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The role of agricultural extension services and farmers' practices in meeting smallholder farmers' needs in China

Chengdong Liao

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Abstract

In China in 2016, 89% of farmers were cultivating less than two hectares of land. Of those, 78% were farming less than two-thirds of a hectare. Meeting smallholder farmers' farming needs is considered critical for the government to alleviate rural poverty and improve food security. The agricultural extension system is considered a major approach. Existing studies have shown that the top-down administrative mechanism of the extension system and its linear technology transfer model have led to mismatches between extension services and smallholder farmers' needs in China; however, limited studies have examined the alignment of extension services with smallholder farmers' needs. This study was designed to examine how well extension services align with smallholder farmers' farming needs in China, and how farmers meet their farming needs.

This study employed the constructivism paradigm and the qualitative method as the research design. The snowball sampling technique was employed to guide the data collection process from provincial level to village level. To understand how the extension services operate, semi-structured in-depth interviews were conducted with agricultural and extension-related departments, organisations and stations at provincial, county and township levels. To understand farmers' perceptions of extension services and farming needs, semi-structured focus group discussions were conducted with smallholder rice farmers in 10 selected villages. Thematic analysis using both deductive and inductive logic and multiple staged coding were employed to guide the data analysis process.

Findings showed that extension services sometimes met smallholder farmers' needs, and sometimes did not. From the extension services' perspective, non-tillage technology and direct seeding technology were rejected by most farmers because of its incompatibility with local conditions and existing practices. The pest and disease management service and soil testing technology had met many farmers' needs; however, farmers reported their limited accessibility. Findings also showed that extension officers at the local level had encountered challenges in providing satisfactory extension services to farmers; for example, non-extension works had occupied time that should have been spent on extension activities. Farmers' cooperatives had also failed to provide services to smallholder farmers because they were aimed at large-scale farming. From farmers' perspectives, to improve farming and solve farming problems, they employed sets of local knowledge and farming practices; for example, neutralising soil with limestone, removing rice leaffolder with brooms, and preventing apple snail with tea seed cake. The farmers identified their farming problems, outlined solutions and were in favour of informal small-scale trials. They saw agricultural input stores as reliable sources of extension advisory services because they were operated mainly by former extension officers.

Based on the findings, this study suggests that, firstly, a feedback mechanism should be constructed in the extension system in China to articulate the voices of extension officers and farmers at the local level. Such feedback should include the effects of extension services and farmers' needs. Provincial-level departments will need to take this feedback into account in order to improve extension services. Secondly, the private sector, agricultural input stores and farmers' cooperatives should be included and viewed as important actors in the extension system. Thirdly, local farming knowledge and culture, existing farming practices and farmers' experiences should be considered in the extension processes, and farmers encouraged to share their skills through small-scale farming trials.

Declaration by author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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This study has obtained ethical approval from the Ethics committee at the School of Agriculture and Food Sciences (Approval ID: SAFS/H17/03) on 31st March 2017. Approval letter is attached in the Appendix 8 of this thesis.

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Keywords

smallholder farmers; agricultural extension; agricultural technology; extension system; extension history; local knowledge; innovation diffusion; social learning; innovation system; rice farming

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List of Abbreviations used in the thesis

ADAS	Agricultural Development Advisory Service
AED	Agriculture Extension Division
AES	Agricultural Extension System
AIS	Agricultural Innovation System
AKIS	Agricultural Knowledge Information System
AKS	Agricultural Knowledge System
APEN	Australasia Pacific Extension Network
ATESC	Agricultural Technology Extension Service Centre
CARI	Central Agricultural Research Institute
FGD	Focus Group Discussion
GFRAS	Global Forum for Rural Advisory Service
MOA	Ministry of Agriculture
NATESC	National Agricultural Technology Extension Service Centre
NGO	Non-Government Organisation
PTD	Participatory Technology Development
RPK	Rural People's Knowledge
RAAIS	Rapid Appraisal for Agricultural Innovation System
RD&E	Research, Development and Extension
SAES	State Agricultural Experiment Station
SSI	Semi-Structured Interview
STB	Science and Technology Backyard
TSP	Technology Supply Push
USDA	United States Department of Agriculture

Chapter 1. Introduction

This chapter presents the background of this study including challenges for agriculture as the broad background, current status of agricultural extension system and smallholder farming and the rationality of smallholder farmers in the theoretical perspective. Then, this chapter presents the research objective and research questions. Finally, it presents the structure of the whole thesis.

1.1 Background to the research

1.1.1. Challenges for agriculture in China

Agriculture is a major industry in China. In response to recent rapid socio-economic changes, the Chinese government has invested in various agricultural, scientific and technological enterprises to support agricultural development and increase farmers' incomes. With limited water resources and arable land, China must provide sufficient food for its population of 1.4 billion, which is nearly 20% of the world's population, and these recent government measures have contributed to a reduction in rural poverty (Huang & Yang 2017). However, the recent increase in imported grains has generated concern about the nation's food security (Gao & Tian 2018; Wang & Chen 2019). Since 2012 the rate of rice imports, mainly from Vietnam, Thailand and Pakistan, has increased drastically because the price of their rice is cheaper, hence self-sufficiency in domestic rice market is threatened (Wang et al. 2018; Yang & Liu 2019). Furthermore, evidence shows that rice import leads to fluctuations in the domestic rice price (Xiao & Wang 2017). This poses potential risks to rice farmers in China.

Multiple challenges have been pointed out for securing the food supply in China, including the decreasing area of arable land, agricultural pollution and climate change. During the past three hundred years, with the population boom, farmland volume has increased 3.2 times in total (Cao et al. 2014). The quantity of farmland reached its peak in 1957 and then began to decrease and kept decreasing until 2013, the main causes being land conversion for industrialisation and urbanisation, and creation for protected areas (Chen et al. 2009; Yi et al. 2013; Zhang & Chen 2014). Also, the land that can be cultivated is small, as the average quantity of farmland per capita in China is half of the global average (Yao 2005), while about 15,000 hectares of farmland has been lost each year since 2012 due to urbanisation, and that loss is predicted to continue by about 10,000 hectares per year until 2030 (Zhang & Chen 2014). Meanwhile, more and more arable farmland has become unsuitable for farming due to moderate to severe metals pollution, for example cadmium, nickel and arsenic, due to the rapid industrialisation and lax environmental enforcement (Li & Pontes 2017; Liu 2018c).

Agricultural pollution is another emerging issue with the government's pushing the use of chemicals. Sun et al. (2012) pointed out that non-point source (NPS) pollution has been the major form of agricultural pollution in China since the 1990s. They found that the main causes of the NPS pollution in China were excessive inputs of nitrogen fertiliser and pesticides, and the rapid expansion of intensive livestock production with little waste management. Ongley et al. (2010) found that NPS in China also caused serious water pollution via contaminations to lakes. It is challenging for the government to control NPS water pollution because the source of the pollution is difficult to monitor and assess (Wang 2006). Cassou et al. (2018) reported that in China in 2015, over 61 percent of groundwater sources and nearly 28 percent of rivers monitored were found to be unsuitable for human contact. Over 30 percent of major lakes and reservoirs did not meet the drinking or bathing water standards, and agriculture was substantially responsible. Evidence showed that rural residents who were exposed to polluted water (mainly surface water) due to agricultural pollution have significantly increased their medical and family caring costs compared to people in the region who drank underground water (Lai 2017). Agricultural extension services are recognised as having an important role in NPS pollution control. For example, according to documentation[1] issued by the Ministry of Agriculture in 2017, the main strategies are reducing the use of chemical fertilisers and pesticides, integrated livestock waste management, crop straw retention and so on. But studies have different findings on their effectiveness. On one hand, Cassou et al. (2018) found that farmers have been overusing pesticides because they did not follow extension officers' instructions and recommendations. On the other hand, Sun et al. (2012) found that inadequate extension services have led to the phenomena to a certain extent, for example, extension officers are not competent to do their jobs because of their lack of knowledge, and they deliberately expand the sales of chemicals to farmers in order to generate more income from their agricultural input businesses.

Climate change is an emerging issue in the agricultural development of China, mainly manifesting as increased temperature and rainfall in the northern areas, and more frequent extreme weather in the southern areas (Pan et al. 2011a). This in turn affects soil fertility, crop performance, crop patterns and incidence of pest and disease, and causes natural disasters such as drought and flood (Zhou et al. 2011; Qin et al. 2013). Other issues include decreased sunlight, increase of greenhouse gases, erosion of soil and destruction of facilities and crops, while indirect issues influence farming systems, plant

[1] *The document* refers to the Nongyebu Bangongting Guanyu Yinfa 2017 Nian Nongye Mianyuan Wuran Fangzhi Gongjianzhan Zhongdian Gongzuo Anpai De Togzhi [The announcement about important work arrangement of agricultural non-point source pollution control in 2017, issued by the general office of the Ministry of Agriculture], issued 24th February 2017.

health and agricultural ecosystems (Xiao et al. 2007; Liu et al. 2010; Pan et al. 2011b). In relation to food security, studies have shown that despite changes in rice variety and farming systems, due to temperature rises the rice yield has significantly declined in southern China (Yao et al. 2007). In particular, the decline of the rice yield is significantly related to the increased night-time temperature wrought by global warming (Peng et al. 2004).

1.1.2. Extension system and smallholder farming in China

In most developing countries, smallholder farming forms the largest portion of agricultural production and will be critical to meet the growing demand for food in the next decades (Fan & Chan 2005; He 2012; Roy 2013). In China, there are various types of agricultural production. The main forms are smallholder farms (individual household farming on less than two hectares of farmland using their own labour), large scale farming (e.g. individual household farms on more than two hectares of farmland using their own and hired labour) and agricultural companies. Within those forms, smallholder farming is the most common. According to the third national agricultural census of China in 2017, as categorised by the size of the cultivation area, smallholder farming (cultivation on less than two hectares of land) accounts for 89.1% of all agricultural production forms, and 78.6% of smallholder farmers cultivate less than two-thirds of a hectare (equal to 10 mu) (Liu & Kong 2018). Smallholder farming is more vulnerable to agricultural challenges and farming issues than other forms of farming such as large-scale farming by agricultural companies. Smallholder farming is categorised as cultivation on less than two hectares (Thapa & Gaiha 2011), with those farms generally being labour-intensive and economically inefficient due to limited financial resources, dependant household members, and production for household consumption as the primary purpose (Csaki & de Haan 2003; Hazell et al. 2007).

Development economic theories have different points of view on the economic-inefficiency criteria, with some arguing that smallholder farming is actually economically efficient given their limited resources and external opportunities (Yao 2010). However, smallholder farmers have limited access to high-value food markets, limited access to technologies and the capacity to adopt them, and limited access to credit (Thapa & Gaiha 2011; Yang 2013; Jouzi et al. 2017). In the agri-food supply chain, the formal production contract is an important approach to link smallholder farmers to the supply chain (Guo & Jolly 2008; Miyata et al. 2009; Ferris et al. 2014; Cai & Ma 2015). However, Liu (2018b) found that smallholder farmers are excluded by deliberately built barriers in the supply chain from. For example, Sino-grain, a rice procurement giant in China, charges higher transactional costs for smallholder farmers because they require more time and manifest higher uncertainties compared to large-scale farmers and supply chain brokers. Land issues and the government's land policies in

China have also been influencing smallholder farmers' decisions. Zhu and Riedinger (2009) pointed out that, up to now, the legal owner of land in China remains the rural collectives (all members of a village make up each collective). Farmers only have the right of land-use, and the sale or mortgage of land is still prohibited although the government is attempting to develop an active rural land market through encouraging farmers to lease or exchange their right of land-use to organisations or companies that are more efficient in agricultural production. However, farmers are still experiencing insecurity when considering leasing or exchanging their lands, because of the opaque title of their land and uncertainty in the government's land policy. Furthermore, under the current land tenure arrangement, some farmers worry about the farming practices used by farmers or companies that rent their land. For example, Gao et al. (2018) found that in central China, crop farmers' rate of adopting a conservation practice, straw retention, on rented land half that of those farming on their own plot. Tan (2014) pointed out that the government seeks to form larger farms in the long term as a strategy to secure food. Thus, government land tenure policies have serious implications for smallholder farming.

In the Chinese context, studies have shown that agricultural universities and their research bases in villages can effectively enhance technology dissemination and adoption among smallholder farmers (Guo & Liu 2013; Zhang et al. 2013; Liao 2015; Qiu 2015), and also can effectively empower smallholder farmers (Zhang et al. 2016); farmers cooperatives can perform effective role in bridging smallholder farmers into high-value agri-food markets, thereby securing and enhancing their income (Yang et al. 2014). While recognising the performance of those organisations and their interventions in supporting smallholder farmers, the government agricultural extension system that covers most local levels is the most common extension service provider to smallholder farmers in China.

According to government documents regarding agricultural policies in China, smallholder farming is recognised by policy-makers as a major form of agricultural production requiring extension support. Studies reveal that smallholder agricultural production has long been considered as the laggard in technology adoption, contributing to poverty and hindering economic development (van der Ploeg 2008; Ye 2015). Hence, instead of supporting smallholder farming, these government policies aim to transform smallholder farming into higher-level forms of production such as mechanised and intensified. The Number One Central Document (*Yi Hao Wen Jian*) issued by the central authority of China, which is usually viewed as the primary program form of the year, has been focusing on agriculture, rural and farmers' issues (*San Nong Wen Ti*) for 16 years until 2019. The Rural Revitalisation (*Xiang Cun Zhen Xing*) implementation and poverty alleviation program also reflects the central government's strategies on supporting smallholder farming and farmers in the nation's

agricultural development. Strategies for supporting smallholder farmers vary each year, for example, through encouraging rural tourism, regional demonstration production areas such as specific vegetables, fruits or crops, and farmer cooperatives and family farms. Certain studies have shown that these robust development agendas have caused rural development issues, for example the rural tourism strategy has caused the loss of critical local knowledge that sustains community connections because the construction of new facilities has destroyed certain local facilities that have long been used for farming (Xie 2011). As these strategies are only for specific regions, places or crops, they appear quite exclusive to smallholder farmers as only small groups of farmers are targeted. It has also been recognised that in most countries, effectively supporting smallholder farming has been a lot more difficult than supporting large-scale farming and intensified farming. Providing consistent extension services to smallholder farmers has been emphasised in policies every year as the Chinese government focuses on the role of science and technology in promoting production and yield, which reflects on improving farmers' livelihood and rural development. Thus, most smallholder farmers should, accordingly to policies, have proper access to extension services.

Chinese policy-makers have assured consistent extension services to farmers, with a well-established agricultural extension system embedded in the administrative system. In 2006 the total number of extension staff throughout the Chinese national agricultural extension system accounted for nearly 58% of the world's total extension staff. In China there is one extension staff member per 0.81 villages or per 283 farm households (Swanson 2008; Hu et al. 2012b; Kaegi 2015). Although cutting extension institutions and reducing extension funds due to budget problems has been a global trend since the late 1980s (Huang et al. 2003b; Swanson 2006; Hu et al. 2012a), China has been continuously investing funds for extension services for farmers, despite the fact that there have been several reforms including the institutional merger that resulted in a decrease of extension staff and the loss of agricultural revenue that led to a decrease of agricultural extension funds. Chinese policy-makers have also been wrestling with the budgetary problem of providing extension services to the enormous number of farmers in China, and have launched privatisation and decentralisation reforms in the extension system since 1985, by encouraging the public-sector extension officers to start their own extension and agricultural input business to achieve their own financial self-sufficiency and hence to overcome the government budget shortages (Huang et al. 2004; Kong & Lou 2012). According to the Number One Central Document[2] in 1983, the nature of the encouragement was to link the salary of

[2] *The Number One Central Document* refers to the first central government document of the year jointly issued by the Central Committee of the Communist Party of China and the State Council.

extension officers to the economic gains arising from their extension services, ensuring the income of extension officers rose with the increases in farmers' incomes. The forms of the encouragement included, on top of their pay, allowing extension officers to contract with producers to receive share of the production and encouraging extension officers to start their own extension business. However, these trials have resulted in problems including the over promotion and usage of pesticides and fertilisers (Huang et al. 2000), and funds for extension works have been significantly reduced, some have even entirely ceased at local levels (Kong 2009).

In a major response, China launched a decentralisation reform regarding the local level extension system in 2002, which merged individual extension stations into one agricultural services centre, and the administrative affiliation of the local level agricultural services centre devolved from the county level agricultural department to the local government (Chen et al. 2009; Huang et al. 2009). This reform has parallels with practice in other countries, for example, the Local Land Services (LLS) in New South Wales, Australia, which results from the merger of different quasi-government agencies in natural resources management and biosecurity and agricultural extension (Hodgkinson 2012). This reform aimed at the reallocation of responsibilities to the LLS, which was allowed to have regional governance arrangements and local control of services activities (Hunt et al. 2014). The intention of this reform was to improve the accessibility of farmers and landowners to integrated agriculture and natural resources management advice from one organisation (Hodgkinson 2012). However, a study found that this arrangement has led to a drop in NRM and agricultural advisory staff, thus a severe reduction in capacity of service provision (Ampt et al. 2015). Further, factors such as government uncertainty and low payments, deter farmers' willingness to participate the schemes provided by the LLS (Page & Bellotti 2015). This reform did not compromise the LLS's autonomy in local service activities. However, the decentralisation reform in China has added duties to extension officers so that the time they could spend on extension work significantly reduced due to the extent of non-extension duties (Hu et al. 2009). Study has pointed out that local level extension departments and officers have been under political coercion from their upper level departments, as the extension system is embedded in the administrative system, the bottom of the system and their "San Quan (*Finance, Personnel and Resource*)" are fully controlled by their upper level departments (Smith 2007). Evidence has shown that such factors significantly limited their capacity to provide satisfactory extension services to farmers. More than 80% of farmers surveyed by Hu et al. (2004). reported that extension officers had not visited their villages between 1996 and 2002. From the agricultural system's perspective, in the provinces surveyed in 2009 and 2014, 58.7% of local level extension stations had not yet recruited university-qualified new staff, while the existing extension

staff had been leaving their positions. The personnel structure of the extension system had thus become insufficient to provide good extension services to farmers (Li & Zuo 2016).

The competency of grassroots extension officers is also becoming a cause for concern. According to the Agricultural extension law of China, the academic institutions, agricultural departments and extension departments at different administrative levels, are obligated to provide routine agricultural technology training for grassroot extension officers, in order to update their knowledge and improve the provision of extension services. In the provinces surveyed in 2009 to 2014, although 91% of grassroots extension officers reported that training was important for improving their extension work, 14.6% had not attended any training and 33.4% had attended no more than two training sessions in years (Li & Zuo 2016). Obviously, extension officers who are not competent are superfluous in the extension team (Gao & Zhang 2010).

Smallholder farmers seek alternatives to the government services. Some see the private-sector as another main source of extension services (Kong 2009), however, studies point to such services as having reliability and quality concerns (Huang et al. 2009), as they have significantly increased the rural use of fertilisers and pesticides and hence caused environmental and resources management issues (Huang et al. 2003a; Hu et al. 2007; Huang et al. 2012). Others rely on other farmers; for example, 41.7% of farmers reported they did not receive support from extension officers when they encountered farming issues; instead they received more support from their neighbourhood (Kong 2009).

Further studies have shown that government extension services have been mismatched to smallholder farmers' needs. Burnham and Ma (2018) found two different accounts in the Loess Plateau Region, a region in Northern China which is highly vulnerable to climate change. The government promoted maize planting and drip irrigation technology to smallholder farmers. The drip irrigation technology was rejected by most farmers because it requires more labour input s for its maintenance, and it increases market risk to farmers. Planting maize without drip irrigation, on the contrary, was widely accepted and adopted. While the government thought planting maize was an approach to increase food security and match the change of food consumption in urban area, most farmers reported that they accepted it because it requires low labour input so that they could have more time to do off-farm work for more income. Other studies reported that smallholder farmers' extension needs were specific and diverse, and the Chinese top-down extension system and its working process failed to meet them (Jiao et al. 2015; Zhao et al. 2015). Further reasons for the mismatch include the task-driven extension mechanism caused by the extension work being embedded in the administrative system (Jian 2007), the pursuit of faster yields by scaling up standardised and industrialised production (Yuan & Anke

2011), overlooking smallholder faming's role in economic development (Kaegi 2015); the lack of an effective approach allowing farmers to express their extension needs and thereby have them met (Li et al. 2017); and bureaucratic decision-making in selectively choosing certain villages and farmers for extension services, thereby excluding others by default (Smith 2007). Some studies have suggested that China's agricultural extension system needs to become more privatised and demand-driven in order to meet smallholder farmers' diverse needs (Jian 2007; Zhao et al. 2015). A more inclusive extension mechanism and participatory extension approach could improve technology dissemination and adoption among farmers in China (Huang et al. 2008; Hu et al. 2012a). One study provided the example of an extension office promoting new varieties to farmers without investigating local conditions, resulting in great financial loss to farmers when the varieties turned out to be unsuitable for local soil and water resources (Li et al. 2016b).

Most existing studies are focused on the perspective of the extension system in analysing the extension supply-demand mismatch question. There is a gap in the research from the smallholder farmer-oriented perspective, including smallholder farmers' perceptions on their farming and extension needs, and how extension provisions, including technologies, varieties and services, have failed to match smallholder farmers' needs.

1.1.3. The rationality of smallholder farmers

With China's recent rapid development of the economy and changes in society, most farmers have transformed from being unable to produce sufficient food to being fully self-sufficient (Huang et al. 2006; Chen et al. 2009). Besides the technological changes and the efforts of the extension system, many studies have pointed out the rationality of farmers and its role in farmers' farming decisions, technologies, environments and resources management, as a major response to the stereotypical opinions that smallholder farmers are economically insufficient and passive actors in the agri-food system (Huang 2008; Lin 2016). Recognising the rationality of farmers can provide insights in analysing farmers' behaviour and decision-making, as most farmers are involved in huge socio-economic changes (Yong 2011; Lin 2016).

Traditional economic thinking, including the works of Adam Smith and David Ricardo, posits that smallholder farmers are economically rational as they are motivated by economic interests, responsive to price and cost changes and their behaviours tend to pursue maximised profit (Yao 2010). They argued that smallholder agricultural production would eventually transform into socialised large-scale production; however, the so-called economic rationality is more complex than that, as evidence has shown many smallholder farmers in low-income rural areas have chosen to opt out of

markets (Barrett 2008), and to reject the improved crop varieties that are capable of higher yield (Lin 2016). Compared to large-scale farming and agribusiness that solely pursue yield and profit, smallholder farmers' decisions are more complex because they produce both for their own household consumption and to some extent for the market. Thus they have to make decisions based on complex considerations (Huang 1985; Huang 2008). Further, farmers actively care about natural resource conservation and its benefits to future farming activities, as opposed to farming solely for economic profit (Kiome & Stocking 1995; Ning 2011; Ye & Fu 2015); and from this rationale they chose traditional methods of cultivation over new farming systems introduced by the government (Dries 1991). Farmers' opposition to technologies and extension has commonly been considered as being due to a lack of literacy and scientific knowledge, but their concerns about implementation costs and loss of flexibility are issues that the extension system has not fully considered (Vanclay & Lawrence 1994; Han 2001; Keister & Nee 2001; Lin 2016).

Many studies have pointed out the role of local knowledge and farmers' practices in rural developments. For example, the "Farmer First" paradigm has provided insights regarding collaboration between agricultural research and development and farmers' knowledge, practice and innovations, pointing out that building farmers' capacity and participation is more effective than top-down and linear technology transfer in improving agricultural production (Chambers et al. 1989), and farmers' needs should be prioritised in any rural development agendas to achieve rural development (Seegers et al. 1994; Chambers 1997). Evidence has shown that, regarding improving farming, farmers have a broader and more holistic approach than that provided by government interventions backed by logic that simply aims to encourage farmers to adopt certain innovations to achieve a higher level of production (Bunch 1989; Ye & Fu 2015; Kokate et al. 2016). Besides improving yield and income, farmers also pay close attention to their environment and natural resources to assure future production by using local knowledge and innovations (Scoones & Thompson 1994; van der Ploeg 2008) in order to build their farm's resilience and sustainability (Folke et al. 1998; Milestad et al. 2010; Song et al. 2016; Tambo & Wünscher 2017; Šūmane et al. 2018). Most agricultural research is based on conventional reductionist and mechanistic world views (Holling et al. 1998), whereas the systems in farming communities are approached in complex and holistic ways (Berkes 2012, pp. 193-4). Farmers use technologies to manage their farm efficiency and reduce negative environmental impact from inputs. For example, farmers use remote sensors to use increasingly expensive fertilisers and herbicides more efficiently and thus minimise the negative environmental impact such as nitrogen emission (Hochman et al. 2013; Rochecouste & Crabtree 2014). Studies have shown that the goal and intervention of government can cause serious problems, for example, the government's pushing

intensive agriculture has led to negative environmental consequences in China such as the overuse of nitrogen in soil (Tang & van Ranst 2005; Lu et al. 2020), and when interventions from planners and policy-makers contradict the interests of local communities regarding environment and resource management issues, the local people intentionally craft the interventions to suit their own needs (Cleaver 2002; Koning & Cleaver 2012). We need to consider if the research and extension system, especially the top-down governmental extension system, has met farmers' objectives and needs, and if not, how do farmers perceive and respond to emerging technologies and changes.

In the Chinese context, studies have highlighted the positive role of local knowledge in connecting human activities and its importance in gradually enhancing rural development under the Rural Revitalisation reform; however, the modernisation process has severely affected the local knowledge system in China (Xie 2011; Qiu et al. 2018). The critical role of the local knowledge system in enabling local people to deal with natural disasters in ethnic regions of China has been acknowledged (Luo 2011), as has its role in potentially enhancing implementation of the national poverty alleviation project (Liu 2018a), but a lack of recognition and protection in policy-making processes is threatening the existence of these local knowledge systems (Zhang et al. 2007). Studies have categorised smallholder farmers as socialised smallholder farmers, as their motivation and behaviour are hugely influenced by rapid social changes (Deng 2006; Xu & Deng 2006). Evidence has shown that the Acquaintance Society (*Shuren Shehui*) and interpersonal relationships (*Guanxi*) and gifts (*Renqing*) that are embedded in rural society in China (Song 2009; He 2011), are also important constituents in farmers' rationality as they provide efficient labour arrangements, and are low-cost and stable, for peasants throughout the cultivation period (Li 2016). However, they are not always positive in supporting smallholder farmers. For example, Liu et al. (2020) found that the interpersonal relationships between large-scale farmers and the rice procurement companies can cause exclusion of smallholder farmers in the rice supply chain. Smallholder farmers have their own adaptive strategies to deal with risks and changes from the market, environment and climate, such as diversifying livelihood through local wage work and labour migration, and the extension system should consider these factors in their extension decision-making (Burnham & Ma 2018). These studies have shown that smallholder farmers in China are proactive actors in their farming and agricultural systems; they are not the passive receivers of technologies and innovations that the top-down extension system implies. However, the lack of knowledge and learning capacity has been constraining farmers' rationality. Liu et al. (2018) found that in the plateau area of northern China, farmers are aware of the land degradation problem and have been taking measures to improve their adaptation to the land degradation. But because farmers lack in-depth knowledge about the land

degradation situation whilst the government and extension system consider the environmental problems simply as technology adoption issues, the farmers can only choose to avoid farming on the degraded land. While these studies commonly discussed political power and policy in relation to distribution of resources and services to support smallholder farmers and rural development. The relationship between the agricultural extension system and smallholder farmers' rationality and local knowledge has not yet been widely considered in the Chinese context. Especially, there is a lack of knowledge about how smallholder farmers perceive their farming needs and how they respond to the services provided by the top-down extension system.

1.2 Research objective and research questions

The main objective of this study is to understand the alignment of extension services with smallholder rice farmers' extension needs in China. This study explores extension services from the extension system including government-sector and private-sector, farmers' perceptions of their needs and extension services, and the alignment of extension services with famers' needs. Furthermore, this study explores how farmers meet their farming needs. The aim is to investigate how the provision of agricultural extension services to smallholder farmers can be improved. The broader implication of this study will be, firstly, the evaluation of the extension system in China including its goals, decisions and approaches regarding extension services to smallholder farmers; secondly, smallholder farmers' approaches to meet their needs, and their role in the extension system.

This study is guided by the following questions:

1. How well are the farming needs of smallholder farmers met by the extension services?
2. How do smallholder farmers meet their farming needs?
3. What are the implications for improving extension services to smallholder farmers?

1.3 Structure of the thesis

This thesis is comprised of seven chapters as shown in Figure 1-1. Chapter 2 reviews literature on the shifts of concepts and paradigms of agricultural extension; the innovation theories: innovation diffusion, knowledge and information systems and agricultural innovation systems; and the learning theories: adult learning and social learning in relation to agricultural extension systems. Chapter 3 provides a brief history of agricultural extension in ancient China and four main changes of the extension system from 1950 to the present. Chapter 4 presents the research design: research paradigm and the selection of methodology; selection of study locations at different levels and the selection of

data collection methods; data analysis processes, data validity and reliability, and ethical clearance. Chapter 5 presents results on how well the interviewed farmers' extension needs were being met. Chapter 6 presents findings on how farmers meet their farming needs. Chapter 7 presents a discussion of the results and conclusions of the thesis. The discussion section answers each research question and discusses the results of this and other relevant studies. The conclusion summarises previous chapters and raises theoretical and practical implications of this study.

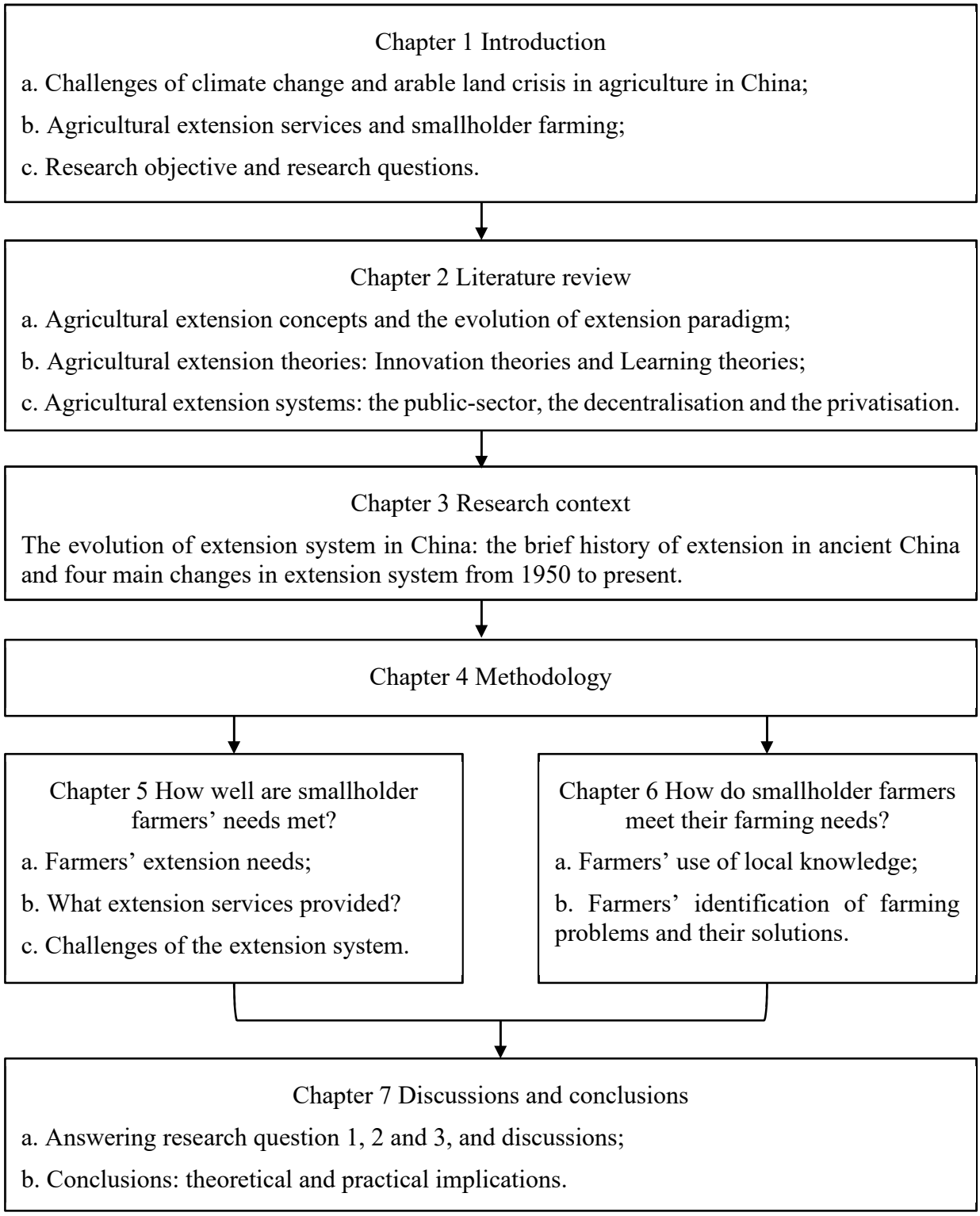

Figure 1-1 Structure of the thesis

Figure 1-1 presents the structure and coherence of each chapter in this thesis. From chapter 1 to chapter 4, it shows how the results were generated into chapter 5 and chapter 6. The chapter 7 discussion and conclusion are based on the synthesis of both result chapters.

Chapter 2. Literature review

This chapter presents literature from four perspectives: agricultural extension concepts and paradigm shifts; extension theories including innovation theories and learning theories; agricultural extension systems in different countries and their changes; and literature on matching extension supply and demand.

2.1 Agricultural extension concepts and paradigms

Existing studies have pointed out the origins of agricultural extension in different regions and contexts. From the mid-1800s extension education emerged in Cambridge, UK, in the form of university-initiated agricultural education activities in rural areas (Swanson & Claar 1984). Around the same time the US state-level agricultural associations emerged to meet the growing demand for agricultural production. This encouraged the development of agricultural education. In 1962 the Morrill Act and related legislations were enacted in the US, and land-grant agricultural colleges were established in a number of states to provide necessary agricultural education and extension services (Huffman & Evenson 2008).

Agricultural extension has been considered and defined in a variety of ways. Maunder (1972, p. 3) defined agricultural extension as "*a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living, and lifting the social and educational standards of rural life*". Similarly, by taking a broader view, van den Ban and Hawkins (1988) defined agricultural extension as the process which helps farmers to analyse their present and expected future situations, to become aware of farming problems and increase their knowledge, to acquire specific knowledge and improve decision-making skills. Anderson (2004) argued that agricultural extension broadly focuses on the delivery of information inputs to farmers, whilst Swanson (2008) said the primary goals of agricultural extension are highly concerned with the transfer of technologies associated with major crop and livestock production. Leeuwis (2004) pointed out that in the early days of agricultural extension, it was usually related to the need to increase food production and to encourage economic development. Agricultural extension has been regarded in terms of technological intervention, as an approach to analyse the impacts of technologies on adopters and households (German et al. 2006). It was also seen as a process of sociotechnical transition, whose pathways include transformation, reconfiguration, technological substitution (Geels & Schot 2007). Ampt et al. (2015) argued that there was a need to use terms such as "innovation" or "knowledge brokering" to re-navigate the practice

of agricultural extension, as the term "agricultural extension" has long been used closely with the technology transfer approach. In terms of the definition of technology, Srivastava (2008, p. 785) said the technology of agriculture is "*the application of techniques to control the growth and harvesting of animal and vegetable products*". Overall, this study considers agricultural extension as the process of technology transfer and provision of advice to solve farming problems, whose main purposes are increasing production and encouraging economic growth. When referring to agricultural extension, this study defines technology as the application of techniques, methods and practices to control the growth and harvesting of crop, vegetable and animal products.

Coutts and Roberts (2011) summarised the paradigmatic shifts of agricultural extension research, including the linear transfer of technology in the 1960s, problem solving in the 1970s, systems thinking in the 1980s, pluralism in the 1990s, and capacity building in the 2000s. Across each era there have been several emergent models of extension including the "Farmer First", participatory extension and the learning platform.

In the 1960s agricultural research and practice were dominated by the linear technology transfer model, particularly when the innovation diffusion model emerged in the 1960s characterising the elements of technology and its dissemination processes (Brooks 1994; Rogers 2003). The innovation diffusion model provides a framework to analyse the process of technology delivery and conceptualises technology and extension as purposeful interventions to rural development. Meanwhile, the risk and uncertainty of innovation adoption were widely recognised, as they were the major concerns of innovation clients and influenced the process of adopting innovations (Marra et al. 2003; Pannell 2003; Ghadim et al. 2005). Human capacity and labour availability were also found to be important factors in innovation adoption (Feder et al. 1985; Rajasekharan & Veeraputhran 2002; Diederen et al. 2003; de Graaff et al. 2008; Duyen et al. 2019). During this period, many patterns were promoted to achieve innovation adoption. Similar approaches can be found in the Technology Supply Push (TSP), which has been employed to boost productivity growth in OECD countries, the Green Revolution in Asia (Hounkonnou et al. 2012), and the aggregate adoption of technology (Feder & Umali 1993). Kuehne et al. (2017) argued that the Innovation Diffusion model from Rogers (2003) has been widely used to conceptualise the innovation adoption processes, but it cannot offer deeper insights to understanding the adoption activities, particularly when agricultural and farming systems perspectives were introduced to the field of agricultural extension and innovation. They developed an ADOPT model, the Adoption and Diffusion Outcome Prediction Tool, for predicting farmers' uptake of new technologies, which considers a wider range of factors and their complexity in farming. Those factors include interactions amongst profit, risk and uncertainties and environment; and the

learnability of the practice. Pannell et al. (2006) used an innovation adoption framework to analyse landholders' adoption of conservation practices. This went beyond the traditional focus of the adoption framework being used in economic and yield focused studies, to offer more holistic perspectives including social, cultural and environmental goals. The linear technology transfer and the TSP assume that through simple extension and adoption of technologies and the boost of yield, farmers would benefit and hence there would be satisfactory changes and rural development. However, after certain failures were widely perceived in extension practices, either in their linear approach or lack of holistic worldview, studies have commonly promoted changes to approaches used in agricultural extension.

In the 1970s researchers started to use group discussion or participatory techniques to ascertain farmers' needs in order to shape agricultural research as a response to failures of the linear transfer of technology. In this paradigm, agricultural extension became a method of problem solving for farmers to assure the relevance of extension provisions (Coutts & Roberts 2011). Additionally, extension became an assistant to help the client be aware of the symptoms of problems and formulate solutions to them, including identifying the causations, diagnosis process and generation of solutions and alternatives, particularly for small farmers who did not have capabilities in those processes (Röling 1988, pp. 57-8).

The 1980s saw the introduction of systems thinking, whereby farmers were involved in research and development and policy-making processes in order to obtain holistic perceptions at the farm level and to shape research (Coutts & Roberts 2011). Douthwaite et al. (2017) call for a "new professionalism" of agricultural research, which recognises the role of agricultural research in supporting the capacities of agriculture and farmers in terms of facing global patterns of change. They also see a need for systemic approaches in improving rural livelihoods, which should be learning-focused and reflexive. During this phase, systems thinking and learning approaches were employed to enhance farmers' understanding of their farm. By employing the systems thinking approach, agricultural extension could look through the lens of a holistic worldview, instead of solely focusing on production and productivity of land, labour and capital in agriculture. The latter focus is not always desirable because production cannot achieve holistic rural development and innovation as it cannot solve the related problems such as unreasonable food prices and environmental issues (van den Ban & Hawkins 1996). The Agricultural Knowledge and Information System (AKIS) perspective argues that knowledge and information are critical in the extension process, alongside technology (Röling 1988); the extension process should be a systematic one that includes the delivery of facility, ability, knowledge, and the way to improve production (Smilor & Gibson 1991; Cao et al. 2005). Whilst the complexity of

agricultural and rural issues has been the main focus of AKIS and AIS studies, sub-topics have been explored, for example, actors and their roles in the innovation network (Clarke et al. 2018); the use of a Theory of Change (ToC) approach to analyse the dynamic of complexity within the AIS (Douthwaite & Hoffecker 2017).

Farmer-driven agricultural research and extension was introduced through the "Farmer First" theory by Chambers et al. (1989). The Farmer First theory considers that farmers' needs should be prioritised in agricultural research and extension activities to avoid "outsider's bias", and that farmers' knowledge and practices should be incorporated to encourage farmers' experiments (Chambers 1983). Farmers started to be viewed as the experts of farming, and this perspective was used to guide research and extension.

In the 1990s agricultural extension was regarded as being able to incorporate a broader range of clients and meet their diverse needs through the use of social learning and participatory approaches (Coutts & Roberts 2011). At this stage, the concept of pluralism was introduced to agricultural extension planning and practices. Pluralism was defined as "*the plurality of technological solutions and service structures, including a readiness to continuously unpack packages as situations change and become better understood*" (Christoplos 1996, p. 11). Pluralism was introduced to overcome the fact that the planning and design of extension packages did not consider the complexity of rural development, and thus agencies have been promoting wrong packages of solutions to rural development (Christoplos 1996; Zijp 1998). The ideas and practices of participatory extension and participatory innovation, through the use of approaches such as farmer field schools (Zhang et al. 2008), participatory learning and communication approaches (Ramírez 1998) and participatory rural appraisal and facilitated workshops, imply that a broader number and range of farmers can be incorporated in the extension process to achieve integrated or systematic rural development goals (Jiggins & Roling 1994; Swanson & Rajalahti 2010).

In the 2000s agricultural extension reflected capacity building and community engagement and focused on information access, facilitation and empowerment, and technological development (Coutts & Roberts 2011). According to this perspective, agricultural extension should be viewed as "*the process of enabling changes in individuals, communities and industries involved in the primary industry sector and with the rural natural resource management*" (Vanclay & Leach 2011, p. 6). From the perspective of farmers, agricultural extension should be the support and link for empowering and improving their adaptability to uncertainties and changes, in response to failures of technology-push approaches (Nettle et al. 2015). The Agricultural Innovation System (AIS) perspective argues that agricultural brokers or intermediaries can effectively orchestrate networks or bridge certain actors

in the system, through such provisions as innovation champions in the building of agricultural production networks (Klerkx & Aarts 2013) and innovation intermediaries to link smallholder farmers with technology providers and agri-food markets (Kilelu et al. 2011; Yang et al. 2014) to empower farmers in the innovation system. Learning has also been emphasised, particularly the role of social learning in the formal context and its facilitation (Kilelu et al. 2013; Schut et al. 2016).

Chapter 1 has pointed out that the situations of smallholder farmers and issues that they are facing are complex. Innovation diffusion and AKIS models have been widely used to understand the process of innovation and knowledge creation, but their emphasis on technologies and the limited involvement of actors have undermined their roles to dissect the complexity of smallholder farmers and their needs. The AIS perspective considers innovation in terms of systemic changes and the outcome of interactions amongst multiple actors, which makes it more suitable to understand the complexity. Chapter 1 also pointed out that farmers' rationality has an important role in farmers' decisions and supporting their farming. Thus, this study uses learning theoretical frameworks to understand farmers' rationality in the system.

2.2 Agricultural extension theories

Innovation theories and learning theories are two main bodies of agricultural extension theories. Innovation theories comprise three main bodies of frameworks: the innovation diffusion theory conceptualises extension services as innovations and their diffusion processes as diffusion processes; the agricultural knowledge and information system theory views extension as the processes of knowledge co-creation and information flow; the agricultural innovation system theory views extension as the processes of innovation creations amongst wide range of actors. Learning theories in extension view extension processes as learning processes with attempts to changes. Adult learning, experiential learning and social learning are three main bodies of learning theories that used in extension studies. Adult learning focuses on education of adults regarding transformative actions; experiential learning focuses on farmers' experiences and how they lead to action changes; social learning focuses on farmers' learning as networks.

2.2.1. Innovation theories

The concept of innovation has been brought into agricultural extension research over time (van den Ban & Hawkins 1988; Rogers 2003; Leeuwis 2004). Innovation theories were first introduced by Schumpeter (1983), Freeman and Louçã (2001) and Hayami and Godo (2005). These authors see innovation as an effective business and economic power booster. The theory was used to analyse how

innovation emerges and is applied within industries. The theory treats firms and entrepreneurs as the core innovators who apply technologies to business in order to achieve their economic goals. However, when innovation theory has been applied to agriculture and agricultural extension analysis, farmers have been seen simply as the receivers of technology.

As Rivera and Sulaiman (2009) point out, Rogers (1995) innovation diffusion theory was the major theoretical paradigm that contributed to the discipline and emergence of the profession of agricultural extension since the 1960s. According to van den Ban and Hawkins (1988, p. 13) and Rogers (2003, p. 10), innovation is the idea, practice or object which is perceived as new by individuals or organisations. Similarly, Smith (2010) considers innovation as a new idea, recent research result or practice that emerges with social or commercial value, otherwise it is only an invention. In the book "*Diffusion of innovation*", Rogers (2003) maintains that adoption and rejection of innovation are the crucial outcomes in a diffusion process. Later, they identified a diffusion of innovation process occurring through certain communication channels among stakeholders in a social system, with four key elements in the process: innovation, communication channels, time, and social system. In many countries a public sector extension system is still the dominant extension service supplier, though the private sector is now supplementing as well. Originally, extension services were the bridge between research and farmers. In this system farmers are viewed as the adopter or receiver of technology. In Rogers (2003) examples of his innovation diffusion theory, some farmers are also seen as the "laggards" in adoption of technologies. Alexander et al. (2020) used an agricultural research value chain approach to analyse the phenomena of adoption and dis-adoption. They found that the capacity of farmers is the major barrier to technology adoption. Also, to navigate agricultural research in terms of meeting farmers' needs and boosting adoption, looking at farmers who are proactive and responsive to incentives is an effective approach. This "diffusion" understanding of innovation implies that innovation is an object that comes from research and scientists are the innovators (Klerkx 2013). Associated approaches can be seen in technology supply push (TSP) (Hounkonnou et al. 2012).

The innovation diffusion theory has had an important influence on extension research since the 1960s; however, after some decades its limitations became apparent. Röling (1988), in the textbook "*Extension Science*", noted firstly that rural populations were not homogeneous, though scientists and farmers were in the same social system. Farmers were different in the aspects of psychological characteristics, life cycles, group norms and access to resources and information. Thus, innovation does not mean the same thing to every farmer. Secondly, small farmers are knowledgeable and innovative if appropriate technologies and tangible opportunities are offered to them; they should not be regarded as passive participants.

While it has been commonly recognised that innovations stem from research outcomes (Rogers 2003; Hounkonnou et al. 2012; Klerkx 2013), some early researchers also recognised that agricultural innovations can also come from farmers (van den Ban & Hawkins 1988, p. 100; Chambers et al. 1989, p. 31). At the same time, Chambers et al. (1989, p. 45) argued that it was necessary to recognise farmers' knowledge and innovation capacity, and called for improved interactions between extension service providers and farmers to reverse and balance the conventional 'top-down' communication and to overcome the gaps and miscommunication.

Based on the perspectives above, including the agricultural knowledge system and agricultural information system outlined by Röling (1988), since 1990s, the agricultural knowledge and information system (AKIS[3]) framework (see Figure 2-1) has emerged to promote a demand-pull approach for innovation analysis. In this system, innovations stem from interactions among scientists, extension providers and farmers. It involves collaboration between researchers and extension providers. Commonly used approaches in regards to small scale farming and farmers can be seen in participatory innovation which involves user-driven innovation (Buur & Matthews 2008), and participatory technology development (PTD), which seeks the way to ensure that technologies are not only effective, but also appropriate to the rural context and match farmers' needs in terms of their circumstances (Chambers & Jiggins 1987; Hounkonnou et al. 2012).

Since the 2000s, besides the perspective that agricultural extension has been focusing on capacity building and community engagement (Coutts & Roberts 2011), studies also reveal an emergence of adopting systematic theory and social change theory to agricultural and rural areas to give a more holistic and comprehensive view and analysis; agricultural extension and innovation are pulled to a broader context, instead of just focusing on technologies. Innovation is seen as a co-evolutionary process combining technological, social, economic and institutional changes (Leeuwis 2004; Spielman 2005; Klerkx et al. 2012), and the interactions among different stakeholders within certain agricultural innovation systems (Roy 2013; Suchiradipta & Raj 2015).

According to Klerkx (2013), the interpretation of the concept of extension and its functions have changed with the evolution of agricultural innovation; for example, Vanclay and Leach (2011) view extension as the process of enabling change, as mentioned in 2.1. In reference to the Agricultural Innovation System (AIS) concept, Klerkx (2013) argued that agricultural innovation was not just

[3] The concept of AKIS is a system that links people and institutes to enhance mutual learning and generate, share and utilise agricultural technologies, knowledge and information. In this system, researchers, extension officers and farmers are integrated to harness knowledge and information within available resources to improve farming and livelihoods (Röling 1988; Berdegué & Escobar 2001).

about farmers adopting technologies invented by scientists, but it also required a balance between new technological practice and alternative ways of organising aspects such as marketing, labour, land tenure and benefit distributions. Hence, innovations should include technologies and further new social, organisational and institutional arrangements. In this point of view, innovation is not just a result of research, instead, it stresses the collaboration of multiple broader stakeholders, not only the three-way connection among scientists, extension officers and farmers, but also organisations that are related to this process, such as traders, food processors and government officials. The main approaches within the AIS framework include: (1) the innovation intermediary (or brokering), which discusses organisations with the role of orchestrating collaboration networks among heterogeneous stakeholders in rural areas in order to promote changes (Klerkx & Leeuwis 2008; Kilelu et al. 2011; Yang et al. 2014; Qiu 2015); (2) the innovation platform, which manifests as a space or network that enables learning and change for a group of individuals with different background and interests (Mulema 2012; Klerkx et al. 2013; Akinmusola et al. 2016; Sanyang et al. 2016); and (3) the innovation networks, which focus on the orchestration of an interactive network for innovation and how different actors (some studies also refer to them as champions) within the network perform their role (Klerkx & Aarts 2013; Wu & Zhang 2013). From the AIS perspective, agricultural extension organisations are viewed as a part of the innovation system and the extension activities are seen as part of the innovation process (Rivera & Sulaiman 2009; Liao & Li 2015). Studies have pointed out that the research institutions and the extension departments in China are operating separately in two different systems, which has made collaboration rare in terms of agricultural extension (Wang 2008; Li & Zhou 2012; Yao et al. 2014). Thus, this is an opportunity to use the AIS framework to test the interactions amongst different actors including research, extension and farmers in the Chinese context, to provide implications in terms of extension services for smallholder farmers.

Figure 2-1 presents a brief evolution of the innovation diffusion, AKIS and AIS models. In the innovation diffusion model, there were three main actors: scientists, extension officers and farmers, and the approach for innovation delivery was mainly linear from top to bottom. In the AKIS model, interactions among the three actors were considered participatory, collaborative and bottom-up, and the innovations embraced not only technology, but also knowledge and information. In the AIS, more actors were identified as important in the innovation processes, for example, the private sector and farmers' groups, and they were considered to be involved in the interactions. Innovation was regarded as systemic change.

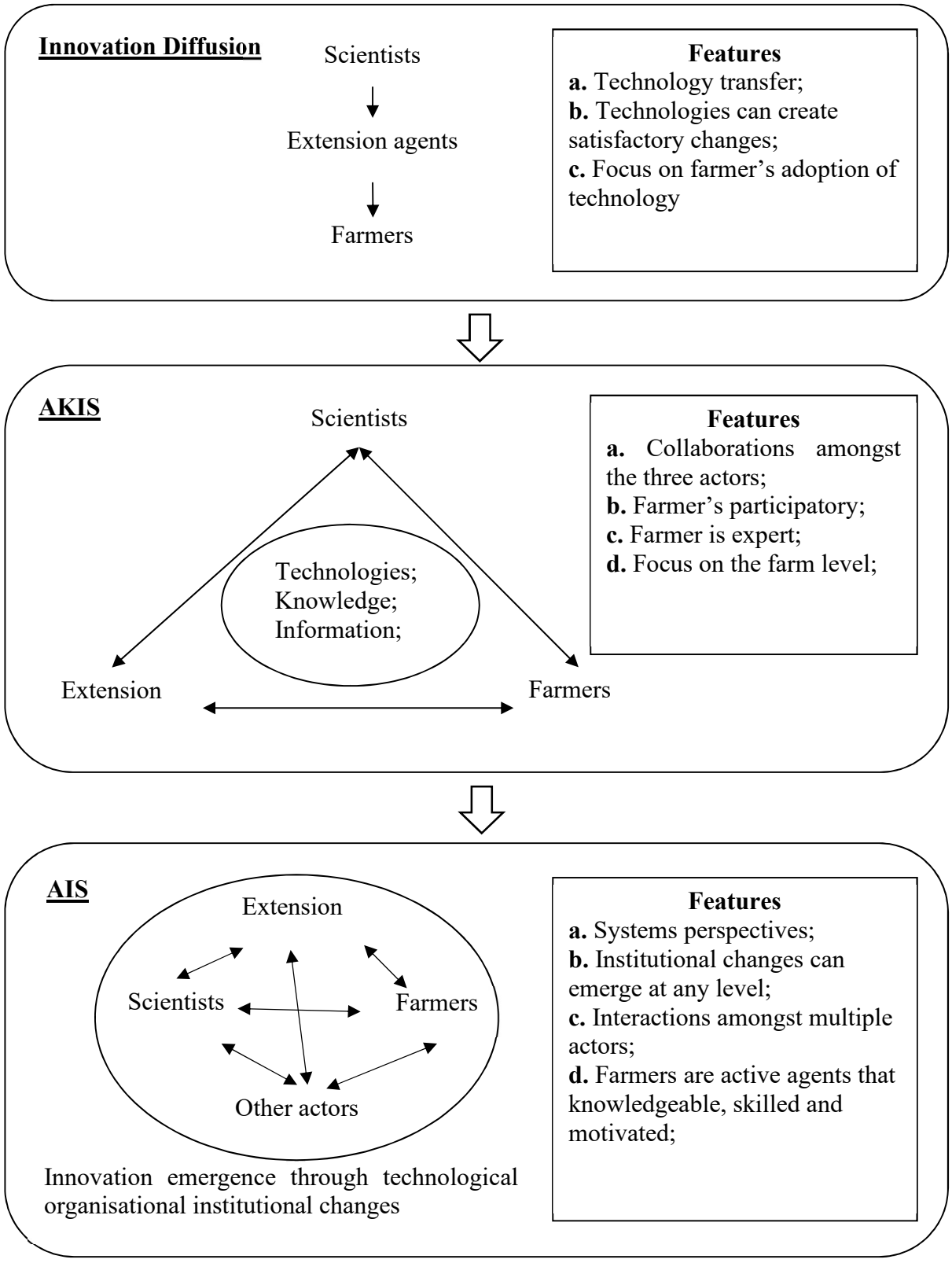

Figure 2-1 Main features of Innovation diffusion, AKIS and AIS

Adapted from Klerkx (2013) and Hounkonnou et al. (2012)

Diffusion of innovation model

In this study the diffusion of innovation mainly refers to the innovation diffusion theory by Rogers (1995), which, as Rivera and Sulaiman (2009) pointed out, is the major theoretical paradigm that contributed to the discipline and emergence of agricultural extension. In the innovation diffusion theory, Rogers (2003) defined diffusion as the process of an innovation being communicated through certain channels in a certain time period among stakeholders in a social system. In the definition, diffusion is a special type of communication as the messages are new ideas. Diffusion also causes social change after new ideas have been invented, diffused and adopted (or rejected). Furthermore, Rogers (2003) divided innovation diffusion processes into four key elements: innovation, communication channels, time, and social system.

The innovation element consists of the technological innovation, which is seen as the "hardware" aspect of innovation, and information, the "software" aspect. Also, innovation always firstly appears uncertain to clients, even though the technological innovation is comparatively more apparent than the information types of innovation. Rogers (2003) introduced a perceived attributes framework to analyse the innovations; these attributes include: (1) relative advantage, meaning to what extent the innovation is perceived as better than the existing one; (2) compatibility, which is the degree that the innovation is perceived as being consistent to the values, experiences and needs of the clients; (3) complexity, which means the degree of the difficulty as perceived by the clients to adopt the innovation; (4) trialability, which is the degree the innovation can be experimented even in a limited resources circumstance; and (5) observability, which is the extent of the innovation's visibility to clients and other people.

Beyond the observability and the complexity of innovations, Marra et al. (2003) argued that it was also important to distinguish farmers' different aspects of risk, uncertainty and learning in order to understand the adoption process correctly. Perspectives include farmers' perceptions about risks and uncertainties, and the role of trialling and learning in their adoption decision. Based on the model, studies have found that clients' attitudes towards the innovation are strongly affected by the relative advantage attribute, as they are more likely to adopt an innovation that has clear relative advantage (Lin 2011). Furthermore, the clients' characteristics and their perceptions towards the innovation attributes are interrelated, and the different perceptions towards the innovation among different people influence the time and outcome of the innovation adoption process (Häggman 2009).

Along with the perceived attributes, re-invention has also been added to assess an innovation and its adoption. Re-invention means the degree an innovation can be modified and adapted to the local

circumstances by the innovator or clients. The re-invention attribute should be considered in order to accommodate different ways the innovation may be adopted by clients depending on their situations (Eveland 1977; Röling 1992; Rogers 2004). Hebel (2010) argued that technologies and materials should be re-invented to adjust their appropriateness to the targeted local areas before being transferred.

The communication channel element comprises two main elements: the communication, which means the process by which the innovation or information is shared or transmitted between parties in order to achieve a mutual understanding; and the channel for communication, or the approaches and means used to achieve the communication. Social factors must be considered, as communication is an interpersonal process (Rogers 2003). The time element relates to the time spent for the whole process from innovation introduction to adoption or rejection, and how the knowledge and experience of the client affects the process, for example, a client that is less knowledgeable and skilled will likely spend more time considering their decision about the innovation. It should be noted that it is also an information collection process, as when clients spend time on decisions, they need more information to support this process. In this process, fast adopters are usually seen as innovators and slow adopters may be seen as laggards (Rogers 2003).

The social system element implies that innovation decisions are made in social systems, in which people interrelate with each other as units, groups or organisations. The structure of the social system not only constitutes a boundary within the innovation diffusion process, but also affects the innovation decision-making of each individual (Rogers 2003). Further, villages with social capital, especially those with connections outside the village, were more likely to adopt innovations (van Rijn et al. 2012).

While the innovation diffusion model and the four elements provide a framework for innovation to be disseminated from a small scale to a large scale, van der Veen (2010) pointed out that in the agricultural field many changes and improvements were small and incremental, instead of large and radical, this also implies that many innovations have to be adapted to local circumstances rather than being adopted wholesale from outside.

Agricultural Knowledge and Information Systems (AKIS) model

Since the innovation diffusion theory was introduced, more theories and models on agricultural extension which focus on the software aspect of innovation have been generated. Some of those theories and models include the communication theory of agricultural extension from van den Ban and Hawkins (1988, pp. 70-1) which explores how messages can be effectively communicated among

people; the communication for innovation services models from Leeuwis (2004, p. 30), which present communication as an intervention for agricultural extension; and the agricultural information system from Röling (1992) which focuses on how knowledge and information can be effectively transferred to farmers in a systems perspective. The latter came to be defined as the Agricultural Knowledge and Information Systems (AKIS), which means the articulation of sets of actors, organisations or networks to work synergistically to support the knowledge process and improve communication at and between all levels. Similarly, the Agricultural Knowledge System (AKS) points to interactions among a collection of actors including researchers, advisors and educators in order to promote the flow of knowledge. The major perspective of these models is their emphasis on knowledge and how it is transferred, by means such as extension services and education (Rudman 2010; SCAR 2012).

The AKIS approach emerged in response to challenges in the theory of technology transfer and adoption. Instead of viewing farmers as the receivers of technology, the AKIS views innovation as the process of different actors sharing their knowledge and learning within a network of individuals and organisations. It emphasises the use of interactive, communicative and participatory approaches to facilitate the innovation, including the rapid appraisal of agricultural knowledge systems, farmer field schools and participatory technology development (Assefa et al. 2009; Munyua 2010; Knierim et al. 2015). AKIS involves a wide range of actors including the public sector, which is mainly the government departments and organisations; research and education institutions and organisations; the private sector including agricultural and food chain actors and independent consultant organisations; and farmer-based organisations such as farmers' cooperatives (Prager & Thomson 2014).

Klerkx et al. (2017) categorised three types of subsystems within the AKIS to cater for diverse types of farmers: (1) a holistic system, which is an inter-organisational system of services supply consisting of different advisory organisations aiming to provide more holistic perspectives for diverse types of farmers; (2) an elitist subsystem, organised by experts in the field to overcome major challenges, where generalists have direct contact with farmers in order to ascertain their needs and articulate them to the expert team; and (3) a public goods subsystem, which is characterised by cooperation between the public and private sectors, particularly for services that are difficult to be turned into commercial services, and when farmers are not willing or able to pay for the required services. Policy-makers should be active participants in the emergence of these subsystems because actors from the private sector typically pay less attention to public concerns such as environmental issues.

Klerkx (2013) explains that recognition of farmers' knowledge and prioritising farmers' needs in agricultural research were important drivers for the emergence of AKIS. The Farmer First theory devised by Chambers (1983) pointed out the common bias of agricultural researchers to rural

development, called for farmers' needs to be put first, and recognised farmers' knowledge and experiments in agricultural research. A decade later, the Rural People's Knowledge (RPK) framework by Scoones and Thompson (1994) was based on the understanding that farmers' knowledge could be primitive and unscientific, but it was a valuable and under-utilised resource that needed to be studied. Most importantly, the framework made it understood that neither the PRK nor science could be regarded as the abiding bodies of knowledge for rural development, thus interaction and collaboration were required. Röling (1994) found that Farmer First required highly decentralised and sustainable facilitation in the field, and technical expertise should be regarded as additional.

Farmer innovation, as a form of farmers' knowledge, presents farmers as active agents who are capable of identifying farming problems and generating solutions. Reij and Waters-Bayer (2001b) found that motivation for farmer innovation was largely related to farmers' perceptions of farming problems, for example, population pressure on their limited land and water resources prompts them to pursue diversified and intensified enterprises. Nonetheless, Nielsen (2001) pointed out that farmers' limited access to resources also significantly hindered their capacity to experiment and innovate.

Studies have also criticised AKIS. The major limitation is that the AKIS model has put much emphasis on knowledge generation and its flow and pays insufficient attention to the influence of political and other forces in emergence of agricultural changes, thus cannot achieve a complete and realistic analysis (Leeuwis 2004; Assefa et al. 2009). Also, Hall et al. (2006) argued that the AKIS concept still emphasised the research or knowledge supply, without giving enough attention to the linkages and interactions among actors, and the identification of farmers' needs for technologies.

Agricultural changes require a systems thinking perspective to embrace holistic points of view. Spielman (2005) also argued that AKIS has limited ability to analyse the nexus beyond research, extension and farmers, including the institutional and historical context that forms their behaviours, and the learning processes that determine the capacity of agents to change and innovate. As concluded, agricultural change cannot only be viewed as technological changes, or changes that can potentially be brought about through technological changes: it has to be the combination and interactions of technical, institutional and other changes.

Agricultural Innovation Systems (AIS) model

The Agricultural Innovation Systems (AIS) model is increasingly used to analyse the emergence of innovation in agricultural and rural development, and explain how to generate linkages and interactions among a heterogeneous set of actors out of complex technological and institutional change processes (Spielman 2005; Hall et al. 2006; Klerkx 2013; Alexander et al. 2017). The AIS

perspective particularly emphasises network building for interactions among actors including researchers, extension officers, farmers, industries, processors, traders, governmental officers and social organisations; and that the innovation outcomes are not only technological changes, but also institutional, requiring the mechanism of organising including markets, labours and distribution of benefits (Leeuwis 2004).

The innovation network performs a central role in the AIS. It implies a group of individuals or autonomous organisations working together to achieve not only their own goals but also a collective goal; the processes of the network creation and shaping are voluntary and dynamic. Individuals and organisations within the network are responsive but also retain separateness and identity (Klerkx et al. 2010; Klerkx & Aarts 2013). King and Nettle (2013) found that the network comprised by public-private extension, researchers and farmers can effectively enhance farmers' decision-making. They found that dairy farmers in Australia were effectively referred to seed specialists by both public and private sector extension agents, for assistance with their pasture seed selection. Furthermore, King et al. (2019) found that in innovation projects, social capital amongst the actors in the network may enable or constrain innovation outcomes. A broker who is able to navigate and manage different social capitals and build trust within the network would be key to achieve innovation. Klerkx et al. (2010) also pointed out the self-organisation mechanism of the innovation network, by placing the innovation system as a complex adaptive system.

An Agricultural Innovation Ecosystem (AIES) approach was developed by Pigford et al. (2018) to identify and manage the different actors and their relationships in the innovation system in terms of supporting transitions. They conceptualise that innovation niches, the spaces that allow actors to experiment, co-innovate and create to enable interactions across boundaries, comprise the innovation system. The AIES approach pays special attention to the plurality of actors and the role of power in shaping the connections amongst different niches and their interaction with regimes.

Studies used AIS framework to analyse interactions among different actors in emerging agricultural innovations. Alexander et al. (2017) pointed out interactions among actors, organisations and institutions and the patterns used to transition subsistence farming to systemic commercialised production. Friederichsen et al. (2013) identified agricultural extension officers' role and their diverse discourses in fostering interaction between outsiders, i.e. private business and organisations, and clients, those being farmers or farmers' groups. It is also potentially possible for extension officers to mediate conflicts between farmers' groups and governmental controls. Roy (2013) discussed the need to engage smallholder farmers in the AIS to identify and meet their technological, supply and value chain needs in developing countries. Further, the capacity building models of Coutts and Roberts

(2011) can also be considered in the AIS designed for smallholder farmers. Schut et al. (2015) introduced a Rapid Appraisal for AIS (RAAIS) technique to analyse innovation capacity in dealing with the different dimensions of problems in agricultural innovation; aspects included the constraints within institutional and technological subsystems in the AIS, and the existence and performance of supports for the AIS. Nettle and Moffatt (2014) found that an effective innovation platform can emerge from collective actions and interactions among a wide range of stakeholders across national and local arenas in response to complex systemic issues.

Existing AIS studies have also focused on the innovation broker and innovation intermediary and their role in the innovation network. Klerkx and Gildemacher (2012, p. 221) defined an innovation broker as "a person or organisations that form a relatively impartial third-party position, purposefully catalyse innovation through bridging actors and facilitating their interactions". Meanwhile, according to Howells (2006), the innovation intermediary is an organisation or body that performs as an agent or broker in the innovation process perspectives between two or among more parties. The functions of the intermediary include providing information for potential collaborations, finding advice and funding for the innovation outcome, and brokering a transaction between two or among more parties. As distinct from the innovation broker, the brokerage function may or may not be the core function of an innovation intermediary. Winch and Courtney (2007) also argued that an innovation broker only acts to enable other organisations to innovate through brokerage and does not focus on organisations and the implementation of innovations: see Table 2-1.

Table 2-1 Comparison between Innovation broker and Innovation intermediary

Types	Innovation broker	Innovation intermediary
Relation with the network	Impartial third-party;	Person or organisation that builds the network; Existing member of the network;
Functions	a. Articulating demand and analysing the context; b. Composing network; c. Facilitating interactions and innovation management;	a. Articulating and voicing demand of users; b. Supplying information for problem solving and responding to user's needs; c. Engaging and supporting actors generating knowledge;

Type	Agricultural consultant;	Agricultural extension service; Farmer's cooperative; Agricultural scientist; Development programme;

Source: Howells (2006); Winch and Courtney (2007); Kilelu et al. (2011); Klerkx and Gildemacher (2012); Yang (2013)

Kilelu et al. (2011) argued that the innovation intermediary framework provides better scope for understanding the complex drivers of agricultural innovation than knowledge brokerage, especially when agricultural innovation is regarded as an emergent property of interactions (Röling 2009). The innovation intermediary framework was used to identify different organisations in the agricultural innovation process, particularly their role in engaging smallholder farmers and articulating their needs. Yang (2013) found that farmers' cooperatives in China performed innovation intermediary functions with smallholder farmers, including engaging farmers in identifying farming problems, sharing knowledge and adopting technologies; bridging farmers to the higher quality agri-food markets; and promoting community development. Klerkx and Leeuwis (2008) also pointed out that, from the matching demand and supply perspective, the innovation intermediary not only articulates demand for the agricultural knowledge users, but also forges links with those innovation services providers and manages the innovation processes. Changes in agricultural production also brings challenges to the farming system and calls for new knowledge and skills for farm advisors. Ayre et al. (2019) found that smart farming as a way of transforming farming and food production, which is viewed as digital innovation in the agricultural innovation system, requires farm advisors to obtain new relationships, skills, and arrangements at a higher level than before. They found that a co-design process, involving iterative problem solving and solution finding, can effectively support farm advisors to adapt their routine advisory practices into smart farming. However, those studies only covered a small portion of farmers, for example, farmers that were capable of being members of farmers cooperatives and had access to digital agricultural technologies. There is a gap to test the innovation theories in the extension system that serves common smallholder farmer that counts the largest portion of all farmers whose major sources of supports are from normal extension services in China.

2.2.2. Learning theories

While conventional extension activities consider the acquisition of technology, information and knowledge and the development of understanding as the basic elements, learning, considered in psychology terms, defines these processes in terms of acquiring or improving the ability to construct

a behavioural pattern through experiences and practices (van den Ban & Hawkins 1988, pp. 79-80). Understanding learning processes in extension activities allows extension agents not only to effectively transfer technologies and knowledge to farmers, but also to improve farmers' understanding of their farming practice (Jensen et al. 1964; Bembridge 1991). The basic principle of learning is the observation of effects or reflections, where people consider the relationship of the actions and outcomes, and the process of cause and effect, for example, if people pray for rain and soon a rain shower follows, they would most likely to do it again when next drought comes, and they would compare situations if appropriate explanations were given and thus the learning process would be enhanced (van den Ban & Hawkins 1988, p. 80). Agricultural extension services have been performing this role in farming. From the smallholder farmers' perspective, due to lack of education, knowledge and resources, they are more likely to encounter failures in attempting learning (van den Ban & Hawkins 1988, p. 81), and it is on remedying this lack that agricultural extension should focus.

The adult learning model was used in extension activities. Briefly, adult learning means the learning process by which adults acquire new knowledge (Mezirow 1978; Hansman 2001; Taylor 2017). A similar term is adult education (Hamilton 1995; Sims & Sinclair 2008). Adult learning is considered as being based on transformative learning, which uniquely focuses on adults and how they change through educational experiences, assuming that adults are active agents because of their significant life experiences, rather than passive participants; also, adults are instinctively driven to make changes (Mezirow 1978; Taylor et al. 2012). Early studies, for example Jensen et al. (1964), point out that adult learning takes place in the natural community setting via day-by-day experiences such as reading, and watching and participating in activities, and in the formal instructional setting via organised activities by experts with professional instruction or guidance. Bembridge (1991) points out two core factors relate to adult learning: firstly, most adult learning takes place through observations; secondly, learning takes place effectively only when it results in a change of behaviour of learners. There are two sources for the way adults act: the inherited source, which is difficult to change; and the learnt source, which usually can be modified. The most practical pathway is that extension agents move step-by-step from the farmers' contemporary knowledge and abilities related to the extension objectives, and then present new information and skills, demonstrate them and provide opportunities to practice them (van den Ban & Hawkins 1988). The transformative learning framework has been used in analysing the formal learning context, for example, farmers field schools, where adults learning emerges in a highly structured program and the learning reflects back to the decision-making of the learners (Taylor et al. 2012). Further, it can also be used to examine informal adult learning in a cross-cultural environment context, for example, small rural landowners whose

voices are often marginalised in the decisions that affect them (Sims & Sinclair 2008). Critiques were also raised regarding the transformative learning model. Percy (2005) argued that the model overemphasised individuals and the rationality and autonomy of adults, as several empirical studies showed learning could also emerge in an organisational context, and people's emotions and relationships could play important role in enhancing learning processes.

The experiential learning model was first introduced in 1984 and used in analysing learning in extension activities. This model views learning as a process in which knowledge is created through transformation of experience. Four major elements of learning were presented in the Lewinian learning model: (1) the concrete experience, or the process whereby learners involve themselves in a new experience; (2) the observation and reflection of the learner on the experiences; (3) the formation of abstract concepts and generalisation, or the process whereby learners integrate their observations and generate concepts and models; and (4) testing implications of those concepts in different situations, by which learners can improve adaptability to complex situations (Kolb 2015, pp. 32-3). The relationship of the four elements is shown in Figure 2-2.

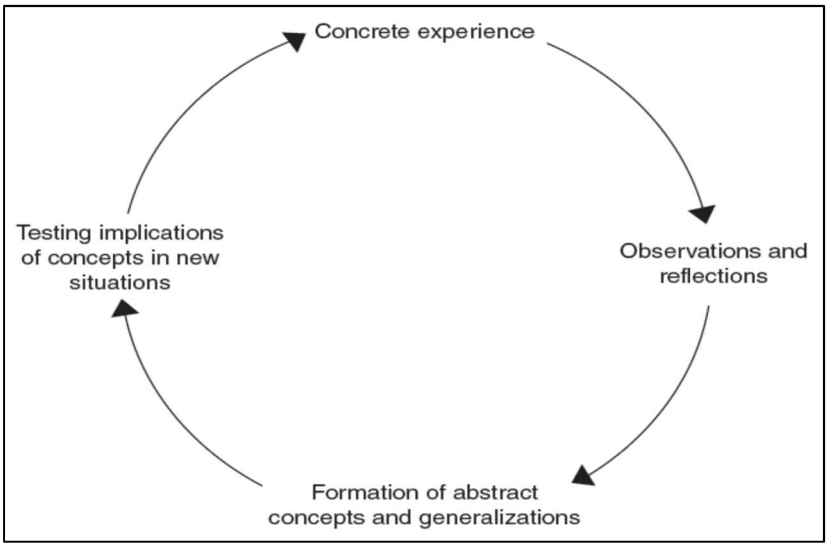

Figure 2-2 The Lewinian experiential learning model

Source: Kolb (2015), pp. 32

In relation to the experiential learning model, Palaniappan (2009) pointed out that farmers' learning styles varied. Farmers who collected a wide range of information from various sources attempted to develop models and patterns of solutions, while farmers who relied only on seeking information from other people showed group behaviour and reliance on "hands-on" experiences. Farmers' experience is a critical source of farmers' knowledge and contributes to the local knowledge system (Stuiver et al. 2004). Šūmane et al. (2018) pointed out that farmers treasure local experiential knowledge because

it has practical, personal and local relevance. Darnhofer et al. (2016) also pointed out that farmers' experiential learning and networking from particular activities, for example being engaged in experimentation, contribute to integrating social and ecological relations and community resilience.

Different approaches were also identified for experiential learning. Early researchers, for example Percy (1999), found that participatory approaches facilitated by the government sector supported the experiential learning processes of farmers. Communication between different heterogeneous actors can also enhance farmers' experiential learning processes (van de Fliert 2003; Leeuwis 2004). In this regard, farmers field schools can effectively foster experiential learning through the participatory and interactive processes (Suzanne Nederlof & Odonkor 2006; van de Fliert et al. 2007; Najjar et al. 2013). Farmers tend to belong to particular types of practical networks, where experiential learning emerges among farmers (Oreszczyn et al. 2010). Further, the use of video as a mediated learning approach effectively enhanced the experiential learning process and thus farmers' capacity in farming (Chowdhury et al. 2015). Local culture, including the shared norms and values and the cultural history, can also influence the experiential learning processes by bridging cooperative behaviour amongst farmers, hence to overcome farmers' fear of risks (Palis 2006).

In rural settings, farmers' learning can be assisted by agricultural extension and development programs on topics such as technology, methods and practices, information and innovations (Ingram et al. 2018a). Technology demonstrations, which commonly aim for farmers' knowledge and information acquisition, should provide immediate learning opportunities. Such demonstrations should also embrace inclusiveness of farmers at all levels, and interactions between stakeholders at all stages from curriculum design to implementation. At the implementation level they should provide sufficient space for interactive dialogue and monitored discussions between all participants, taking into account the individual farmers' varying learning capacities and learning preferences (Ingram et al. 2018b).

Studies have pointed out the oversimplification and separation of different elements in the learning process analysis (Palis 2006; Lankester 2013; Ingram et al. 2018a). These studies argued that learnings emerged in different stages and levels, within which agricultural extension, which aims at technology and information transfer and acquisition, is in the zero-loop of learning activities as it engenders no capacity building or empowerment (see Table 2-2). Community, organisational or empowerment learning, which are driven by collective or regional issues that may influence the organisational or group interests and values, are located in the higher level of learning loops (Coudel et al. 2011; Lankester 2013). Studies also showed that in the farmer field school context, learning is not simply about acquisition of information and technology due to the influences of local culture and

farmers' values, particularly in adoption of technology and practices that enhance ecological management (van de Fliert & Braun 2002; Palis 2006).

Table 2-2 Learning loop types and features

Types of learning	'Zero'-loop	Single-loop	Double-loop	Triple-loop
Driving factors	Need for updated information	Loss of efficiency	Difficulties in solving problems	Need to adapt to permanent change
Relationships between actors and their organisation	Person to person	Individuals or group	Stable organisation	Unstable organisation (no limits to define the actors concerned)
Change in practice	Integration of new information in current routines	Change in routines (towards improved efficiency)	Innovation to find new solutions	Creativity to find new references
Change in values	Does not affect values	Values do not change	Change in internal values (of the organisation)	Also affects external values (change in paradigm)

Source: Coudel et al. (2011)

Studies also showed that learning can emerge in informal settings. One major example is knowledge and experience sharing, within which farmers form a network and discuss and share knowledge, ideas and experience through casual chatting to neighbours, visiting other farmers' farms, or attending formalised farmers' group meetings, particularly if the meetings discuss pioneering technology adoption (Ingram 2010). Farmers also discuss new ideas and experiences informally at places such as markets, small social group meetings, or large group meetings held for another purpose (Reij & Waters-Bayer 2001a). For example, during conventional extension field days farmers also share and discuss their experiences and sometimes innovations, as within this model farmers are more likely to initiate knowledge sharing as they have received insights from the extension policy and agenda (Abay et al. 2001). Farmers process the knowledge and information they gain from both formal and informal approaches, synthesising it to suit their actual needs (Šūmane et al. 2018). The key is to facilitate a

sufficient space for social learning among all farmers (Schneider et al. 2009), and provide a platform to erase the influence of power imbalance and distrust, and instead enable the divergence of knowledge (Ingram 2008). However, some farmers choose not to interact with other farmers, and isolate themselves from networks and outside communication for reasons including dislike of publicity, or a failed attempt to visit another's farm, or unwillingness to share due to the local competitive attitude (Ingram 2010).

Social learning as another form of learning activity has been also emphasised in describing extension activities, particularly when participatory and knowledge-based extension approaches are employed. Social learning contrasts with linear technology transfer and individual learning, particularly in situations and regarding issues that require multiple individuals, stakeholders or organisations to be involved, as different perspectives and sources of information are needed (Mostert et al. 2007). Social learning has been used in analysing the learning processes of local people with collective natural resources and environment issues (Holling 1978; Maarleveld & Dabgbégnon 1999; Keen et al. 2005; Berkes 2009). For example, Schneider et al. (2009) found that farmers' learning was facilitated in a soil protection project for soil erosion issues through interactions, knowledge and trust. They also emphasised the importance of facilitation. Mostert et al. (2007) found that in river-basin management, social learning processes emerged through interactions, trust building and increased understanding of the key issues among actors in a network. van de Fliert et al. (2007) pointed out that social learning facilitation (through platform) made the farmer field school more effective in assisting farmers to collect information and make informed decisions. Colvin et al. (2014) established that social learning processes also created concerted action among diverse stakeholders, and even when facilitation ceased, individuals would carry forward the requisite experiences and reopen social learning processes if the policy environment was favourable. Another study found that conflicts in agricultural projects between researchers and farmers hindered the learning process (Eshuis & Stuiver 2005). In the top-down extension system that mainly employs technology transfer approach, farmers were simply viewed as receiver and adopter of technologies. Also, farmers' goals were generally considered as increasing production and economic growth. In the Chinese context where top-down system has long been employed in agricultural extension, there is a gap to use learning theories to identify if farmers' learning emerges in their daily farming and the extension process. This will provide implications for improving the extension system and services to smallholder farmers, for example, changes of policy goals and extension approaches.

2.3 Agricultural extension systems

Extension is an important component in agricultural and rural development, and contributes to issues such as the reduction of hunger, alleviation of poverty and increase of productivity (Swanson 2006; Huffman & Evenson 2008; Hunt 2014). A major example is the Green Revolution and its performance in drastically increasing the global food supply and enhancing the food system (Swanson 2008). In past decades extension services in most countries have been through similar change processes, from government dominated to privatisation, involving various actors such as NGOs and civil society; from linear technology transfer to approaches that are participatory, inclusive, knowledge-based and capacity building; and from emphasising technology to broader and systemic focuses such as environment, natural resources management, sustainability, changes and innovation (Coutts & Roberts 2011; Sulaiman & Davis 2012). Generally, those changes were a response to meet the growing pluralistic needs of extension services for agricultural development and farmers (Hunt et al. 2011; Roy 2013). Different countries have different experiences in processes of establishing extension systems and making changes. This section aims to review extension systems in different countries and give implications for this study.

2.3.1. Government-sector extension systems

In most countries, agricultural extension services were initially provided by the government sector. In the 1860s the United States (US) started to establish a national extension system in response to the growing needs of farmers for agricultural development. The process was promoted by the farmers' societies in each state. In 1962 the Land-Grant College Act, also named the first Morrill Act of the US Congress, was enacted. This act granted land, funding and related policies for each state to construct agricultural colleges in order to provide education for farmers and support the development of agriculture. The land-grant colleges provided an institutional foundation for the establishment of the national agricultural extension system. Then, with the enactment of the Hatch Act in 1887, federal funding was provided to the land-grant college in each state to create a series of State Agricultural Experiment Stations (SAES) embedded within each college. The colleges and their SAES were the newly emerged providers of extension services and operated in conjunction with the extension department of the United States Department of Agriculture (USDA). Their relationship was described as the USDA-SAES collaboration. At that time, farmer education was the main approach of extension services; the cotton boll weevil eradication program in southern US was an example of an outcome from that system. In 1914 the Smith-Lever Act was enacted. It established a cooperative extension services system and specified the core position of the land-grant college and its SAES, and their

function of building connection between the federal government and farmers (True 1928; Huffman & Evenson 2008; Liao & Li 2015). Thus the research, education and extension (three-dimensional) agricultural extension system was established (Li & Zhou 2012).

Agricultural extension in Australia has a similar history of change. In the 1880s political land reforms drove the establishment of state-level agricultural colleges in several states. In the 1900s the research, development and extension (RD&E) model emerged in the Bureau of Sugar Experiment Stations under the Queensland Government. The RD&E initially emphasised pest management and then extended to encompass plant breeding and agronomy (Hunt et al. 2012). At present, many entities still employ the RD&E model to overcome farming challenges. For example, RD&E in the dairy industry creates a knowledge partnership between researchers, extension service providers and farmers (Kenny & Nettle 2006). However, RD&E is increasingly industry-driven because of reduced investment from the public sector. It emphasises involvement of multiple actors – public, private, farmers and other providers of extension services – which has created challenges in the governance of the RD&E system (Paschen et al. 2017).

Agricultural extension is still a key component of government in most developing countries (Swanson & Davis 2015). In Asia, for example Pakistan, the Directorate-General of Agriculture and Applied Research tops the extension system and is responsible for giving advice to the provincial government, and then the chain of command goes to district level extension organisations and lower level extension offices. Their institutional structure follows the governmental institution arrangement, for example the Ministry of Agriculture (Davidson & Ahmad 2003). However, they operate separately on their own system, unlike countries such as China, where different level extension service centres are affiliated to agricultural bureaus at each level. Public universities are also part of the public extension service provider system in Pakistan, as they all have agricultural extension departments which offer higher education in extension, and extension staff who run farmer schools for educating farmers (Davidson & Ahmad 2003).

The extension system in Myanmar is also government-centred. Myanmar is the second largest country in Southeast Asia. Its extension services are mainly provided by the Agriculture Extension Division (AED), which is affiliated to the Ministry of Agriculture and Irrigation, and its staff stage covers the managing director at the national level and different managers in the state, divisional, district, township and village levels. Extension approaches include farmers field schools, farmers groups (called the Ten-members), training and visiting, technology transfer, agricultural projects and programs. Public research and education institutions are also involved in extension such as the

different divisions in the Central Agricultural Research Institute (CARI) and the Yezin University of Agriculture (the only university that teaches agricultural science in Myanmar) (Swanson 2008).

Israel in Western Asia also has a government-centred extension system but is outstanding for its effectiveness. The agricultural sector became the main sector for self-supply and food export in Israel through the high technological R&D investment. Shaham is the main provider of extension services; it is affiliated with the Ministry of Agriculture and has a highly educated extension advisor team: most have a research degree, and 10% have a doctoral degree. Those advisors are encouraged to engage in national and regional level R&D and in educating farmers. As irrigation equipment and husbandry fields have companies engaged to give advice, Shaham only focuses on practical issues that farmers are facing. And unlike the national level extension department in most countries, which is usually responsible for policy making and principle formulating, Shaham in Israel covers the whole institutional range of extension tasks (Davis 2015).

Overall, management of agricultural extension in most developed countries has transferred to the private sector, and employs participatory, systemic and knowledge-based approaches; while agricultural extension in most developing countries is still dominated by the government, there have been trials or reforms centring on decentralisation and privatisation. Further, the extension approach employed in most developing countries is mainly top-down linear technology transfer. However, research institutions are major actors in the extension systems of both developed and developing countries.

2.3.2. Decentralisation of extension services

Although agricultural extension services and the system were commonly centralised by the government sector, in part due to the huge financial burden on the government many countries have initiated decentralisation of their extension services (Rivera 1997; Muwonge 2007; Swanson 2008). Decentralising extension services means devolving extension tasks from central governments to the grassroots level departments and other organisations, mainly farmers' cooperatives and NGOs, so that other organisations perform the extension role formally delivered by government.

Decentralising extension within governmental departments and sectors requires the central government and its departments to transfer extension planning, decision-making and management functions to their lower level agricultural or extension departments, including field departments and governmental subordinate units (Rondinelli 1987; Rivera & Alex 2004). This process has emerged in some developing countries, for example in Thailand the Ministry of Agriculture and Cooperatives and the central department of the agricultural extension were the main units to initiate extension

planning and decision-making, later they were devolved to six main sub-regional extension offices and the operational centres and the district offices affiliated to them (Davis 2015).

In the Chinese context, as discussed further in Chapter 3, extension decision-making and planning processes were centralised in the central government and the Ministry level of the agricultural department and the national extension centre from the early 1950s. After the perception shifted to different provinces having to initiate specific strategies depending on the circumstances of the province, the extension power then was largely devolved to provincial level agricultural and extension departments from the 1980s (Chen et al. 2009). However, extension decision and planning processes are still concentrated in the upper levels of these departments. Local levels have some say in the process, but their circumstances can be very different from each other.

Overall, decentralisation of extension services has given more autonomy for lower level extension departments and officers to run extension activities. This also allows the extension services to become more suitable and specific for local areas. However, in some cases, the decision-making and planning of extension being centralised in the upper levels still hinders the adaptability of extension services to local levels.

2.3.3. Privatisation of extension services

Privatisation of extension services emerges when the services aim for private good, and also as an approach to reduce the public financial constraints of providing extension services to all forms of farming (Vanclay & Lawrence 1995). One study pointed out that privatisation of extension services is the ultimate form of extension decentralisation, as government services and power have been entirely granted to the private sector and users have to pay for them in various ways (Gao & Zhang 2010). The practice of privatisation or commercialisation of extension services has emerged in developed countries. The Agricultural Development Advisory Service (ADAS) in the United Kingdom was viewed as a succession of privatisation of public-sector extension services.

In 1987, the governmental extension system was transformed into an agricultural consultancy firm, which took governmental extension contracts and projects as their means to provide extension services. This privatisation transformation has made extension services accessible to most farmers, rather than being solely available to large commercial farmers (Pray 1996; Chapman & Tripp 2003; Garforth 2004). In Australia and New Zealand, countries that are agricultural-industry-dominated, in most cases both the public and private sectors have been attempting to transfer extension costs to commercial farmers, although some also tend to obtain governmental funding or projects to provide extension services (Swanson 2008). In Australia, the role of the private sector has increased and

diversified in terms of contributing to agriculture, farmer incomes and the sustainability of environment and resources (Ampt et al. 2015). Private sector farm advisors are actively changing their practices to better support farmers to cope with emerging challenges; processes that enable the changes include establishing new advisory role, experimenting with new advisory identities, and legitimisation of new advisory practices (Nettle et al. 2018).

There have also been some moves toward privatisation in developing countries. In 1978 Chile launched a trial to transform the national extension system of technology transfer into a market-oriented system, through a contract-based approach of rural services that allows all forms of agricultural production, including smallholder farmers, to effectively access and use extension services; however, the trial has limited capability to enhance farm incomes and meet farmers' needs, as the policy mostly benefits large- to medium-sized farms, while small-scale and poor farmers obtain minimal benefit (Bebbington & Sotomayor 1998; Cox & Ortega 2004). Concerns have also been raised as to the effectiveness of the private-sector, for example, the private providers are most likely to focus their work narrowly on the crop that their clients buy or the input they sell, rather than addressing the broader concerns that farmers encounter such as environmental sustainability and poverty reduction (Feder et al. 2011). Furthermore, producers have perceived risks in terms of the reliability and independence of the advice being provided by commercial agents, for example, the Tasmanian wool industry has been negatively affected by the policy change (Hunt & Coutts 2009). The privatisation extension trial in Hubei province, China, as one prominent case in the Chinese context mentioned in the previous chapter (the Yi Qian Yang Shi reform), has achieved a degree of success through provision of extension services to large scale and high-value farms (Zhou & She 2008; Mei & Xiang 2014); however, it has also been criticised for not effectively meeting smallholder farmers' needs, and has in fact decreased the extension services accessibility of smallholder farmers (He 2012; Mao 2018). This discussion is expanded in Chapter 3.

Agricultural extension services have also been privatised to farmers' cooperatives, agricultural societies and non-governmental organisations. In the farmers' cooperatives case, farmers involved are able to access technologies and farming advisory services (Ortmann & King 2007; Abebaw & Haile 2013; Yang et al. 2018). Farmers' cooperatives can also perform roles that the conventional extension system cannot achieve, including linking farmers to better agri-food markets (Wollni & Zeller 2007; Yang et al. 2014). In India, the government constructed the Agricultural Technology Management Agencies (the ATMA) in pilot districts to coordinate with the regional agricultural extension and rural development programs (Rivera & Alex 2004; Singh & Swanson 2006). NGOs also have a role in providing extension services to these Indian farmers, as they have certain programs

in the pilot sites. Of particular interest is that NGO initiatives usually focus on goals of holistic sustainability of rural development through introduction of technologies or practices that reflect long-term sustainability, rather the focus of conventional extension activities on yield increase and production; the extension approaches and methods that NGOs use are also commonly seen as participatory and communicative, as opposed to conventional top-down and linear transfer (Garforth 1997; Swanson & Samy 2002; Snapp et al. 2003).

In the Chinese context, studies have pointed to the emergence of NGOs and their positive role in supporting social-related issues (Lu 2008; Hsu & Hasmath 2014; Hasmath & Hsu 2015). Studies also have pointed out the positive role NGOs can perform in providing technological supports to alleviate poverty in China (Zheng 2002; Xie & Gu 2007). However, even though NGOs in China are registered as social societies and are separated from governmental organisations, their performance has still been limited as their main activities overlap with governmental duties. In many cases NGOs are required to work with government officials instead of being able to initiate work independently. Also, although the social acceptance of NGOs has improved mostly in the developed regions, governmental officials in the less developed regions of China still lack understanding of their activities – some even confuse the terminology of 'non-government' with 'anti-government', which causes tensions to some extent (Schwartz 2004).

Farmers' cooperatives, on the other hand, have been through a rapid expansion in China and are seen as critical vehicles to involve smallholder farmers in the agricultural modernisation process through provision of technology and extension services. According to the census of the Ministry of Agriculture in 2018, there were 2.17 million registered farmers' cooperatives in China, which implies each village has (on average) 3-4 farmers' cooperatives throughout the country. Furthermore, over 50.1 percent of all farmers are reported to have experience in using services or training from farmers' cooperatives (Yuan et al. 2019). Studies have indicated the positive role that farmers' cooperatives can have in bridging smallholder farmers to agri-food markets and providing technology and extension services (Yang 2013). However, studies have also pointed out that a considerable number of farmers' cooperatives, at least one third nationally and over 60 percent in some areas, are "empty-shell cooperatives", which are not providing any services to farmers and have become a mere formality (He 2019; Yuan et al. 2019). The major cause was because the leaders of those empty-shell cooperatives were only aiming for the government's stimulus package for setting up farmers' cooperatives (Wang 2019). Evidence also shows the number of farmers' cooperatives was viewed as an item of local government performance assessment in some areas, for example, some provinces in central China required each village to have a farmers' cooperative. Hundreds of cooperatives emerged

shortly after, which also led to the creation of "empty-shell cooperatives" (He 2019). Furthermore, most of the cooperatives have failed to include or benefit smallholder farmers (Hu et al. 2017). Their participation in famers' cooperatives has also been minimal due to an unreasonable entrance criteria and admission fee, which has caused a farmers' differentiation phenomenon within the cooperatives (Ito et al. 2012; Qu & Ren 2019).

Overall, the privatisation of extension services was the Chinese government's approach to improve the efficiency of extension services; however, most of the practices have challenges in meeting farmers' needs. Comparatively, extension services provided by farmers' cooperatives and NGOs have potential advantages in meeting farmers' needs.

2.4 Matching supply and demand in extension

The topic of matching supply and demand in agricultural extension has been perused over time. Teixeira (2005) investigated the different priorities between research and development in the context of dairy farmers in Brazil and found that the research departments focused mainly on large scale dairy farmers' needs, and that the approaches used to identify farmers' needs were mainly via quantitative surveys, which cannot provide a deep understanding of smallholder farmers' perspectives and needs. The study suggests that a more interactive engagement between multiple stakeholders would more effectively identify the priorities in dairy production. Minh et al. (2014) designed a demand-driven agricultural extension approach, named the Farmer Researcher and Extension Network, implemented in the northern uplands of Vietnam. The approach identified extension workers at the commune level as strategic actors in the extension system and found that they can play a crucial role in interactions amongst actors within the network. From an agricultural innovation process angle, based on the market and systemic failure, Klerkx and Leeuwis (2008) pointed out that the effectiveness of a demand-driven innovation process is hindered by mismatches between agricultural services and users. They promote use of the innovation intermediary concept to analyse extension demand and supply, which aims at the interactions and the building of networks among multiple role. The functions of innovation intermediaries include demand articulation, network brokerage and innovation process management.

In China, studies on matching the demand and supply sides of extension services were mainly based on surveys at the macro level. In regards to investigating the multiple extension services supply organisations and the demand-supply situations in China, Kong (2009) and his project team launched a survey in the northern Shandong, Shaanxi and Shanxi provinces. They found that an individual

responsibility mechanism for extension officers can effectively make extension services match farmers' needs. Farmers' cooperatives, on the other hand, can also effectively support farmers in the production chain levels. Hubei province (in central China) has been at the forefront of agricultural extension innovation and reform since around 2000, especially in the public sector. Mei and Xiang (2014) launched a provincial investigation of 13 counties in Hubei province in 2011 via a quantitative approach and found that the integrated satisfaction rate of farmers experiencing extension service was 68.7 degrees (in 100 scale), which is the lowest rate among variables such as agricultural supporting policies. It is even lower among younger farmers (below 35 years old) and higher educated farmers (who have been in higher technical education and above).

The grassroots agricultural extension system is also an important section in China. In regards to this, Li and Zuo (2016) and their project team launched a national survey in 10 provinces, covering the whole map scale of China (five counties for each province). By using quantitative approaches, they discovered that 58.7% of extension departments had not recruited any higher educated staff during the past five years. For current extension officers, although 91% of them agreed that training was necessary, 14.6% had not had any training within five years. In regard to the training content, 41.9% was on cultivation technology and management, while training in marketing, organisation management and policies extension was very rare. Furthermore, the content and curriculum of the training for extension agents are not qualified for new situations in reality (Kong 2009). Similar criticisms have also been made in other countries, that extension agents are not performing necessary roles in rural changes due to the competency of extension agents (Khalil et al. 2008; Mundial 2012).

In regards to the heterogeneity of farmers and in order to understand how technology supply matches demand, Zhao et al. (2015) constructed an agricultural supply and demand model to analyse data from Shandong province. It found that for smallholder farmers, both the effective supply and effective demand were insufficient. Technologies such as fertiliser and pesticide were over-supplied, and other types of technologies such as those aimed at disaster alleviation, agricultural resource management, agricultural production processors and quality control were far under demand level. In their national survey, Hu et al. (2009) discovered that extension officers spent much less time than their duties on providing agricultural extension services; furthermore, with the privatisation reform, extension officers' salaries were partially from commercial extension activities, which decreased the time they spent providing extension services to farmers and influenced interactions with farmers.

Recent extension research that adopts innovation theories in China can also be seen. Qiu (2015) has done a comprehensive analysis on the role of different organisations as innovation intermediaries,

including extension officers, dragon head agricultural companies[4], farmers' cooperatives and universities and research institutes. The researcher discovered that those individual and organisations were effective in articulating demands from agricultural producers, building innovation networks with resources management and enhancing collaborations among different actors. Digging into the role of farmers' cooperatives as innovation intermediaries in China, based on the context of small scale farming in a changing environment, Yang (2013) explored the functions of three types of farmers' cooperatives and found that they effectively helped small scale farmers with access to technologies, involvement in high quality food market and value chain, and collective resource management such as infrastructure development and management. More studies are needed to explore the source of challenges in the extension system, particularly extension system in the local level, and their influences on smallholder farming, in terms of building the demand-driven mechanism in the extension system. This is broadly linked to the mechanism that extension system meeting smallholder farmers' needs in the agricultural innovation system.

2.5 Summary

This chapter reviews literature from four perspectives. Firstly, it reviews the concepts and paradigm shifts of agricultural extension. This section summarises the different definitions of agricultural extension, and the paradigm shifts from linear technology transfer, participatory extension, systems thinking, pluralism to capacity building. Secondly, it reviews two bodies of extension theories. The innovation theories section reviews the innovation diffusion theory, the AKIS and the AIS model in a theoretical shift order and points out the main features of each innovation model. The learning theories section reviews the adult learning, the experiential learning and social learning theories. Thirdly, it reviews the agricultural extension systems in different countries and their changes. I categorise it into three major trends, which are the public-sector extension system, the decentralisation extension and the privatisation extension. Fourthly, I review literature on matching supply and demand in extension services.

[4] 'Dragon head' is a Chinese term that means a particular company that is in the leading position in a particular industry with outstanding technologies, revenue payment and managerial systems etc.

Chapter 3. Research context

3.1 The evolution of extension system in China

The establishment and development of the agricultural extension system in China has gone through several major changes as the government has attempted to achieve the specific goals of economic development, to adapt agricultural production through difficult times when encountering huge natural disasters and societal changes, and to overcome the challenges of meeting the pluralistic needs of farmers and markets. This chapter aims to summarise those major events and changes in the development of the agricultural extension system of China, and the drivers of those changes.

Agricultural extension existed in ancient dynasties of Eastern Asian, when emperors tried to stabilise the society and enrich the economy through introducing new crops to conventional farmers, especially when agriculture was the economic foundation. For example, records of the Han dynasty (C. E.[5] 20-220) document the earliest event of *Quan Nong Ke Sang*[6], in which governmental officers advised farmers to grow mulberry to meet the growing demand for silk (Gao 2008, pp. 3-5). The mechanism of advising farmers in the governmental sector was formalised in the Song dynasty (CE 960-1279), during which the silk market developed to its peak (Duan 2018). The *Quan Nong*[7] has been a major assessment item of governmental officers' job competency throughout most Chinese dynasties. In the Yuan dynasty (C. E. 1271-1368), the governmental agricultural sector and its officers were encouraged to disseminate materials about farming practices, and were asked to report the performance of the county level officers in these activities (Wang 2005). In the Qing dynasty (CE 1644-1912), the government department of *Quan Nong* and the event of *Xing Shui Li*[8] performed positive role in improving agricultural production through introducing new varieties from overseas and providing farming needs (Zheng 2006; Duan 2018). The *Quan Nong* can be viewed as the earliest form of agricultural extension in China and was a critical approach for governments of every dynasty to develop agricultural production and improve people's livelihoods.

[5] C. E. refers to Common Era, the world's most widely used calendar era in the notation system.

[6] *Quan Nong Ke Sang* is a Chinese phrase that means advising farmers to grow mulberry.

[7] *Quan Nong* is a Chinese phrase that means advising farmers.

[8] *Xing Shui Li* is a Chinese phrase that means encouraging the building of irrigation infrastructure.

From the 1950s the agricultural extension system in China evolved through four major changes, as shown in Figure 3-1. These changes include the establishment of the national agricultural extension system from 1950 to 1960; the deconstruction of the system from 1960 to 1978; the reconstruction of the system from 1978 to 2000; and improvement of the system from 2000 to the present.

The systematic and formalised national agricultural extension system was established from 1950, after the People's Republic of China was founded in October 1949, as a major action of the government to boost agricultural production in response to the serious shortage of food throughout the whole country following a lengthy civil war (Hu et al. 2004; Kong 2009; Yan 2013). According to the Ministry of Agriculture (MOA), there were only 472 agricultural researchers and about 2000 extension staff throughout the whole country in 1949 (Ministry of Agriculture 1999, p. 106). The national agricultural extension system established by the Ministry of Agriculture launched building agricultural extension station trials in the northern provinces in 1951, then extended the building of extension stations throughout all provinces through a series of policies made in 1953 (Kong & Lou 2012). According to an MOA report, by 1957 about 16,466 agricultural extension stations had been created, and 94,219 extension staff recruited across the country (Ministry of Agriculture 1999, p. 70). By then the national agricultural extension system was considered to have established a reasonable capacity.

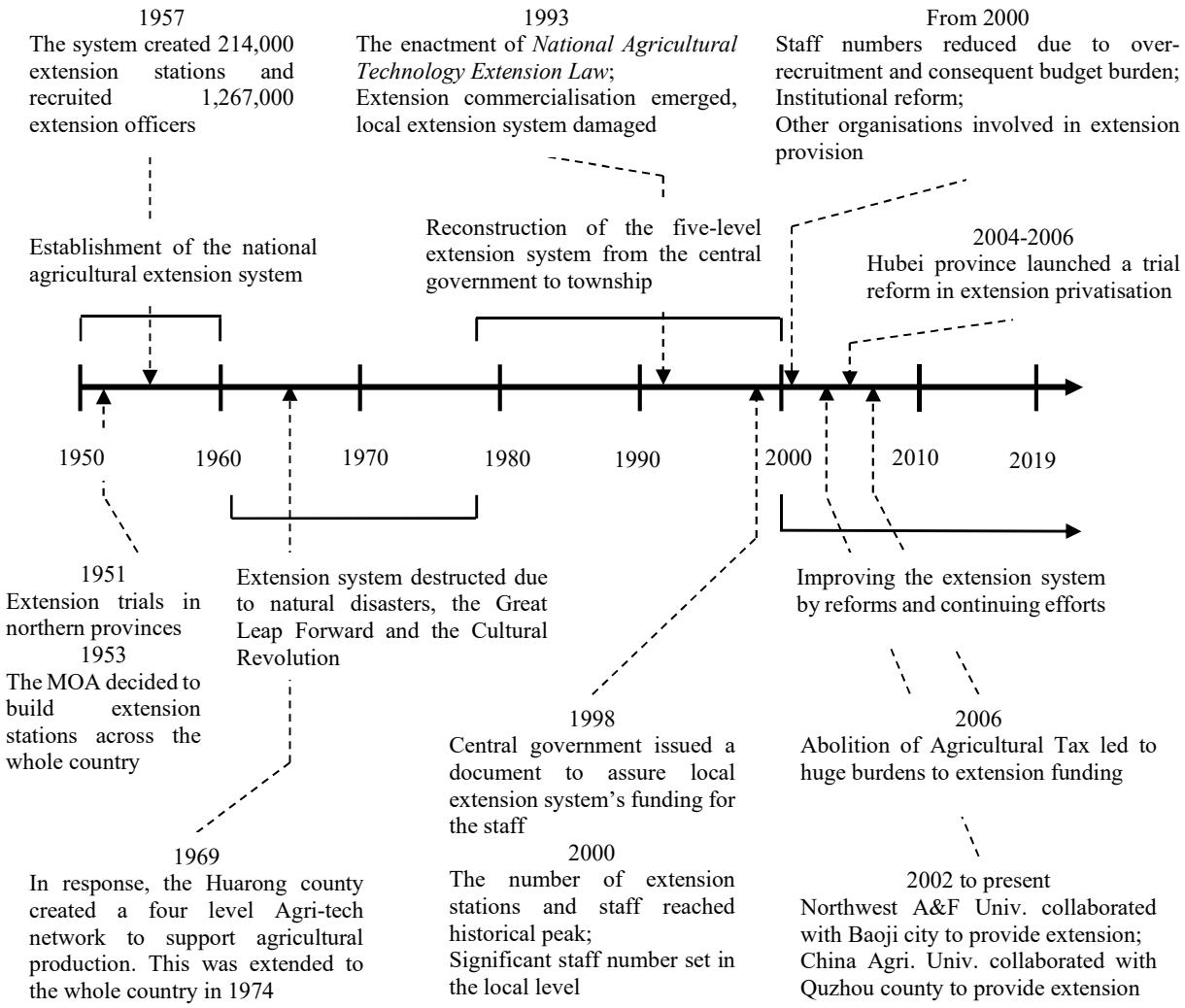

Figure 3-1 Timeline of the evolution of agricultural extension system in China

Source: adapted from Kong (2009, pp. 179-88) and Hu et al. (2012b)

From 1940 to 1978, agricultural production in China was under the collective farming mechanism across the country. During the early period the national agricultural extension system performed a critical role in transforming agricultural production after the modern nation was founded. The system successfully extended improved crop seeds, good farming methods and practices and agricultural machinery, which significantly increased the yields of major crops (Zhang 1990; Xu 2007, p. 106; Zhu & Hu 2009); however, there was also evidence of failures of the system in meeting farmers' needs. The extension of the *Shuang Lun Shuang Hua*[9] plough tractor was one major case. The central government introduced the plough tractor from the Soviet Union and trialled it in the northern

[9] *Shuang Lun Shuang Hua* is the name of a type of plough tractor means two-wheeled and double-shared.

provinces in 1952. When it turned out to be successful, the government proceeded to extend it to all provinces, but it failed in the southern provinces in 1956, due to the tractor's unsuitability for the paddy land and highland areas. That caused a huge loss in public finance and resources (Zhu & Hu 2009). Further, the focus and resources of the system were largely devoted to leading and elite farmers; smallholder farmers were overlooked (Kong & Lou 2012).

The critical role that the extension system was performing did not last long due to major societal changes. From 1960 the extension system was seriously affected by three years of drought, as well as the Great Leap Forward plan, in which the government tried to enhance industrialisation and modernisation but damaged agricultural production with unreasonable plans, and the Cultural Revolution, which was a campaign that sent people from cities to villages and during which the extension staff were largely removed from their positions to villages in 1966. The extension system was damaged and extension activities almost ceased because staff were redistributed to other careers (Kong & Lou 2012).

In order to meet farming needs, farmers in Huarong county, Hunan province, created a four-level agricultural extension network (*Si Ji Nong Ke Wang*) in 1969, in response to the absence of the extension system and highly collectivised agricultural production. The four-level network connects and organises cooperation among the local level agricultural research stations, the communes and farmers' groups at the village level, to introduce improved seeds and agricultural technologies, provide farming advice and run field trials and experiments to support agricultural production (Zhu 2012, pp. 119-20). The four-level network obtained significant outcomes in improving agricultural production. This was recognised by the central government, so this model was formally extended to all counties in Hunan province in 1971, and soon after to the whole country through widely launched demonstration trainings (Kong 2009, pp. 180-1). The four-level agricultural extension network performed a certain role in a difficult period but eventually it collapsed with the transformation from the collectivised production system to a household responsibility system in 1978, after which individual farmers were allocated a certain piece of farmland and, instead of farming for the commune, they conducted farming for their households' own consumption and preference (Li et al. 2008; Kong & Lou 2012; Zhong 2013; Mei & Xiang 2014). The case of the four-level extension network is evidence that farmers and their communities can be proactive to meet their farming needs, even when the extension system is entirely absent.

After the nationwide economic reform[10] in 1978, the Chinese government started to reconstruct the national agricultural extension system in a five-level form, which ranged from the central government to the township level and covered most villages as shown in Figure 3-2. This reform highlighted the position of the county-level agricultural extension centre (Mei & Xiang 2014, pp. 19-21), and its role in integrating all aspects of extension including production, communication between upper and lower levels, and management of extension activities at the township level. However, as the extension officers were encouraged to launch agricultural and extension related business, the county level finance in many counties across the country had reduced extension funding, as extension officers were considered able to achieve self-sufficiency with their extension business. Eventually this caused a huge funding shortage for extension activities (Kong 2009, pp. 181-2). In 1993 the *National Agricultural Technology Extension Law* was enacted, and each provincial government made enforcement regulations, which were viewed as a milestone event in the development of agricultural extension in China as the extension law placed agricultural extension activities into a legal framework (Li & Zhao 1995).

Many extension officers at the township level started to leave the extension stations to join other departments or launch agricultural input businesses because the extension funding was increasingly less assured under the county level finance system. This was noticed by the central government and soon, in 1998, the central government released a document[11], which commanded the lower level government and departments to increase the number of extension stations and officers at the township level. Two years later, the number of agricultural extension stations and extension officers nationwide reached a historical peak, in which the system expanded to 214,000 extension stations and 1,267,000 extension officers (Kong 2009, pp. 183-4). During this period the national agricultural extension system was viewed as having been completely reconstructed to meet the agricultural production needs of the reform era, and as being differentiated from the previous extension systems.

[10] *The 1978 reform* refers to the decisions and reforms in the 3rd Plenary Session of the 11th Central Committee of the CCP, which has been widely recognised as a turning point for China's economic reform.

[11] *The document* refers to the *Guanyu Dangqian Nongye He Nongcun Gongzuo De Tongzhi* [*The announcement about current agriculture and rural affairs*] by the Central Office of the CCP and the Office of the State Council in June 1998.

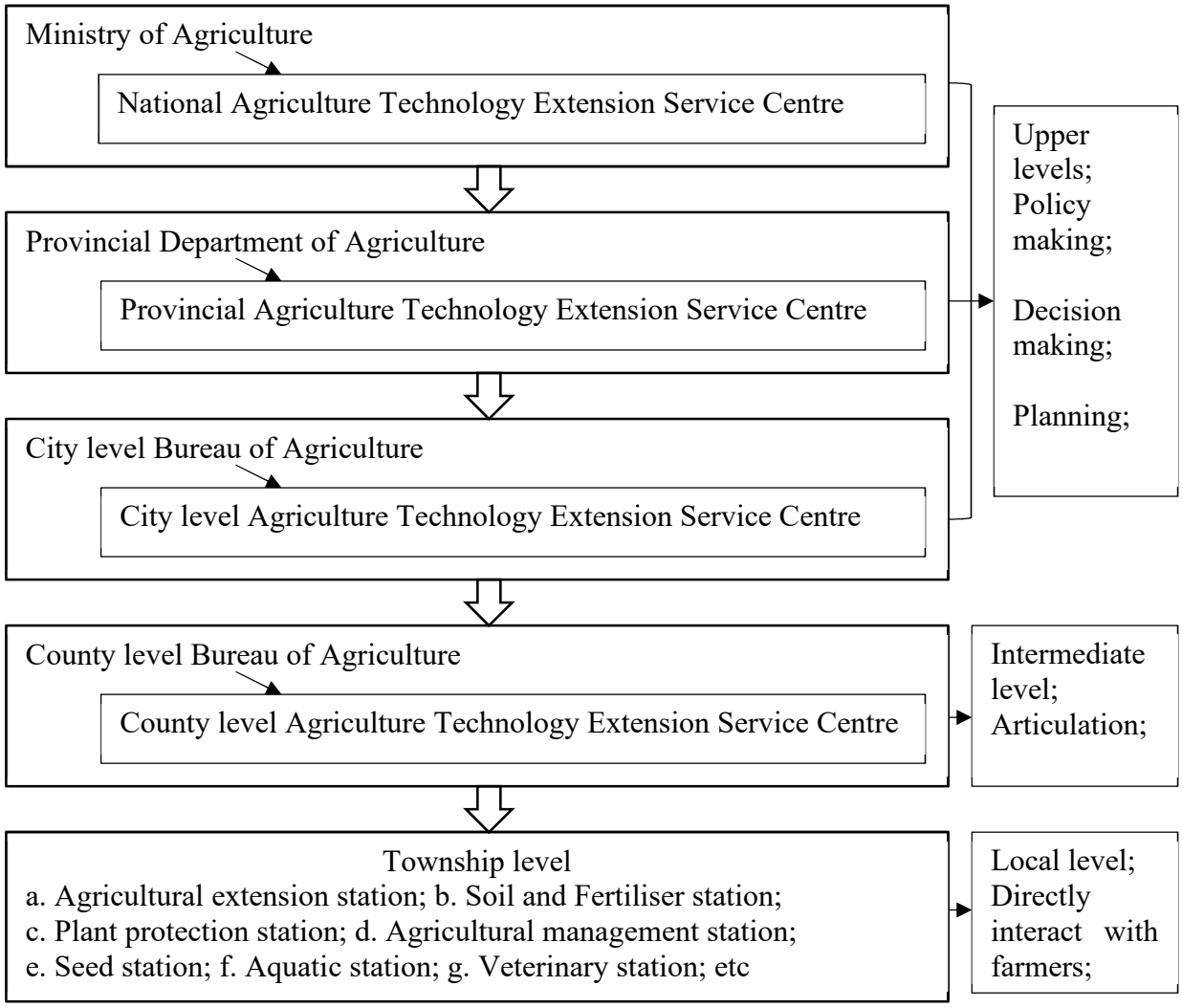

Figure 3-2 The five-level agricultural extension system in China

From 2000 the central government launched a rural tax reform with an intention to abolish the agricultural tax to increase farmers' income. However, as the finance for extension activities came mainly from the agricultural tax, this reform could potentially bring budget burden, jeopardising extension funding. Meanwhile, the over-recruitment issue in the township level extension staff was noticed. Thus, the central government started another institutional reform to reduce the redundant extension stations and less competent extension officers at the township level. The changes of the relationships and features under the institutional reform are shown in Figure 3-3. The major actions of the institutional reform were: firstly, all extension-related stations at the township level merged into one agricultural services centre; secondly, the centre's finance, personnel and resources were devolved from the county level Bureau of Agriculture to the township government. Through the institutional merge, redundant extension-related stations were removed, for example, some townships did not have aquatic production, but had an aquatic station in operation. Hence, the number of

extension officers was reduced. By 2002 about 3,000 extension stations were removed and about 21% of extension officers left the system (Kong 2009, p. 185). Under the rural tax reform, the agricultural tax was abolished in 2006 nationwide. Studies have commonly shown that although the central government supplemented funding for extension activities nationwide, the tax abolishment did cause a significant budget burden to the county level finance, thus decreased extension services provisions (Mo et al. 2006; Kennedy 2007). Furthermore, the devolution of the finance, personnel and resource of the township agricultural services centres from the county level Bureau of Agriculture to the township government significantly reduced the time that extension officers could spend on extension activities because many non-extensions works from the township government were added to their workload (Kong 2009).

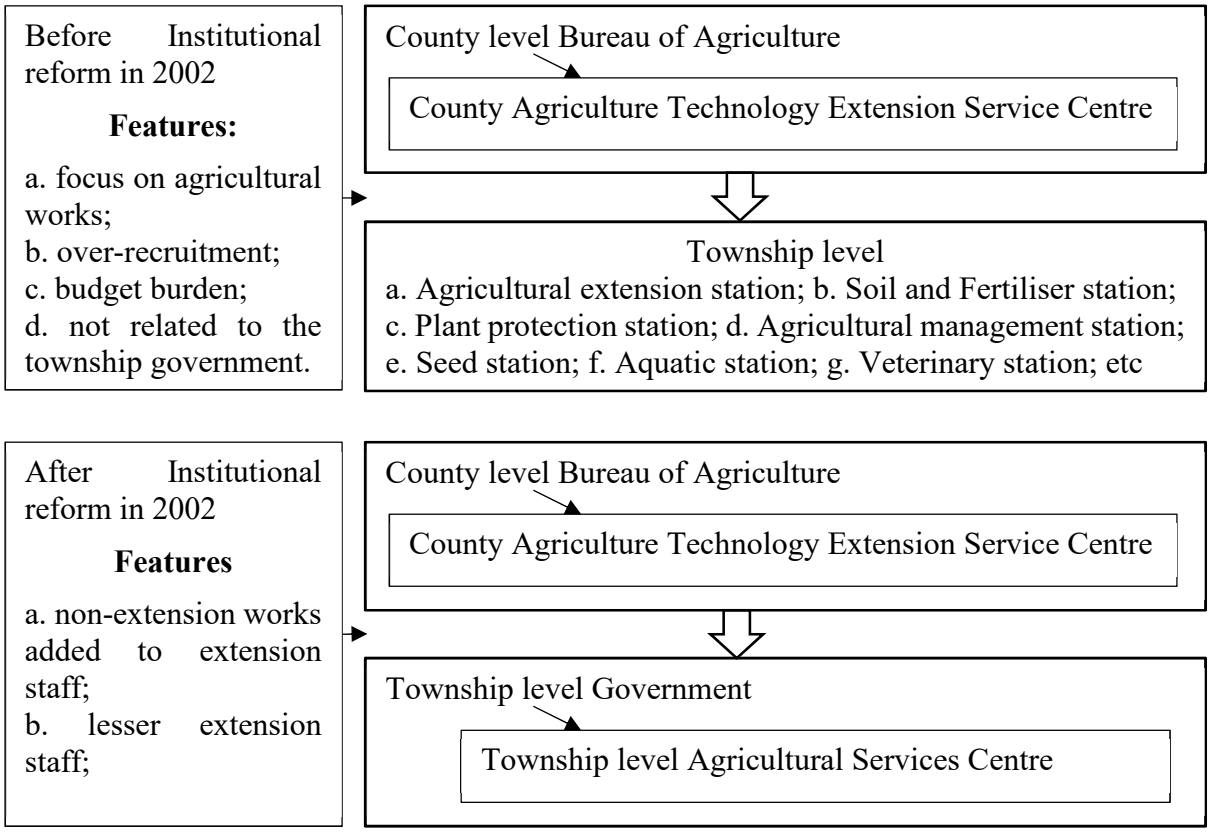

Figure 3-3 Main features before and after the institutional reform in 2002

Besides the institutional reform as a solution for the budget burden in the public-sector extension system, from 2002 the central government was also encouraging diverse forms of extension services provisions. The extension privatisation reform in Hubei province in 2004 was a prominent case from the public-sector. Also, several agricultural universities started to work with local governments to initiate research and extension linkages and provide extension services to farmers.

The extension privatisation *(Yi Qian Yang Shi)* reform trial in Hubei province

The extension privatisation reform of Hubei province in 2004 was an outstanding event in the development of the extension system in China. It was a response to the national institutional reform and the common budgetary issues with public extension stations and staff. Instead of cutting down extension stations and staff, the *Yi Qian Yang Shi* reform trial in Hubei province was designed to transform the public-sector extension stations to become enterprises or social organisations, which were to undertake governmental extension projects. The extension staff were all transferred from the extension stations to the new extension organisations, and their source of income was transferred from governmental payroll to the governmental projects that they undertook (Zhou & She 2008; Wang & Chen 2013; Mei & Xiang 2014, pp. 22-4). The *Yi Qian Yang Shi* was planned to relieve the governmental budget burden and meanwhile improve the extension services.

After this reform was completed in 2006, studies showed that the reform had improved the efficiency of the extension services, reducing staff costs while achieving more implementation of extension projects. This improved the services received by farmers (Huang et al. 2009). The reform also improved the quality of the extension staff as better educated and more professional staff were recruited in the extension teams. The non-government mechanism also improved the proactivity of extension staff in providing extension services, instead of being reactive when they were on governmental payroll (Mei & Xiang 2014, pp. 24-5). However, studies have also shown failures of the reform, including that the actual quantity of non-profit extension services, which should be targeting most smallholder farmers, has significantly reduced because services from extension organisations were mainly focusing on large-scale farmers (He 2012). The extension projects were opened to competition by all business, agents and social organisations, but they failed to attract other types of agents and organisations, as most were won by the reformed extension organisations, thus the primary design of the reform was not reached (Chen & Qi 2014). The position of transformed extension organisations and their staff were not made clear enough and this caused confusion during extension implementations (Wang & Chen 2013). Most importantly, the extension projects put out to tender were determined and designed by upper level governmental departments, which made it even harder to meet farmers' needs than under the governmental system (Huang et al. 2009). Studies have also shown rent-seeking behaviour in collaboration between privatised organisations and government departments, where both obtained benefits by sacrificing smallholder farmers' benefits through introducing unnecessarily high-tech and unsuitable varieties of crop and advising farmers to grow them (Li et al. 2008).

It appears that the *Yi Qian Yang Shi* reform was a distinctive reform path in the institutional reform period, but only changed the mechanism and process of the system. From farmers' perspectives, improving the accessibility and quality of extension services should be the major focus. While the reform improved the quantity of extension services received by farmers (Huang et al. 2009; Mei & Xiang 2014), it did not fundamentally change the ways that extension services were delivered, hence it only performed a limited role in meeting farmers' needs.

The university-initiated extension services

In China and worldwide, universities and research institutions are the main source of new agricultural technologies. The land-grant college system and its core role in the American agricultural innovation system has shown that agricultural universities are not only research domains, but also proactive providers of extension services to agricultural businesses and farmers in their specific states, and that this system provokes collaboration between education and extension for mutual benefit (Huffman & Evenson 2008; Liu & Dong 2012). In the Chinese context, universities and the extension system have been working separately in different systems, which limits both the research at universities and universities' potential role to provide extension services in a national agricultural innovation system framework (Li & Zhou 2012, pp. 100-4; Liao & Li 2015). Many studies have pointed out that indigenous farming knowledge and practices and farmers' experiences can be fundamental sources of agricultural research, hence it is critical to have researchers and farmers working together and to have farmer participation in technology development (Farrington 1989; Ashby 1990; Hoffmann et al. 2007).

The agricultural innovation system of the US was constructed through proactive enactment of a series of acts to provide land and funds to establish agricultural colleges and give them a central role in the agricultural system (Liao & Li 2015). In China, the research-farmer collaboration has been initiated either where the universities wish to promote their technology transfer, or on the demand-side, where local government or companies proactively approach agricultural universities, driven by regional agricultural development issues. The collaboration between the government of Baoji city, Shaanxi province and the Northwest Agriculture and Forestry University in Xi'an in 2002 was viewed as the first government-university collaboration case. It was driven by the university's intention to promote their technology, while the government sought to enhance local agricultural production, as a number

of research bases (*Zhuan Jia Da Yuan*[12]) had been constructed in 20 different counties of Baoji city, each aimed at one particular crop variety or industry in the specific county, including wheat, corn, vegetables, fruit, beef and dairy, depending on the opportunities of the county. The university encourages researchers to transfer their technologies to promote agricultural production; the provincial government meanwhile provides sufficient policy and funding to run the research bases in the counties, townships and villages (Zhang 2005; Hai & Li 2007; Guo & Liu 2013). However, studies have shown that the government has a strong intervention in the actual process of the collaboration, which has disabled its primary intention, developing agricultural industries through marketisation mechanism, as some of the projects implemented did not meet the growers or the market's needs but were still promoted (Guo & Liu 2013). Further, the intention of this collaboration was strongly driven by the university's aim for technology transfer and the government's aim to boost agricultural industries, which meant it performed very little role in providing extension services to smallholder farmers.

Another well-recognised government-university collaboration is that between the government of Quzhou county, Hebei province, and the China Agricultural University (Beijing) in 2004. It was different from the previous case in that the collaboration was initiated by the government of Quzhou county due to the lengthy and worsening regional soil salinisation problem, and the yield loss and farming difficulties that it caused to all farmers in that region. After the government of Quzhou county approached professors at China Agricultural University, they decided to construct experimental premises in that region, which were named Science and Technology Backyard[13] (STB) platforms, in which the university located post-graduate students to do their placements, field experiments and theses, meanwhile to extend their soil testing technology to solve the soil salinisation issue (Zhang et al. 2016).

Studies have shown that the STB approach has involved farmers in the technology transfer process in a participatory way, as students were studying full time in villages and professors made constant field visits to assist farmers with their soil salinisation issues, meanwhile conducting their experiments and collecting data for their soil salinisation projects (Liao 2015). In this sense, solving farming issues and research projects proactively promoted each other. Also, as students were working with farmers, they were also helping farmers with other farming issues. For example, some farmers

[12] *Zhuan Jia Da Yuan* is a Chinese phrase, which means the courtyard for experts, is the premise of the research base constructed from the government-university collaboration, which allows research and extension activities initiated in the local levels including county, township and village.

[13] The Science and Technology Backyard (STB) refers to the Chinese phrase Ke Ji Xiao Yuan.

were in the habit of identifying fertiliser quality by tasting the fertiliser on their tongue. Students learned of this practice and educated farmers regarding the harm to their health (Zhang et al. 2013; Qiu 2015). Another major feature of the STB is the trust built between the STB and farmers, as besides working in the STB experiment premises, students launched field schools for farmers, and sometimes broadcast movies for farmers. Also, students were encouraged to do short stays in farmers' houses and students reported it effectively built connections between them and farmers (Zhang et al. 2013). Thus, the collaboration initiated through local demands, especially regarding particular regional farming issues, can achieve a win-win situation for both farming problem-solving and research. Also, interactive and participatory modes of extension advisory provisions are critical in farmers' innovation adoption.

The historical changes in the agricultural extension system in China have shown that meeting farmers' needs is complex. In the public sector, design and implementation of reforms to the agricultural extension system were highly driven from the system's perspective rather than the farmers' perspective; for example, privatisation enacted due to the shortage of extension funds, which targeted problems in the extension system without due consideration of ascertaining and meeting farmers' needs. The university-orientated extension model has shown that extension services orientated to solve particular regional farming problems could create satisfactory changes in rural areas. The model also implied that greater involvement and collaboration with actors, in this model universities, is the key to design, plan and extend satisfactory services for farmers. More studies are needed to explore whether other actors, for example the private sector and farmers themselves, can be involved in the extension process.

3.2 Summary

In this chapter I summarised the history of agricultural extension activities in ancient Chinese dynasties, and major changes in the agricultural extension system from 1950 to the present. Agricultural extension was a major governmental intervention and an item in assessing the competency of government officers in most of the Chinese dynasties. After the new nation was founded in 1949, the agricultural extension system went through four major changes. From 1950 to 1960 the central government established the agricultural extension system nationwide through the building of extension stations at all levels of administration, particularly at the township level, and the recruitment of extension officers. From 1960 to 1978, due to natural disasters and social campaigns, the extension system was damaged. But during this period, Huarong county created a four-level Agri-tech Network to provide extension services for farmers as a response to the damaged

extension system. From 1978 to 2000, after the farming mechanism in China was transformed from collectivised farming to a household responsibility, the central government started to reconstruct the agricultural extension system in a five-level form, from the central government to township. During this period, in 1993, the extension law was enacted, and in 2000 the number of extension stations and staff reached a historical peak. From 2000 to the present there has been the extension system improvement period. Changes include the institutional merge of extension stations at the township level, the extension privatisation trial in Hubei province, and the start of agricultural universities providing extension services to farmers in various forms.

Chapter 4. Methodology

4.1 Research paradigms

Patton (1990, p. 37) defined a paradigm as "a world view, a general perspective and a way of breaking down the complexity of the real world". Historically, science has heavily emphasised quantification (Guba & Lincoln 1994), the hard sciences and hard systems (Checkland 1981), and reductionism as representing scientific discipline (Verschuren 2001). As more and more methodologies have been applied in social science research, arguments have been made about paradigms including that quantitative approaches commonly strip context out of consideration, exclude meaning and purpose, and disjunct theories from local context, and also that quantitatively generalised data and results are inapplicable to individual cases because of exclusions of dimensions that cannot be quantified (Guba & Lincoln 1994). Guba and Lincoln (1989, pp. 57-62) pointed out that the conventional positivism and post-positivism paradigms do not contemplate the stakeholders' need and their claims, concerns and issues because they consider truth as a verification process using physical and statistical controls, without taking contextual factors into account. Therefore, a constructivism paradigm is needed to embrace the contextual factors in social sciences.

Guba and Lincoln (1989, pp. 84-5) explained the differences between the constructivism paradigm and the positivism paradigm under the ontology[14], epistemology[15] and methodology[16] perspectives. Ontologically, the constructivism paradigm considers that realities are multiple and socially constructed, ungoverned by any natural rules. Meanwhile, the positivism paradigm considers that there is a single reality that is independent from any observer's interest and that it operates according to specific natural laws. Epistemologically, the constructivism paradigm considers that the researcher reaches the findings in a subjective way and emphasises the interactions between the researcher and what is to be researched. Meanwhile, the positivism paradigm emphasises and seeks objective knowledge, and views the researcher and what to be researched are separated and non-interactive. Methodologically, the constructivism paradigm uses hermeneutic and dialectical ways of exploring

[14] Ontology: the form and nature of reality, and what can be known about it (Guba and Lincoln, 1994).

[15] Epistemology: the nature of the relationship between the people to know and what can be known (Guba and Lincoln, 1994).

[16] Methodology: the way that the researcher uses to find out whatever he or she believes can be known (Guba and Lincoln, 1994).

research participants' realities. This can involve continuing iteration between data collection and analysis.

Röling (2002) argued that bodies of knowledge and perception may be coherent internally, but may not correspond with the external environment, as certain aspects of research participants' reality are ignored (Leeuwis 2004, p. 101), particularly with regards to systematic problems and their interactive processes. Thus new theories and conceptions inspired by constructivism are needed to provide new ontological and epistemological angles to address those challenges (Röling 2002).

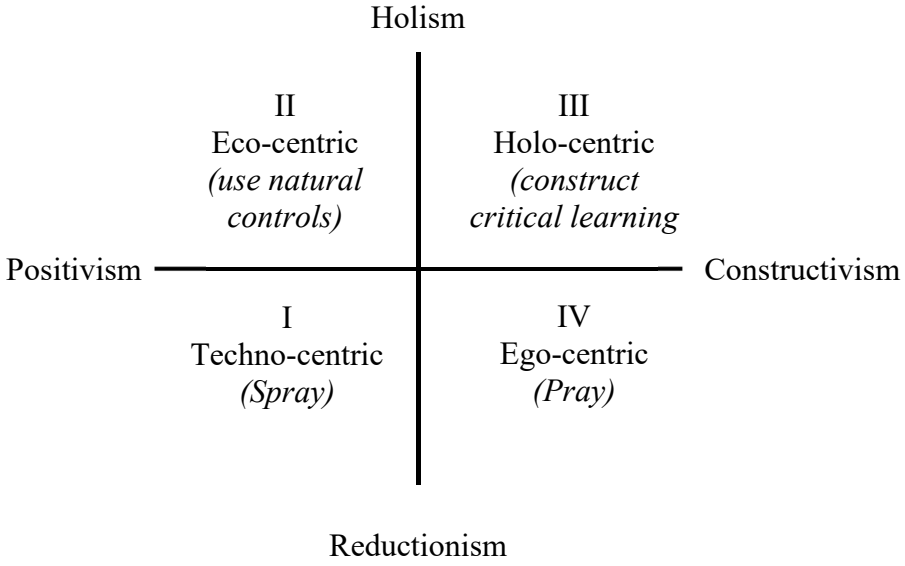

Figure 4-1 The Miller/Bawden quadrants

Source: Röling (2002, p. 29)

Leeuwis (2004, pp. 102-3) has pointed out the phenomenon of "blindness" in both scientific and practitioner worlds. Disciplinary blindness is a phenomenon whereby science in different disciplines uses different languages and concepts that can create boundaries across the disciplines and difficulties in integrating different disciplinary perspectives. Also, politicians and policy-makers tend to observe and measure society and social problems in the reductionist way, which can cause considerable risks that the reality is diminished. Thus, as Röling (2002) has pointed out in quadrant 3 of the Miller/Bawden quadrants (Figure 4-1), the world needs a holistic and constructivist perspective, for example, soft systems thinking.

Extension research has been influenced massively by the positivism paradigm, later the constructivism paradigm and now both combined sometimes (Teixeira 2005). Agricultural extension

has long been focusing on linear technology transfer and the effectiveness of production. This did function for specific development purposes in most countries for dealing with the issue of growing population and food demand. However, as issues caused by this technological focus have been noticed such as the broadening of the income gap, the pollution of the environment and the heterogeneity among smallholder farmers, the blanket extension service is likely to have limited relevance (Sanyang et al. 2016). This study explores how the extension system and farmers meet farmers' extension needs by recognising the complex situations that smallholder farmers encounter. This study employs existing theoretical frameworks including innovation system framework and learning theories to analyse the complexity of smallholder farming, the extension process and farmers' learning process, to understand and construct their interactions. Thus, this study is positioned in a paradigm of continuum from post-positivism to constructivism. Epistemologically, this study is positioned from objective to subjective. In terms of world view, this study is positioned in the holism paradigm.

4.2 Methodology

4.2.1. Conceptual framework

This study uses two main units of analysis, the agricultural extension services (at several levels of government) and the smallholder rice farmers. In the agricultural extension services, this study sought staff perspectives on: (1) What extension services have they been providing for smallholder rice farmers? (2) What were the intentions of those services? (3) How were the extension services decided upon, and extended to the farmer level? (4) Staff assessments of the extension services and (5) Perceived challenges in the agricultural extension system. The questions align with research question 1 (how well are farmers' needs met?).

In seeking the smallholder rice farmer perspectives, this study explored the following questions: (1) What advice and support do farmers need for their farming? (This may be general, about what they need to improve their farming, and/or about solving specific farming problems). (2) How did farmers perceive the effectiveness of the agricultural extension services in terms of meeting their farming needs? (3) What farming problems have farmers encountered, how do they perceive them and how have they identified them? Question (1) and (2) align with research question 1 (how well are farmers' needs met?). Question (3) align with research question 2 (how do farmers meet their needs?).

This study employed innovation and learning frameworks to analyse information from these two main units. The innovation diffusion framework from Rogers (2003) was used for analysing the

characteristics of innovations (in this study the technologies promoted by extension services) including their compatibility with farmers' needs and the relative advantages, and the dissemination process, to analyse the extension process. The innovation system framework from Röling (1988) and Klerkx and Leeuwis (2008) was used to analyse the system of extension services provisions, including the main public sector actors and other actors such as the private sector and farmers. Learning theories, especially experiential learning (Kolb 2015) and social learning (Jiggins et al. 2007) were employed to analyse farmers' processes of obtaining and using extension services, farmers' perceptions and identification of farming problems and actions that were taken accordingly. Relations between these two main analytical units were also discussed. The analytical framework is shown in Figure 4-2.

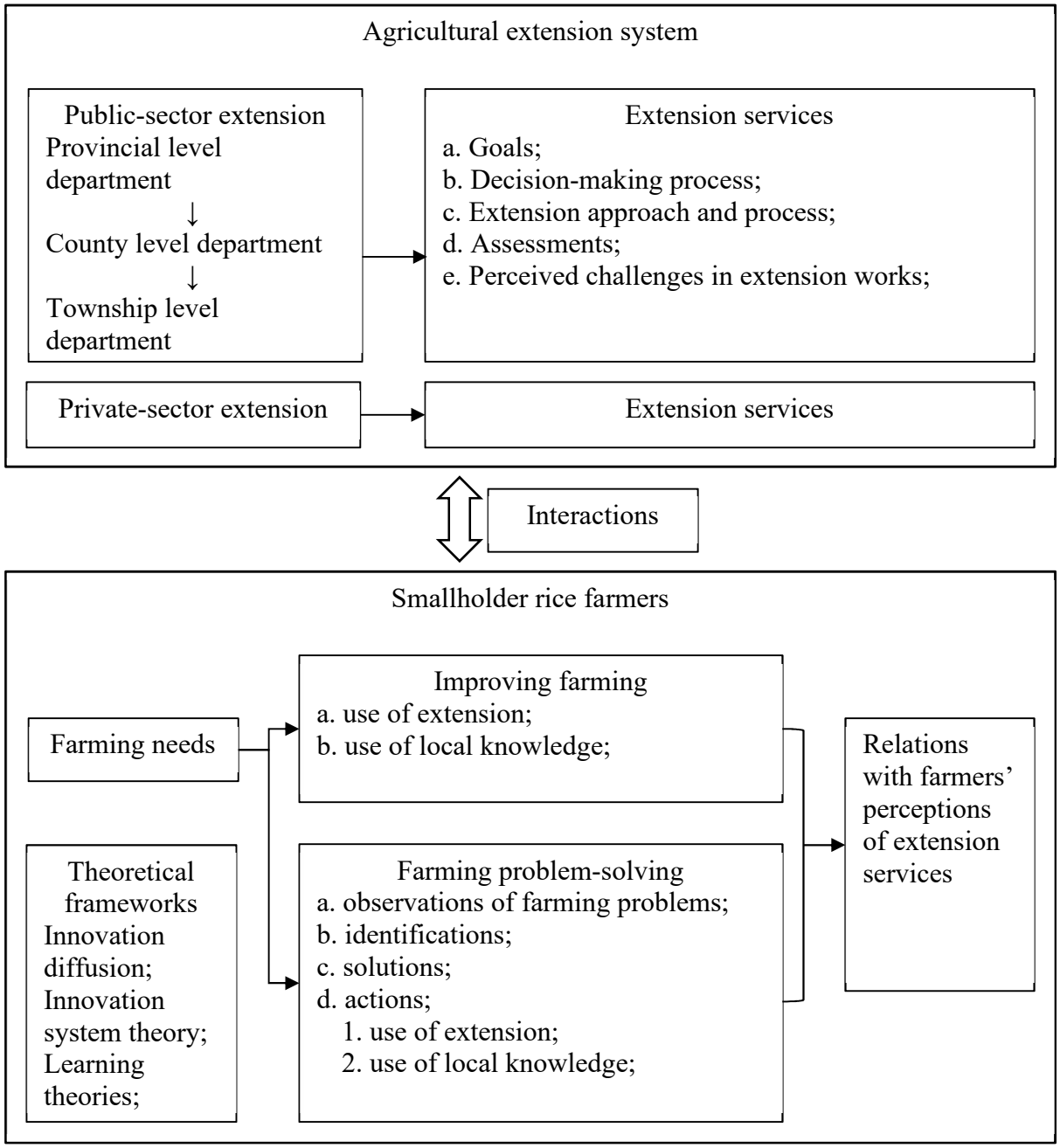

Figure 4-2 Analytical framework

As shown in the analytical framework, the analysis of this study was guided by two main units, which are the agricultural extension system and smallholder rice farmers. The extension system unit includes different providers in the system and the services provided to smallholder farmers. The smallholder rice farmers unit includes farmers' needs, farming improvements, farming problem-solving and farmers' perceptions of extension services.

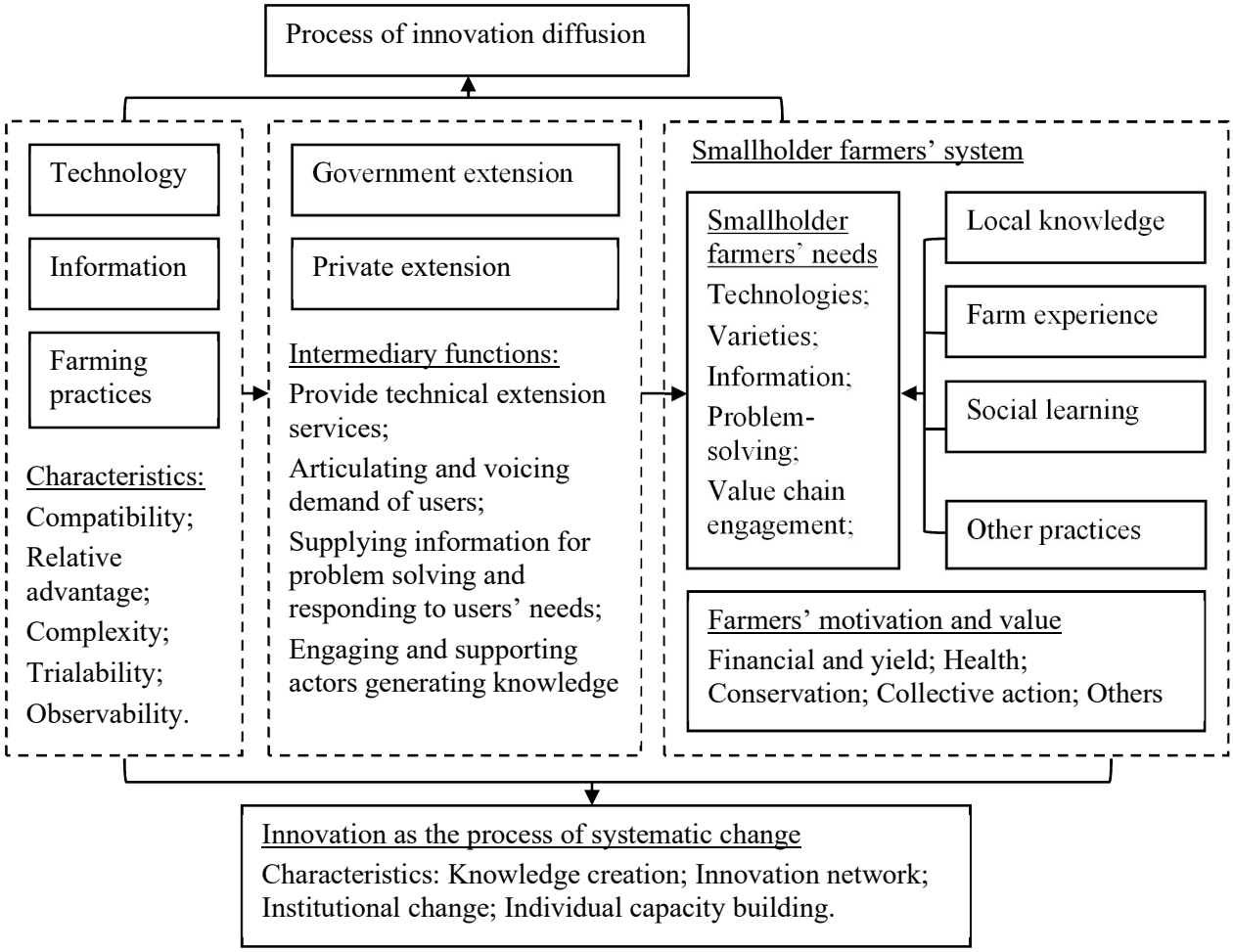

Figure 4-3 Conceptual framework

As shown in Figure 4-3, this study considers innovation as the process of systematic change, which emerges from the network and interaction of multiple actors. In this study, as we employ the AKIS and AIS framework, innovation intermediary and its functions are important to analyse how smallholder farmers' needs are articulated and met. Innovation diffusion is viewed as a part of the systematic change because it simply implies the process of technology adoption. As recent theoretical development implies, innovation adoption does not necessarily bring satisfactory changes. Further, this study considers learning as an important process in the creation of innovation. By employing experiential learning framework this study aims to investigate farmers' farming experiences and how decisions were made accordingly. By employing social learning framework this study aims to discover the role of social leaning in farmers' farming activities.

4.2.2. Qualitative methods

Quantitative and qualitative methods are two dominant ways of conducting research. Neuman (2006) summarised the differences between those two methods as shown in Table 4-1.

Table 4-1 Quantitative versus Qualitative Approaches

Quantitative Approach	Qualitative Approach
Measure objective facts	Construct reality based on subjective view
Focus on variables	Focus on interactive processes
Reliability the key factor	Authenticity the key factor
Value free	Value explicit
Separate theory and data	Combined theory and data
Independent of context	Constrained situation
Many cases and subjects	Few cases and subjects
Statistical analysis	Thematic analysis
Researcher detached	Researcher involved

Source: Neuman (2006)

In social science research, both approaches are important. In terms of a research paradigm, the quantitative approach is based on positivism and functionalism, which consider reality exists objectively and independently from human perspectives; while the qualitative approach is based on constructivism, which considers reality to be socially constructed and within specific social contexts. Different approaches are selected to suit different types and forms of research topics and questions. Many social studies may also combine quantitative and qualitative approaches to extend the breadth and depth of the research or answer different questions.

Both research methods can be suitable for research in agricultural extension. Using the quantitative method, studies have pointed out the relationships between technology adoption and rural poverty alleviation (Mendola 2007; Kassie et al. 2011), relationships between extension services and the amount of pesticide use (Huang et al. 2003a) and fertiliser use (Huang et al. 2012; Huang et al. 2015), with concerns of rural environmental issues. The quantitative method has also been commonly used in surveying farmers' extension needs. Kong (2009) contended that farmers' extension needs included fertilisers, pesticides, irrigation, machinery, packaging and storage services, forage, veterinary and farming information. Studies also show the capacity of extension services provision, which includes the quantity of extension stations and officers, the structure of age and education of extension officers (Kong 2009), the budget for extension stations and extension activities (Li & Zuo 2016) and the time that extension officers spent in visiting villages and launching extension activities (Hu et al. 2012a).

In these studies, the quantitative method was commonly used to give a broad picture of the extension system and farmers' extension needs.

Using the qualitative method, studies in rural development have mainly focused on explaining interactions between different actors, for example, agricultural extension services' functions as innovation brokers in engaging farmers in the innovation network (Qiu 2015); the role of farmers' cooperatives as innovation intermediaries in bridging smallholder farmers to technologies and higher-value agri-food markets (Yang et al. 2014); and the interactions between agricultural extension services, organisations and subsistence farmers in achieving commercialisation of subsistence farming in the innovation system perspective (Alexander et al. 2017). The qualitative method has also been used to explore farmers' perceptions about extension services. Baah (2017) explored subsistence farmers' perceptions of pluralistic extension services, including how farmers' perceptions on climate change affect their choices of extension services, and how sometimes extension services solved the targeted farming problems but raised another. From the systems perspective, the qualitative method is also suitable for explaining the complexity of technological interventions and farming systems. Whitfield et al. (2015) pointed out that technological initiatives that target increasing yield and scaling adoption can be incompatible with the resource constraints and competing land use priorities of smallholder farm systems.

Guba and Lincoln (2005) note that constructivism represents a relativist ontology, a transactional and subjective epistemology, and a hermeneutical and dialectical methodology. Meanwhile, they also point out that qualitative inquiry deals with how social experience is created and given meaning. Extension research demands an interdisciplinary approach to understanding complex problems involved in agricultural and rural systems (Wilson 1990), for example, through the social experiences of smallholder farmers. Chapter 2 presents studies in the literature that demonstrate the complexity of issues relating to smallholder farmers and the extension system in China. Many factors are dynamic and relate to each other internally and externally. A qualitative method within the constructivism paradigm is suitable for analysing the complex problems based on farmers' thinking and experience, farmers' needs and the nature of the extension system.

4.3 Data collection

4.3.1. Study locations

This study was conducted in China, which is a developing country facing rapid socio-economic changes, with major agricultural production and emerging governmental reforms and interventions

implemented in the agricultural sector. Smallholder farming accounts for the majority of farming in China.

Regarding the selection of study location, this study was guided by criteria including having agricultural extension services from both public-sector and private-sector, and smallholder farming being the dominant form of agricultural production. To keep the study within a manageable scope and focused on the interactions between farmers and extension services, it was decided that farmers associated with a single crop should be the focus. Accordingly, this study selected rice, as it is the main crop cultivated by smallholder farmers.

Based on these criteria, Guangxi Autonomous Region was selected as the primary provincial-level study location. Guangxi is located in the mountainous terrain in the far south of China, sitting in the converging region of southern sub-tropical and middle-tropical area and having plenty of rainfall, sunlight and temperature resources. Rice has constantly been the primary grain production in Guangxi, which accounts for two-thirds of the total sown area and four-fifths of the total production of grain in China. Rice farming has two seasons in an annual year and is the primary crop of most farmers in Guangxi (Xu 2013).

After selecting the province, I employed a snowball sampling technique to identify suitable locations for data collection from the higher-level agricultural department to the lower-level agricultural departments and eventually farmers at the village level, based on selection criteria for each level. A snowball technique in sampling is suitable for constructivism and qualitative research when the units of analysis are emergent and interactional, and the potential participants are difficult to find and approach directly. Snowball sampling may also help to identify relationships between the different levels of participants (Noy 2008). The snowball sampling approach used in this study is shown in Figure 4-4.

Provincial level

Objective 1: seeking relationships between research, extension services and farmers
Criteria: a. institution and researchers focus on rice research;
b. researchers with good knowledge about rice production in Guangxi;
Selection: a. institution: College of Agriculture, Guangxi University;
b. researchers who have rice projects experience in Guangxi;

Objective 2: seeking relationships between extension services and smallholder farmers
Criteria: a. department that is responsible for agricultural extension;
b. officer that has good knowledge about rice technology extension;
Selection: a. the provincial Agricultural Extension Station,
affiliated in the provincial Department of Agriculture;
b. officer responsible for rice technology extension;

⇩

County level

Objective: seeking relationships between extension services and smallholder farmers
Criteria: a. counties that are rice farming dominated;
b. counties that have extension services;
c. department that is responsible for agricultural extension;
d. officers that have good knowledge about rice technology extension;
Selection: a. the county Bureau of Agriculture;
b. the county Agricultural Extension Station;
c. officers that is responsible for rice technology extension;

⇩

Township level

Objective: seeking relationships between extension services and smallholder farmers
Criteria: a. townships that are rice farming dominated;
b. townships that have extension services;
c. department that is responsible for agricultural extension;
d. officers that have good knowledge about rice technology extension;
e. other providers of extension services to smallholder rice farmers;
Selection: a. the township Agricultural Service Centre;
b. the township agricultural input stores;
c. the township farmer cooperatives;

⇩

Village level

Objective: Smallholder rice farmers' perceptions of extension services
Criteria: a. villages that are rice farming dominated;
b. villages that are smallholder dominated;
c. villages that have access to extension services;
d. farmers that have been cultivating rice in less than 2 hectares of land;
e. farmers that have experiences with rice farming and extension services;
Selection: a. farmers have been cultivating rice in recent 5 years;
b. farmers have been cultivating land size ranges from 0.2 to 1.4 hectares;
c. farmers have used extension services;

Figure 4-4 Snowball sampling process of data collection

The snowball sampling started from the provincial level, where I selected the School of Agriculture, Guangxi University, to obtain researchers' perspectives, and the provincial Agricultural Extension Station affiliated in the provincial Department of Agriculture. The criteria for selecting research institutions are shown in Figure 4-4. As part of each interview at provincial level, I asked participants for recommendations of lower level fieldwork locations. Recommendations for county level study locations were sought from an officer in the provincial Department of Agriculture and two researchers in the School of Agriculture, Guangxi University, based on the criteria shown in Figure 4-4. From this advice, I obtained and selected two counties as my county level study locations. These were Lingshan county and Hepu county. These two counties are neighbours in the southern part of the province, with similar natural and environmental conditions and acreage and population. Lingshan county was declared the model county for rice farming (out of seven counties in the province) in 2012, according to the General Office of the Guangxi Government[17], which was viewed as having good performance in rice farming within the province. Hepu county is not a model rice farming county. I selected them both to offer a broad picture of the situation of rice farming and agricultural extension services, instead of solely looking at the best location. The location of these two counties is shown in Figure 4-5.

[17] *The document* refers to the Guangxi Zhuangzu Zhiziqu Renmin Zhengfu Bangongting Guanyu Jiakuai Xiandai Nongye Chanye Keji Shifan Xian Jianshe Shishi Fangan De Tongzhi (Guizhengban Fa [2012] 267 Hao). In literal translation: The General Office of the Guangxi Zhuang Autonomous Region released the Information about Accelerating the Construction of the Modern Agricultural Industry Science and Technology Model Counties (the General Office of the Government [2012] number 267).

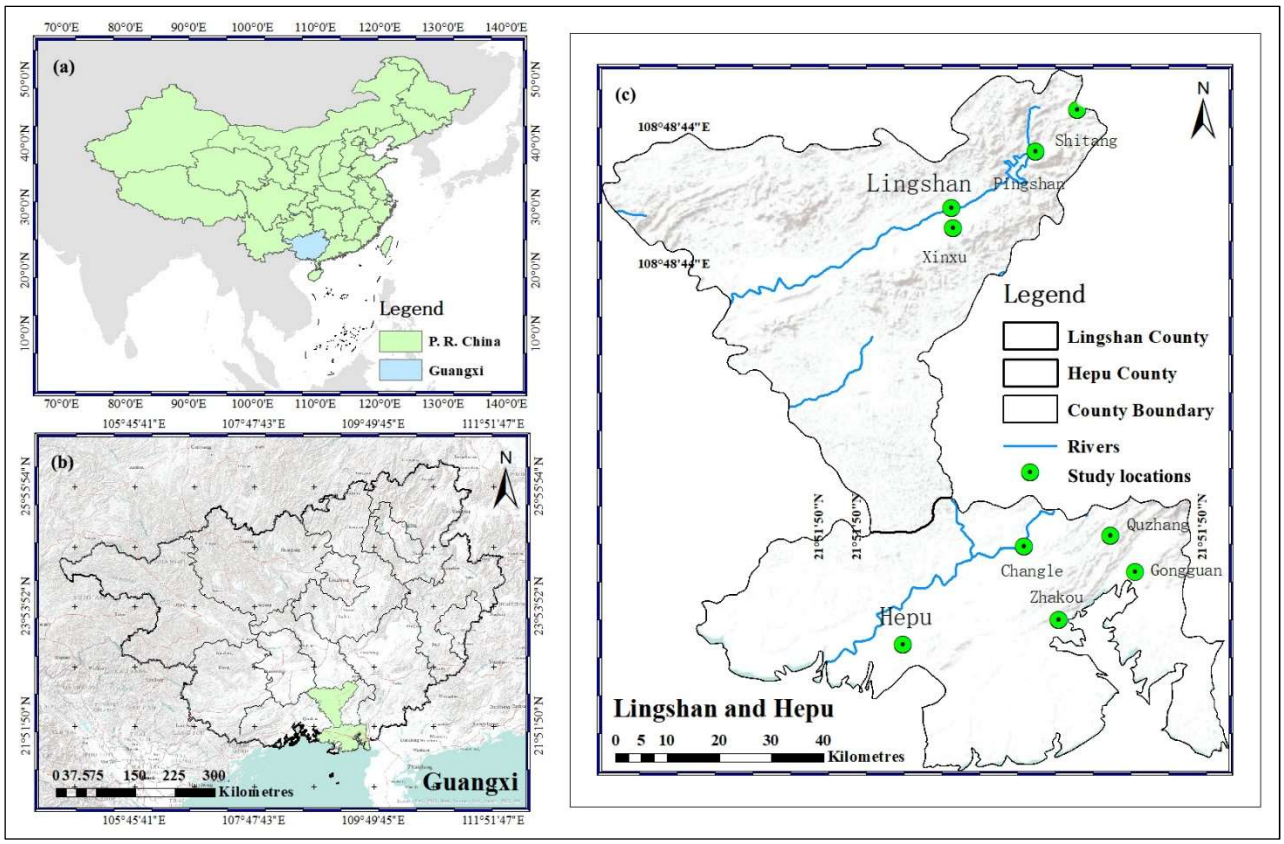

Figure 4-5 Maps of study locations

In turn, the selection of townships was based on the recommendation of the county level officers in the Department of Agriculture, and the village selection was recommended by the township level agricultural extension officers based on criteria shown in Figure 4-4. I also selected several villages that were recommended by farmers, to reach farmers who were not necessarily connected with extension officers but had been using extension services. For each township I selected one to three villages, depending on availability and accessibility, including factors such as the workload of the extension officers and farmers, and if farmers or other people were willing to introduce and take us to the field. Details of the selected townships are shown in Figure 4-5. During the fieldwork in each county I continued to select townships until no new data was emerging, which was taken to mean that the data in that county was sufficient.

Table 4-2 Summary of selections of townships and villages

Study locations	Lingshan county	Hepu county
Townships selected	3	4
Villages selected	3	7

As shown in Table 4-2, in Lingshan county I have selected 3 townships and 3 villages, and in Hepu county, I have selected 4 townships and 7 villages. At least one village was selected in each township, which was sufficient for the township. But in several townships, I selected more than one village, based on the recommendations from farmers. Details on townships and villages are shown in Table 4-4.

4.3.2. In-depth Interviews

The purpose of a qualitative interview is to collect people's voice and their experience; it is flexible and interactive to ensure the validity of the collected data (Rabionet 2011).

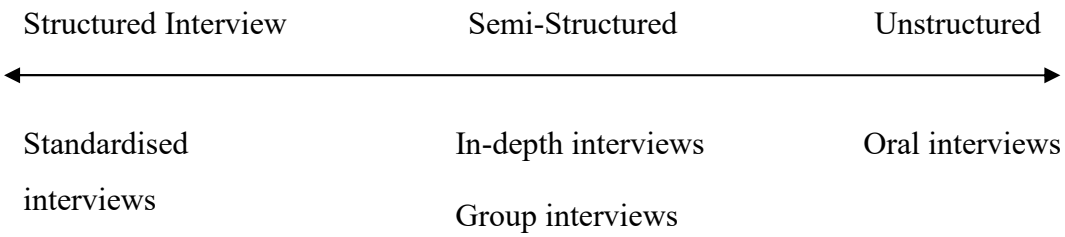

Figure 4-6 The Continuum Model of Interviews

Source: Minichiello et al. (1990)

As shown in Figure 4-6 from Minichiello et al. (1990), at the left of the spectrum interviews are designed and implemented in strictly structured and standardised ways. In this format, interview questions are planned. To the right-hand side, interviews are unstructured and open-ended. Only some simple and broad questions are prepared in advance; in some extreme forms of unstructured interview it is not even necessary to plan questions.

As a data collection method, the semi-structured interview suits a variety of research situations. This method sits in between structured and unstructured interviews and is suited to individual and group interviews. An in-depth interview, whether using a semi-structured or unstructured questioning approach, is suitable for collecting reliable and in-depth qualitative data as it is more flexible, interactive and open-ended (Punch 2013). A semi-structured in-depth interview allows the interviewer and interviewee to diverge from the main line of questioning to pursue an idea or response in more detail (Gill et al. 2008). In practice, the interviewer should consider the interview process a spoken interaction instead of being a simple two-way question-answer process, which may potentially make the interviewee feel uncomfortable and participants may even wonder if they are answering the questions correctly and hence the information collected could lose its reliability (Irvine et al. 2012).

This study employed the semi-structured in-depth interview technique for data collection with researchers at the university, officers in the agricultural departments of provincial, county and township levels and other extension services providers including leaders of farmers' cooperatives and owners of agricultural input stores. Each interview followed a question guideline prepared beforehand, but the interview process was not bounded by the set questions and the interviewer was prepared to seek more details for unexpected and surprising answers. Each interview was conducted for between 30 to 60 minutes, depending on the time availability of the interviewee. All interviewees granted written or verbal consent. Most of the interviews were voice recorded with the consent of the interviewees. The interviewer made written notes for the few interviews where participants did not grant consent to audio recording. All recorded interviews were transcribed verbatim for further analysis.

(1) In-depth interviews with researchers

The purpose of these interviews was to gain an overall understanding of rice farming in the province, how the agricultural extension system was situated in the province, and the role of the university in supporting agricultural development and smallholder farming. This allowed collection of basic information regarding agriculture and extension in the province before approaching officers in the agricultural departments. Also, many studies have implied that agricultural universities actively provide supports for farmers, so I also took an interest in whether the university and researchers had been doing this.

Sampling

Criteria for selection of the researchers included: (a) Being employed at the agricultural related institutions or university in the targeted province; (b) Having conducted agricultural projects in the targeted province; (c) Being familiar with agricultural production and policies in the targeted province; (d) Being familiar with the connection and relations between research and extension in the targeted province.

To find suitable researchers we looked through the website of the School of Agriculture at the Guangxi University, which is the leading institution of agricultural research in the province. Most staff have made their professional profile and contact information public on the website. We sent enquiry emails to several researchers within the school who met the set criteria and received two positive responses. One interviewee is an expert in pest and disease prevention and has conducted projects in rice farming in the province. The other has an agricultural science background and good knowledge of how the school's research connects with government and extension.

Questions

The in-depth interviews with researchers at the university followed topics including: (a) The overall introduction of rice farming in the province; (b) The overall introduction of the agricultural extension system in the province, including advantages, problems and challenges; (c) The current role of the university in agricultural technology extension in the province, including government and smallholder farmers perspectives; (d) Implications for improving agricultural extension services to smallholder farmers from university-oriented perspective. These questions align with the innovation diffusion process and the innovation intermediary section in the conceptual framework.

Procedures

These interviews were conducted face-to-face in the researchers' offices. The process was based on questions in an interview guideline but also some unexpected answers were explored, for example, an interviewee reported the role of farmers' innovations should be considered in both research and extension. The in-depth interviews lasted for around 60 minutes and were recorded under written consent.

(2) In-depth interviews with officers in the agricultural departments

The purpose of these interviews was to explore the agricultural extension system, extension services for smallholder rice farmers and the decision-making process of the extension services. Detail guiding questions were slightly adjusted for different levels of officers.

Sampling

Criteria for interviewee selection were: (a) Being employed in the agricultural department or the extension departments; (b) Being responsible for agricultural extension work; (c) Being familiar with rice farming in the studied locations.

At the provincial level I selected an officer in the rice office, the provincial Agricultural Technology Extension Station affiliated in the provincial Department of Agriculture.

At the county level I selected two counties as mentioned previously in the study location section. In both counties I selected one to two officers of the county level Bureau of Agriculture, who were responsible for agricultural extension work and had good overall knowledge of rice farming in the county.

At the township level, I selected three or four townships in each county. In each selected town I selected one officer in the township level Agricultural Services Centre (township extension station)

who was responsible for rice farming, as the major interviewee to collect information about rice farming and extension services.

Questions

The in-depth interviews with officers at each level of the extension services included questions on: (a) Overall introduction of the rice farming in the province/county/township; (b) Technologies that have been extended to smallholder rice farmers; (c) Expanded information regarding each technology, including the sources, decision-making process, goals, extension approaches and assessments; (d) Overall introduction of the extension system, including the structure, major events and challenges of extension work; (e) Implications to improve extension services for smallholder rice farmers. These questions align with the innovation diffusion process and the innovation intermediary section in the conceptual framework, to identify the characteristics of extension services and the government-sector extension system as innovation intermediary.

Procedures

All interviews were conducted in the officer's office and were recorded, under informed consent, for further analysis. Each interview followed the questions guideline and lasted between 45 to 60 minutes.

(3) In-depth interviews with farmer's cooperative leaders

The selected farmers' cooperatives were at the township level. They emerged in interviews with county level officers. The purpose of these interviews was to obtain data about extension services for smallholder rice farmers from providers other than the public sector.

Sampling

The selection of the farmers' cooperatives was based on the criteria that they were specialised in rice farming and aimed to provide extension services for all rice farmers. During my visit to Lingshan county I was advised by officers that two farmers' cooperatives in Shitang township had been providing extension services to rice farmers. I was taken to the cooperatives for a tour with the officers, and I then conducted interviews with the leaders of those two cooperatives.

Questions

The questions for in-depth interviews with leaders of farmers' cooperatives related to: (a) Brief introduction of the foundation process of the cooperatives; (b) Extension services that provided to rice farmers; (c) Connections with agricultural departments; (d) Challenges on providing extension services to farmers. These questions align with the innovation diffusion process and the innovation

intermediary section in the conceptual framework, to identify the characteristics of extension services and the private-sector extension provider as innovation intermediary.

Procedures

Both interviews were conducted in the office of the cooperative and lasted for around 45 minutes. Both interviewees provided written consent to participate, rejected use of the voice recorder but granted consent for the interviewer to make written notes.

(4) In-depth interviews with agricultural input store owners

The purpose of these interviews was to obtain data about extension services for smallholder rice farmers from providers in the private sector.

Sampling

Agricultural input stores were identified through the recommendations of farmers. All in-depth interviews with the input store owners were conducted after the focus group discussions (FGDs) with farmers (see below). There was a close association with extension services, in that some of the input stores were operated by extension officer's spouses, and the other was operated by former extension officers. I conducted one interview with an input store owner who is the spouse of the extension officer in Pingshan township; farmers advised they chose that store as their main source of agricultural inputs because they trusted it. I also conducted one interview with an input store owner who was the former extension officer in Gongguan township, as farmers in Shayin village advised that this was a critical factor that made them trust this store.

Questions

Questions for in-depth interviews conducted with agricultural input store owners related to: (a) Overview introduction on what agricultural input products and services provided to smallholder farmers; (b) Approaches employed to provide services; (c) Capability and resources of the provided services; (d) Challenges and implications in providing services to farmers. These questions align with the innovation diffusion process and the innovation intermediary section in the conceptual framework, to identify the characteristics of extension services and the private-sector extension provider as innovation intermediary.

Procedures

Each interview lasted for around 45 minutes. Verbal consent was granted by the interviewees.

Table 4-3 Summary of In-depth interviews conducted

In-depth interview	Numbers	
Researchers at Guangxi University	2	
Officer in provincial Department of Agriculture	1	
Total	3	
In-depth interview	Lingshan county #	Hepu county #
Officers in county Department of Agriculture	2	2
Extension officers in township Agricultural Services Centre	3	4
Owners of Agricultural input stores	1	1
Leaders in Farmers' cooperatives	2	0
Total	8	7

As shown in Table 4-3, I have conducted interviews with two agricultural researchers at the College of Agriculture, Guangxi University, who were familiar with rice farming in the province. Then, I have interviewed one officer in the provincial level agricultural department who specialised in rice production. In the county level, 8 interviews were conducted in Lingshan and 7 interviews in Hepu county.

4.3.3. Focus Group Discussion

Focus group discussions (FGD) were decided upon as a suitable method to collect farmers' perceptions. FGD is a qualitative research technique in which a group of people are interviewed in a facilitated semi-structured way through discussing one or more topics. Focus groups differ from other types of group interviews in that the facilitator sets up a conversation between the participants to produce new data, often more than the sum of views of the individuals participating. Focus groups are useful for collecting rich and detailed information on people's opinions on certain topics, especially when all gathered people are allowed to share and compare their perceptions and experiences (Kitzinger 1994; Carey & Asbury 2016; Nyumba et al. 2018). There are certain advantages of using FGD as a data collection method compared with semi-structured individual

interviews, including that an informal context allows people to speak naturally, people tend to feel empowered in a group atmosphere, people query each other and express their opinions to each other and shy people are prompted to share if the group moderator acts properly (Neuman 2006; Parker & Tritter 2006). Suitable topics for FGDs are usually social issues such as people's public attitudes towards a new product or a political candidate, people's personal behaviours and so on, and the information expressed is often more reliable than that gained in an individual interview (Nyumba et al. 2018). In the Chinese context, Chen (2000) found that the FGD approach was ideally suited to explore collective knowledge, and the approach itself could be viewed as a research unit, for example, the interaction and communication among participants. There are, however, limitations when compared with individual interviews, for example, the expression of quiet participants could be quashed by talkative people. The moderator should be in a position to encourage all participants to express their opinions equally. For this study, an FGD approach would be suitable for collecting information to capture farmers' perceptions on farming issues and extension services. It would allow the researcher to observe interactions and communication among farmers and would provide an opportunity for smallholder farmers to bring attention to their views so that their farming problems could be addressed. While taking into consideration the limitations in the method design such as potential fear of speaking, I employed FGD to obtain information about farmers' attitudes towards extension services, and their perceptions on farming problems and experiences. As a researcher, I was able to take the part of moderator and ensure all participants gave their opinions.

Sampling

There are two levels of selection at this stage: villages and then farmers. The village selection was based on the criteria: (a) Villages that have access to both public and private sector extension services; (b) Villages in which rice is the primary grain; (c) The land size of most rice farmers is less than two hectares. The criteria for selecting farmers included: (a) Farmers who have been doing rice farming for at least the past five years; (b) Farmers who cultivate less than two hectares of land; (c) Farmers who grow rice as their main grain. The study locations are not ethnic, thus all FGDs conducted are not ethnic groups.

To check the selection, in the first question of each FGD participants were asked to describe their rice farming enterprise, including land size under cultivation, time spent in farming and if they had farmed in the past five years.

In Lingshan county, suitable participants for all FGDs were recruited by extension officers. In Hepu county, suitable participants for FGDs in Lingjiao village and Xianggu village were recruited by

extension officers. Participants for FGDs in Liannan village, Shayin village, Qumu village and Zaohe village were recruited by local farmers. Participants for FGDs in Zhangjia village were recruited by the women cadre of the village women's representative committee.

Questions

The FGDs covered questions on: (a) An overview of the rice farming enterprise of each farmer; (b) Major farming problems and challenges in recent years in farming, including farmers' perceptions and the way of identification; (c) Solutions to farming problems and challenges; (d) Perceptions towards existing agricultural extension services from the public sector, including technologies introduced and services provided; and perceptions towards private-sector services; (e) What was needed from extension services. These questions align with the smallholder farmers' system section in the conceptual framework, to identify smallholder farmers' extension needs, local knowledge and learnings.

Procedures

During the fieldwork in each county I continued to select townships until the data started to replicate, at which time it was viewed that sufficient data had been drawn from that county. People who helped to recruit farmers also helped with logistics such as preparation of premises. All FGDs were moderated by the researcher apart from one FGD in Zhangjia village where I hired a trained moderator. This was to test the effects between hiring moderator and the researcher being moderator in FGDs. It turned out that the researcher being moderator in FGDs was better, giving the researcher was more familiar with the FGD topics and could ask questions further to valuable answers that given by participants in the FGDs.

All participants to FGDs were contacted by the person who helped with the recruitment, to assure their time availability and willingness before they made their decision to attend. Also, before the FGD started I politely asked the extension officers (if present) not to participate and to leave the premises because their presence may influence the objectivity of farmers' responses. I followed the prepared guideline in each FGD and the approved ethical protocol. All participants were given information sheets to assure they were fully informed, especially the voice record request, and asked to grant written consent before the FGD proceeded.

All FGDs were conducted during August and early September in 2017, as it was the quiet period of field management after land is ploughed and seedlings transplanted (which is normally from late July to early August), so that farmers were most likely to be available to participate in the FGD.

Table 4-4 Summary of conducted focus group discussions

County level	Township level	Village level	FGD #of participants		FGD conducted time
			Male	Female	
Lingshan	Shitang	Longan	5	3	Aug 2017
	Pingshan	Dalupai	6	2	Aug 2017
	Xinxu	Longtang	7	1	Aug 2017
Hepu	Changle	Xianggu	8	2	Aug 2017
		Liannan	4	3	Aug 2017
	Quzhang	Zhangjia 1	4	0	Aug2017
		Zhangjia 2	0	13	Aug2017
		Qumu	9	2	Sep 2017
		Zaohe	7	1	Sep 2017
	Gongguan	Shayin	6	4	Sep 2017
	Zhakou	Lingjiao	4	4	Sep 2017
Total number of participants			60	35	
Total number of FGDs			11		

As shown in Table 4-4, overall, I conducted 11 FGDs with a total of 95 participants. Before all FGDs I confirmed that mixing genders in the same group discussions was culturally appropriate, after being advised by the local people in all villages. Nevertheless, in consideration of possible complications, in the first two villages I used two models of FGD to check if there would be any difference in the level of participation: in Zhangjia village I conducted two FGDs for each gender, and in Liannan village I mixed genders in one FGD. Both models were sufficient to reflect the whole situation of their village as both genders were involved. However, the model of mixed genders could provide more insights, for example, different genders may have different roles in farming in some households, given it was confirmed culturally appropriate and both genders could talk freely in the group. Thus, the other FGDs were all mixed genders. In all, 63% of participants were male, and 37% female. One FGD in Liannan village had seven participants; the male-only FGD in Zhangjia village had four participants; and each of the other FGDs had more than eight participants. All FGDs lasted for 60 to 90 minutes and were voice recorded based on all participants having been fully informed and having granted written consent.

4.4 Data analysis

Two professional transcription companies, located in the province studied, were hired to do the voice transcription of the recorded interviews and group discussion. These two companies were asked to make sure their staff were familiar with Mandarin and the local dialect and to transcribe the recordings verbatim. Transcription samples were checked to identify the quality of the service prior to hiring the companies. After the companies finished all transcriptions, the researcher, who is a native speaker of Mandarin and the local dialect, checked all transcriptions to make sure the transcriptions were correct and complete. After all voice recorded interviews and group discussions were transcribed verbatim, I employed a thematic analysis approach to analyse the data. There have been some arguments on choice between content analysis and thematic analysis regarding qualitative data analysis, as the content analysis approach tends to embrace the meaning of the qualitative data as well as validating the analysis and reliability through quantitatively counting the numbers of the content categories, while thematic analysis, although sharing many principles and procedures of content analysis, focuses on the themes drawn from theories or the empirical evidence and permits the researchers to analyse the meaning of the themes, without quantification. This keeps the focus on the themes in their contexts and may emphasise their complexity (Marks & Yardley 2004; Braun et al. 2018).

The data analysis process was conducted on the Chinese-language transcriptions and the researcher has translated quotations for presentation in the thesis. This study employed two rounds of coding: deductive coding, and inductive coding. In deductive coding, as shown in Table 4-5, themes are pre-drawn from theories and literature reviews, and are used to organise the empirical evidence. The agricultural extension services and agricultural extension system categories align with the innovation diffusion and innovation intermediary sections in the conceptual framework. The smallholder farmers' needs and farmers' meeting their needs categories align with the smallholder farmers' system section in the conceptual framework. In inductive coding, themes are drawn from the empirical evidence, without presumption from theory and literature at that stage. This is consistent with the design in which the researcher was not bounded by the questions prepared and was able to follow up unexpected answers.

Table 4-5 Deductive coding guideline

Category	Definition	Example	Coding rules
Agricultural extension services	Agricultural extension service refers to support, information and advice provided by extension agents to farmers to improve their production. In the Chinese context, agricultural extension service for rice farming refers to provision of technologies, information, infrastructure and processing (Kong 2009). Problem-solving is also viewed as a type of extension service. Characteristics of innovation diffusion include compatibility, relative advantage, trialability, observability and complexity. Provider of extension service includes government-sector and private sector. The purpose of each type of service, e.g. what are they trying to achieve?	The soil-test service provided by the agricultural department to farmers who have been farming in severely salinised field (Zhang et al. 2013).	Explicit services reported in interviews by officers in government-sector and private-sector.
Agricultural extension system	Extension system covering different administrative levels. The extension processes, e.g. decision-making, policy-implementation, service delivery. Approaches employed to identify smallholder farmers' needs and deliver extension services. Extension providers' perception of issues in extension system in terms of meeting smallholder farmers' needs. Intermediary functions including: Provide technical extension services; Articulating and voicing demand of users; Supplying information for problem solving and responding to user's needs; Engaging and supporting actors generating knowledge.	Extension system in China cannot provide satisfactory services for farmers because the top-down mechanism does not determine farmers' needs (Hu et al. 2012a).	Extension providers' perception of extension system.
Smallholder farmers' extension needs	According to Kong (2009), farmers' needs include improved seed and varieties, fertiliser, use of machinery, pesticides, seedlings, infrastructure, irrigation, and processing.	An improved kiwi fruit variety was extended to farmers by extension agents in Shaanxi province;	Farmers' perception of extension needs and how existing

Category	Definition	Example	Coding rules
	Farmers' perceptions of extension services.	however, it failed because it was not compatible with local soil conditions (Li et al. 2016b).	extension services meet their needs.
Farmers' meeting their needs	Local knowledge used in terms of farmers' needs. Farmers' experience and what they learn from those experiences, e.g. contemporary knowledge, new information, observation and reflection, change of behaviour. Farmers' source of information. Does social learning occur? Do farmers conduct small experimentation?	Farmers learned from a large amount of different and conflicting information to find the most relevant solution to their situation (Lankester 2013).	Farmers' use of local knowledge, experience and source of information.

Qualitative coding can be done manually or by employing computer software. The selection of coding approach depends on the quantity of data, time availability and personal preference of the researchers (Auerbach & Silverstein 2003; Basit 2003), although Mauthner and Doucet (2003) argued that the use of computer software in qualitative data analysis reinforced the neutrality of the researcher and the analysis process. Either way, the researcher has to undertake analytical thinking and procedures. Given that the use of software assists the efficient organisation of data, particularly when the size of the qualitative data is large (John & Johnson 2000; Lee & Esterhuizen 2000). I chose to use software to conduct the thematic analysis.

This study used QSR Nvivo 12 Plus software as the software tool for the qualitative coding of the data. The data analysis has gone through three main stages including the open-coding process to generate main themes from the interview and group discussion transcripts, the grouping process that categorises generated themes into different groups, and the synthesis of the generated themes and categorised groups for seeking linkages between each other and to the research questions.

Studies have pointed out that the role of the researchers in the qualitative data collection and the analysis process may be questioned due to their substantial participation throughout the research process (Fink 2000), the researcher's bias from culture or the use of language (Hatch 1996) and the emotional sentiments of the researcher or the interviewees regarding the study topics (Rowling 1999). As being both the major participant of the data collection process and analyst of the data analysis process, I was well aware of the potential bias from my personal subjectivity and have tried to be fully guided by the deductive coding guideline that was prepared beforehand, and the data.

Generation of themes

At this stage I employed open-coding to review and code all the interview and focus group discussion transcripts. I summarised the themes by each set of interviewees including the agricultural researchers at the university, officers in the agricultural and extension departments and farmers. Details of the codes from open-coding are shown in Table 4-6.

Table 4-6 Summary of themes from open-coding

Participants	Codes from open-coding
Agricultural researchers at Guangxi University	Deductive 1. Extension system is government-led; 2. Functions extension station regarding pest disease management; 3. University's role in extension; 4. Local level extension system has broken; 5. Issues about extension officer being involved in input business; 6. Government does not know what researches universities are doing. 7. Universities are not participating in extension directly; 8. Universities do trainings for extension officers; 9. Many researchers do not know what farmers' needs; 10. Government is promoting large farms; 11. Top-down approach in extension system; 12. Farmers' innovation is overlooked by researchers and extension; 13. Issues with farmers' cooperatives; 14. Short of funding for local extension system;
	Inductive 1. Academic assessment system at universities; 2. University graduates tend to find job at cities, not rural areas.
Officers in agricultural and extension departments	Deductive <u>Extension services for smallholder rice farmers</u> 1. Non-tillage method; 2. Pest and disease management; 3. Soil test and fertiliser formulation; 4. New varieties; 5. Direct seeding method; 6. Weather forecasting for farmers; 7. Seedling broadcasting; 8. Seedling nursery and industrialised transplanting; 9. Rice drying through farmers' cooperatives; 10. Farmer's extension trainings; 11. Technology demonstrations; 12. On-site extension and problem-solving advice for farmers; <u>Extension system</u> 1. Demographic situations; 2. Short of fund for local extension officers; 3. Institutional merge in the township extension stations;

Participants	Codes from open-coding
	4. The "three-right" reform; 5. Relationship with county level agricultural departments; 6. Short of staff; 7. Additional duties from the township government; 8. Additional duties: Food safety and input market monitoring; 9. Opportunities to attend trainings are not enough; 10. No incentive to do extension work: no performance assessment; promotion and salary; 11. Transportation issues – officers use their own motorcycles;
	Inductive: 1. Extension special vehicle granted from upper levels; 2. No fund for petrol and vehicle maintenance; 3. Many input stores are not qualified: fake inputs and lack of knowledge; 4. Extension stations are discriminated in the government system; 5. Officers in the government have privilege and are prioritized regarding promotion and salary; 6. Unreasonable incentives for farmers to attend trainings;
Leaders of farmers' cooperatives	Deductive 1. Provide field management, irrigation; fertiliser, pesticides and machines services for farmers; 2. They mainly provide services for their members; 3. Rice farming was not profitable for smallholder farmers; 4. Agricultural department has provided trainings and subsidies for their establishment; 5. Have obtained governmental subsidies in machine purchases; 6. Rice drying service only aims at large scale farming.
	Inductive 1. Many farmers quit doing farming; 2. Planning to do high value crops and production.
Owners of agricultural input stores	Deductive 1. Dwarf disease outbreak in rice farming; 2. Farm visit to provide advice; 3. Pest and disease information update for farmers; 4. Farmers bring crop samples to identify problems; 5. Use photographic books to help farmers identify crop disease; 6. Displayed infected crop in stores to help farmers identify crop disease; 7. Clearly mark instructions in the pesticide bottle;
	Inductive 1. Do not sell pesticide to farmers when approaching harvest time for food safety; 2. Most farmers do not understand how to correctly use fertiliser and pesticides; 3. Some extension officers are not competent;

Participants	Codes from open-coding
	4. Many input stores sell illegal high-toxic pesticides; 5. Input sellers communicate to update pest and disease information;
Smallholder rice farmers – farmers' needs and perceptions on extension services	Deductive 1. Improved cultivation technologies: reduce labour and time; 2. Farming problem solving advices: identification and solutions; 3. Improved rice varieties: high yield, good pest and disease resistance and suitable taste; 4. Soil information: soil condition and fertiliser advice; 5. Low toxic pesticides and weedicides; 6. Drying rice is difficult; 7. The Boyou hybrid variety has poor pest and disease resistance; 8. Suitable varieties for accommodating cropping rotation pattern; 9. Non-tillage seedling method: high risk, high cost and difficult to perform; 10. Seedling broadcasting method: effectively reduce labour and time; 11. Direct seeding method: weed problem; 12. Pest and disease prevention services: not timely, no on-site information; 13. Soil test and fertiliser formation technology: farmers need it, but its provision did not continue and only focus on a small scale of land; 14. Transportation is difficult to visit the extension station; 15. No support from extension officer when attempting to do other varieties; 16. Extension trainings are uniform, not specific to their village;
	Inductive 1. Agricultural input stores run by former extension officers are preferred; 2. Collective actions amongst all farmers: pesticide and fertiliser application; 3. Attempt to engage in production of high value crop and value chain; 4. Experiences with fake seeds and fertilisers; 5. Soil fertility concern for future farming;
Smallholder rice farmers – farmers' knowledge and learning	Deductive 1. Improved land ploughing using leveler; 2. Rice-leaffolder management: identification and solutions; 3. Apple snail management: identification and solutions; 4. Rice dwarf disease management: identification and solutions; 5. Small farm trials on new varieties before scaling up to the whole crop; 6. Attempt to high-value crops and value chain; 7. Identification of input stores and sources of inputs; 8. Fertiliser distinguish; 9. Soil neutralisation: identification and limestone solution; 10. Soil classification: identification and solutions; 11. Soil fertility management: cropping rotation pattern, diverse usage of fertiliser; 12. Learning from books and materials;

Participants	Codes from open-coding
	13. Learning from other farmers: social learning; use of pesticides; pest and disease identification; soil management; 14. Learning from extension services: soil management; usage of fertiliser; 15. Learning from farmer's own experiences: experiential learning; use of pesticides; pest and disease identification; soil management;
	Inductive 1. Non-chemical solution for apple snail management: use of tea seed cake; 2. Sometimes help neighbors to monitor pest and disease;

Themes generated from open-coding were furtherly categorised to seek their relationships in the next step.

Categorisation of themes

Theme categorisation in qualitative analysis is the process of sorting a collection of similar themes into the same place (Morse 2008). Researchers need to define codes that share common characteristics and group them to categories. They also need to decide whether to divide categories into sub-categories or to pool them into broader categories, based on the comparison and contrast amongst those categories (Silverman 2015; Graneheim et al. 2017). The major challenge in theme categorisation is to maintain all categories in the same logical level of abstraction and interpretation, and it is not always required in the qualitative coding if the codes are rich and themes are expressive (Graneheim et al. 2017). This study conducted the theme categorisation based on the categories defined in the deductive coding guideline. Details of the process of theme categorisation are provided in Table 4-7 and the Nvivo code book in Appendix 3.

Table 4-7 Summary of themes categorisation

Participants	Themes categorisation
Agricultural researchers at the Guangxi University	1. Challenges for agricultural extension system; 2. Problems for township level extension officers; 3. Lack of collaboration among university, government and farmers; 4. Challenges for smallholder farming; 5. Importance of farmers' innovations and local knowledge; 6. Challenges for farmers' cooperatives.
Officers in the agricultural and extension departments	1. Technologies that extended to rice farmers; 2. The extension decision-making; 3. The approaches of extension; 4. Challenges in township level extension officers.

Leaders of farmers' cooperatives	1. The foundation of the cooperatives; 2. Services that provided for rice farmers; 3. Challenges in providing services for rice farmers.
Owners of agricultural input stores	1. Perceptions of problems in rice farming; 2. Services that provided for farmers; 3. Approaches that employed in providing services; 4. Challenges of providing services for farmers.
Smallholder rice farmers	1. Farming problems and their perceptions, identification and solutions; 2. Perceptions towards the agricultural extension services; 3. Local farming knowledge; 4. Challenges in farming.

Synthesis of themes

In qualitative research, theme synthesis is the process whereby themes are systematically combined to create a more complete picture of findings (Thomas & Harden 2008; Major & Savin-Baden 2010). There are many approaches to achieve theme synthesis, for example, Thomas and Harden (2008) used thematic synthesis to understand children's views on fruits and vegetables and their implications to intervention; Edmonds and Kennedy (2016) used theme synthesis to construct composite and structural description of experiences of the individuals. This study use theme synthesis to combine the generated and categorised themes to answer the research questions because the answer to each research question required synthesis of themes from different categories. For research question one, which is *How well do the extension services provisions align with smallholder rice farmers' extension needs*, I combined all themes generated from extension service providers and smallholder rice farmers. And for research question two, which is *How do smallholder farmers meet their farming needs, and how do they regard extension services*, I combine themes from smallholder rice farmers. And answers for research question three, which is *What are the implications to improve extension services provisions to smallholder farmers*, were generated from linkages among the themes.

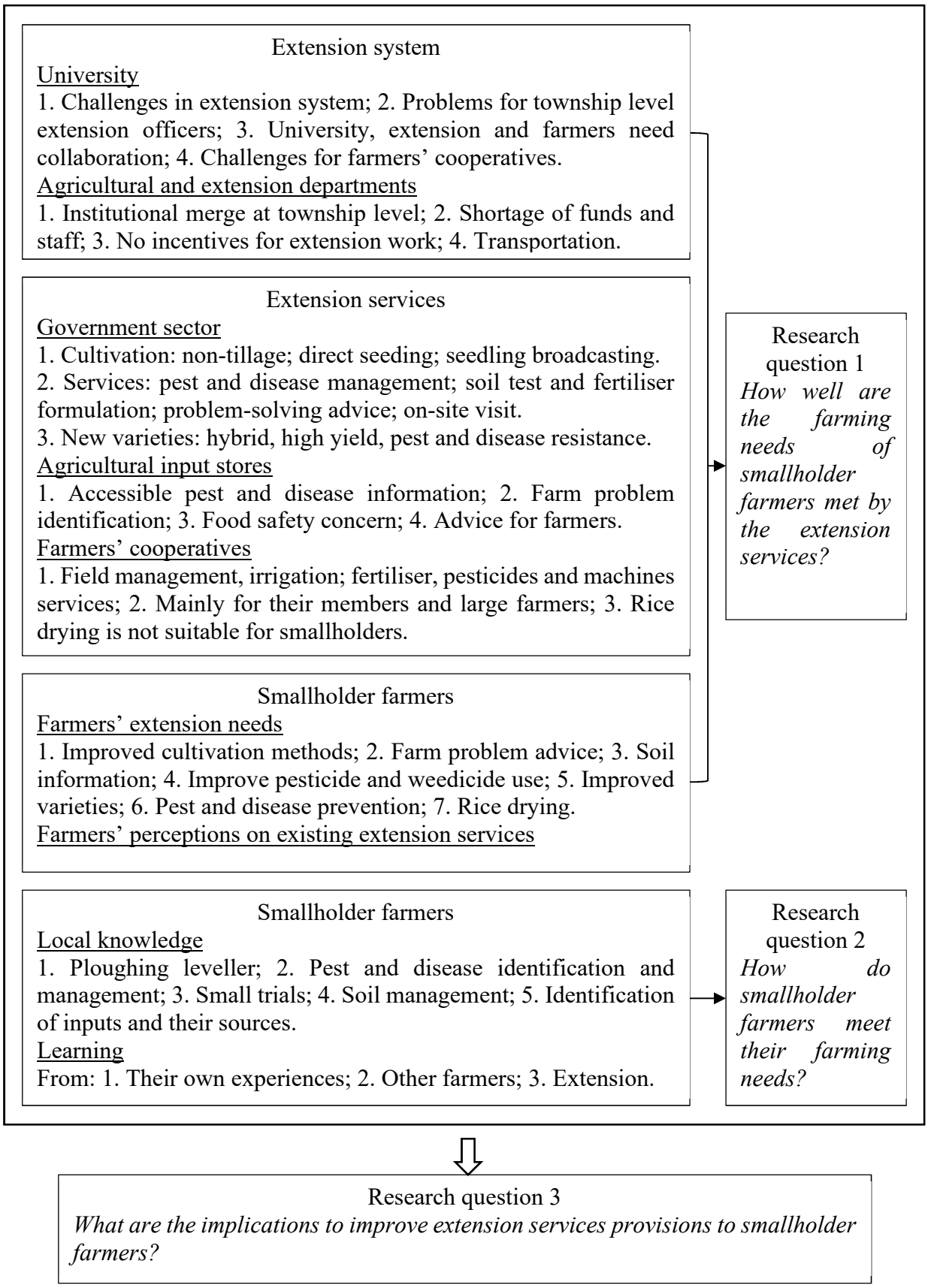

Figure 4-7 Themes synthesis with research questions

As shown in Figure 4-7, all themes generated from interviews of extension providers and partial themes from FGDs on farmers' perceptions of extension needs and extension services, were considered together to answer research question one. Themes generated from FGDs on farmers' farming experience, local knowledge and learning processes were combined to answer research question two. The combination of the two main research questions was used to answer research question three. I compared and contrasted themes between different categories. I amended and pooled a few themes based on their fit in relation to the conceptual framework and research questions. For example, the themes "Improved rice varieties – good pest and disease resistance" and "The Boyou variety has poor pest and disease resistance" share the same meaning and were combined to answer research question one (how well are farmers' needs met?); the theme "planning to do high value crops" from leaders of farmers' cooperatives was rejected because it is not relevant to smallholder farmers outside their cooperatives. An example of theme synthesis is provided in Appendix 4.

4.5 Data validity and reliability

Validity encompasses the truthfulness of the findings. There are many arguments relating to measurement of validity in qualitative inquiry, compared to quantitative studies where validity is necessary and commonly tested. Whittemore et al. (2001) pointed out that the qualitative validity debate stems from completely different ontological and epistemological assumptions to quantitative research. Quantitative studies commonly employ the positivism paradigm, which considers the world can be observed objectively. Furthermore, generalisability to populations is a significant goal in quantitative research, which implies the standards for its validity are objectively measurable. Opinions on qualitative validity vary depending on research paradigms. Many constructivism researchers believe the concept of "validity" does not fit qualitative studies; instead, they encourage using credibility or truthfulness (Hammersley 1992). They insist that the reality and nature of truth are variant and contextual in constructivism, which is ontologically and epistemologically different to positivism (Feldman 2007; Lincoln & Guba 2013). Nevertheless, post-positivism researchers hold that qualitative research should recognise and support validity. They insist that qualitative validity needs to find quantitative equivalence but use different protocols (Creswell & Miller 2000; Maxwell 2012). Maxwell (1996) argued that there were three validity threats in qualitative research: 1. Description. The threat is the inaccuracy or incompleteness of the data. Audio or video recording can significantly solve this problem. 2. Interpretation. The threat is imposition of one's own meaning rather than understanding the perspectives of the participants. 3. Theory. The threat is not paying attention to discrepant data or not considering alternative explanations. Collecting rich data is one

solution to ensuring qualitative validity. The data collected should be complete, detailed and sufficient to provide a full picture of the topic. In this study, all FGDs and most individual interviews were voice recorded and transcribed verbatim. To assure the objectivity of analysis, members of the advisory team performed multiple coding on FGD transcript to compare and contrast codes. The researcher has also identified the convergence of data from different participants, for example, extension services that were reported by extension officers were confirmed by farmers.

Regarding the potential for bias in responses from participants, knowing their information and responses would be kept anonymous encouraged respondents to express their true attitudes freely in the interviews and group discussions. In the group discussions, the informal atmosphere of the group setting may also have reinforced the information validity from farmers.

Ensuring the rigor of qualitative data can be done by both the researcher, including the investigator and the analyst, and the reader (Morse et al. 2002). From the researcher side, it is my responsibility to ensure the reliability of the data. Furthermore, I have most interviews and all group discussions voice recorded and transcribed verbatim, ensuring reliability in recording what participants said. Regarding the reliability of the data analysis process, I have had the data analysis process, including the thematic analysis framework and code books, stored in the projects of the QSR Nvivo 12 Plus software. Also, I have had transcripts from one individual interview and one focus group discussion translated into English and verified by the supervisors of this study.

4.6 Ethical clearance

In the fieldwork preparation stage this study and the affiliated materials, including the information sheet, the consent form and the guidelines of the interviews and group discussions, were granted ethical clearance approval by the Ethics Committee, School of Agriculture and Food Sciences, The University of Queensland (Approval ID: SAFS/H17/03). Before going to the field trip, I had all fieldwork materials translated verbatim into simplified Chinese for use in the Chinese context; those materials included the information sheets, consent form, guidelines of the in-depth interview and guidelines of the focus group discussion. In the information sheets and consent form, considering the major responsible person's contact information are all Australian, I also provided a Chinese contact number, which is owned by the researcher and kept activated, in case any participant wished to enquire anything after the interviews or group discussions.

In the fieldwork stage, I made sure that all interviewees and farmers were approached ethically. In the individual interview and group discussion process, I gave interviewees and farmers information

sheets and explained the goal of the study, making sure they were well informed that participation was voluntary, they could withdraw without disadvantage at any stage, their personal information including full name and contact would be kept anonymous and the information they provided would only be used for study purposes in this specified study and stored in a secure place only accessible by the researcher. I also sought their approval for the use of the voice recorder during the interview. For individual interviews, most participants granted consent to using the voice recorder; for the few participants that did not, I made written notes of the interviews for data analysis purposes.

For the focus group discussions, I made sure all participants were well informed that if they were not willing to be recorded, they had the absolute right to leave the event premises without any consequences. Furthermore, for each focus group discussion organised by an extension officer, I politely asked the officers to leave the premises in order to allow farmers to talk comfortably. I was extremely careful to avoid constraining factors that would limit the contribution of participants. Farmers were found very happy to be part of the discussion because they saw this as an opportunity to express their views. I took some photographs of the focus group discussions with the verbal consent of all farmers in each group discussion. For individual interviews I gave an appropriate gift to all interviewees, and for focus group discussions I gave a proper gift or reasonable cash stipend to all farmers in each group discussion, depending on the suggestions of the extension officers. No breaches of the code of ethics occurred.

4.7 Limitations of the methodology

Firstly, this study only looked at one region of China, and was confined to rice farming. While the data collection was thorough, data from other regions or about extension services oriented to other food products could differ.

Secondly, the processes of farming and farmers' using extension services are relatively long-term and longitudinal; they can change over time. While this study was only conducted at one point in time, it is also important to obtain farmers' perceptions over a period of time, given the researchers have sufficient time and supports.

Thirdly, focus group discussions conducted in Longtang village and Zaohe village had only one female participant each, results from these two villages may mainly reflect the opinion of male.

Fourthly, some FGDs contained dominant talkers, and a few participants manifested a fear of speaking, but the moderator navigated all FGDs to include opinions from all participants equally.

Chapter 5. How well are farmers' needs met?

This chapter firstly summarises farmers' extension needs, which are improved cultivation technologies, advisory services to farming problems, improved rice varieties and soil information. Secondly, it examines what extension services were provided to smallholder farmers. From the government-sector there were rice cultivation technologies, pest and disease prevention information and the soil testing and fertiliser formulation technology. From the private-sector, the agricultural input stores provided pest and disease prevention and control information, and the farmers' cooperatives provided services including rice drying, seedling nursery and seedling transplanting. Then this chapter summarised how farmers perceived those services. Thirdly, it examines the challenges in the extension system, which are non-extension works had been added to local extension officers' workload due to the institutional reform, insufficient fund for extension services and unreasonable arrangement of technology trainings.

5.1 Farmers' extension needs

Farmers discussed the topic "what is needed to improve farming" during the focus group discussions (FGDs). Their responses were summarised as: improved rice varieties that provide a high yield; cultivation technologies that can save labour and time; and farming advisory services for pest and disease prevention.

5.1.1. Improved cultivation technologies

Farmers in both counties reported the need for improved, modern cultivation technologies to reduce labour and time in farming. They discussed modern seedling broadcast methods that took half the time of the methods still used by many farmers. The shorter timeframe had a flow-through effect in reducing problems with pests and diseases, freeing up farmers' time for other jobs, and providing a quicker turnaround time to grow seedlings. Also, farmers spent less time in the field, and hence avoided the danger of long-term sun damage to their skin. Similar views were expressed towards the use of the plough and the harvest machines.

Regarding the direct seeding method, farmers in Xianggu township reported that it was more efficient than conventional transplanting; however, it required more labour and time to manage weeds as the fields should be kept dry the whole time, and more money was spent on weedicide. Farmers in Liannan village had similar views on the direct seeding method, saying the method was also unsuitable for their low geographic location, as rain would wash the seeds away.

Farmers also reported the need to improve their method of drying rice after harvest. The process currently relies mainly on sun drying, which means a lot of time is spent monitoring the weather, and then if it rains a lot of labour is required to collect and protect the grain from moisture. Farmers in Shitang township reported some agricultural machine cooperatives owned rice drying devices; however, they only served large-scale farms, as the machines processed tonnes of rice in one operation and hence did not accept small amounts of rice.

Farmers in Liannan village reported that the harvest machine could cause a certain amount of yield loss, and although it saved labour to harvest, it was not as efficient as they expected. Also, regarding the non-tillage methods introduced by the extension system, which were designed to replace the ploughing process and improve yields, save time and physical exertion, the farmers commonly reported that these methods were not suitable for their circumstances, thus brought them risks.

5.1.2. Advisory services to farming problems

Farmers commonly reported the importance of farming advisory from extension officers. The majority of the farmers mentioned that they required information and alerts on pest and disease prevention and management advice. Farmers commonly reported the need for precise and timely information and alerts towards the pest and disease, explaining the importance of taking actions before the pest and disease developed and spread. Regarding the communication methods, farmers commonly reported that extension officers do not provide on-site services in recent years, however, the information is still available by visiting the township agricultural services centre. Villages located further to the townships reported inconvenience in getting the information, not timely information and hence advisory. Farmers also reported the need for on-site services as officers had done in the past. Of those villages located close to the township, farmers commonly reported their willingness of visiting the services centre to obtain information and obtain advice directly from officers if needed.

5.1.3. Improved rice varieties

The need for better or more appropriate rice seed was reported by farmers in most FGDs, particularly in relation to the desire for higher yield and suitability to the taste of local people. Farmers in Qumu village said a higher rice yield was desirable because the high cost of hiring machines and labour and the increasing price of agricultural inputs had made rice farming less profitable. They reported that 500 half-kilogram yield per mu was the minimum cost of rice farming in the autumn season; thus, a higher yield than this meant a net profit for the season.

> *... any yield that is less than 500 half-kilogram per mu would not obtain any profit, let me count, say choosing the Boyou hybrid seed I can obtain 800 half-kilogram yield per mu, the vendor pays 1.5 yuan per half-kilogram, thus I can obtain 1,200 yuan per mu. The ploughing machine costs 140 yuan per mu, harvest machine costs 120 yuan per mu, two labours for transplant seedlings, which is 260 yuan per mu, one labour for sun drying rice, which is 130 yuan per mu, and fertiliser and pesticide cost 130 per mu, the total basic cost is 780 yuan per mu.; if the seed obtains less than 500 half-kilogram per mu we would not choose, it does not even meet the cost* (FGD with farmers in Qumu village)

Farmers in Dalupai and Longan village wished they could obtain rice seed that both produced a high yield and had a suitable taste. Specifically, farmers in Shitang reported that the hybrid rice seed yield was high due to its larger size, but it did not suit the taste of local people. The conventional rice seed is smaller and has a lower yield than the hybrid one, but its taste is suitable for the local people. To accommodate those two types of rice seeds in the annual two seasons of rice farming, farmers grow the hybrid seed in the spring season for selling, then the conventional rice seed in the autumn season for their own consumption, with any surplus sold.

> *... we wish the rice seed can be both high yield and suitable for our taste.* (FGD with farmers in Dalupai village)

> *We usually select the conventional seed, it is smaller and lower yield, the difference can be hundreds of half-kilograms compared to hybrid seed, but its taste is suitable, the hybrid seed is bigger in size and higher yield, but not good taste ... we do hybrid seed for spring season for selling, because of its high yield, and the conventional seed for autumn season, for our own eating.* (FGD with farmers in Longan village)

Farmers in Zaohe village reported that they selected a rice seed named Jingui, which was suitable for making rice cakes and rice noodles. Although the yield of Jingui is very low, it sells for a good price in the market because of the demand for making rice cakes and noodles.

> *We also do some Jingui because it has good sale in the market, although its yield is very low, 600 half-kilogram per mu, but it is suitable for making rice cake and rice noodle.* (FGD with farmers in Zaohe village)

In summary, farmers' needs for improved rice varieties were related to perspectives including high-yield, suitable tastes for themselves and the consumers and suitable for making local rice related foods.

5.1.4. Soil information

Farmers' needs for soil information were mainly regarded to soil health and its importance in improving yield. There were two main soil issues in the study locations. The first issue was the soil acidification issue. Most farmers reported their soil was acidified, some farmers reported the soil acidification was worsening, and it significantly decreased yield.

The second issue was the lack of nutrients in the soil. Farmers reported different crops consume different kinds of nutrients in each farming season, and they did not know what fertilisers should be used to balance the soil nutrients. Farmers in Shayin village gave an analogy that it was similar to human who lack calcium and requires supplements, thus, fertilisers should be based on what the soil lacks. Farmers in Zaohe also reported some farmers over used urea fertiliser causing a significant decline in yield.

5.2 What the extension services provided?

Two sectors were providing extension services for smallholder farmers, the government-sector and the private-sector. Services provided by the government-sector included, firstly rice cultivation technologies, which were the rice seedling broadcasting technology, non-tillage technology and direct seeding technology; secondly pest and disease prevention information, which were weather, pest and disease monitoring, routine prophylactic pesticide schedule and on-site services; thirdly the soil testing and fertiliser formulation technology. Regarding private-sector there were two main bodies, the agricultural input stores and farmers' cooperatives. Services provided by agricultural input stores were mainly pest and disease prevention and control. Services provided by farmers' cooperatives were rice drying service, seedling nursery and seedling transplanting services.

5.2.1. Government sector

The government sector extension provider refers to the agricultural extension system from provincial agricultural department, county level agricultural department and the township level extension station. Officers in the system reported three main services that they provided to smallholder farmers, which were improved cultivation technologies, pest and disease prevention information and soil testing and fertiliser formulation technology.

5.2.1.1. Rice cultivation technologies

Seedling broadcasting technology (Paoyang Jishu)

Seedling broadcasting technology was a transplanting technique introduced in paddy rice farming in south Asia. Compared with conventional seedling transplanting, whereby farmers prepare seedlings in the nursery bed then transplant seedlings to the paddy field with a thin layer of water and plant them into the field, the seedling broadcasting technology requires seedlings to be prepared in a bubble-shaped nursery tray that has a little hole on the bottom for the root of the young seedlings covered by mud ball. Then, in the transplanting stage farmers broadcast those prepared young seedlings from the tray to the paddy field with a thin layer of water, which does not require as much labour and time as the conventional transplanting. Existing studies also refer to it as seedling throwing technology (Peng et al. 2009; Huang et al. 2011). The mud ball in the root of the young seedlings is key to the success of the broadcasted seedlings, particularly for the successful 'stand establishment' of those horizontally lying plants. Ploughing land before broadcasting seedlings is required to remove the old shoots and weeds.

According to the officer in the provincial agricultural department, the department focused on technologies that could save labour and time for farmers. The seedling broadcasting technology was one of the targeted technologies to achieve this goal. At the county level, officers in both counties reported that most farmers in the paddy field areas had adopted this technology. Officer in Lingshan county reported that this technology had taken several years to be adopted by farmers in the 1990s. Farmers in Dalupai village confirmed that most of them rejected the technology in the beginning, but after several farmers trialled it and confirmed that the yield was comparable with conventional transplanting, most of them adopted it.

> *··· the seedling broadcasting technology was introduced decades ago. The extension officer at that time gave us the nursery bed, which has a hole in it; he taught us how to fill mud and seeds in it and prepare seedlings … most of us did not believe it, people said it is lazy person's work (laughed), particularly farmers walked past the field when the broadcasting was just finished and seedlings were all lying horizontally, but days later the seedlings started to grow, and the yield turned out no difference relatively..* (FGD with farmers in Dalupai village)

Officer and farmers in Hepu county reported similar circumstances in the extension and adoption of the seedling broadcasting technology. Farmers in Qumu village reported this technology effectively reduced fatigue and sun exposure for farmers as it required less time. Also, using the conventional seedling transplanting technology requires farmers to bend over in the field for a long time, whereas by using the seedling broadcasting technology farmers could stand in the field. Farmers in Lingjiao

village reported that the reduced time spent transplanting seedlings allowed for other farming activities to be more consistent among all farmers in the area, for example, spraying pesticides was more likely to be in the same period when farmers spent less time on their own and other farmers' seedling processes.

> *… long time ago when transplanting seedlings, it was very fatigue for bowing in the field for a long time, even face got swollen (laughed), being bitten by insects, now the broadcasting technology is faster.* (FGD with farmers in Qumu village)

Officers at the provincial level reported that from 2006 they decided to extend the non-tillage technology to rice farmers to reduce labour and time for the ploughing of land. In the study locations, the non-tillage technology was designed to be integrated with the seedling broadcasting technology. The non-tillage technology is the technique of growing crops from season to season without disturbing the soil through tillage. Technically, it requires water retention on the field from last season harvest to have the field fully soaked, and the old rice shoots and weeds fully withered by using weedicides, to replace the land tillage process using buffalos or plough tractors. Thus, it reduces time and cost for farmers in the tillage process. County level officer in both counties reported that the technology was extended and adopted by most farmers.

However, the perceptions of officers in the township and farmers in villages on non-tillage technology were different. Officers in Zhakou township reported that the non-tillage technology was extended for two years and was rejected by most farmers, because it required a long period of stable water supply, which most of the villages did not have. Furthermore, this technology did not bring advantages compared with the existing practices. An officer reported that the technology did not bring significant yield increase yet raised the total cost of farming because more weedicides were needed relatively, stating that the yield was not much different to that gained from ploughing land. Thus, farmers generally rejected it.

> *The seedling broadcasting method is another one; we tried to introduce the non-tillage method as well but it was not satisfied, why, the water and irrigation in our region cannot be secured, we have been introducing it for two years, it does save farmers' labour force and time, but it also turned out increasing cost, farmers have to use weedicides, and the capacity of yield increase is limited, and the field is not level, weather influences, this is the non-tillage method.* (In-depth interview with officer in Zhakou township)

Farmers also reported on the economic disadvantage of non-tillage technology, with more weedicides being needed. Furthermore, farmers also discussed risks associated with using this technology as it

appeared complicated and not conducive to local farming arrangements. Farmers in Qumu village reported that the non-tillage technology was suitable for farmers who did two seasons rice every year, and who were mostly large-scale rice farmers or rice farmers' cooperatives. In contrast, most smallholder rice farmers grow peanuts or corn in spring and rice in autumn, hence the non-tillage technology was not suitable as they needed to plough land before transplanting rice seedlings. Some farmers reported that even though sometimes they did two seasons of rice they would not consider the non-tillage technology to replace the ploughing of land, as it appeared complicated to them. The processes of non-tillage require long-term water retention on the field to fully soak the field and wither the old shoots and weeds. It is a long period of time as the local plough tractors were generally only available for 3 to 4 days. Farmers reported if they did not soak the field properly, they would miss the use of the plough tractor.

Farmers in several other villages also reported that the key issue with the non-tillage technology was that their villages did not have a stable water supply to soak the field. Farmers in Qumu village reported that if they wanted to practice the non-tillage technology, they needed to pump water from the river, and using the water pump cost much more than ploughing land. Farmers in Shayin village said they also rejected the non-tillage technology because they did not have a stable long-term water supply. As they pointed out, the water supply for farming in the village relied heavily on the farm dam located upstream. Water for farming was only available when the floodgate of the farm dam opened. Thus, there was no possibility for the village to practice the non-tillage technology. Farmers in Dalupai village reported they preferred using plough tractors because the effect of the non-tillage technology in eliminating weeds was not evident, while land ploughing processes removed weeds thoroughly.

> *…the non-tillage method was introduced, you have to apply weedicide and release water to the field right after the spring season harvested, and manage the water to fully sock the old shoots, so that you do not need to plough land in the autumn season, it kind of gave us a feeling that if you do not manage the old shoots properly it will bring a lot troubles, it was mainly for the big scale farming and cooperatives because there is a huge risk if we smallholders do not do it properly, and we do not do spring season rice anymore, most of us do not, there are plough machines very convenient to rent, we cannot afford risk, we want stability, it is not joking. (FGD with farmers in Qumu village)*

The seedling broadcasting technique introduced in the 1990s had been a success in the study locations, as extension officers reported their goal was to reduce farmers' labour and time spent in farming; and

farmers' perceptions affirmed its effects. Farmers also reported it reduced fatigue and made farming activities more consistent among all farmers in the village. However, the non-tillage technology was rejected by most farmers in the paddy field villages, as it required a stable water supply that most of the villages did not have. This reflects the likelihood that when decisions were made about technology being promoted to villages, there was no investigation or consideration of the local circumstances.

Direct seeding technology (Zhibo Jishu)

Direct seeding is the technique of rice crop establishment through seeds sown in the field, rather than the conventional seedling transplanting from the nursery bed. It requires less labour and time and reduces seedling damage from the transplanting process. As mentioned in the previous section, while the seedling broadcasting technology was extended to the paddy field townships, the direct seeding technology was mainly extended to dry field townships from 2000. Changle was one of these townships. An officer in Changle reported that direct seeding was introduced there after its success elsewhere in the county. Farmers in two selected villages, Xianggu and Liannan, affirmed that they did not have a stable water supply in the farming period, which aligned with the statements of the extension officers. However, most farmers reported that they had rejected the direct seeding technology and instead were still using the conventional transplanting technique. Reasons for the rejection varied in each village. Farmers in Xianggu village reported that they did have a river running across their village; however, because of being located in the upland they were not able to use water from the river. The farmers said they discussed a water pump solution among themselves, but the scheme did not go ahead because they could not come to an agreement on electricity costs. The farmers also reported that both the extension officers and the cadre in charge of agriculture in the township government had declined to offer a solution because they declared that irrigation infrastructure was not their business.

In Xianggu village most farmers reported that the direct seeding technology brought no advantages compared with the conventional transplanting technique. Although this technology did not require a seedling transplanting process, comparatively it required a higher level of weed control, which was problematic and costly in terms of labour and time. Also, it required much higher seed rates but did not achieve a higher yield than the conventional transplanting technique. Hence, most farmers reported they had rejected this technology.

> *Direct seeding grows weeds easily and requires higher seed rates; conventional transplanting requires one half-kilogram seed per mu, direct seeding requires two. And*

conventional transplanting obtains higher yield, this is undeniable, about 20 percent higher. (FGD with farmers in Xianggu village)

One farmer reported that he had, however, adopted the direct seeding technology because he perceived it could obtain a higher yield than the conventional transplanting. He said that after the seeds were sown, he irrigated them frequently to make sure the crop grew well. He also reported the drought-resistant characteristic of the seeds was better under the direct seeding technology.

Farmers in Liannan reported that the direct seeding technology was not suitable for the low-lying land of their village. Their fields did not have good drainage: once it rained their field could be drowned easily, and the seeds washed away. While practicing the conventional transplanting technique they were not concerned much about the drainage problem. They also reported that, owing to the low-lying field, their soil was very fertile. Although the conventional seedling transplanting technique was more costly in labour and time, it was more stable, and they could easily obtain high yields.

Technology has to be compatible to circumstances of the village (Yin Di Zhi Yi), we have to do seedling transplanting, we can easily obtain 1,000 half-kilogram per mu, so we do not want to risk anything; we want stability. (FGD with farmers in Liannan village)

In summary, there were three cultivation technologies introduced to farmers. The goals of those technologies were to reduce labour and time for farming, which complied with farmers' needs. However, there were both matches and mismatches. The seedling broadcasting technology matched farmers' needs and was gradually adopted by most farmers in the paddy field. The non-tillage technology and the direct seeding technology were rejected by most farmers due to issues including difficulties in managing weeds, lack of stable water and high complexity.

5.2.1.2. Pest and disease prevention

Officers and farmers in the studied region reported that pest and disease prevention was a major concern in rice farming. Officers in both counties reported that weather, pest and disease monitoring and introducing improved rice varieties were two main services for farmers in terms of pest and disease prevention.

Weather monitoring and pest and disease management

In the region under study, weather and the emergence of pest and disease were very much related. Officers generally reported weather monitoring was the key to pest and disease prevention. Officers at the county level said there were two primary aspects of weather monitoring: low temperatures in

spring and autumn, and typhoons. In spring, generally in March when farmers started to nurse seedlings, low temperature can influence the growing of seedlings and cause dwarf disease. In autumn, around early October, low temperatures can influence the rice inflorescence and hence decrease yield. An officer in Pingshan township reported that some villages were located in hilly areas, and low temperatures affected crops worse there than in other villages. Officers reported they needed to deliver the low temperature information to farmers so that necessary action could be taken to deal with it. In spring they recommended that farmers use dense seedling nursery services provided by farmers' cooperatives, and in autumn they recommended farmers shift their farming activities to an earlier date to avoid the impact of low temperatures.

Typhoons were experienced most years in the region, and badly affected crops. The severe storms, similar to hurricanes and tropical cyclones, generally emerge around August to September, just when the rice panicle starts booting and heading. Storm damage makes the rice more fragile and vulnerable to pest and diseases and brings exotic rice pests and diseases that are difficult for the local people to manage. Officers reported they needed to deliver typhoon forecast information to farmers so that necessary action could be taken beforehand. Also, they closely monitored the emergence of pests and diseases after the typhoon and provided solutions for farmers to prevent outbreaks.

Officers at the township level also reported they provided routine and prophylactic pesticide application information for farmers. The routine application of pesticide was not mandatory. It was based on officers' experiences that several kinds of pests were commonly found in the studied region, including rice leaffolder, rice planthopper and apple snail. Farmers were advised to use pesticides for those pests with or without judging the pest infestation level. Generally, when farming activities started, extension officers would start to announce pesticide arrangements to farmers. Officers also reported they provide on-site pest and disease monitoring services for farmers through visiting farmers' fields, and random farmers approached extension stations to seek problem-solving services; officers also helped them to identify farming problems and provide solutions.

Two major approaches were employed by the extension officers to deliver pest and disease prevention information to farmers. One approach was through visiting villages and providing information to the village committee. Farmers in turn visited the village committee to obtain information. Officers stated that information was transmitted faster through farmers communicating with each other. Another approach was for officers to post information at the township extension station, generally on the board out front. Farmers obtain the information when they visit town.

Officers at the township level reported that the weather, pest and disease monitoring was important to raise farmers' awareness of pest and disease prevention, because most farmers focused on control and management of pests and diseases, rather than prevention. Thus, it was important for farmers to use pesticides based on the monitoring and forecasting of extension stations.

> *The main purpose of monitoring is prevention; most farmers were not aware of prevention, they perceive pest and disease then use pesticides, we need to raise their awareness of prevention.* (In-depth interview with officer in Zhakou township)

In terms of weather monitoring, farmers said they did not look to extension services for much information. Most farmers reported good access to weather forecasts from television and mobile phones, particularly when a typhoon was approaching. Some farmers subscribed to severe weather text alert services provided by network carriers. One farmer in Xianggu had recorded the timing of typhoons every year to conclude long-term patterns. Farmers reported they would ensure the field drainage system worked before a typhoon arrived, e.g. by removing blocks on the field to avoid water retention damaging the crop.

Most farmers reported their routine and prophylactic pesticide application mainly relied on announcements from the extension officers. Farmers said if the extension station did not inform them when and how to use pesticides, they would not know. Farmers in Lingjiao agreed, saying the routine pesticide application arrangement issued by the extension station enhanced the consistency of application among all farmers in the village, which was beneficial because the pesticide was more effective when all farmers used it in the same period.

Most farmers reported extension officer used to do on-site pest and disease monitoring and the information was generally available in their village committee, but in recent years the officers' farm visits had been infrequent. The pest and disease information were still available in the township, but not all farmers could obtain it in good time. In villages located close to the township (less than three kilometres), farmers commonly reported they were happy to visit the extension station to obtain pest and disease information as they visited the township frequently. However, farmers who did not visit the township often reported they did not receive the information. Some farmers in Qumu said they did not hear about the rice planthopper and rice leaffolder pesticide arrangements until they heard other farmers discuss them in the FGD.

Farmers in two comparatively remote villages, Zaohe (6 kilometres to the township centre) and Zhangjia (12 kilometres to the township centre), reported they did not visit the township frequently, thus were always delayed in getting pest and disease information and applying it. Particularly the

farmers in Zhangjia said their village was very remote and transportation to town was difficult. Most of them believed extension officers should visit their villages to provide necessary pest and disease information.

> *We have always been late on the pest and disease forecast, we did not know when pest and disease emerged and when to use pesticides (Bu Zhi Dao Tou Wei). By the time we obtained the information it was always days overdue, what do we need an extension station for?* (FGD with farmers in Zhangjia village)

Pest and disease resistant varieties

Besides weather monitoring for disease and pest prevention, extension officers also pointed out approaches such as improved rice varieties and technologies. Officers in Lingshan county reported that they offered different types of improved rice varieties to villages that had different disease and pest prevention needs. For villages that suffered serious rice dwarf disease every year, they would introduce varieties with better disease and fungi resistance capacity; for villages in low-lying areas with challenging water drainage issues, and where disease would be easily occurred and transmitted, or in villages where pests had caused serious problems in the past few years, they would suggest specific types of seeds to better suit the locations.

> *To villages that have serious dwarf disease we would introduce high disease resistance type of seeds, ignore the easily disease infected type; the governmental extension is more systematic than the private sector, for example, we know whether a village has serious disease, or villages that in the low-lying areas or have bad water drain system, we introduce disease resistance type of seeds to them.* (In-depth interview with officer in Lingshan county)

Officers in Hepu county reported the governmental extension stations did not sell rice seeds directly to farmers (this was done by seed vendors), but they had two important roles in extending and monitoring the rice varieties. One was that they allocated free new varieties to each village committee, and farmers could collect them to do trials. Another role was to monitor the seed market and seed vendors. Varieties available from the seed vendors each season had to be certified by the county agricultural department as being from legal manufacturers, suitable for the season compared to the last season, and suitable for the weather. One officer told of a year in which some local seed vendors wholesaled a variety from another province that turned out unsuitable for the locale. The officer explained that the farmers suffered yield loss as a result.

In terms of disease and pest prevention via introducing improved seeds, farmers in Longan reported that most had adopted the improved hybrid rice variety.

> *Nowadays we usually choose the improved hybrid seed (in Chinses: Za You), most of us, the conventional rice seed was difficult to manage, our village used to have one third farmers choosing Za You, nowadays most of us chose it because it has better disease and pest resistance.* (FGD with farmers in Longan village)

Comparatively, farmers in Longtang reported that they were still growing the conventional rice variety because the improved hybrid varieties were too expensive for them.

> *We generally do the conventional seed, improved hybrid seed is expensive, 40-50 yuan (CNY) per half-kilogram, one Mu land cultivation costs one-kilogram seed, which would be 100 yuan (CNY).* (FGD with farmers in Longtang village)

Farmers in Gongguan, Quzhang and Zhakou townships of Hepu county reported that they had been encouraged to grow the hybrid rice variety named Boyou, due to it having a higher yield than the conventional varieties. However, they had encountered a historically huge amount of dwarf disease on their Boyou hybrid varieties in 2017. The disease was especially serious only in the hybrid variety – the conventional seed was not affected. Instead of having better pest and disease resistance as extension officers had led them to expect, the Boyou hybrid variety actually required more work and pesticide.

> *I don't understand why they are all growing Boyou, it has a lot of dwarf disease, this year (2017) especially, those did not do Boyou are lucky this year … dwarf disease also occurred in past years, and even in conventional seed, but this year is especially serious, and the Boyou seed – I bought Boyou from the agricultural station, it is bad, it gains me a lot more field work and yield will decrease.* (FGD with farmers in Zaohe village)

In summary, most farmers agreed the pest and disease prevention information provided by extension stations was useful. However, extension officers failed to provide them to the village level, only available in the township extension station. This has led to delay of farmers' getting the information. Also, the role of extension services in monitoring the suitability of rice varieties regarding pest and disease resistance has also failed in meeting farmers' needs, from the outbreak of the dwarf disease in the hybrid variety during the field work period.

5.2.1.3. Soil testing and fertiliser formulation technology (*Cetu Peifang Jishu*)

Soil testing and fertiliser formulation technology was new in the studied region. Officers at the county level reported that the soil testing was intended to deal with the farmers' inappropriate fertilising activities, and the resulting issues relating to soil health, environmental damage and decreased yield. Farmers in the studied region had been over-using nitrogen fertiliser, which had caused the soil to harden and deplete soil elements such as phosphorus and potassium. Fields polluted by heavy metals also needed to be tested for safety.

> *The soil test technology is mainly for improving the soil, before farmers use too much nitrogen fertiliser, the soil has digested too much nitrogen, for starter crops grew very well, by further the soil becomes lacking of phosphorus and potassic, which ills crops and decreases yield, in this case, by testing the soil farmers would know what is lacked and what fertiliser to use precisely, the heavy metals pollution can be tested as well, safer and efficient.* (In-depth interview with officer in Gongguan township)

Extension officer reported the aim of the soil testing technology was to test soils in each village and provide results for farmers so that they knew how to change the fertiliser application process. Officers reported they had finished soil sample collections in each village, delivered to soil technicians in county level departments and posted results in villages. Officers thought that farmers already knew whether their soil was acid or alkaline, or contaminated by heavy metal, and how to formulate nitrogen, phosphorus and potassic fertilisers. This technology was vital for improving the health of the soil.

> *We township levels do not have professions and devices, we follow the upper level's requirement to sample soils in every piece of field in every villages, return them to the department, they have professions and devices to do labels and tests, after that they post results online and return to villages, we post them on public premises, farmers should know what elements their soil has and what fertiliser to use. It is about formulation of fertiliser, different pieces of field have different conditions, using formulated fertiliser improves yield and soil's condition, otherwise soil gets dense.* (In-depth interview with officer in Quzhang township)

Farmers agreed that soil health influenced crop yield. Farmers in Shayin reported that their soil condition was facing challenges as farmers had used too much of same fertiliser every year and did not know what essential nutritional elements their soil lacked. They perceived that those factors had weakened the fertility of the soil and thus decreased the yield.

I think formulating fertilisers based on the soil's conditions would improve yield. We farmers use same fertiliser every year. I am not an expert, but I think that makes the soil fertility weaker year by year. It is like a person who lacks calcium; he should be having more calcium. Farmers do not know, they use the same fertiliser every year, I think that leads to lacking some elements in the soil; farmers have been using fertiliser more than the soil needs, they have to use fertiliser reasonably. (FGD with farmers in Shayin village)

However, in terms of the soil testing technology provided by extension officers, farmers did not receive any soil information after the testing. Farmers in Shayin reported that in 2015 extension officers had launched training to introduce soil testing technology to the village, but after the training, officers did not revisit to tell them the test results as promised. Farmers in Changle and Quzhang reported that they knew extension officers had come to their villages to collect soil samples several times, but only on small samples of land and did not reach their own field. Further, farmers reported that officers were task-oriented as they chose villages that were convenient to travel to. They believed that the soil testing should be done on a wider range of land otherwise it would be useless.

… about the soil test, two years ago the village committee has announced to do it, they have launched training in the village committee premise, farmers got money for participation, they mentioned to test soil, formulate fertiliser and improve soil and yield, but no one has ever come for it afterward. (FGD with farmers in Shayin village)

It would be very helpful if all field can be tested, but they are basically task-oriented, which village is convenient to travel to, they choose there, they are not testing every piece of field, they have to test every piece of field so that the soil test is sensible. (FGD with farmers in Xianggu village)

In summary, farmers agreed the soil testing technology was important to keep soil health, hence future production. However, extension officers only did partial the soil testing technology processes and failed to finish the whole processes. This did not match farmers' needs.

5.2.2. Private sector

The private sector extension services provider refers to agricultural input stores, which provided pest and disease prevention and control services; and farmers cooperatives, which provided rice drying services, seedling nursery and seedling transplanting services.

5.2.2.1. Agricultural input stores

Agricultural input stores are common in the study locations. They are small shops that sell fertilisers, pesticides and weedicides. Existing studies considered them as business-embedded extension services because they provided advisory services motivated by profit, which hindered the quality of the services. However, in the field study, agricultural input stores were mentioned by farmers as an important source of extension advisory services and information.

One input store owner reported they did on-site visit to identify farming problems and provide accurate solutions for farmers, and farmers visited them for advice on farming issues, sometimes bringing samples for them to identify. If farmers did not bring samples, they used books to identify pests, and they also had an information board in front of their store illustrating the latest disease and pest forecasting and prevention information. The owner also reported that they were involved in a plant protection network, where input store owners shared information on farming related issues.

The input store owner also reported that they placed emphasis on instructing farmers on how to use pesticides. For example, to ensure farmers understood the instructions of the pesticide and to avoid misuse, they marked on the bottle what crop the pesticide was for (e.g. rice, peanuts, corn) and guidelines for using (e.g. one cap for one barrel of water). Also, they reported that some farmers tried to buy pesticide near harvest time because they had no knowledge regarding the dangers of pesticide residue and/or they had not used pesticide correctly earlier in the season and so disease and pest had emerged, but the store owner would refuse to sell the pesticide due to potential food safety concerns.

> *I provide guidance to farmers by visiting farm to sample and identify; many farmers bring their sample over my store as well. I have information board on disease and pest forecasting, when farmers walk past by, they can see updates on pest and disease information. I am involved in a plant protection network, in which we share information on farming related issues… there is an example, one couple farmers were illiterate, his wife accidently used peanut weedicide on rice, eventually all seedlings died, so I have to carefully teach farmers how to use pesticide.* (In-depth interview with input store owner in Gongguan township)

Farmers reported several factors that made them consider the farming services from input stores were reliable. First, many agricultural input stores in the township level were operated by former extension officers, whom farmers recognised. Second, because currently employed extension officers are public servants, they are not allowed to operate input stores directly, so many of them have their spouse operate the store. Farmers reported they trusted these stores more than they did others.

Two data-driven themes were generated from the interviews with input store owners. Firstly, input store owners emphasised interactions with farmers. From the interviews with input sellers in both counties, it was perceived that they took good advantage of farmers visiting their stores. They gathered information about diseases and pests affecting farmers in different villages and posted them on the board in front of their stores so that when farmers pass by, they can quickly obtain farming information. This is vital at the local level as different villages have different situations. At the time of the interview, the input store in Pingshan township, Lingshan county, was displaying a bunch of yellow dwarf disease-infected rice shoots on the front counter in order to teach farmers how to identify an infestation. They also encouraged farmers to bring pictures or a sample to better identify the cause of any problems and offer solutions.

Figure 5-1 Picture of one input store in Hepu county

Source: The author

Sign on board outside input store: Title: *Rice disease and pest update;* Content: *Ten days ago, with the typhoon Mawa strikes, several villages have found leaffolder pest, but high temperature (34-36 celsius) continues in recent ten days, it prevents pest laying eggs so don't worry unless temperature drops. Dwarf disease has been found in BX, NS, SH, XS, LG, ZL, LW, CM and CW villages, we suggest pesticide application between 8th-13th September dealing with them; Person signature (mosaiced); Date: 6th September 2017.*

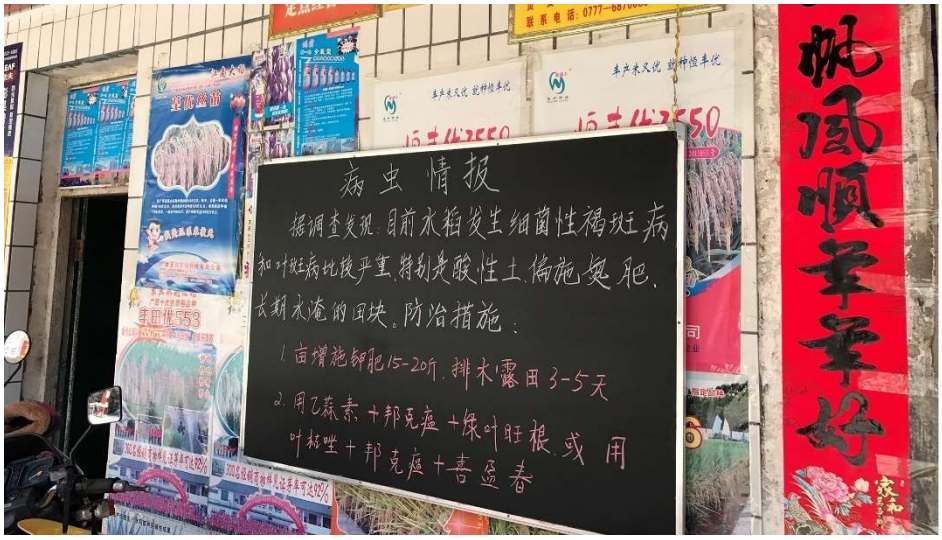

Figure 5-2 Picture of one input store in Lingshan county

Source: The author

Sign on board outside input store: Title: *pest and disease update.* Content: *According to investigation, the bacterial brown spot disease and leaf-spot disease emerged in rice, particularly in acid soil field, nitrogen fertilised field and long-term drown field. Solution: 1. Use potassic fertiliser 15-20 half-kilogram per mu, remove water on the field for 3-5 days; 2. Use several kinds of pesticide.*

Secondly, input store owners emphasise food safety issues. The input store owner in Gongguan township, Hepu county, reported some stores still had banned weedicides and pesticides available, and sometimes farmers still tried to buy them. This underlines the countrywide issue of food safety that stems from farmers over-using or wrongly using pesticides, and store owners taking no responsibility. The input store owners interviewed said they rejected farmers' requests to buy pesticides close to harvest time. Those farmers perceived pest and disease when it was close to harvest time because they did not use pesticides correctly in the earlier growing stages or did not monitor their field on time. They reported that it was better to teach farmers to use pesticide correctly, rather than ask them to use more pesticides.

By reading news nowadays, I realised how terrible is the agri-food safety issue, the government has forbidden many types of high-toxic pesticides but still some farmers try to buy them from other illegal sources. Another situation is that, farmers tend to buy pesticide at the time that was close to harvest, problems occur to their field at that specific time, that was usually because they did not use pesticide properly before, but I cannot

sell them pesticide when it is close to harvest, it is dangerous. (In-depth interview with input store owner in Gongguan township)

The government extension officers had different opinions on input stores' advisory services. Officers at the county level claimed that the government extension services were more systematic than the private sector's. Officers in Zhakou township, Hepu county, also reported that many input stores operated without certification. Many people started up input stores without agricultural extension knowledge, thus the services that they provided to farmers were not reliable or helpful.

Input stores sell whatever farmers request, but the extension system provides what the whole region needs based on the situations, for example, for the serious dwarf disease region we extend disease resistance varieties to them; input stores lack profession and reliability, anyone who has money can open one, many stores do not have certifications, in the township only one or two out of ten to twenty stores hold a certification. (In-depth interview with officer in Zhakou township)

An officer in Shitang township, Lingshan county, said the qualities of the input stores were uneven and intermingled in the township. Some stores provided unnecessary pesticides that were unsuitable for the task. For example, the rice leaffolder pesticide works for both rice leaffolder and rice borer, and where the extension officer would tell farmers to use only that one type of pesticide, he said the input stores would tell farmers to use two or more types of pesticide, which increased farmers' costs and potentially compromised the environment.

Input stores would tell farmers to use more types of pesticides, there is no difference and influence if farmers use more types of pesticides, but many of them were unnecessary and increased farmers' farming cost. (In-depth interview with officer in Shitang township)

In summary, farmers generally reported that input stores were reliable source of extension services because the stores were operated by former extension officers or spouses of current extension officers. According to owners of input stores, they were familiar with farming in the local area, they used approaches to identify farming problems and put food safety issues into consideration when instructing farmers. Extension officers reported the extension services provided by input stores were poor quality and sometimes misleading.

5.2.2.2. Farmers' cooperatives

Officers and farmers reported that farmers' cooperatives were also extension services providers in the study locations. A researcher at the provincial university reported that the provincial government has been encouraging the foundation of farmers' cooperatives through providing financial subsidies

for their establishment and the farming machines that they want to purchase. There were two major purposes for those supports. One was that farmers' cooperatives were an effective model to intensify smallholder farming. Farmers who were involved in the cooperatives farm and make farming decisions jointly, and also receive farming supports. But he said that because of the mountainous geographic condition of the province, the farm land was generally fragmented into small pieces, which limited the capacity of the cooperative model. He gave the example that lands in the northern provinces of China were plain and contiguous, which allowed more farmers to be involved in one cooperative. Comparatively in Guangxi, lands were fragmented into hundreds of mu per piece, hence, it was difficult to engage more farmers in each cooperative.

Another purpose of farmers' cooperative was to provide farming services to other farmers. Services including rice seedling nurseries, mechanised seedling transplanting and rice batch drying services which were open to all farmers in the locations.

Rice drying services

An officer in Lingshan county reported that farmers' cooperatives were extension service providers to smallholder farmers. I was introduced to two rice farmers' cooperatives in Shitang township, which were both rice production cooperatives with specialising in rice machinery services. They were both capable of providing wholesale services throughout all processes of rice farming, including rice seedling nursery, transplanting, harvest and batch drying. However, they both reported that their services were mainly for their own members. They reported the machines that they owned were mostly big machines for large scale farming, as they both involve hundreds of farmers with 800 mu of lands. They also reported that non-member farmers who hire their services were also mainly large-scale farmers. They gave an example of the rice drying services. Both cooperatives owned one to two big re-circulating batch dryers with the capacity of 21 tons of rice per operation. The rice drying services would not be suitable for smallholder farming as the rice that they harvested in each season was relatively much less than the capacity of the dryer, and it would waste electricity if they used it for small quantities.

The smallholder farmers reported they knew the rice production in the cooperatives was very efficient, and particularly that the rice would be dried easily through the batch dryer after harvest. They thought it was a pity that they could not use the rice drying services, and that most had to rely on sun drying. Farmers reported that at worst sun drying could take nearly one month, because the rain was frequent and unpredictable, and if the weather was cloudy, they needed to wait until sun came out. Sun drying

was also tiring and took labour and time. Sometimes when rain came unexpectedly the farmers needed to gather other farmers to collect the rice on the ground immediately.

> *We can only use sun drying. Cooperatives dry the rice in a straight forward way after it is harvested, they also have storage units to use.* (FGD with farmers in Longan village)

> *Sun drying is a handful, but it is our only approach. If we could use a rice dryer it would be more convenient, but we smallholder farmers have only this small amount of rice, they would not help us with it. The weather is unpredictable, all of a sudden, the cloud gets dark and it rains, sometimes it takes one month to fully dry the rice.* (FDG with farmers in Shayin village)

The researcher at the provincial university reported that the government's priority in establishing farmers' cooperatives was to encourage more farmers to be involved in this model, so that farmers could receive those advanced technologies and services. However, as reported previously the arable lands in the study region were fragmented in small pieces in the mountain conditions, so farmers in those areas cannot intensify their farming, so cannot be involved in farmers' cooperatives. Also, the conditions for joining farmers' cooperative was exclusive. Leaders of farmers cooperatives reported that they generally only accept farmers who own over 10 mu of land, because their production was highly mechanised and not suitable for small scale. In conclusion, this was a mismatch as most smallholder farmers were excluded from the farmers' cooperative model and the government subsidies that support cooperatives.

Seedling nursery and mechanised transplanting services

Officers at both the provincial and county levels reported that they were extending the seedling nursery and mechanised transplanting services to farmers. The seedling nursery service has two components. Farmers can bring their own seeds to be grown at the nursery, where greenhouses can prevent the rate of seedling death through low temperature and frost that occur in the open. The nursery also grows its own seed, that farmers can buy. These services were also carried out by local farmers' cooperatives (see above). In different farming seasons the service has different purposes. In spring, officers reported they mainly focus on the seedling nursery service for farmers to avoid the influence of low temperature on seedlings. In autumn, the seedling nursery and the mechanised transplanting services were integrated. Officers reported they encourage farmers to use the mechanised seedling transplanting, which employs the seedling transplanting tractors provided by the farmers' cooperatives. Officers reported that this reduced farmers' labour and time and allows more space for the growth of seedlings. They said that by using the transplanting tractor, farmers can use

their own seedlings or employ the seedling nursery services provided by the farmers' cooperatives, which would be more compatible for the transplanting tractor.

In terms of the seedling nursery service provided in spring, farmers reported they did not need that at all because most of them no longer farm rice in spring, instead, they have switched to grow corn or peanuts as the water was not reliable in spring. Hence, there was no need to avoid the low temperature risks to rice seedlings. Farmers reported that the seedling transplanting service in autumn was not effective enough. Compared to the seedling broadcasting technology, by which rice seedlings were broadcasted randomly on the field, the advantage of using a transplanting tractor was to achieve rectangular planting, which allows wide spacing between rows for better growing of the rice panicles. Farmers in Lingjiao village reported that they understood that wider spacing allows better air flow and sun exposure amongst the seedlings, hence it was better for the growing of the seedling. However, the transplanting tractors that were provided by the cooperatives were too big and thus not suitable for their land. They said the corners of their field could not be reached effectively by the tractor, they need to cultivate the missed parts manually. One farmer in Lingjiao village reported he employed the seedling transplanting services in the studied year (2017) but he used his own seedlings to save money. He said his relatives were working in the city, so he has been cultivating his own and his relatives' lands, which was in total nearly 25 mu (equals to 1.67 hectares). He reported this land size was too much to manage with his own household's labour hence he decided to employ the services. However, he then found that the seedlings that he prepared himself were not compatible with the transplanting tractors, as the transplanted seedlings were too sparse on the field and he needed to recultivate those parts.

> *The seedlings that I prepared were not good, they were not packed densely enough in the nursery tray so that after they were transplanted to the field, they were too sparse. I need to hire some farmers to recultivate those parts, but it is also tricky because I did not have many seedlings left. Next year maybe I will use their seedling nursery service.* (FGD with farmers in Lingjiao village)

The seedling nursery and mechanised transplanting services also showed that farmers' cooperatives were focusing on big scale farming. Even though smallholder farmers knew that by employing transplanting tractor the seedlings could grow better, they could not use them because the tractors were too big for their fields. Also, the farmers' cooperatives did not give sufficient support for farmers who employed the transplanting tractor but used their own seedlings. The government should consider encouraging the farmers' cooperatives to provide services that suit smallholder farmers.

Otherwise, smallholder farmers would obtain no benefit from the government subsidies for supporting farmers' cooperatives at all.

5.3 Challenges in the extension system

5.3.1. Additional duties for local extension officers

The literature review chapter pointed out that public sector agricultural extension service departments in China have been through several major changes and reforms. From 2000, agricultural service centres (*Nongye Fuwu Zhongxin*) were established in every township based on the merger of agriculture-related departments at township level, which were mainly the agricultural station (No*ngye Zhan*), the plant protection station (*Zhibao Zhan*), the soil and fertiliser station (*Tufei Zhan*) and so on. In the studied locations, the institutional mergers took place in 2002. Most farmers said that they knew the location of the services centre and staff. A few farmers were specifically familiar with the change of the agricultural station to services centre, while most farmers still referred to it as agricultural station across all group discussions.

The three-right (*San Quan*) reform was another major change towards the township extension system after the institutional reform in the studied location. The three-right implies the controls over personnel, finance and material resources (*Ren, Cai, Wu*) of the township level agricultural extension centre. The reform devolved the control of the extension centre from county level agricultural departments to the township level government. Each county level agricultural department only provides professional guidance to the township extension centre, called the professional relation (*Yewu Guanxi*). The township government is the leading relation (*Lingdao Guanxi*) with the township centres. After the reform, township level extension centres and officers were given less autonomy in extension activities.

> *Before 2002 there were several institutions in the township levels – agricultural station, plant protection station, fertiliser station and so on – after 2002 all those merged to one agricultural services centre, it is in the bottom of the extension system, it is still responsible for extension but the personnel, money and material resource change over time, now they are controlled by the township government, we are only the professional leading.* (In-depth interview with officer in Hepu county)

The major issue that the reform brought to township level extension officers was that non-extension duties were added to their workloads. Officers in both study areas reported that they were required to do the central work (*Zhongxin Gongzuo*) of the township government and assist with village-related

affairs. Central works included social security and governance (*Yingji Fendui*), and market and street governance (*Shichang Jiedao Zhengzhi*). Village-related affairs included village committee elections and poverty alleviation projects. An officer in Changle reported that the township government was not an agricultural department and agricultural tasks were not related to their assessment items. Thus, limited attention was paid to extension work. The officer reported that given the huge amount of non-extension tasks added to their job description, extension-related tasks were now well down the list for extension officers.

An officer in Gongguan reported that the extension centre had 10 officers: two were allocated to do village finance accounting for the township government, and five were allocated to work as village cadres (*Nongcun Gongzuo Zuzhang*) in several different villages, mainly to communicate with the village head and the women's cadres (*Funyu Zhuren*), and deliver and implement policies (*Zhengce*) and governmental documents (*Wenjian*) of the Communist Party. During the fieldwork period extension officers were also allocated to supervise the village committee elections (*Cunwei Xuanju*). The officer conceded that those works meant there was less time for extension duties, but it was necessary to obey orders from the Party (*Zuzhi*).

An agricultural unit named the agri-food quality and safety detection station (*Nongchanpin Zhiliang Anquan Jiancezhan*) was added to township level extension centres in Lingshan county from 2013. It was created to monitor food quality and safety at the township level; however, officers reported that the upper level agricultural department did not recruit any new staff for the establishment of the new station and the works that it brought. Staff were now required to do both extensions works and monitor food quality and safety, which reduced the time spent on extension services.

> *… after the reform (agri-food system) we have been added one job, after 2013 our office has got one new plate named the township agri-food quality and safety detection station, we same group of staffs have two sets of jobs, two plaques in our office, it is basically same staffs doing two sets of jobs. We have one periodic agri-food quality and safety trainings to participate.* (In-depth interview with officer in Pingshan township)

> *… this agri-food quality and safety detection is necessary every month, we need to travel to food production bases to collect samples and detect them, we have to do monthly report to the upper level on this, it is the task (Renwu).* (In-depth interview with officer in Xinxu township)

In summary, the additional duties to extension officers' workload influenced the provisions of extension services to smallholder farmers. It was because of the unreasonable administrative structure

and arrangement in the township level, which were allocating the rights of personnel, finance and resource of extension stations and officers to the township level government and establishing the agri-food quality and safety detection station to the extension station without recruitment of new staff.

5.3.2. Insufficient fund and incentives for extension services

Insufficient funding for extension activities was reported by most township level extension officers. The shortage was mainly because the township government had taken charge of the personnel, finance and resources of the extension centres and officers, and the government paid less attention to extension services. This created problems especially because extension officers were now required to pay farmers for their participation in technology training (see section 5.3.3). Officers commonly reported that they had to use their own wage to pay for transport to visit villages and provide services for farmers. This influenced the incentive of extension officers, and so reduced the frequency of visits and provision of extension services.

> *We do not have sufficient funding for going to villages, neither money nor subsidies, sometimes we pay with our own wage to keep village level work going, not even our daily office money, higher levels do not care about we grassroot staff, which influences our enthusiasm to our jobs, going to village and launching technology trainings cost money.* (In-depth interview with officer in Zhakou township)

An officer in Zhakou reported that the extension centre has obtained a vehicle for extension services from a project several years ago. It was aimed to assist with the transportation of extension officers to villages; however, there were no funds for maintenance and repair of the vehicle, or for petrol to use it. Thus, they have never used it. Extension officers reported they mostly used their own motorcycles for transportation to villages. This 'vehicle project' reflects poor judgement on behalf of the upper level departments. It suggests that there was potential funding for extension officers and services, but the upper level departments did not inquire as to what local level extension officers needed.

> *there is a vehicle outside, it was from a project of higher-level, but after that there was no anymore money coming down for maintaining and repairing the vehicle, no continuous funding.* (In-depth interview with officer in Zhakou township)

Officers also reported they were treated unfairly in the administrative system in terms of payroll and promotion. An officer in Changle township reported that extension officers and township government officers were both registered public servants and under government payroll, but officers in the

township government were always prioritised regarding wage raise. An officer in Zhakou township reported that there was no promotion for extension officers in the system.

> *We lack motivation and enthusiasm, not only that we have much work to do, but also, we were treated differently in the administrative system, when it comes to increasing payroll, officers in the government always obtain first, we were always two or three years later.* (In-depth interview with officer in Changle township)

> *There was no incentive at all, no any promotion for good technician performance.* (In-depth interview with officer in Zhakou township)

In summary, there was a lack of funding for extension officers to initiate extension activities, namely no funds for transportation for extension officer to travel to villages. Lack of proper incentives for extension officers at then township level also negatively affected their enthusiasm for providing extension services.

5.3.3. Incentives to attend technology trainings

Running technological training for farmers is one of the main duties of agricultural departments. Township level extension officers reported that the upper level departments had budgets to run such training in villages every year, covering topics such as farm management and introducing special cultivations (*Tese Yangzhi*). Officers reported that they provided incentives for farmers to participate, usually monetary incentives (e.g. 30 to 50 yuan or more per person) or commodities (e.g. fertilisers or pesticides equal to the value of the money usually paid). The money paid to farmers is usually regarded as the work-time compensation fee (*Wu Gong Fei*) for farmers' work. When asked why officers should pay farmers for participating in training that aims to benefit the farmers themselves, an officer in Changle reported that in the 1990s farmers were not paid for training participation and they were still happy to participate. An officer in Quzhang reported that a certain number of participating farmers was a training requirement. An officer in Pingshan said that if they did not pay for training, farmers would criticise them and not participate.

> *Trainings are a little different than before, in the 1990s down to village there were adult education sector, it was a lot easier to gather farmers than now, hundreds of participants, and did not need to pay them money; the upper levels have certain budgets for launching trainings every year, extension officers must spend them all, they have to arrange certain amount of participants each village, this is the requirement; paying farmers for participating trainings is formalised, no money for farmers trainings would be difficult*

to launch, that is the work compensation fee (wu gong fei) for farmers. (In-depth interview with officer in Changle township)

Officers also reported that paying for farmers to participate in training sessions created a dilemma: the sessions typically attracted more participants than what had been planned for, which made the actual cost over budgets. An officer in Quzhang said that some training was specific for certain types of crops, but some farmers who did not grow the targeted crops still requested to join. Some were even too old to do farming. The officer said those farmers only attended for the money, but the officers could not reject any farmers due to social stability considerations. Also, officers did not want farmers to have any bad impressions of them because it could cause them trouble if the upper level officers come over to their village.

Farmers strive to join trainings because they get money, sometimes farmers request to join trainings for specific types of crops that they do not even grow, some farmers are even too elder to do farming, a lady aged eighty-nine criticised us for not informing her about trainings, otherwise they would complain you, there was a training that was planned for two hundred people eventually four hundred came, officers have to borrow money from the township to pay all them, or they will fight with you, the rural area is like this (laughter). (In-depth interview with officer in Quzhang township)

According to Hu and Sun (2018), the government pays farmers for their participation in non-profitable technology training as the result of 'administerisation of extension work', which means extension work has become task-driven and a part of the administrative process, instead of being a provider of useful services and training. It appears that farmers are losing interest in extension activities. Our findings have shown that it is common for extension officers to pay farmers for their participation in technology trainings; however, the response from farmers is mixed. Farmers commonly expressed satisfaction regarding training related to the crop that they grew, but farmers in Quzhang and Zhakou expressed disappointment that the extension training run in their villages was largely aimed at fruits and eucalyptus, instead of rice. Farmers in Lingjiao village also reported that in eucalyptus training, extension officers provided growers with free fertiliser, while the smallholder rice farmers did not have the opportunity to attend rice technology training and receive free products. Those factors contribute to farmers attempting to attend irrelevant training only to obtain the allowance. Part of the problem is essentially because smallholder rice farmers are overlooked by the extension system to some extent, not because farmers have lost interest in attending trainings.

5.3.4. University's role in extension system

Existing studies implied that agricultural universities and institutes can play active role in extension system and services. The case of the land-grant colleges in each state of the US was a good example of how state level universities provided extension services to farmers and hence supported the development of agriculture in that state. Also, the state universities played the intermediary role between the upper-level agricultural department and farmers by providing technologies, knowledge and professions (Huffman & Evenson 2008; Liao & Li 2015). In the Chinese context, some agricultural universities were playing roles in provision of extension services, with the goals of development of particular crops or solving regional farming problems (Guo & Liu 2013; Zhang et al. 2016).

Researchers at the College of Agriculture, Guangxi University, one of the major institutes of agricultural research in Guangxi, reported there was a need to build effective linkages amongst research, extension and farmers to meet smallholder farmers' needs, as the government played a minimal role in bridging researchers and farmers.

They said that the technologies, knowledge and professions that the agricultural production needed were not effectively fulfilled by the university. The major issue was that the research conducted by the university did not match the needs of farmers to improve agricultural production. They explained that many areas in the province hold good resources for agricultural production, however, farmers are not able to access suitable technologies to improve farming. The government sector extension system was not aware of the research conducted by the university, and researchers at the university were not familiar with farmers' needs. Also, agricultural graduates from the university inclined to find jobs in cities rather than local levels.

A researcher said there were few researchers that had experimentation station in the local levels, the studies that they conducted were closer to matching farmers' needs. However, in terms of providing suitable services to smallholder farmers, the government sector extension system continues to be the dominant service provider, thus the government needs to strengthen their connections with university.

5.4 Summary

This chapter presents the findings of how well farmers' needs are met by extension services. Firstly, this chapter summarised smallholder farmers' needs: (1) improved cultivation technologies that can reduce labour and time for farming; (2) farming advisory services including information on pest and disease prevention and farming problem-solving services; (3) improved rice varieties that are pest

and disease resistant and suit the tastes of farmers themselves and local consumers; (4) soil management information including information on soil condition and advice on fertiliser, with the goal to maintain soil health and improve yield.

Secondly, this chapter summarised what the extension services provided to smallholder farmers, and how did they meet farmers' needs. There were two major sectors of extension service providers, which were the government sector and the private sector. Services provided by the government sector included three main aspects. (1) Rice cultivation technologies. This included the seedling broadcasting technology that introduced in the 1990s and was adopted by most farmers in the paddy field as it reduced labour and time in the seedling transplanting stage; the non-tillage technology and the direct seeding technology, however, were rejected by most farmers because adoption of those technologies required more labour and time for managing weeds. The non-tillage technology requires stable water supply, which most villages did not have. (2) Pest and disease prevention information and advisory services. Farmers reported that extension officers used to deliver the information to the village level, but at present they were only available in the township extension stations. In villages that were located close to the townships, some farmers reported they were satisfied with visiting extension station to obtain the information, while the other farmers reported they did not know the information. Farmers in villages that were located far away to the townships generally reported they were not satisfied with visiting the extension station because it was not convenient, and often caused delays. (3) Soil testing and fertiliser formulation technology. Some farmers reported the technology training was only conducted once and did not see any officers to collect soil sample. Some farmers observed that officers conducted a soil sampling in their villages, however, these were only carried on a small-scale field and were task-driven. Most farmers agreed there were no further soil advice provided. In summary, the goals of the extension services matched farmers' needs, however, their implementation has failed to meet farmers' expectation.

Extension officers and farmers also reported two private-sector extension service providers. One was the agricultural input stores. Most farmers reported the stores were operated by the former extension officers or the spouses of current extension officers, which provided reliable farming advice. Another one was farmers' cooperatives. They provided services including rice drying, seedling nursery and mechanised seedling transplanting. However, they were failed to meet smallholder farmers' needs.

Several challenges in the extension system were reported by extension officers and researchers. (1) additional duties were added to the workload of township extension officers because of the unreasonable institutional arrangements. This significantly reduced the time extension officers could spend on extension activities; (2) insufficient funds and incentives for township extension officers;

(3) incentives for farmers to attend technology trainings, which increased the financial burden to extension officers; (4) the university was playing a minimal role in extension services.

Chapter 6. How do farmers meet their farming needs?

This chapter described five farming practices that farmers engage in to solve their own farming problems. The first practice was the improvement of cultivation technology. Farmers in Qumu village reported the uneven and over-depth problem of the ploughed land that was caused by the ploughing tractor and their practices of modification of the ploughing tractor. The second practice was the pest and disease management. Farmers reported two main types of pests including the rice leaffolder and apple snail, and the dwarf disease. Farmers reported their identification and practices in preventing and controlling these pests and disease. Farmers also reported their practices in using pesticides properly. The third practice was the soil management, including soil neutralisation, soil classification, crop rotation pattern and diverse usage of fertilisers. The fourth practice was experimentation with new varieties including small-scale trials and farmers' sharing the risk of involvement in high-value crop productions. The fifth practice was addressing the issue of fake agricultural input including identification of input stores and purchasing inputs from manufacturer-direct channels.

6.1 Improvement of cultivation technology

6.1.1. Improving land ploughing

Land ploughing is one of the main processes of rice farming in the study area. Land must be ploughed before broadcasting seedlings in order to smash old shoots from the previous season, destroy any weeds, and level the land to make the seedlings grow well. Traditionally, farmers raised their own buffalo to plough the land. Farmers reported one advantage of using buffalo was the depth to which the land was ploughed, making it suitable for growing crops and further farming activities after ploughing, for example, applying fertilisers and pesticides.

> *One farming change is that before we all breed buffalo to plough land, ploughing land is important, it smashes old shoots and destroy weeds, it also levels the land to allow broadcasting seedlings. Buffalo ploughing is good because the depth is just enough for crop growing firmly in a short time, also, easily for us to walk in the field to do other farming activities, fertilisers and pesticides, and farming managements.* (FGD with farmers in Qumu village)

Farmers reported that one of the biggest farming changes in recent years related to the use of agricultural machines. Farmers in both counties agreed on the significance of employing machinery in farming, especially for ploughing and harvesting. Officers reported that in recent years, the

government had been encouraging the development and extension of agricultural machinery as one approach to agricultural modernisation. The government had investment policies to encourage organisations to engage in agricultural machinery, for example, via an agricultural machine subsidy and a loan offer from banks. As a result, considerable numbers of agricultural machinery providers had rapidly emerged in rural areas and were providing machine hiring services to farmers.

Farmers in Shayin discussed the changes relating to agricultural machinery in their region. Previously the main machinery providers were from the northern provinces (*Bei Fang Gong Si*), but in recent years local organisations such as farmers' cooperatives were taking their places; even a few individuals in villages had obtained bank loans and started their machinery business with the help of the government subsidy. Most farmers said they were willing to hire machines to do farming, mainly for land tillage and harvesting. Most farmers agreed that, in terms of the low net income from farming, the cost of machine rental was expensive; however, they considered saving labour and time by using machines was more important.

> *Biggest change is before we use buffalo to farm, now all are machines, (Q: When did it start?) It was the recent three years thing, the state has rapidly developed, machines are very common now, there is an agricultural machinery subsidy; before the machinery companies come here more often, now our village has our own machinery owner, they bought the machines by loans and subsidy for making money, those machines are very expensive; before one mu of land costs five to six buffalo, plus labours, needs three days' work, nowadays the machine is a lot faster; the harvest machine is more important.* (FGD with farmers in Qumu village)

Farmers in Qumu and Shayin reported problems with using the plough tractors, including that the depth the machine ploughed was too deep. A few farmers thought that deep tillage thoroughly smashed the old shoots, destroyed the weeds, and made the soil soft, but most farmers reported it made the field too difficult to get in, and hence hindered further farming activities on the field. Another common grievance was that the machine-ploughed field was usually not flat enough; farmers needed to slightly level the land again by using buffalo after the machine plough. Then, since the field had been ploughed too deep, it made buffalo moving on the field very difficult, hence required a lot more work. Farmers perceived that it was because the ploughing machine itself was too heavy for their field.

> *recently many farmers reported that the machine ploughs the land too deep and soft, it takes longer for the crop to grow firmly, and buffalo does not dare to go in, you have to*

admit it, I bet you employ plough machine for two years you will not dare to allow buffalo to go in; the problem is that the machine itself is too heavy for the field, look at the wheels and how they roll on the field, the tyres themselves are very heavy, we only need like 15 horsepower capacity is enough; some farmers complaint they haven't employed machines for years, the land ploughed too deep, they cannot even go in the field themselves, it is very inconvenient and costs a lot more work. (FGD with farmers in Qumu village)

In terms of the tillage depth problem, farmers reported the effective solution of putting a land leveller on the back of the ploughing machine. While the machine ploughs, it levels the land at the same time, which prevents the need for the buffalo to go in afterward. The land leveller was the same one used with the buffalo, hence was easily accessible for farmers. Most farmers agreed this procedure was effective.

Actually, you can put a leveller to the machine while ploughing, it levels the land at the same time, and it saves a lot more work to level the land again (group affirmed). (FGD with farmers in Qumu village)

However, farmers held different views in terms of the practice of using leveller. In Qumu, a few farmers reported that the tractor operators were always willing to cooperate with them, while other farmers reported that they found the opposite. In most cases farmers needed to pay extra money for the work, and some were willing to so as they did not need to level the land afterwards. One farmer said he treated the machine operators to lunch as payment for using the leveller. Other farmers thought the machine rental was already costing money and were not willing to pay extra or provide favours, and they still used buffalo to level their land. Some farmers who did not have buffalo said they used simpler levellers (*Tang Pai*) on the uneven parts, although the result was not satisfactory.

If the machine operators agree to put the levellers while land ploughing it would be so much better, it makes the field even, but usually they are not willing to do this for you; yes, if only they are willing to; commonly they do not agree. If they do not agree, I pay them twenty yuan to do it so that I do not need to spend labour to level the land. Some operators are very shrewd; you need to do them favours. I always buy them lunch, every time they do the leveller for me; if not even I would just use buffalo to level it, if do not have buffalo then you can use Tang Pai to slightly level the uneven parts yourself. (FGD with farmers in Qumu village)

This case is also about interaction between the extension services and farmers. The provision of agricultural machines meets most farmers' needs with saving labour and time for farming; however,

on the other hand, it causes other farming problems, mainly relating to the tillage depth of the ploughing machines. Some farmers have discovered solutions to that, although to some extent it depends on the machine providers' willingness to cooperate.

6.2 Pest and disease management

Farmers reported three types of pest and disease including the rice leaffolder, the apple snail and the dwarf disease. The following section presents farmers' identification of the pest and disease, their solutions of prevention and controlling. Farmers also reported how they properly select and use pesticides.

6.2.1. Rice leaffolder management

Farmers in the study area commonly reported the emergence of rice leaffolder in rice farming, and that using pesticide to eliminate it was a routine and prophylactic process in each rice farming season. Farmers in Qumu said that the town's agricultural station and input stores regularly made announcements about the pest, including the location of any infestations, date schedules to apply pesticides and the types of pesticides to be used. The announcements were generally posted on the notification boards of the agricultural station or input stores. Farmers in several villages including Qumu and Shayin also reported they often communicated with each other in the fields or through households to share such information. Sometimes they also observed what other farmers were doing in their fields to anticipate the schedule and to take their own actions in terms of pesticide applications.

Besides receiving information from the extension stations or input stores, farmers also reported their own field observations of rice leaffolder. Farmers in Qumu reported that unlike other pests, rice leaffolder was easily observed and eliminated if proper action was taken in time. There were clear indicators of the pest, for example, white mist on the surface of the leaves meant the leaffolder was present, and white spots on the leaves meant the worms had started to grow and were about to fold the leaves. Also, farmers said that rice leaffolder was usually observed in the early stage of the rice growing, especially on newly sprouted leaves. Based on those observations, farmers reported that the routine preventative pesticide arrangement regarding rice leaffolder was generally effective.

The Qumu farmers said they trusted the store and/or station's schedule because prevention of rice leaffolder was not difficult if they strictly complied with the schedule and used the correct types of pesticides collectively in the area; however, not all farmers were able to obtain the pesticide schedule on time. Farmers in Qumu reported that only a few farmers knew the exact period for using pesticide for rice leaffolder as announced by the extension station. Some farmers, who did not know the

schedule but had observed symptoms of the pest in their field, told others that pesticides should be used shortly. Other farmers within the group discussion said they did not visit the agricultural station or the agricultural input stores, nor they did not visit their own farms for a certain time and did not necessarily communicate often with other farmers and were unaware of the rice leaffolder schedule.

> *Now is the time to use pesticide for the rice leaffolder; according to the agricultural station announced pesticide should be used from eighth to twelfth; what date is it today?; Today is eleventh yet; yes now is most suitable for controlling the rice leaffolder, I have seen several leaves are about to be folded; tenth to twelfth is the best timing; I have used pesticide ten days earlier; when it is time to use pesticide, one or two days' delay would not be acceptable.* (FGD with farmers in Qumu village)

Although farmers reported that rice leaffolder was an observable and manageable pest, failure to observe it and use pesticide on time would compromise effective management of the pest. Farmers in Lingjiao explained that the white mist of rice leaffolder disseminates over one night, and the leaves fold soon afterward. Once the leaves are folded, the rice leaffolder is hidden within; pesticide used thereafter will not effectively reach the worm and thus remove it. Farmers in Qumu reported that some farmers did not use pesticide properly beforehand and their crops became infected with rice leaffolder. There were always farmers who did not know the pesticide schedule and hence did not use pesticide on time. Farmers in Lingjiao also reported that some farmers did not use pesticides properly; some used expired pesticides left over from the previous year, which did not work effectively; some even used the pesticide designated for peanut crops because they considered there was no difference between pesticides – it did not work for the rice leaffolder.

Farmers in Shayin reported they did not follow the rice leaffolder prevention schedule provided by extension officers the previous year and did not apply pesticide because of laziness; subsequently their rice was all infected by rice leaffolder. Thereafter the farmers paid close attention to the extension officers and applied pesticide once the schedule was announced. Other farmers reported that the rice leaffolder was easy to control if found and action was taken in time. They agreed that the extension officers' pesticide schedule was usually precise.

> *The rice leaffolder prevention is to follow the extension station's schedule, they can seize its precise emerge time and if the leaves folded you cannot control them by pesticide; last year my partner did not use pesticide in time for the rice leaffolder, at the time we should use pesticide he said he does not use it, leave it, then afterwards all leaves were folded,*

he then started to use pesticide, this year after the extension station schedule announced he uses pesticides immediately. (FGD with farmers in Shayin village)

Farmers in Qumu and Lingjiao said that once the rice leaves had folded, the worm could only be removed manually. Hand-picking was the most common approach but was inefficient. Some farmers said it was more efficient to use brooms, specifically a type of broom made from Beackea, a native plant with hard branches. The broom can penetrate the gaps of the folded leaves then remove the leaffolder from inside. Even so, farmers said that keeping a close eye on their fields and using pesticides on time were still the major approaches to prevent a rice leaffolder infestation.

6.2.2. Apple snail management

Apple snail is another commonly reported pest in the study locations. It was first introduced to the region some decades ago when farmers were encouraged by the government to farm it due to a perceived market demand. But the aquaculture experiment failed, as it turned out that the snail not only tasted bad, it contained a parasite that made people ill, particularly as many people ate it undercooked. Even though the apple snail was rejected by both farmers and customers, farmers throughout the region cannot get rid of its infestation due to its strong and rapid reproduction capacity. Up to the field work period, it was still one of the most common pests that required routinely prophylactic pesticides in every rice farming season.

Apple snail usually emerges after seedlings are transplanted or broadcasted, as they prefer to eat tender seedlings. The pest commonly inhabits swamps and ditches alongside the fields, usually near to freshwater, and lays eggs on the walls or objects in the ditches. Farmers in Shayin reported that some farmers' fields had been all eaten overnight after seedlings were transplanted, and they had to recultivate the whole field.

The apple snail cannot be monitored and anticipated. Farmers said that it took a lot of work to manage the water level after broadcasting seedlings, as releasing water in the field attracted apple snail, hence seedlings would be eaten. On the other hand, keeping the field dry meant the seedlings would have difficulty growing, and weeds would more easily grow. Unpredictable and frequent rainfall was another matter.

Hand picking was the most common action taken to control the apple snail; however, this method was not efficient enough to control their influence on the field. As farmers reported, one cannot pick them all from the field because there are too many. Farmers in Qumu said that they implemented strict management of water levels on the field after broadcasting the seedlings in order to maintain a thin layer of water – not quite enough to attract the apple snail, and just enough to grow the newly

broadcasted seedlings and prevent weeds growing. This regime was necessary until the seedlings had grown thick and firm. However, other farmers in the focus group discussion reported how difficult this method could be, as the rain was unpredictable in the farming season. Farmers in both Lingjiao and Longan said that they added apple snail pesticide into the fertiliser and applied it after broadcasting seedlings.

Another approach to control apple snail was by using the non-chemical tea seed cake (Camellia seed cake). Farmers in Shayin and Qumu reported using tea seed cake to effectively prevent apple snail without using pesticides. Tea seed cake was originally used in shrimp aquaculture to control fish infestations, as it is toxic to predatory fish but not to shrimp. The tea seed cake can also fertilise the soil to some extent. Obviously, using the tea seed cake allowed farmers to use fewer chemical pesticides.

Extension officers had similar perceptions of the apple snail issues for farmers, but they advised differently regarding solutions. An extension officer in Quzhang agreed that the apple snail issue for rice farming in the villages included the risks of seedlings being eaten after broadcasting, the unpredictability of rain and the rapid reproduction of the species. However, officers reported that prevention of apple snail was straightforward, whereas farmers perceived it as a challenge. The officers said that farmers should apply apple snail pesticide before broadcasting seedlings, thereby preventing the pests' emergence when the new seedlings were still tender. Afterwards the apple snail would do no harm to the field when the seedlings had grown hard. An extension officer in Gongguan said that his office had been seeking and introducing high-tech (*Gao Ke Ji*) pesticides to prevent apple snail. These pesticides were high-grade (*Gao Dang*) and multi-purpose, preventing a wide range of pests including apple snail, and made by reliable manufacturers, some even imported from Germany.

6.2.3. Rice dwarf disease management

Farmers in Hepu county reported an outbreak of dwarf disease during the field study period in 2017. Farmers said they had never encountered a worse pest and disease situation than in 2017. Yellow dwarf disease (*Huang Ai Bing*) had massively emerged, and the disease had caused irretrievable damage to the crop. Farmers in Qumu compared the grown conventional rice and the hybrid rice and perceived that the yellow dwarf disease had mainly occurred with the hybrid seed, while farmers who had planted conventional rice seed perceived their crop was fine. Hence farmers determined the disease outbreak was related with the hybrid seed itself.

> *It is unlucky for farmers who have grown the hybrid seed (Boyou) this year, it has lots of yellow dwarf disease, crops grow mixing tall and short; the conventional rice does not*

have that much, the emergence of the hybrid rice is especially serious; the disease leads to short shoot of the crop, and it ends up with empty husk, it is irretrievable, you cannot re-cultivate them once perceived; past years also more or less have some yellow dwarf disease but this year is particularly massive; it is the problem of the seed breeding, don't know if they have compensation for that. (FGD with farmers in Qumu village)

Farmers in Shayin discussed the massive dwarf disease outbreak and its causes. A few farmers posited that it could be because of the heavier and more frequent rains. But afterwards some farmers said that other years had seen heavier and more frequent rains and in none of them had this massive dwarf disease happened. Furthermore, farmers reported that from their experience crops grew well in years of plentiful rain. The farmers concluded that it could only be because the seed bred this year had been particularly attractive to pest and disease; it was the seed breeding mills' problem and next year they were considering changing to other types of rice seeds.

The short shoot problem is massive this year (2017). The shoots are short and not even on the field, and it would not grow rice (empty husk, from their experience), we have not seen this for years, this year is especially massive; many farmers have this problem; maybe it is because of the heavy rain this year; but rain in this year was not the heaviest, we have seen heavier than this and no such disease like this year; it is not about the rain, rain can only make the crop grow better, it should be because of the seed, the seed breeding unproperly this year. (FGD with farmers in Shayin village)

Farmers in Lingjiao reported the same situation, and also ruminated upon the cause. Comparing the two types of rice, farmers reported that the leaf of hybrid rice appeared more tender than that of conventional rice. Pests usually preferred tender leaves: the rice planthopper prefer to stay on tender leaves, and the rice leaffolder prefers to fold them as well. As the hybrid seed was more attractive to pests, this could also have explained why dwarf disease had been such a problem in the season.

As we observed the leaf of the hybrid seed is tenderer than the leaf of the conventional seed, it is common that pests prefer to eat tender leaf and stay on tender leaf (all agree); yes, pests prefer tender leaf, this is absolute, the hybrid seed attracts pest and disease easier. (FGD with farmers in Lingjiao village)

Farmers reported how they used extension services for controlling the dwarf disease. Farmers in Qumu reported how yellow dwarf disease had struck the hybrid rice that season. A few farmers had heard the extension station officers suggest that the same type of pesticide used for rice planthopper could be used to prevent yellow dwarf disease, but they had not followed the advice. Some farmers

complained that they did not know about this suggestion, and they should have been told earlier when the rice was ripening. (Extension officers explained that controlling rice planthopper could effectively prevent dwarf disease, as it was thought that the pest was the main transmitter of the virus that caused the disease.)

> *The yellow dwarf disease I think it was because (noise); the extension officer actually has said that for the hybrid seed we should use a type of rice planthopper pesticide, for two or three days, and last for a week around, it particularly controls the rice planthopper, and the dwarf disease would be prevented as well; Why they did not tell earlier, the rice is ripening now; no, they have told early ago, I was just lazy to use the pesticide.* (FGD with farmers in Qumu village)

Farmers further reported their experience with yellow dwarf disease two years previously. Some farmers had observed rice planthopper on the field and used pesticides as suggested, while other farmers had not, believing it was unnecessary. Eventually, those farmers who did not use the pesticide had a serious infection of yellow dwarf disease in their fields. Fields located close to the infected fields were slightly infected even if they had applied pesticide. The same farming problem had happened before. It can be understood that that extension department and officers had not disseminated the advice widely enough, as certain farmers had no idea about rice planthopper and yellow dwarf disease prevention. Some farmers had been advised to use rice leaffolder and rice planthopper pesticides at the same time, to control as many pests as possible and save application times, regardless of whether they were emerging or not.

> *Just two years ago, they perceived rice planthopper, my neighbour has told me not to use pesticide, he said it is useless, I did not listen, I use pesticide as followed, it turned out that eventually his field has infected seriously, all turned yellow and fell to the ground, we all saw it when harvesting, my field is close to his field, one or two metres of my field that close to his field also got slight infected, turned yellow, even I have fully applied pesticide the rice planthopper still flew over my field, scary; so when it is time to use rice leaffolder pesticide, you can just use rice planthopper at the same time, don't take the risk of doing more works, and they are not very expensive, regardless it will be emerging or not.* (FGD with farmers in Qumu village)

Farmers in Zaohe discussed the outbreak of dwarf disease on their hybrid rice seed, and how they combined their experience, other farmers' experience and extension advice to determine their actions. They reported the emergence of massive dwarf disease exclusively on the hybrid rice seed (*Boyou*)

bought from the input store run by the extension officer. Nearly half their seedlings did not grow properly, and they needed to add seedlings of other types afterwards. The extension officers advised them to use fewer seedlings to decrease crop density and hence control the emergence of pests, which farmers agreed made sense, as from their experience a denser crop attracted more pests, especially rice planthopper and rice leaffolder.

> *This year the hybrid rice seed from the agricultural station is terrible, not even half of broadcasted grow, they do not grow after broadcasted; I need to complement afterwards, different types of rice mixed together; officers advised not using too many seedlings otherwise it attracts pests, I only used two half-kilogram seed per mu of land, I try to keep it not too thick and not too loose; two half-kilogram can be too thick, some farmers used three half-kilogram, using lesser seedlings, pest and disease can be lesser.* (FGD with farmers in Zaohe village)

Several farmers reported that an extension officer advised them to use more fertiliser to control the dwarf disease and enhance the rice growing, of which advice farmers had different perceptions. Some said that, from their experience, using too much fertiliser was deleterious for crops. Other farmers reported their relatives' experiences of over-applying urea fertiliser and having the leaves of the rice turn dark green and eventually wasted. They determined that in future they should both plant fewer seedlings and use a proper application of fertiliser.

> *Agricultural station advised to use more fertilisers, but they said using too thick of fertiliser crops do not grow as well; I remembered my relatives have applied too much urea fertiliser once, eventually their crops turned too green, even dark, and wasted, too much fertiliser would not help; it should be loose seedlings and proper application of fertiliser that makes crop grow well.* (FGD with farmers in Zaohe village)

In a further link to the background of the pest and disease outbreak that year, farmers reported that they combined their field observation of the hybrid rice seed with the advice of extension officers. Previously farmers had been using more seedlings to maximise the capacity of the land; however, in recent years, during field training on farm management, extension officers had advised that using too many seedlings increased plant density on the field, which limited air flow around the field, prevented efficiency of pesticide application and reduced the leaves' consumption of sunshine. Those factors not only influenced the growing of crops and hence reduced the yield, but also lead to the emergence and dissemination of pest and disease, and hence raised the cost of pesticide and labour input. A further consideration was that the leaf of hybrid rice was larger than that of conventional rice seed,

which would mean higher crop density if they broadcast the same number of seedlings. As a result, farmers determined to broadcast fewer seedlings when growing the hybrid seed in order to help control pests and disease.

> *Usually they (extension officers) would tell us to use lesser seedlings while broadcasting, to avoid over thickness, which attracts pest and disease easier, should allow enough space for air flow; compared to the conventional seed, the hybrid seed Boyou grows thicker, air flow is not good, so it attracts pest and disease easier, the conventional seed's leaf is smaller, air flows better and sunlight consumption is better; when growing the hybrid seed they should broadcast lesser seedlings than the conventional seed.* (FGD with farmers in Lingjiao village)

A few farmers reported they approached the extension officer about the dwarf disease, and they were advised to pull the infected shoots out of the field to prevent further contamination because the dwarf disease was caused by virus and was contagious. Most farmers did not realise it was contagious, as they thought it was a stable disease. They said they could not remove it from the field because there were too many dwarf shoots. Only a few farmers knew that the virus was contagious and infected crops should be pulled out of the field as early as possible after observation. When asked where and how they obtained this knowledge, they reported they had good connections with the extension officers and had visited the extension station to obtain farming advice. The other farmers said that if not for the focus group discussion, they would not know.

6.2.4. Usage of pesticides

The previous section discussed some of the repercussions for farmers who did not follow extension officers' advice, and their corrective action taken afterwards. One farmer in Qumu said that he had never followed extension officers' instructions on using pesticides. He had frequented the store run by an extension officer and bought pesticide there but had used double the dosage that the officer instructed because he said it worked more effectively to prevent pest infestations, and it would be troublesome if the pesticide did not work and he needed to apply it again.

> *I have been visiting the extension officer's store, and have been buying pesticides there, I never follow their instructions, he tells me using one lid of pesticide (for one mu of land), but I use two lids every time, not only the pesticides are lower toxic than before, but also I have to make sure pests would be fully eliminated, if not, I need to apply one more time, that would be troublesome.* (FGD with farmers in Qumu village)

This farmer had his own logic. He understood the instruction on the bottle, and how it complied with what the extension officer advised; however, he thought it was not practical. One mu of land needs at least two buckets of water to be fully sprayed, and the pesticide instruction advised to use one lid of pesticide for one mu of land. If he strictly followed the instructions, the farmer must separate one lid of pesticide into two buckets of water, but he thought that concentration was not enough for the pest. The farmer used one lid of pesticide per bucket of water, hence two lids of pesticide for one mu of land, which doubled the instructed usage. This illustrates that effectiveness is the main driver and priority of using pesticide for some farmers.

> *I have checked the instruction on the bottle, it is same with what the officer advises, one lid for one mu of land, I think one lid for one bucket of water is sensible, its concentration should only be enough, but one mu of land needs at least two buckets of water to be evenly sprayed, (if one lid for two buckets water) it would be too thin and not working, then I need to apply pesticide again.* (FGD with farmers in Qumu village)

His fellow farmers in the FGD argued that the instructed dosage was the safe dosage, and that his overuse was the consequence of not following the pesticide schedule and not using pesticide on time. Most farmers agreed that the instructed dosage of pesticide was enough if their usage complied with the schedule. Some farmers also expressed their concern that over use may strengthen the pesticide resistance of pests.

> *The instructed dosage is the safe dosage, and they do not manufacture the high toxic pesticide anymore, manufacturers are not allowed to because those have residue for longer time; it is this case, the schedule advises to spray pesticide from the eighth to tenth, but you delay it to fifteenth or sixteenth, of course you have to use double dosage, it is because you do not follow the instructed schedule, if you follow, it would not go wrong, for example, you should have breakfast at eight, but you delay it to nine, you get to eat more, right (laughter); I use one lid, it works fine, the worm grows bigger, of course you need to use more pesticides, the resistances are different yet; raising dosage can also lead to pesticide resistance.* (FGD with farmers in Qumu village)

Farmers discussed how the government enacts policies to control the use of pesticide for rural environment concerns; they also learned from experience to limit the usage of pesticide, especially highly toxic pesticide, for the sake of their own health. Farmers in Shayin reported that years before they did not realise the consequences of inappropriate usage of pesticide and had been using it excessively. After illnesses were perceived they realised that the residue of pesticide on crops harmed

their health. They now used less pesticide of lower toxicity, and instead reinforced field management practices to control pest and disease. They did not use any pesticide in the crop flowering season.

> *Farmers nowadays are not like years before, farmers concern their health, because before farming uses huge amount of pesticide, and various kinds of pesticide, which leads to diseases like the Osteoarthritis and other diseases, so concerning the physical health, and the quality of crops, we use lesser pesticides, and stop using high toxic pesticide, use low toxic pesticide, and reinforce field management, we stop any pesticide from the crop flowering season; before, people used Methamidophos, now they do not produce those high toxic ones, those have high residue; those high toxic ones smelled irritant.* (FGD with farmers in Shayin village)

Farmers also discussed an organic farming case in the township. Some rich people in town had hired farmers to grow organic food for their own consumption in response to concern that foods in the market were commonly grown with over usage of pesticide and chemical fertilisers. This led to a discussion about how some farmers had changed their options for feeding livestock from massive composite forage to naturally grown corn and rice bran. This was an illustration of a farmer's focus being less on the effectiveness of feeding and livestock growing and more on whether their practice benefited or harmed health.

> *If people also have livestock farm they would fertilise crops by manure, because it is good for health, many people realise this issue, like some rich people in town they spent money to hire farmers grow organically for their own consumption, they specify what fertilisers to use and do not use any pesticide and preservatives; do not use that much pesticide, people are afraid now; including those livestock farmers, before they massively feed by composite forage, now they mainly use corn and rice bran, before, people focused on how to feed them and how to make them grow, now people only care whether it benefits or harms health.* (FGD with farmers in Shayin village)

A few farmers in Liannan reported that they had never achieved a yield over 1,000 half-kilograms per mu on their farm, but some other farmers said they have been achieving more than 1,000 half-kilograms per mu with theirs. The farmers with a smaller yield said they had encountered serious rice planthoppers infestation on their fields and had been applying multiple types of pesticides, including rice-pest cleanser (*Gu Chong Jing*) and plant-protection spray (*Zhi Bao Pen*), as advised by input stores, but their effectiveness was disappointing. The farmers discussed how they had identified the problem and approached solutions, saying they firstly applied four or five packs of rice-pest cleansers,

which was a huge amount judging by the group's reactions, but they still observed the pest. Then they changed to the plant-protection spray. Respondents described how they applied the whole bottle of spray. It did not work, so they bought another bottle and applied that whole bottle again, but still it did not work. After all those efforts rice planthoppers were still flying around the field and beneath the leaves they stuck on the rice shoots. They did not know how to deal with it.

> *really, over one thousand half-kilogram per mu of yield, I never achieved that, I don't know what happened, my field has attracted massive rice planthopper, I don't know what pesticide can eventually work for them; rice-pest cleanser; I have applied a lot, I have applied four or five packs yet, they should have got inside, but can still see them flying around; can try some plant-protection spray as additions; I have applied it as well, I put the whole bottle in at once, and then another bottle, still don't work, massive rice planthoppers fly around in the morning.* (FGD with farmers in Liannan village)

A few other farmers within the group said that those farmers had used the correct types of pesticides but the way they applied it was incorrect: they should unfold the leaves while spraying because the shoots beneath the leaves were where most rice planthoppers rested. It was useless to spray on top of the crops.

> *It is useless if you only spray on the surface of crops, you have to spray them inside, unfold the leaves as the rice planthoppers mostly stay on the shoot; it is useless to spray from above.* (FGD with farmers in Liannan village)

The lesser yield farmers reported that they had been advised to use a specific type of pesticide; however, it was not to be used close to human living areas. Farmers reported although thinking it may work effectively, they were still concerned that it was highly toxic, thus they did not take the advice and changed their options.

> *I was advised to use a very strong pesticide that may work, but it was advised not to use close to human living area, I concerned about it, so I did not take it.* (FGD with farmers in Liannan village)

Farmers also reported their concern over the toxicity of weedicides, as they thought the residue was unavoidable. As a result, they used only one-time weedicide after broadcasting and did frequent field management afterwards to control weeds.

> *Weedicide is unavoidable to have certain residue on crops, especially doing peanuts, I try to use as lesser as I can, I only use one-time weedicide after broadcasting, and then I*

do manual field management, though it takes labours, but the peanuts are good quality; we also manage our peanut field this way. (FGD with farmers in Liannan village)

In summary, farmers were careful in using pesticides regarding the hazard of the toxicity. Farmers have different practices in using pesticides, group meeting and sharing can correct farmers' misusing pesticides.

6.3 Soil management

Farmers reported four practices in terms of soil management. The first practice was soil neutralisation by using limestone. The second was soil classification including the sandy soil and clay soil. The third practice was use of a crop rotation pattern to prevent the soil from lacking certain kinds of nutrients. The fourth practice was a diverse use of fertiliser, inspired by the soil testing training.

6.3.1. Soil neutralisation

Multiple traditional soil classification methods were reported by farmers when discussing how they dealt with farming problems and changes. Most farmers reported that their farmland soil condition had been acidic over the years. Some farmers reported the highland geographical situation of their areas as one cause, as they perceived the lands at the foot of every mountain were especially coloured red (described as 'rusted'); crops on those areas were particularly difficult to manage and yields were exceptionally low.

Our field condition has been acidity; we knew that, especially fields on the foot of the mountains (Shan Chong Tian). This is common sense to us, it is because they are full of a type of mineral element, the water on those field appeared red, like the iron rust water, that means it is high acidity, the mountain-foot fields are commonly seemed deserted. (FGD with farmers in Zaohe village)

Farmers in Qumu reported that too much rain could exacerbate the acidity of soil. This phenomenon could be due to rain washing minerals down from the highlands, which is the main source of the acidity. Also, farmers reported that there were concrete factories in the township: the rain could be polluted by their emissions and then acidify the soil. As those villages were located in the surroundings of the township, the polluted rain worsened the acidity of the soil. A few farmers reported that some farmlands were full of minerals; if they did not have good drainage system, the water could not be diluted, and the acidity spilt out to the surface of the field and influenced the crop growing.

This year has been a lot of rainfalls, this makes the soil gets acid easily. (Q: Why rainfall makes acidity worse?) Rainfall flows the yellow dirt from the highlands to the farmland, especially those been excavated for building roads, it is well observable, also the rainfall can be polluted by the emission of the nearby concrete factories, lots of dust emits to the air, there has to have some relations to the acid rain; some farmlands do not have good water drain system, water cannot drain away in time, and they have mineral down beneath the land, hence they become acid easier. (FGD with farmers in Qumu village)

According to extension officers in Gongguan, overuse of nitrogen fertiliser is another factor that leads to soil acidifying – and farmers had been overusing nitrogen fertilisers. As officers reported, when nitrogen fertiliser is first applied, crops grow well, the leaves are green and bright. Farmers see this and therefore add a lot more nitrogen fertiliser, which eventually causes soil acidity and depletes other important elements such as potassium and phosphate.

We have been advising farmers to use less nitrogen fertilisers, instead, to balance the use of different types of fertilisers. Farmers have been overusing nitrogen fertilisers, for example, those acidity soil is just because of consuming too much nitrogen, at the beginning, nitrogen does improve crop growing, the leaves are green and bright, but when you overuse it, the soil would become acidified and lack of potassium and phosphate, that significantly decreases crop yield, also soil gets densified. Farmers have to decrease the use of nitrogen fertiliser, farmers knew this. (In-depth interview with officer in Gongguan township)

To deal with the soil acidity problem, farmers in the studied region have created their own solutions. Farmers in Qumu reported that the most common and effective solution was applying limestone on the first round of the fertilising period (limestone first, and five days later other chemical fertilisers). As they pointed out, this was the traditional method used to neutralise soil acidity since the days of the collective economy of China. During the collective farming time, the village leaders collectively got limestone and dissolved it for every farmer. It effectively controlled the acidity of the soil. Nowadays, farmers still used limestone for farming. Farmers reported that limestone was accessible through the building material market or the limestone factories in the townships. They usually bought raw limestone chunks, put them into water to dissolve into powder, and then applied it to the field.

Limestone is one solution to the soil acidity, it has been used since the collective farming, during that time the village collectively got and dissolved them, and now as we have our own lands, we buy limestone from the building material market or the limestone factories,

the raw limestone chunk, put it in the water it dissolves itself into powders. (FGD with farmers in Qumu village)

Farmers reported that applying limestone effectively neutralised soil acidity and improved the crops, making rice leaves green and bright and increasing yield. Some farmers in Hepu county also reported that limestone kept rats away from their field, which saved money and labour to control rats, meanwhile some farmers in Lingshan county reported that limestone also helped to prevent certain types of pests on the field.

About limestone, I do not know why but if you apply it the rats will go away, we do not know the function, but it is better than using the rat clamp; limestone is alkaline, it kills pests. (FGD with farmers in Longtang village)

Extension officers hold positive attitudes to the limestone solution and have been advising farmers to use it themselves if they did not yet know about it. Officers in Shitang reported that some farmers complained to them that their crop did not grow well, as they perceived the crop leaves sprouted abnormally (they did not sprout as many leaves as they should by a certain time), affecting yields. These farmers were confused; they had bought and applied fertilisers and thought the fertilisers must have been fake, but in fact it was because the soil was too acidic. Officers reported they would suggest farmers to use mixed limestone and ashes of grass and firewood to neutralise the acidity of the soil. Extension officers in Quzhang had similar points of view, saying farmers who used limestone, grass and firewood ash had produced quality crops and high yield. In this case, extension officers were actively disseminating effective traditional knowledge for farmers.

Sometimes farmers come to me said their rice did not grow normally, I would suggest them to use limestone and some firewood ashes mixed, usually after this their crop grows well. (In-depth interview with officer in Longan township)

Farmers know their own stuff on farming, for example, the soil is acid, the colour is different, farmers know, and when they use limestone and firewood ashes, their crop grows much better, those did not do this would finally find out what is happening. (In-depth interview with officer in Quzhang township)

Farmers reported several challenges in accessing the limestone and ash. Firstly, due to governmental environmental policies and regulations, many limestone factories were forced to close down, which limited farmers' accessibility of limestone. A few farmers reported that some local vendors were still selling crushed limestone, but they were not willing to buy them as they were comparatively expensive (0.8 yuan per kilogram, which was nearly equal to the cost of fertilisers). Secondly, farmers

reported that the firewood ash used to neutralise the soil mainly came from firewood cooking; however, as most farmers had transferred to using gas for daily cooking, the firewood ash became rarely accessible.

> *Before, during the collective economy production they have good accessibility to limestone, now who can still find those things; you still can, but it is more expensive, if you can afford the limestone you rather to buy more fertiliser, they are actually similar; not quite similar, rats are afraid of limestone, you apply limestone on the field rats would go away.* (FGD with farmers in Qumu village)

Farmers also reported using livestock manure to fertilise as an alternative to using chemical fertiliser, as they thought chemical fertiliser caused soil acidity. According to farmers, using livestock manure made the crop grow better because the soil was not acidified. But farmers also reported that it was difficult to get manure nowadays as most farmers transferred to using machinery and only few were still breeding buffalo (in the studied region buffalo was used for ploughing land).

> *Using livestock manure (Nong Jia Fei) is better for crops, diseases are lesser; yes, nowadays by using chemical fertiliser the soil acidifies easily, using manure can avoid this problem; especially this year has rained a lot, soil acidifies very easily; but as I just said, it is difficult to get livestock manures, no one breeds buffalo nowadays, and it is difficult to transport them; firewood ash is also good, but we do not use firewood for cooking anymore, although some farmers still are but that small amount of ash would not be enough.* (FGD with farmers in Qumu village)

In summary, farmers have their own observation on the worsening of soil acidification, which was mainly due to the use of chemical fertilisers and changes in local conditions. Farmers were using old practices such as limestone and livestock manure and firewood ash to neutralise the soil. Farmers also reported that access to these materials were now limited.

6.3.2. Soil classifications

The field study also discovered that most characterise soil types by their constituents to better situate different crops. Commonly, farmers categorised soil as sandy soil or clay soil, meaning sand or clay constitutes most of the soil in that area. Farmers in the sandy soil areas reported that their soil could not hold water and elements of fertilisers well, hence more water and fertilisers were needed. Farmers also reported that from their perspective, a clay soil field grew better quality and heavier rice than the sandy soil. Sandy soil was more suitable for growing peanut and corn, while clay soil was comparatively more suitable for rice.

Sandy soil cannot hold water and nutrients as good as the clay soil, sandy soil is better for peanut, corn and banana, the clay soil can hold water and nutrients better comparatively. (FGD with farmers in Qumu village)

Farmers in Zaohe reported that by being aware of their soil type, they could reconsider the advice given by extension officers. One farmer said that because of the different soil conditions, the advice and training delivered by extension officers did not necessarily apply to their farming practices. Some farmers were advised by experienced farmers to apply a certain amount of fertiliser in the first 15 days of seedling broadcasting, which they did on their farm, but it turned out that it was still not enough. They subsequently determined that it was because the soil textures were different.

The practice of farming would be quite different regarding to your soil type, two farmers use the same amount of fertiliser, one is better than the other, it is just because of the soil type, I was told by my father-in-law, who is in different village, that use certain amount of fertiliser in the first fifteen days but it turned out not enough for us, the rice was still weak, it was because the soil textures were different. (FGD with farmers in Zaohe village)

The rice farmers also reported that they learned from the experiences of banana farmers in their village, who had been invited to a banana technology training run by extension officers in other townships. Those banana farmers practiced the recommended fertiliser technique, but their bananas came out two months earlier than the time officers advised. Eventually they ascertained it was because the soil types were different between the training township and their village. The soil type in the training township was sandy, whereas the soil in their village was clay, which holds fertilisers better.

Speaking up soil type, extension officers have launched a banana technology training in the township over the Nanliu river, the banana farmers came back and practiced it accordingly to the training, the management and fertiliser, but as a result the banana came out two months earlier, it was because the training place was sandy soil, it is over the river side of the county, and we are the clay type, fertiliser holds firmly on the soil, so it is quite different. (FGD with farmers in Zaohe village)

Some extension officers reported that they were aware of the soil differences and would consider this while giving advice to farmers. Officers said conditions varied between villages, and for villages with seriously acidified soil they would introduce a particular type of rice to them. In terms of soil problems, extension officers had also been introducing the soil test technology (*Cetu Peifang Jishu*) to farmers. As officers reported, the soil test aims at reporting specific conditions of the soil, including acidity or basicity, nutrients and elements; farmers should then be able to use fertilisers based on the

scientifically tested conditions of the soil. Furthermore, officers in Hepu county pointed out that some of the fields had been polluted by heavy metal elements. Officers in Lingshan county also reported soil pollution by inappropriate use of weedicides. As perceived from interviews with farmers, soil pollution has not been commonly recognised. By doing soil tests, pollution in the field can be detected; however, as pointed out in previous chapters, the extension of the soil test was not successful for multiple reasons.

6.3.3. Crop rotation patterns

The farmers' group discussions revealed that crop rotation pattern was largely understood by farmers. As mentioned in previous chapters, the study area is located in a sub-tropical climate, which has enough warmth, rainfall and sunlight for multiple and various crops. Most farmers in both studied counties reported that they had two seasonal crops every year, roughly in the spring season from February and the autumn season from July. Farmers said that in previous years they were keen to do two seasons of rice, but in recent years they had begun planting other crops in spring and rice in autumn.

Growing certain types of crops other than rice in spring benefits the growing of rice in autumn. Farmers in Hepu county reported that growing peanuts in spring enhanced the growing of rice in autumn because the peanut fertiliser left from the spring season was good for rice growing. The idea that peanut fertiliser benefited rice growing was raised several times within different group discussions. Also, farmers reported that growing peanuts made the soil soft, which is also good for rice farming. Peanuts gained good yields, had multiple usages and met market needs; crops could be sold directly to nut vendors or oil manufacturers. Also, growing peanuts did not require strict water management, with spring in the studied region being the dry season. The leaves of peanuts can be left on the field as an organic fertiliser to benefit the soil for rice farming in the coming season. Furthermore, peanuts can be stored easily and for a long period of time. As a requirement of rotation, farmers also tended to grow different types of peanuts in different years. A few farmers in Lingjiao village reported they intended to swap to the black peanut, which contained more nutrition and had better market demands.

> *We still do two season crops in a year, in spring season we like to do some peanuts because it is good for the growing of rice in the autumn season, because the soil after growing peanuts will be still very fertile, the peanut fertiliser that used contains lots of urea, it is very expensive, and the soil will be soft and fluffy after growing peanuts, which is also good for rice farming; growing peanut in the spring season is better than corn,*

> *the leaves of peanut can be directly left on the field, for fertilising the soil, it is purely organic, it is good for rice faming in the coming season, comparatively corn cannot do this, we have to throw away corn's shoots; peanut' yield is good, usually four hundred half-kilogram per mu of land.* (FGD with farmers in Liannan village)

Although most farmers agreed that peanut was ideal for the spring season, they could not grow it every year, and most farmers said that they grew corn in the spring season as well. Farmers in Qumu claimed that growing corn benefited the autumn season rice because the field would have been thoroughly ploughed, and fertiliser left over from growing corn was also good for the rice. Farmers in Shayin thought growing corn consumed more soil nutrients and weakened soil fertility but agreed that corn had more uses (*Shi Yong*) than other crops; for example, it was good for feeding livestock such as chickens, ducks and pigs. Farmers in Liannan village grew corn to sell. They chose different types of corn, such as sweet corn (*Tian Yu Mi*), and big sticky corn (*Da Hua Nuo Yu Mi*). They reported that vendors had been preferring and buying their corn for a good price.

> *Generally speaking growing rice on the field that has grown corn is better, doing corn on the spring season, the rice on the autumn season grows easier, on one hand there is still fertiliser left, on the other hand the land grown corn has been thoroughly ploughed, it is soft and lesser mess; peanuts is better but we cannot do peanut every year, corn consumes soil nutrients, it weakens the soil; corn is more useful, it is easy to store and can be used to feed chicken, duck and pig; I have been growing good corn for selling, the vendors like my corns, sweet corn is good but I cannot do sweet corn every year, I have heard they have a sticky corn, the seed store introduced that it has good disease resistance and good yield, I trusted them.* (FGD with farmers in Qumu village)

Besides peanut and corn, other types of crops were grown in the spring season for crop rotation, including chilli, green bean and sweet potato; however, no further details about these crops were reported.

Another aspect of the crop rotation pattern developed by farmers is that farmers have been changing rice types in the autumn season. Farmers in Hepu county reported that they needed to change the type of rice in different years. They explained that growing the same type of rice in successive seasons taxed the same nutrients in the soil, which made the soil lack specific types of nutrients. Therefore, farmers argued that they must mix rice types each year, and they had been actively looking for different types of rice to grow. Farmers in Lingshan county also said that they had been changing the

types of rice each year, as they perceived that growing the same type of rice over two years attracted crop pests and diseases, and changing types worked better for soil fertility and water supply.

> *This year (2017) I have grown a new type of rice called Long Liang You, the input store introduced to me, it says it is the number one rice in the world on the bag; this is a new rice type, we need change types of rice every year, years before it was mainly Tai Feng You and Shun Feng You, this year you do Tai Feng You, next year you change to Shun Feng You, you cannot do the same type for over two years.* (FGD with farmers in Dalupai village)

> *If you do same type every year, they consume the same nutrients, the soil would particularly lack those nutrients, so must mix them; Rice type changes frequently, we change it year by year, doing the same rice type every year attracts pests and diseases easily; changing them is also good for the soil fertility and water.* (FGD with farmers in Liannan village)

In summary, farmers mainly have two sets of crop rotation patterns, one pattern was rotation between the spring season and autumn season, and the other pattern was rotation within the rice farming in the autumn season. Farmers also reported their consideration of the suitability of the rotation pattern when they attempted new varieties and how the crop would impact soil health.

6.3.4. Diverse usage of fertilisers

Soil fertility was one of the main topics mentioned by farmers in FGDs. Previous sections described how farmers in the studied region had certain methods to stabilise and improve their soil fertility, including using limestone to neutralise acidity and add mineral nutrients, and certain crop rotation patterns. Farmers in Shayin reported that in spring they rotated crops between corn and peanut to avoid the soil being depleted of certain types of nutrients. as from their experience, different crops absorbed different soil nutrients: if they did one crop in two rotations the soil would be robbed of certain nutrients. Farmers in Liannan also reported that in autumn they rotated different types of rice for the same purpose. This was before the extension officers ran soil test training in the village.

> *The soil is basically stable, if you do corn every year, nutrients would be lost, the soil would get worse, so we rotate one or two years for corn to keep the fertility; we also do peanut in the spring season, and peanut is better than corn, peanut is better for rice in the autumn season, it makes the soil softer.* (FGD with farmers in Liannan village)

Farmers knew to rotate crops to manage soil fertility from their own experience and understood that the soil test training run by the extension officers gave them further skills in relation to fertiliser application that ultimately resulted in increased yield. Officers in Lingshan county reported that the purpose of soil test technology was to advise farmers on using fertilisers scientifically, as they perceived that farmers had been misusing fertilisers. An officer in Hepu county said that farmers had been over using urea fertiliser with serious consequences such as hardening of the soil.

> *Farmers have been using fertilisers blindly, especially nowadays most of them are elder people in the household, we launched this soil test, to the field to collect sample and test them, then tell farmers what elements and nutrients are lacking, lack of potassium we advise farmers to use potassium fertiliser, acid soil we advise them to neutralise soil, lack of urea use urea, we have launched trainings to teach farmers how to fertilise, avoid fertilise blindly.* (In-depth interview with officer in Lingshan county)

> *We perceived that soils in the field of our region have hardening problems, farmers have been over using the urea fertiliser, it increases the nitrogen in the soil and hence hardens the soil, it hinders the growing of crops, hinders the dissolving of organic matters in the soil, the soil test technology is new in our county, it is to test the content of nitrogen, phosphorous, potassium and calcium in the soil, then fertilise regarding the test result. Fertilise this way can also soften the soil to allow crops grow and organic matter dissolves.* (In-depth interview with officer in Hepu county)

Farmers in Shayin village reported how the soil test training inspired them to improve soil fertility in other ways. The pattern that they had been pursuing assumed the soil stayed unchanged, but they now understood that the opposite was true. As they had been using the same type and quantity of fertilisers, the soil fertility had weakened year by year. As advised via the soil test training, using fertilisers that were recommended based on the soil test would be beneficial.

> *I tell you, the soil test is very important, we farmers use the same fertilisers every year, we assume the soil remains unchanging, but this is not possible, although I am not an expert, but I think using same fertilisers every year the nutrients will be washes away, hence the soil fertility will be weakened, this is not good; Like now, if the fertilisers can be adjusted based on the soil's conditions, and also their applications, will greatly improve the yield; no need to say other issues, you use the same fertilisers every year, no change at all; we buy the same fertilisers every year (laughter); farmers do not know much about soil, they just fertilise, people say potassium and phosphorous are good then*

they use them, but using the same fertilisers leads to the lack of certain elements of the soil. (FGD with farmers in Shayin village)

Farmers used analogy to reflect their learnings regarding soil testing. The health of the soil could be compared with human health, e.g. if a person lacks calcium, they need to supplement with calcium, rather than blindly supplement with other nutrients. Also, constantly eating the same type of food was not good for a person's health either.

I think soil quality is the first priority to farming, because soil is like human, lack of calcium you should supplement calcium, lack what eat what, otherwise you eat nutrients that you do not need, it is useless, it is a blind action; and always eating the same thing is also useless, should change to the fertilisers that are actually needed for the soil. (FGD with farmers in Shayin village)

In terms of soil health and increasing yield, farmers discussed how to use fertilisers properly. They said that the base fertiliser should mainly contain phosphorus, and another round for composite fertiliser after that would be better. Also, it was best to avoid using too much urea fertiliser and nitrogen fertiliser (farmers referred the latter as 'eyes irritation fertiliser'), as it was understood that overuse could cause hardening of soil. A few farmers also said it was best to avoid using too much potassium fertiliser for the base fertiliser because the purpose of potassium was for the shoots grow strong.

No adjustments for the use of fertilisers at all, farmers do not know, even say potassium is suitable for base fertiliser, and every year use phosphorous as base fertiliser solely, it leads to the lack of certain elements on the soil, how can yield be increased? yes, farmers do not know, they just fertilise; usually phosphorous is suitable for base fertiliser, and maybe one more round of composite fertiliser; and don't use potassium, it is for the shoots grow strong and thick; and don't use too much urea fertiliser and eyes irritation fertiliser (nitrogen fertiliser). (FGD with farmers in Shayin village)

At this point it can be concluded that farmers do have various farming problems regarding their soil, and they actively search for ways to solve problems to achieve better farming and yield. Local knowledge mainly comes from farmers' experience; it tends to be functional, observable and easily accessible. Meanwhile, extension advice tends to be scientific, systematic and thorough. Also, extension officers have a certain influence on the dissemination of traditional and local knowledge at the local level. We can also conclude that to a certain extent, changing circumstances have significant limitations on farmers' implementation of local knowledge and practices. Sometimes farmers can

overcome them and sometimes they cannot. Extension services, as the major source of support for smallholder farmers, have a role in helping farmers to obtain better access to materials for soil practices, rather than solely looking for highly technical solutions.

6.4 Trials of new crops

6.4.1. Farmers-initiated small-scale trials

Farmers in the study area are facing harsh environmental changes including the lack of irrigation in the spring season, unseasonal cold weather, unreliable rainfall and extreme weather in the autumn season, severe soil acidity, pests and disease. Although the extension system has been introducing new crops, technologies and farming methods to the villages, farmers approach them carefully. With regards to new types of seeds, farmers prefer to trial them before they eventually decide to grow them.

A few farmers in Qumu reported that they had been allocating a small portion of land for trailing new types of crops. The farmers reported that they preferred growing corn as an alternative rotating crop pattern in the spring season rather than peanuts. Compared with peanuts, which require constant field management, corn does not require as much labour and time to manage. It has multiple usages as it can be used to feed livestock and pigs and does not carry much risk as there is good demand. Farmers reported that they have been setting aside a small portion of land for two seasons for growing corn every year, including the trialling new types of corn. It is necessary to do trials on new corn varieties before they can be applied to the whole crops, as corn has many types in the market, and they have been updating as well. Farmers reported growing peanuts did not require trials, as the peanut type had been the same. The main driver for the trials was to anticipate the performance of the seed, as farmers understand the types are continually updated, even though they are mainly for crop rotation purposes. The trails are also implemented to avoid risks associated with using varieties from overseas.

> *I mainly do corn in the spring season as the season lacks of water, and corn is easier, peanut is also an option but it requires labour and constant management, growing corn I can just leave it there, and corn has multiple usages, it can be used to feed chicken or pig, if not, it can be selling directly to the market; we only have three or five mu of lands, it is just enough to feed the pig, peanut has better price but no need to bother; I have a small portion of land for two seasons corn to try different types, this year spring season I have trailed DiKa, it is an American type, then the autumn season, also DiKa, oh, I have done two season Dika they are the same. It is the rotation requisition, every season is*

required to do different types; even corn you have to rotate, last two years I have grown domestic corn. (FGD with farmers in Qumu village)

When asked whether they had trials for different types of rice, that being the main crop of the year and hence more important to the annual yield, farmers responded that rice was more complex than corn. Generally, they had two options for rice in the local market: conventional seed and hybrid seed, and they rotated between those two types of seed. However, even for the same types of seed, there were differences every year due to the breeding processes undertaken for the seed by the mills; hence farmers could not run trials on rice seed performance even if they wished to. Such trials appear even more vital since farmers in the study area commonly reported the hybrid seed attracted pest and disease this year (2017), especially yellow dwarf disease.

Rice also requires rotation, conventional seed and hybrid seed, but it is not like the corn and peanut rotation, peanut does not need rotation, it is the same every year, but rice seeds are different every year, it depends on the seed breeding mill's process, for the hybrid seed every year differentiates, this year's Boyou hybrid seed is different with the next year's Boyou hybrid seed. (FGD with farmers in Qumu village)

Farmers in Zaohe reported they had grown chilli through small trials in the spring. The main driver was the higher costs of agricultural inputs and hiring of machinery, hence rice had been less profitable, and they wanted to make the most of the spring season crop. As an alternative to corn and peanuts, farmers had eventually targeted a type of chilli with good market value and sales called Chao Tian. As it was the first time that they had grown chilli they started with a trial on a small portion of land. As they discovered, the growing of rice in the autumn season benefited the growing of chilli in the spring season, mainly from the soil perspective, which made it a good alternative for crop rotation in the spring season. However, farmers reported chilli attracted pest and disease much more than other common crops. Extension officers in the area could not help with chilli disease, meaning farmers needed to hire professionals from other places, which was not convenient. The farmers said if the chilli disease could be effectively controlled it would be better for their farming and household income.

We have adapted growing chilli in the spring season now, for starter I have no idea about chilli, never grew it, I checked books and materials and found the Zhi Tian chilli has high price and good sale, so I took a trial, I only did one third mu of land and it turned out great, now all my five mu of land is growing chilli, and we village many farmers are doing it; more and more farmers started to adapted chilli, and the only village in the township;

chilli makes a good rotation crop for rice, because chilli attracts pest and disease easily, easier than other normal crop, doing rice can reduce the pest and disease of chilli. (FGD with farmers in Zaohe village)

In summary, farmers use small-scale trials on new varieties before growing them for the entire crop. This was mainly for seeing the effects of the new varieties in the location and to avoid risks when they grow them to the entire crop. The finding also showed that only a few farmers reported they did small-scale trial.

6.4.2. Farmers' perceptions of high-value crops

When discussing low profit returns on growing rice, farmers discussed the possibility of engaging in intensified farming, high-value crop production and contract farming. Farmers explained that rice farming did not earn enough money due to increases in in the input price. They also discussed the consequences that those actions may bring. In terms of being involved in intensified farming, they discussed the risk of combining their lands. At the time of the field study, agriculture in the study area mainly consisted of irregular small-scale farms. Each farmer had a small piece of land that was irregularly fragmented, which seemed to limit the operation of machines and hence production efficiency. Intensified farming would require combining all small-scale lands together; however, as a consequence the land could not be evenly and fairly distributed back to farmers at a later date, as the boundaries between lands would become unclear. The farmers argued it would engender conflict among farmers and was not good for the village. The farmers argued it would engender conflict among farmers and was not good for the village. Some farmers suggested setting up poles in the field to precisely mark the boundaries between their different properties; however, other farmers thought the poles would hinder the operation of machines.

Do you think the government would transfer our lands to do big scale farming? Many farmers would not agree, the lands are linked but also bounded, once they are transferred they cannot evenly distribute the lands back, it is a one-off thing (all agree); intensified farming must be big scale, all lands are transferred together for using machines, it would be more efficient; once intensified the lands can only be redistributed piece by piece, it would not be even and fair, farmers would have conflicts; they cannot use poles to mark the boundaries because it hinders the operation of machines, they must use machines. (FGD with farmers in Shayin village)

During their discussion about possible involvement in contract farming of other crops with higher value and better market demands, farmers spoke about the consequences of not meeting the

contractor's requirements and the risk of loss. Farmers reported that some people had recently come to their village and announced a plan to start farmers' cooperatives, with the farmers' involvement being specifically to grow taro. The farmers had been promised a supply of agricultural inputs including high yield seed, pesticide and fertiliser, advice and training. The taro would be purchased by the cooperatives at a good price, but farmers would be required to grow taro weighing at least one kilogram per taro. The farmers were surprised by the hefty weight requirement. If they could not meet the requirement it would be a big loss to ordinary farmers.

> *This year people came over and planned to give us free taro seed and engage use in taro farming, they are willing to provide seed, pesticide and fertiliser, and advice and trainings, they promised to purchase the product for 1.8 yuan per half-kilo but we were required to grow those taros over one kilogram per each; one kilogram per each is huge, if not met we need to keep those small ones ourselves, we cannot eat that much; if not met it would be big losses; they provide fertilisers in advance, by the time of purchase if you do not meet the requirement they would even charge you for costs of fertiliser (laughter).* (FGD with farmers in Shayin village)

Similarly, farmers in Xianggu village also expressed interest in contract farming a high value crop other than rice. They had been approached by a "businessman" suggesting that they grow sweet corn. The businessman would supply seeds and purchase the product at a secured price. Although farmers in this village had experience in growing corn and hence the land was suitable, sweet corn must be harvested and delivered in a very short period as it goes dry quickly and cannot be stored for long; hence its sale is highly risky. The farmers thought it would be better to focus on crops that would bring more stable profits.

> *We farmers have requested extension officer to introduce new crops in and businessman purchase product, they have secured price for purchase as the stable sale is important for a new crop; they also provide seeds; they introduce sweet corn, how to say, it is different with the dry normal corn, sweet corn sells in fresh; yes, they did not deceive you by introducing sweet corn if they would be harvested and delivered in time, once the corn goes dry it is another story; it goes dry easily on the field, and also after harvested, it cannot be stocked long, so there is a huge risk, if no one buys them it is useless to grow them.* (FGD with farmers in Xianggu village)

In summary, farmers attempted to be involved in intensified farming and high-value crop productions. However, there were challenges regarding the desires, including the land redistribution issue, the risks of not meeting the producers' requirements and difficulties in transportation.

6.5 Addressing fake agricultural input issues

6.5.1. Identification of inputs and store options

It was often reported in focus group discussions that farmers had been sold fake agricultural inputs, mainly seeds, fertilisers and pesticides. Some reported their own experience and others were aware of other farmers' experiences. Thus, farmers were not confident with the input market due to the possibility of purchasing fake products. Farmers in Qumu knew people who suspected they had been sold fake fertiliser, as their crop did not grow well. Farmers discussed how fertilisers on the market were of diverse quality and price. Cheap fertilisers contained less of the marked element and were usually made by small manufacturers, while expensive fertilisers contained the full content as marked and were made by established manufacturers. The farmers agreed that it was a trade-off between purchasing fertiliser and the yield to be obtained.

Farmers in Shayin had a different experience. They reported that the price of agricultural inputs had been increasing, and even expensive fertiliser could be fake. They related how some farmers bought a type of potassium fertiliser that costed 200 yuan per package, which was considered expensive, but the rice did not grow as expected and they determined the fertiliser was fake. When they applied the real potassium fertiliser the rice shoots grew firmly. Other farmers reported similar fake input purchases such as pesticides that did not effectively eliminate the targeted pests.

The farmers met such deception in various ways. They claimed that agricultural input stores at village level were more likely to sell fake inputs than stores in towns, therefore they mostly made their purchases in town. Only in times of urgency did they consider the village vendors. They also pointed out that inputs made by small manufacturers were more likely to be fake, while those made by reputable (*Zheng Gui*) manufacturers were more reliable. Farmers in Shayin had been applying a technique to identify the quality of potassium fertiliser by putting it in water to observe any change in colour. If the colour faded in water, it could be identified as fake. This was an innovation developed and practiced by the farmers.

6.5.2. Inputs from manufacturer-direct channels

A few farmers in two villages had created their own path to reliable input sources. Two farmers in Liannan reported that they had been purchasing fertiliser and pesticides through online stores and had full confidence in the process. They said the main advantage of purchasing inputs online was that they were much more reliable than those in the local input stores. They made their purchases generally via the website T-mall (*Tian Mao*), which is a well-established formal online platform for input manufacturers to list their own products. The farmers browse the online stores and place orders which the manufacturers then ship to them directly, thereby removing all intermediaries in the supply chain and effectively avoiding the possibility of purchasing fake inputs. The farmers said there was better regulation and enforcement of online purchases than of the local stores. If the online seller sold fake products, the platform promised to compensate a dozen times the value of the purchase, whereas with the local input stores it took a lot of time and effort to finalise any compensation process. Finally, the total price including shipment was cheaper than that offered by local input vendors.

A vital factor that influenced any online purchase decisions was the assistance of younger, educated relatives. The farmers doing so reported receiving assistance from their children, who were studying at university and familiar with the procedure of purchasing online. The farmers said that, despite the proof of their resulting good yields, other farmers in the community did not dare to imitate them as they could not understand the possibility of gaining cheaper and better-quality products simply through online purchase. Some farmers understood a bit more but still dared not try without assistance. The two Liannan farmers also explained that they would not help other farmers in the village to purchase inputs through online stores on their behalf, as it would create difficulties if any problem occurred.

Similarly, another farmer in Lingjiao reported that his brother was an agricultural university graduate who worked in an agricultural technology company, and the agricultural inputs he required mainly came through his brother's workplace. His brother also advised him about farming knowledge and information.

6.6 Summary

This chapter summarises five farmers' practices in terms of meeting their own farming needs. The first practice was the improvement of land ploughing through the improvement of the ploughing tractor. This was caused by the uneven and over-depth problem from the tractors. Farmers have their

effective idea to solve the problem, which was assembling the leveller on the plough tractor. But the limited willingness of the tractor operators hindered the use of the idea.

The second practice was pest and disease management. Farmers reported three types of pests and disease including the rice leaffolder, the apple snail and the rice dwarf disease. Farmers reported the importance of using pesticides under the routine prophylactic schedule from extension stations. In some instances, farmers cannot obtain information in a timely manner, with some farmers reporting that they observe other farmers' activities in the field to anticipate the schedule. Farmers also reported certain practices, including the use of a broom made from a local broom grass to effectively remove the leaffolder hidden inside the folded leaves, and the use of tea seed cake to prevent the infestation of apple snail. Farmers reported their identification through comparison between the hybrid variety and conventional variety, to conclude the causes of the outbreak of rice dwarf disease, including through the characteristics of the leaves and crop density. Farmers also reported the proper usage of pesticides regarding the hazard of toxicity. Within the focus group discussions farmers also shared their experiences with using pesticides and corrected misuse of pesticides by other farmers within the discussion.

The third practice was soil management. Farmers reported four practices including (i) soil neutralisation through the use of limestone, (ii) soil classification in term of sandy or clay soil, (iii) crop rotation patterns for maintaining soil nutrients and (iv) diverse use of fertiliser for soil health. Farmers reported their observation that the soil acidification was worsening by the massive use of chemical fertilisers and the emission of construction factories located in nearby townships. The limited access to limestone, livestock manure and firewood ash also hindered farmers' use of old practices for neutralising soil. Farmers were also actively paying attention to the soil nutrients, maintaining soil health through crop rotation and diverse use of fertilisers.

The fourth practice involved trials of new varieties. A few farmers reported they launched small-scale trials when they attempted new varieties before they decided to grow an entire crop. Farmers also reported certain challenges in terms of involvement in intensified farming and high-value crop productions.

The fifth practice was addressing fake agricultural input issues. One practice was the identification of the brand and manufacturer of the inputs. A few farmers reported identification of potassium fertiliser through the fading of its colour in water. Farmers also described their experiences of input storeswith those at the township level most trustworthy than those from the village levels stores. Another practice was through manufacturer-direct channels, which avoided all the middlemen in the

supply processes. A few farmers reported they purchased their inputs through manufacturer-direct channels, which were reliable online platform and agricultural company. Their relatives who studied at universities have performed important role in those processes.

Chapter 7. Discussion and conclusions

This chapter presents the overall findings, discussion and conclusions of this study. Section 7.1 presents the main findings, how they answer each research question, and relate to theory and existing studies. Section 7.2 presents limitations of this study. Section 7.3 presents implications for future studies. Section 7.4 presents conclusions and contributions to knowledge of this study.

7.1 Discussion on the main findings

7.1.1. Research question one: How well are farmers' needs met?

(1) Answers to the research question

Research question one explored the question: how well were farmers' farming needs met? The findings identified four main farmers' needs, which were: (1) improved cultivation technologies that can reduce labour and time for farming; (2) farming advisory services including information on pest and disease prevention and farming problem-solving services; (3) improved rice varieties that are pest and disease resistant and suit the tastes of farmers themselves and local consumers; (4) soil management information including information on soil condition and advice on fertiliser. These needs were partially met by the extension system, taking both government and private sectors into account.

Improved cultivation technologies

Several improved cultivation technologies had been provided by the extension system. The purpose of these technologies, according to governmental officers, was to reduce labour and time spent on farming, which would seem to comply with farmers' needs. However, farmers' perceptions of these technologies matching their needs varied. Most farmers in the paddy field areas reported the seedling broadcasting technology matched their needs and most had adopted it, but the non-tillage technology introduced from 2006 did not match their needs and had been rejected, mainly because it required a stable water supply that could not be obtained in their villages. Most farmers in the dry land areas reported the direct seeding technology did not match their needs and had been rejected because the technology required more labour and time to manage weeds and was not suited to the low-lying areas.

Farming advisory services

In terms of farming advisory services for pest and disease prevention, most farmers reported that the services were important and effective for preventing pest and disease; however, the extension station had not delivered such information to their villages for many years; it was only accessible in the

township extension stations. Most farmers in villages located close to townships reported they were happy to visit the extension station for information, although several farmers reported they did not know the information was available. Farmers in villages located far from the townships reported that the system failed them: it was not convenient to visit town frequently, and so any information they received was generally too late. In terms of farming advisory services for problem-solving, most farmers reported it did not match their needs because the extension officers no longer provided on-site services.

Improved rice varieties

In terms of improved rice varieties, extension officers reported their purpose was to introduce varieties with good pest and disease resistance. This complied with farmers' needs. Officers reported they did not sell seeds directly but were in charge of monitoring and permitting varieties in the market to make sure their characteristics were suitable for local pest and disease conditions. In the field study period (2017), most farmers in Lingshan county were satisfied with the pest and disease resistance of the varieties available. However, in Hepu county, most farmers reported an outbreak of dwarf disease that emerged exclusively in the Boyou hybrid variety bought from the seed vendors. Given the variety was permitted in the market, the officers apparently made a poor judgement on it. This did not match farmers' expectations. In terms of improved varieties that were provided by extension stations freely for farmers' trials, farmers reported they were high yield and had good pest and disease resistance but were not suitable for the tastes of local people. Farmers reported they would rather buy seeds or grow low yield conventional varieties than grow these free varieties. Thus, this also failed to match farmers' needs.

Soil management advisory services

In terms of soil management advisory services, officers provided initial soil testing and fertiliser formulation technology. The purpose of this technology would have matched farmers' needs, as most farmers reported fertile soil was important to achieve high yield and soil health was critical for future production; however, the provision of this technology did not continue. Most farmers reported officers only came once to run the soil testing training and no further activities were observed. In some villages, farmers reported they saw officers collecting soil samples, but no further soil information was provided after that. Farmers also reported the soil was only collected in a small part of the region, which would not be helpful to them. Some farmers reported the soil testing was task-driven because extension officers chose fields that were convenient to reach.

Two private-sector organisations were reported as important sources of extension services. One was the agricultural input stores. Farmers reported they went to input stores to seek farming advice and pest and disease prevention and problem-solving services because those stores were operated by former extension officers who had good knowledge and experience of farming in the area. Farmers also reported many stores were operated by the spouses of the current extension officers, so inputs in their stores were more reliable than those in the other stores. Owners of input stores reported that they used photographic books and crop samples to help farmers identify pests and diseases, hence to give better problem-solving advice. The owner of one store in Gongguan also reported that he refused to sell pesticides to farmers at the approach of the harvest period, due to food safety considerations.

Farmers' cooperatives were also providers of extension services. They received governmental subsidies for their establishment and machine purchases. They were not only providing services for their member farmers but were also entitled to provide services for non-member farmers. However, their services did not match farmers' needs. Two farmers' cooperatives in Lingshan county provided rice drying services as they owned batch dryers, but the dryers were 21 tons of capacity in one operation, which was not suitable for smallholder farming. The farmers' cooperative in Hepu county provided a seedling nursery service to avoid the low temperature issue in spring, and mechanised transplanting services for farmers. But most farmers did not grow rice in spring, hence there was no need for them to use the seedling nursery service. The seedling transplanting tractors were also too big for small fields. Thus, they did not match smallholder farmers' needs. Leaders of farmers' cooperatives reported they mainly focused on large scale farming, even in involving new members. This contradicted extension officers' expectations that the government subsidies for farmers' cooperatives were to engage more farmers in the cooperative model and that smallholder farmers outside the cooperatives should be able to receive services.

The findings showed the goals of the extension services matched farmers' needs in general terms. The technologies, farming advice and seed varieties provided aimed to sponsor labour and time reduction, high yield, and pest and disease prevention; however, several mismatches occurred between the extension services and farmers' needs and most of them lay in the decision-making, implementation and provision stages. Regarding the non-tillage technology and the direct seeding technology, mismatches manifested as technologies were not compatible with the local conditions of villages, particularly in relation to lack of stable water supply and low-lying land. Although the adoption of these technologies could reduce costs for the targeted processes as farmers were led to expect, they would raise costs for other processes, which did not make change beneficial overall. For example, the adoption of the non-tillage technology reduced the ploughing land process but required

a stable water supply and constant field management for water and weeds, which required more money in using water pump and labour. The non-tillage technology also appeared complicated to farmers, which brought them risks. These mismatches occurred because officers at the provincial and county level did not investigate local circumstances at village level before they made the decisions to provide these technologies.

In terms of the farming advisory services for pest and disease prevention, mismatches occurred because extension officers failed to provide village-level pest and disease prevention notification for farmers, including on-site services and disseminating notification through village committees. Pest and disease prevention information was only available at the township-level extension station and difficulties in access caused farmers to receive and use the notification late or not at all. In terms of the improved rice varieties, mismatches occurred due to the poor judgement of officers in not considering the taste suitability to local people. In terms of the soil management information, mismatches occurred because the extension of the soil testing and fertiliser formulation technology was ceased halfway. No soil collection activities were seen by farmers, or soil collection was only in small areas of fields and task-driven, then no further soil information was provided afterwards.

Several challenges regarding the township-level extension officers and extension services were reported by officers. Firstly, due to institutional reform, non-extension works from the township government were added to extension officers' duties, which heavily occupied extension officers' time that should be spent on extension activities. Insufficient funds for extension activities also limited the provision of extension services to farmers. Those challenges resulted in mismatches that occurred in the pest and disease prevention and the soil management information provision, as extension officers did not have sufficient time and funds to fulfil the on-site services and village level notification or provide the soil testing technology. Providing services at the township level extension station was a compromise to suit officers' limited time.

There was a need for the provincial and county levels to learn from effects and seek feedback on innovations and problems at the township and village level, rather than simply accept and pass on decisions and solutions that were linearly transferred from top to bottom in the system. The upper levels in the system need to investigate local conditions before any extension decisions are promoted to the local level. Extension decision-makers need to examine if the adoption of the new technologies can bring cost and other advantages to farmers' existing practices, rather than solely looking at what kind of goals the technologies can achieve without consideration of the local context.

The voice of township-level extension officers should be articulated to the upper levels. This study showed two important messages from the township level officers. First is the effect of the promoted technologies. Whether the technologies succeed or fail, the upper level can learn from them to enhance their decision-making processes. Second is the challenge facing the township-level extension officers. Time and resources are fundamental to provision of extension services, and they were not secured in the institutional reform in 2002. Extension services became fragile and vulnerable because their provision depended heavily on whether the township government assigned non-extension work to extension officers. This greatly influenced smallholder farming. The provincial level department should have a role in institutional and administrative changes to solve the challenges encountered at local levels. County level agricultural departments can also perform an intermediary role between the provincial and township level.

(2) Discussion of the findings

The innovation attributes framework by Rogers (2003) pointed out the compatibility and relative advantage factors that influence the innovation process. The compatibility attribute factor emphasises the consistency of the innovation to the existing values, experiences and needs of the potential receivers. Results of this study showed that the goals of extension decisions agreed with farmers' needs. Mismatches occurred because of the incompatibility of the extension services to the local conditions. Li et al. (2016a) pointed out that incompatibility of innovations emerged in the governmental extension system in China. This occurred because the innovations that decision-makers thought would benefit the rural areas eventually turned out to be unsuitable to the local environment and conditions. This study revealed that it was because the extension decision-makers at provincial level did not obtain information on local conditions before they made the decision to promote innovations to farmers and persuade the adoption of them. This study showed farmers had lost income by adopting incompatible innovations, and potentially lost trust in the extension system. The study also considered the failures were related to the government having solely pursued standardised, intensified and yield-driven innovations, rather than focusing on farmers' actual needs.

Bunch (1989) pointed out that a common goal of agricultural development in most government agendas was to increase production and yield through introducing certain sets of innovations to smallholder farmers and persuading farmers to adopt them. Smallholder farmers were seen as empty vessels in the innovation process. However, many of those innovations fail because other important agricultural developmental factors are overlooked. van der Ploeg (2008) said that governmental goals in most countries tended to pursue large scale production as an effective approach to achieve food security and hence develop the national economy. Small-scale farming was seen as a lagging form of

agriculture that hindered those processes. Ye (2015) maintained that smallholder farmers sought a sustainable livelihood through embracing a holistic picture of their production, taking in ecological, social and functional perspectives rather than solely pursuing yield and profit.

Rogers (2003) argued that the innovation process should consider the compatibility of the innovation to the culture of the location, previously introduced innovations, and the experience and past practices of the adopters. Findings from this study showed that the decision-makers attempted to introduce new rice varieties to farmers without appreciating those factors. The new varieties were rejected as farmers found they did not suit either their tastes or that of their consumers, whether or not they were 'improved' and high-yield varieties.

Relative advantage is another innovation attribute of innovation diffusion theory. Rogers (2003) explained that relative advantage was about how much an innovation was perceived to be better than the methods it replaced, mainly from economic and social aspects. From an economic aspect the cost of an innovation may potentially increase over time, which may hinder or suspend the use of the innovation. From the social aspect, the innovation adoption rate would be affected by the change of social status resulting from the innovation adoption. Findings from this study showed the critical influence of the economic efficiency aspect in helping or hindering the adoption of innovations. The non-tillage technology case in this study showed that farmers rejected the innovation because it could not bring relative advantage. Compared with the existing practices, although the non-tillage technology reduced labour and time for ploughing lands, it raised costs and labour required to manage weeds.

Apart from the consideration of economic efficiency in the relative advantage attribute, this study also showed a risk aspect of relative advantage. The non-tillage technology appeared complicated and therefore risky to farmers, as it required more procedures and a longer period for field management to achieve the non-tillage effects, while their existing practice of ploughing land was much faster and more thorough in eliminating weeds. Innovations with relatively less risks, compared with existing practices, should be considered as another aspect of advantage in extension decisions and innovation adoptions.

Studies have shown that innovation failures occur because smallholder farmers have not been prioritised or involved in the decision-making agenda. Teixeira (2005) said that in order to balance extension priorities with stakeholders' needs, effective communication and interaction was required between researchers, extension officers and stakeholders, as researchers and extension officers had a relatively narrow problem-solving approach, while stakeholders in the production required outcomes

on a more holistic level. Innovation failures generally occurred because decision-makers in the top-down extension system tended to assume that simply scaling up the adoption of advanced innovations would achieve rural development goals (Bunch 1989; Ye & Fu 2015; Kokate et al. 2016). Communications and interactions allowed different groups of people to exchange opinions and bridge the gaps in those processes. Results of this study affirmed that the provincial extension officers tended to promote advanced innovations that they thought were important for the development of agriculture; however, these turned out to be mostly suitable for large-scale farmers with the capacity to use them, while being unsuitable for smallholder farmers. In other words, smallholder farmers were not prioritised in the extension system.

Chambers (1997) argued that smallholder farmers are important for rural development. Smallholder farmers considered their farming decisions in a more holistic perspective, taking in environments, diversity, complexity and systems, rather than focusing solely on economic benefits (van der Ploeg 2008; Ye 2015; Šūmane et al. 2018). But they were short of support to cope with changes and emergencies. Thus, decision-makers should renavigate their goals to focus more on the empowerment of smallholder farmers (Burnham & Ma 2018). From our findings the mismatches between extension services and smallholder farmers' needs show there is a lack of understanding on both sides; hence decision-makers need to formalise effective communication and interaction channels and mechanisms within the extension system.

Existing studies on extension supply-demand suggest that the extension system has not been meeting smallholder farmers' needs properly, mainly due to the lack of a mechanism to ascertain farmers' needs in the top-down system. These studies advised establishing a mechanism or approach to involve smallholder farmers in extension decision-making agendas in order to build a demand-oriented extension system (Kong 2009; Hu et al. 2012a; Zhao et al. 2015). Kong (2009) argued for the need to build a bottom-up extension system oriented in farmers' needs in response to the failures of the typical top-down extension system, whose services were usually performed as government interventions. Furthermore, Nettle and Paine (2009) said that the mediating and negotiating roles in the extension system can be performed by extension profession to align top-down policy with bottom-up farm perspectives. This requires a transparent policy-making process and the facilitation of communication. A feedback mechanism set up in the extension system to ascertain farmers' extension needs could be achieved by setting up consultancy phone lines in township agricultural extension stations and allocating staff specifically to communicate with farmers at village level. The results of this thesis affirmed that articulating smallholder farmers' extension needs would be a positive approach to improve the effectiveness of the extension system. Furthermore, this study found that the

system should also be open to feedback, assessment and comments (whether positive or negative) regarding the extension services provided to smallholder farmers.

Studies have found that under the household responsibility system after the collective economic era, farmers were able to decide what to grow independently and this raised challenges for the extension system. The extension service's capacity, particularly the governmental sector, was limited to meet the diverse needs of all farmers. Thus, the extension system should build a demand-oriented mechanism to ascertain farmers' needs and meet them (Hu 2006; Jian 2007; Jiao et al. 2014). The findings of this thesis affirmed that the needs of smallholder farmers were diverse, and their goals were holistic rather than focused solely on yield. For example, farmers with a livestock farm may prefer to grow corn in spring because it can be used as forage, while other farmers prefer growing peanuts because the plant can be used as fertiliser for the autumn season of rice farming. In the demand-oriented extension mechanism, farmers' needs and the goals behind them should be considered by extension officers before they reach decisions about what to provide for farmers. This would help to improve the effectiveness of the extension system.

Hu et al. (2012a) explained that an inclusive agricultural extension system could effectively improve the accessibility and adoption of extension services to the huge number of smallholder farmers in China. Features of the inclusive extension system should include smallholder farmers being prioritised by the public-sector extension system, establishing a systematic approach to obtain smallholder farmers' extension needs, a proper accountability system, and an incentive system for extension officers. This study affirmed the reported features, including that the agricultural extension system was targeting large-scale farming and farmers' cooperatives when they were making decisions and providing services, and there was no mechanism to identify smallholder farmers' needs. Also, extension officers in the township level did not have stable funding, resources or proper incentives to provide extension services to smallholder farmers.

Harman (2018) implied the participation of innovation users in the innovation processes would effectively enhance the innovation adoption rate and hence the development of remote communities. According to the examination of the technology and practices in the extension provisions and their alignment with smallholder farmers' needs, it was affirmed that extension decisions were dominated by the provincial level agricultural department and officers. Lack of participation by the users led to failures in the innovation processes. Further, extension officers at township level and in the private sectors had not been invited to participate in the extension decision-making processes either, despite their good knowledge of local situations and direct connections and interactions with farmers. This

study suggests that a wider range of participation within the extension decision-making process would enhance the effectiveness of the extension system.

Zhang et al. (2016) and Qiu (2015) argued that strengthening the role of universities and research institutes could work to mediate between the top-down approach and bottom-up approach in the extension system and process in China, to overcome failures of the linear top-down system. Universities and researchers embedded in the rural areas and farming activities effectively enhance communication between the innovation supplier and users, and hence improve innovation adoptions. Agricultural universities can perform the role of innovation intermediary in the agricultural innovation system to effectively bridge researchers and smallholder farmers. Both studies agreed that employing interactive and communicative approaches in the extension processes could effectively improve innovation adoption within smallholder farmers.

The results of this study highlighted communication gaps between researchers and farmers, and between extension officers and farmers; extension officers had reduced or suspended their visits to villages due to a lack of sufficient resources, and thus reduced the quality and quantity of services provided to smallholder farmers. Also, the provincial university was not performing an active role in the extension system as researchers reported their faculties did not have effective village level research bases that allowed them to have direct interaction with farmers. Even though some researchers did have project sites at the village level, they were solely focusing on their experiments. Researchers reported it was difficult to formalise links between researchers, officers and farmers as the extension system was top-down and the extension services were very task-driven.

Jian (2007) pointed out that private-sector and market-driven extension services can complement the limited capacity of the governmental extension services. They found that the governmental extension services failed to meet farmers' needs in introducing new crop varieties to farmers. Their findings revealed that extension officers led farmers to expect the adoption of the new varieties would improve their yield and income; however, officers were not confident about the expected outcomes themselves. When officers were asked if they would be willing to adopt the varieties they were promoting if they were the targeted farmers, they reported they would not.

This study found that the private-sector agricultural input stores were performing critical role in providing advisory services to smallholder farmers. Firstly, the advisory services from input stores were more accessible than any provided by extension officers as there was more than one store available and farmers had options. Secondly, input stores provided reliable advice. Farmers reported many input stores were operated by the spouses of concurrent extension officers or former extension

officers. They were well recognised by farmers. Farmers generally tended to trust those stores as the staff had experience in identifying fake agricultural inputs. Thirdly, input stores displayed disease-infected crop samples and used photographic books to help farmers identify farming problems, hence to give better solutions.

Previous studies have declared that the private sector is not an effective and reliable provider of extension services because most are profit-driven and farmers are sold fake inputs (Kong 2009; Xia & Yu 2010). The findings of this thesis oppose the point that input stores are solely profit-driven. For example, one input store owner refused to sell farmers pesticides near the harvest period due to food safety concerns. They reported that farmers sought to use pesticides during the harvest period because they had not been advised of the correct use of pesticides in earlier stages; if they had then there would be no incidence of pest and disease in the harvest stage. Hence, they preferred to champion the food safety of the crop and advise farmers to use pesticides correctly in the growing stages, rather than sell pesticides to farmers in the harvest period. Based on the previous finding that extension officers did not have sufficient time and funds to provide extension services for farmers, particularly pest and disease prevention information, this study suggests that the extension system can consider cooperating with input stores as providers of extension services to smallholder farmers. The extension system can also perform role in empowering the private-sector and building their capacity in extension services.

Studies have argued that the farmers' cooperative model is effective in engaging and supporting smallholder farmers in China. Study perspectives included cooperatives provided technologies for farmers and engaging farmers in high-value food supply chains. Also, cooperatives provided resources for smallholder farmers to improve their resistance to production and market risks (Hu et al. 2017; Yang et al. 2018; Qu & Ren 2019). However, most of those perspectives focused on smallholder farmers involved in the cooperatives. This study found that cooperatives excluded smallholder farmers with very small-scale land (less than 10 mu), thus, this model would not work for all farmers as anticipated by the decision-makers. Furthermore, decision-makers also expected that farmers outside the cooperatives could use their services, but findings showed the services were not compatible to small-scale farming, even though the services were needed by smallholder farmers. Farmers' cooperatives were in a rapid expansion in China through governmental subsidies and supports. Decision-makers should consider how to better accommodate this cooperative model to benefit more farmers, rather than solely consider how to involve all farmers in cooperatives.

7.1.2. Research question two: How did farmers meet their farming needs?

(1) Answers to the research question

Research question two explores how smallholder farmers met their farming needs. This study found that farmers had certain sets of practices in place to meet their farming needs. Those practices were categorised as: (1) improvement of cultivation technology, which was mainly the ploughing tractor; (2) prevention and control of pests and diseases, which were primarily rice leaffolder, apple snail and dwarf disease; (3) soil management through using limestone, crop rotation patterns and soil classifications; (4) attempting new varieties; (5) addressing the issue of fake agricultural inputs. Knowledge and experience sharing between farmers were observed in focus group discussions. For example, a few farmers were corrected on their ways of using pesticides by other farmers.

Improvement of cultivation technology

The first practice was the improvement of the cultivation technology, which was the ploughing tractor. Farmers report that fields ploughed by the tractor are not level, so they need to use a leveller after ploughing. However, the machine ploughed too deeply, which hindered the use of the leveller, as it made it difficult for buffalos to move on the field. Some farmers reported that the leveller could be assembled on the back of the tractor and plough, so that it levelled during ploughing. Not all operators agreed on this, however, because it increased workload and hence price, especially when they were very busy during the ploughing period.

Pest and disease management

There were three major types of pest and disease impacting the study area: rice leaffolder, apple snail and dwarf disease.

Farmers reported the emergence of rice leaffolder was observable, but their field observation was not always timely. Township level extension stations have a routine prevention schedule for the rice leaffolder; however, they no longer communicated this information at village level, and so if village farmers received the schedule it was haphazardly. Once the worm folded the leaves, the pesticide would not work. Farmers reported that using a broom made from a local grass was a labour-intensive way they had developed to remove the leaffolder once it was inside the folded leaves.

The apple snail is an exotic rice pest that grows and reproduces rapidly, and whose infestation is difficult to monitor. Farmers reported that an infestation could emerge overnight after the seedlings were transplanted or broadcast and could damage the whole crop. Farmers reported using tea seed cake to effectively prevent apple snail from getting to the field.

Farmers reported an outbreak of dwarf disease in 2017 on the hybrid rice variety named Boyou; the conventional variety was not infected. Farmers observed that the leaf of the hybrid variety was softer and larger than the conventional variety. The softer leaf attracted pests which disseminated the disease, and the larger leaf increased crop density, which hindered both the pesticide's effectiveness and crop growth. A few farmers reported they had visited extension stations and were advised that the dwarf disease was a virus, and all infected shoots must be taken out of the field to prevent further infection. A few farmers also reported they were advised by officers that rice planthopper was the major transmitter of dwarf disease, and they needed to use rice planthopper pesticide in the seedling nursery stage to prevent dwarf disease.

Soil management

The third practice was soil management through crop rotation patterns, soil classifications, and using limestone for soil neutralisation. Regarding the latter, farmers said soil acidification was worsening due to the use of chemical fertilisers, and heavy rains. They reported the use of limestone, an old practice that has been used over centuries, to neutralise the soil. Limestone was also being used as a supplement to the soil fertiliser and a few farmers reported it also kept rats away from the field. However, access to limestone had become limited because many construction factories nearby had closed. Farmers also reported that the use of manure and firewood ash to fertilise the field could prevent soil acidification problems, but their accessibility was now also limited because most farmers used tractors to plough; only a few still had buffalo, the main source of manure fertiliser. Most farmers now also used gas for cooking, thus there was no firewood ash.

Farmers reported the consideration of crop rotation patterns when they chose crop varieties and said this was for soil health. Solely growing one kind of crop or variety could deplete the soil of certain nutrients. Two major rotation patterns were reported. One was the spring season corn or peanut, then autumn season rice. Farmers reported spring season peanut benefited the autumn season rice because the peanut plant could be used directly as fertiliser after harvest when it was ploughed to the field. Corn also worked but gave less benefit to the rice. Some farmers also reported growing chilli to benefit the rice. Another type of rotation pattern was changing rice varieties every year in autumn.

Regarding soil classification, farmers reported there were two types of soil – sandy and clay. Farmers reported the soil classifications helped them make decisions on adopting advice on fertilisers. Clay soil holds water and fertilisers better than sandy soil, hence farmers in the clay soil areas reported they did not need to use fertiliser as much as farmers in the sandy soil areas, which was good for soil health.

Trials on new crops

The fourth farming practice regards to farmers' desire for new crops. The first aspect was farmer-initiated small trials on new varieties. Some farmers reported that they had been reserving small sections of land to trial new varieties. This was a means to avoid production risks. The second aspect was farmers' sharing perceptions on new crops. Farmers were considering production of high value crops, including taro and sweet corn; however, there were potential risks including the lack of technological support and transportation.

Addressing fake agricultural inputs issues

Farmers reported they were sometimes sold fake agricultural inputs, including fertilisers, pesticides and seeds. They had learned to judge genuine products by close reading of the labels: inputs manufactured by large and reputable branded manufacturers were more likely to be genuine. Several farmers reported purchasing inputs through the manufacturers' online stores or direct suppliers, thereby avoiding intermediaries. Those processes relied heavily on the assistance of farmers' younger, university-educated relatives.

(2) Discussion of the findings

Chambers et al. (1989) found that farmers tended to develop practices to improve their farming for various reasons including environment protection and resource management, including soil erosion, soil fertility, pollution and land use; increasing yield; fulfilling their own family consumption needs; and solving farming problems including pest and disease prevention. The findings of this study affirmed that farmers' practices and experiences were related to these factors. In study areas, the farmers' practices of using brooms and tea seed cake to deal with pests were driven by farming crises. Chambers et al. (1989, pp. 49-51) also pointed out that new technologies and innovations and their adoption in rural areas could cause rapid changes and challenges for rural residents and farmers. Those changes were not always positive, for example, the "green revolution" on the one hand improved grain yield, human health and water supplies in rural areas, but on the other hand led to rural environmental problems. The findings of this study showed that farmers were active agents in observing changes in their villages. Farmers reported the soil acidification problem was not prominent until commercial fertilisers were introduced and largely adopted. They saw limestone as an effective solution, but it was limited. Smallholder farmers were no longer provided with soil testing services, whose purpose was to guide the proper use of fertiliser.

Smallholder farmers being active agents corresponds with major perspectives in knowledge and innovation system theories. For example, farmers as innovator and key participants in the innovation

system cycle is considered crucial for conservation agriculture (Bellotti & Rochecouste 2014), and farmers' knowledge should be equally treated during extension decision-making and implementation (Assefa et al. 2009; Klerkx et al. 2017). The finding of this thesis implied that smallholder farmers were not viewed by officers as key participants in the extension process and were instead perceived as simple receivers of technologies. However, farmers used local knowledge of agricultural resources and of their environment, particularly in regards to soil management. Some reported the use of non-chemical approaches due to their concern for the environment and future farming. This suggests that farmers should be treated as key participants in the extension processes and agents in the innovation system. This aligns with the view that knowledge should be 'exchanged' between agronomists and farmers, rather than presented via one way delivery (Ingram 2008). A view also put forth by King (2011) in explaining the benefits of sharing expertise in a RD&E network whereby individuals can contribute technical competencies and socially engaged in joint activities. The finding of this thesis explained that smallholder farmer in China should be involved as an actor in the innovation system in order to address the complexity of agriculture and rural development, rather than simply promoting production and economic growth.

Furthermore, the results of this study align with Ayre et al. (2019) who explained that a co-design process dominated by farm advisors can effectively bring digital innovation to farmers. The findings of this thesis found that smallholder farmers themselves were actively seeking the use of digital approaches to improve their farming decisions, particularly for sourcing agricultural inputs, which had very little connection with extension officers. This suggests that farmers' self-organisation and agency can also lead to digital innovation.

Results from this study showed how smallholder farmers identified farming problems within a process to improve their farming. Farmers identified farming problems through their own experiences, through other farmers' experience and through the use of extension services. Röling and Wagemakers (1998) and Kroma (2006) pointed out many innovations came from farmers' individual learning from their experience, which evolved into a process of sharing knowledge and validated innovation within their farming network. By employing the experiential learning cycle of Kolb (2015), results from this study show farmers' individual learning starts from the concrete knowledge of what they have been observing and experiencing, and then continues when causations are deduced and then farmers' observations and reflections occurred. In the case of dwarf disease outbreak in one hybrid variety, farmers observed the different appearance between the hybrid variety and the conventional variety and concluded the possible causes of the outbreak. In the case of rice leaffolder prevention and rice planthopper, farmers reported that when they did not comply with the pesticide schedule their crop

was infected by those pests. Then they decided to change their action. Farmers also reported the hazards of using highly toxic pesticides, thus they tended not to purchase and use them.

Social learnings also occurred during focus group discussions when farmers were discussing their farming experiences and sharing their knowledge. For example, farmers expressed their perceptions on extension advice on the dosage of pesticide. A few farmers reported they usually doubled the dosage recommended by extension officers, to make sure the pests would be effectively eliminated, while other farmers said that they had been using the advised dosage and complying with the pesticide usage schedule strictly, and that more dosage would be needed only when farmers did not follow the pesticide schedule on time. Some farmers reported they had been using many types of pesticides but had failed to eliminate rice planthopper, and other farmers corrected them, saying that their spraying methods were not correct. Farmers also discussed the possible risks of being involved in contract farming, and the reasons that they did not become involved.

Kroma (2006) pointed out that social learning not only allowed knowledge to be shared among individuals, but also validated practices and innovations within networks. Leeuwis (2004) said that learning was a process of continuous interaction in an iterative cycle of reflection and actions. For example, farmers reported that by following the pesticide schedule provided by extension services, they had made a collective action on using pesticides among most farmers in the villages. Before, when there was no schedule, farmers used pesticides randomly and it affected the effectiveness of the pesticides since not all neighbouring properties were treated at once. This study suggests that extension services can play a role in facilitation of farmers' social learning.

Besides the basic elements in the experiential learning cycle and social learning framework, other elements perceived in farmers' experiences should also be noted. Lankester (2013) found that experiential learning was a good framework for examining the learning process; however, researchers should not be bound by its prescriptive elements, and other elements that are related to the process should be included. Ingram et al. (2018a) highlighted the importance of recognising the contexts of learning and the multiple elements that contribute to the process of enabling learning. Coudel et al. (2011) pointed out that a learning dynamic occurred when a new collective structure emerged and there was a change of environment, and the organisation was usually non-hierarchical and non-stable. Also, they combined the different features of the learning loops framework for analysing learning actions.

7.1.3. Research question three: What are the implications for extension services?

Research question three seeks to ascertain implications for the extension system in China based on the overall findings of this study. In order to improve the alignment of extension services with smallholder farmers' needs, the extension services should be better available at the local levels and the system should explicitly recognises the contribution of the private sector. At local levels the extension system requires a feedback mechanism to be created with extension officers at the township level, to monitor the efficiency of technologies promoted at the local level and improve decision-making processes at the provincial level. Furthermore, a feedback mechanism could articulate the voice of township level extension officers to the provincial level, allowing them to explain the challenges and unreasonable institutional arrangements occurring at the township level and promote changes. The county level agricultural department, being between those two levels, could perform a critical role in the feedback processes. At the farmers' level, the feedback mechanism could articulate the conditions of villages and farmers' extension needs to decision-makers at the provincial level, to improve extension decisions before they are promoted to the villages. This could reduce failures due to incompatible extension services being delivered to the villages; and hence reduce the waste of time and funds.

Further, the extension system should consider incorporating the private sector more explicitly. Results from the study showed the local agricultural input stores were the main providers of farming advice to smallholder farmers. Most of them were able to provide effective and reliable services. The extension system could thus consider how it could help to improve the capacity of input stores to provide services to farmers. Also, extension services provided by farmers' cooperatives were supposed to serve smallholder farmers, but their focus was on large-scale farming and provisions were not compatible with small-scale farming. The extension system can consider encouraging farmers' cooperatives to provide services to farmers outside the cooperatives that are compatible with their needs, for example, encourage them to purchase smaller capacity batch dryer and seedling transplanting tractors so that smallholder farmers can employ them.

Based on the network formation perspective of the agricultural innovation system framework, different organisations can form a network to improve the provision and quality of the extension services to better meet smallholder farmers extension needs (Klerkx & Leeuwis 2009; Friederichsen et al. 2013). Findings of this thesis showed that there were multiple actors effectively providing technology and advisory services within the extension system. They could form and work as a network, in which they interact with each other and farmers. There were different roles among different actors in the extension system. The provincial level agricultural department was the

decision-maker regarding extension services provision. It also had rights to allocate resources, subsidies and make policies. But staff lacked knowledge on farmers and the effects of the extension services. The county level agricultural department received directives from the provincial level and delivered them to the local levels. They also provided extension advice to township level extension officers for distribution to farmers. These two levels did not have much direct interaction with farmers. Meanwhile the township level extension officers and owners of input stores did have knowledge of farming at the local level and direct interactions with those farmers they could reach easily. In terms of delivering new technology and practices, township extension officers were at the bottom of the governmental extension system, they received and delivered decisions from upper levels but could not influence them.

Findings of this study showed that farmers' needs were different within the two-hectare land smallholder farming criteria. Most farmers reported they owned a half hectare of land or less (ranging from two to seven mu). Farmers reported this size of land was manageable with their own household labour, another criterion of smallholder farming. A few farmers reported they were farming their relatives' field, because their relatives had quit farming and worked in cities. This added their cultivation to one and a half hectares (around 15 to 20 mu), which was too much to manage by their own household labour and they intended to hire machines to assist with the farming. Based on the definition, both types of farmers were still smallholders, but their needs were different. Farmers who had been cultivating 20 mu of land reported they engaged the seedling transplanting machines from the farmers' cooperatives. They needed to use the machines to boost the seedling transplanting processes otherwise they would not match the time for using pesticides consistently with other farmers. Farmers reported the transplanting machine that was provided was only economically efficient at a larger scale of cultivation because the machine could not reach corners of the field; hence if smaller scale farmers employed them, they needed to recultivate seedlings on the corners afterwards. One third of the lands needed to be recultivated afterwards. Extension officers should consider the different needs of smallholder farmers when making extension decisions to better match their needs.

The implications from farmers' farming practices and learnings from experiences were: firstly, the extension system can consider collaborating with smallholder farmers in order to incorporate practice and experience, previously introduced innovations and local culture into the extension decision-making and implementation processes. This would entail conversions from a one-way transfer of technology model of extension to two-way communication and ideally co-innovation. This could improve the adoption of innovation by smallholder farmers in a more interactive and adaptive process

rather than simply giving prescriptions and telling farmers what to do. Results from this study showed smallholder farmers met their farming needs by sets of farming practices. Farmers were also concerned about whether innovations suited their local culture, for example, the rice varieties that are introduced should be suitable for local people's tastes and for making rice-related foods such as rice noodle and rice cake. Farmers have their own farming experience and that influenced their decisions on innovations.

Secondly, extension services could encourage farmers' small-scale experimentation and improve farmers' capacity in launching experimentation. Results from this thesis showed that some smallholder farmers ran their own small-scale trials on new crop varieties such as corn and chilli, to avoid risks before they adopted the new varieties for their entire crop. Bunch (1989) pointed out that farmers ran small experiments rather than large scale, to reduce the risks from failures of the chosen variety caused by weather changes, inappropriateness of the innovation to the local conditions, and inadequate understanding of the innovations. Bentley (1994) pointed out that encouraging farmers' experiments can fill the gaps in knowledge from both a research and a farming perspective. Bunch (1989) also mentioned that farmers' experiments were good opportunities for farmers to learn deeply from observing their farming activities and there was no learning by comparison if farmers only made changes to their entire crop. Nielsen (2001) pointed out that farmers view extension services as an important source of information for small-scale experimentation, not simply for obtaining direct technology. However, extension services in China tended to pass down rigid prescriptions to be used and adopted directly by farmers. Haile et al. (2001, pp. 70-1) pointed out that local knowledge and farmers innovation were based largely on farmers' experimentations, so organisations and agents should consider giving sufficient support for farmers' experiments to help recognise and assess those experiments and the knowledge produced, and reflect them back to research if possible. Stolzenbach (1994) said that helping farmers to improve their farming through enhancing their experimentation was a good learning process for all actors, and communication in the field was easier. Leitgeb et al. (2014) pointed out that farmers' experiments were based on their own ideas, which means it supports farmers to meet their own farming needs themselves and adapt to changing conditions. In this study it appeared that farmers lacked some capabilities for doing useful and effective experiments, for example, taking records and proper observations of their experiments. This calls for assistance from researchers or extension officers. Pandey et al. (2015), for example, pointed out that smallholder farmers' agency can be facilitated through farm experimentation and learning about cropping systems, whereby researchers actively provide guidance and farmers are involved in all stages of an innovation cycle. Kummer et al. (2012) pointed out that farmers' experiments could support building resilience

for better adaptation to changing environments, and implied that researchers should encourage and create conditions that supported farmers in their experiments. For example, Bellotti and Rochecouste (2014) suggest that farmer innovation can be further supported through creating networks of relationships within the rural community. Farmers in the network are heterogenous and sometimes other actors and interventions can be involved in the network, however it is farmers in particular who play a central role in the innovation process.

This study found that smallholder farmers were encountering many farming problems and changing environments, to some extent due to the poor provision of extension services and lack of knowledge. Smallholder farmers were active agents in their farming. The extension system in China can consider providing support and knowledge to encourage smallholder farmers to run their own experiments. The findings also implied that extension officers have potential role in helping farmers to improve their small-scale trials on new varieties and farming patterns, and improvement of local knowledge, rather than solely pushing innovations to farmers. Potential functions of the extension system should include recognising farmers' experimentation and their assessment of farming problems, dissemination of good local knowledge, and helping farmers to build ideas.

Thirdly, extension services should facilitate social learning opportunities for smallholder farmers. Results from this study showed that in a facilitated social environment where smallholders can be together and share experience of their farming, farmers can obtain more farming knowledge and learn more about their farming. However, besides random farmer-to-farmer communication, farmers did not have proper opportunities to share their farming problems and knowledge. The occasions of farmers' gathering with extension officers were mainly technology trainings, in which farmers were introduced to certain sets of new technologies, but not encouraged to share their farming experiences. Hellin (2012) said evidence showed that even the linear technology transfer extension modality can effectively facilitate collective actions in the rural context, but in formalising a stable social network and facilitating group learning for farmers the extension system should engage more approaches and actors collaboratively in the extension process. For example, a trusted local farmer can perform a good role in networking and group facilitating. Extension officers could consider incorporating those actors in facilitating farmers' social learning.

Essentially, policy makers should be aware of the systemic and complexity of agricultural and rural issues and find suitable interventional points within the system. From the findings of this study, several key actors and factors were found to be critical in the system. I borrow the system diagram of intervention, the Leverage Points from Meadows (1999) to clarify the relations amongst those actors and factors identified.

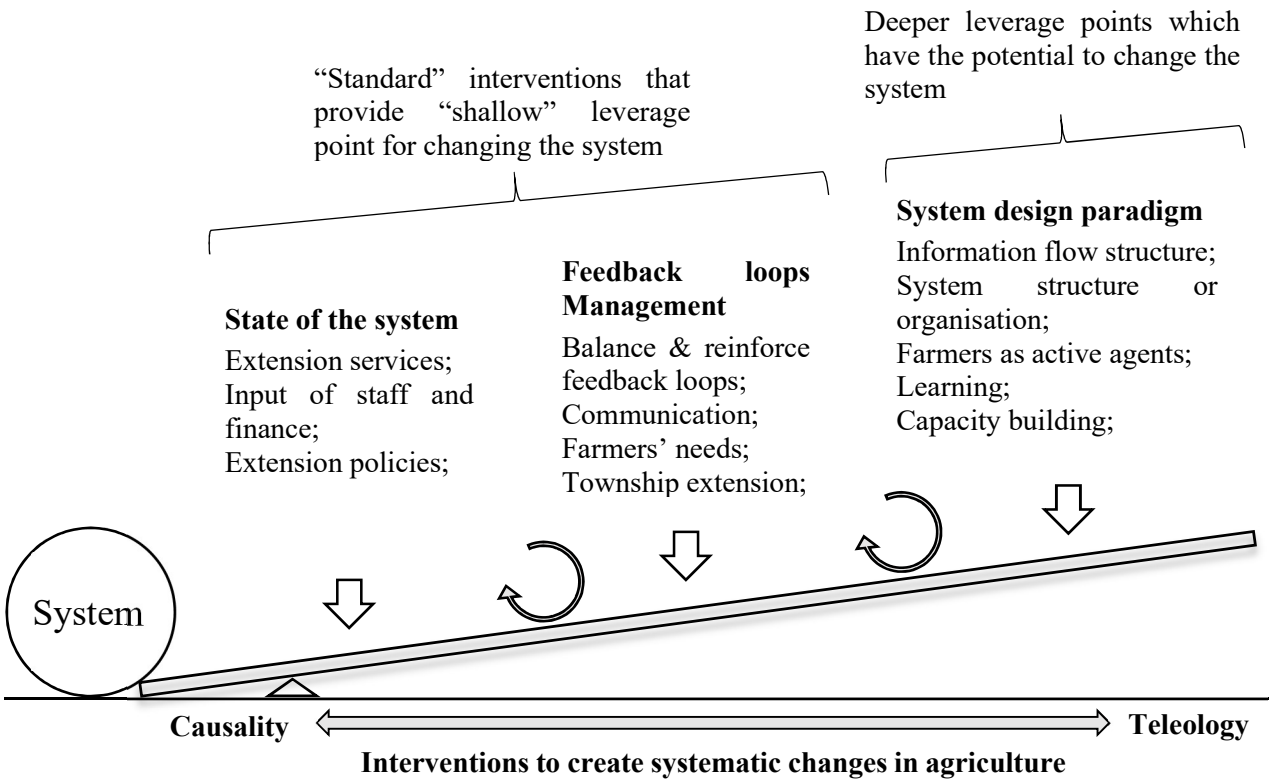

Figure 7-1 Agricultural innovation system via the leverage points perspective

Adapted from Meadows (1999) and Fischer and Riechers (2019)

As Figure 7-1 shows, according to the findings of this study, the places to intervene in the system can be categorised as three realms. The first realm involves shallow leverage points for creating changes, which in this study represents conventional methods that the government has been using. The major issue in this realm is that unsuitable extension services have been delivered to smallholder farmers which have results in minimal changes. The second realm highlights a need for feedback loops in the management of the system. In the "standard" intervention sense in the system, according to the findings of this study, the construction of a feedback loop mechanism would move the effectiveness of conventional interventions to a higher point of leverage within the system. In this study, the feedback loop mechanism would allow voices of officers at the township level and farmers' needs to be articulated to the upper government levels to improve the consistency of the extension services. The third realm of the system involves a paradigmatic change in the system, including changes in the design and goals of the system. According to the findings of this study, there is potential for the extension system to shift to a new structure or organisation, for example, changes to the township extension stations to allow officers to have viable time to do extension tasks. It is also possible for the system to shift its focus to learning and capacity building for farmers, as findings show that

farmers are active agents and play an important role in the innovation system. Within this third realm, an effective innovation system would value and respect the knowledge of smallholder farmers and would promote the sharing of information through farmer networks. wh. Satisfactory changes would be achieved for both the extension system and farmers, particularly for extension officers at the township level and smallholder farmers.

This study positions smallholder farmers as actors in the innovation system. On the one hand, as previous sections have discussed, smallholder farmers are active agents and are knowledgeable in their farming. On the other hand, as our findings have shown, smallholder farmers were limited in their capacity to use and expand their farming experience and knowledge. While extension service can build the capacity of farmers, our findings have shown that in China, farmers were generally regarded as receivers of technology and services. The lack of policy priority given to smallholder farmers has made it harder to achieve capacity building goals. Thus, the government should prioritise smallholder farmers and their actual extension needs in their policy-making, to be a better service provider at first, then a deeper consideration in the learning and capacity building. Furthermore, international organisations such as the Food and Agriculture Organisation (FAO) have been funding projects for improving farming practices in South-eastern Asian countries. For example, the FAO has been investing in projects to extend the Integrated Pest Management (IPM) technology by using farmer field school approach in Indonesia, Vietnam, Cambodia and Philippines (Van de Fliert et al. 2002). Based on a review of those projects, farmers' capacity was increased to become IPM experts (Ketelaar & Kumar 2011). Our findings have shown that there was no project or aid from international agencies in the study locations. This implies that farmers in China are more reliant on national aid. It is thus the national extension system that needs to change in order to meet smallholder farmers' needs.

The implications of this study can be difficult to be implemented in China, giving that the Chinese extension system is closely embedded in the public administrative system and the goal of agricultural production is to form larger farms rather than supporting smallholder farming. However, as pointed out in Chapter 1, it is recognised by top officials that smallholder farming would be the major form of agricultural production in China in the long term. When policy priorities switch to smallholder farming and the government decides to set up demonstration sites for smallholder farmers, implications of this study will contribute to related arrangements.

7.2 Limitations of the study

The results and implications of this study need to be considered with certain limitations in mind. Firstly, this study was conducted in only one province of China, thus its findings may or may not reflect situations elsewhere in China. Also, this study only targeted rice, as it was the staple crop in the study location and the crop that most smallholder farmers grow. The provision of extension services, and farmers' needs, may differ for other types of crops. Furthermore, this study was conducted in a specific time period. Extension services and farmers' perceptions can change over time, and this study could not capture such long-term information.

Secondly, the focus group discussions in Longtang and Zaohe villages only had one female participant each, despite the local person who helped to organise the groups trying their best to find more female participants in these villages. Both genders performed equal role in rice farming in the study locations. It should be noted that data from those two villages heavily reflected the opinions of male participants.

7.3 Implications for future studies

This study implies two directions for future research on agricultural extension and smallholder farmers. Firstly, how to enhance the effectiveness of the extension system to meet smallholder farmers' needs? Researchers may consider to what extent the institutional changes can be created. For example, how can a feedback mechanism for local voices be effectively established and what outcomes are likely to be generated. Secondly, what role can extension officers perform in supporting smallholder farmers' learning? Future studies could also consider applying a similar framework and methodology to different regions and types of crops. This would enrich the patterns revealed in this study.

7.4 Conclusions

Prior studies on supply-demand relationships in agricultural extension in China have put much focus on the extension system and its mechanisms, without equivalent attention to farmers' needs and perspectives. They have also been oriented to larger farms, to the relative neglect of smallholders. This study was designed to analyse how well smallholder farmers' farming needs were met by extension services, considering both the public and private sectors. Also, how farmers' farming needs were met by the farmers themselves through local knowledge, making their own changes to farming

practices, and learning from experiences. This study was conducted in Guangxi province with a particular crop sector, rice, which most of the smallholder farmers were growing. The study used in-depth interviews and focus group discussions to collect data on the goals and provisions of extension services, farmers' perceptions of those services, farmers' farming needs, farming practices and experiences.

The findings showed that the goals of extension services appeared to match farmers' general needs, for instance farmers sought help with pests and diseases and the extension services were supposed to provide this information. However, farmers reported mismatches because the technologies promoted were often not compatible with the village conditions; the varieties of rice promoted were poor in pest and disease resistance and not suitable for the tastes of the local people; information on pest and disease prevention was not provided at village level; and soil management services were discontinued. Farmers also reported many ways of solving farming problems themselves, through developing and sharing certain sets of farming practices and learning from experience. Examples of such practices included improvement of cultivation technologies, pest and disease prevention and controls, identification of reliable agricultural inputs, soil management and attempting to grow new varieties.

The principal conclusion was that the extension system, particularly the decision-makers in the upper levels, did not have any mechanism for investigating local conditions before extension decisions were promoted to farmers, or for soliciting and receiving feedback after technologies were transferred to farmers. This led directly to mismatches whereby farmers were introduced to sets of technologies that required specific resources which they did not have, and the rice varieties that extension officers encouraged farmers to trial did not suit the tastes of local people. Also, technologies that were introduced to farmers offered no relative advantage over farmers' existing practices. These factors should have been assessed to determine whether the technologies were suitable for the villages before they were promoted to farmers. The findings also revealed that administrative arrangements at the township level reduced the time that extension officers could spend on extension activities, hence causing avoidable mismatches in services of pest and disease prevention and soil management. The strength of the private sector can also be deployed in the system, including the agricultural input stores operated by the formal extension officers as farmers expressed a preference for their services. Farmers' cooperatives may also play a more prominent role in terms of providing suitable machinery and rice processing services for smallholder farmers.

The second conclusion was that smallholder farmers were active agents in addressing their farming needs. While they regretted lack of access to better extension services, they were not wholly dependent on such services. Farmers observed changes in their environment and identified farming

problems through observation, comparison and sharing. Farmers also used solutions from old farming practices and group sharing alongside extension services. Farmers learned from these practices, rather than simply receiving and adopting the technologies provided to them.

The study suggests that systematic institutional changes are required to reshape the extension system and services to meet smallholder farmers' needs. The system needs to be converted from one-way transfer of a technology, to a system with feedback loops from farmers – and the success of new technologies in the field – to all levels of the government system. Regular group meetings of smallholder farmers, or other forms of interaction on their farming issues and needs, would be useful for improving extension decision-making and implementation. This study showed that most farmers did not organise such group occasions themselves yet were happy to communicate. Extension officers may play a role in directly facilitating such meetings or encouraging farmers to organise them themselves. Formalised mechanisms for the extension system to seek and incorporate feedback and obtain desired outcomes are also needed.

As shown in the conceptual framework, the process of innovation diffusion is viewed as a process of the innovation system. Our findings have shown that both the government and the private sector extension providers did not perform the role of innovation intermediary satisfactorily due to the extension of incompatible technologies to farmers and the poor provision of services. Our findings have shown that local knowledge and learning play important roles in meeting farmers' needs. Thus, from the innovation system perspective, meeting smallholder farmer's needs requires changes to the existing extension system and approaches; greater involvement of more actors; and greater consideration of local knowledge and learning.

Furthermore, there is potential for a new extension model in which, rather than delivering pre-determined technologies to farmers, extension officers can work collaboratively with farmers to encourage and reinforce farmers' ideas and help them to generate (then extend) solutions based on them. Such an approach could take from and go beyond existing extension models in the international literature, for example the problem-solving model and farmers' capacity building model, whose solutions still tend to be based on extension officers' ideas. The model proposed here incorporates farmers as active agents, taking advantage of their endogenous practices, experiences and learnings. Farmers observe changes in their environment and identify farming problems. This guides much of their decision-making. Reinforcement of farmers' ideas can provide satisfactory, locally appropriate solutions for farmers. Through the proposed process, farmers can learn better than by being told what to do. This is the building of learning capacity that helps farmers to better cope with unexpected and unforeseen farming problems, particularly when the provision of extension services is limited. The

operation of the new model in the Chinese context would require a paradigmatic goal, structure and institutional change in the system.

This study contributes to the academic literature relating to agricultural innovation systems and farmers' learning. The findings of this study have shown that the extension system in China has been using technology and information delivery approaches in terms of provision of services to smallholder farmers, and the challenges in the extension system, particularly at the local level, have constrained both its performance in meeting smallholder farmers' needs, and the capacity of the agricultural innovation system to create systemic changes. This study contributes empirical evidence in the Chinese context that smallholder farmers are active agents in perceiving, identifying and solving their farming issues. This suggests that smallholder farmers are important actors in the agricultural innovation system; however, the findings also suggest that farmers' capacity to do so is limited, and thereby highlight the direction to which extension services in China can switch their focus. At the methodological level this study demonstrates that using a mixed method to investigate the nested provincial-to-village levels can provide insights for the understanding of agricultural extension systems and farmers.

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Appendices

Appendix 1: Semi-Structured Interview Guide

Semi-structured interview guiding questions

Guiding questions

1. How many years have you been in the job of agricultural extension service?
2. Can you briefly describe your work regarding rice farming? What services do you provide (expand: marketing information? supply chain? input market governance?)
3. What are the relations of your work to your business (private sector)?
4. Can you tell technologies or farming practice that promoted and contributed to the regional rice farming in recent years?
5. What are your goals in your agricultural extension services regarding rice farming? (expand: food security? productivity improvement? farmer's livelihood?)
6. What do you think is the role of smallholder farming in contributing to agriculture? What do you think smallholder farmer needs from extension services regarding the rice farming? What are the approaches to identify their needs?
7. What do you think are the major role/functions of agricultural extension services to smallholder farming (expand: technology delivery? problem solving with farmers? supply chain? encouraging farmer's learning?)
8. What are your perceptions to farmer's own ideas and practices in their farming?
9. What do you think are the challenges of current agricultural extension services? Do you have any ideas or practices that will potentially improve smallholder rice farming and extension services?

Conclusion

Thank you for your participation. This has been a very successful interview.

Your opinions will be valuable to the study.

If you find anything that you are uncomfortable with or wish to complain about, please do not hesitate to contact me, the supervisor of this study or the academic ethics officer at the university.

We would like to remind you that your comments featuring in this thesis will be anonymous.

Please come over and collect your gift as our sincere thanks to your participation.

Appendix 2: Focus group discussion guideline

Facilitator's greeting, introduction and instructions to participants

Greeting

Welcome and thank you for volunteering to participate in this focus group discussion. You are invited to participate as your opinions are important to this study. We realize you are busy, and we appreciate your time.

Introduction

This focus group discussion belongs to the research project for obtaining the PhD degree at the University of Queensland. It has been granted the academic ethics approval. It is designed to know about your farming and your experience and point of views about the past or current agricultural extension services in this region. This focus group discussion is going to take no more than two hours. The assistant moderator will take notes while you are discussing. May we record the discussion by digital device for the only purpose of recollection? (if yes, turn the recorder on)

Anonymity

We hereby assure that this discussion and any information that you provide will be kept anonymous. The notes and recordings will be kept safely in secured place and facility. We will transcribe notes and recordings into transcripts, and we would like to remind you that the transcripts of the focus group discussion will not contain information that would allow individual subjects to be connected to specific expressions. We hereby inform that your participation is fully based on your willingness and consent. You have rights to withdraw your participation and your provided information at any time and there will be no consequences. It will be appreciated if you would refrain from discussing any comments with other group participants outside this group.

Ground rules

Generally, only one person speaks at a time. If anyone has any temptations to jump in when someone is talking, please wait until they finished. Please avoid side-chats while someone is talking. We would like to remind you that there are no right or wrong answers, and you do not have to speak in any order. Please feel free to express because it is important to obtain everyone's opinions. Please note that you do not have to agree with other participants' opinions within the group.

Warm up

We like everyone to introduce themselves. Can you tell us your crops that you farm and their size?

Focus group discussion guiding questions

Introductory question

We are giving you two minutes to think about your farming and experience with the extension services and officers.

Guiding questions

1. Can you give an overview on your rice farming within recent years?
2. What are the challenged changes that emerged in recent years regarding your rice farming?
3. What do you do to deal with those changes? Whom do you turn to?
4. What did you get form the current extension services? The public sector and the private sector?
5. What do you expect to get from the extension services? The public sector and the private sector?
6. What are your perceptions on the extension services? The public sector and the private sector? The good things and/or the bad things?
7. Are there any approaches that you use to deal with changes without extension services present? If yes, can you give some one to two example(s)?
8. What do you learn from those experiences?
9. How do you think can the extension services be improved regarding effectively meeting your needs?

Concluding question

What do you think are the most important issues that we discussed today about the extension services in your region?

Conclusion

Thank you for your participation. This has been a very successful focus group discussion.
Your opinions will be valuable to the study.
If you find anything that you are uncomfortable with or wish to complain about, please do not hesitate to contact me, the supervisor of this study or the academic ethics officer at the university.
We would like to remind you that your comments featuring in this thesis will be anonymous.
Please come over and collect your gift as our sincere thanks to your participation.

Appendix 3: Nvivo codes used for qualitative analysis

Tree nodes 2

Name	Files	References	Created By
Researchers at the university	0	0	CL
Extension system is government-led;	1	2	CL
Functions extension station regarding pest disease management;	1	3	CL
University's role in extension;	2	21	CL
Local level extension system has broken;	2	10	CL
Issues about extension officer being involved in input business;	1	3	CL
Government does not know what researches universities are doing.	1	2	CL
Universities are not participating in extension directly;	1	1	CL
Universities do trainings for extension officers;	2	15	CL
Many researchers do not know what farmers' needs;	2	9	CL
Government is promoting large farms;	1	1	CL
Top-down approach in extension system;	1	1	CL
Farmers' innovation is overlooked by researchers and extension;	1	6	CL
Issues with farmers' cooperatives;	2	6	CL
Short of funding for local extension system;	3	10	CL
Academic assessment system at universities;	2	3	CL
University graduates tend to find job at cities, not rural areas.	2	4	CL
Officers in the agricultural and extension departments	0	0	CL
Non-tillage method;	6	11	CL
Pest and disease management;	8	18	CL
Soil test and fertiliser formulation;	7	19	CL
New varieties;	11	24	CL
Direct seeding method;	6	13	CL
Weather forecasting for farmers;	7	7	CL
Seedling broadcasting;	10	24	CL
Seedling nursery and industrialised transplanting;	5	10	CL
Rice drying through farmers' cooperatives;	1	1	CL
Farmer's extension trainings;	14	106	CL
Technology demonstrations;	3	7	CL
On-site extension and problem-solving advice for farmers;	6	10	CL
Short of fund for local extension officers;	8	27	CL
Institutional merge in the township extension stations;	7	10	CL
Short of staff;	7	7	CL
Additional duties from the township government;	3	3	CL
Additional duties~ Food safety and input market monitoring;	2	4	CL
No incentive to do extension work~ no performance assessment; promotion and salary;	4	8	CL
Transportation issues – officers use their own motorcycles;	3	3	CL
Extension special vehicle granted from upper levels;	1	1	CL
No fund for petrol and vehicle maintenance;	1	1	CL
Many input stores are not qualified~ fake inputs and lack of knowledge;	2	4	CL
Unreasonable incentives for farmers to attend trainings;	2	3	CL
Owner of agricultural input stores	0	0	CL
Dwarf disease outbreak in rice farming;	1	2	CL
Farm visit to provide advice;	1	1	CL
Pest and disease information update for farmers;	2	2	CL
Farmers bring crop samples to identify problems;	1	1	CL
Use photographic books to help farmers identify crop disease;	1	1	CL
Displayed infected crop in stores to help farmers identify crop disease;	2	2	CL

Tree nodes 2

Name	Files	References	Created By
Clearly mark instructions in the pesticide bottle;	1	1	CL
Do not sell pesticide to farmers when approaching harvest time - food safety concern	1	1	CL
Most farmers do not understand how to correctly use fertiliser and pesticides;	1	1	CL
Some extension officers are not competent;	1	1	CL
Many input stores sell illegal high-toxic pesticides;	1	1	CL
Input sellers communicate to update pest and disease information;	1	1	CL
Leaders of farmers cooperatives	0	0	CL
Provide field management, irrigation; fertiliser, pesticides and machines services for farm	2	3	CL
They mainly provide services for their members;	2	2	CL
Rice farming was not profitable for smallholder farmers;	1	1	CL
Agricultural department has provided trainings and subsidies for their establishment;	2	2	CL
Rice drying service only aims at large scale farming.	2	3	CL
Planning to do high value crops and production.	1	1	CL
Smallholder rice farmers – farmers' needs and perceptions on extension services	0	0	CL
Improved cultivation technologies~ reduce labour and time;	7	12	CL
Farming problem solving advices~ identification and solutions;	11	18	CL
Improved rice varieties~ high yield, good pest and disease resistance and suitable taste;	11	80	CL
Soil information~ soil condition and fertiliser advice;	10	38	CL
Low toxic pesticides and weedicides;	6	9	CL
Drying rice is difficult;	5	6	CL
The Boyou hybrid variety has poor pest and disease resistance;	7	43	CL
Suitable varieties for accommodating cropping rotation pattern;	10	46	CL
Non-tillage seedling method~ high risk, high cost and difficult to perform;	2	2	CL
Seedling broadcasting method~ effectively reduce labour and time;	11	64	CL
Direct seeding method~ weed problem;	4	10	CL
Pest and disease prevention services~ not timely, no on-site information;	7	13	CL
Soil test and fertiliser formation technology~ farmers need it, but its provision did not co	6	20	CL
Transportation is difficult to visit the extension station;	3	5	CL
No support from extension officer when attempting to do other varieties;	1	3	CL
Extension trainings are uniform, not specific to their village;	1	1	CL
Agricultural input stores run by former extension officers are preferred;	3	6	CL
Collective actions amongst all farmers~ pesticide and fertiliser application;	8	20	CL
Experiences with fake seeds and fertilisers;	8	22	CL
Smallholder rice farmers – farmers' knowledge and learning	0	0	CL
Improved land ploughing using leveler;	1	1	CL
Rice-leaffolder management~ identification and solutions;	9	46	CL
Apple snail management~ identification and solutions;	11	28	CL
Rice dwarf disease management~ identification and solutions;	5	25	CL
Small farm trials on new varieties before scaling up to the whole crop;	3	10	CL
Identification of input stores and sources of inputs;	7	20	CL
Fertiliser distinguish;	7	10	CL
Soil neutralisation~ identification and limestone solution;	9	19	CL
Soil classification~ identification and solutions;	9	20	CL
Learning from books and materials;	6	10	CL
Learning from other farmers~ social learning; use of pesticides; pest and disease identific	5	7	CL
Learning from extension services~ soil management; usage of fertiliser;	7	9	CL
Learning from farmer's own experiences~ experiential learning; use of pesticides; pest an	7	18	CL

Appendix 4: Example of coding processes and theme generation

Transcript text	Open-coding theme	Categorised theme	Synthesised theme
"*We follow the upper level's requirement to sample soils in every piece of field in every villages, return them to the department, they have professions and devices to do labels and tests, after that they post results online and return to villages, we post them on public premises, farmers should know what elements their soil has and what fertiliser to use.*" (In-depth interview with officer)	Process of the soil test technology for farmers – Extension officer Soil test extension approach, soil sample collection and test – Extension officer	The soil test service offered by extension officer	Extension officer and farmers' agreement that the soil condition has worsened; Farmers' perception on soil changes; Mismatch of the soil test service because of inconsistency of provision.
"*The soil test technology is mainly for improving the soil, before farmers use too much nitrogen fertiliser, the soil has digested too much nitrogen, by testing the soil farmers would know what is lacked and what fertiliser to use precisely, the heavy metals pollution can be tested as well, safer and efficient.*" (In-depth interview with officer)	The soil situation worsens, overuse of nitrogen fertiliser – Extension officer Farmers have been misusing fertilisers – Extension officer		
"*I think formulating fertilisers based on the soil's conditions would improve yield. We farmers use same fertiliser every year. I am not an expert, but I think that makes the soil fertility weaker year by year.*" (FGD with farmers) "*Farmers do not know, they use the same fertiliser every year, I think that leads to lacking some elements in the soil; farmers have been using fertiliser more than the soil needs, they have to use fertiliser reasonably.*" (FGD with farmers)	Soil condition worsens because farmers do not know how to use fertiliser – Farmers	Farmers' perception on the soil test service	
"*…they have launched training in the village committee premise, farmers got money for participation, they mentioned to test soil, formulate fertiliser and improve soil and yield, but no one has ever come for it afterward.*" (FGD with farmers)	Government came for soil test technology, but only once – Farmers		
"*…they are basically task-oriented, which village is convenient to travel to, they choose there, they are not testing every piece of field, they have to test every piece of field so that the soil test*	Officer only did a small scale of land, which is not useful – Farmers		

Transcript text	Open-coding theme	Categorised theme	Synthesised theme
is sensible." (FGD with farmers)			
"*…soil is like human, lack of calcium you should supplement calcium, lack what eat what, otherwise you eat nutrients that you do not need, it is useless, it is a blind action; and always eating the same thing is also useless, should change to the fertilisers that are actually needed for the soil*." (FGD with farmers) "*…usually phosphorous is suitable for base fertiliser, and maybe one more round of composite fertiliser; and don't use potassium, it is for the shoots grow strong and thick; and don't use too much urea fertiliser and eyes irritation fertiliser (nitrogen fertiliser).*" (FGD with farmers)	Recognition of diversify the use of fertiliser – Farmers	Farmers' learning from extension service	Farmers' learning Farmers' knowledge and experience Farmers as active agent in farming.
"*The practice of farming would be quite different regarding to your soil type, two farmers use the same amount of fertiliser, one is better than the other, it is just because of the soil type, I was told by my father-in-law, who is in different village, that use certain amount of fertiliser in the first fifteen days but it turned out not enough for us, the rice was still weak, it was because the soil textures were different.*" (FGD with farmers)	Soil categorisation and classification – Farmers	Traditional soil management practices Farmers' identification of soil issues.	
"*This year has been a lot of rainfalls, this makes the soil gets acid easily. Rainfall flows the yellow dirt from the highlands to the farmland, especially those been excavated for building roads, it is well observable, also the rainfall can be polluted by the emission of the nearby concrete factories, lots of dust emits to the air, there has to have some relations to the acid rain; some farmlands do not have good water drain system, water cannot drain away in time.*" (FGD with farmers) "*Limestone is one solution to the soil acidity, it has been used since the collective farming.*" (FGD with farmers)	Soil neutralisation – Farmers Perceptions on soil – Farmers		

Appendix 5: Information sheet for participants in data collection

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Information Sheet

Empowering smallholder farmer through innovation and learning in China

Purpose of the study

This research project is being conducted by the researcher, Chengdong Liao, as a part of the requirement of obtaining the Doctor of Philosophy at The University of Queensland under the supervision of Dr Gomathy Palaniappan and Prof Helen Ross. This study will explore the interactions amongst smallholder farmers who are involved in rice production and extension services, and the innovation and learnings of the farmers. In order to gain a deeper insight in this content, the researcher would like to work with you and explore your perception, experience and knowledge related to your farming. The way of its conducting will be semi-structured interviews with the extension officers and focus group discussion with the farmers.

Participation and withdrawal

You are invited to participate in this study voluntarily. Under your agreement, you will be involved in a focus group discussion and will be asked questions related to your knowledge and experience about your rice production and your perceptions on extension services. Your provided information will be coded and stored with secured methods. The expected timeline for this interview will be sometime between March to August in 2017. The duration of each interview will be 45 to 60 minutes and each focus group discussion will be 90 to 120 minutes. If you permit, the interview will be recorded by a device. The recorded materials will be used for transcription for this study only. The precise timing for this interview will be determined by your convenience and its process will be finalised only between you and the researcher.

Please note that your participation to this study is completely voluntary and you are free to withdraw from this interview at anytime. If you decide to withdraw from this interview, all the recorded materials, hardcopy notes and digitally stored information will be destroyed and not be used in this study. You can determine whether quotes and comments within the research outputs are identified personally to you, to your organisation, to your interest group or be kept anonymous on the informed consent form. All the materials related to this research project will be stored securely and only be accessible to the researcher and his team. All the identified information on the raw data will be removed to maintain confidentiality. All the information that provided or related to you in all circumstances will be used in the research purpose of The University of Queensland solely. A short summary of report will be made and be available to you as a important feedback of this interview.

Ethical clearance and contacts

This study coheres to the Guidelines of the ethical review process of The University of Queensland. While you are free to discuss your participation during or after this study with the principle researcher Chengdong Liao, by email: [redacted] or phone: [redacted]). If you would like to speak to an officer of the university who is not involved in this study, you may contact Dr Ammar Abdul Aziz (email: [redacted] or phone: [redacted]). Furthermore, if you would like to speak to the principle supervisor of this study, you may contact Dr Gomathy Palaniappan (email: [redacted] or phone: [redacted]).

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

课题信息卡

课题介绍

朋友，您好！我们正在进行一次社会调研，目的是了解您在农技推广工作或农业生产过程中的相关经验，以便更好地丰富农业推广理论，促进中国的农技推广事业发展。此次调研属于澳大利亚昆士兰大学农业与食品科学学院，是昆士兰大学廖成东博士研究课题的数据搜集环节。其课题的核心内容为探索中国小农户的创新与学习行为及其与农技推广体系的互动，指导老师为昆士兰大学农业与食品科学学院 Gomathy Palaniappan 博士和 Helen Ross 教授。调研方式为半结构式访谈或核心小组讨论。

您的参与权与撤回权

我们郑重向您说明：此次邀请您参与调研的行为将完全基于您的意愿。我们将邀请您回答一些关于您的农技推广工作或农业生产的问题。我们将在您方便的时间邀请您参与调研。此次调研将在 2017 年 4 月至 8 月展开。关于时长，若是半结构式访谈则为 45 至 60 分钟，若是核心小组访谈则为 90 至 120 分钟。届时我将严格控制好时长，绝不耽误您宝贵的时间与空间。

我们郑重向您承诺：您在此次调研里提供的一切信息将会被做完全匿名处理并绝对安全和严格地保存好。您的一切个人信息（包括姓名、工作单位和联系方式等）将不会体现在任何地方，包括原始数据、访谈记录和研究报告等。此次调研过程中研究者或许会对您提供的信息做简单笔记。如必要，或许还需要使用录音设备，但我们会在调研前明确向您说明并征求您的同意。您在此次调研中提供的一切信息将只用于科学研究的目的并保存于昆士兰大学，同时也仅限于该课题内研究人员能够查询。

我们同时向您说明：您有权在调研期间内的任何时间取消参与，或在调研后未来的任何时间内撤回您所提供的一切信息。如果您决定取消或撤回，我们保证您将不会承担任何责任并把您提供的一切信息作完全销毁处理并向您寄送相关证明。调研结束后我们承诺将适时向您寄送相关报告以让您知晓您提供的信息的处理方式。

伦理评估与联系方式

此次调研的设计与执行严格遵守昆士兰大学学术伦理规范指导并已通过昆士兰大学学术伦理委员会评估。若您对此次调研有任何疑问，请联系该课题承担者廖成东（电话：[redacted]、电子邮件：[redacted]）。若您希望联系与该课题无关的负责人，请联系 Ammar Abdul Aziz（电话：[redacted]、电子邮件：[redacted]）。若您希望联系该课题的指导老师，请联系 Gomathy Palaniappan（电话：[redacted]，电子邮件：[redacted]）。

Appendix 6: Informed consent form for participants in data collection

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Consent Form

Empowering smallholder farmer through innovation and learning in China

I volunteer to participate in this research project conducted by Chengdong Liao from the University Of Queensland. I understand that the project is designed to collect information about academic work for the project. I will be one of the participant that being interviewed for this research.

1. My participation in this project is voluntary. I may withdraw and discontinue my participation at any time. If I decline to participate or withdraw from the study there will be no consequences.

2. My participation will involve being interviewed by the researcher. The interview/ discussion will last approximately 45-60 minutes/90-120 minutes. Notes will be written by the researcher during the interview/discussion. I understand that this interview/discussion will be recorded. If I do not want to be recorded I will let the researcher know and not be able to participate in the project.

3. I understand that the researcher will not identify me by name in any situation. My confidentiality will remain secure.

4. I understand that he collected information from me will be only accessible by the researcher and his/her researcher team.

5. I understand that this study has been reviewed and approved by the School of Agriculture and Food Sciences at the University of Queensland. For research problems or questions the institute and people can be contacted through.

6. I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

Name: ..... Signature: .....

Date: ..... /..... /.....

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

知情同意表

通过阅读以上“课题信息卡”的相关内容以及该课题负责人廖成东的介绍和补充，我已知晓该课题研究者为昆士兰大学农业与食品科学学院廖成东，此次调研是其完成博士研究数据搜集环节的内容之一。我将与其他参与者一样参与此次调研。参与形式为半结构式访谈或焦点小组讨论。

一、我已知晓此次调研的参与是完全自愿的。我有权在调研期间的任何时间内退出，以及在调研后未来的任何时间内撤回我所提供的信息。如果我决定退出访谈或撤回信息，我将不用承担任何后果。

二、我已知晓此次调研的时间安排，若为半结构式访谈则为 45 至 60 分钟，若为焦点小组讨论则为 90 至 120 分钟。调研期间研究者将对内容做书面笔记。录音设备可在我充分了解并同意后合理地使用。

三、我已知晓我所提供的任何信息、在任何时间内都将被匿名处理并被安全、妥善地保管。

四、我已知晓我所提供的任何信息、在任何时间内都仅能被与该课题有关的人员所查询和获取。

五、我已知晓此次调研的设计与实施已经通过昆士兰大学农业与食品科学学院学术伦理评估委员会的评审。我了解在调研期间或未来的任何时间内，如果我有任何疑问我都能够联系到相关的负责人进行询问。

六、我已阅读并了解这个调研的相关信息。关于参与该调研的相关疑问我已得到满意的答复。

基于以上，我同意并自愿参与此次访谈或小组讨论。

姓名：_____

签名：_____

日期：_____/_____/_____

Appendix 7: Summary of data collection date

Data collection conducted	Date
Interview with researcher #1 at Guangxi University	5th May 2017
Interview with researcher #2 at Guangxi University	27th May 2017
Interview with officer #1 in Provincial agricultural department	22nd May 2017
Interview with officer #1 in Hepu county agricultural department	6th June 2017
Interview with officer #2 in Hepu county agricultural department	6th June 2017
Interview with officer #1 in Lingshan county agricultural department	30th August 2017
Interview with officer #2 in Lingshan county agricultural department	30th August 2017
Interview with officer in Gongguan township	31st July 2017
Interview with officer in Quzhang township	14th August 2017
Interview with officer in Changle township	29th August 2017
Interview with officer in Zhakou township	13th September 2017
Interview with input seller in Lingshan county	1st September 2017
Interview with input seller in Hepu county	16th September 2017
Interview with officer in Shitang township	31st August 2017
Interview with officer in Pingshan township	1st September 2017
Interview with officer in Xinxu township	1st September 2017
Interview with leader #1 in farmers' cooperative in Lingshan county	31st August 2017
Interview with leader #2 in farmers' cooperative in Lingshan county	31st August 2017
FGD with smallholder farmers in Zhangjia village	3rd August 2017
FGD with smallholder farmers in Liannan village	12th August 2017
FGD with smallholder farmers in Xianggu village	29th August 2017
FGD with smallholder farmers in Shitang village	31st August 2017
FGD with smallholder farmers in Pingshan village	1st September 2017
FGD with smallholder farmers in Xinxu village	1st September 2017
FGD with smallholder farmers in Zaohe village	6th September 2017
FGD with smallholder farmers in Qumu village	11th September 2017
FGD with smallholder farmers in Lingjiao village	13th September 2017
FGD with smallholder farmers in Shayin village	14th September 2017

Appendix 8: Ethics approval letter

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Agriculture and Food Sciences

CRICOS PROVIDER NUMBER 00025B

31 March 2017

Approval ID: SAFS/H17/03
Student ID: 43972506

Dear Chengdong

Ethical Research Application – APPROVED

On behalf of the SAFS Ethics Committee this letter is to formally advise that your application for ethical research involved with your PhD research project titled 'Empowering smallholder farmers through innovation and learning in China' has been approved.

We wish you every success with your research.

Yours sincerely

Keryn Eaton | Academic Services Officer
School of Agriculture & Food Sciences | Faculty of Science
The University of Queensland | Gatton Queensland 4343 | Australia
T: +61 7 5460 1691 F: +61 7 5460 1324
E: SAFS_Student_Admin@uq.edu.au W: http://www.uq.edu.au/agriculture/