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Farmer's Adaptation to Climate Risk in the Context of China

-A research on Jianghan Plain of Yangtze River Basin

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Abstract

Frequently unknown climate change increases the risk of agriculture, more attention have been paid to agricultural system itself in the research field, but few has been attached to the perspective of social dimension. Based on the research on Yangtze River Basin of China, the paper has adopted vulnerability theory including the exposure of agricultural ecosystem, farmers' sensitivity to exposure and adaptive capacity to climate risk, to explain farmer's adaptation to climate risk. It concludes that climate change has increased climate risk in agriculture and the uncertainty of agricultural production. Confronting climate risk in agriculture, different farming bodies have shown different farm and off-farm/non-farm adaptations in pre-risk, during risk and post-risk, which has reduced their short-term vulnerability. Household life cycle, pressure, institution, available resources and technologies are the key influential factors. From the adaptation in long term, it still requires external support and more investment including agricultural insurance system, village-level information and technology dissemination mechanism.

Key words: Climate risk; vulnerability; adaptation; traditional knowledge; exposure-sensitivity 1S

1. Introduction

With large emissions of greenhouse gases, changes in temperature and humidity, as well as extreme weathers [1], climate change has been an existing and obvious fact in our world and more and more research are taking on in this field. Agriculture is arguably referred as one of the most climate sensitive sectors [2] and it has produced positive and negative implications to climate change. Olesen et al. [3] summarizes that the intensive farming systems would have great impact on emissions of greenhouse gases such as in Western Europe, whereas some of the low input farming systems currently located in marginal areas may be most severely affected by climate change like in sub-Saharan Africa. Therefore, in the context of global climate change, more attention on reducing agriculture's contribution to the greenhouse gas should be paid to intensive farming systems while the subsistence farming systems should work more on decreasing agricultural vulnerability to climate change. The latter situation will be discussed in this paper.

Agricultural production has always been a risky endeavor [4] and the agriculture vulnerability to climate change is widely recognized in scientific and policy circles, as identified in international policy agreements [5]. The research on climate change in international rural development began in the 18th to 20th century, and it mainly concentrated in the climate impact on crop growing environment and crops itself adaptation. When came to 21st century, with the frequent occurrence of extreme events in the world, farmers' adaptation perspectives become the dominant theme. Actually, many studies in different countries have explored farmers' vulnerability and adaptation

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to climate risk such as in USA, Canada and Africa [5] [6] [7]. All of the studies have provided some empirical evidence and remarkable lessons for farmer's adaptation to climate change. Adaptation science and international framework for joint or collective action are also in the on-going process [2]. Besides, Monirul et al. [8] believes that developing countries are vulnerable to extremes of normal climatic variability, and climate change is likely to increase the frequency and magnitude of some extreme weather events and disasters.

As a developing country, China is also facing the similar problem in the arena of rural development. However, in the context of China, farmer's response to climate risk, as one of the issue on social dimension research on climate change, has yet to become a high priority item and there is little evidence and lessons being taken to facilitate the adaptation.

Based on empirical research at farmer level in two administrative villages of Jianghan Plain of China, which are located in the Middle and Low Reaches of Yangtze River Basin, this paper explores Chinese farmers' exposure, sensitivity, adaptive responses and adaptive capacity to climate risk in crop farming systems. The remainder of this paper is organized as follows. Section 2 reviews the adopted theories. Section 3 provides an overview of agriculture and climatic variance in Jianghan Plain. Section 4 discusses research approach and methodology, research framework, study area, data collection and analysis. Section 5 presents results and concludes.

2. Climate change, vulnerability theory and adaptation

Climate change has been an existing fact in today's world. For research issues on climate change, at first, many studies focused largely on predicting how certain biophysical systems were being affected by and would respond to climate change. After getting better understanding of how climate changes affect biophysical processes, the research has been shifted into its implications to human activity and that requires attention to human dimensions [10]. Since farmers are sensitive and exposed to a range of climatic and non-climatic forces which do not act in isolation of each other [5], systematic analysis method has been introduced to explore the complicated relationship between climate change and farmer's adaptation. Vulnerability theory is such a kind of method.

Vulnerability is such a concept that was mentioned in different research traditions [11]. Research on vulnerability to the impacts of climate change spans all the antecedent and successor traditions [12], because it is explicitly referred to in the United Nations Framework Convention on Climate Change where commitments are made by countries to promote adaptation to address vulnerable regions and peoples [10].

In order to target the vulnerable regions and peoples, many indicators and measurement methods have been explored. One of the most influential and widely-used components is the one defined by IPCC, and it includes exposure, sensitivity and adaptive capacity [10]. Exposure in this case is the magnitude and duration of the climate-related exposure such as a drought or change in precipitation, sensitivity is the degree to which the system is affected by the exposure, and adaptive capacity is the system's ability to withstand and recover from the exposure [13].

For the relationship, Ford et al. [10] believe that exposure-sensitivity is dependent upon both the characteristics of climatic conditions and the nature of the community in question which varies among groups of the community; adaptive capacity is dynamic, varying over space and time with the characteristics of the human system; there are not mutually exclusive between exposure-sensitivity and adaptive capacity and here is the example, the range of technological available for adaptation may enable exposure to be managed while the same technology may also affect risk evaluation strategies and result in more risk taking behavior. Based on the experimental research in Africa, Hahn et al. [14] have given some further major sub-components and indicators, such as Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water and Natural Disasters and Climate Variability. Multiple factors including broad-scale and local factors have been approved to affect vulnerability too.

Depending on the scale of the target group, vulnerability concept can be applied in different levels including the state level, the institutional level, community level and farmer level. Top-down approach and bottom-up approach are two different modes for assessing vulnerability perspective. Since farmers are the first actor confronting the change of climate and farming system change, it is necessary to understand and gather farmer's perception and adaptation to climate changes.

Adaptation is a process of deliberate changes, often in response to multiple pressures and changes that affect people's lives, and successful adaptations may be viewed as those actions that decrease vulnerability and increase

resilience overall, in response to a range of immediate needs, risks and aspirations [15]. In order to create a harmonious environment both internal and external; and to invest in social adaptation, it will be very favorable to identify the precise drivers and determinants and understand the strategic process of adaptation at farm-level.

3. Overview of climate change and agriculture in Jianghan Plain of China

China is a developing country in the world with large land area, which determines that in the context of China, climate change and agriculture varies in relation to time and space. The Jianghan Plain in Hubei Province, located in the central area of China and as one of the four plains in Yangtze River Basin, is selected as the research study site. It was formed by the rushing water of Yangtze River and Hanjiang River and located at north latitude of 29°26′-31°10′ and east longitude of 111°45′-114°16′ [16]. Water table is usually 0.5-1.0 meters away from the earth's surface [16], which makes water logging easily happen in the rainy days.

For climatic resources, Jianghan Plain has a subtropical monsoon climate with 2000 hours in Sunshine Duration, 460-480 KJ per square centimeter in Annual Solar Radiation, 240-260 days for frost-free period and 5100-5300 ℃ for active accumulated temperature [16]. The abundant agricultural climatic resources make the local area famous for "a land of milk and honey" and the well-established agricultural infrastructure, especially the irrigation facilities, has increased the advantages for the local villagers in the area of agriculture farming.

However, the global climate change also influences the local agricultural climate resources. According to the data provided by the 147 climate sites in Yangtze River Basin, the average temperature in 1990s had increased by 0.33 ℃ and during 2001-2005, the temperature had increased by 0.71 ℃; as for the rainfall of the whole years in 1961-2005, the change was not so significant but with slender increase, while in seasonal trend, it changed a lot [17]. The research also predicts that in the following 50 years, the ground temperature in Yangtze River Basin would raise 1.5 -2 ℃ and the frequency of extreme climate occurrence will show a further increase trend. Based on the meteorological data in Hubei Province, related research also shows that the main agricultural climate risk is just increasing, and seasonal wind, temperature and rainfall are the key climate risky factors [18] [19].

Traditionally, the agriculture of Jianghan Plain is double-crop rotation annually and two types of farming field, the paddy field and dry land can be found. Different crops are grown in different types of land and different demands for water are required depending on the growing periods. Accordingly, the farmers in Jianghan Plain have relatively strong adaptive capacity to climate change due to the available facilities in the area such as infrastructure and relative high economic status compare to the other regions, however, it couldn't prove that the climate risk on agriculture is negligible towards the external environmental risks and farmers have to respond to the climate change by themselves.

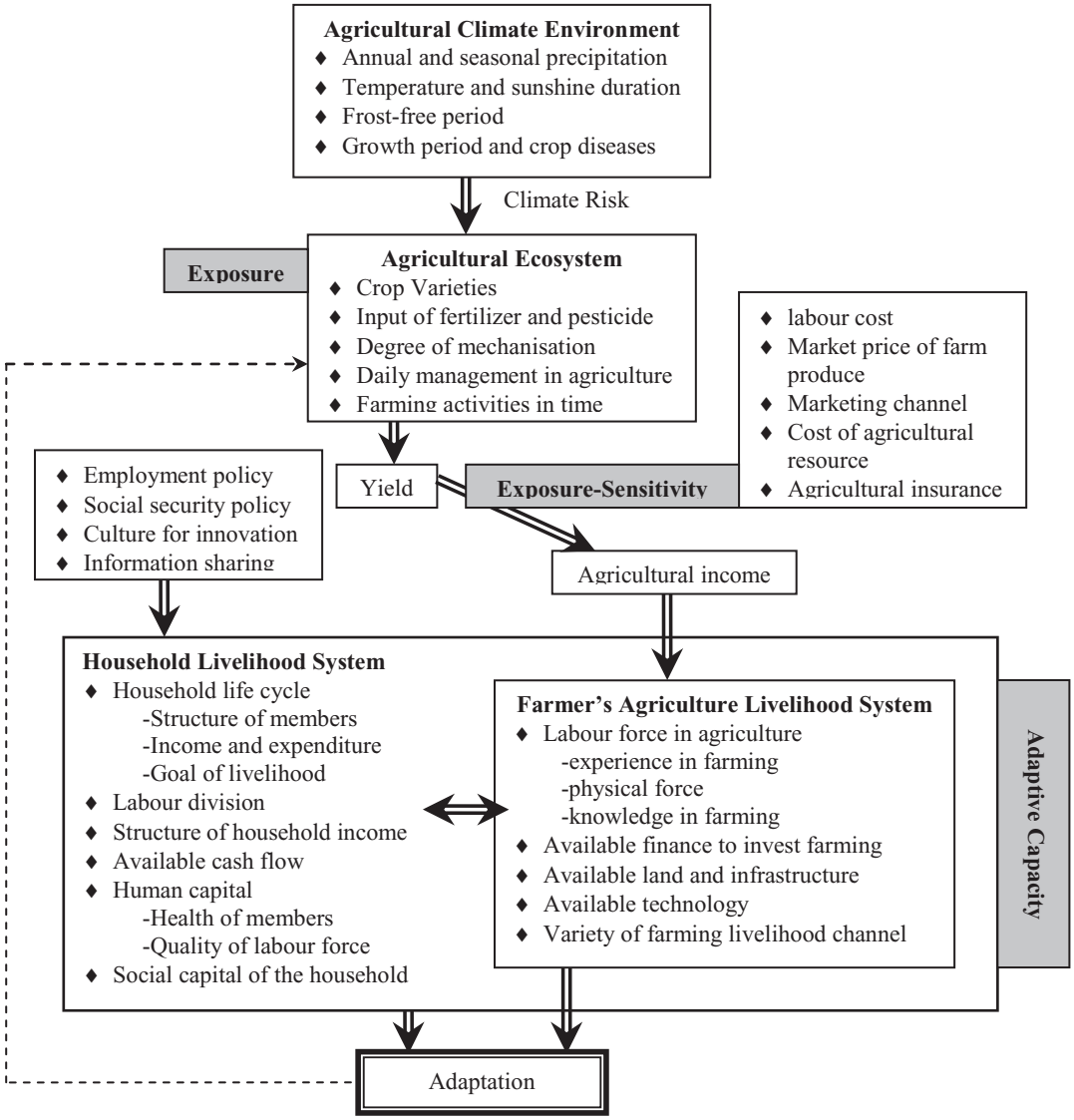
4. Research approach and methodology

This paper is based on both, a review of the existing literature and empirical research methods have been adopted. Since climate risk is usually connected with many other attributes of farmer's livelihood system, humanism methodology [20] is also used to understand the real circumstance; farmer's losses to climate risk and decision-making process to cope with all the risky factors involved.

4.1. Conceptual framework

The conceptual framework employed in the study has been shown in Figure 1. Agricultural climate risks are embedded in a series of changes in agricultural climate environment. These risks have been exposed to agricultural eco-system and a combination of forces in social dimension takes place dependently, which can be called "farmer's exposure-sensitivity". Farmer's agricultural income becomes changeable and finally farmer' vulnerability occurs. As agriculture is part of farmer household's livelihood system and farming risk is usually shared within the members of the whole family [21], farmer's adaptation is interlinked not only to the agricultural system, but also to the off-farm activities and human, social capital of the household. After deep consideration of all the surrounding factors such as; social, environmental and economical, farmers continues for adaptation to changes, which can also bring new risky opportunities for them.

Figure 1 Conceptual Framework of Farmer's Adaptation to Climate Risk



Source: Adopted from IPCC, 2007 & Reid S. et al. 2007 and modified

4.2. Data collection and analysis

The conceptual framework shows the relationship between climate risk and farmer's adaptation. Various internal such as structure of the family and external factors such as social security policy can influence farmer's vulnerability

in climate changes. The empirical research was designed to document farmer's perception, direct and indirect influences and decision-making progress. Key informant interview and household semi-structured questionnaire used to identify individual farmer's specific attributes of livelihood. Key informant interview was designed to know about the general picture of the villages and the former climate risk, thus would help finish the preparation for designing the household semi-structured questionnaire, which is a guideline and reference to do the in-depth interview of individual household.

In order to avoid the predominated factors and bias on response, firstly, the information collected on demographic characteristics and socio-economic conditions of the family/households, as well as of those members living in the same house and whose income and expenditures are counted as part of the family economic conditions. Secondly, we reviewed the yield and income of household's from agricultural farming system, the variation of yield compared with former years and extreme climate change affects to the main crops. Thirdly, agricultural production (inputs and costs); fourthly, income from other off-farm activities Lastly, open-ended questions were asked about the perception on agricultural climate resources such as the direction of the change of seasonal precipitation, temperature, natural hazards and their sense on the international finance crisis, agricultural insurance, agricultural policy, market mechanism and price , available and applied technology.

As of the main agricultural production zone/area, farmer's adaptation strategies ascertained by asking questions about the various influential factors and the actions they take to counteract the perceived agricultural risk. The way in which the question was phrased aimed to separate out a "farmer's response to agricultural risk" rather than from their responses to focus mainly on climate change. Data were analyzed using SPSS. During the data processing, each household's attributes of vulnerability, livelihood situation, exposure-sensitivity and adaptive capacity was identified and validated from one household situation to the other considering the causality behind each attributes.

4.3. Research area

XT County is a typical region in Jianghan Plain of China with large agricultural farming population. The climate risk has occupied 85% of the natural hazards in the county [22]. Two administrative villages (A and B), conducted in-depth interview in 70 households using semi-structured questionnaire. According to the official statistics, the farmers' net income per capita of the county is about 769.4 $ (1$=6.82 RMB, hereinafter) in 2008 [23] including relative developing agricultural industries and convenient work opportunities for working outside. The relative higher income has made the farmers here with more adaptive capacity to climate risk in finance. Meanwhile, the farmer's heterogeneity can't be ignored.

, Village A has 245 households with 1200 persons and total of 120 hectares farming land while Village B has 408 households with 1600 persons and total of 200 hectares farming land. . Crop farming, animal husbandry and non-farm activities (migrant workers) are the major source of income. . However, majority of the population are involved in crop farming business. After 30 years' of development, farmers have formed a relative stable structure in crop farming business. Rice, cotton, wheat and cole are the main crops and other crops like barley, corn, soybean and sesame are grown in the area.

Since 1990s, along with the development of market economy, the young and elite's population involved in the market oriented business which become relatively more comparative advantage towards the agriculture sector. It also contributed to that some farmers give up farming and migrating to the city areas for work. The households members like the elderly and disadvantaged couples have been left behind in the village and they were engaged in the agriculture farming which ultimately affected the function of agriculture farming.

The relative high area in farming land and part-time migration has improved the life quality of the crop farming group. From the total structure of their livelihood situation, they were first in self-sufficiency level and then came to the well-off level. However, from the nature of the farmer's livelihood, they are still in the developing process and the lack of risk insurance and social security always expose them to vulnerable position.

5. Research findings

5.1. Climate risk and agricultural ecosystem

Farmer's viewed a number of climate risks in their agriculture farming eco-system in the last twenty years. In their experience, climate has become more unpredictable since the last three years and the extreme climate events happened more frequently. Take Farmer A for example, he planted wheat in Winter 2008 but had loss of crop relatively during the growth period and harvest season due to the precipitation; in Winter 2009, he changed to plant cole, but due to the early frost and the hail stone the cole plant was almost destroyed which made him hopeless for farming.

By reviewing the total 70 households' experience and perception on climate change, climate risks which had influences crop farming system into four categories, which are drought, excessive rainfall, degree of temperature, hailstone and plant diseases and insect pests.

Located in the Middle and Lower Reaches of Yangtze River Basin, the infrastructure such as irrigation canal development and good management system can supply sufficient water for food crops like rice in drought in summer. However, for winter crops like cole which requires moderate weather while growing, rainfall is the only way to get enough water in the drought because the cole crop cannot hold much water as compared to the rice crop. Irrigation system or artificial watering has increased more labor and cash input in crop farming because it requires systematic maintenance of the irrigation canals and payments for the equipments if required. Meanwhile, high degree of mechanization has reduced crop plants adaptive capacity and increased their exposure to climate risk.

Compared with drought season, the excessive precipitation would bring more damages to crop-farming. As mentioned above, water table is usually 0.5-1.0 meters below the earth's surface, which makes water logging easily happen in the rainy days. Generally, the winter crop is more vulnerable to rainy weather. If the rain water is excessive in the grouting period of wheat, the yield significantly reduced; if too much water in harvest time, the mature wheat will sprout and their selling price will be 30% off normal price.

When talking about temperature, 70% farmers mentioned and agreed that it brought great influences to crop production, especially due to the high temperature. Generally, the increased temperature would promote the plant diseases and insect pests. As a whole, all the climate risks have decreased the quality and yield of farm produce.

Agriculture production is more related to the seasonal change of climate.. Winter crops are more vulnerable to climate risk. According to the research on winter wheat in the Middle and Lower Reaches of Yangtze River Basin, it concludes that the growth period of winter wheat shows the decrease trend, but the greenhouse gas and temperature is increased meantime. When the growth period decreased, the time for plant photosynthesis would be shortened and the calculation of dry-matter yield would be decreased too, both of which would finally make the drop-down of wheat yield [16].

In farmer's perception, the favorable weather is considered to be a combination of heat, sun, moisture at the "right time" [5] and the climate risks always result decrease in crop yields. Farmers have to invest more and do more innovations on agriculture; but that would lead to an increase in agricultural opportunity cost and decrease in farmer's profit in crop farming.

5.2. Farmer's sensitivity to the exposure

Farmer's economic losses in the exposure not only came from the crop yield, but also affected by a series of related sensible factors, such as high prices which can compensate for climate-induced yield losses, thus it would result in more average income years [5] and so does the available agricultural insurance.

In the context of Jianghan Plain of China, agricultural insurance program has been implemented for several years. But due to lack of effective cost-benefit measurement tool to determine the yield losses caused by climate risk, the institution exists in name only and farmers show little interest in it actually.

Crop prices can be determined by both market price and farmer's marketing channels. In the research village, nearly all the farmers sold the crop to the private door-to-door grain trader. Since the price is changeable along with the market price, some farmers have stored some grain for higher price. The farmers' seasonal storing behaviors and prediction on the change of crop price can influence farmers' decision on the storage, which finally determines farmer's direct income on the fixed crop yield. Both of the labor cost and agricultural input like fertilizer, pesticide and crop seeds can also influence agricultural cost. Besides, non-farm income of the household can also influence farmers' sensitivity to climate exposure.

Labor availability is considered an important input constraint. The expectation is that farm households with more labor are better able to take on various adaptation management practices in response to changes in climatic conditions compared to those with limited labor. Health is one of an important factor that affects the availability at the farming activities. Health factors determine the ability of the available labor force to work on different farm activities. A healthy labor force means that the household is able to take various farm activities, including adaptation farming management practices to climate change. Taking an example of Farmer B' family comprises six members in the family, the elder couples, the young couples and two grandchildren. Since the health of the young son is not very good and the elder couples are too old, the family contracted 2 hectares of pond in 2007 to breed catfish which would take four years to grow up and 0.3 hectares of farming land for subsistence farming, in order to fulfill the basic needs of the family. On the other end, in 2009, when wheat was in harvest time, heavy precipitation happened and at the same time, the elder mother got burst appendicitis and had to stay in hospital for curing. Lack of labor and the climate risk caused decline of the wheat yield by 50% and exposure of the family into vulnerability.)

5.3. Farmer's adaptation to exposure-sensitivity

To cope with the losses caused by climate risk and to reduce the possible same losses in future, farmers take different movements to adapt the exposure-sensitivity. There are two ways of farmer's adaptation to exposure-sensitivity, firstly, through new livelihood channels in off-farm/non-farm area and secondly, through adaptive innovation in the crop farming system.

5.3.1. Seeking for new livelihood channels

The common and easy way in off-farm area is to completely or partly give up agriculture and the whole or part of the family members become migrant workers or so called employed farmers. Agriculture then becomes an abandoned occupation. Some farmers believe that the structure of planting has been formed and when the climate risk happens, they would like to do some part-time work to compensate the losses caused by climate risk.

There are also some farmers who are forced to learn some new skills suitable and available in order to continue crop-farming. Farmer C is a householder of a family with three members. He is 42 years old in 2010 with little experience working outside and his son is an undergraduate whose tuition has occupied most portion of the family's expenditure. Before the implementation of agricultural subsidies policy, he could contract more farming land to sustain the large expenditure of the family while other villagers give up farming because of little profit in agriculture. However, in 2007, the new land policy came into effect and half of his land had to return to the original contractors. Because of the climate risk of that year, the family's income was largely decreased and Farmer C was forced to find new cash income to sustain the family. He began to learn culinary skills and contracted some rural feast on weddings and funerals, which has become the main income source of the whole family.

5.3.2. Adaptive innovation in crop farming system

More efforts and inputs are given in the crop farming system. The adaptation in crop farming system can be divided into three parts including in pre-risk, during risk and post-risk.

5.3.2.1. Pre-risk adaptation

In pre-risk, collective actions are more tend to good infrastructures of irrigation and drainage; meanwhile professional officers in the County Bureau of Plant Protection also deliver some guidelines in the form of newspapers on climate risk such as when the meteorological information has shown the tendency of occurrence of plant diseases and insect pests, the guideline would tell the farmers to use pesticides to prevent the risk. After consideration of the previous year risk factors and farmer's own experience, as well as the collected information, individual households take varieties of adaptations such as crop diversification, using different crop varieties, reallocating the crop land area, changing the planting and harvesting dates, drought-resistant varieties and high-yield water sensitive crops.

Generally speaking, varieties of crop planting is an effective way to reduce climate risk, but for the farmers in Jianghan Plain of China, only the medium-size households would take such measures, since the food security is the basic principle of small farmers and convenient employment with less cost is the goal of those farmers who have a large family. To reduce the climate risk in farming, a farmer in Village A kept on noting the weather and crop

growth situation for 35 years. These notes were usually used to predict the tendency of climate change which helped him to take some pre-risk adaptation. In the spring of 2009, by using the right estimation, he changed the time of wheat planting and finally, the measures helped him avoid the excessive rainfall successfully. The household not only had a good harvest in wheat yield, but also got good benefit by selling them at a high price.

During risk adaptation

During climate risk, some farmers have taken more time on observing the crops, for instance, when new hazards happen, they would take available measures like replanting seedlings in drought season, artificial drain in excessive precipitation and more pesticide in plant diseases and insect pests. There are also some farmers who would do nothing during the risk since they believe that much input on agriculture can't guarantee the good harvest or better income. The uncertainty of climate changes causes them to make such a decision.

Available technology can also reduce farmer's risk in crop farming. For agricultural adaptation, the report [16] supported by World Wildlife Fund points out that climate change makes the crop yield in Yangtze River Basin decrease rapidly and while the effect of fertilizer brought by the concentration of carbon dioxide can reduce the unfavorable factor effectively, the yield would not be reduced so rapidly. If considering the adaptation like breed substitution, the disadvantage brought by climate change would be reduced and avoided, and the positive effect of climate change would be exerted and finally leads the improvement of farm produce yield. From these points, we can see that technology would be a good way to increase farmer's adaptive capacity and mitigate their vulnerability to climate change.

One farmer gave an example of cotton planting: in 2008, the excessive rainfall postponed the harvest time of cotton, which finally made the wheat planting impossible, and they had to plant barley as alternative crop.

5.3.2.2. Post-risk adaptation

For post-risk adaptation, some farmers exchange their experiences with other surrounding farmers through social capital. Only one farmer of the 70 interviewees mentioned about using network to obtain more information and related knowledge. A few of farmers begin to do some experiment on new technology like the new crop variety in a small plot. By comparing crop profits in paddy land and dry land, some farmers in Village A have changed their dry land to paddy land. Since less output is required for Winter Crop unlike Summer Crop, some farmers change the farming system of one-year double-crop planting into one-year one-crop.

During the interview, most farmers realized that the climate risk is an increasing important factor in present agricultural system and they indeed have a demand for agricultural insurance. However, famers who participated in agricultural insurance haven't received any compensation so far because of the unreasonable cost-benefits of the institutional arrangement. The validity and effectiveness of the institution have restricted farmers' behavior and make them just waiting.

Based on the above analysis, it can be concluded that nearly all the farmers have made the decision on adaptation just for short-term period like two or three years just to cope with the forthcoming climate hazards. For the systematic risk management in long-term, it would still need more external supports financially and technically.

5.4. Key factors on farmer's adaptation

The conceptual framework shows that many internal and external factors can influence farmer's adaptation to climate change. For the non-farm adaptation, the employment policy and migrant worker's capability are the two important factors in the process of farmer's decision.

For the adaptation within agriculture, it is related to many attributes of the household and the members who are engaged in agriculture. 77% of the households has been engaged in agriculture for their entire life. The average age of the household respondents is 56.4 years old ranges from 39 years old to 78 years old. In household life cycle, all the families are either in the stage of raising unmarried children for study or savings for their marriage, or helping young couples looking after the grandchildren or farming for basic needs of their own living.

Agriculture is an important part to sustain the livelihood of the family. For the families with young students or unmarried children, they usually contract the land as much as they can and also take some part-time jobs to support their family. Based on the perception and attitudes on agriculture, they devote more time and energy as well as more

material input on crop farming. Regarding adaption behaviors, farmers tend to take adaptive innovations in agriculture, and innovative behaviors on part-time jobs/ non-farm, off-farm or livestock breeding are also engaged sometimes.

For the household with elder couples and grandchildren, agriculture has played the role of sustaining the basic needs of the family members in the village. Since social security and pension for the aged haven't been implemented in the research area, the elder couples with no children around fulfill their own life thru farming. Among these households, if the regular management can meet their basic living demand, they may take some adaptation measures to climate risk or adopt those technologies applied by most of surrounding farmers and with affordable cost.

Therefore, the status of farmer household life cycle is an important factor to influence farmer's adaptation, and household pressures always make farmers with strong willingness to take adaptive innovation positively. However, willingness requires available resources and technologies to guarantee the implementation of the final adaptive behavior. Available resources are embedded in farmer's livelihood assets and more related to the household's social capital.

For available technology in research area, most of the farmers are the experimental farmers rather than science and technology farmers. Most of the technologies are gained from farmer's own experience of "learning by doing". When climate risk happens, farmers usually use their own traditional knowledge to take actions to adapt the risk. As for technology from the point of view of agricultural extension services, most information and the product in Village A and B are from the shop in the town and the county where agricultural materials are sold, besides only one farmer in the 70 interviewees mentioned network. Among the 70 respondents, only two farmers have mentioned that they would take the initiative to do experiments on new technologies like crop variety and other reluctant farmers would take it into practice in the next year when they have better understanding after communication with others.

New technology can bring benefits for agricultural ecosystem but it can also bring some technology risk. Take mechanization for example, it has saved a lot of labor force in agriculture of Jianghan Plain, but while facing drought season, the highly mechanized sowing of wheat seeding would be more vulnerable than the traditional planting practices.

In information sharing, authority is usually a key factor. Just like the farmer who notices changes in climatic conditions for 35 years, he shared his perception of climate change with the surrounding farmers. The perception suggested farmers should sow the wheat seed a few days earlier than usual and he did so while others didn't. The final result proved that the farmer's conclusion was correct. The case shows that role of authority is a key element in information sharing and if there is a platform between scientific and local knowledge, the common knowledge and technology would be more suitable for practice and thus farmer's adaptive capacity for climate risk would be highly improved.

Institutional arrangement mostly determines local farmer's innovative space. Since the reform and opening up in 1978, China has implemented Household Contract Responsibility System and farmers got freedom to arrange the farming activities, which has brought rapid development in rural China. In Jianghan Plain, the vast expanse of arable land in Village B was joined together to share the irrigation infrastructure and for the joint land area, farmers had to plant same crop and adopt same technology for sharing the irrigated water. Collective action has played a key role in the farming system. On the contrary, farmers in Village A did irrigate their arable land separately and they could make their own choice to determine the land to be paddy land or dry land.

6. Conclusion

The study has adopted vulnerability theory to explain farmer's adaptation to climate risk in Jianghan Plain of China, which is located in the Middle and Low Reaches of Yangtze River Basin. Although the research area has better irrigation system and relative higher economic status, most farmers who are engaged in crop farming still have some vulnerability and the climate risk to a certain degree has increased the vulnerability. Famers have taken variable adaptations to reduce the exposure in pre-risk, during risk and post-risk scenario.

Farmer's adaptation is a process of learning by doing and also an interactive result of internal and external factors. In climate risk, nearly all the farmers have their own adaptation and coping strategies, but still it is limited to face the increasing vulnerability while confronting the great climate instability. It requires more external support, such as the connection and cooperation of modern knowledge and local knowledge, which is an important factor to strengthen social adaptive capacity.

Internationally, different farmers in different areas usually face the same climate risk but take different adaptations. If all the adaptive behaviors are accumulated and shared effectively, human society will have more adaptive capacity to cope with the climate risk, and the vulnerable groups will have more opportunity to escape from poverty and will leads to enjoy happier and much more beautiful life in the future.

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