In-situ Adaption and Out-Migration: Enablers and Constraints Among Rural Households of the Mountainous Region of Southern Ningxia, Northwest China

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Abstract: International literature suggests that sustainable livelihoods (SL) provide an appropriate approach to conceptualising the relationship between climate (environmental) change and human adaptation strategies. In China, however, there is little research into the relationship between livelihood assets and adaptation behaviour in response to climate change from a micro (household) perspective. This study addresses this knowledge gap by developing a two-stage (impact stage, response stage) conceptual framework, based on an SL approach, and by focussing on the rural context of Xiji county, a climate change hot spot, ethnically-mixed and poverty-stricken area located in southern Ningxia Hui Autonomous Region. The study examines how, and to what extent, the livelihood assets (measured as five types of capital) of rural households influence four major agro-ecological domains (agricultural production, land area, water supply, and soil fertility) of livelihoods, and subsequently influence their decisions on adaptation strategies to climate change. A two-stage regression procedure is used to analyse primary data collected from 304 households in Xiji in September 2012. Results show that responses to climate change at the household level are significantly influenced by frequency of climate change perceived by people, by five dimensions of livelihood assets – natural capital, financial capital, physical capital, human capital, and social capital, and mediated by the willingness of people's participation in policy-making processes. Both in-situ adaptation and migration (including relocation) policies that aim to address poverty and environmental stresses in the case study area need to focus on diverse income resources, accessibility of modern agricultural techniques and facilities, education, ethnic equity and social networks of households affected by climate change.

Keywords: climate change, sustainable livelihoods, in-situ adaptation, migration, southern Ningxia, China

1. Introduction

In the rural areas of developing countries, sustainable livelihood (SL) is a major entry point for investigating the relationship between the environment and population (de Sherbinin et al., 2008; Aggarwal, 2009). When facing deteriorating environmental conditions including climate change, households tend to pursue in-situ adaptation and out-migration as livelihood strategies (Bilsborrow and Okoth-Ogendo, 1992; Deressa et al., 2009). A household's choice among various livelihood strategies is shaped by livelihood assets owned by the household and mediated by contextual factors involving environmental, institutional, socio-economic and cultural conditions (de Sherbinin et al., 2008). Despite contextual factors being virtually the same among all households within a specific community, livelihood assets possessed by the households differ significantly and thus lead to different choices among livelihood strategies. A growing body of international literature shows that livelihood strategies in response to climate and environmental change are influenced by livelihood assets that can be measured in terms of five types of capital: natural capital (Henry et al., 2003; Barbieri and Carr, 2005), financial capital (Goldberg and Frongillo, 2001; Deressa et al., 2009), physical capital (Cutter, 2011), human capital (Deressa et al., 2009) and social capital (Homewood, 1997; Boko et al., 2007).

In China, studies into rural livelihoods have focused on the role of contextual factors in shaping rural livelihood strategies (e.g., Hageback et al., 2005; Liu et al., 2008). These studies suggest that in-situ strategies are strongly influenced by national agricultural policies, resource prices, and scientific and technological innovation. Massive rural-urban migration since the mid-1980s has been mainly induced by the collapse of the collective agricultural system, the relaxation of the household registration (*hukou*) system, the growing disparity of economic development (especially between eastern and western regions, and between rural and urban areas), and governmental policies regarding ecological rehabilitation and poverty alleviation (Bao, 2005; Zhu and Luo, 2010; Knight et al., 2011). However, little research has addressed the relationship between livelihood assets and adaptation behaviour in response to climate change from a micro (household) perspective. The present paper seeks to make a contribution in this area.

The mountainous region of southern Ningxia Hui Autonomous Region is a major climate change hotspot that has experienced severe drought and water scarcity due to a consistent warming process and decreased precipitation since the 1960s (Hugo et al., 2009; Li et al., 2013). The region, geographically located in the one of ecologically vulnerable zones of western China, is characterised by high agricultural drought vulnerability (Wu et al., 2010), a lack of rainfall and irrigation, high elevation with cold temperatures, and having a majority (70%) of the rural residents living in absolute poverty. Aiming to relieve pressure on the environment, rehabilitate the deteriorating ecosystem and eradicate poverty in this region, Ningxia has relocated 700,000 rural people over the past three decades. Another 350,000 rural residents are planned to be relocated from the mountainous areas of southern Ningxia during a 5-year period to 2015 (Wu, 2011). This number will dramatically increase if spontaneous migrants arising from such areas are included. Xiji county, one of eight counties situated in this mountainous region, is selected as the case study area of this paper. Xiji, an area where apparent climate change, fragile ecology, under-developed agriculture, serious poverty and massive relocation overlap, provides a particularly salient place to study the interrelationship between climate change, rural livelihoods and household adaptation behaviour. This paper therefore examines in what ways, and to what extent, the livelihood assets (or capital) of rural households influence their decisions on adaptation strategies to climate change in such a fragile and poor region.

The issue is addressed by an integrated analysis of potential drivers influencing adaptation and migration. First, the paper, builds on existing literature on SL frameworks and develops a conceptual model to analyse the relationship between climate change perceived by people, livelihood assets, contextual factors, and adaptation strategies (against non adaptation). This is followed by a brief discussion of the main environmental, demographic and socio-economic characteristics of the study area. Third, we also briefly discuss the field survey and primary data used in this paper. Then the methodology and variables in econometric models are explained, and the factors and estimates of the marginal effects of perceived climate change, the factors that measure the five types of capital and the other contextual factors affecting adaptation behaviour are identified. Finally, some implications for policy and institutional arrangements relevant to adaptation to climate change and improvement of livelihoods in rural settings are drawn out in the discussion and conclusion.

2. Conceptual Framework

The climate change–adaptation nexus is better to be framed within a broader population–environment (PE) relationship. Choosing an appropriate approach to examine the PE relationship is dependent on the specific issues in a particular context a study seeks to address. This study takes a Sustainable Livelihoods (SL) approach as an appropriate approach to conceptualising the totality of factors influencing people's adaptation behaviour, because it takes the household as its core analytical unit and enables increased understanding of breaking out the vicious circle of poverty and environment problems (de Sherbinin et al., 2008; Hummel et al., 2012). This framework has been used by other researchers (e.g., Aggarwal et al., 2001; Biddlecom et al., 2005) in investigating some interactions between environment, household assets, contextual factors and livelihood strategies and outcomes in rural communities of South Africa and Nepal.

Livelihood comprises 'the capabilities, assets (including both material and social resources) and activities required for a means of living' (Chambers and Conway, 1991:6). Livelihood is further considered as 'sustainable' when it '…can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (ibid.). The most critical element influencing livelihood is the assets held by households. The SL framework acknowledges five categories of assets: natural capital, financial capital, physical capital, human capital and social capital (Ellis, 2000). They interact with one another and accumulate over time to shape the household's responses to environmental change. Moreover, they can be mediated by contextual factors including institutional, socio-economic and environmental conditions (Hummel et al., 2012). When facing environmental stresses, households tend to pursue a 'livelihood strategy'. This may comprise different adaptation activities (e.g., changing tenure regime, extending the cultivated area, technological innovation, out-migration, and fertility regulation) in order to survive and prosper (Bilsborrow and Okoth-Ogendo, 1992). Resulting outcomes of different livelihood strategies can be much diversified, consequently reshaping livelihoods in a positive or negative manner (Ellis, 1998).

However, one important factor – people's perception of "power" is not encapsulated in existing SL frameworks. International research into adaptation has shown that the degree of

participation in decision making is crucial in shaping people's capacity and outcomes of adaptation to climate change (Fraser, 2001; Thomas and Twyman, 2005; Paavola and Adger 2006). In addition to the five types of capital represented in the SL framework, a domain of *power condition* should be included in the analysis of livelihood and adaptation strategies. This domain reflects people's political status (e.g., membership of the dominant political party), and actual participation in, and influence on, the decision-making process for adaptation or migration.

This paper extends the SL framework, depicted in **Fig. 1**, to unravel the decision-making process of livelihood strategies (or household behaviour) in response to climate change. There is a consensus that choosing among adaptation strategies at the household level is not directly caused by climate change, but is significantly influenced by the livelihood assets and power condition of the families and mediated by a variety of contextual factors (Castles, 2002; Black et al. 2011a, 2011b). International studies acknowledge that the decision-making of climate adaptation strategies is a multi-staged process that involves at least a stage of climate change impact, followed by a stage of choosing among adaptive options (McLeman and Smit, 2006; Perchi-Nielsen et al., 2008; Black et al., 2011a). However, the staged nature of the decision-making process is not the main focus of these conceptual frameworks, nor is it explicitly examined in empirical studies. This study seeks to fill the knowledge gap by studying livelihood assets' influence on adaptation strategies to climate change in *two stages*. At the *first stage*, households' livelihoods are affected by climate change, which stimulates people's awareness and intention to adapt to adverse impacts. At the *second stage*, livelihood assets interact with subsequent impacts of climate change on household's livelihoods, power condition and other contextual factors to influence the households' choices among various livelihood strategies.

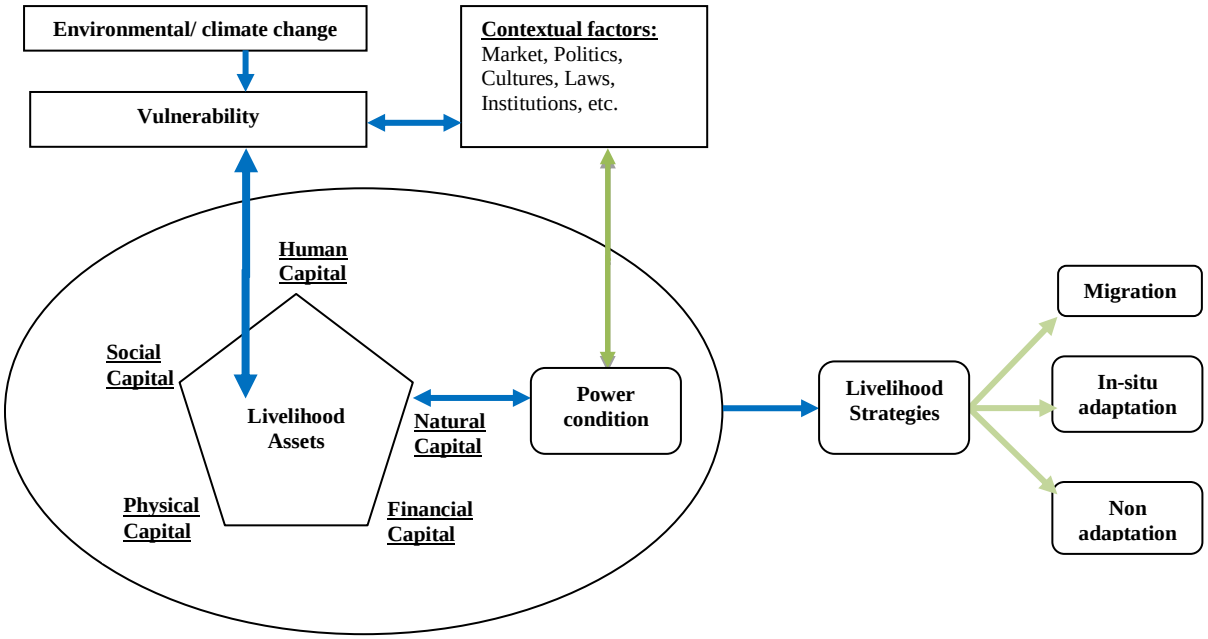

Fig. 1 Sustainable Livelihood framework: climate change and adaptation strategies

Source: adapted from www.livelihoodscsr.org.uk

Note: The blue arrows represent the original SL framework and the green arrows represent new elements framed for the purpose of this study.

2. Study Area

The study area encompasses four townships of Xiji county, three of which are located at the mountainous areas in northern part of the county (**Fig. 2**). Xiji county is semi-arid, with annual rainfall being 350-400mm whereas annual evaporation is as much as 1,400mm (Agriculture and Animal Husbandry Bureau of Xiji County, 2011). The county has experienced rising temperature at a rate of 0.6°C per 10 years over the past three decades and decreasing precipitation by 50mm per annum in the last decade. This has increased the frequency and severity of droughts in the region. For example, it has witnessed 27 severe drought events over the past 30 years, of which 5 were extreme ones. Increasing water scarcity has severely hindered agricultural production and rural economic development in this county.

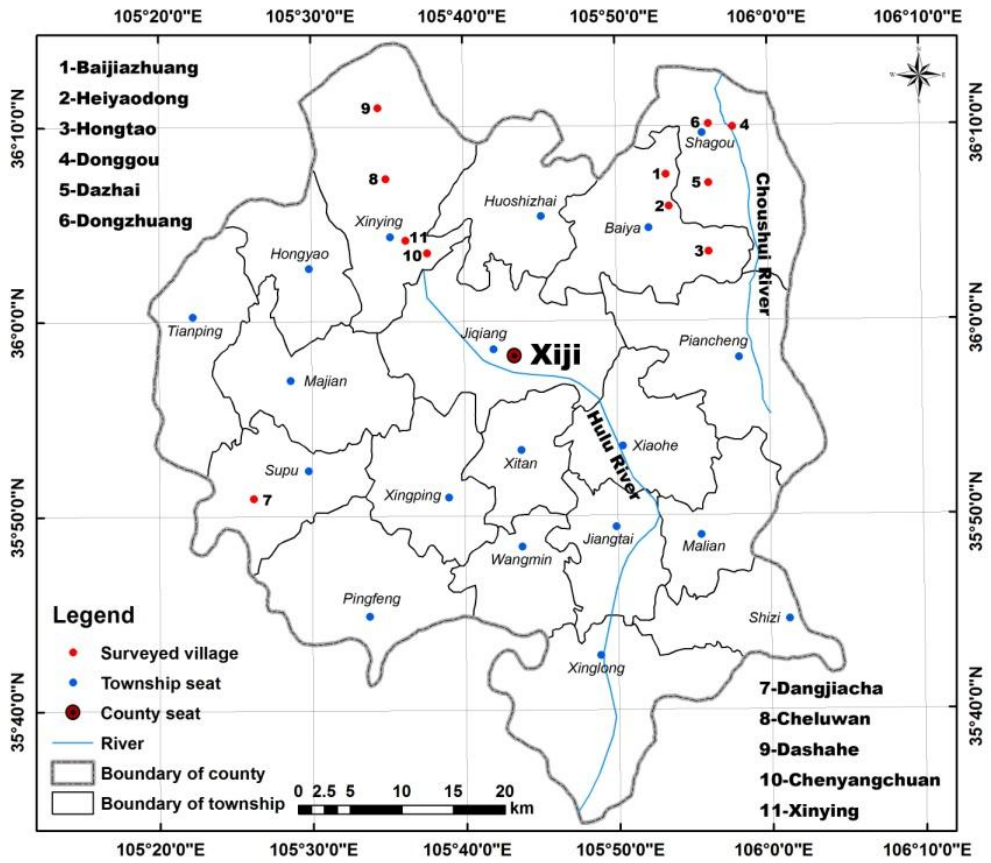

Fig. 2 Location of Xiji county in northwest China, and surveyed townships and villages

Xiji county has a population of 508,000 according to the 2010 China census, over half of which (56.6%, or 287,000) are Hui people (i.e., Chinese Muslims). The factor of ethnicity adds a particular dimension to both poverty alleviation and adaption to climate change in this county. Xiji is one of the 592 national poverty-stricken counties and the largest county in Ningxia in terms of the percentage (25%) of the population that is poverty-stricken. The overwhelming majority of its population (91%, or 354,321) are farmers, and in 2011over half of them (51.4%) lived under the national absolute poverty line (annual net income less than USD 218). Fragile ecosystems, water scarcity, soil infertility, geographical disadvantage and poor transportation are perceived to be key factors causing the prevalent poverty in Xiji (Development and Reform Bureau of Xiji County, 2011).

Since 1998 some 33,000 villagers in Xiji have been relocated through the following environmental and resettlement programs: Ningxia Yellow River Pumping Irrigation Project (1998-2000) (Qiang, 2008), National Poverty Alleviation and Relocation Program (2001-2007) (National Development and Reform Commission of China, 2000), and Intra-county Ecological Migration from Dry Zone of Central Ningxia (2008-2011) (The Central People's

Government of the People's Republic of China, 2008). According to the 12th Five Year Plan for Ecological Migration in Central and South Ningxia (Development and Reform Bureau of Xiji County, 2011), another 70,000 rural people will be relocated from 19 towns in Xiji between 2011 and 2015, accounting for one fifth of the total number of people to be relocated in Ningxia. Seventy percent of the 70,000 people will be settled in other counties of Ningxia via distant resettlement schemes.

3. Primary Data Collection

The selection of the four townships surveyed was based on several essential criteria: frequency and severity of climatic events over the 5-year period to 2012, vulnerability of the biophysical environment, population living under the poverty line, and being a major source of out-migrants or villagers to be relocated. The total sample size (N=304 households) were proportionately distributed to each township in terms of population size in 2010 by using a Probability Proportionate to Size (PPS) sampling method. In selecting suitable villages in each township surveyed, the demographic, social, economic and cultural factors of the resident populations and the institutional factors relating to these villages were considered. Specific factors included the size and composition of resident populations, number of migrants, process of government-led relocation and migration schemes, dissimilarity of agricultural structure, accessibility of basic infrastructure (e.g., water, transportation) and public social services (e.g., school, market). As a result, 11 villages were selected (see **Fig. 2**). Finally, a random sampling method based on the geographical location of households was used to select potential households. Obtaining a simple random sample of households is rarely possible due mainly to a major obstacle: the sparse distribution of villages and their villagers in this mountainous region.

A structured questionnaire survey was conducted through face-to-face interviews in September 2012. To fully understand responses to climate change it is necessary to study both migrant households and non-migrant households for their in-situ adaptation and/or migration means over the last 5 years (2008-12). The survey questionnaire comprised four main sections: (1) climate change perceived by people and its associated impacts; (2) adaptation means in terms of both migration and in-situ approaches (including those provided by local government and those deployed by the households themselves); (3) livelihood assets of household; and (4)

contextual factors influencing the adaptation capacity of the households. A full copy of the survey instrument is available upon request. The household head responded to the questionnaire. Where the household head was unavailable, his/her spouse or the household member who best understood the situation of the household answered the questions.

4. Data and Methods

4.1 Dependent and independent variables

4.1.1 Climate change and its impact on livelihoods

According to the theory of 'planned behaviour' (Ajzen, 1991), it is the perception of impact of environmental hazards that shape people's intention to adapt to those hazards, consequently leading to adaptation behaviour. This study, therefore, assesses climate change and its impact using a subjective measurement: people's perception of that change and subsequent effects. Information on the frequency of both climatic variations in temperature and rainfall and rapid-onset climatic events (e.g., droughts, cold spells, floods) in the past five years (2007-2011) was collected. Answers were coded in a continuous manner from 0 (very rare) to 10 (very frequent) to capture nuanced differences in perceptions among respondents.

Previous research suggests that the major aspects of climate change impact are related to: (1) increased mortality and declining health status (Shuman, 2010; Peng et al., 2011), deterioration of economic situation (Tol, 2009; Oral et al., 2012), and worsened living conditions (Morton, 2007; Lwasa et al., 2009). Nevertheless, rural households particularly bear negative impacts of climate change on their agricultural production and access to natural resources (Perch-Nielsen et al., 2008; Massey et al., 2010). To understand the major impacts of climate change on rural livelihood, the study collected primary data on the effects of climate change on the following dimensions of livelihoods: agricultural production, quality (measured as soil fertility) and quantity (measured as area) of farmland, access to water resource (measured as water supply), financial condition, health situation and living environment. Questions included: 'to what extent do you think climate change (e.g., decreased or increased temperature and rainfall, drought, cold spells) is responsible for declines of your household's agricultural production (mainly cropping and livestock), land loss, soil fertility, water supply, water quality, income, and overall health, and for damaged

housing, disconnected or damaged transportation and communication, respectively?' Their responses are coded from 0 (the least responsibility) to 10 (the greatest responsibility). Primary data shows that climate change may have generated great deterioration in agriculture production, land area, water quantity and soil fertility. These four domains are considered as dependent variables in Stage I (impact stage) analysis, and independent variables in Stage II (response stage) analysis to predict households' adaptation and migration behaviour. At Stage II, the study hypothesises that greater adverse impacts of climate change on these four aspects will be associated with higher likelihood of out-migration or in-situ adaptation.

4.1.2 Dimensions of adaptation

The surveyed households are categorised as three groups in terms of their fundamental response to climate change impacts: migration, in-situ adaptation and non adaptation. This study defines *migration* as a movement of a whole household or part of its membership beyond the original township for 6 months or longer during the period of 2008-2012. *In-situ adaptation* is defined as the adoption of one or more of following public adaptation means without undertaking any movement during the period of 2008-2012: improving water conservation and irrigation systems, applying water-saving techniques in farming, and cultivating drought resistant crops. Households which did not take any migration or in-situ adaptation means fall into the *non-adaptation* group.

Table 1 shows that for the Stage II response model, 18% of the households in the valid sample (N=304) experienced migration in 2008-12; about 42% of the total valid households undertook various in-situ adaptation, while 40% of the total valid sample did nothing but to accept climate change impact.

Table 1. Summary of the dependent variable in Stage II adaptation model

Households		**N**	**%**
migration (=1)	entire household move	33	10.9
	partial household move	22	7.2
in-situ adaptation (=2)		127	41.8
non-adaptation (=3)		122	40.1
Total		304	100.0

Source: authors' survey, 2011.

4.1.3 Explanatory variables: five sets of livelihood assets

De Sherbinin et al. (2008) suggested some specific indicators of each livelihood capital as follows.

- Natural capital: the natural resource stock, or local environmental endowment (water, soil, etc.);
- Financial capital: income, cash savings, supplies of credit, etc.;
- Physical capital: the productive assets owned and communal assets accessed by the households (e.g., roads, communication infrastructure);
- Human capital: formal and informal education, local knowledge, the ability to work, and good health;
- Social capital: interpersonal networks, membership in groups, relationships of trust, and access to wider institutions of society.

In this study indicators of *natural capital* are derived from respondents' answers to a series of questions asking the area of farmland and storage of, and access to, both drinking and irrigation water of each household. Land and water are two fundamental natural resources on which rural livelihoods depend.

In addition to total income, savings and loans, a particular interest of this study is to measure *financial capital* by disaggregating the key components of household income in order to examine how different income sources could influence households' responses to climate change. One question asked respondents was: "how much did your family's annual income arise from agricultural production, secondary industry or family business, remittances, and government subsidies, respectively, in each of the past 5 years?" The proportion of specific income from each source against total income is then calculated and used as a continuous independent variable in the two-stage analysis

Measures of *physical capital* are derived from respondents' answers to four sets of questions: (1) "what agricultural techniques and facilities have been used by your household to protect agricultural production from the negative impact of climate change?" Respondents were provided with six choices: i) facilities that improve water storage and irrigation systems, ii) improving soil fertility, iii) techniques that develop water-saving farming, iv) drought or high-

temperature resistant crops, v) adopting value-added forest, fruit and vegetable cultivation, and vi) cultivation of waste land. Each facility or technique reported by a household is indexed as "1", yielding a total score for the derived variable 'agricultural facility' ranging from 0 to 6. (2) "How many minutes do you spend on going to the closest place to fetch water, to the farthest farmland to work, to the farthest school, to the market you usually go to, and to the closest public transportation station?" (3) "How many kinds of communication means does your family use?" and (4) "How frequently does your family use public facilities (e.g., health clinic, community library, information centre, religious or cultural centre) in your village?"

Human capital usually refers to education level and health condition of people. Other demographic factors regarding age, gender, family size, dependency ratio and ethnicity are also used to measure the human capital of a household as these factors combine together to shape the household's experience, ability to work and access to public resources (Croppenstedt et al., 2003; Leiserowitz, 2006; Deressa et al., 2009). Given that the impacts of climate change are not distributed, or felt, evenly across social groups and communities, it is important to identify these demographic differentials for strategy formulation to reduce vulnerability and enhance adaptive capacity.

In China, the *social capital* of a household is often measured as its social relationship to people in power or controlling resources (e.g., government officials or successful entrepreneurs) (Gold et al., 2002). Spatial distribution of social networks influences people's livelihood strategies (especially migration behaviour) and outcomes (Zhao, 2003). Therefore, a set of questions asked respondents: "how is your family's relationship to the township cadres?", "Does your family have any relative or close friend who works in a governmental department or operates enterprises?" and "Does your family have any relatives or friends who live in other townships within the same county (i.e., Xiji), or other counties within the same prefecture (i.e., Guyuan), or other cities within the same province (i.e., Ningxia), or other provinces beyond Ningxia?" Further, the objective consequences of a household's social relationship (or network) in terms of help, assistance or support received by the family were also used to measure the social capital of the household. Specific definition and coding of five sets of corresponding capitals are presented in **Table 2** in the next section.

4.1.4 Control variables: institutional arrangement and power condition

Contextual factors in this study mainly consider *institutional arrangements* that help reduce people's vulnerability to climate change or natural disasters and economic hardship. These include the aged-pension system and medical insurance scheme in rural areas, governmental in-situ preparedness and intervention (including relocation and resettlement) for the adverse impact of climate change. Governmental in-situ programs are measured by the numbers of various programs implemented in this study area, including providing weather information, access to renewable energy (e.g., wind, solar, methane gas), environmental programs (especially the national Grain to Green program – returning cropland on steep slopes with a gradient of 25 degrees or above to forest or grassland), improving water conservation and irrigation systems, industrial re-structuring, protecting food security, building agricultural product marketing networks, improving health and medical services and capacity, and enhancing basic infrastructure. For each program participated in by the household, the governmental in-situ program is indexed as 1, yielding a total score of this factor ranging from 0 to 11.

Research into adaptation suggests that the degree of participation in decision making can differentiate people's access to public resources and assistance, and consequently influence people's adaptation to climate change (Thomas and Twyman, 2005; Paavola and Adger 2006). In the context of China, participation in decision making is largely influenced by people's political status, decided by whether a person is a government cadre or a Party member of the Communist Party of China (CPC) (Nee and Lian, 1994; Bian, 2002). Thus the *power condition* of a household is measured by three factors: (1) whether any family member is a Party member of the CPC or other minority political parties; (2) the willingness of the household to participate in any policy-making process, and; (3) the acceptance level of the household's suggestion that has been adopted by local government or the villagers' committee.

Table 2 presents the names and definitions of the independent variables of stage I (impact) and stage II (response) models. One major difference in the two-stage models is that stage II model includes the predicted probability of being impacted by climate change in the four domains – agriculture production, land loss, water quantity and soil fertility. The empirical modelling process seeks to include the independent variables that best describe the impact on the dependent variable in terms of the significance level and have the highest fit in terms of

BIC (*Bayesian information criterion).* Hence other independent variables may appear either in Stage I or Stage II model or both.

Table 2. Definitions of independent variables

Variables	Definition	Stage I	Stage II
frequency_cc	discrete variable, frequency of climate change related events: [0, 10]=[very rare, very frequent]	√	√
Domains of climate change impact			
agriculture	discrete variable, the extent to which climate change is responsible for declines in crop and livestock production: [0, 10] = [not at all, very much]		√
land_loss	discrete variable, the extent to which climate change is responsible for decrease in land area: [0, 10]=[not at all, very much]		√
water_quantity	discrete variable, the extent to which climate change is responsible for decrease in water quantity: [0, 10]=[not at all, very much]		√
soil_fertility	discrete variable, the extent to which climate change is responsible for deterioration of soil fertility: [0, 10]=[not at all, very much]		√
Natural Capital			
land	continuous variable that measures the total amount of farmland of the household (*mu*)	√	
irrigation_r	continuous variable that measures the proportion of irrigated farmland against total land area	√	√
water_storage	1=if the household has water storage equipment; 0=otherwise	√	√
water_access	1=if the household has tap water facility or well in their house; 0=otherwise	√	
Financial Capital			
income_total	continuous variable that measures the total annual income of a household ('000 *yuan*)	√	
income_pp	continuous variable that measures annual income per person ('000 *yuan*)	√	√
income_agri_pc	continuous variable that measures the proportion of household income from agricultural production: [0, 1]	√	√
income_non_agri_pc	continuous variable that measures the proportion of household income from non-agricultural activities: [0, 1]	√	√
income_remittance_pc	continuous variable that measures the proportion of household income from remittance: [0, 1]	√	√
income__subsidy_pc	continuous variable that measures the proportion of household income from government subsidies (including pension): [0, 1]	√	
saving	continuous variable that measures the household's total saving ('000 *yuan*)	√	
loan	continuous variable that measures the household's total loan ('000 *yuan*)	√	
housing_area	continuous variable that measures per capita living area (m^2)	√	
diversity_production	discrete variable that measures the number of production types employed by the family. These include: cropping, livestock, labour export, business, secondary industry, horticulture, commercialised lovestock, forest, vegetable, medical herbs, fishing, and others: [0, 12]	√	√
Physical Capital			
agricultural_facility	discrete variable that measures the number of agricultural techniques and facilities used by a household to protect agriculture from negative impact of climate change.: [0, 6]	√	√
time_water	continuous variable that measures time spent on going to the closest	√	

	place to fetch water (minutes)		
time_farmland	continuous variable that measures time spent on going to the farthest farmland to work (minutes)	√	
time_school	continuous variable that measures time spent on going to the farthest school (minutes)	√	
time_market	continuous variable that measures time spent on going to the market usually to go (minutes)	√	√
time_transport	continuous variable that measures time spent on going to the closest public transportation station (minutes)	√	√
communication_no	discrete variable that measures the number of communication means used by the family: [0, 10]	√	
public_facility	discrete variable, frequency of public facilities used by the family: [0, 10]=[very rarely, (very often]	√	√
Human Capital		√	
age	continuous variable that measures age of household head	√	
elderly	1=if there is any member in the household who is 60 years or older; 0=otherwise	√	√
dependency	continuous variable that measures the ratio of those not at the working age (aged 15 years or younger, or 60 years or over) against the total number of household members: [0, 1]	√	√
male_ratio	continuous variable that measures the ratio of males relative to the total number of the household members: [0, 1]	√	
hh_size	discrete variable that measures the number of household members	√	
edumax_hh	continuous variable that measures years of the highest schooling of the household members: [0, 16]=[illiterate, university degree]	√	√
health	discrete variable, self-reported overall health status of all family members: [0, 10]=[poor health, excellent health]	√	
disability	discrete variable that measures the total number of disability and/or chronic diseases that the household members have. These include any intellectual problem, physical disability, mental problem, and chronic disease: [0, 5]	√	
ethnic_differ	1=if all members of the household are Hui-people; 0=otherwise	√	√
Social Capital			
assist_no	discrete variable that measures the number of various types of assistance received by the family. These include helps from relatives/friends, neighbours, villagers, government departments, NGOs, Banks or credit agencies, and others: [0, 7]	√	
assist_friend	1=if the greatest help comes from relatives/friends; 0=otherwise	√	√
assist_cash	1= if cash or living material donated by people is the key type of assistance received; 0=otherwise	√	√
rel_cadre	discrete variable, relationship between cadres and ordinary people: [1, 10]=[very bad, very good]	√	
rel_ethnic	discrete variable, relationship between different ethnic groups: [1, 10]=[very bad, very good]	√	
rel_official	1 =if a family has any relative or friend who works in a governmental department; 0=otherwise	√	
rel_entrepreneur	1=if a family has any relative or close friend who operates enterprises; 0=otherwise	√	
rel_town	1=if a family has any relative or friend who lives in other town within the same county (i.e., Xiji); 0=otherwise	√	
rel_county	1=if a family has any relative or friend who lives in other county within the same prefecture (i.e., Guyuan); 0=otherwise.	√	
rel_city	1=if a family has any relative or friend who lives in other city within the same province (i.e., Ningxia); 0=otherwise	√	
rel_province	1=if a family has any relative or friend who lives in other province beyond Ningxia; 0=otherwise	√	
Institutional arrangements			

aged_pension	continuous variable that measures the ratio of family members who have joined the rural aged-pension scheme against the total number of persons aged 16yrs or over: [0, 1]	√	
health_insurance	continuous variable that measures the ratio of family members who have joined the rural health insurance scheme against the total number of family members: [0, 1]	√	
govt_mobility	1= if the family has participated in government-assisted displacement and migration program (e.g., ecological migration, anti-poverty relocation, labour export, and educational migration); 0=otherwise	√	
insitu_program	discrete variable that measures the number of public adaptation programs that the family has participated in: [0, 11]	√	√
govt_support	discrete variable, governmental assistance received by the family when natural disasters occur or when it faces economic difficulties: [0, 10]=[very little, very much]	√	
Power			
political_party	1=if any family member is a member of the Communist Party of China (CPC) or other minority political parties; 0=otherwise	√	
policy_will	discrete variable, the willingness of the household to participate in any policy-making process: [0, 10]=[very unwilling, very willing]	√	√
suggestion_accept	discrete variable, acceptance level of your suggestion that has been adopted by local government or the villagers committee: [0, 10]=[not adopted at all, fully adopted]	√	

4.2 Two-stage regression models

Based on the two-stage framework constructed in Section 2, a two-stage regression procedure is adopted to analyse the survey data. In Stage I, a *seemingly unrelated regression* (SUR) model (Greene 2008: 254-257) is estimated to examine how the frequency of overall climate change perceived by people, the five types of capital, and contextual factors interact to influence four major domains of household livelihood. The purpose of the Stage I model is to obtain the predicted severity of each impact. The predicted severity is used as the independent variables in the Stage II model. Stage II uses a *multinominal logit model* (MLogit) (Greene 2008: 843-845) to investigate in what ways and to what extent these specific impacts, in combination with capital indicators and contextual factors, influence household's adaptation behaviour: migration, in-situ adaptation, or non adaptation. MLogit model is one of the most frequently used regression models in the situation of multi-choice dependant variables (Greene, 2008: 843-845).

The key domains of impacts of climate change on household in Stage I impact model include: agricultural production (especially cropping and livestock), loss of farmland, decline of water quantity, and deterioration of soil fertility. Hence a four equation system of SUR is constructed as follows, according to Greene (2008: 254-257).

$y^{*}_{m} = x'_{m}\beta_{m} + \varepsilon_{m}$, $y_{m} = [0,10]$, m=1, 2, 3 and 4 (1)

where y_m is a Likert scale, which is treated as a continuous variable, from 0 (no impact at all) to 10 (most severe impact), indicating that climate change has varying degrees of impact on households' agricultural production (m=1), loss of farmland (m=2), declining water quantity (m=3), and deteriorated soil fertility (m=4); x_m are vectors of explanatory variables that measure five categories of capitals and contextual factors; ε_m are the error terms.

One advantage of estimating the first stage regressions in a system of equations instead of four separate OLS (Ordinary Least Squares) models is that the former allows correlations between the error term of each equation in the system which is more relevant for reality since it is likely that the error term of each equation contains the same unobserved variables that explain whether climate change and other factors affect a household's agricultural production and related livelihood resources (land, water, and soil), respectively. The SUR model results confirm this point given the significant correlations between the residuals of each equation in the system. We use Stata11 to estimate the SUR model.

The independent variables in the initial model of Stage I include a full spectrum of factors measuring five categories of capitals, factor of frequency of perceived climate change, institutional factors, and political factors (Table 2). We used lagged independent variables in the estimations. In the questionnaire, many variables are surveyed for the year of 2007. For example, if one reported that his family (or at least one family member) migrated, or adopted at least one public in-situ adaptation means, during the past 5-year period (2008-12), we then consider all relevant variables reported in 2007. Note that the accuracy of the retrospective information still is of some concern (Som, 1973).

The estimation procedures of the Stage I impact model involve step by step removing of the least significant independent variable until all the remaining independent variables are at least significant at the 10 per cent significance level. The advantage of this procedure is that the final model would have fewer irrelevant independent variables and therefore minimise the standard errors of the estimates of the remaining independent variables. The disadvantage is that the final model may suffer from omitted variable bias if any variable that is fundamental to explaining the dependent variable is dropped in the process. When we compare the final model and the initial model with all the independent variables, the variables in the final model

are as significant as in the initial model and have the same sign. This indicates that dropping the insignificant variables does not produce an omitted variable bias that affects the estimates of the remaining variables.

The dependent variable of the Stage II response model is classified into three categories, namely, migration (Y=1), in-situ adaptation (Y=2), and non adaptation (Y=3). The multinomial Logit can be thought of as simultaneously estimating binary logits for all comparisons among the choices, which according to Greene (2008: 843-844) can be expressed as

$$\text{Prob}\,(Y=j|w) = \exp(w'\alpha j)/\sum_{j=1}^{3} \exp\,(w'\alpha_j),\ \ j=1,2,3 \qquad (2)$$

where Prob denotes probability, j denotes the dependent variable categories (1, 2 and 3), w is a vector of explanatory variables. Estimation of the models is based on the maximum likelihood method and is carried out by Stata11.

5. Results

5.1 Result I: household assets, contextual factors and impacts of climate change

Table 3 presents the results of the Stage I *impact model*. Many variables are dropped out of the final models because they are not statistically significant. Frequency of perceived climate change, the five types of capital factors, and contextual factors influenced the four domains of household livelihoods differently.

Table 3. Regression results: impact model

Variables	Impact on agricultural production		Impact on land area		Impact on water quantity		Impact on soil fertility	
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
frequency_cc2007	0.341***	0.000	0.111	0.119	0.267***	0.000	0.044	0.535
Natural Capital								
land2007	0.029**	0.016	0.032***	0.002			0.030***	0.005
water_storage	1.040**	0.033	1.588***	0.000	2.315***	0.000	0.946**	0.022
Physical Capital								
time_water2007							0.035***	0.003
time_school2007					0.022***	0.007		
time_market2007					-0.027**	0.030		

time_transport2007					0.029**	0.011		
communication_no2007							0.571***	0.000
Human Capital								
health2007			0.221**	0.026			0.403***	0.000
disability2007			0.371***	0.008				
ethnic_differ	-1.260***	0.007	-1.553***	0.000			-1.475***	0.001
Social Capital								
assist_friend	-3.017***	0.000	-1.396***	0.001	-1.289**	0.010		
rel_cadre2007					0.358***	0.000		
rel_county2007			-1.670***	0.000			-0.819**	0.030
Institutional arrangements								
aged_pension2007			0.901**	0.018			1.294***	0.004
govt_mobility					0.679**	0.028		
insitu_program	-0.175**	0.026			-0.347***	0.000	0.243***	0.002
Power condition								
political_party	-1.829***	0.000	-1.643***	0.000	-2.410***	0.000		
policy_will2007			0.292***	0.000			0.107**	0.021
suggestion_accept2007			-0.267***	0.004			-0.275***	0.008
_cons	5.405***	0.000	2.279***	0.001	-0.171	0.836	-1.706**	0.015
Obs.	303		303		303		303	
Wald Chi^2 Statistics	129.32***	0.000	204.97***	0.000	155.11***	0.000	145.70***	0.000

* p<.10; ** p<.05; *** p<.01.

The following factors are found to have significant influences on the reduction in *agricultural production* due to climate change: frequency of climate change assessed by people, household landholding, water storage facility, ethnicity, assistance from relatives or friends, number of in-situ adaptation programs, and political status. Specifically, the higher frequency of climatic events perceived by people the greater possibility for them to attribute climate change as a significant factor causing declined agricultural production. Households that have more farmland and water storage equipment (e.g., wells, ponds) are more likely to suffer declines in cropping and livestock production than those who have less farmland or have no water storage facility. There is a fact that the greater exposure to climate change, the greater possibility for the household to equip themselves with water storage facilities. However, water storage facilities still could not supply adequate water demanded by cropping and livestock production when the household experiences severe climatic variation or sudden climatic events, resulting in decreased agricultural production. If all members of the household are Hui, it has a less risk to experience decreased agricultural production than a Han family or a mixed household with members having different ethnic background. This might be because of two reasons. One is because local development policy is more favourable to ethnic groups. The other, based on the authors' observation during the fieldwork, is

because Hui people usually pay less attention and spend less time in agricultural production than Han Chinese, so that Hui people are not as sensitive as their Han counterparts to climate change impact on agricultural production. Assistance from relatives or friends is significantly associated with a household's reduction in agricultural production. This is not surprising as it is in circumstances when a household needs help from other people to halt agricultural production declines that relatives or friends provided prompt and greatest help. Those households engaged in more in-situ adaptation programs have greater risk of agricultural production being affected by climate change than their counterparts who did not participate in or only undertook few programs. The primary reason is that a household needs to engage in more in-situ adaptation programs if its agricultural production runs a greater risk of being affected by climate change than those who do not. Interestingly, if a family member is a Party member of the CPC or other minority political parties, agricultural production of this household is less likely to be affected by perceived climate change than households whose members do not have any political preference. In rural China, Party members have privileges of access to political and economic information, capacities of building broad connections within and beyond the locality, and preferential access to resources and jobs (Morduch and Sicular, 2000). Thus their households have stronger resilience in circumstances of climatic events and other natural hazards.

Factors significantly and positively influencing the reduction in *land area* due to climate change include: household landholding, water storage facility, self-reported overall health status, disability, aged pension, and willingness to participate in the policy making process. Specifically, households which have more farmland and/or have facilities to store water are more likely to lose land than other households which do not hold much land and do not have water storage facilities when climatic events occur. For households in which family members are generally healthy, it is more possible for them to lose land than those households whose members have medical conditions. Also, households that have disabled persons have greater risk to lose farmland than those who don't have when facing severe climatic events or variation. If there is a higher ratio of family members who have joined the rural aged-pension scheme against the total number of persons aged 16yrs or over, the family has a higher likelihood of losing farmland than its counterpart who does not join, or has a lower participation rate in the aged pension program. The group of households reported having a greater level of willingness to participate in policy making process is found to be significantly associated with more loss of farmland. The factors of ethnicity, assistance of relatives or

friends, and political status of household members impact on land loss in ways similar to what they negatively impacted on agricultural production. If a household has any relative or friend who lives beyond Xiji but lives in other counties within the same prefecture (i.e., Guyuan), it is less likely for the household to lose land. It is also less likely for a household to lose land if its suggestions are often accepted by local government or their villagers committee.

The impact of climate change on the reduction in *water quantity* has a statistically significant association with some household capital factors (excluding human capital) and contextual factors. Those households having experienced more frequent climate related hazards or severe variation in rainfall and temperature, having water storage equipment, taking longer time for children to go to school or public transportation station, having bad relationship with local cadres, and having participated in government-led relocation and migration programs have higher risk of declines in water supply. In contrast, those households living close to the local market, receiving assistance from relatives or friends, having pursued in-situ adaptation schemes, and having family members who are CPC members are less likely to experience reduction in water supply.

The impact of climate change on deterioration of *soil fertility* has a significant and positive association with the following factors: household landholding, water storage equipment, time spent on going to the closest place to fetch water, the number of communication means used by a household, overall health status of household members, participation in aged pension, the number of in-situ adaption schemes participated in, and the willingness of the household to participate in policy-making processes. Interestingly, the higher the rate of participation in aged pension for the household members aged 16 years or older, the greater the risk of land degradation this household may have experienced. In a similar manner, those households having participated in more in-situ adaption programs and having stronger willingness to participate in policy making process would have greater likelihood of land degradation than their counterparts. Those households with all members being Hui, or having relatives or friends living in other counties within the same prefecture, are less likely to experience land degradation. The higher level of the household's suggestion accepted by local government or the villagers' committee, the less likelihood of the household's land being deteriorated.

5.2 Result II: impacts of climate change, household assets and responses

The response model estimates to what extent the three responses adopted by different household groups are associated with the likelihoods of four domains of climate change impact (**Table 4**). How explanatory variables and contextual factors influence the changes in probability of choosing among the three responses is presented in **Table 5.**

Table 4. Regression results: response model

Variables	**Migration VS. Non adaptation**		**In-situ adaptation VS. Non adaptation**		**Migration VS. In-situ adaptation**	
	Coef.	P-value	Coef.	P-value	Coef.	P-value
frequency_cc2007	-0.542***	0.002	-0.141	0.430	-0.401**	0.033
Domains of climate change impact						
arigiculture07_hat	1.851***	0.000	1.805***	0.000	0.046	0.917
land07_hat	-2.348***	0.000	-1.800***	0.000	-0.548	0.153
water07_hat	-0.124	0.576	-0.332	0.133	0.208	0.324
soil07_hat	0.903***	0.001	0.354	0.187	0.549*	0.055
Natural Capital						
irrigation_r2007	-0.089	0.924	-1.269	0.114	1.180	0.289
water_storage	-1.579**	0.033	-3.084***	0.000	1.505*	0.062
Financial Capital						
income_pp2007	0.177***	0.001	0.027	0.597	0.151***	0.000
income_agri_pc2007	-0.792	0.490	0.308	0.776	-1.100	0.394
income_non_agri_pc2007	-4.258	0.116	3.945**	0.026	-8.203***	0.001
income_remittance_pc2007	0.037	0.976	2.396**	0.041	-2.359*	0.061
diversity_production2007	-0.629**	0.049	-0.565*	0.052	-0.063	0.851
Physical Capital						
agricultural_facility	1.339***	0.003	2.782***	0.000	-1.443***	0.001
time_market2007	0.055*	0.053	-0.011	0.522	0.066**	0.016
time_transport2007	-0.051*	0.060	0.008	0.595	-0.059**	0.018
public_facility	-0.282***	0.005	-0.184*	0.091	-0.098	0.384
Human Capital						
elderly07	-1.232	0.127	0.192	0.736	-1.423*	0.081
dependency07	2.561**	0.022	0.599	0.561	1.962*	0.093
edumax_hh	0.051	0.492	-0.182***	0.008	0.233***	0.005
ethnic_differ	1.451*	0.088	1.610**	0.042	-0.159	0.848
Social Capital						
assist_friend2007	1.320	0.213	2.994**	0.015	-1.673	0.218
assist_cash2007	1.412**	0.039	0.799	0.301	0.613	0.310
Institutional arrangements						
insitu_program	-0.210	0.211	0.100	0.557	-0.310	0.128
Power conditipn						
policy_will2007	0.382***	0.000	0.343***	0.001	0.039	0.680
_cons	-4.642**	0.043	-9.256***	0.000	4.614*	0.093

Obs.	302
Wald Chi^2 Statistics	161.38***

* p<.10; ** p<.05; *** p<.01.

Table 5. Change in probability of responses to climate change

Baseline model/variables	Migration	In-situ adaptation	Non adaptation
Baseline model	0.214	0.497	0.289
frequency_cc2007	-0.076	0.022	0.054
Domains of climate change impact			
arigiculture07_hat	0.119	0.255	-0.374
land07_hat	-0.204	-0.201	0.404
water07_hat	0.014	-0.070	0.055
soil07_hat	0.114	-0.007	-0.107
Natural Capital			
irrigation_r2007	0.120	-0.308	0.188
water_storage	0.022	-0.539	0.517
Financial Capital			
income_pp2007	0.027	-0.012	-0.015
income_agri_pc2007	-0.166	0.161	0.005
income_non_agri_pc2007	-1.135	1.439	-0.304
income_remittance_pc2007	-0.248	0.595	-0.347
diversity_production2007	-0.046	-0.075	0.120
Physical Capital			
agricultural_facility	-0.070	0.553	-0.483
time_market2007	0.010	-0.009	-0.002
time_transport2007	-0.009	0.007	0.002
public_facility	-0.028	-0.016	0.044
Human Capital			
elderly07	-0.183	0.154	0.029
dependency07	0.367	-0.122	-0.245
edumax_hh	0.028	-0.051	0.023
ethnic_differ	0.068	0.236	-0.304
Social Capital			
assist_friend2007	0.025	0.483	-0.508
assist_cash2007	0.143	0.065	-0.208
Institutional arrangements			
insitu_program	-0.046	0.047	-0.001
Power condition			
policy_will2007	0.028	0.045	-0.073

* p<.10; ** p<.05; *** p<.01.

Note: Probability change for each response to climate change is calculated as a change from 0 to 1 for dummy variables and as one unit change from the mean for numerical variables.

The *frequency of climate change* perceived by respondents is statistically significant, negatively influencing households' choice between migration and non adaptation and between

migration and in-situ adaptation. If people reported that their households experienced more frequent climate change related events, they would have less likelihood of taking migration over non adaptation, and also have less chance to pursue migration over in-situ adaptation. The probability of taking up migration would decrease by 7.6 percentage points for a one unit increase in the level of perceived frequency of climate change above the mean (4.6 out of 10 scales).

Three out of four domains of climate change impact on households are found to be statistically significant factors influencing adaptation choices (**Table 4**). If a household reported that *agricultural production* was reduced due to climate change impact in 2007, the household is more likely to choose migration and in-situ adaptation over non adaptation. Looking at the change in probability of each outcome, the probability for a household (or part of its members) to migrate (or adapt in-situ) would increase significantly by 11.9 percentage points (or 25.5 percentage points) on the baseline model level (**Table 5**). Being affected on deteriorated *soil fertility* the probability for households to choose migration increases significantly by 11.4 percentage points, while that of adopting in-situ adaptation remains virtually unchanged (decreases by 0.7 percentage points). Clearly, reduced agricultural production and land degradation "push" rural households (or some members) to migrate to other places where living conditions may be relatively better-off, or "force" them to undertake in-situ adaptation schemes. A drop in agricultural production potentially raises the probability of migration, as farmers used migration as a coping strategy for combating bad harvest. This finding is consistent with literature from other studies (e.g., Warner, 2012). Reduction in household *land area* significantly decreases the probability of migration and in-situ adaptation by 20.4 and 20.1 percentage points, respectively. Normally, one may expect that loss of farmland will potentially raise the probability of migration (or in-situ adaptation), as farmer households may seek migration as a coping (or adapting strategy) for combating land loss. However, our empirical data show that households which suffer from land reduction usually face tighter financial constraints so that they cannot move, or adapt locally.

Among a set of *natural capital* factors, only "water storage facility" is significantly associated with household responses to climate change. Those households which have water storage facilities are less likely to take migration or in-situ adaptation than non adaptation. The probability for such households to have no active response is estimated to rise dramatically

(by 51.7 percentage points) while the probability of taking in-situ adaption drops substantially (by 53.9 percentage points).

A set of income related *financial capital* factors are significantly associated with the selection of adaptation strategies. The study found that a one unit (i.e., 1,000 yuan, USD 1=RMB 6.12 yuan as of 14 August 2013) increase in the level of "annual income per person" of a household above the mean (5,919 yuan in 2007) raises the probability of taking migration by 2.7 percentage points. Two sources of household income have significant influences on the choices of adaptation strategies: non-agricultural and remittances. The probability for households to undertake in-situ adaption would rise tremendously (by 143.9 percentage points), while that of taking migration would decrease correspondingly (by 113.5 percentage points) for a one unit (i.e., 0.1) of increase in the "share of non-agricultural income" against total income above the mean (0.024). This suggests that those households which have the capacity to establish small industries or household businesses would prefer adapting locally when facing climate impact to out-migrating their whole households or some family members. "Remittances" that migrant workers sent to their families could significantly and greatly enhance local adaptive capacities, increasing the probability of adopting in-situ adaptation schemes by about 60 percentage points. This finding offers strong support for Adger et al. (2002) views that remittances can help support the remaining family members to adopt in-situ adaptation. The greater "diversity of production activities" that a household employed, the less probability that it may migrate or adapt locally, compared to those doing nothing. For a one unit increase in the number of production activities (e.g., cropping, livestock, labour export, business, secondary industry, horticulture, planting vegetables or medicinal herbs) above the mean (2.1), the probability for a household to choose migration (or in-situ adaption) is likely to decrease by 4.6 (or 7.5) percentage points.

Among a number of *physical capital* factors, "agricultural facilities and techniques" used by households to protect agriculture from negative impact of climate change has the most significant influence on choice among adaption means. Households are more likely (increase by 55.3 percentage points in probability on the baseline model level) to adapt locally than to migrate or do nothing if they increase the utilisation of available facilities that improve water storage, irrigation system and soil fertility, and techniques that develop water-saving farming practice, drought or high-temperature resistant crops, value-added forest and horticulture, and cultivation of waste land. Three other factors – "time to the market", "time to the nearest

transportation station", and "access to public facilities" – are also statistically significantly, but to a lesser extent, associated with household's choice among adaptation means.

Among a set of *human capital* (or demographic) factors, four factors are statistically associated with the choice among adaptation strategies: "aged family members", "dependency ratio", "highest schooling of family members", and "ethnicity". Households having aged family members have a stronger propensity to adopt in-situ adaptation than migrate. The probability of migration would decrease significantly (by 18.3 percentage points), while the probability for in-situ adaptation increases greatly (by 15.4 percentage points) for households having elderly members (**Table 5**). If households have a higher dependency ratio, they are more likely to have entire households or some family members migrate than undertake in-situ adaptation or do nothing. The probability for such households to choose migration would increase dramatically by 36.7 percentage points for a one unit (0.1) increase in the level of dependency ratio above the mean (0.31). This result reflects the actuality of rural society in China in that out-migration of rural labour has largely left young children, spouses and parents behind in rural villages (World Bank, 2009). For households whose members received more years of schooling than those whose members did not, they are more likely to migrate than adopt in-situ adaptation. The probability of taking migration would rise by 2.8 percentage points for 1 year of increase in schooling above the mean (8.4 years) level. The findings are consistent with the literature (e.g., Boyd 1989; Massey et al. 1993; Castles 2011). Strikingly, the propensity for Hui households to chose in-situ adaption over doing nothing is greater (increase the probability by 23.6 percentage points on the baseline model level) than purely Han or mixed ethnic families.

A couple of *social capital* factors – "assistance from relatives or friends" and "assistance in cash" (including living material) – are found to be significantly associated with households' response to climate change. Those households which received help from their relatives or friends are more likely to select in-situ adaption over doing nothing, increasing the probability of in-situ adaptation substantially (by 48.3 percentage points) on the baseline model. This suggests that family kinship or friendship network facilitates local adaptation when people encounter climatic events or unusual variation in rainfall or temperature. Among a number of sources that a household may have received help, only assistance in cash is significantly and positively associated with choice of migration over non adaptation. Assisting households in cash raises the probability of migration significantly (by 14.3 percentage points). This

indicates that receiving money donated by others is of significance, facilitating some households or some of its members to migrate.

Among a number of *institutional* and *power condition* related variables, only one factor – the willingness of a household to participate in any policy-making process – significantly influences household responses to climate change. For households reporting stronger willingness to engage in policy-making processes, the probability of taking in-situ adaptation rises by 4.5 percentage points while that of pursuing migration increases marginally (by 2.8 percentage points) for a one unit of increase in the level of willingness above the mean (3.9).

6. Discussion and Conclusion

Livelihood of rural households is an important issue of adaptations (including migration) to climate change but is little empirically addressed in climate change and adaptation studies. To understand the interrelationship between climate change, livelihood assets (or capital which measure the adaptive capacity), adaptation and migration, this study, built on existing Sustainable Livelihood (SL) approaches, developed a conceptual framework consisting of two important stages of the adaptation decision-making process – Stage I: impact stage, and Stage II: response stage. Based on this framework, a two-stage regression procedure was used first to examine the influence of a host of indicators that measure five categories of household capital among different groups of rural households on four major agro-ecological spheres on which climate change has statistically significant and quantitatively great impact (i.e., reductions in agricultural production, land area, water supply, and soil fertility). It then examined how each set of livelihood capital factors, contextual factors and climate change impacts interact to differentiate adaptation strategies adopted by people. This study adds increased knowledge to the current literature that human responses to climate change at household level are significantly influenced by frequency of climate change perceived by people and by five dimensions of livelihood assets – *natural capital*, *financial capital*, *physical capital*, *human capital*, and *social capital*, and mediated particularly by the willingness of people's participation in policy-making processes. A two-stage conceptual framework and a two-stage analysis approach developed in this paper contribute to the research methodologies for unravelling the climate change–adaption (migration) nexus. This analytical tool and methods can be applied to other study areas.

The study suggests that the impact of climate change is assessed, and felt, differently by different households, and responses to that change also differ between households living in similar rural settings, according to different levels or status of five assets that rural households own. In the rural communities of the case study (Xiji county of Ningxia Hui Autonomous Region of China), a number of policies and programs that have been implemented in the past five years are found to have no significant role in influencing household choices among adaptation means (including migration). Some households did not recognise climate change as a risk of their livelihoods. Some chose passive acceptance of climate impact due to two primary reasons. One is because they have little, or low level of, adaptive capacity (as indicated by the circumstances of their household assets) to respond to climate impact actively. The other is because some households were planned to be relocated and resettled by local government under the recent or ongoing environmental and resettlement programs, which consequently reduced incentives (by both governments and individual households) to adapt or seek migration actively. The majority of financial resources have been invested in government-led resettlement programs. Other types of population movements, particularly export of migrant workers and educational migration, are practiced inadequately. These findings suggest that some policies (or institutional arrangements) fail in practice, and that a critical issue "maladapation", as raised by other researchers such as Barnett and O'Neill (2010), may exist in the case study area. This issue will be further examined in our next paper.

Some characteristics of household financial, human and social capitals, particularly household income per capita, proportions of household revenue from non-agricultural production and migrant remittances, accessibility of modern agricultural techniques and facilities, educational attainment and skills training, ethnicity, and social networks (especially with relatives and friends), are critical factors for people to choose (or not choose) migration or in-situ adaptation in the study area. Both migration and adaptation policies that aim to address rural livelihood needs of various groups of the population affected by climate change and to improve their migration or in-situ adaptation outcomes need to target groups with these characteristics.

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