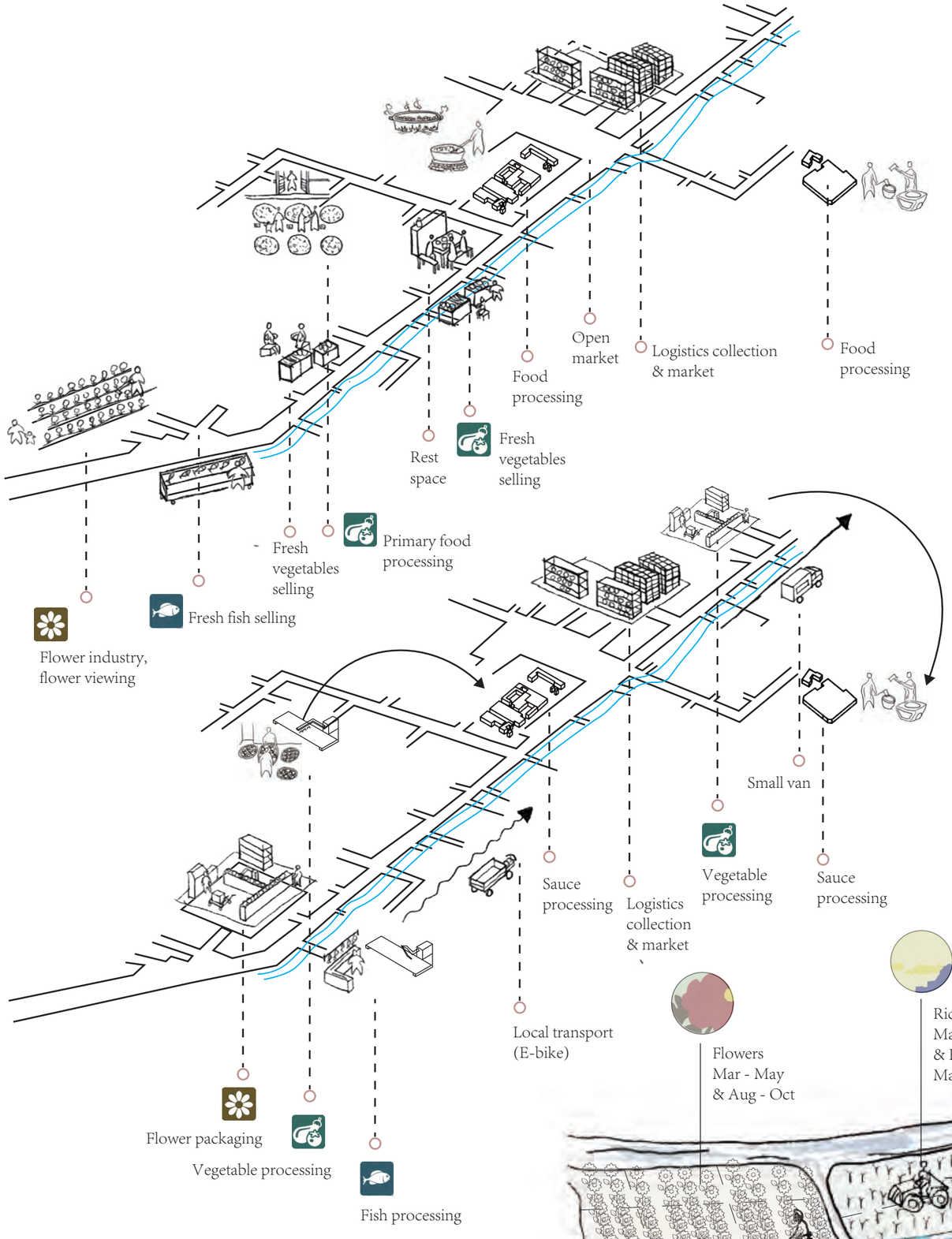


Fig 9.2.3 Production and sale along the main street

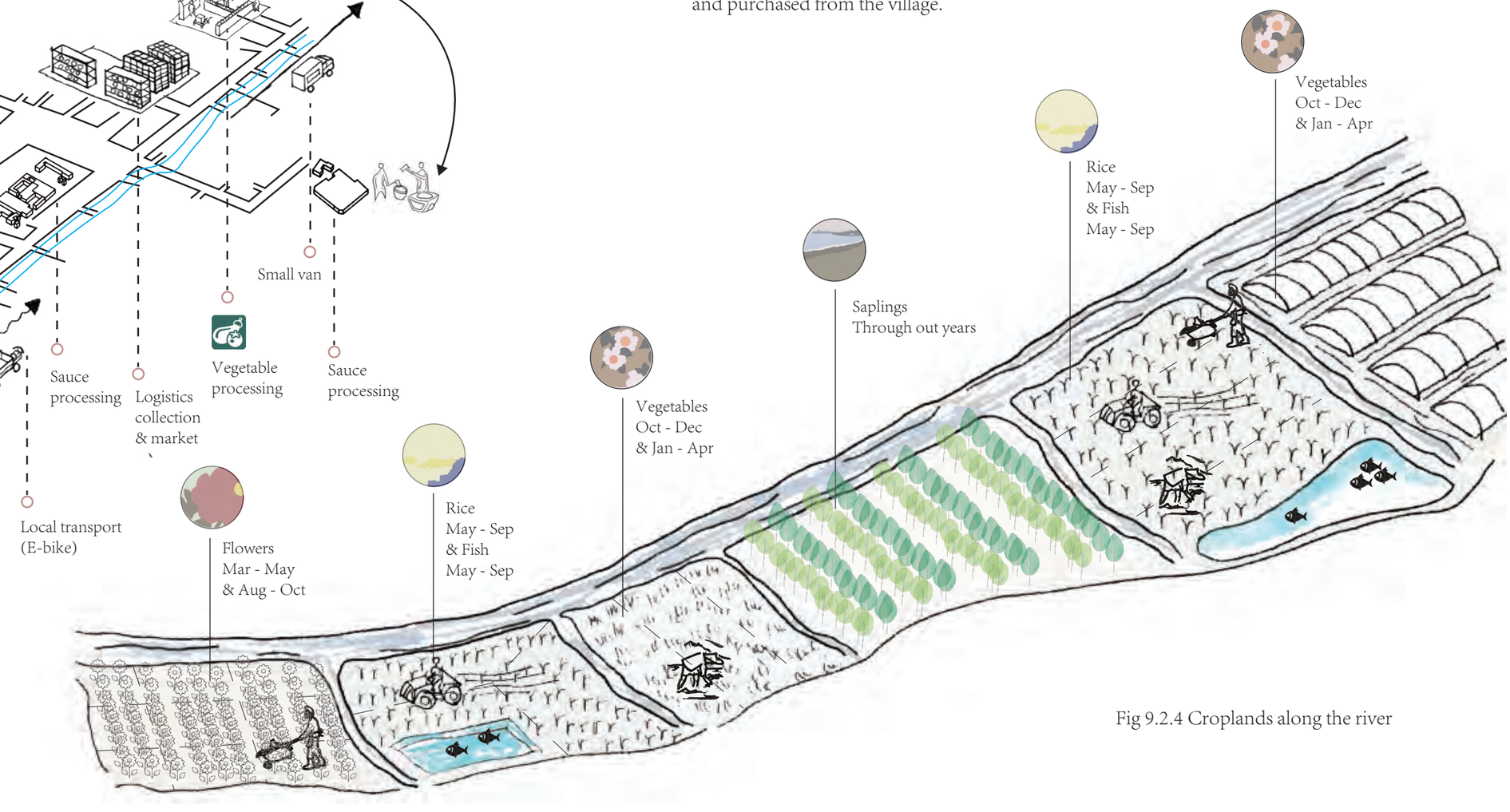


Fig 9.2.4 Croplands along the river

Vegetable and chilli bean sauce in the village and sales distribution

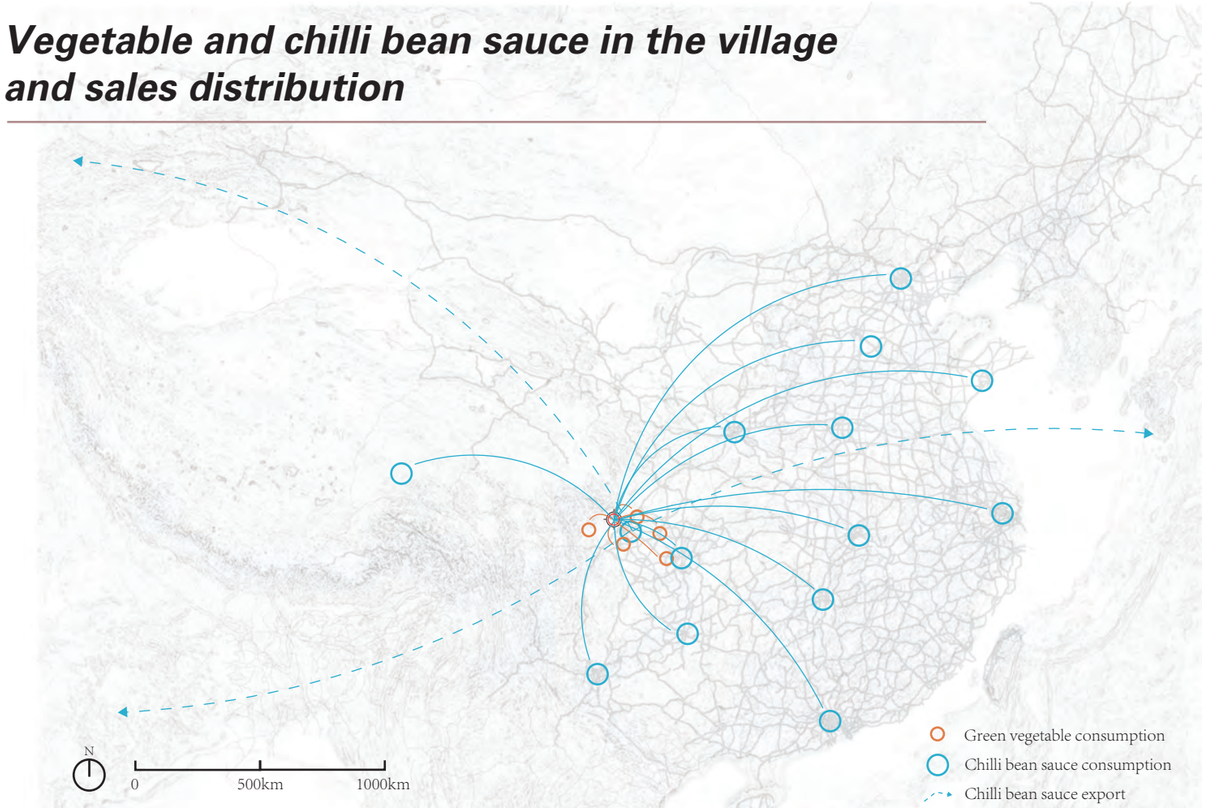
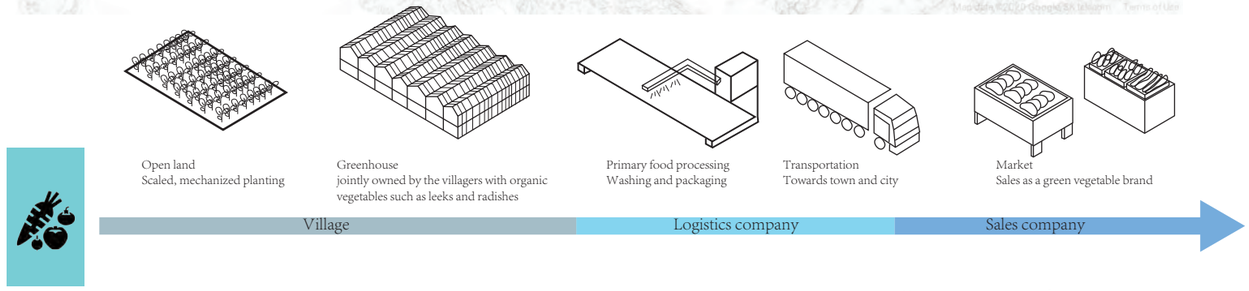
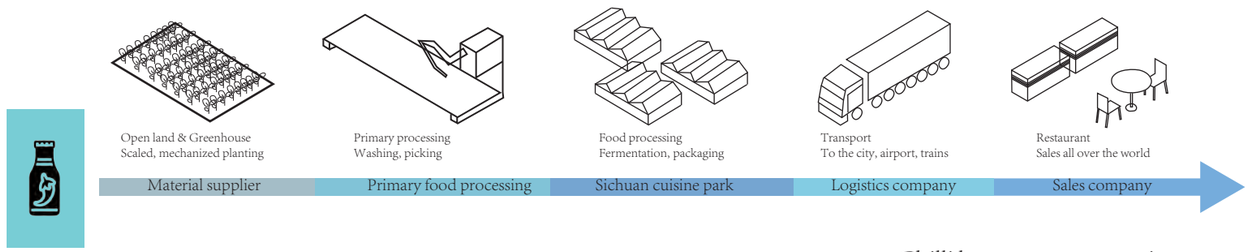


Fig 9.2.5 Chilli bean sauce and vegetable sales distribution



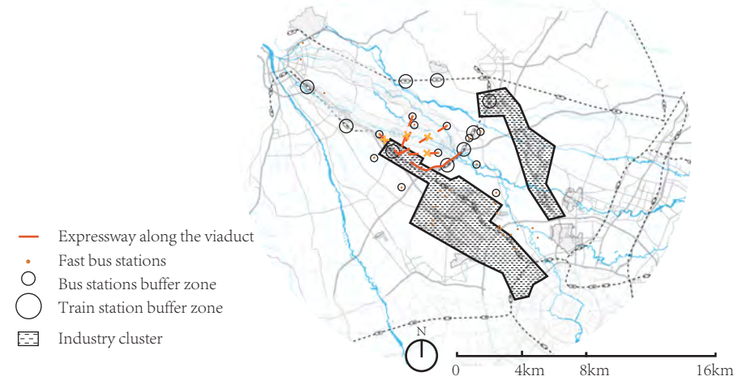
Organic agriculture processing



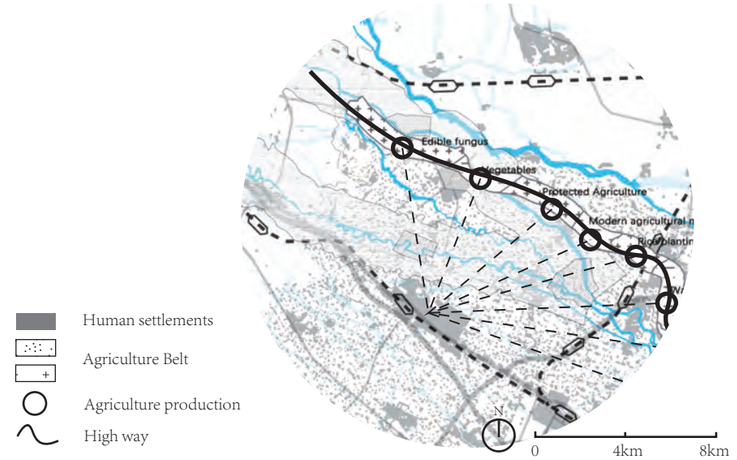
Chilli bean sauce processing

The village will also occupy a further position in the supply chain, thereby increasing income.

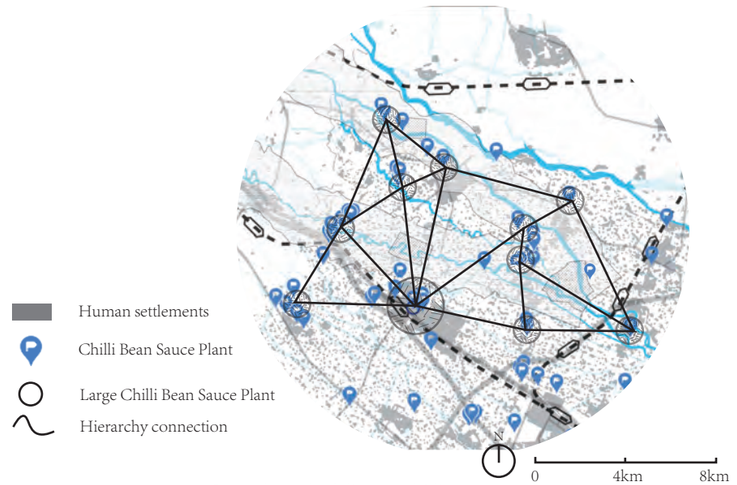
Fig 9.2.6 Organic food and food processing industry



Transportation connection



Agriculture cooperation between villages



Local brand of diverse chilli bean sauce

Fig 9.2.7 Regional support for local development

Agricultural production and sales

The busiest main street has the largest chilli bean sauce processing plant in the village. The processing plant is semi-open, and it is also a display space for rural industries. Adjacent to the processing plant is the place for the primary processing of several vegetables and the agricultural product sales booth.

This is a combination of production and sightseeing, as well as a display interface for rural charm.



Fig 9.2.9 The scene of the green vegetable market

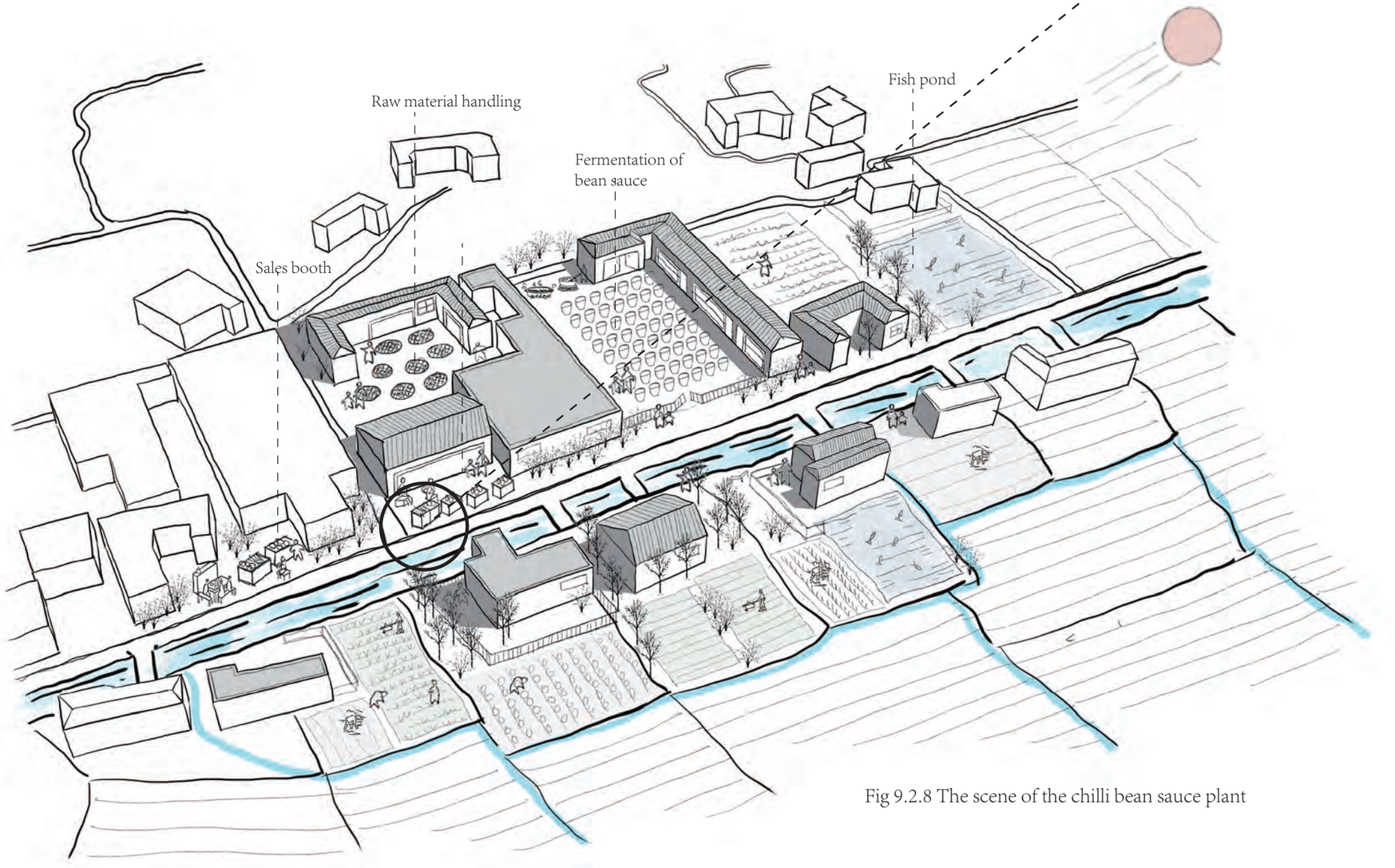


Fig 9.2.8 The scene of the chilli bean sauce plant

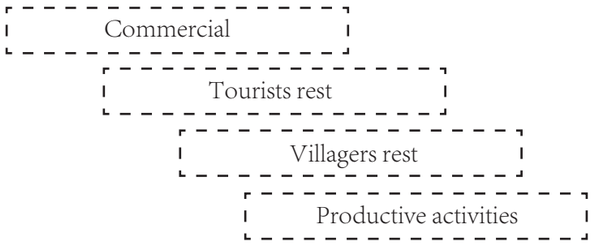


Fig 9.2.10 Multi-function public space

Commercial spaces in villages are usually multi-functional places where people can gather and gain public services. The chilli bean sauce plant on the main street will not only be a space for agriculture production sales in the village, but also space for villagers to gather and chat and relax.

Tourism

Agricultural landscape tourism

Local tourism development

Pidu District hopes to rely on its own water culture and agricultural landscape to develop a regional tourism industry, and arrange hotels, sightseeing, commerce, etc. Most of the villages located in water conservation areas are also located in the tourism development belt of this region.

Paotong Village is also a part of it. In the layout of the whole tourism line, the main development is agricultural landscape, ecological trail, camping site and waterfront landscape. In Scenario I, due to new environmental conditions and protection requirements, Paotong Village has made some adjustments, mainly developing agricultural landscapes, experiential agriculture, vacation and long-term rental tourism. Therefore, tourism is mainly divided into three types, weekend trip, vacation house and second home, which refer to different rural experience needs. At the same time, this is also the development sequence of the tourism industry, from accumulating popularity to enriching tourism products.

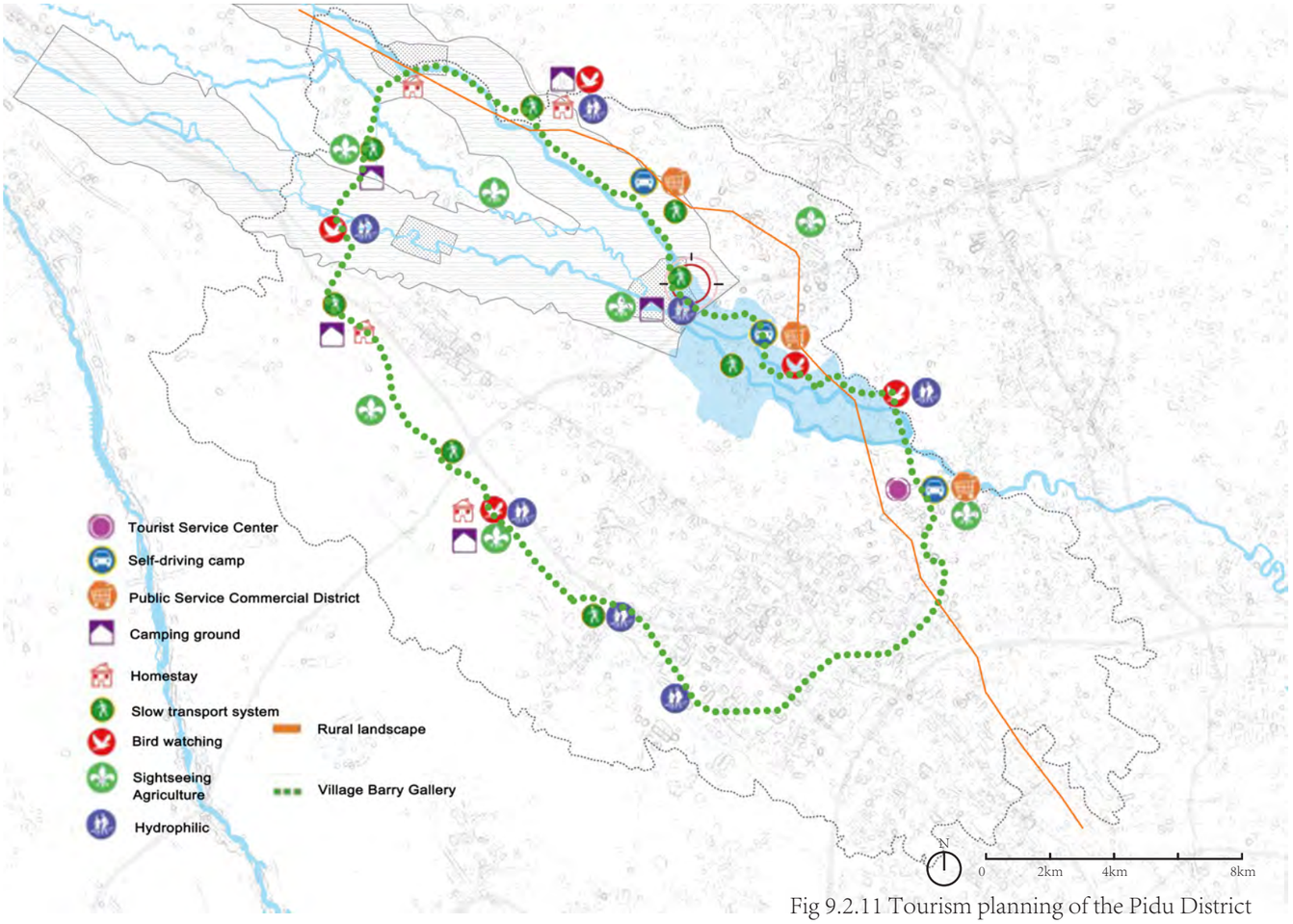


Fig 9.2.11 Tourism planning of the Pidu District
Source: BES Culture and Tourism Group (2012)

Types of tourism

Two-day weekend trip





Flower sightseeing



Sketching activity

Summer vacation house





Planting



Fishing



Picking

10 years long-term lease
Second home





Idyllic scenery



Leisure activities



Tea tasting

Distribution of tourism plots

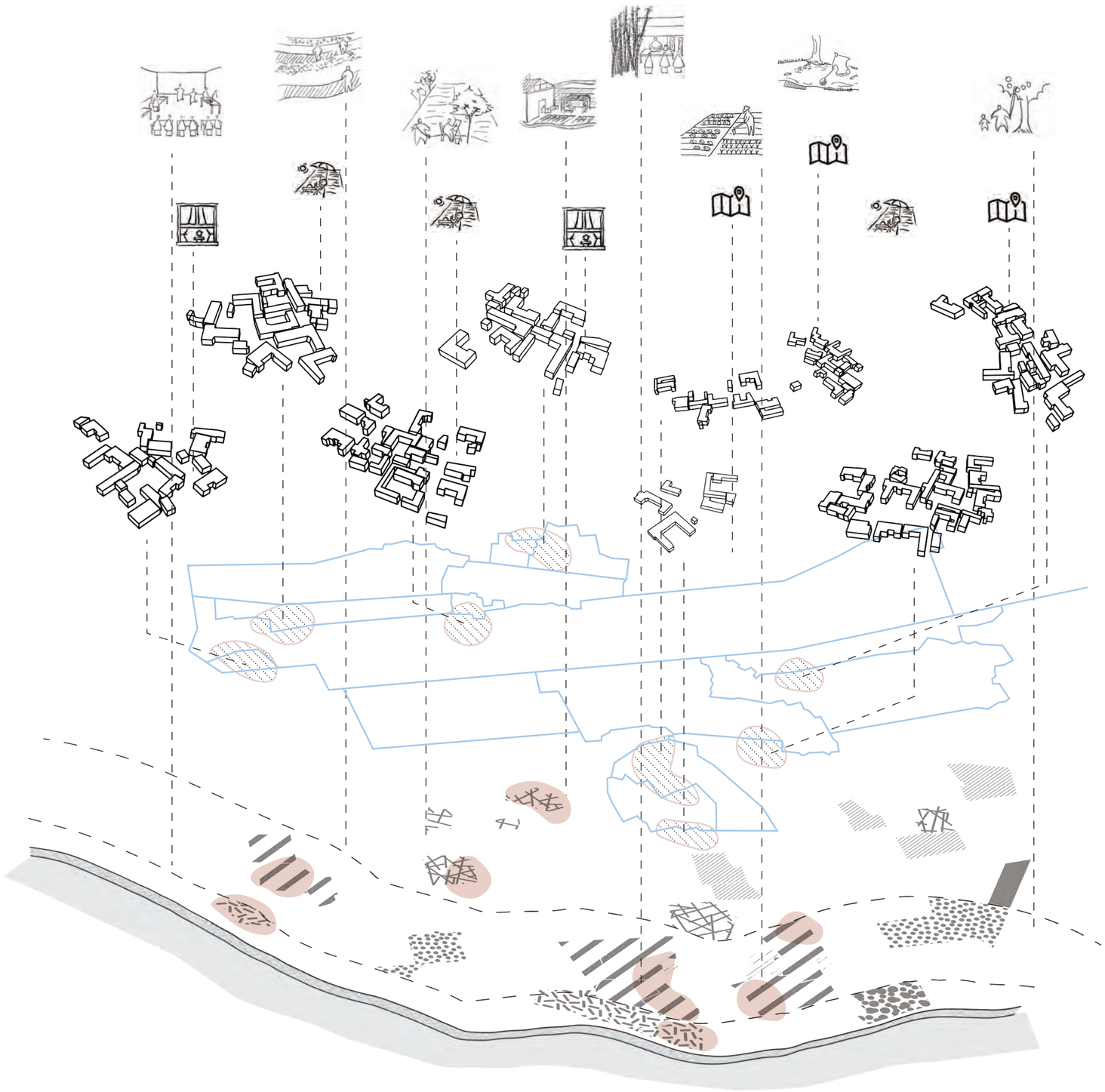


Fig 9.2.12 The sightseeing plots in the Paotong Village

Weekend trip

The plots by the river, there are old houses, fields, and the crooked canal

Vacation house

Located in a more private place with complete facilities for short vacations.

Second home

Property long-term rent, acting as a second home, the owner has the freedom to renovate and build his own residence

Getting things in order.
1. Increase attractiveness
2. Improve product value
3. Diversified formats

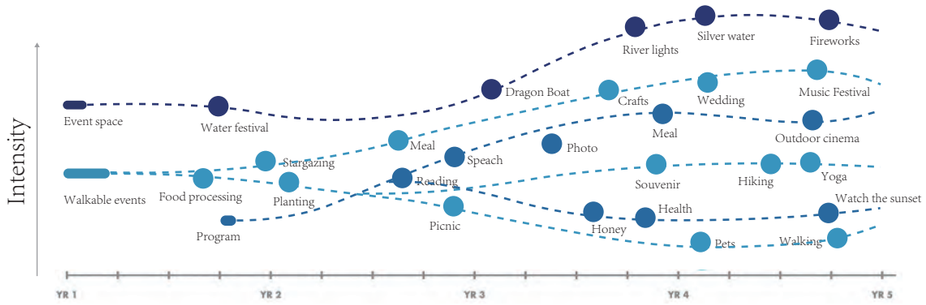
Transport system

The travel route consists of a widened water system, and boating becomes the main mode of transportation, linking homestays, old houses, flower fields, and riverbank, etc.

Plots selection

Sightseeing-oriented plots are selected.

8 plots are selected for tourism development, in which 30 houses would be renovated. The main form of tourism is the experience of rural life and homestays. These tourist facilities are closely integrated with the living environment of the villagers, sharing the scenery and public life. Only the form of long-term rent has a higher privacy space.



Diversification in time (diversified performance / increased potential)

Fig 9.2.13Activities in the village throughout phasing

Design testing plot of tourism

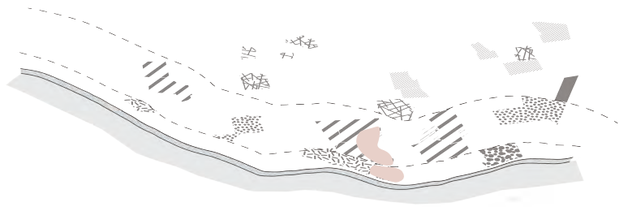


Fig 9.2.14 Location of the testing plot

The selected test area is located in the middle of the village, most of which are located in the second-level protection area, and some houses have entered the first-level protection area. There is a traditional canals system and preserved vernacular building, which is a typical characteristic of western Sichuan wooded plot and can provide a good reference for other settlements.

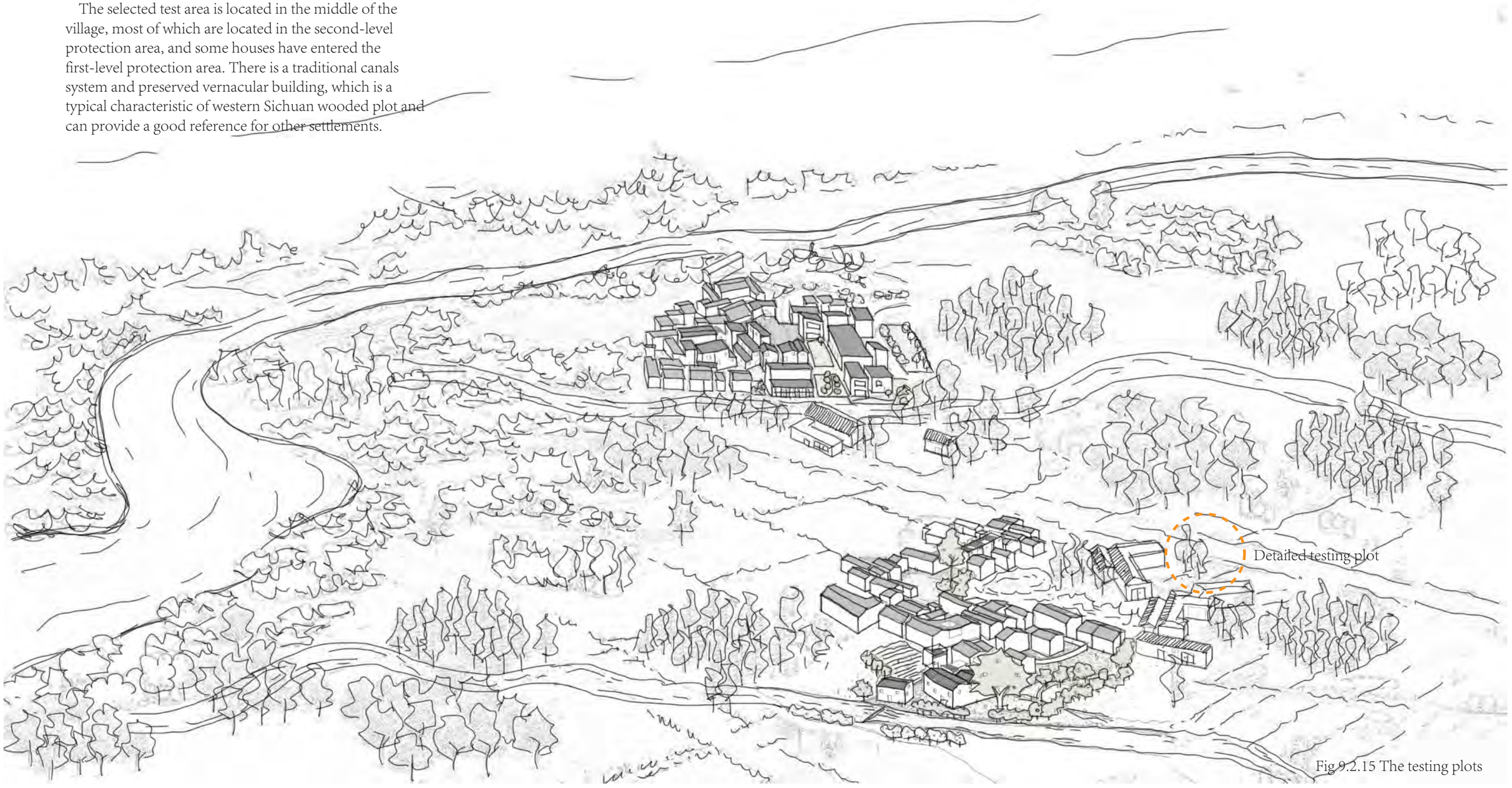
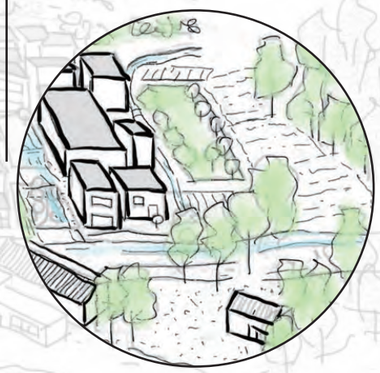


Fig 9.2.15 The testing plots

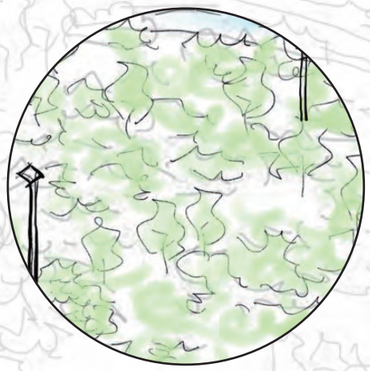
Landscape & Public spaces

Several typical scenes are included in this test plot. After the implementation of the compensation balance, the area by the river bank is mostly giving back to the natural forest. The settlement combines the needs of tourism development and the needs of the villagers to improve their living conditions, setting up improved fruit forests, fish ponds, leisure spaces, etc. In addition, there are plots of vegetable products which are also a close part of the villagers' lives.

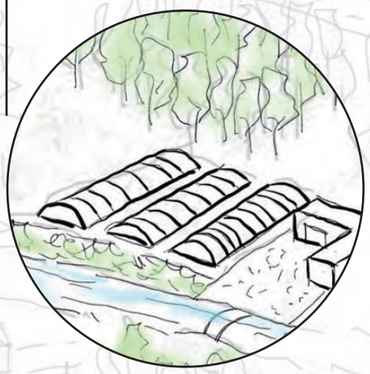
Private natural vegetable farm
Weekend trip, homestay



The protected area, natural vegetation
The automatic environment detection system



Green vegetable production
Preliminary product processing, transfer node



Public space within the plot
Fish pond for both production and little climate



Open market
The vegetable field for villagers' own



Fig 9.2.16 Detail of the testing plots

Tourism plot example

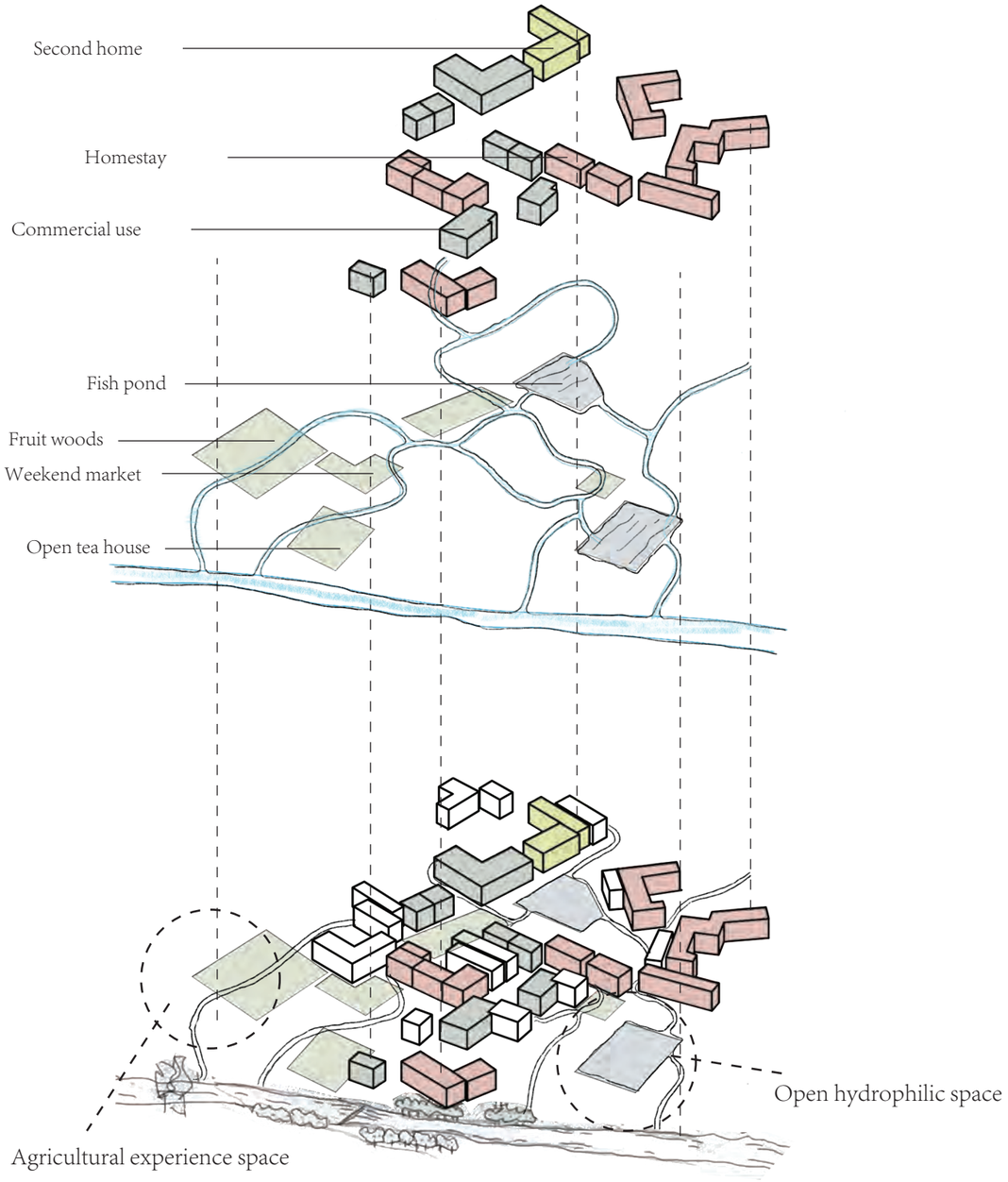


Fig 9.2.17 Functions and canals system
of the houses in the example sightseeing plot

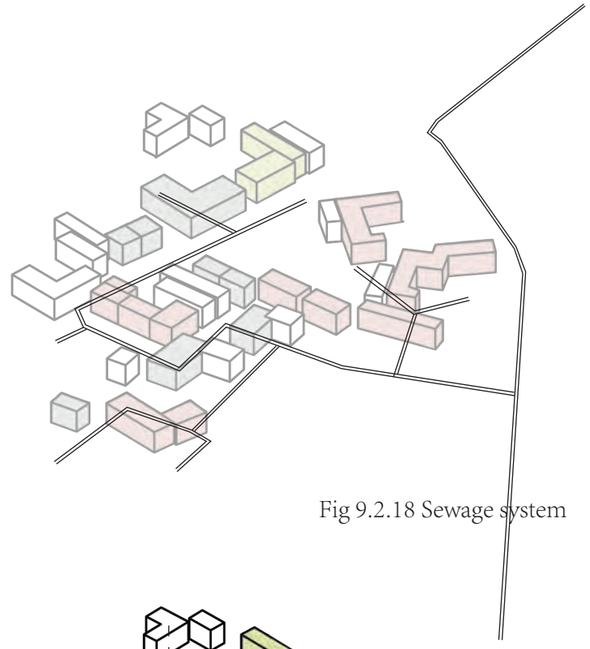


Fig 9.2.18 Sewage system

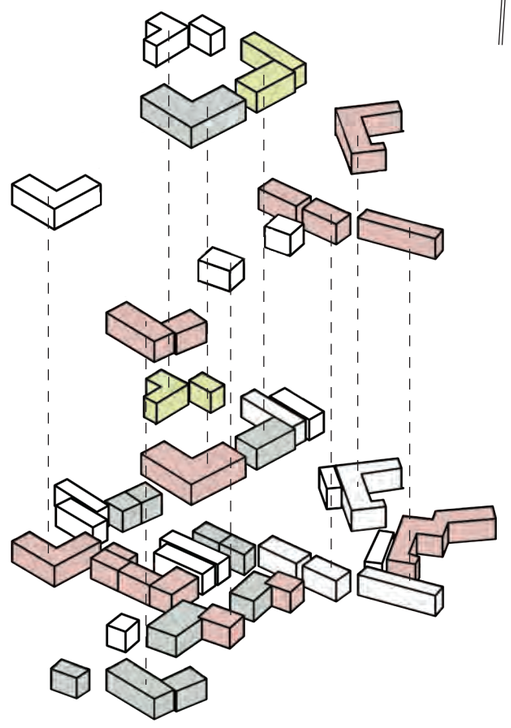


Fig 9.2.19 The flexibility of the tourism development

This tourism plot example shows the distribution of different types of development. The tourist commercial space is close to the public space and landscape, and the second home is located in a more private location.

In addition, based on the existing canal system, the new canal will be expanded, linking fish ponds, fields, fruit trees and activity spaces in settlements, shaping hydrophilic spaces and enhancing the attractiveness of the landscape.

The sewage system and domestic water pipes will be connected to every household in the plot while considering the shortest distance to save costs.

Besides, a flexible tourism development system is settled here. For example, if one family does not want to be involved in the tourism industry, then this family has the right to choose. At the same time, neighbouring families may join this development. The willingness of the villagers is taken into account at this level, which will not affect the development of the entire plot.

The business in the settlement will also follow the traditional model in the village, relying on the courtyard of the building and the living room facing the street for development.

Open hydrophilic space

The waterfront space on the south side of the test plot is an important open space. Surrounding this important leisure space are three homestays and shops, serving people who travel here.

Obeying the traditional way of living with water, the canals system consists of the basis of the open space, linking the fish pond and paddy fields as well. There are grassland and woods in the middle and facilities for water activities adjacent to fish ponds and rivers. The section of the fish pond shows the place that people could touch the water. Farmland is on the east side, mainly landscapes such as flower fields.

The most important event space relies on the garden of a homestay with bonsai and tables. It is not only an open restaurant but also a venue for chess and card activities, which is traditional and common entertainment in the village. The homestay is converted from a traditional house and is a part of the village's house.

In conclusion, this plot complies with the villagers' traditional lifestyle, which is in line with the rural life experience tourism.

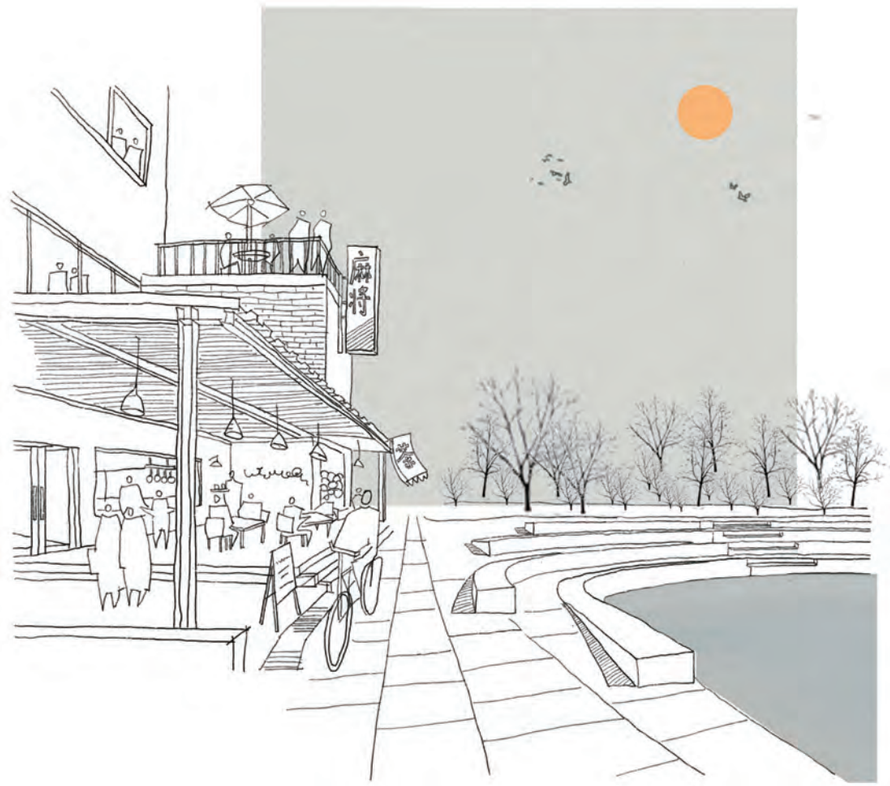


Fig 9.2.21 The public square and fish pond

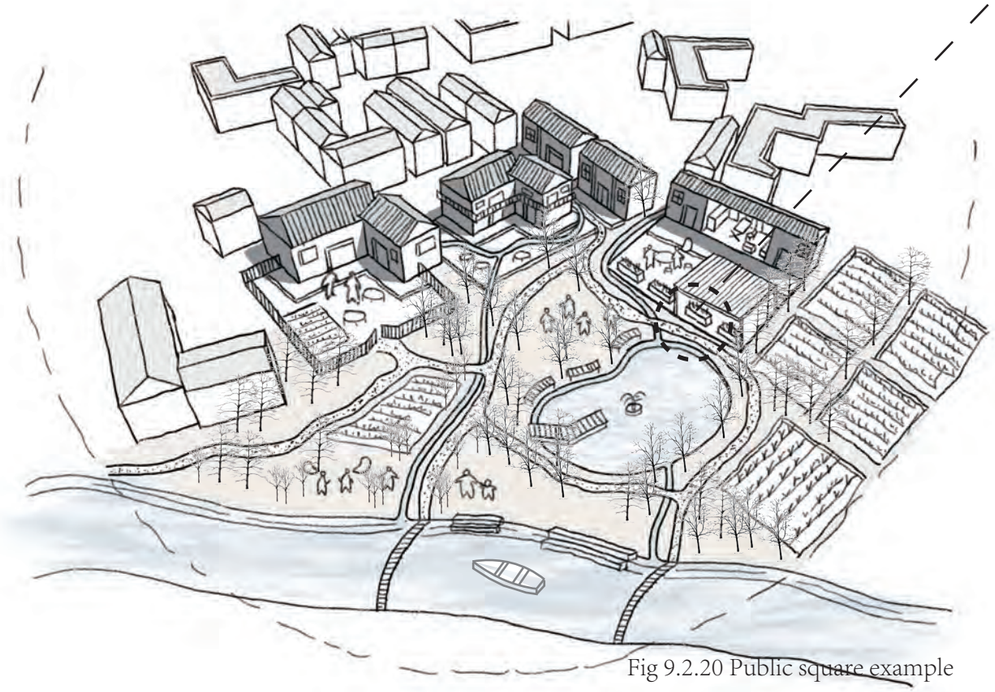
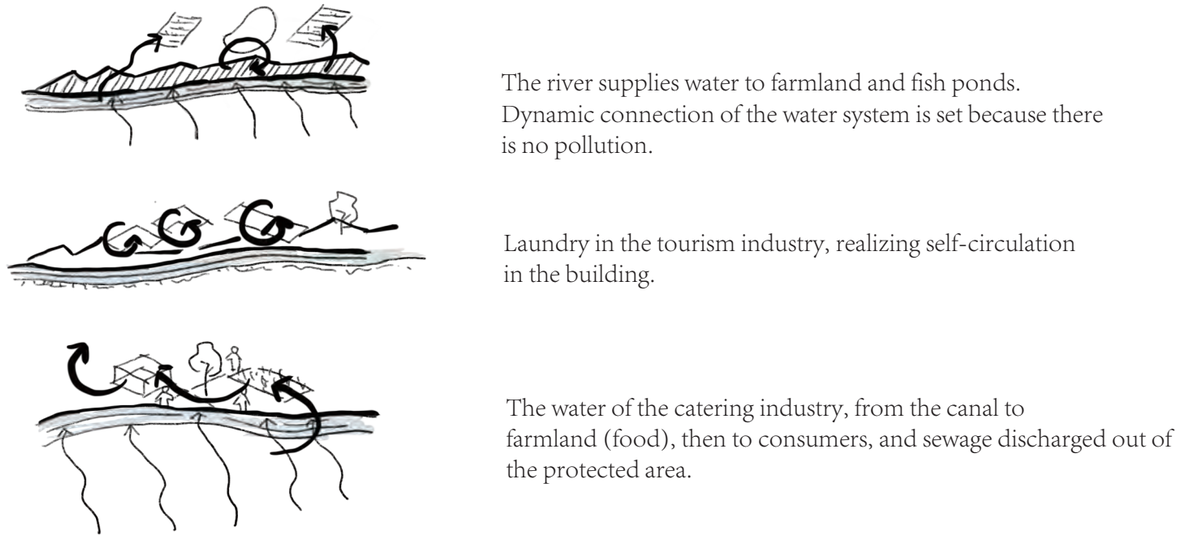


Fig 9.2.20 Public square example



The river supplies water to farmland and fish ponds. Dynamic connection of the water system is set because there is no pollution.

Laundry in the tourism industry, realizing self-circulation in the building.

The water of the catering industry, from the canal to farmland (food), then to consumers, and sewage discharged out of the protected area.

Fig 9.2.22 Water circles

Agricultural experience space

On the other side of the sightseeing plot, there are more traditional agricultural experience projects. In addition to the hydrophilic landscape of the water village as always, there are also fruit forests, weekend fresh produce markets, and picking gardens. Experience the leisure life where all the ingredients are taken from the nearby fields.

Besides, the water used for the initial processing of vegetables and irrigation water is re-entered into the canal system through a wetland. This is also a falling water landscape.

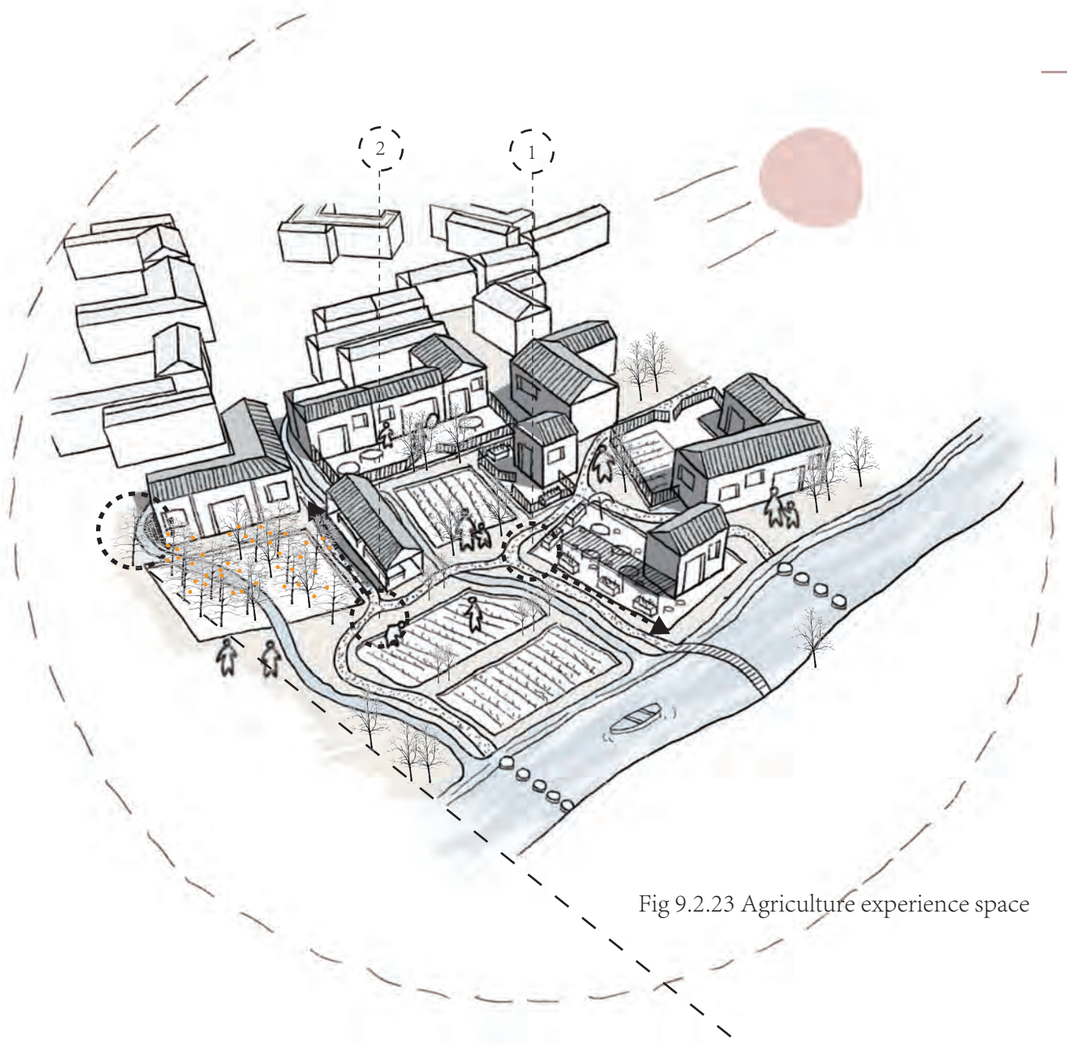


Fig 9.2.23 Agriculture experience space

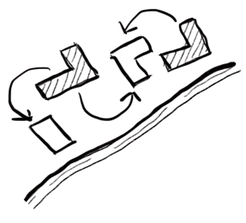


Fig 9.2.24 Homestay and shops

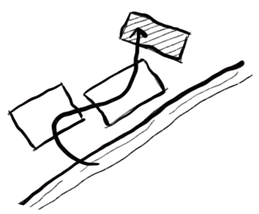


Fig 9.2.25 Production flow

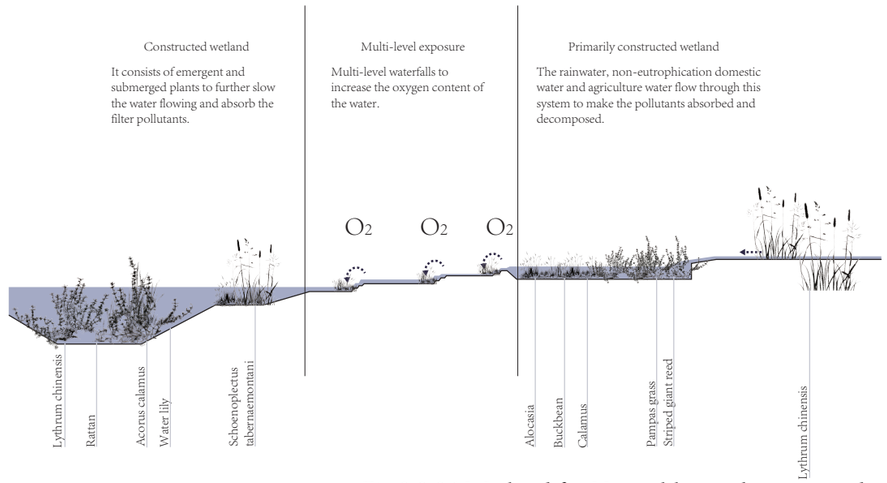


Fig 9.2.26 Wetland for Vegetables washing water dealing
Source: Hu, Zhang, & Wang (2014)

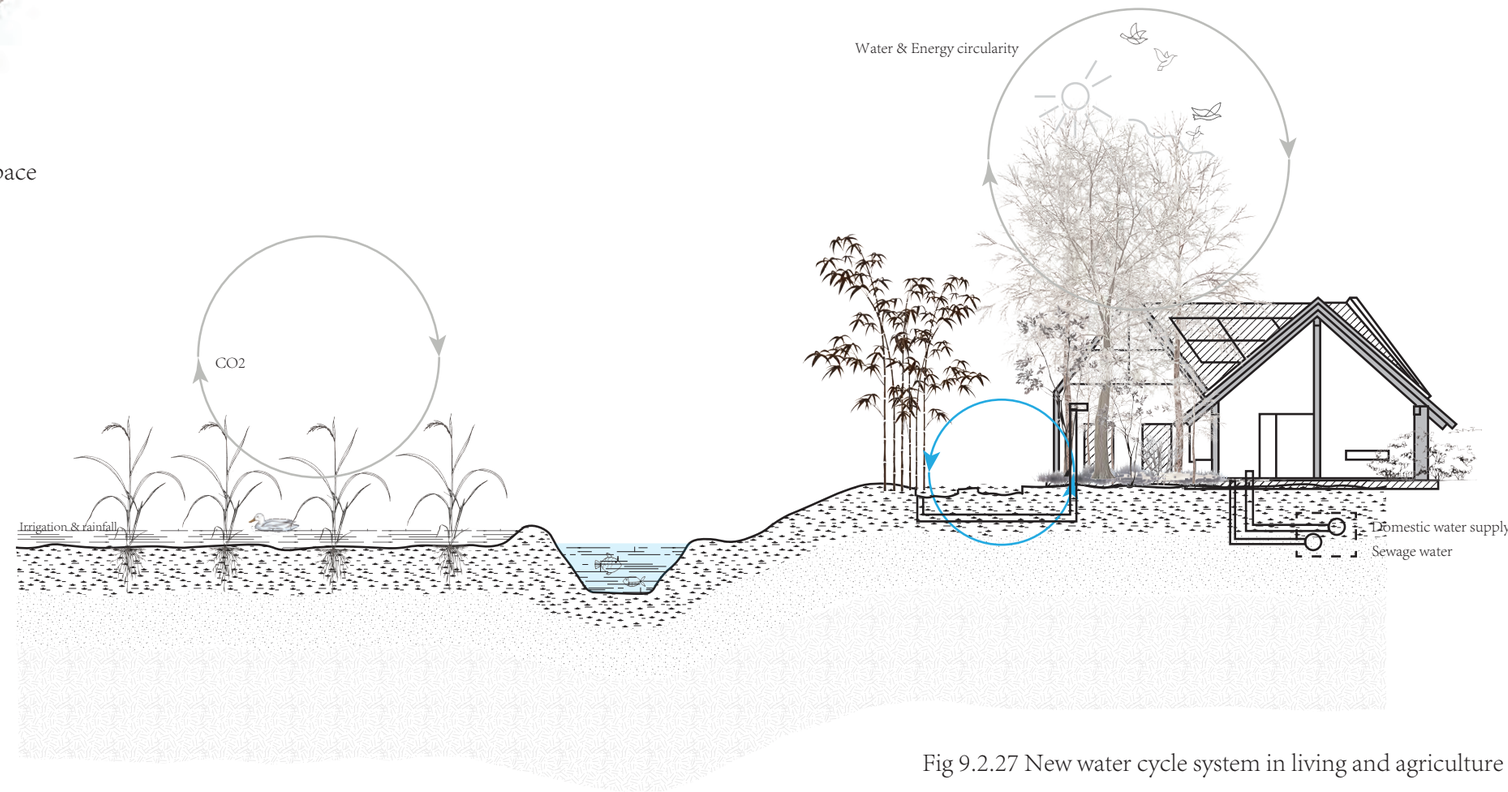
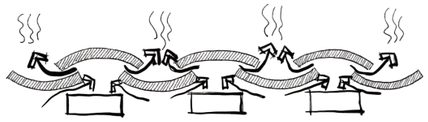


Fig 9.2.27 New water cycle system in living and agriculture

Leisure space and open market

Relying on the public space formed by the existing store, it has been updated and organized to set up a new rest space, while respecting the hobbies of the villagers' leisure activities. The flower beds and hardened roads are all recycled materials made from houses renovation. House retrofitting and renovation uses traditional local building materials to reduce virtual water consumption.

An open market is newly built on the original open space. It provides a place for agricultural products trading to serve both the villagers and tourists. This is also an activity space for villagers to communicate. Orchard is an open space and has become an experiencing project in the tourism industry chain. The use of materials still follows the principles of using recycled materials and localization. It not only maintains the style and appearance of traditional villages but also saves water resources.



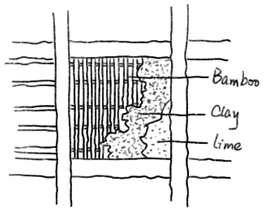


Fig 9.2.28 Materials and tiles

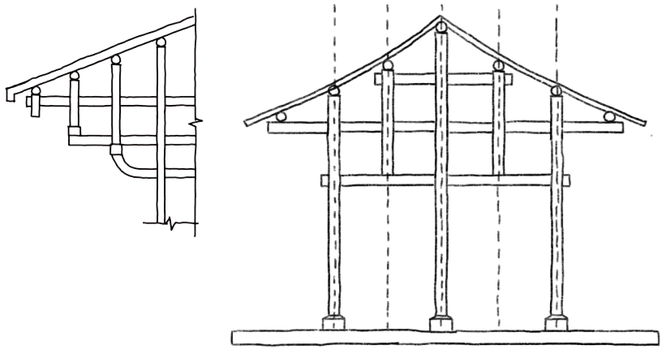


Fig 9.2.29 Structure and eaves

cardboard
timber
metal
glass
gravel
brick
concrete

1

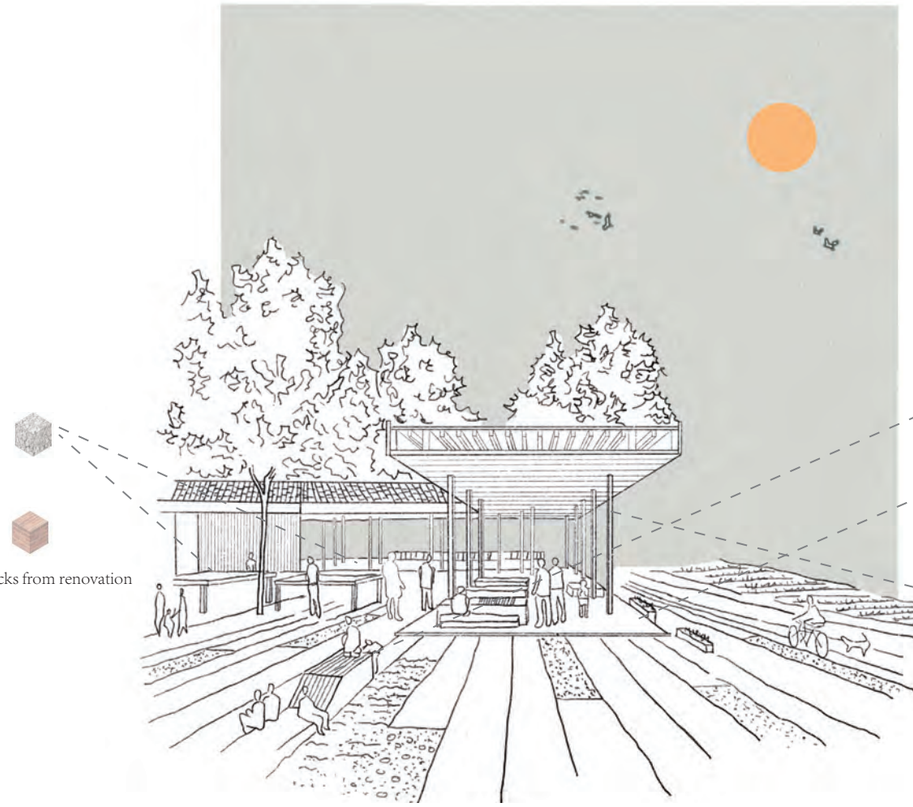


Fig 9.2.30 Leisure space for the villagers

2

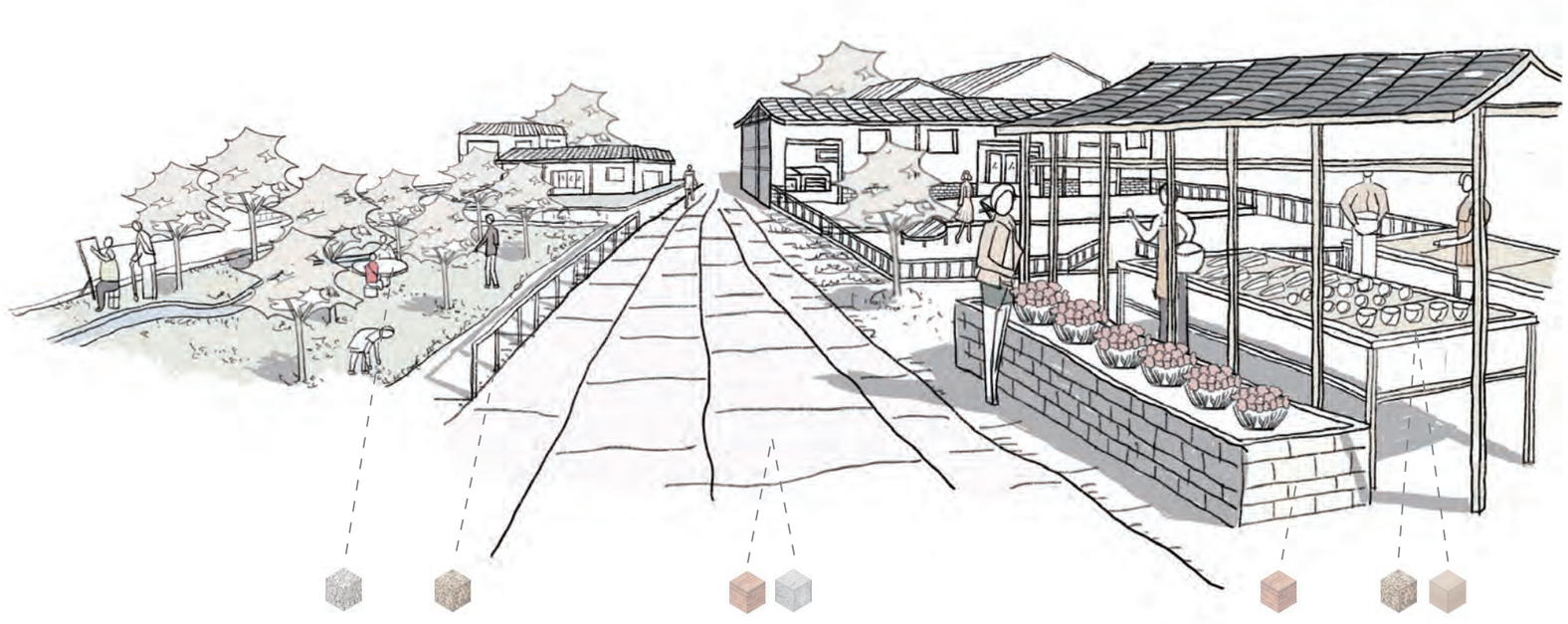
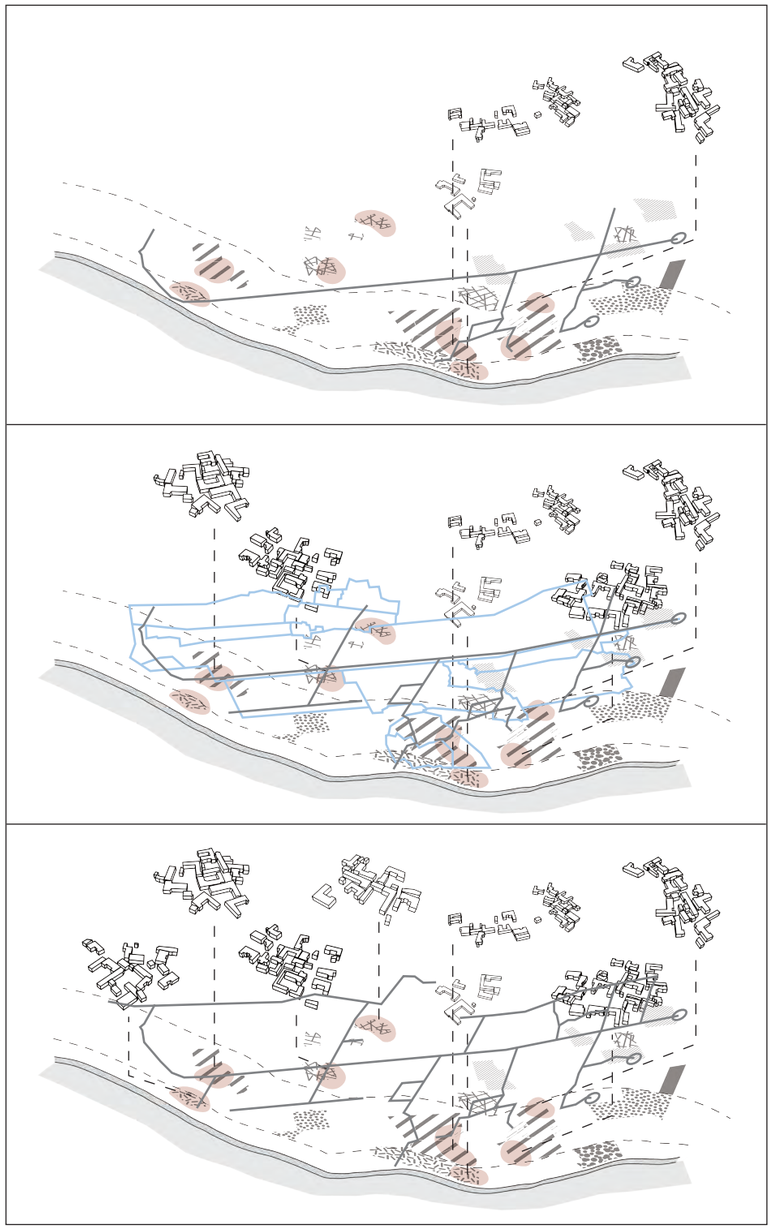


Fig 9.2.31 Open market and orchard

Local tourism development



In 3 years
1.Geological survey, pipeline design
2.Weekend trip sewage; water supply pipeline
3.Weekend trip plot renovation
4.Parking lot
5.Converting farmland to forest, soil erosion prevention

In 5 years
1.Resort renovation
2.Resort sewage; water supply pipeline
3.Construction of resettlement houses
4.Widen Canals
5.Converting farmland to forest

In 8 years
1.Second home renovation
2.Finish sewage; water supply pipeline
3.Woodland conservation

Local production development



In 3 years
1.Chilli bean sauce factory renovation, sewage facilities
2.Green vegetable industry
3.Green rice and fishery

In 5 years
1.Productive plot renovation
2.Vegetable sales industry chain
3.Open market in the village

In 8 years
1.Flower plantation
2.Flower sightseeing industry
3.Other productive plots renovation

Fig 9.2.32 Phasing of scenario I

Phasing

Scenario I

The construction of the village is carried out in stages. In the first three years, the pilot project was the priority, the sightseeing plot for weekend trips was built, and the tourism brand was established to attract tourists. At this time, sewage and domestic water pipe mainly serve these two settlements, and the main pipeline in the village has been built. Industrial development focuses on the production of chilli bean sauce and solving the pollution problem, as well as the fish-rice symbiosis field and the green vegetable industry.

In 5 years, the tourism industry has further developed rural vacation tourism, and the water supply and sewage pipes have been further constructed. The industry focuses on the development of sales channels for geographic brands.

In 8 years, the tourism industry has been included in the second home, and the structure is basically complete. In the industry, the development of flower planting and viewing will further enhance the attractiveness of rural tourism.

Engagement of actors & timeline of scenario I

Different actors play different roles in the development process of the village. The designers, engineers and government are in charge of the water supply and sewage system, which is the basic and first step. Then the hydropower stations, tap water plant step in to assist the villagers renovate houses and build the facilities for both tourism and productive activities. The NGOs mainly act as a supervisor for the water conservation and ecology requirement in the after-construction stage.

Throughout this process, all actors do their job and the villagers are taking part in almost every step to make their voices heard. Besides, a dynamic feedback and information system is established by the government, tap water plant, NGOs and villagers.

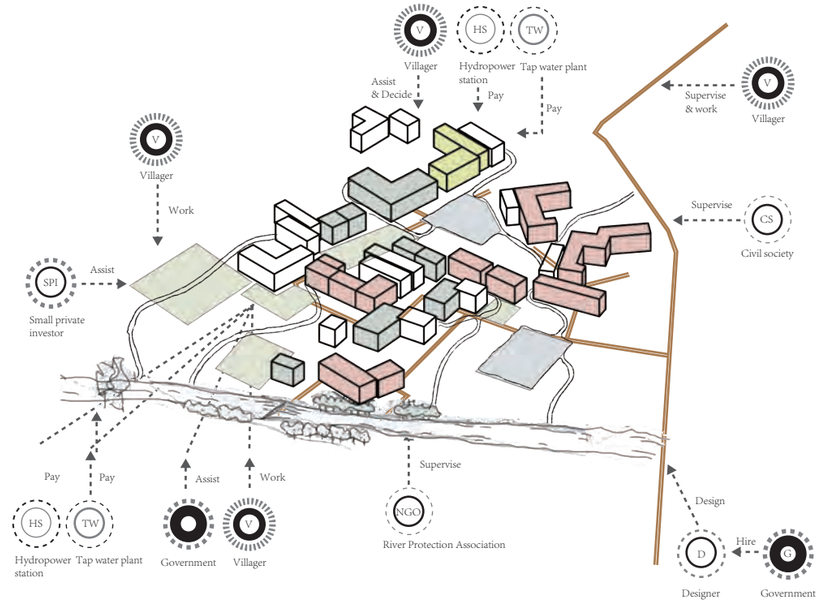


Fig 9.2.33 Actors in the tourism plot development

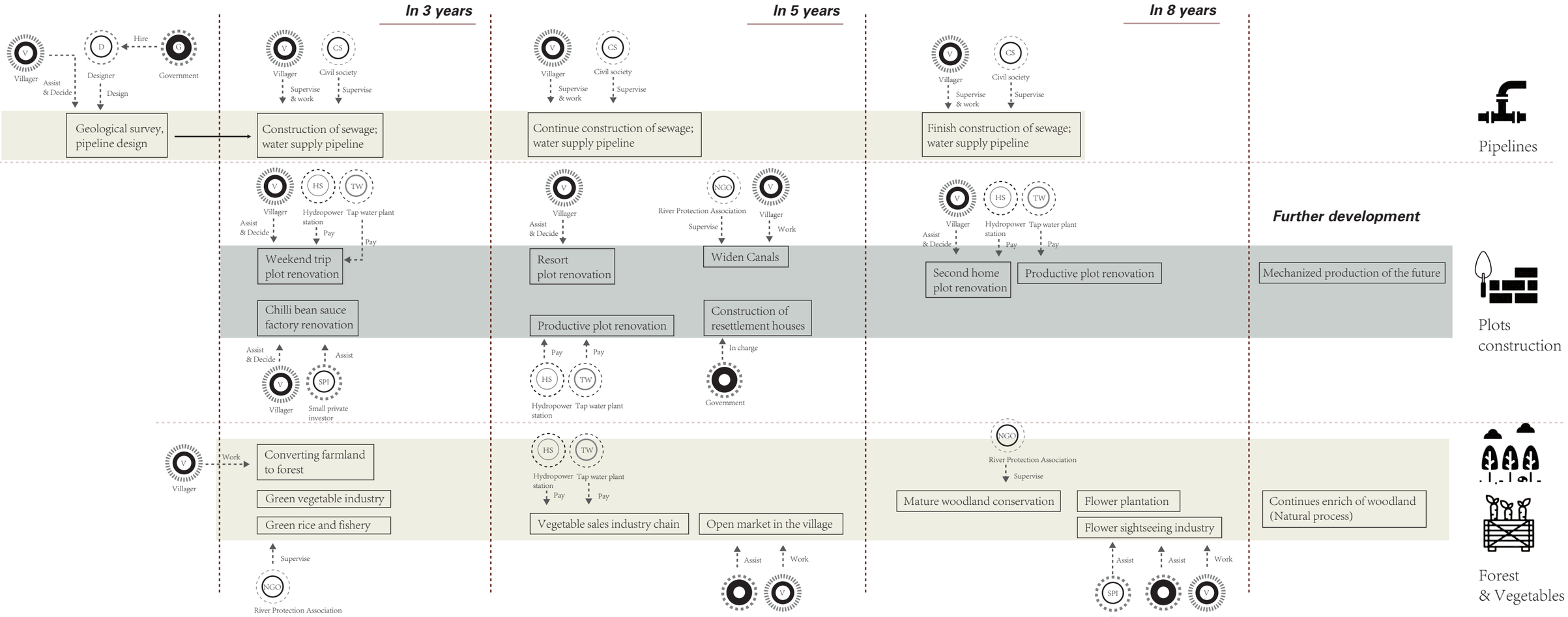


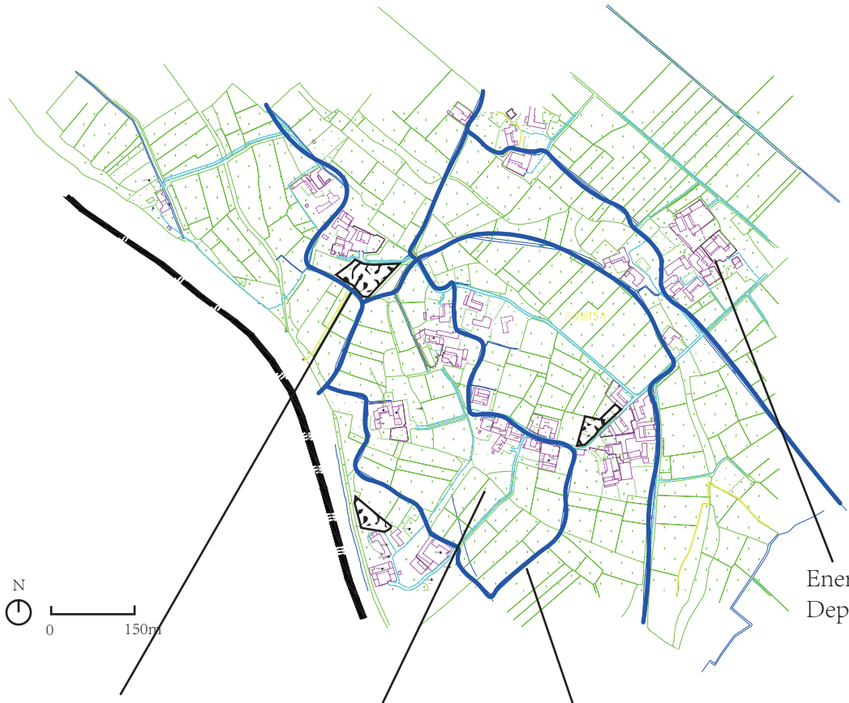
Fig 9.2.34 Actors and timeline of scenario I

Reward mechanism for active participation

This reward mechanism is aiming to encourage the villagers to actively participate in achieving the goals of the water circularity. Throughout the scoring system of 5 aspects, measure the engagement level of the plots. Then based on the score, providing a discount on the domestic and irrigation water price.

Encourage the villagers to
1.thriving wetland (fish ponds, household wetland)
2.Maintain natural canals
3.Bio-energy use
4.Economic cropland - increase biodiversity index
5.Community-based monitoring

Those five parts account equally for 9 points.



Energy use conditions of the 51 households there.
Depend on the percentage of using bio-energy.

Wetland (fish pond, wetland in plot of 8): total points of 9, how much of it are maintained is counting for the score, if it finishes 3 fish pond and 5 household wetland, then they get 8/11=6.5 points.

Maintain the natural canals, counting from percentage, if 70% of canals maintain natural, then get 6.3 points

Biodiversity of the cropland.
How many croplands are growing more than one plants.

Fig 9.2.35 Reward mechanism
Source: Based on the Nature Conservancy (TNC), (n.d.)

The class scale based on production groups

For justice between the production groups, the total point of a production group would be the same as 45 points. If a community reach the full score of the protection requirement. then they would get a 45% discount on both domestic and irrigation water price.

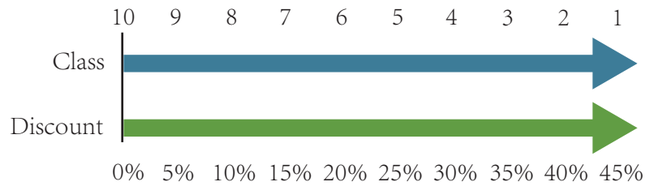


Fig 9.2.36 Discount calculation

Community-based monitoring

Take place within one village and also between villages.

The water resource management department set up clear water rights or quotas and based on that promoting community-based monitoring, to encourage villagers to save irrigation water (Zhang, J. L., & Zhang, F. R., 2008).

Irrigation water exceeding the quota will be deducted in proportion to the total score, for instance, the actual irrigation water use exceeds 10%, then the score would be 8.1.

Management and implementation

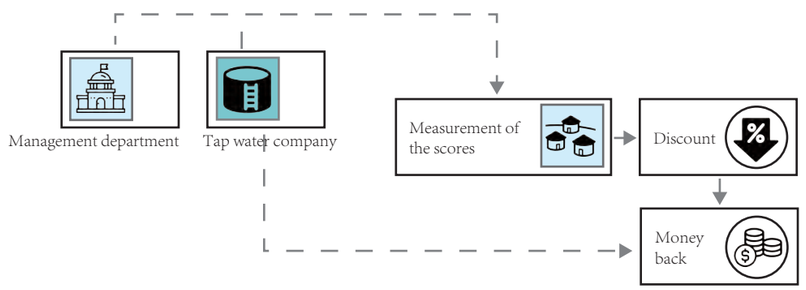


Fig 9.2.37 Paying for the discount

The tap water plant and the irrigation management administration, and the energy company would in charge of this.

Water justice evaluation of scenario I

Domestic water

According to the survey data of two villages in the same town (Sandaoyan Town) that have developed tourism, the average income of the whole village is CN¥ 24,398 per household, of which 75% is contributed by tourism. The 130 homestays in the tourism industry of nearby villages contributed about CN¥ 18,300 of average income, so it can be estimated that in Paotong Village, 30 homestays can contribute about CN¥ 4,200 of income increase.

The relationship between income and domestic water

Y=0.014496X+5.027312
Significance F = 0.00068

The income increase of CN¥ 4200 brought about CN¥ 61 for water consumption, which refers to 20 cubic metres

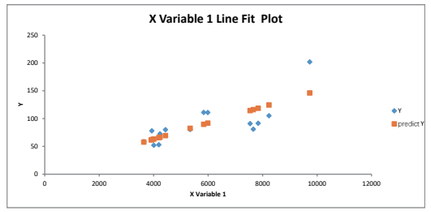


Fig 9.2.38 Income and water consumption

Productive water

According to the profit analysis of the bean paste production plant Xinxiang Food Co., Ltd. at Paotong Village, if it can continue to produce, it will bring about CN¥ 715 per household income increase for the villagers. The upgrading of other agricultural industries, such as the high-yield grain and oil demonstration base, has brought more than CN¥ 6,100 in income to the surrounding villages. Therefore, the green vegetables and other industries in Paotong Village will also have similar benefits.

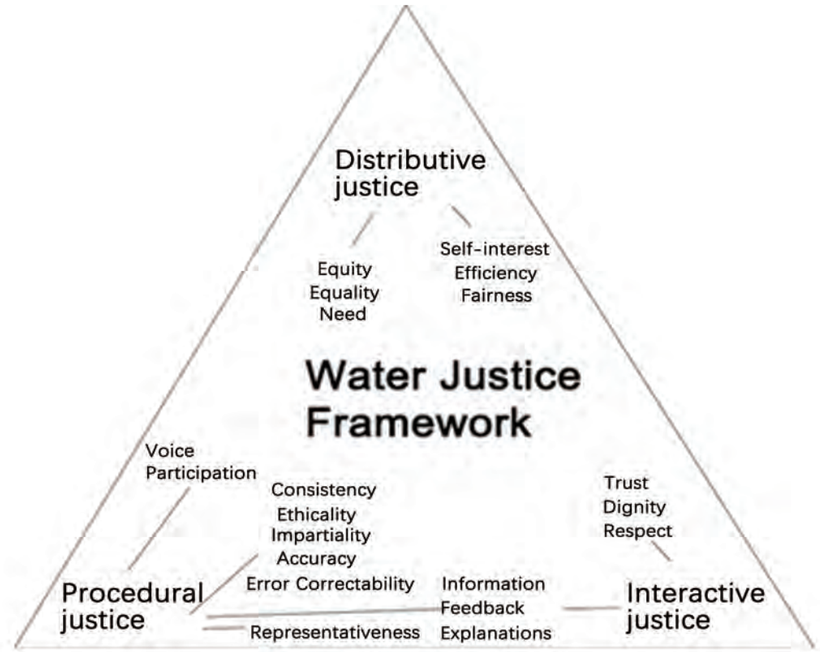


Figure 2.1: Water Justice Framework
Source: Adapted from Lukasiewicz, Bowmer, Syme, & Davidson (2013)

Changes based on water justice framework

Distributive justice			*Procedural justice*				*Interactive justice*	
Domestic water	Productive water	Other forms of compensation	Participation of all parties' interests	Level of public participation	Information transmission	Unified water management system	Dynamic feedback mechanism	NGOs, media supervision
++	++	+++	++	+	+	+++	++	+
Increase in income and establishment of the water supply system	Development of agricultural industry and food industry	Preferential water price, tourism development cost	Cooperation of the different stakeholders	Everyone can decide whether to participate in tourism or new agriculture		One department in charge of all relevant issues	Constantly adjust during the three construction phases	Water Resources Protection Association assists in supervising water source protection

Projection scenario II

Resettlement development model

Scenario II complies with the minimum water source protection regulation. Villagers within 50m need to move into the resettlement community and develop local industries based on this situation.



Scenario I

Scenario II

Fig 9.3.1 Scenario II

Land quota transfer

In Scenario II, following the water source protection rules of Sichuan Province, all residents within 50m need to be relocated. However, residents within a range of 50m to 200m can freely choose whether to relocate (the local government requires all relocation within 200m). The government and related actors will assist in this settlement process.

For villages, the resettlement community means that more land quotas will be released, which can be used for the development of the village's agricultural industry and tourism. Vegetable processing and food processing plants in the village can continue to expand their production capacity. These land quotas can also be used to build high-end resorts and other facilities for the tourism industry.

For Paotong Village, 80 households entered the resettlement community, which means that there are about 4 medium size plots that could be used for new construction.

Land transfer from resettlement
80 households relocate in the resettlement community
The resettlement community: Three floors, two flats with one staircase
The current area of one plot is 300 ㎡; Based on the current resettlement format
The released land quota equals 43 households, about 4 medium size plots

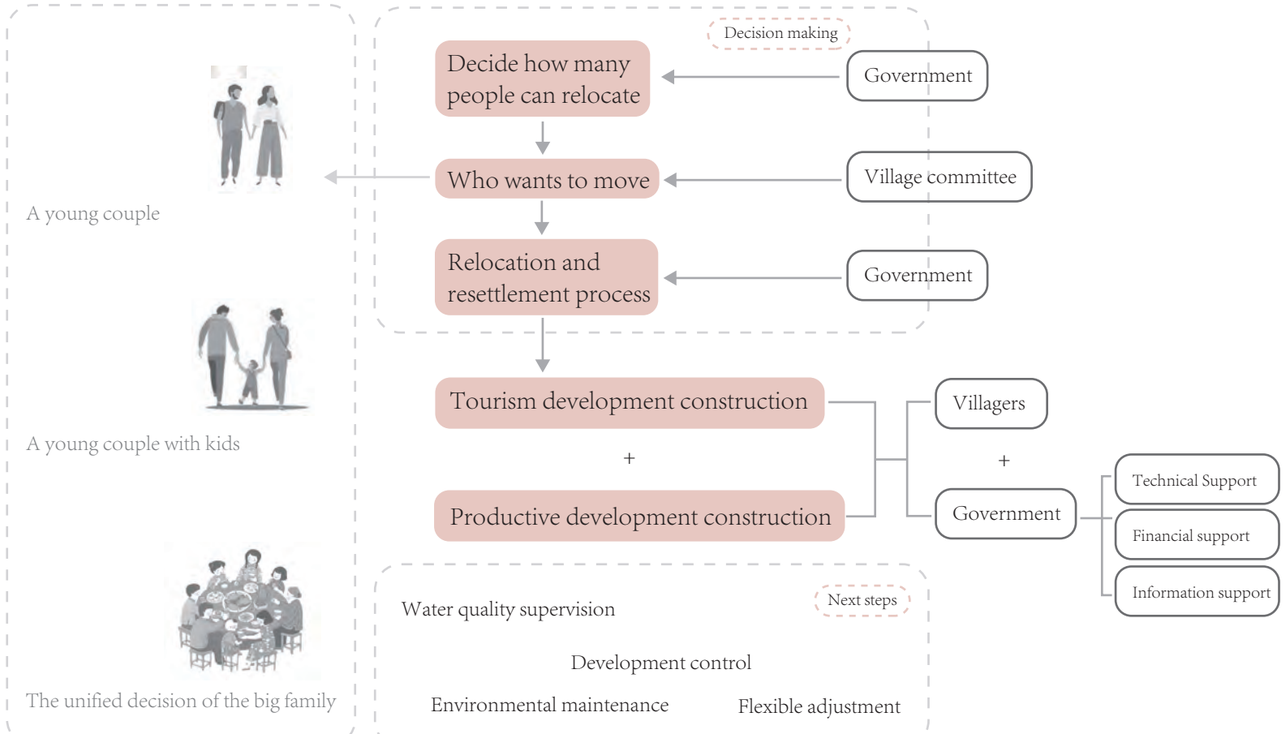


Fig 9.3.2 Resettlement process

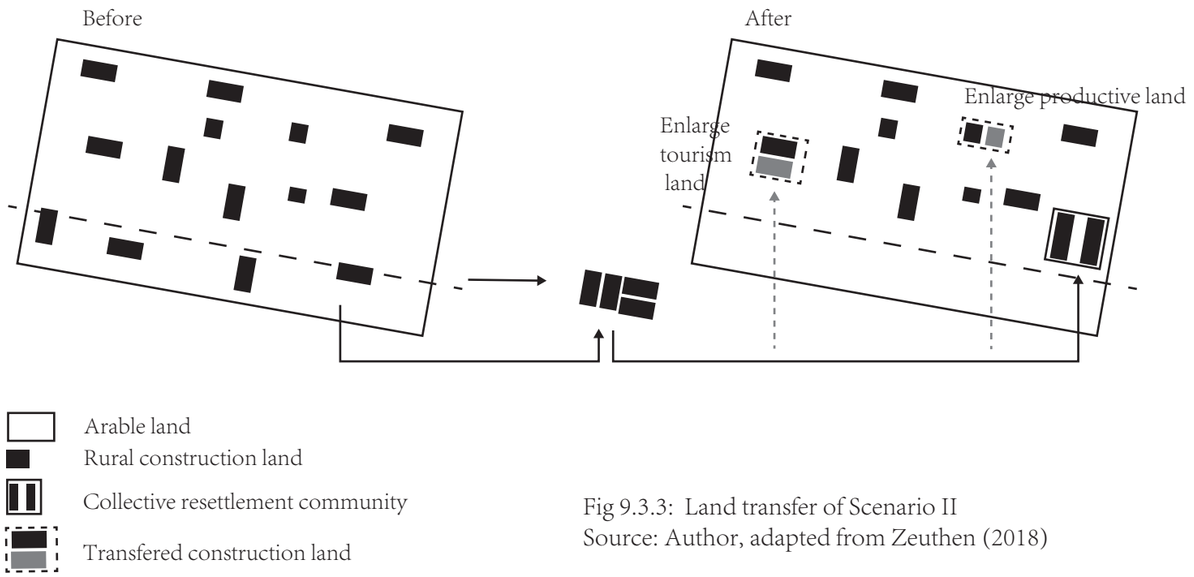


Fig 9.3.3: Land transfer of Scenario II
Source: Author, adapted from Zeuthen (2018)

Production

Agriculture based industry

Village
-Unified management and planning of construction land quotas

Farmers
-Co-owns greenhouses
-Working in the owned greenhouses
-Shareholders of the processing industry

Local factory
-Expanded chilli bean sauce production
The raw materials come from the greenhouses
-Villagers use the land to invest in the expanded production capacity

Ecology plot
-Croplands converted to forest
-Villagers still live there
-Converted cropland considered as being rented by water conservation with extra compensation

Production
-Flower planting upstream
Sightseeing oriented combination with a technology production line
-Vegetables with both greenhouses and open land
Provide materials for the sauce industry
-Mechanized rice production

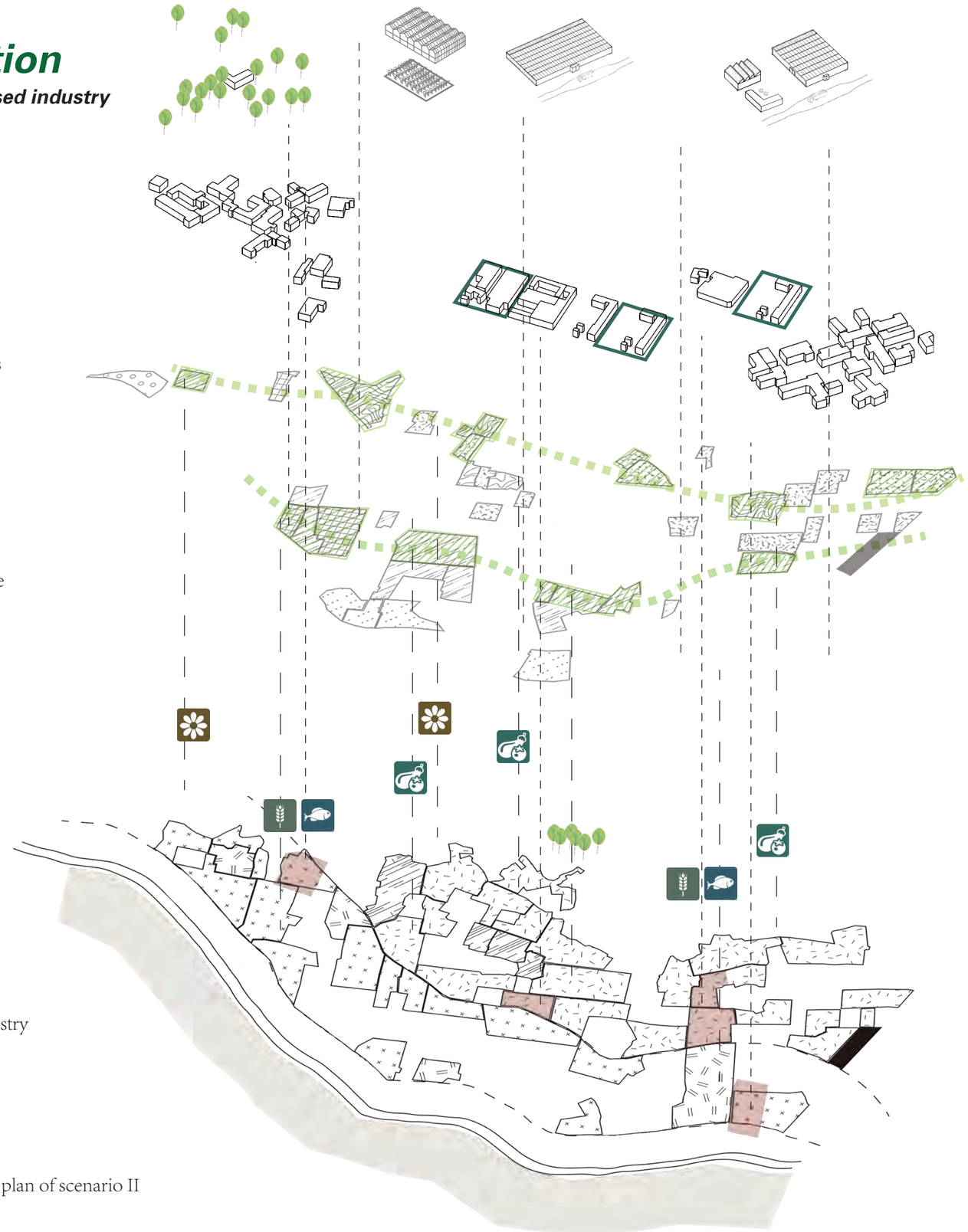


Fig 9.3.4 : Production cooperation plan of scenario II

Greenhouses

Because of the increase in the land quota that can be used for construction, the supporting facilities of the greenhouse are constructed, such as the primary vegetable processing and packaging factory. This has also accelerated the increase in the establishment of the brand and planting scale of green vegetables, and the income of the villagers has been further increased.

Ecology corridor

In response to the requirement of water balance, several ecological oriented plots are shifted from productive function to ecological preservation functions, from cropland to natural forest.

These plots form a new ecological corridor to enhance the ecological functions.

Expanded sauce industry

With new construction land quotas, the existing chilli bean sauce factory can also be expanded to increase production capacity. Both existing plants can be enlarged using nearby buildings and sites.

The increase in production capacity also contributes to the construction of geographic brands, and the increase in demand for raw materials drives the increase in relevant agricultural production.

Enlarged agricultural production

The largest chilli bean sauce processing plant in the main street has been enlarged with nearby buildings and land. Automated fermentation facilities are introduced to increase the production capacity.

The greenhouses are also built for the green vegetable industry, providing raw materials for the sauce industry and selling to the high-end vegetable market.



Fig 9.3.6 The scene of the greenhouses

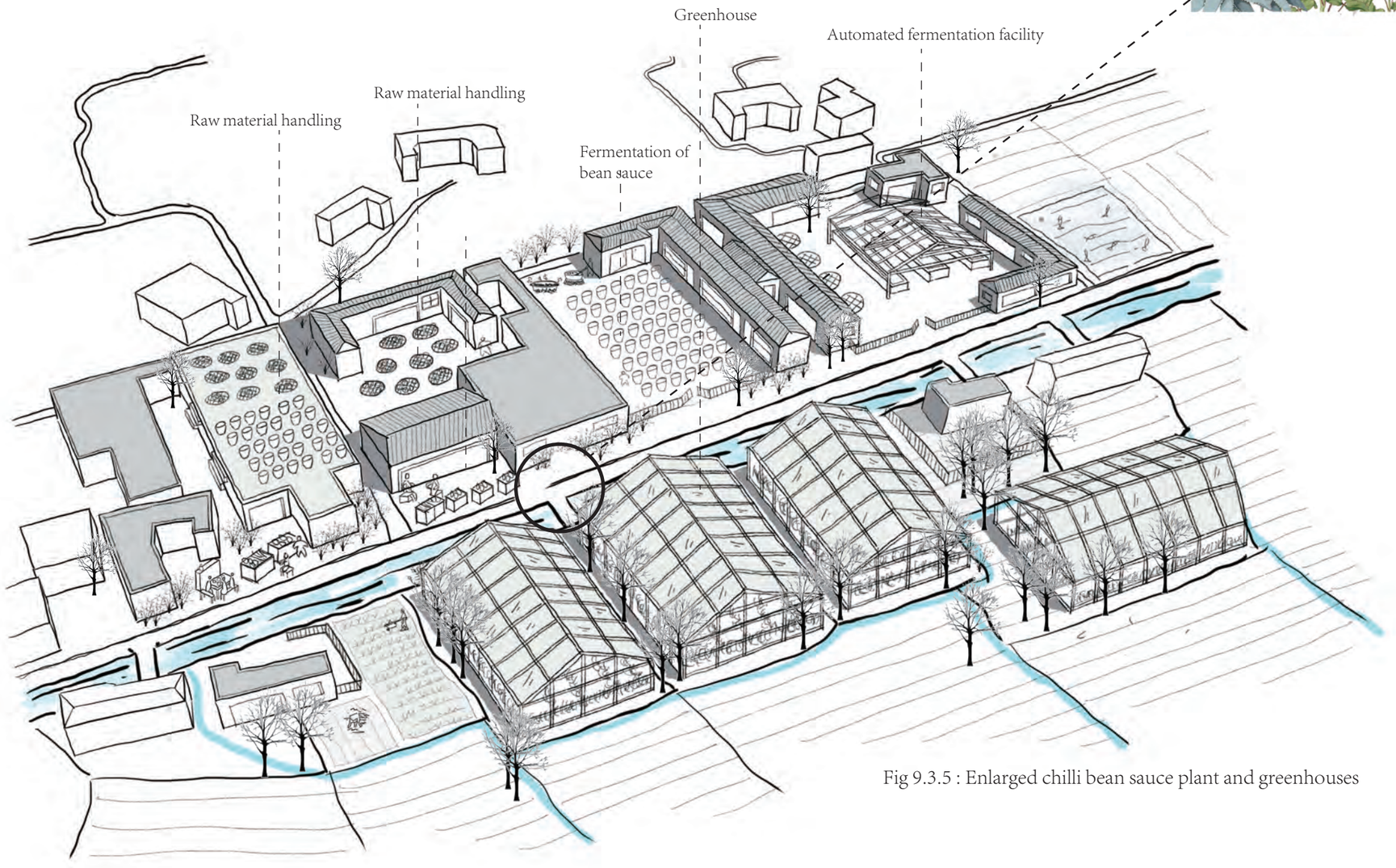


Fig 9.3.5 : Enlarged chilli bean sauce plant and greenhouses

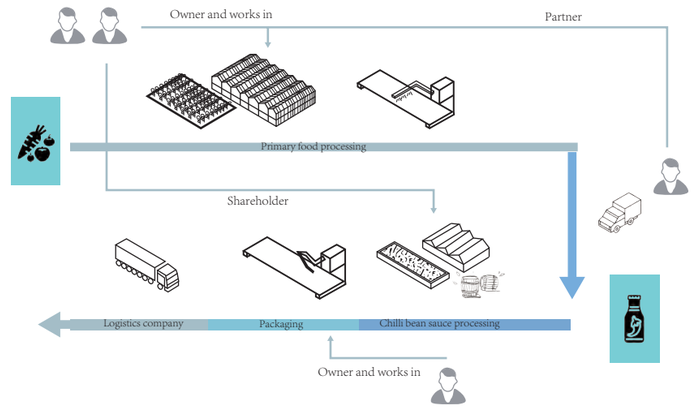


Fig 9.3.7 Raw material and sauce processing industry in the village

Resettlement community

The resettlement community is located on the side close to the built-up area of the city, with 3 houses, as well as the village committee and public activity space. Instead of typical collective flats, it provides a small garden for the villagers and a water landscape central public space.

Besides, a bus stop is established for the villagers working in the town or industry park. And a sewage treatment station is built nearby.

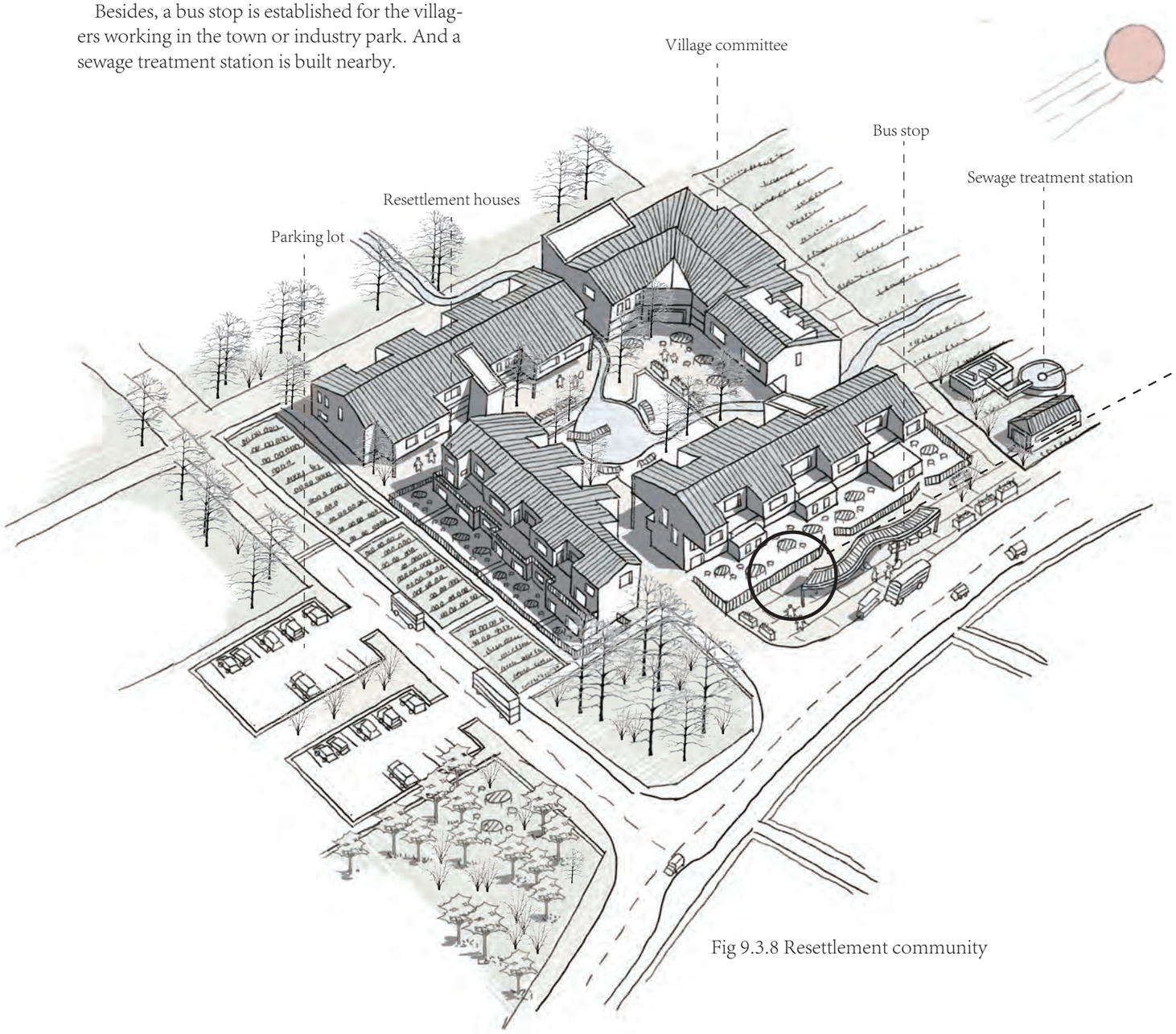


Fig 9.3.8 Resettlement community



Fig 9.3.9 The scene of the resettlement community bus stop

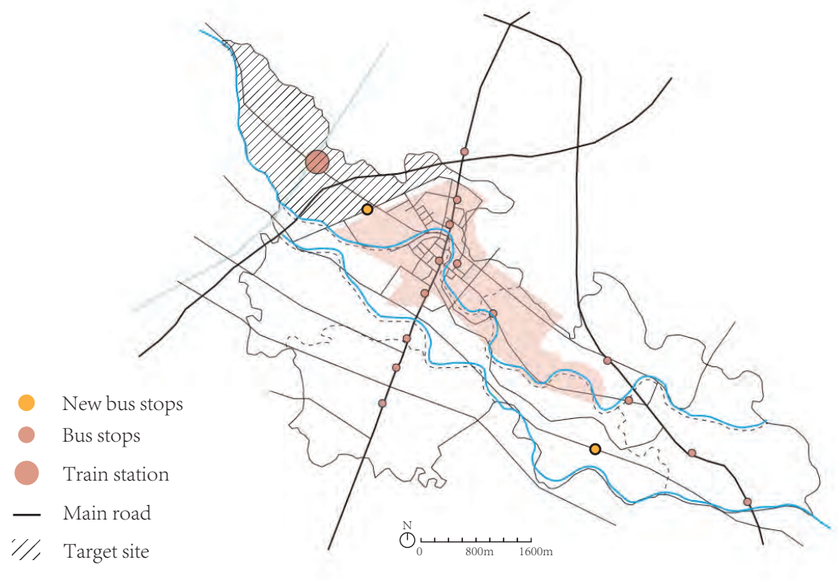


Fig 9.3.10 New bus stops to better cover the villages in the town

Tourism plots development in scenario II

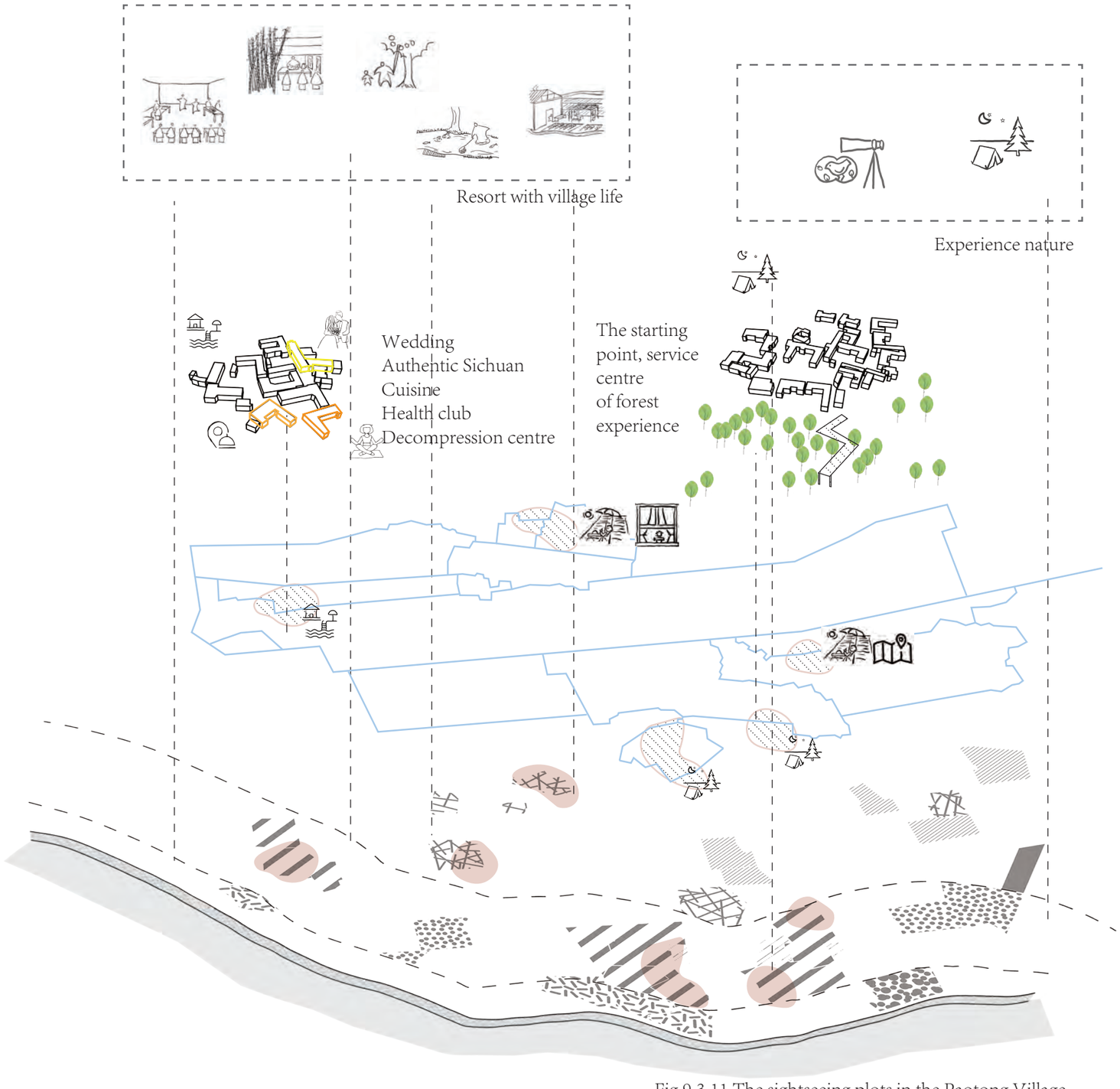


Fig 9.3.11 The sightseeing plots in the Paotong Village

Tourism

Agricultural landscape tourism

Since there are new construction quotas, and some villagers moved into the resettlement community, a new hotel area could be built. It is a boutique resort with better facilities combined with water village experience and vacation needs.

Besides, because of the formation of the forest belt, limited forest tourism such as camping, hiking and bird-watching platforms will enrich the tourism activities in the village.

Types of tourism

Forest sightseeing





Camping



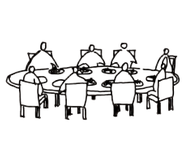
Bird watching

Boutique Resort





Wedding

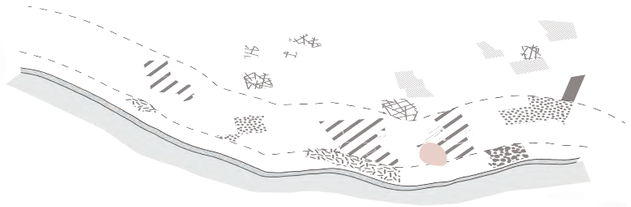


Authentic cuisine



Yoga/Health

Design testing plot of tourism



The selected test areas are located at the riverside of the village, which has the best conditions for tourism development. The north one is in a quiet and private place suitable for the resort.

Fig 9.3.12 Resort plot location



The south one is at the border of the forest aiming for relevant events.

Fig 9.3.13 Forest border plot location

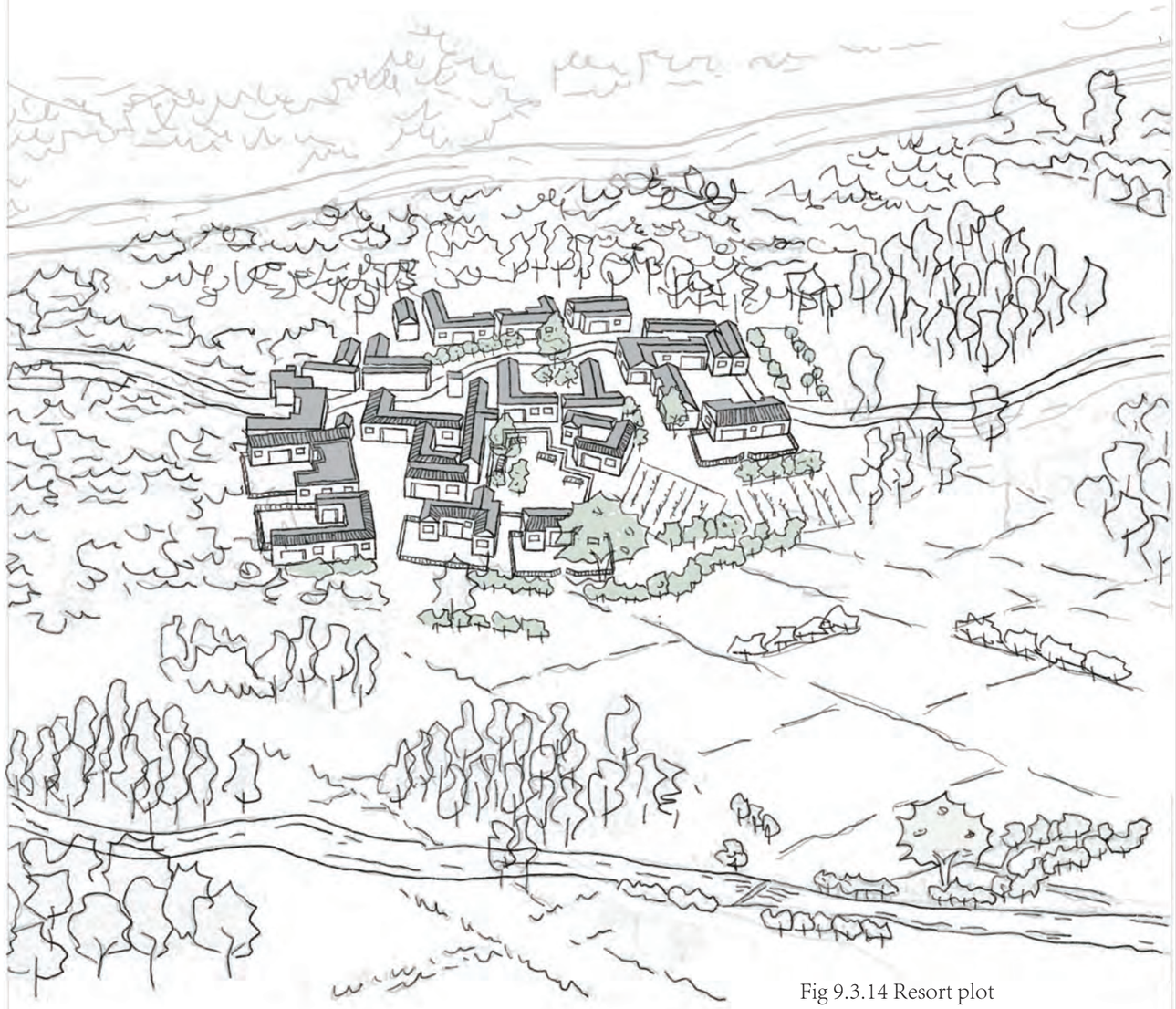


Fig 9.3.14 Resort plot

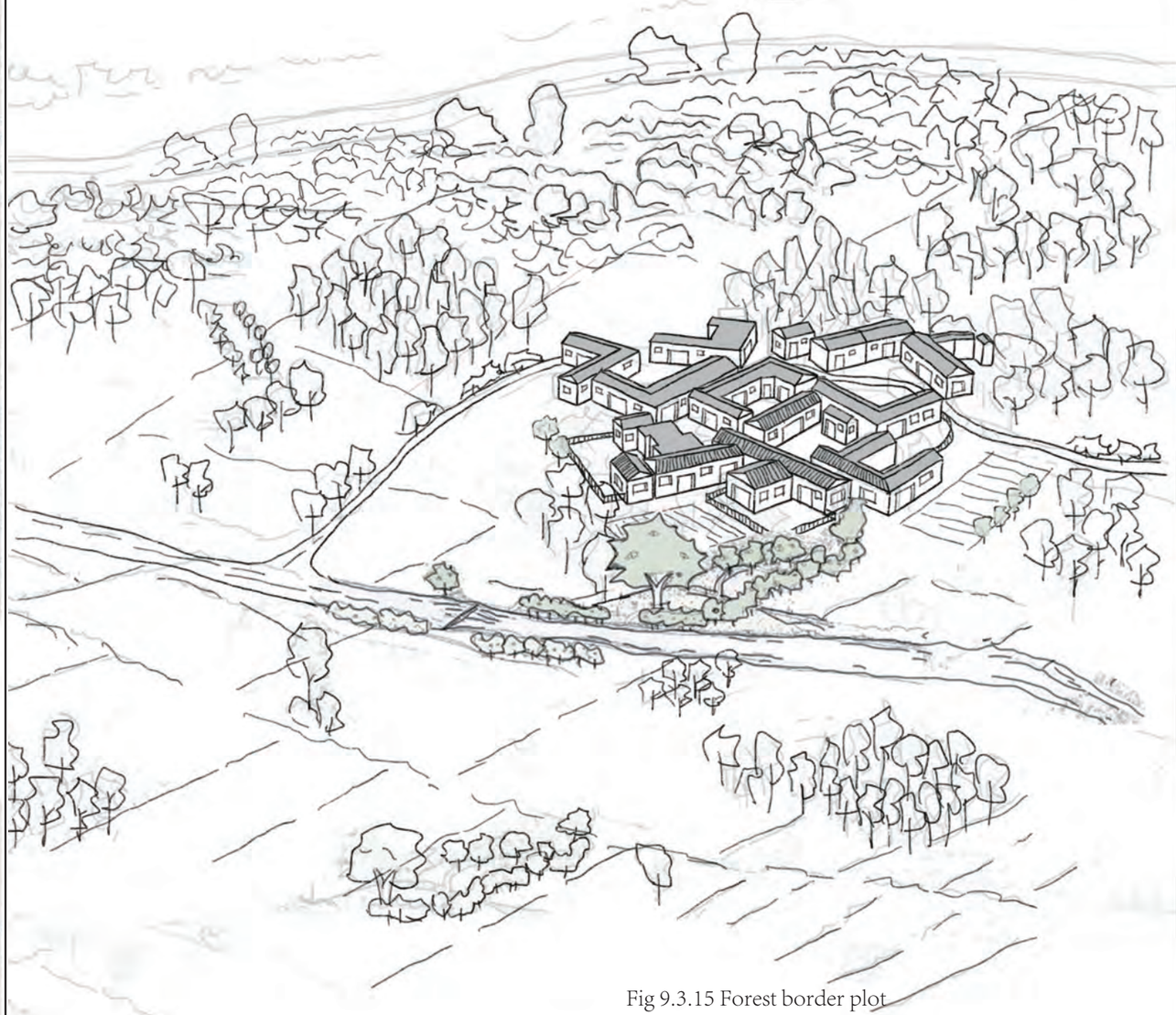


Fig 9.3.15 Forest border plot

Forest landscape

Due to the determination of the ecological protection zone within 50m, combined with the natural woodland on the opposite bank of the Baitiao River, a nature protection zone has been formed, and a new nature experience project could be established.

The plot located on the 50m border serves as the starting point for the bird watching platform to provide basic requirements for natural experience activities, such as equipment rental and guide. At the same time, as a base for camping activities, it also provides rental of tents, etc.

Besides, for those who are amateurs, there are also services such as accommodation and food. The plot is giving full play to the advantages brought by nature protection to develop natural experience tourism.

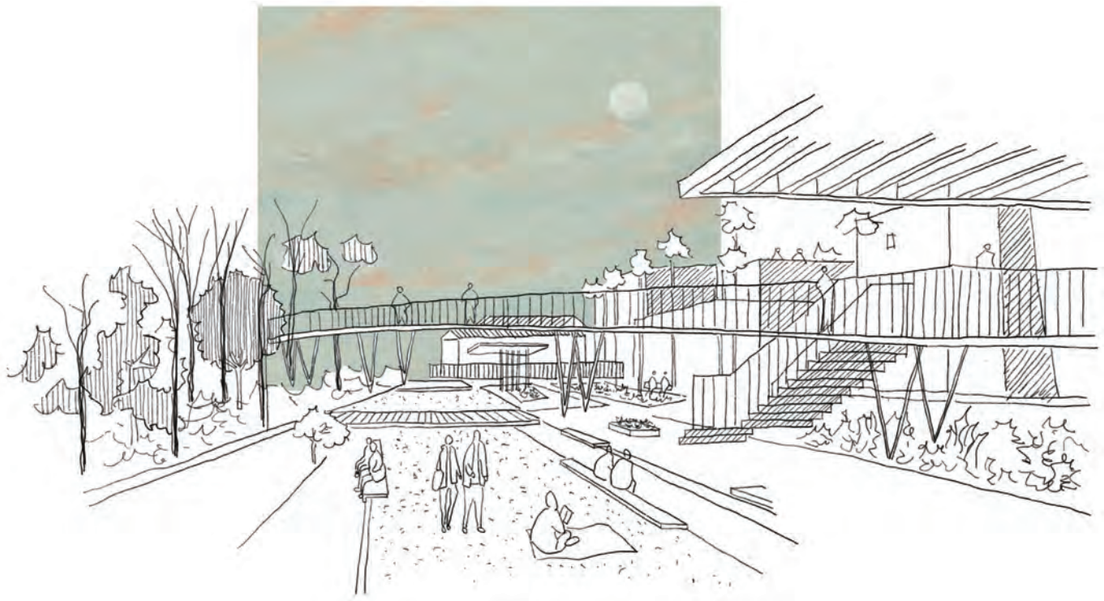


Fig 9.3.17 Start point of the bird viewing platform

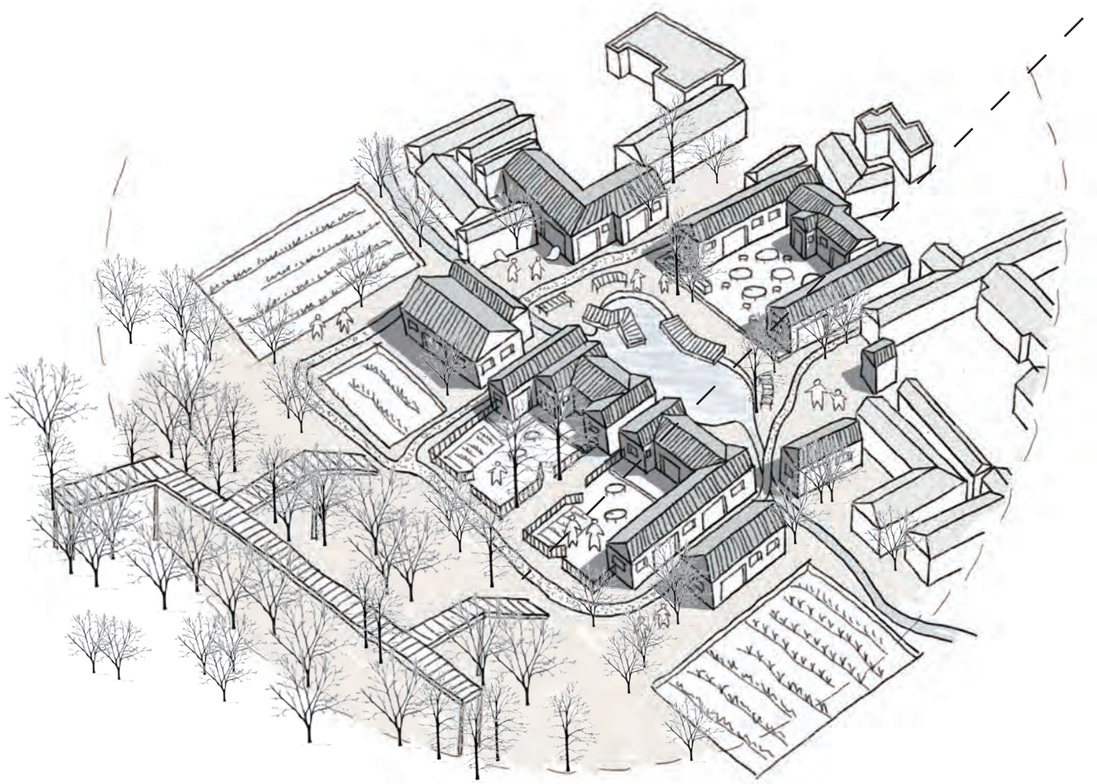


Fig 9.3.16 Forest landscape plot

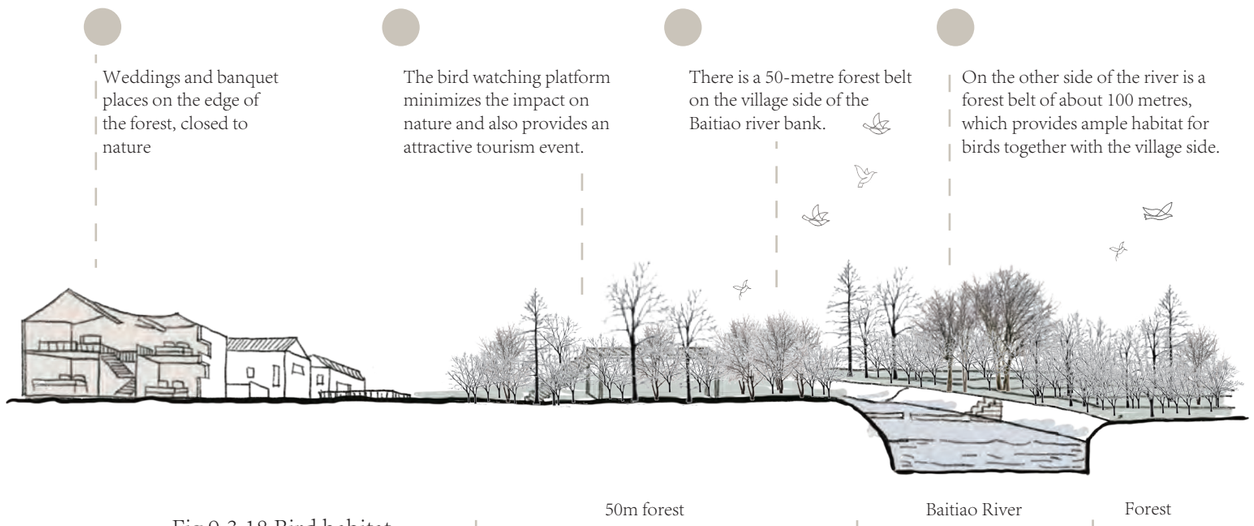


Fig 9.3.18 Bird habitat

Boutique Resort

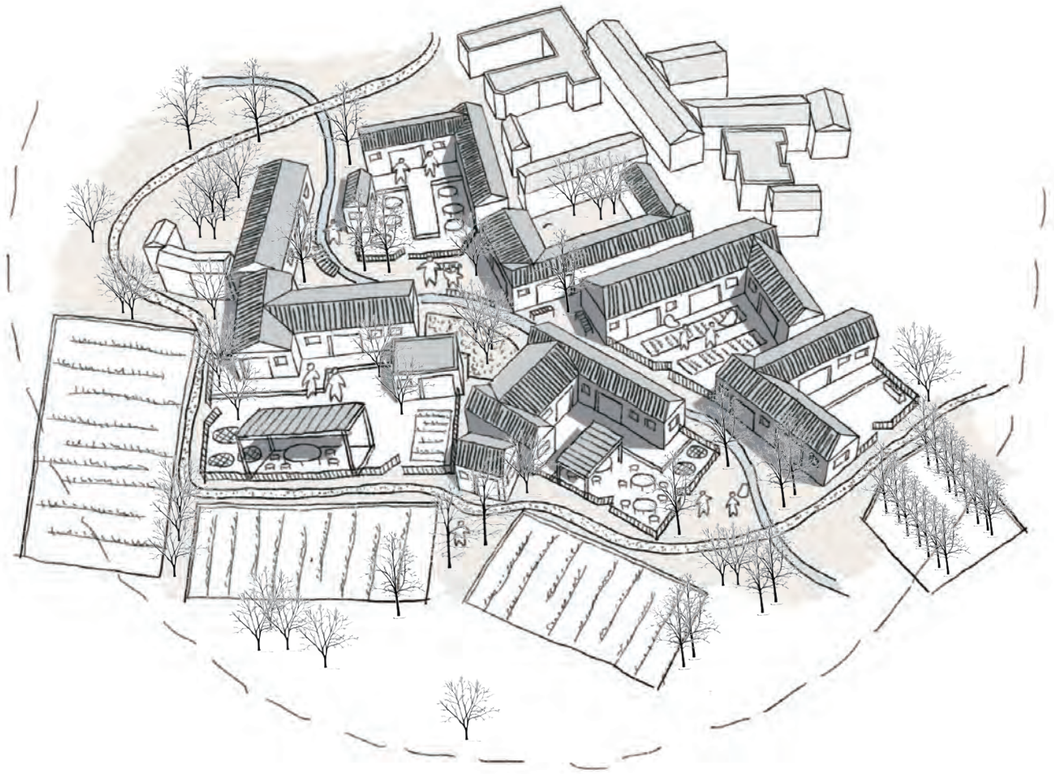


Fig 9.3.19 Resort plot

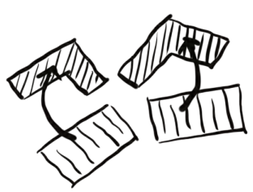


Fig 9.3.20 Material source for cuisine

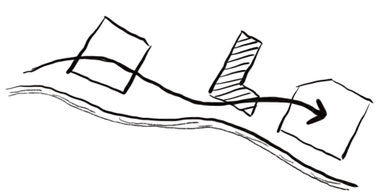


Fig 9.3.21 Wedding spaces

The boutique resort is consists of several activities and hotels with fewer villagers living in it. It has more court-yard space for the wedding, health events and teahouses combined with the most traditional style.

For Sichuan cuisine, it is an exquisite dishes of which the material is green vegetables from nearby cropland.

For the wedding, the traditional way of walking throughout the village is added here. As well as the traditional wedding cuisines.

It is also a place for the citizens to get close to nature and do stress-reducing activities.

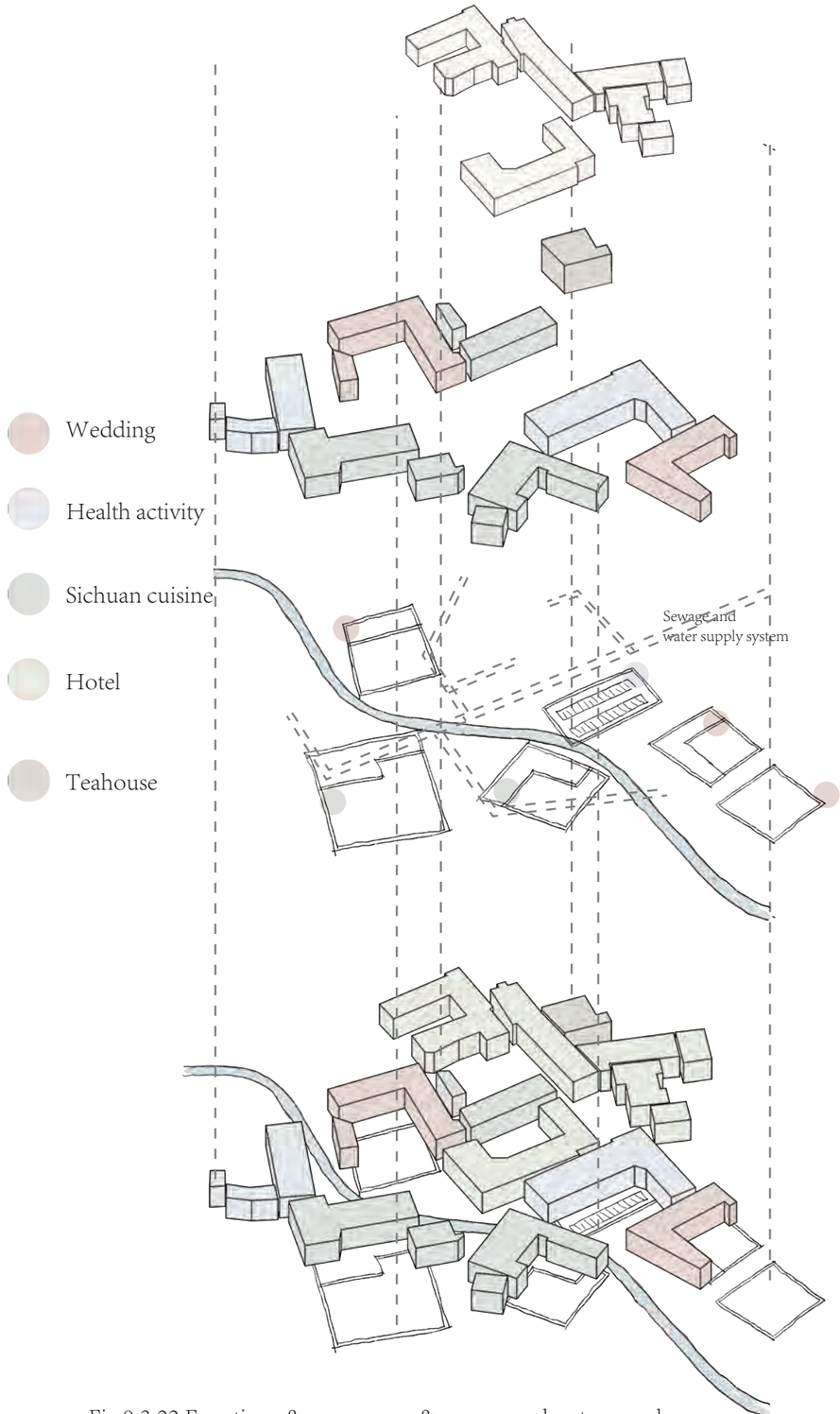
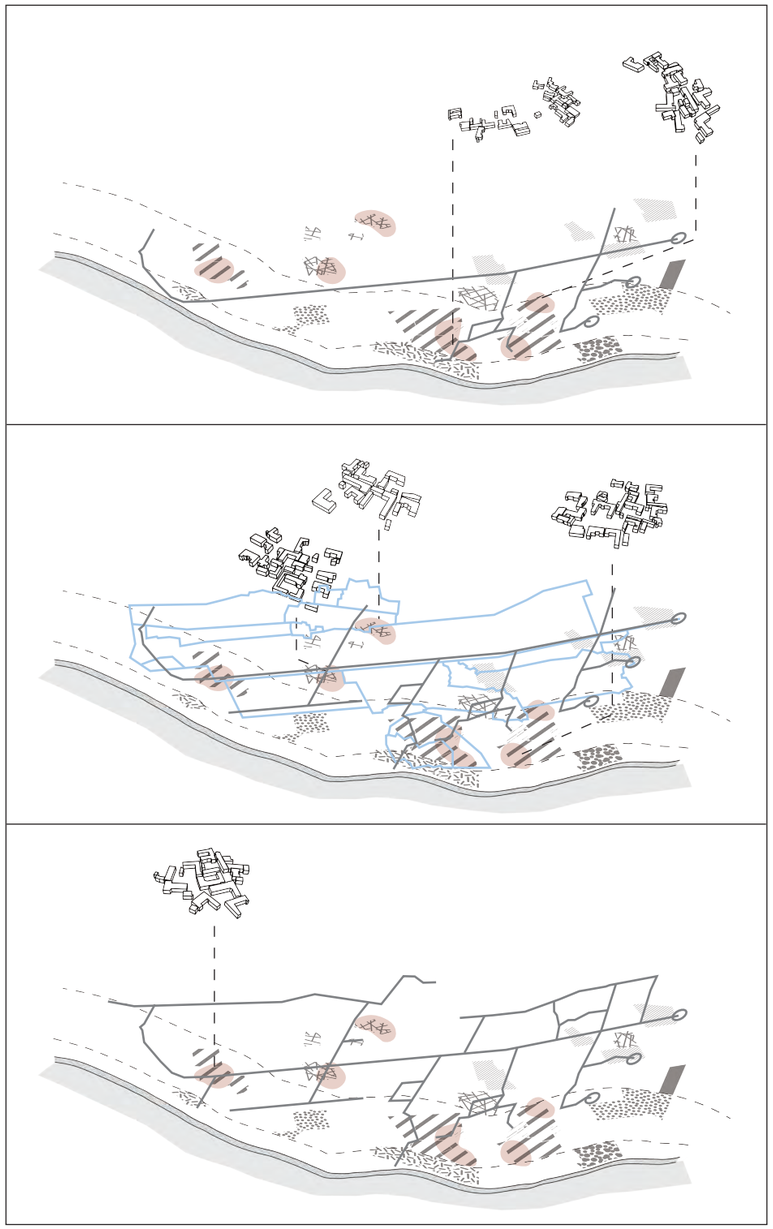


Fig 9.3.22 Functions & open space & sewage and water supply

Local tourism development

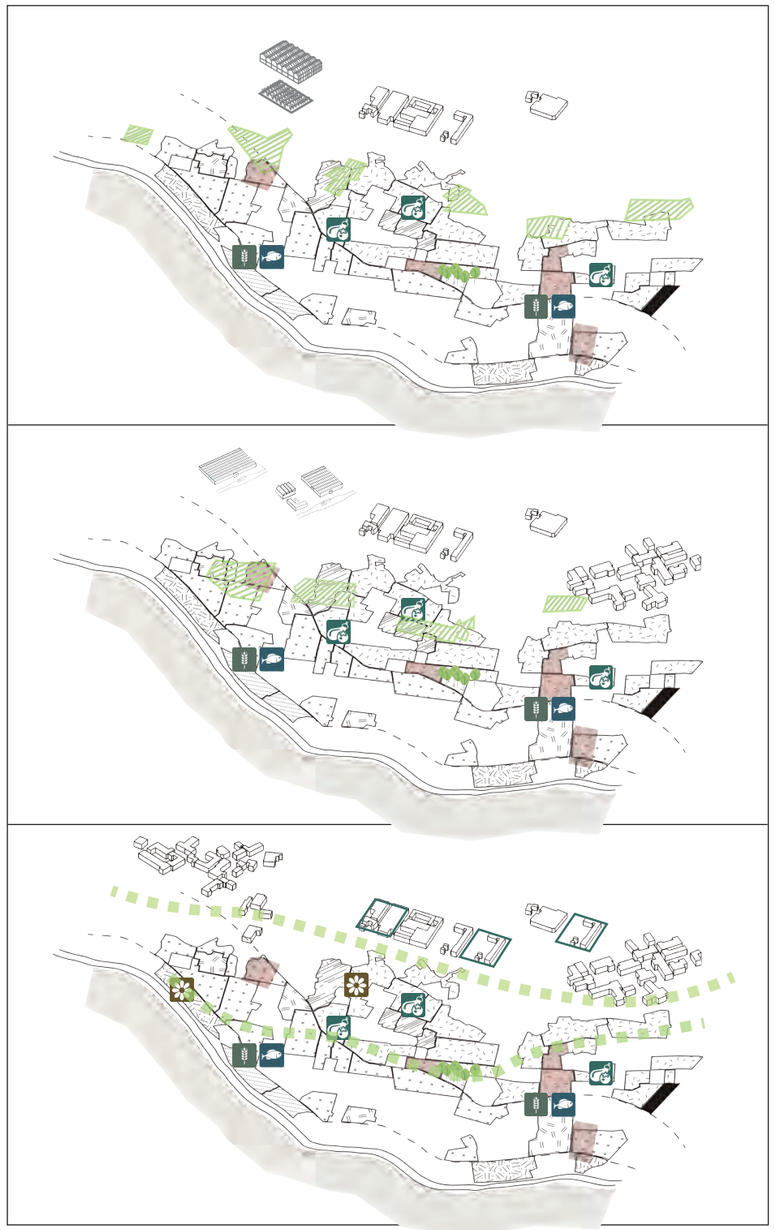


In 3 years
1.Geological survey, pipeline design
2.Weekend trip sewage; water supply pipeline
3.Weekend trip plot renovation
4.Start construction of resettlement community
5.Converting farmland to forest, soil erosion prevention

In 5 years
1.Resort renovation
2.Resort sewage; water supply pipeline
3.Resettlement houses finish
Start of the relocation process
4.Widen Canals
5.Converting farmland to forest
6.Bird viewing platform

In 8 years
1.Relocation process finish
2.Finish sewage; water supply pipeline
3.Woodland conservation
4.Boutique resort renovation

Local production development



In 3 years
1.Chilli bean sauce factory renovation, sewage facilities
2.Greenhouse vegetable industry
3.Green rice and fishery
4.Start converting the ecological plots

In 5 years
1.Productive plot renovation
2.Vegetable sales industry chain
3.Expending Greenhouse vegetable industry

In 8 years
1.Expending Chilli bean sauce factory
2.Chilli bean sauce brand established
3.Other productive plots renovation
4.Finish converting the ecological plots

Fig 9.3.23 Phasing of scenario II

Phasing

Scenario II

For scenario II, the construction phases start with the sewage and water supply system as well. The weekend trip plot would be renovated first to attract tourists. In the meantime, the construction of the resettlement community and relocation process begins. In 5 years, the nature experience plot would be built and the final stage is for the boutique resort after the relocation finished.

For the industry development, after the construction of the sewage system, the expansion of chilli bean sauce starts, as well as the greenhouses for green vegetables planting. All the ecological plots are settled in the first 3 years and then give back the process to nature.

Engagement of actors & timeline of scenario II

In scenario II, the sewage system construction and renovation of plots would gradually be finished. In the second stage of 5 years, the ecological belt along the river was initially formed, the bird viewing platform is built. In the 8 years, the boutique resort is built after the relocation process.

The tap water plant and hydropower stations would provide financial support for the bird viewing, camping and resort facilities. NGOs like Chengdu River Protection Association would supervise environmentally friendly tourism activities and ecological plots conversion.

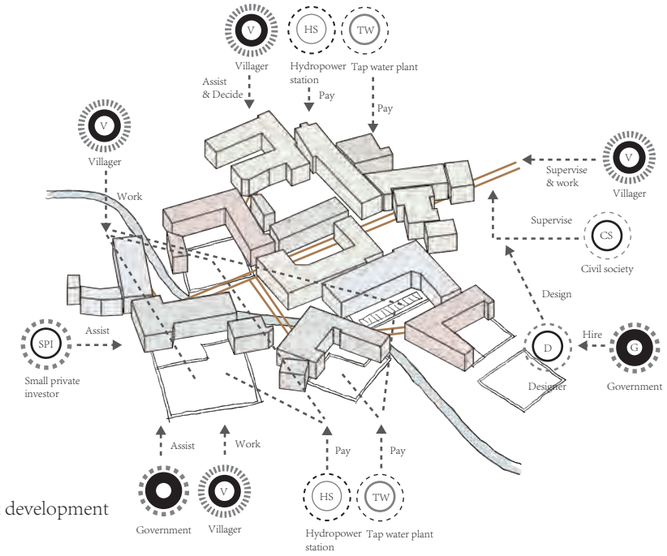


Fig 9.3.24 Actors in the resort plot development

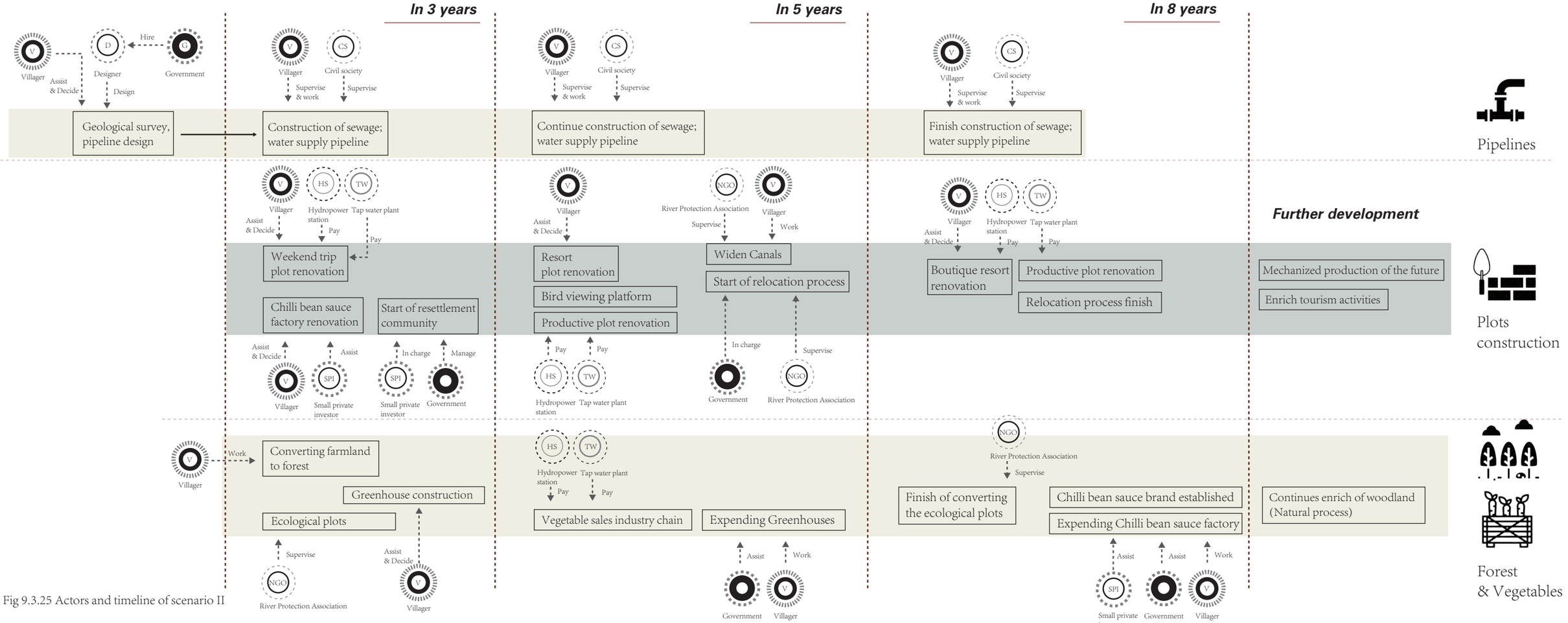


Fig 9.3.25 Actors and timeline of scenario II

Water justice evaluation of scenario II

Domestic water

Increased income by tourism

For Paotong village in scenario II, there are 30 homestays or inns developed in the village, which will bring about CN¥ 4000 income increase according to the nearby villages (the same as scenario I). Besides, due to the newly built boutique resort which can hold several activities and the bird viewing and camping events in the 50 m border plot, the income would further increase.



Increased income by industry

As the shareholders and staff of the chilli bean sauce plant and greenhouses whose production capacity has been further expanded, the income of the villagers will increase. In addition, for the villagers who move into the resettlement community, working in the city will increase their income. The average annual income of urban work in Pidu District is about CN¥ 48,000 (Chengdu Statistical Yearbook, 2019), which is much higher than the rural income.



Productive water

The bean paste production plant at Paotong Village brings about CN¥ 1400 per household income increase for the villagers when it doubled the capacity. The greenhouses in the village will greatly expand the production capacity of green vegetables, and a larger scale is prone to building a brand to increase the income of villagers. Therefore, the green vegetables and sauce industries in Paotong Village will have great benefits by gaining productive water.



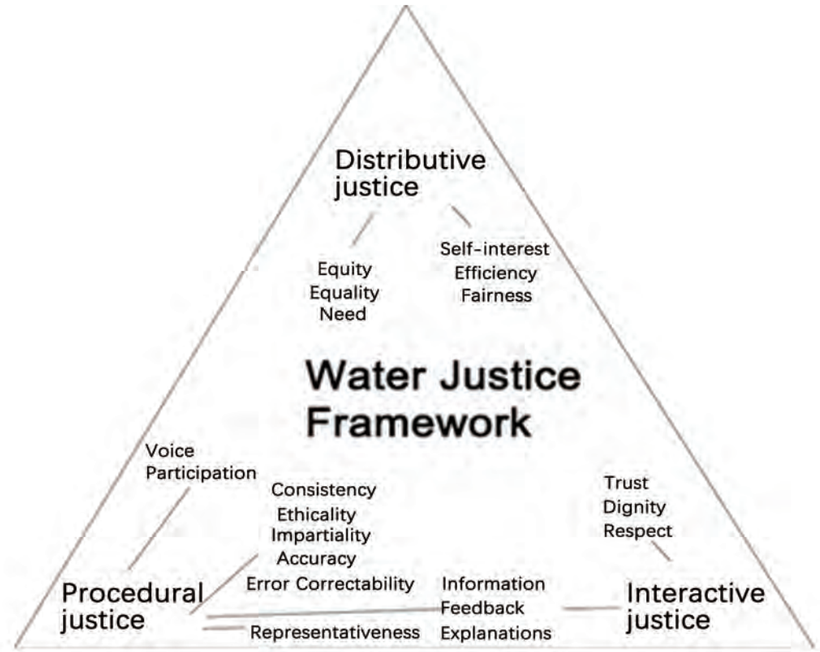


Figure 2.1: Water Justice Framework
Source: Adapted from Lukasiewicz, Bowmer, Syme, & Davidson (2013)

Changes based on water justice framework

Distributive justice			*Procedural justice*				*Interactive justice*	
Domestic water	Productive water	Other forms of compensation	Participation of all parties' interests	Level of public participation	Information transmission	Unified water management system	Dynamic feedback mechanism	NGOs, media supervision
++	++	+++	+−	++	+|	+++	++	+
Increase in income and establishment of the water supply system	Expanded agricultural industry	Improvement of traffic conditions in the resettlement community	The residents in 50m range need to relocate	Residents out of 50m could decide whether to relocate	Concentrated residence makes messaging convenient	One department in charge of all relevant issues	Constantly adjust during the relocation process, flexibility in the capacity of resettlement community	Water Resources Protection Association assists in supervising water source protection

Feasiblity

For testing Paotong village

Due to the requirement of the monetary balance and water balance, the number of households that can relocate is limited. Therefore, the ideal situation is that most of the villagers are willing to stay. In the meantime, they are likely to actively participate in the local agriculture and tourism development.

For the local factories, based on the supporting regulations, they are able to stay in the village for being close to the material and market. Besides, there would be further technical support for the local industry from the local government and institutions.

Scenario I	Less than 20 households move out, that is, less than 50% of the households in the first-level protected area
Scenario II	Less than 80 households move out, that is, less than 40 households relocate in the second-level protected area

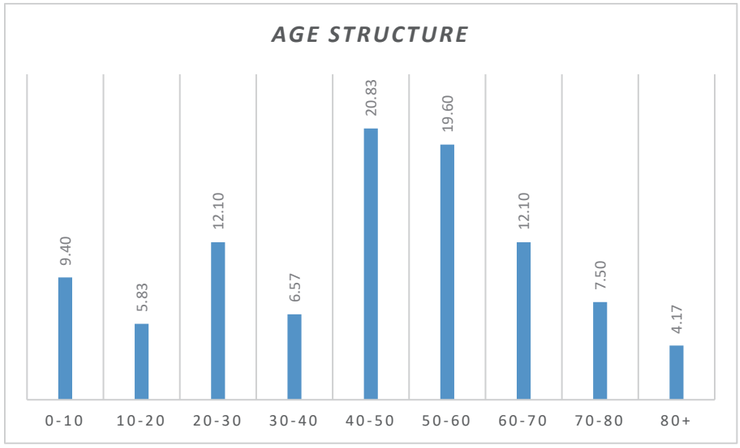


Fig 9.3.26 The age structure of villages

According to on-site survey data, the proportion of elderly people in rural areas is relatively high. Besides, young people work more outside, and those who stay in the countryside are mainly old people. Most villagers engaged in agricultural production are reluctant to move out and are happy to develop local agricultural tourism.

For other villages in the water conservation zone

What if there are many people who want to move?

First, the pilot project shows that this mechanism works well for the improvement of life, and could preserve the traditional culture of living with water.

Second, if there are a relatively larger amount of villagers who wants to relocate, they need more monetary compensation and more cropland converted into the forest. Otherwise, the use of local water-saving building material and agriculture methods would support a larger resettlement community.

Therefore, the construction period would longer, the basic elements like the water supply system and resettlement community could start by borrow money from tap water plant or hydropower stations. If the village located in the second level protection zone, it would be ok to implement an on-site sewage treatment method instead of expensive sewage pipes.

The advantage is that the region could preserve the traditional rural landscape which represents the living style. Villagers in the resettlement community could be part of the urban industry but still, retain the cropland and rural life.

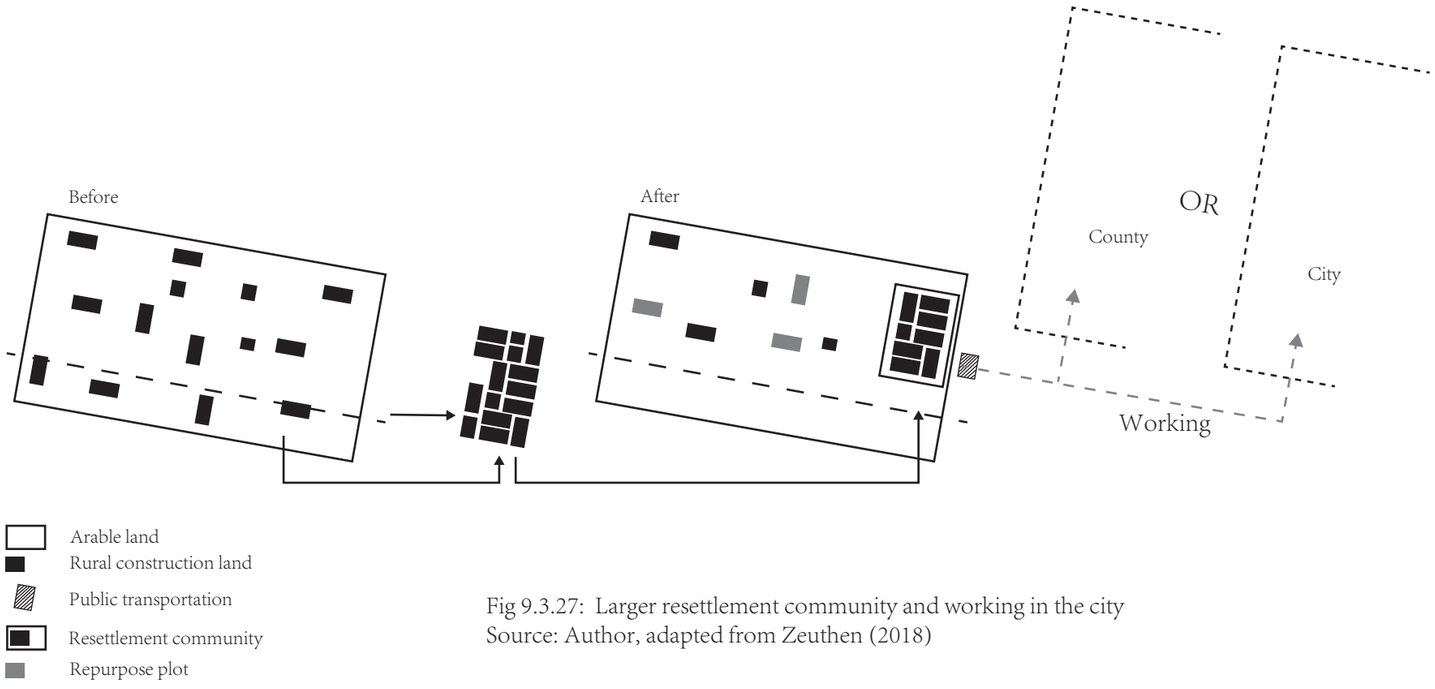


Fig 9.3.27: Larger resettlement community and working in the city
Source: Author, adapted from Zeuthen (2018)

10 CONCLUSION AND REFLECTION

Conclusion

Answering the research question

Reflection

Societal relevance

Methodology

Limitation on data collection

Transferability

Ethical issue and feasibility

Conclusion

How can a strategic and policy framework based on fair use of water and respect for local cultural knowledge lead to a sustainable and inclusive development of water conservation area in Dujiangyan Irrigation District?

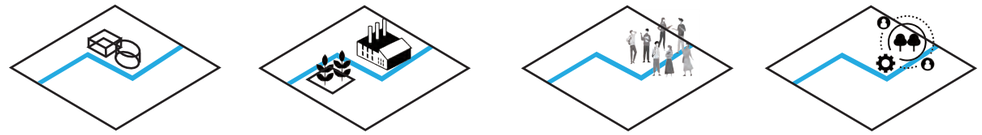


Fig 11 Sub-questions

1.How to make the water allocation process justice between water source area and water use area and prevent from pollution?

--How to supply health and affordable water for both water source area and water use area?

--How to make water supply and sewage system efficient and eco-friendly?

Health domestic water requires water conservation in the water intake place. To protect the ecology of the water source, the priority step is to set up a sewage treatment system at the local level by the ecological compensation, as well as the pollution-free local agriculture, food processing industry and tourism.

Then the water supply system is established along with the sewage pipes for the villagers to provide healthy water. Besides, through reward mechanism, the water price decrease for the vulnerable groups.

To minimize the impact of the pipes, they are designed to go less distance and under the paved road in the village.

2.What virtual value of water need to be considered while making a sustainable and inclusive development of water conservation area?

--How to reimburse the value of a water ecology system?

--How to reimburse the potential economic value of the water system?

--How to measure the virtual value of a water system in new development?

First, to protect the ecological value of the water system, the naturalized canals system and fish ponds are retained in the village. With the densely distributed canals, the biodiversity of forest and cropland increased and the flexible water adjustment is achieved for downstream flood control.

Second, since all the agriculture and food processing industry rely on water, the scaled green agriculture and continuous food industry in the village ensure the economic value of water for the indigenous people.

Last, virtual water is considered in the relocation and renovation from the local development to achieve water circularity at the regional level.

3.How can traditional aspects of village practices and environments be preserved and adapted as part of a strategy of the new development?

--How can the local village be empowered through the traditional water culture?

--How can the local village maintain their culture of living with water in the new development?

In both scenarios, most of the living format in the village is preserved. The water-related public space in the household, plot and village level are renovated, and the traditional social structure remained in the new development since the villagers kept the connections by keeping the living styles in the dispersed settlements.

During the relocation process, the villagers could decide whether they want to move, as well as whether they want to be involved in the tourism development. The hydropower stations, tap water plant, downstream citizens and NGOs are included to supervise this process because they are all relevant actors. A more transparent and dynamic system is set to empower the local village.

4.How can the strategy and policy be justice and flexible in the water governance level?

--How to make an institutional system that allows disadvantaged groups to speak out?

--How to make an institutional system to achieve a fair ecological compensation?

Through the new ecological compensation system, the beneficiaries of the water conservation paid for the local villages and the upstream actors also paid for the negative impact. Besides, since the compensation is for both mandatory cost like sewage treatment and future development, it is fairer from a local sustainable development perspective. Moreover, this compensation system would also promote more organized and sustainable water use in the entire basin.

In this development model, the unified government acts as a supervisor, a platform is set for different stakeholders to cooperate. The disadvantaged groups are supported by the village committee, local authority and civil supervision. Since the new development does not need much investment, the vulnerable groups could participate as well.

Reflection

This research started from a personal experience of a village in the conservation zone. In fieldwork, I interviewed a local family who was preparing to relocate and enter a new resettlement community. Despite the resettlement compensation, the family still expressed concern about the distance from the farmland after moving in and the rising cost of living in the future. And this is common in the village.

From a regional perspective, it is undoubtedly correct and necessary to establish water source protection areas, protecting vegetation, the water and soil, and prohibiting the impact of human activities. However, the interests of local people were sacrificed in this process, especially those vulnerable groups. Therefore, this research focuses on the water right between the villagers and citizens, trying to find out a way of just and coordinated development in the urban-rural region.

The definition of water justice.

The definition of water justice is very diverse, the framework to achieve justice in the water conservation zone is adapted from the social justice framework (Lukasiewicz, Bowmer, Syme, & Davidson, 2013): Egalitarianism in the domestic aspect, effectiveness in the productive sector and emphasizing the participation of the indigenous people.

A just model of ecological compensation.

For the monetary balance, the compensation comes from the downstream citizens, tap water plant and upstream hydropower stations who have effect on the water in the conservation zone. Another balance is to achieve water consumption stability for the local county, save water resources in the development process.

It is considering willingness from both indigenous people and downstream citizens, as well as the ecological requirement, trying to find a reasonable and acceptable solution for all sectors in this process. The involvement of water plant and hydropower stations reflect the systematic thinking in watershed research, and it also urges enterprises to assume their due social responsibilities.

The culture consideration.

In this process, also put effort into exploring the meaning of traditional water culture behind the rural space. For a farming society, all activities are inextricably linked with water. In this water conservation zone project, the position of the canal in the built environment, the connection between production activities and water, water in social capital and water-relevant festivals have been preserved and reflected in the design of the future development of the village.

Societal relevance

Because of the multiple layers of the water value, water justice is not merely access to water itself. It also refers to the economic, environmental, and cultural values which is the development right of indigenous people and upstream cities and towns. It is essential to understand the demand of both metropolis and conservancy area people.

This project provides a balanced approach to compensate the indigenous people who suffer from water conservation but also pays attention to the other actors in the frame. It considers the interests of the vulnerable group from the perspective of development, pursuing justice and development opportunities for them. In the meantime, it also takes the ideas of the person who provides compensation into account, aiming for a sustainable and coordinated development of the region.

Besides, through the survey for the downstream citizens, it has made efforts to enhance the social awareness of water conservation areas.

The method of in-depth contact with local people and the local environment also helps to protect the

originality and uniqueness of local culture and environment and contributes to the participatory planning process. It is helpful to carry out rural development in different ways and avoid losing local sustainable wisdom in the same collective neighbourhood.

Methodology

In the theoretical chapter, this research first reviews the concept of water justice in general, proposed a justice framework to guide the interventions. Then it provides the idea of water justice in this specific context of the water conservation zone. This approach makes the research not only has a wide range of adaptability but also considers the particularity of the research area.

Then, the analysis of the water utilization starts from the regional level, including both upstream and downstream water-using companies and towns. This is due to the fluidity and regionality of water resources and the mutual influence of upstream and downstream. Therefore, analysis from the perspective of the entire basin can provide a more comprehensive understanding of the water allocation process.

The analysis from a historical perspective on the water-related culture is essential for preservation in the local context. This approach involves both the regional connections and the household level cooperation in the irrigation system, which helps to understand the local wisdom of water usage and live with water. Through interviews of the indigenous people, In this rapidly changing era, the villagers' understanding and perception of traditional culture provide a deeper understanding of the relationship between culture and space.

Eco-compensation is the core of realizing water justice because only reasonable compensation can meet the water demand of both downstream cities and upstream local communities, and achieve a win-win situation. At the same time, it also gives local people a new opportunity to use such compensation to achieve sustainable development.

Therefore, interventions are on both regional and local level, aiming to reduce water stress in the county and pursuing sustainable development at the village level. Such a comprehensive strategy can not only meet the resource needs of regional development but also ensure the smooth implementation of local measures. Several plots in the testing village are selected to implement the new development model, such as the food processing industry and tourism. Besides, culture preservation always needs to be integrated into development strategies.

Ultimately, the estimation on the income of the local community, the new scenarios of local production and the decision-making process will to evaluated to measure the achievement of water justice, which refers to the water justice framework in the theoretical concept.

One of the limitations is that the companies in this water utilization process are not involved. The tap water plant is a listed company, seeking to maximize profits. Therefore, how much responsibility companies are willing to bear in this compensation and how to make them more willing to join this development plan needs further consideration.

Another part that can be considered in the future is the role of NGOs. For example, in this example, the Chengdu River Research Association actively participates in the work of water source protection. They are organizing volunteers to conduct inspections on rivers where water sources are located. Villagers can find work related to water source protection in such organizations, and at the same time, they are also an important window for publicizing awareness of water source protection.

Because of the limitation on the fieldwork, there is only one village in the conservation zone selected for the data collection. If a few villages are selected for comparative research, more comprehensive information about the income of villagers and the idea about relocation is obtained, this research would be more convincing.

Limitation on data collection

The data for the interview comes from a dataset that I did in the water conservation zone before. Since that social survey is not specifically for the water justice issue, there are no specific questions. For example, would you like to move out? Whether you think the compensation measures are reasonable, etc. Therefore, in the plot level intervention, the flexible design does not specify which household must be remodeled. Instead, it applies flexibility to give the villagers' willingness to land. The procedure and interactive justice require this process to be transparent under civil supervision, and the villagers should have a comprehensive consideration to decide whether to move or not.

Many villages located in the water conservation zone have already begun the relocation process. If the changes in the lives of the relocated villagers can be tracked and interviewed, more accurate data samples can be provided for research. However, in the estimation of the income increase, basic data from other villages in the same area were used, the results are also credible.

Transferability

Firstly, this project established an analysis framework for water justice issues in drinking water source protection areas. Through the analysis of upstream and downstream water consumption enterprises and agricultural and industrial water use, it can indicate who is the subject of ecological compensation.

Then, a reasonable compensation system is established, including a clear implementation path: starting from the stakeholder analysis, determine who is responsible for which part of the compensation, and the water balance requirements of local development. It generally answers several aspects that need to be considered in ecological compensation for water source areas, who will make the compensation, who will be compensated, how it will be used, and what are the ecological requirements. Due to the similarity of drinking water sources, this implementation path has transferability, and other villages in the water conservation zone can follow this path to set sustainable development strategies. Other types of water protection areas, such as agrarian area, remote district, can also start from stakeholders, and build a similar compensation system and development strategy based on this path.

Ethical issue and Feasibility

The focus of this research is the relationship between the lives of indigenous people and water justice. In fact, not all local people will lose their interests in this water source protection project. For some wealthy villagers and villages with the prospect of developing tourism, this is an opportunity for them to improve the quality of life. Therefore, it is important to pay attention to the different demands of different groups of people and they have the chance to choose whether they want to resettle.

The vulnerable group in the village is usually at a disadvantage in terms of economic and political power, the implementation of the regional interventions depends on the large-scale strategy of the provincial and metropolis level. The local scale intervention relies on the compensation system and participation of villagers led by the government. For the water justice between the villages, it is essential to put more effort from the Chengdu Rural Planning Department to provide specific local design interventions to the villages in the water conservation zone. And through this compensation system, the vulnerable group could also gain opportunities and be part of the local development without much individual investment. If they are not willing to be involved in the renovation, they still could keep the former lifestyle.

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12 APPENDIX

12.1 Drinking water history in core urban areas

12.1.1 Stage 1: Direct water withdrawal



Fig 12.1.1.1 Water take river basin

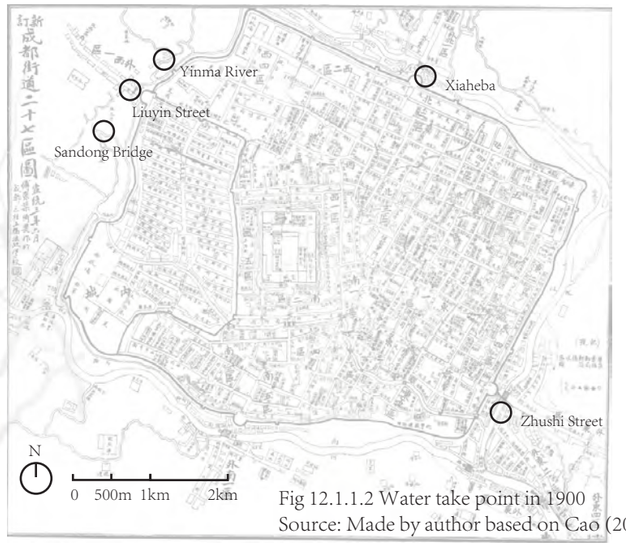


Fig 12.1.1.2 Water take point in 1900
Source: Made by author based on Cao (2020)

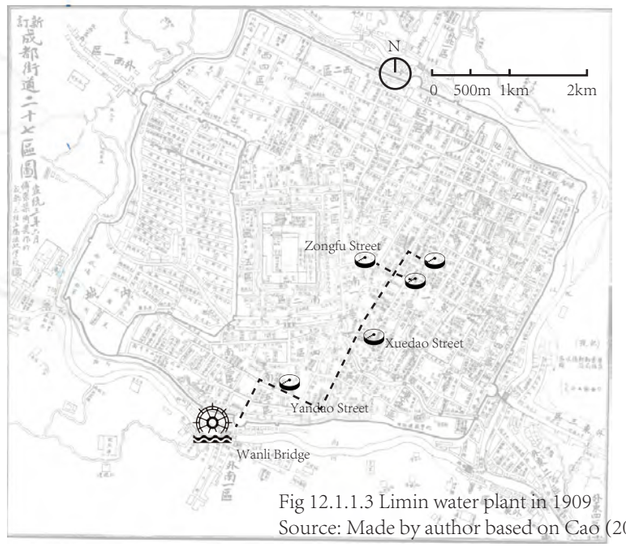


Fig 12.1.1.3 Limin water plant in 1909
Source: Made by author based on Cao (2020)

According to Fu (1987), in the early years of the Republic of China, that is, around 1900, all river wells in the urban area of Chengdu were polluted. The slightly affluent Chengdu people generally used well water for cooking and washing but drinking tea by using river water.

The first water plant in Chengdu, Limin Water Plant, was built in 1909, but it only took water from the river at the south gate of Chengdu and transported it into the city. There were large reservoirs in the city, and water carriers were sending water. There are no steps such as sterilization and filtration. At this time, the water source Fu River and the Nan River were both downstream of the Baitiao River, which is the water source of Chengdu now.



Fig 12.1.1.4 Water bearer and water tank
Source: Wang, D. (2003)



Fig 12.1.1.5 Waterwheel of Limin water plant in 1909
Source: Chengdu Commercial Daily (2014)

12.1 Drinking water history in core urban areas

12.1.2 Stage 2: Modern tap water plant

Tap Water History from 1940s to 1980s

The first water plant in Chengdu was originally called Qingyanggong Water Plant. It was built in 1944 and put into operation in 1946. It is the first modern water plant in Chengdu. The tap water is disinfected and sampled and monitored by the quarantine centre every day. In 1954 and 1978, the second and fifth water supply plants were established. The first water plant takes water from the Qingshui River system, and the second and fifth water plants take from the Baitiao River and Xuyan River systems (Chengdu Folk History, 2020).



Fig 12.1.2.1 Water take point in 1980s

Tap Water History from 1990s

The first water plant in Chengdu has now ceased production. The sixth water plant was built in the 1990s and the seventh water plant was completed in 2013. At present, 90% of the water supply in Chengdu is provided by the sixth and seventh plants, and the rest is provided by the second and fifth plants. In 2012, the second and fifth water plants in Chengdu moved their water intake 3 kilometres up due to water pollution (Xueshutang, 2014).

The development of Chengdu's drinking water extraction started with water drawn from the rivers surrounding the city. As the city's water pollution became more and more serious, it slowly moved to more upstream areas. Moreover, the current water intake in Chengdu are all from the same water system, and their ability to respond to emergencies is insufficient. Besides, this also reflects the idea of giving priority to cities. If urban rivers are polluted, they will seek water from areas with good water quality upstream to meet the needs of urban development.

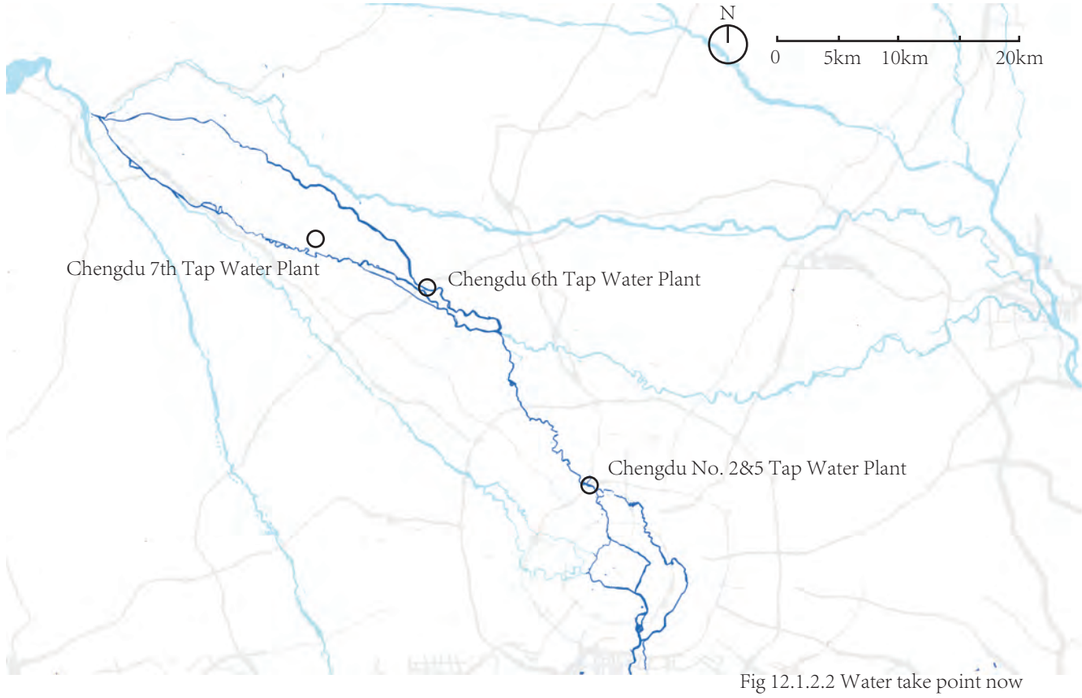
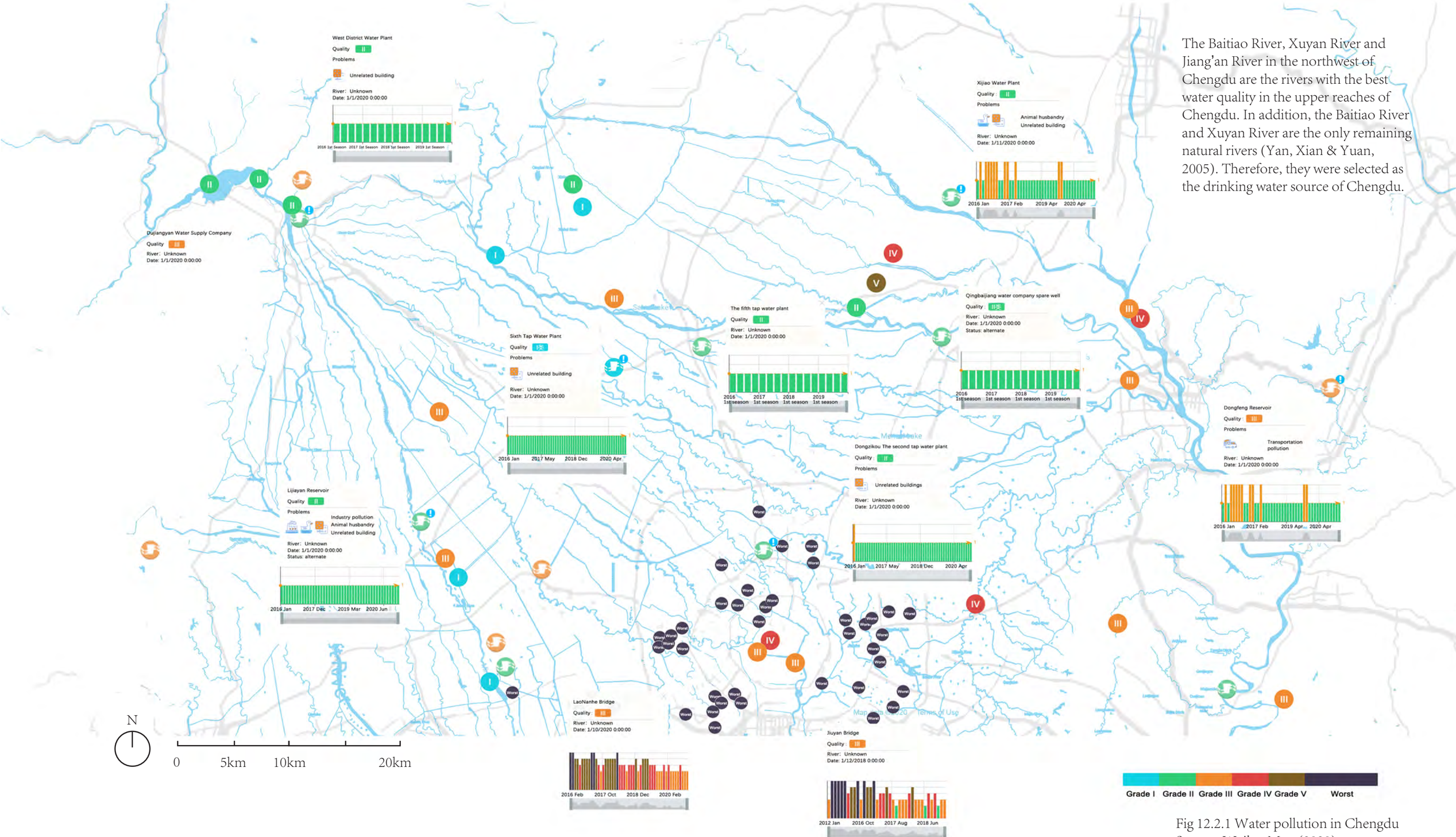


Fig 12.1.2.2 Water take point now

12.2 Water pollution situation in Chengdu



The Baitiao River, Xuyan River and Jiang'an River in the northwest of Chengdu are the rivers with the best water quality in the upper reaches of Chengdu. In addition, the Baitiao River and Xuyan River are the only remaining natural rivers (Yan, Xian & Yuan, 2005). Therefore, they were selected as the drinking water source of Chengdu.

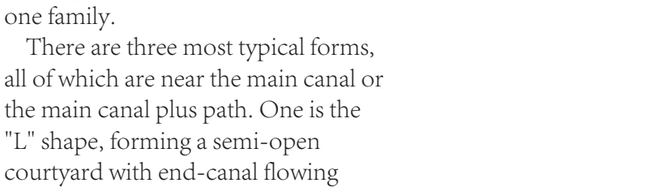
Fig 12.2.1 Water pollution in Chengdu
Source: Weilan Map (2020)

12.3 Topology of the single house in Paotong village

The settlements in the Chengdu Plain are divided into two types according to their scales. The first is the single house, which consists of one family.

There are three most typical forms, all of which are near the main canal or the main canal plus path. One is the "L" shape, forming a semi-open courtyard with end-canal flowing through. One is close to the canal without a courtyard, usually because the homestead has a limited area. The last type is a closed courtyard, the water system is included in the court-yard, and the surrounding wall is composed of brick walls and plants.

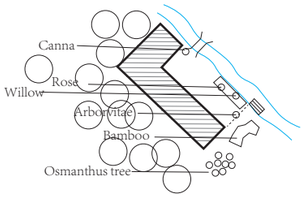
Through interviews, people with children care about their children's education, young people care about jobs and are willing to go to cities to find opportunities, while older people tend to stay in the countryside. On average, each household does not has much arable land. Whether they look forward to looking for opportunities or local development, they all hope to keep their arable land.



A young couple with a simple but new house. They have 0.1 ha of cropland and the husband is running long distance transportation, which is the mainly income.
If possible, they are likely to move into the new resettlement community and willing to new jod opportinities but remian their land in the village.



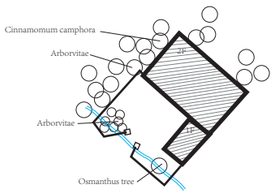






50 years old lady with a couple of about 25 years old. Both of the younger generations are working in the town and the grandson is at primary school. All the income can only cover the living expense, including the tuition fee of the grandson and the cost of buying seeds and fertilizers. What they want is better education, better chances for work and enough compensation.







A couple about 50 years old, without son or daughter.
Relatively wealthy, the house has recently been renovated, the family has 0.2 ha of land, all rented to the contracting company to grow flowers.
There is no expectation for the future, just to live quietly in the village.

Fig 12.3.1 Houses and people living in

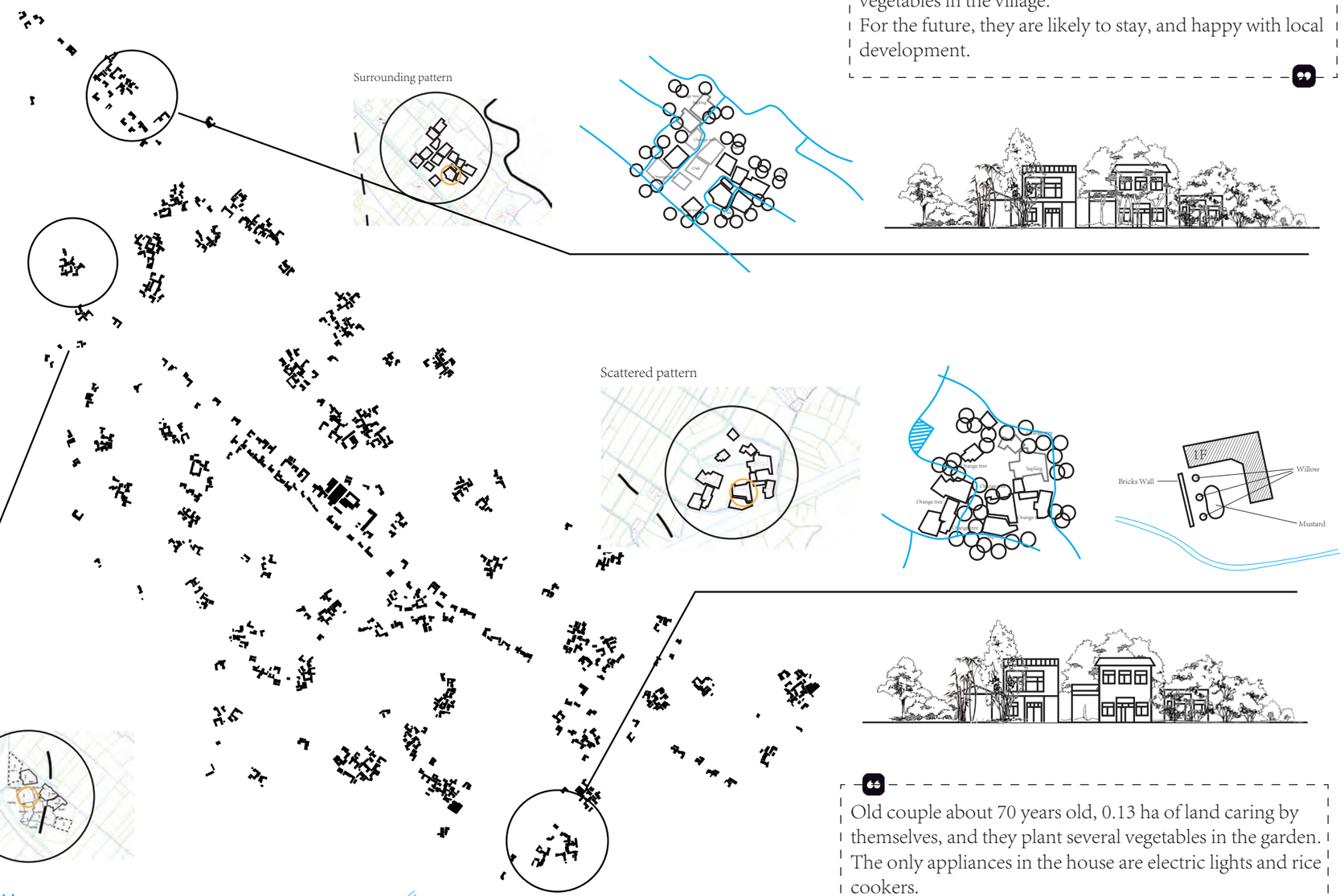
12.3 Topology of the cluster in Paotong village

Another type of settlement is a cluster with several houses. They are a little far away from the main road, there are end-canal and path passing the settlement.

One form is that there is one larger family in the cluster, and the others are small families. The houses of the same family are close to each other. One is a complete dispersal, and there is no kin relationship between neighbours. The last one is the formation of a settlement with one big family.

From the perspective of vegetation distribution, one is surrounded by trees, leaving a public space in the centre, the other is half-surrounded by trees, only some houses have lush trees, and the last is that trees are in the centre. It reflects the difference in the use of the central public space and is also related to the flow direction of the canal.

In the interview here, a large family made a unanimous decision to move into the resettlement community. Other settlements have diversified opinions. Some are willing to see local development, and some villagers want to maintain the atmosphere of the village.



50 years old man with his son. 0.27 ha cropland just in front of their houses, planting corns and rice, half of them growing leeks. They are primary vegetable buyers, responsible for the purchase and distribution of leeks and other vegetables in the village.
For the future, they are likely to stay, and happy with local development.

A big family already moved into the new resettlement community. 0.8 ha of land and all the younger family numbers are working in the town. All the cropland are rent to a company and they are making some bamboo basket, straw shoes.
They are likely to move into the new neighbourhood.

Old couple about 70 years old, 0.13 ha of land caring by themselves, and they plant several vegetables in the garden. The only appliances in the house are electric lights and rice cookers.
They likes to live a natural way of life, it is ok if the village stay the situation now.
There is no expectation for the future, just to live quietly in the village.

Fig 12.3.2 Clusters, houses and people living in

Water Justice in Peri-urban Contexts

--An Intervention Principles Framework of Water Equity in China's Dujiangyan Water Conservation Area

Abstract

In areas where water stress is getting more and more serious, conflicts and fairness about water have become more prominent. Especially in the peri-urban context, because neighbouring big cities usually have a prioritized discourse in economics and politics, the rights of indigenous people are often sacrificed in the process of water resource utilization. Therefore, the unfairness on the local scale caused by the regional water using methods should all be taken into account in the process of water allocation. The flexible water governance and the empowerment of the local people could be a key point to pursue justice in this context. This paper focuses on the water injustice in the peri-urban basin in the upstream of Chengdu where the conflicts of water using city and water source settlement occurs. To pursue water justice, this research builds a framework of the water distributive principles and the essential methods of procedural and interactive justice. And then it figures out how to implement these ideas into the special peri-urban context of the Dujiangyan irrigation district.

Key words: Water justice, Peri-urban context, Justice-achieving principles, Dujiangyan Irrigation Districts in China

Introduction

In many countries, the structure of rights in obtaining water, water management, and participation in water decision-making process is very unfair. As the global demand for water increases and the available water resources decrease, this trend is at risk of exacerbation. Water resources are important for human life and production, and the control of water means important social and economic status (Swyngedouw, 1997). Therefore, water justice is an important part of social justice.

Water justice issues have been explored in agrarian contexts (Boelens et al., 1998) and urban contexts (Heynen et al., 2007). Little attention has been paid to issues of water justice in peri-urban contexts, with a specific focus on water conflicts between urban and peri-urban areas. Irrigation, domestic and industry water in peri-urban districts is usually threatened by the neighbouring metropolis. Some market-driven or government-led interventions that try to improve the water rights and quality of life of indigenous residents even exacerbate this injustice because of the ignorance of local water use norms and culture. Therefore, how to fairly allocate water sources and achieve fair decision-making of water use is worthy of more attention (Zwarteveen & Boelens, 2014).

This article will discuss the issue of water justice from the perspective of the peri-urban context, focusing on the structure of water power between urban and peri-urban areas. The issue of water equity is complicated and sometimes even self-contradictory because it is a concept of socio-economic distribution, including cultural identity and political rights (Goff & Crow, 2014). This article first reviews various theories about the principle of justice in water distribution. They have their own emphasis and different conditions for implementation. Subsequently, a general framework containing various water justice theories was proposed, namely distributive justice, procedural justice, and interactive justice. These three components consist of diverse principles and the different social backgrounds in which they are implemented. This framework not only answers what is water justice but also discusses how to achieve water justice. Then, the article studied the case of the Dujiangyan Irrigation District, expounded the practical principles of these three justice aspects in this example, and provided a case reference for the peri-urban context of water justice issues. Finally, it is concluded that water justice is the balance of social relations and power structure of all parties.

The theoretical framework of water justice

Water justice lies not only in ensuring that everyone enjoys a healthy environment and the basic requirements necessary to sustain life but also in the satisfaction of fair water distribution in addition to basic needs. There is almost no controversy regarding the basic needs of life. But the principles related to justice in the distribution of surplus water are very rich. There was the river bank theory in the early days. The owner of the land adjacent to the river can determine the principle of water distribution according to land ownership, which is based on the principle of first-come, first-serve (Movik, 2014). Then water was regarded as a common good, and the national government is the entrusted body leading the distribution, which is against the river bank theory (Movik, 2014). Another well-known theory on the principle of distribution is the idea of justice as a pluralistic concept embodied in the metaphor of how three children distribute the flute (A. K. Sen, 2009). The first child is poor and he deserves the flute on the ground under the principle of egalitarians. The second child claims that the flute is made by him, so he should have ownership. This view is based on the notion of 'desert by labour'. The last child said that only he can play the flute, so the flute should belong to him. This is in line with the value judgment of maximum utility. In addition, there are luck egalitarians who hope to emphasize luck in economic life through certain principles of design (Lippert-Rasmussen, 2015). And liberals, emphasizing just process in the distribution of resources results (Zwarteveen & Boelens, 2014).

All in all, the concept of water justice is very complicated and it is not suitable to be defined by referring to any one of the principles. As mentioned in these different principles of justice, they are usually contradictory, but they can all be used to understand the concept of justice. Justice is not a single, unified viewpoint, so it is unreasonable to pursue a single principle of justice (A. K. Sen, 2009). A diverse framework is needed in the discourse of water justice, including these competing claims (Lukasiewicz et al., 2013). In fact, in practice, the issue of water justice is usually complex and is affected by the socio-economic and political background. Even if the research is focused on a specific area, the process of realizing water justice is also very complicated. In this process, many stakeholders are involved. The different processes of different participants require different propositions about justice, which is the

purpose of this framework.

Lukasiewicz, Bowmer, Syme, & Davidson (2013) proposed a social justice framework (SJF). This framework includes a variety of principles describing justice in the distribution of environmental resources. It can help make the best balance between various interests and be applied to the allocation of natural water resource. This decision-making model includes three aspects of justice, namely, distributive justice, procedural justice, and interactive justice.

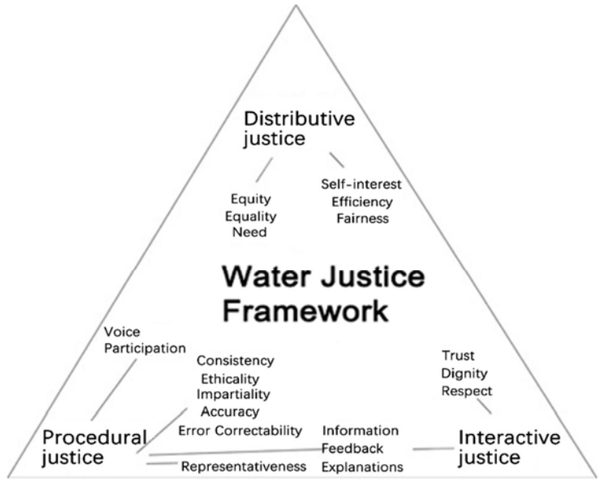


Figure 2.1: Water Justice Framework
(Source: Lukasiewicz, Bowmer, Syme, & Davidson, 2013)

Distributive justice

Distributive justice mainly includes two theories. The first one is the theory of Deutsch (1975) based on need, equality, and equity, emphasizing the dominant position of justice in social relations. Need refers to the priority of emergency water use under socially recognized values. In an area with fragile ecosystems, ecological water demand may be the priority of water resource allocation. In an area where urban domestic water is in short supply, citizens' water demand will be given priority. Equality and equity refer to the relationship status between different groups of people in water distribution and the sustainable development between generations.

The second one is Wilke's (1991) greed, efficiency, and fairness (GEF) hypothesis, assuming that everyone who uses water is greedy, but constrained by the two motives of water efficiency and fairness. The efficiency principle is closely related to the distribution of market-oriented water, and it is a principle that managers tend to choose under water shortage conditions (Movik, 2014).

These six principles can be used to guide just water distribution, but they are not complementary or even conflicting with each other. Therefore, water allocation decisions cannot meet all six principles at the same time, but one or some principles are most applicable under certain circumstances. For example, the principle of equality will be the guiding principle in the place where social relations are most important. In the case of personal development as the mainstream purpose, the principle of demand will step out (Lukasiewicz et al., 2013).

Procedural justice

The core of procedural justice is the fairness of the decision-making process. In fact, regardless of the outcome, a fair decision-making process will increase the satisfaction of the participants (Lawrence et al., 1997). The first one of the three core elements of procedural justice is the right to participate, which represents recognition. The second is participation in the decision-making process, which is the rule of the decision-making procedure. And the third is the level of power of each participant (Lukasiewicz et al., 2013).

The rules in the decision-making process include consistency, ethicality, impartiality, accuracy, and error correction capabilities. Consistency is reflected in the rules of different regions, as well as between generations. Ethicality and impartiality are concerned with the recognition of the decision-making process itself, emphasizing the choices made by participants with complete understanding. Accuracy and error correction capabilities pay more attention to the expression in regulations and policies and the dynamic adjustment ability.

Interactive justice

Interactive justice also pays attention to the fairness of the water distribution process, but it concentrates on the social relations in this decision-making process rather than the power structure (Cropanzano et al., 2002). It highlights each participant's dignity, respect, trust, and effective transmission of information. For example, condescending decision-makers are obviously not conducive to interactive justice. And when it comes to certain professional terms and concepts, it is necessary to explain the relevant situation to all participants.

Interactive justice also involves respect and recognition of different views and values. For example, rural communities believe that irrigation water is necessary to maintain the identity of farmers, and scientists believe that water is essential to a healthy water-dependent ecosystem (Lukasiewicz et al., 2013). Here interactive justice means a way to integrate various viewpoints so that participants can have a more comprehensive understanding.

Background and problems of the Dujiangyan Irrigation District

Peri-urban refers to rural fringe areas that are surrounding cities and has a close connection with the city (Narain, 2014). The Dujiangyan Irrigation District is the peri-urban area of Chengdu, and it is located in the urban drinking water source. Since 2014, due to the rapid growth of Chengdu's population, the demand for domestic water has increased tremendously. Therefore, the water intake of the Chengdu Waterworks along the Baitiao River in the Dujiangyan Irrigation District has increased year by year. In addition, policies for the protection of drinking water sources have become increasingly strict. The new policy prohibits all agricultural, industrial and tourism activities that may pollute water sources, and requires local villagers to move out of their residences in water conservation areas and move into new

settlement communities.



Figure 2.2: Water protection zone in the Dujiangyan Irrigation District
(Source: Made by author based on Hamish Jackson-Mee, 2015)

In this process, the first injustice between urban and rural areas is the drinking water gap between urban and rural areas. According to the data of China Industry Information Network (2018), the average domestic water consumption per capita in the central area of Chengdu is 67 cubic meters per year, while the outer circle of Chengdu where the water source protection zone is located is only 57 cubic meters per year. For farmers who live in peri-urban areas, the main source of drinking water was free well water. Moving to a resettlement community means entering a centralized water supply network. The increase in drinking water costs is a burden for some low-income villagers, which also contributes to the gap in water consumption between urban and rural residents.

The second unfair problem is that urban water rights actually deprive the local industrial and tourism water rights of villagers in the water source area. In addition to the drinking water from the tap water plant in the Dujiangyan Irrigation District, the water of various industrial parks and commercial sectors in the urban area also come from the same water supply system. In other words, the tap water plant is established for both domestic and production water use of Chengdu. Because of the water source protection policy, irrigation water used by local villagers is restricted, and local aquaculture, industry and tourism are even prohibited, which means high quality production water request of city has a higher priority than local industrial water.

The next chapter will discuss the principles of solving these peri-urban inequities between urban and peri-urban areas in the framework of distributive justice, procedural justice and interactive justice.

The Practical Principles of Distributive Justice in the Dujiangyan Irrigation District

In the 'Santa Cruz Declaration on the Global Water Crisis' (2014), an operating principle of distributive justice in practice is described. It believes that there are two types of water equity. The first is the equity within the same water use method where social relationship is most important, such as the equity of drinking water of all the residents in the same river basin. The fairness within the use can be simply explained as a group of farmers or residents or enterprises are able to obtain the same amount of water, which is the principle of egalitarianism. The second is the fairness between different water uses, such as the fairness between agricultural and industrial. The fairness between uses focuses on functional comparison rather than quantitative comparison with a develop-oriented objective, reflecting the principle of efficiency raised by Wilke (1991).

1. Drinking water justice between urban and rural areas

Drinking water between urban and rural areas is justice within one using methods, and its distribution principle should be egalitarian. Phansalkar (2007) believes that egalitarianism of drinking water refers to precise comparison in quantity. For every household in the Dujinagyan Irrigation District, there is a water pipe of the same thickness that leads to the home. The services of the drinking water supply system are also treated equally. For example, when there is a water outage, everyone is affected. The water supply condition is the same between urban and peri-urban areas, as long as you are in a centralized water supply system.

The ideal situation is to treat everyone the same in the centralized water supply system, but the practice of egalitarianism will actually be a more complicated issue. In the drinking water protection area in the Dujiangyan Irrigation District, villagers who use free well water move into the resettlement community with a centralized water supply. In principle, everyone has access to drinking water with the same conditions. However, water supply requests service cost and the difference in actual family conditions makes this process of pursuing fairness actually cause greater unfairness because of the unaffordable water for low-income villagers.

2. Productive water justice between urban and rural areas

The comparison between methods of use is the comparison of functions, which is dominated by self-interest, efficiency, and fairness in the principle of distributive justice (Wilke, 1991). Sen (2014) argues that a more comprehensive comparison from a functional perspective is about job creation, human well-being, and other social goals. The agriculture or local small industries in the peri-urban area of the Dujiangyan are not as efficient as the urban industries with cluster effects and higher technological content. The transfer of water from agricultural production to urban production creates more employment opportunities in cities, and improves social productivity, which is in line with greed, efficiency, and fairness (GEF)'s distribution justice (Wilke, 1991).

This water distributive principles represents the current belief in the view of water equity, which is the faith in the market and engineering technology (Sneddon & Fox, 2007). This new form of water management is actually reshaping the status of different interest groups in the process of water utilization. For instance, modern engineering-oriented users such as large commercial enterprises, agribusiness, private drinking water companies, and mining and hydropower stations have become examples of efficient use of water resources. And there is a criticism that traditional agriculture is wasting too much water (Boelens & Vos, 2012). This change has been reshaping the agricultural production of the entire irrigation district. Through modern technology, more water is controlled through hydropower stations, reservoirs, and sluices. And water resource utilization is inclined to modern, high-efficiency projects. The

Dujiangyan Irrigation District is welcoming large water plants, like the Coca-Cola, and gradually abolish the small township and village enterprises with this efficiency demand distribution principle. This redistribution and deprivation of water, as well as the erosion of existing water culture and knowledge forms, is a new round of 'new enclosures' or 'accumulation by dispossession' (Perreault, 2013), which is unfair to the local people's water rights and development rights.

The examples of drinking water and production water show that water justice should actually consist of two aspects. The first is the description of justice in ideal conditions, which embodies the concept of 'should be'. Drinking water should be in line with the principle of equal distribution. Production water should be based on the principles of efficiency and market-led. However, these distributive principles encountered problems in practice, because justice is also a socially recognized concept with certain time-space and the dimensions of the crowd, which means at a specific time and in a specific area, it is socially fair to a specific person (Roth, n.d.). The existing local norms and water control practices, as well as the power relations surrounding them, are part of water justice (Zwarteveen & Boelens, 2014). Therefore, although the principle of pursuing efficiency in the production water and egalitarianism of drinking water is the right direction, they should not be 100% realized. While pursuing equality or efficiency, water distribution cannot ignore the demands of the indigenous people. The key to determining this part of social water justice is procedural justice.

The Practice Principle of Procedural Justice in the Dujiangyan Irrigation District

Procedural justice is the justice of the decision-making process and methods. The question to be discussed is: Who will decide the way of water distribution? Who has the right to participate in the preparation of water regulation and policy? Whose opinions and norms should be accepted? Whose definition, priority and interest prevail? These questions can be summed up as three powers in practical procedural justice regarding water: the right of recognition, the right to participate, and the right to redistribute (Zwarteveen & Boelens, 2014). The right of recognition is the confirmation of the particular value of a certain group in the use of water. For example, granting people or water user communities the autonomy to formulate and apply their own water use rules is a form of cultural recognition, and this is actually seeking different rights, not equal rights. Participation rights refer to the power of the original water users to participate in the formulation of new rules. Redistribution describes the material and economic aspects, and it involves cultural and political considerations (Zwarteveen & Boelens, 2014). For the people in the water source protection area of the Dujiangyan Irrigation District, they should have the community to choose their own water rules, participate in the formulation of regional water policy, negotiate acceptable water distribution principles, and protect their water culture.

1. Drinking water justice between urban and rural areas

For these vulnerable groups of villagers in all irrigation areas, procedural justice requires that their access to drinking water in their previous lives be recognized. They can get free well water for drinking water is their own water use rules, which has culturally recognized value. Therefore, the intervention that changes their way of drinking water should give them a certain amount of compensation for their water use rules and culture (Bakker, 2013). And the villager has the right to participate in the decision-making process of this new change measure because he is closely related to the villagers' interests. In this decision-making process, the requirement of consistency in procedural justice must be fully considered (Lukasiewicz et al., 2013). In the water source protection area, the current situation and needs of each household's water use should be fully respected as a part of the community water norms and the basis of compensation policies. The rights and interests of the next generation should also be taken into account, to reserve the right to choose the water use method for them, so that the next generation will still have the opportunity to return to the natural village water use. In the right to redistribute, the villagers have a highest level of power to choose their own lifestyle, they can decide whether to adopt a new way of centralized drinking water supply and put forward compensation requirements for their loss. The ethicality and impartiality of procedural justice (Lukasiewicz et al., 2013) require that in the process of redistribution, the villagers should be able to fully understand the various impacts that the new proposal may bring, not only the way of water use but also the change of lifestyle from the village to the city.

2. Productive water justice between urban and rural areas

The original norms and practices of the villagers in the Dujiangyan Irrigation District to control water in agricultural production and local industry should first be recognized. These water use methods are of great significance to the local people because it is not only an economic source but also a reflection of the local people's lifestyle (Perreault, 2013). For instance, the local chilli bean sauce processing is not only a local industry but also a cultural icon of the region. If a city or enterprise that conforms to the efficiency principle of distribution justice wants to be favored in the distribution of water resources, it needs negotiation among various local stakeholder groups. The negotiated subsidy in this process is the recognition of social regeneration property rights (Bakker, 2013). Local villagers have important rights to participate and redistribute. Their water demand of local agriculture and food processing industry should be met as much as possible, unless these industries are helped to achieve technological innovations that reduce water use and pollution or relocated to other places outside the water protection zone by the negotiated compensation. At the same time, with the development of society and the advancement of production methods, the previous efficiency relationship and division of labour between local production and urban water use may change. For example, new agricultural production methods and the food industries may become complementary to urban formats. Therefore, compensation policies and water use structures need to be dynamically adjusted during changes to strengthen the accuracy and adaptability of procedural justice (Narain, 2014).

Practical principles of interactive justice in the Dujiangyan Irrigation District

Interaction justice is especially important in the peri-urban context because big cities usually have priority. In the Dujiangyan Irrigation District, Chengdu is a metropolis in the region. It has priority in economics and politics and represents the most efficient use of water resources. The villages and towns in the water conservation area are small in size. The asymmetry of the relationship needs more emphasis on respect, dignity, and trust of interactive justice (Lukasiewicz et al., 2013).

1. Drinking water justice between urban and rural areas

Essential elements of interactive justice are transparency, accuracy, and feedback of information transmission (Lukasiewicz et al., 2013). This stands on both interactive justice and procedural justice. The city or regional government can easily obtain overall data and information but does not pay enough attention to specific local matters. The resettlement strategy currently implemented in the Dujiangyan Irrigation District is to compensate each family with a fixed amount of money. However, every family has different economic conditions and different works. Some families who rely on agriculture for their livelihoods cannot afford the water costs of the resettlement community. The resettlement compensation set by the government need interaction and feedback with local people to fully understand the resettlement needs of each villager. In the meantime, the villagers would have a more comprehensive understanding of the impact of these changes. The structural realization of interactive justice requires the government's information disclosure platform to be more transparent, to describe policies in a concise and efficient manner, and to make dynamic adjustments based on villagers' feedback.

2. Productive water justice between urban and rural areas

For the communication between producers in the water source area and the government, due to differences in society and power structure, interactive justice is more necessary. The government or water plant should fully understand the water needs of the local agricultural and industry, respect the values of the local people, combine value orientation with reality (Pim et al., 2010) and establish a dynamic communication platform to respond to changing conditions and local development demands. The key to interactive justice here is that this communication platform should be open to the public or supervised by a third-party organization, to ensure that the producers of water sources and the tap water plants are equal in negotiation about how to allocate water resources reasonably (Zwarteveen & Boelens, 2014). Local NGOs, such as the Sichuan River Protection Association, the Villagers' Autonomous Committee, and local industry associations such as the Food Processing Industry Association, should play an essential role in public supervision on fair water use (Martinez-Alier et al., 2016).

Conclusion

The main issue of water justice in the drinking water source protection area of Dujiangyan Irrigation District is the conflict between urban water rights and the water rights of indigenous people. The pursuit of healthy drinking water is positive and progressive, but when the urban drinking water supply system want to involve the indigenous people, objective thresholds have blocked some vulnerable groups to the services. The service expansion to the periphery has caused trouble. Another aspect of the water injustice comes from the neglect of local water norms and culture in the era of pursuing technology and efficiency. The city has taken away most of the water resources at the cost of local agricultural and industrial water use.

The core of water justice in Dujiangyan Irrigation District is to protect the water rights and interests of local people in the process of water source conservation and ensure their rights of recognition, participation, and redistribution through procedural justice and interactive justice under the values of equality and efficiency of distribution justice. Local residents have the right to choose their own water use method and decide whether they are involved in a centralized water supply system. Local industries, especially those with cultural significance, should also have ways to get reasonable compensation or assistance through proper procedures. Ultimately, an efficient information transmission and negotiation platform with effective public supervision will strengthen the understanding and communication among various water stakeholders in the Dujiangyan Irrigation District, which will greatly help the realization of dynamic water justice.

Therefore, water justice is the balance of the interests of all parties. In the peri-urban area around big cities, the principle of equalization should be used for the distribution of drinking water, and the principle of efficiency in other industries. But the water rights and production rights of local people should also be fully considered with their development status and economic conditions. In addition, an effective negotiation and interaction platform should be established in just procedures and interactions in order to realize the dynamic acceptable distribution and compensation of water benefits to all parties.

The framework of water justice discussed in this article focuses on society and power structure. The environmental and ecological benefits of water are not discussed, and the environment is also a stakeholder. Besides, water can also be a starting point and means to achieve broader social justice. In addition to equity issues directly related to water, for example, the exchange of city rights for water rights may also be a way to achieve water justice and it will be further discussed in the graduation project.

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Relaxed Water Protection Policies

1992/2008	*2012*	*2014*	*2019*
Second level			
（1）It is not allowed to build or expand construction projects that discharge pollutants into water bodies. Reconstruction projects must reduce pollutant emissions.	（1）It is forbidden to build, rebuild, or expand construction projects that discharge pollutants; the local people's government at or above the county level shall order the removal or closure of construction projects that discharge pollutants that have been completed;	（1）Set up sewage outlet;	（1）It is forbidden to build, rebuild, or expand construction projects that discharge pollutants; the local people's government at or above the county level shall order the removal or closure of construction projects that discharge pollutants that have been completed;
	（2）Restrict the use of pesticides and fertilizers;	（6）Forbid abuse of pesticides and fertilizers;	（4）Ban the use of pesticides and restrict the use of chemical fertilizers
		（2）It is forbidden to set up large-scale breeding farms;	（8）Those engaged in tourism and other activities shall take measures in accordance with regulations to prevent pollution of drinking water bodies
First level			
First level （3）It is forbidden to engage in poultry and livestock breeding activities that pollute drinking water. （4）Tourist activities and other activities that pollute water sources are not allowed.	（3）It is forbidden to set up livestock and poultry farms; （6）It is prohibited to engage in tourism, swimming, fishing or other activities that pollute drinking water bodies.	（3）Prohibition of livestock and poultry breeding, tourism	（3）It is forbidden to set up livestock and poultry farms; （6）It is prohibited to engage in tourism, swimming, fishing or other activities that pollute drinking water bodies.
Restricted area （3）It is forbidden to stock poultry and livestock in the waters, breeding, water recreation and sports activities, and non-environmental water operations.			

Industry　Livestock
Pesticides & fertilizer　Tourism

Source: The People's Government of Sichuan Province, (1992; 2008; 2012; 2014; 2019)

Investigation on the Willingness to Protect Drinking Water Sources in Chengdu

1、What is your age? (Single-choice questions *Required)
◯ Less than 16
◯ 16-30
◯ 30-50
◯ Above 50

2、What is your educational background? (Single-choice questions *Required)
◯ Elementary School
◯ Secondary school
◯ High school
◯ Specialist
◯ Bachelor degree and above

3、Your monthly income level? (Single-choice questions *Required) (CN¥)
◯ Less than 3000
◯ 3000-5000
◯ 5000-10000
◯ 10000-30000
◯ Above 30000

4、Which district do you live in? (Single-choice questions *Required)
◯ Chengdu City
◯ Longquanyi District
◯ Qingbaijiang District
◯ Xindu District
◯ Wenjiang County
◯ Shuangliu District
◯ Pidu District
◯ Jianyang District
◯ Dujiangyan City
◯ Pengzhou County
◯ Qionglai County
◯ Chongzhou County
◯ Jintang County
◯ Xinjin County
◯ Dayi County
◯ Pujiang County

5、Do you know the protection of drinking water sources (the domestic water intake place)？ (Single-choice questions *Required)
◯ Yes
◯ No

6、Do you know the ecological policy and ecological compensation of the water source area? (Single-choice questions *Required)
◯ Know it well
◯ Know a bit
◯ Only heard of
◯ Do not know at all

7、Do you think that the upstream water source protection area has made sacrifices for the ecological environment? (Single-choice questions *Required)
◯ Yes
◯ No

8、Are you satisfied with the quality of drinking water? (Single-choice questions *Required)
◯ Satisfied
◯ Basically satisfied
◯ Not satisfied
◯ Very dissatisfied

9、Are you willing to pay for the ecological protection of drinking water sources? (Single-choice questions *Required)
◯ Yes
◯ No

10、How much are you willing to pay each year? (CN¥) (Single-choice questions *Required)
◯ 5,
◯ 10,
◯ 20,
◯ 30,
◯ 40,
◯ 50,
◯ 60,
◯ 80,
◯ 100,
◯ 150,
◯ 200,
◯ 300,
◯ 400,
◯ 500,
◯ 600,
◯ Over 1000

11、What is your preferred payment method? (Multiple-choice questions *Required)
☐ Donate
☐ Pay more utility bills
☐ Participate in voluntary labour
☐ Ecological tax
☐ Buy environmental lottery tickets
☐ Others

12、If you are unwilling to pay, what is the reason? (Multiple-choice questions *Required)
☐ Funds should be raised by the government
☐ The water company should be responsible
☐ Water using companies should take responsibility
☐ The upstream should be responsible for ecological degradation
☐ Inability to pay
☐ I don’t believe that the compensation will be used reasonably
☐ Not interested in drinking water source environment
☐ The environment of the drinking water source has little effect on myself
☐ Others

Water of Dujiangyan.
Source: Yichiqupujing. (2019).