



Sensitivity of livelihood strategy to livelihood capital in mountain areas: Empirical analysis based on different settlements in the upper reaches of the Minjiang River, China



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ABSTRACT

Livelihood strategies denote the range and combination of activities and choices made by households. Some research has focused on the potential impacts of sustainable livelihood, and only a few studies have begun considering sensitivity of livelihood strategies. Based on the gradient altitude and resettlement project, mountain settlements are classified into four types: the high-mountain settlement, the semi-mountain settlement, the river valley settlement and the resettlement area. Using semi-structured interviews, we have defined the farm and non-farm livelihood strategies as dependent variables, while the natural, human, physical, financial, and social capitals are considered as independent variables in order to model the relationship between livelihood strategies and livelihood capitals. In term of different settlements, we estimate the sensitivity of farm and non-farm livelihood strategies to livelihood capitals. The results indicate that natural and human capitals exhibited a positive correlation with the farm livelihood strategy, although the effect varies with the four types of settlements. Financial and social capitals are the catalyst for driving non-farm activities. Our findings suggest that no size fits all solutions to the livelihood strategy issues, and only livelihood capitals will be helpful in the long term if they are complemented by relative policies that enhance capital capacity as well as increase access to capitals.

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1. Introduction

1.1. Three core concepts

The term “livelihood” has been defined in a variety of ways by various authors. Considering the most common definition, a livelihood can be defined as people’s capacity to maintain a living (Chambers and Conway, 1991). In the last few decades, several institutions (e.g. FAO, UNDP, DFID etc.) have developed frameworks to analyze sustainability of livelihoods. Most of these frameworks are similar. DFID’s (the UK Department for International Development) conceptual framework, however, draws attention to the measured changes in different factors that contribute to livelihoods: five capitals, institutional process and organizational structure, vulnerability of livelihoods, livelihood strategies, and outcomes (DFID, 1999).

“Livelihood capitals” refer to the resource base of a community and of different categories of households (FAO, 2005). They are

grouped into human, natural, financial, physical, and social capitals (DFID, 1999; FAO, 2005). The capitals available constitute a stock of asset which can be stored, accumulated, exchanged, and put to work to generate a flow of income (Rakodi, 1999; Ellis, 2000; Babulo et al., 2008).

Using the available five capital assets, people engage in various livelihood strategies to achieve livelihood objectives. Therefore, “livelihood strategies” are the range and combination of activities and choices that people make in order to achieve their livelihood goals (DFID, 1999; FAO, 2005). These livelihood activities are subject to the endowment of livelihood capital because they determine the possibilities for rural household to achieve goals related to revenue, safety, and welfare (Van den Berg, 2010). In other words, livelihood strategies can also be understood as the means to cope with external disturbance and maintain livelihood capabilities (Chambers and Conway, 1991; Ellis, 1998, 2000; DFID, 1999; Adato and Meinzen-Dick, 2002).

Due to spatial variations of capital assets in settlements and agro-climatic zones, the differential access to, or endowment of, livelihood assets determines the choice of a household’s livelihood strategies (Babulo et al., 2008). It means that livelihood outcomes become critical to rational use and improve efficiency of livelihood

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capitals at the household level subject to the goal of maximizing these outcomes (Brown et al., 2006).

1.2. Literature review

The livelihood strategy has been increasingly studied over the past years in the world, and the significant progress has been made in classification of livelihood strategies, impact elements of livelihood strategies, and role of livelihood strategies in poverty alleviation.

1.2.1. Classification of livelihood strategies

According to the definition of a livelihood strategy, many scholars have conducted the classification study of livelihood strategies (Pichón, 1997; Browder et al., 2004; Jansen et al., 2006; Brown et al., 2006; Alemu, 2012). For example, in Alemu's (2012) study, livelihood strategies have been classified into four categories: only farm, farm and non-farm, only non-farm, and non-labor. Different from Ansoms' study, Soltani et al. (2012) emphasized the classification of livelihood strategies and highlighted the dynamic natures of a livelihood strategy. In the case of Zagros from Iran, they classified livelihood strategies into three types as follows: forest/livestock strategy, crop farming/livestock strategy, and non-farm strategy. Their study revealed that a number of households have shifted from a strategy based on forest and livestock to a strategy of mixed practices since the end of 1980s.

1.2.2. Impact factors of livelihood strategies

Since 1990s, livelihood analysis has become the dominant approach to understanding how rural residents make a living (DFID, 2007; Ellis, 2000; Scoones, 2009). An increasing recognition that the ability to pursue different livelihood strategies is dependent on the basic material and social, tangible and intangible assets that people have in their possession (Scoones, 2009). For this reason, some recent studies give more emphasis to factors determining a livelihood strategy. These factors include the biodiversity protection (Salafsky and Wollenberg, 2000), soil fertility (Tittonell et al., 2010), policies (Barrett et al., 2001a), market liberalization, agricultural intensification (Orr and Wmale, 2001), tourism (Wall and Methiesion, 2006; Tao and Wall, 2009; Iorio and Corsale, 2010; Mbaiwa, 2011), cropping, forestry and livestock products (Stoian, 2005; Babulo et al., 2008; Kamanga et al., 2009; Tesfaye et al., 2011; Adam et al., 2013; Diniz et al., 2013; Zenteno et al., 2013), and natural capital (Fang, 2013a), as shown in Table 1. In addition, Alwang et al. (2005), Van den Berg (2010) discussed the dynamics of livelihood strategies in Nicaragua using a multidimensional manner. By identifying determinants of livelihood strategy, they suggested that the approach motivation would be associated with increasing the family welfare of farmers. Through the literature review, the quantitative livelihood approach has become an increasingly popular way of understanding the inter-relationship between livelihood strategies and impact factors. Based on the regression analysis, the relationship between livelihood strategies and consumption is already being observed (Alwang et al., 2005). The impact of labor force and land on livelihood strategies is examined in the study conducted by Jansen et al. (2006). Ulrich et al. (2012) described the causal relationship between livelihood strategies of rural families in Kenya and livelihood capitals portfolio, by employing welfare indexes as a means of quantifying analysis. They concluded that the portfolio of agricultural and husbandry production, stable non-farm activities, and flexible and diversified livelihood capita, might become considerable importance to livelihood strategy. Adam et al. (2013) identified the key factors that influenced rural livelihood strategies and quantified their effects on livelihood strategy. They argued that regulatory, technical and financial support related to non-timber forest products greatly improved the effect of a livelihood strategy.

Similarly, the importance of viewing livelihood capitals as a driving force of livelihood strategy practices is emphasized in the paper prepared by Zenteno et al. (2013). Regarding livelihood strategy, we have seen that insights about the interaction between livelihood strategies and livelihood capitals are crucial to improving our understanding of sustainable livelihood in rural areas.

1.2.3. The role of livelihood strategies in poverty alleviation

There continues to be much debate about how poverty should be defined, but it is increasingly accepted that poverty is understood as deficiency in individual's capabilities of obtaining materials necessities and social services (Coudouel et al., 2002), and such deficiency is characterized by a lack of livelihood assets (Sen, 1993). Of course, the increased inequality for welfare indicators (e.g., income) will almost be associated with a higher level of poverty (Ellis, 2000). Livelihoods analysis can serve a wide variety of applications, such as explanation of the root cause of rural poverty, and development of effective methods for alleviating poverty. Consequently, the link between livelihood strategies and poverty is of fundamental importance to the long-term poverty reduction (Table 2). Indeed, it is generally believed that non-farm activities play an enormous role in breaking the vicious cycle of poverty (Lanjouw and Feder, 2001; Haggblade et al., 2002; De Janvry et al., 2005; World Bank, 2009; Haggblade et al., 2010). Ansoms and McKay (2010) and Alemu (2012) have done a similar exercise in alleviating poverty although they did not explicitly refer to non-farm livelihood strategies. Their studies point to the important role of poor household's access to non-farm income activities. They founded that rural poverty could be alleviated by non-farm activities rather than local development in agriculture. Similarly, scholar such as Soltani et al. (2012) also claimed the positive correlation between off-farm livelihood strategies and poverty reduction. Van den Berg (2010) provided unique perspective on the relationship between natural disasters and household's income. He also addressed the necessity for the poor in rural areas to participate in non-farm strategies. On the contrary, studies (Reardon et al., 2000; Shackleton et al., 2007; Alary et al., 2011; Christiaensen et al., 2011; Hogarth et al., 2013; Soltani et al., 2012) also pointed to the important role of conventional farming strategies (e.g. agriculture, forestry, and animal husbandry) in poverty reduction. They argued that the increasing area of farmland, developing high value-added farming products, adjusting the structure of agricultural production, improving productivity of land, and fulfilling the basic requirements for agricultural activities, would produce less poverty. Furthermore, the fishery livelihood strategy was considered as one of the most approaches to alleviation poverty in rural areas (Thorpe et al., 2006; Weinberger and Lumpkin, 2007; Walmsley et al., 2006). In addition to insights inherent in perceptual processes, the impacts of climate change are increasingly recognized as significant factors of livelihood strategies, particularly, effective linkages to livelihood vulnerability, poverty alleviation (Fang et al., 2011, 2012; Gentle and Maraseni, 2012; Fang, 2013a,b).

1.3. Objects of the study

Based on existing literatures, livelihood strategies contribute to poverty alleviation and identify the determinants for livelihood strategies although there is a growing body of research on quantifying the relationship between livelihood strategies and capital. There is a lack of empirical information and research on the sensitivity of livelihood strategies to livelihood capital. In particular, there are few analytical studies on the differences between rural settlements in mountainous areas, site-specific characteristics of livelihood strategy processes, and sensitivity of livelihood strategies. Although 60% of rural households still depend on agriculture, the non-farm activity has been playing an active role in increasing

Table 1
Summary of selected studies on impact factors of livelihood strategies.

Authors	Study area	Methods	Relevance of main factors
Adam et al. (2013)	Sudan	Questionnaires survey, descriptive statistics, multiple regression analysis	Non-timber forest products, product markets, resource base, political context and household characteristics
Fang (2013a)	Source region of the Yellow River, China	Livelihood analysis farmework	The effect of Natural capital (grassland) protection
Zenteno et al. (2013)	Northern Bolivian Amazon	Sustainable livelihood framework, household survey, Kruskal–Wallis (K-W) tests	Contribution of forest products
Soltani et al. (2012)	Iran	Sustainable livelihood framework, household Survey, village Survey	Land, financial capital, education, Location capitals
Tesfaye et al. (2011)	Southern Ethiopia	Sustainable livelihood framework, random utility maximization theory model	Household characteristics, possession of cropland, geographical factors
Mbaiwa (2011)	Botswana	Face-to-face household interviews, thematic analysis	Tourism development
Tittonell et al. (2010)	East Africa	Household surveying, principal component analysis, cluster analysis	Soil fertility status and spatial variability
Iorio and Corsale (2010)	Romania	Sustainable livelihood framework, field research, household interview	Rural tourism
Kamanga et al. (2009)	Malawi	Descriptive statistics, Gini-coefficient analysis, chi-square testing and multiple regressions	Forest resources have a particular importance in poor households' livelihood strategies
Tao and Wall (2009)	Taiwan	Sustainable livelihood framework, field research, household interview	Tourism
Babulo et al. (2008)	Northern Ethiopia	Sustainable livelihood framework, clustering analysis, multinomial logit regression, random utility maximization theory model	Forest product collection
Stoian (2005)	Bolivian Amazon	Semi-structured interviews, non-timber forest products valuation method	Extraction of Brazil nut and palm heart, migrant and educational background
Orr and Wmale (2001)	Southern Malawi	Rapid rural appraisal, quantitative methods, household case studies	Market liberalization, agricultural intensification, livelihood diversification
Salafsky and Wollenberg (2000)	Across Asia and the Pacific	Literature review	Defining the linkage between livelihood strategies and conservation

income and reduction poverty for china's rural areas owing to the reform and opening-up policies (China Statistical Yearbook, 2011). However, there is a geographically significant difference in production and living condition of rural residents in mountain areas compared with plain areas. The natural resource base for the poor and livelihood-insecure is always narrow in mountain areas. Specially, mountains cover approximately 70 percent of the China's surface and are home to 46 percent of the total population. And the challenges for unbalanced development will have major impacts on the more than 615 million people who depend on natural resources and primary industries for their livelihoods. A particularly instructive setting in which to consider rural sustainable development is mountain settlement. Because mountain settlement is the most basic social and economic unit, it is also usually synonymous with poverty in China. It can be said that the development of mountain settlement has a decisive effect on the construction of well-off society (Chen et al., 2007). Against this background, the development of mountain settlement clearly has major implications for equity, poverty and quality of life in China. For this reason, more efforts are needed to assess the sensitivity of livelihood strategies to capital in mountain areas of China. Due to increasing pressures including population growth, sustainable livelihood and climate change, we are particularly keen to getting a clear understanding of the role of livelihood capital in livelihood strategies at settlement level. We adopt the approach of settlement classification analysis in order to address the different livelihood response to capital, rather than practices occurring at different settlements. The aims of the present study are to shed some light on the sensitivity of livelihood strategies to livelihood capitals for different settlements and the key capitals affecting livelihood strategies of different settlements in mountain areas. Its contribution is threefold: first, it quantifies the sensitivity of livelihood strategies to livelihood capitals, in contrast to the existing literature which mostly focuses on potential

impact of livelihood strategy; second, it adopts a suitable econometric method, i.e. the Logistic Regression Model, to investigate the determinants of livelihood strategies at the community level; third, it highlights the implication of livelihood strategies in mountain areas.

In pursuing these objectives, the remainder of the paper is organized as follows. In Section 2, we describe the methodology. Section 3 identifies different sensitivities of livelihood strategies to livelihood capitals. And conclusions are summarized in Section 4.

2. Methodology

2.1. Description of research sites

Located in western Sichuan of China, the upper reaches of the Minjiang River is characterized by both mountains in the western boundary of Sichuan Basin and alpine valley of West Sichuan Plateau, with an altitudinal range from 700 m to 5588 m. It has become increasingly important to study the ecosystem in mountainous areas of China owing to its complicated landforms, diversified climate types, and rich biological species (Fig. 1). At the same time, this area is also the home to many ethnic groups such as Tibetans, Qiang, Hui and other minorities. Due to undeveloped economy, this area typically experience higher rates of poverty. Therefore, a pilot research in this area is considered to be the best way to learn the root cause of poverty and alleviation poverty practice. For Ganbao Township of Lixian County, located in the southwest of the upper reaches of the Minjiang River, the income per capita is 85.7% and 55.8% of the average levels of rural inhabitants in Lixian and Sichuan Province respectively (Fang et al., 2012). Consequently, we choose Ganbao Township as a case to conduct the sensitivity analysis of livelihood strategies to capital. To further understand the differences in sensitivity,

Table 2
Summary of selected studies on the roles of livelihood strategies in poverty alleviation.

Authors	Study area	Methods	Main results
Alemu (2012)	South Africa	Two-stage approach, multinomial logistic regression	Age, labor endowment, education, and community characteristics in terms of access to basic infrastructure are some of the barriers that poor households face to enter into high-return livelihood strategies
Gentle and Maraseni (2012)	Nepal	Climate vulnerability and capacity analysis, participatory social research methods	The changing climate is an additional burden to the poor people who are already living in poverty, are vulnerable and excluded with predictions of additional risks to livelihoods and further inequity in the future
Soltani et al. (2012)	Iran	Sustainable livelihood framework, household survey, village survey	Increasing commercial cropping and non-farm activities may be one of the desirable paths of rural development
Alary et al. (2011)	Mali	Income-based approach, asset-based approach	Asset-based approach reflects the roles of livestock in terms of security and vulnerability. But only a dynamic approach to indicators can account for the complex role of livestock in reducing poverty
Christiaensen et al. (2011)	Global	Elasticity analysis, regression analysis, econometric approach	Agriculture is significantly more effective in reducing poverty among the poorest of the poor.
Ansoms and McKay (2010)	Rwanda	Sustainable livelihood framework, participatory poverty assessments, cluster analysis	Rwandan rural policies should adopt distinct and appropriate interventions for impoverished peasant groups, each having their own particular livelihood profiles
Haggblade et al. (2010)	Global	Descriptive statistics, Literature review	Non-farm economy can significantly expand economic opportunities for the rural poor.
Shackleton et al. (2007)	South Africa	Literature review	Access to and use of forest resources can undoubtedly prevent intensification of poverty
Weinberger and Lumpkin (2007)	Global	Descriptive statistics, document summary	Horticulture can offer good opportunities for poverty reduction because it increases income and generates employment
Thorpe et al. (2006)	Asia	Content analysis methodology, descriptive statistics	Identification the socio-economic importance of fisheries in the region in terms of its contribution to primary exports, domestic protein consumption, employment and poverty alleviation
Walmsley et al. (2006)	Western Indian Ocean region	Poverty reduction strategy assessment, sustainable livelihood approach	Promotion of the importance of the fisheries sector for poverty reduction is important in order that the sector receives the appropriate recognition and budgetary support and is subject to appropriate interventions focused on alleviating poverty
Ellis et al. (2003)	Malawi	Field research	Existing tendencies for monetized farm and nonfarm activities to be seen more as sources of potential revenue than as engines of growth and poverty reduction
Ellis and Mdoe (2003)	Tanzania	Field methods	Rural poverty is strongly associated with lack of land and livestock, as well as inability to secure nonfarm alternatives to diminishing farm opportunities
Bebbington (1999)	Global	Literature review	Particular attention is paid to the importance of social capital as an asset through which people are able to widen their access to resources and other actors

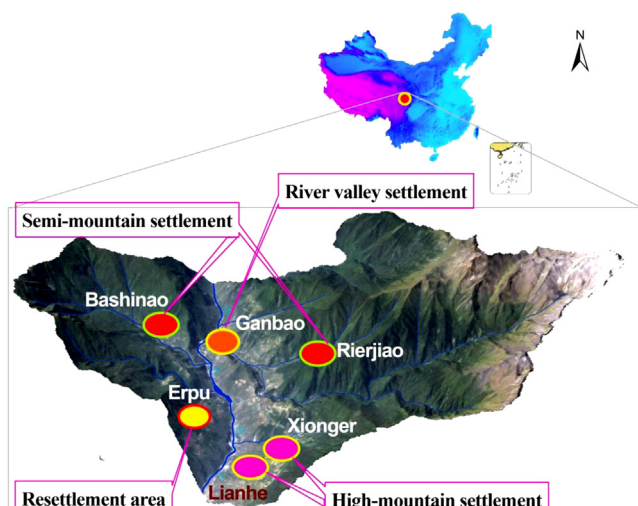


Fig. 1. Types of settlements and sample spatial distribution.

we categorize mountain settlements into four types: the river valley settlement (Ganbao), semi-mountain settlement (Baishinao and Rierjiao), high-mountain settlement (Xionger and Lianhe), and resettlement area (Erpu) (Fig. 1) (Fang et al., 2012). The major features of these four types of settlements are summarized in Table 3.

2.2. Methodological approach

2.2.1. Sample size and distribution

Using the integrated method of both generalized proportional and selective sampling, we distributed 450 questionnaires (e.g. 189 for Ganbao, 76 for Erpu, 55 for Xionger, 51 for Rierjiao, 69 for Bashinao, and 10 for Lianhe). We received 400 completed questionnaires, of which 169, 108, 47, and 76 were from the river valley settlement, semi-mountain settlement, high-mountain settlement, and resettlement area respectively, representing a response rate of 88.9% (Table 3). The questionnaire survey lasted from April 2010 to May 2010.

2.2.2. Measuring method of livelihood capital

Combining the livelihood capital and questionnaire method, main proxy variables are selected in Table 4. In order to measure the contribution of different capitals in livelihood strategies, standardizing every variable is important based on the following equation.

$$Z_i = \frac{x_i - \bar{x}}{S} \quad (1)$$

where, x_i corresponds to the i th measurement of variable, \bar{x} is the average value of x , and S is the standard deviation. As a result, we write livelihood capital C_i as:

$$C_i = \sum W_i Z_i \quad (2)$$

Table 3
Sampling distribution and proportion based on different types of settlements.

Category of settlement	Main features of settlement	Name of settlement	Number of sample (household)	Share of sample in permanent household (%)	Share of sampling distribution (%)
River valley settlement	This kind of settlement is at an elevation of about 1800 m a.s.l, with convenient transportation, fertile soil, good irrigating system, high agricultural productivity, and limited average farmland area	Ganbao	169	81.3	42.3
Semi-mountain settlement	Located at an altitude between 2100 m and 2150 m a.s.l, the settlement has larger average farmland area, which is mainly sloping farmland for dry farming, than the river valley settlement, but inconvenient transportation and infrastructure	Bashinao	69	90.8	17.3
High-mountain settlement	Located at an altitude between 2250 m and 2300 m a.s.l, the settlement mainly is featured by scattered farmers, poor soil, rain-fed farming, large farmland area, and inconvenient transportation, the major sector fund in this region is agriculture, and over 80% of households derive their livelihood from rain-fed subsistence agriculture	Rierjiao Xionger	39 37	63.9 30.8	9.8 9.3
Resettlement area	With the supports of policies such as post-disaster reconstruction (5.12 earthquakes in Sichuan) and ecological resettlement, some settlements that are located in the high- and semi-mountain have been resettled in new communities near river valley areas	Lianhe Erpu	10 76	76.9 80.9	2.5 19.0
Total			400	69.9	100

Table 4
Key variables of livelihood capital and weights.

Category of capital	Proxy indicators	Weights
Natural capital/C ₁	Area of arable land (hm ²)	0.730
	Area of converting the farmland for forestry (hm ²)	0.190
	Homestead area (m ²)	0.080
Human capital/C ₂	Family size (person)	0.080
	The number of labor force (unit)	0.800
	Education level of labor force (year)	0.120
Physical capital/C ₃	Housing value (yuan)	0.500
	Value of productive material (yuan)	0.250
	Infrastructure (index)	0.125
	Capacity of public service (index)	0.125
Financial capital/C ₄	Family savings (yuan)	0.200
	Family loan (yuan)	0.500
	Cash holding (yuan)	0.300
Social capital/C ₅	Employment channel (index)	0.550
	Capacity of association participation (index)	0.450

Note: Financial capital denotes the financial resources that people use to achieve their livelihood objectives. The definition used here is normalized data of deposit and loan per household. Social capital is taken to mean the social resources upon which people draw in pursuit of their livelihood objectives. The definition used here is normalized data of employment and social participation per household.

where, C_i is the estimated value of the livelihood capital (i = 1, 2, 3, 4, 5), W_i indicates the weight for the ith observation (i), and Z_i represents the normalized value for the ith observation (i).

The detailed steps of the weighted scoring method are as follows:

Step 1: Identify the key attributes and variables related to capitals.

According to the definition of livelihood capital and the features of regional conditions, as well as the availability of data, we identify 15 key variables to describe the attributes of five capitals. For these key variables, three are for human capital, four for physical capital, three for financial capital, two for social capital, and three for natural capital in the aspects such as area of arable land, area of

converting the farmland for forestry, and homestead area. Table 4 lists the key attributes and proxy variables that are relevant to the case.

Step 2: Select an expert group.

We define a group of people with high authority and much expertise in a special field as an expert group. The expert group consists of the following members: village cadres of Ganbao Township, deputy chief of Ganbao Township, technicians from Lixian and Wenchuan County Bureau of Agriculture, financial staff from the Agricultural Department of Sichuan Province, and researchers from Sichuan Academy of Social Sciences. The total number of people in the expert group is 25.

Step 3: Score the options.

Options are scored against the attributes by reference to a scale, say from 0 to 10. The score of 0 indicates that the option offers no benefits at all in terms of the relevant attribute, and the score of 10 illustrates that it represents some maximum. The scores between 0 and 10 indicate the intermediate levels of performance. The allocation of scores to each option reflects their relative importance. Step 4: Calculate the weighted scores.

According to Step 3, a score is weighted by the indicator weighting within each capital category. Then, all the weighted scores are added. For example, the size indicates that the account for 10% of the sample aggregate size variable will contribute 0.10 to the total score (as each of the five capital categories is normalized to a score of one) (Table 4).

2.2.3. Models estimation of livelihood strategy sensitivity

In this paper, logistic regression is used to describe the causal relationship between livelihood strategies (e.g. independent variable Y) and livelihood capital (e.g. dependent variable C_i). When using the logistic distribution, we need to make an algebraic conservation to arrive at our usual linear regression equation, the logistic regression model will be (Hosmer and Lemeshow, 2000):

$$p = b_0 + \sum_{i=1}^m b_i C_i \tag{3}$$

where, P is the probability, b_0 is the constant, and b_i ($i = 1, 2, 3, m$) is the regression coefficient. In practice, the dependent variable (P) is not continuous. Therefore, we convert P into the probability ratio (Ω) of non-farm livelihood strategies. The logistic formula is stated as follows:

$$\ln(\Omega) = \ln\left(\frac{p}{1-p}\right) \quad (4)$$

where, \ln symbol refers to a natural logarithm, and Ω is called log it (p). Then we further obtain the following equation:

$$\log it(p) = b_0 + \sum_{i=1}^m b_i C_i \quad (5)$$

where, $b_0 + \sum_{i=1}^m b_i C_i$ is our familiar equation for the regression line. P can also be computed from the regression equation. Therefore, if we know the regression equation, we could theoretically calculate the expected probability for a given value of C_i . Eq. (5) is transformed as follows:

$$\Omega = \frac{p}{1-p} = \exp\left(b_0 + \sum_{i=1}^m b_i C_i\right) \quad (6)$$

where \exp is the exponent function, and it is opposite to the natural logarithm. We are interested in estimating the probability (e.g. non-farm or farm strategy), because the value of C_i increased or decreased in one unit. The derivative transformation of Eq. (6) is:

$$\Omega' = \exp\left(b_j + b_0 + \sum_{i=1}^m b_i C_i\right) = \Omega \exp(b_j) \quad (7)$$

where, $\exp(b_j)$ is the elasticity of probability, and it will change when C_i increases or decreases by one unit. Here, we define $\exp(b_j)$ as the sensitivity of livelihood strategies to livelihood capitals. The explanatory variable (C_i) includes natural, physical, human, financial and social capitals. Based on the Eq. (7), we can calculate the $\exp(b_j)$ value. It should be noted, however, there is a positive relationship between livelihood capital and non-farm livelihood strategies if the regression coefficient is positive. This means that the probability of non-farm strategies increases by $\exp(b_j)$ times as the livelihood capital (C_i) increases by one unit. On the contrary, there is an adverse relationship livelihood capital and non-farm livelihood strategies if the regression coefficient is negative. This means that the probability of agricultural livelihood strategies increases by $\exp(b_j)$ times as the livelihood capital (C_i) increases by one unit. SPSS14.0 is used to conduct statistical analysis in this paper.

3. Results and discussion

The way a household copes with environmental changes and withstands stressful situations directly depends on the availability and accessibility of livelihood assets. A livelihood strategy is, to a large extent, the ways whose livelihood assets are arranged and selected. That is to say, different combinations of livelihood capitals result in different abilities to follow livelihood strategies. In order to further understand the determinants of each livelihood strategy and compare the differences in sensitivity in this study, we divide livelihood strategies into two categories: farm and non-farm strategies, according to the proportion of non-farm earnings to the total household' revenues. Specifically, the household of non-farm strategies earns more than 59% income from non-farm activities, and the household of farm strategies earns less than 59% income from non-farm activities. Table 5 clearly illustrates that the levels of livelihood capitals possessed by households are closely related to livelihood strategies. Natural and human capitals have positive effects on farm livelihood strategies, whereas financial and social capitals have positive effects on non-farm livelihood strategies. The

sensitivity of livelihood strategies to capitals varies greatly between different settlements and within settlements (Table 6).

3.1. The river valley settlement

On the basis of the 169 questionnaires, the proportion of households engaged in farm activities is 50.3%, whereas households engaged in non-farm livelihood account for 49.7%. As shown in Table 5, a particularly close relationship exists between livelihood strategies and the natural, financial and social capitals. The results demonstrate that the association between natural capital and farm strategy is generally positive. Households with higher levels of proximate natural capital are more likely to engage in farm activities. In contrast to natural capital, households have better access to financial capital which improves their access to better non-farm opportunities. This implies that financial capital is an important driving force for rural households to choose non-farm livelihood strategies. From the sensitivity analysis perspective, the probability of farm livelihood strategies increases by 0.057 times if the natural capital increases by one unit; the probability of non-farm strategies increases by 2.704 times if the financial capital increases by one unit; the probability of non-farm strategies increases by 2.295 times if the social capital increases by one unit (see Fig. 2 and Table 6).

The sensitivity is expressed in the value of the slop. The highest value of sensitivity (slope) reflects a steeper grade. Therefore, Fig. 2 explicitly indicates that the non-farm strategy has higher sensitivities to financial and social capitals compared with natural, human, and physical capitals. Clearly, livelihood strategies (farm and non-farm options) of different categories of households are shaped by their asset base. Different livelihood capitals possessed by rural household also lead to different livelihood strategies. And different livelihood strategies lead to different livelihood outcomes. Due to the relatively convenient position but limited farmland resource, the surplus labor has certain features in common for the river valley settlement. As for chance, the massive rural labor flowing into off-farm sectors has become a significant phenomenon in the river valley settlement, and the off-farm income continues to grow as a share of the total household income. Furthermore, labor migration affects the local non-farm economy through the financial capital. Thus, there is a general agreement that the financial capital (non-farm earnings, deposit, regular remittance etc.) possessed by rural households has been a catalyst in increasing the opportunity of non-farm activities. Moreover, the social capital of the river valley settlement, for example, employment channel and capacity of association participation, is more open than that of the semi-and high-mountain settlements. In addition, the comparative advantages of non-farm sectors result in the migration of labor capital from the agricultural sector to the non-agricultural sector although farm strategies are sensitive to the human capital (in particular labor force).

3.2. The semi-mountain settlement

Turning to the semi-mountain settlement, farm households account for 59.3%, whereas non-farm households account for 40.7% according to questionnaires. Table 5 shows that natural, human and physical capitals have a positive effect on farm livelihood strategies. In this sense, the increase in such capitals will result in higher possibilities of farm livelihood strategies adopted by rural households. The results indicate that there is a significant positive relationship between financial capital and off-farm livelihood strategies, social capital and off-farm livelihood strategies. That is, the increase in financial and social capitals results in higher possibilities of non-farm livelihood strategies. Compared with social capital, financial capital has a greater effect on non-farm livelihood strategies (Fig. 3).

Table 5
Statistical analysis and testing of livelihood strategies.

	Total sample	River valley settlement	Semi-mountain settlement	High-mountain settlement	Resettlement area
Natural capital/C ₁	-0.773*** (0.157)	-2.868*** (0.717)	-0.479 (0.352)	-1.494** (0.774)	-0.587 (0.381)
Human capital/C ₂	-0.291** (0.129)	-0.127 (0.211)	-0.261 (0.264)	-0.186 (0.498)	-0.687** (0.302)
Physical capital/C ₃	-0.019 (0.185)	0.208 (0.262)	-0.287 (0.505)	0.757 (1.523)	-0.476 (0.705)
Financial capital/C ₄	0.619** (0.196)	0.995*** (0.354)	0.396 (0.316)	5.658** (2.723)	0.290 (0.637)
Social capital/C ₅	0.400** (0.165)	0.831*** (0.260)	0.168 (0.302)	0.371 (0.904)	0.001 (0.606)
Constant	-0.387*** (0.110)	-1.588*** (0.446)	-0.713*** (0.215)	1.766 (1.216)	-0.132 (0.276)

The data in parenthesis present standards error.

* Indicates significance levels: 10%.

** Indicate significance levels: 5%.

*** Indicates significance levels: 1%.

Table 6
Sensitivity estimation of livelihood strategies to livelihood capitals.

	Total sample	River valley settlement	Semi-mountain settlement	High-mountain settlement	Resettlement area
Natural capital/C ₁	0.462	0.057	0.619	0.224	0.556
Human capital/C ₂	0.748	0.880	0.770	0.830	0.503
Physical capital/C ₃	0.981	1.231	0.750	2.131	0.622
Financial capital/C ₄	1.856	2.704	1.485	286.480	1.336
Social capital/C ₅	1.492	2.295	1.183	1.449	1.001
Constant	0.679	0.204	0.490	5.847	0.876

In accordance with sensitivity analysis, it should be noted that the probabilities and chances of farm livelihood strategies dramatically increase by 61.9%, 77% and 75% respectively if the natural, human and physical capitals increase by 1%; the probabilities of non-farm livelihood strategies increase by 1.458 and 1.183 times respectively if financial and social capitals increase by one unit (see Fig. 3 and Table 6).

Fig. 3 clearly demonstrates that the slopes of the sensitivity curves are similar. Considering the graph feature, the slopes of financial and social capitals are positive, whereas the slopes of natural, human and physical capitals are negative. These observed

characteristics illustrate that financial and social capitals are sensitive to non-farm livelihood strategies, and natural, human and physical capitals are sensitive to farm livelihood strategies for the semi-mountain settlement. Perhaps the key issue relating to sensitivity is the geographical dispersed locations. As described previously, the semi-mountain settlement lies between the river valley settlement and the high-mountain settlement. Compared with the river valley settlement, inconvenient transportation and limited surplus labor force restricts the probability of non-farm decision-making regardless of the larger per capita farmland. Another explanation to the phenomenon is that the livelihood

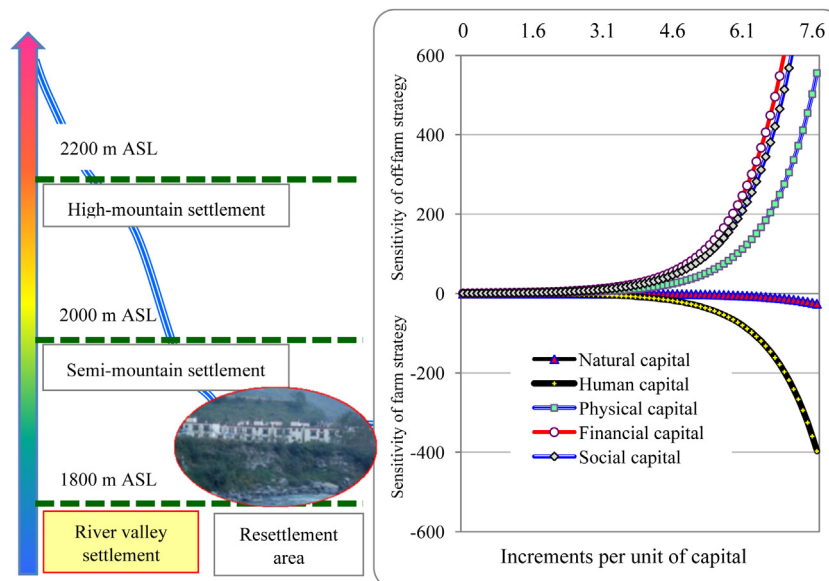


Fig. 2. Sensitivity of livelihood strategies for the river valley settlement.

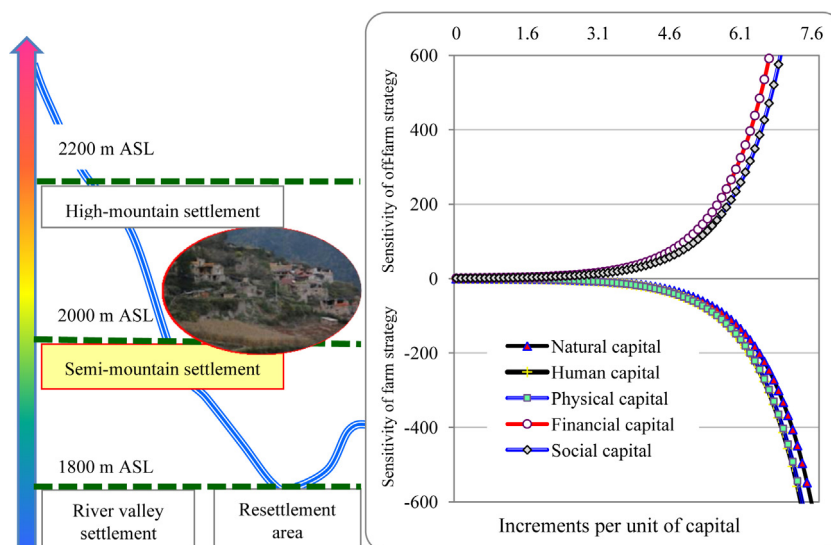


Fig. 3. Sensitivity of livelihood strategies for the semi-mountain settlement.

outcome of farm strategies may be consistent with non-farm strategies in the process of livelihood decision-making. This problem seems to be particularly challenging in the context of maximization of livelihood outcome and poverty reduction. However, we would argue that the emphasis on the effective portfolios of livelihood capitals in the semi-mountain settlement, including land resource, agricultural infrastructure, and institutional frameworks in enhancing financial and social capitals, is significant for maximization of livelihood outcome and poverty reduction.

3.3. The high-mountain settlement

In light of 47 questionnaires, farm households account for 74.5%, whereas non-farm households account for 25.5%. The proportion of non-farm households is 15.2% lower than that for the semi-mountain settlement and 24.2% lower than that for the river valley settlement. This indicates that lower nonfarm households are associated with a higher altitude. As shown in Table 5, there is a close relationship between livelihood strategies and the natural capital, livelihood strategies and financial capitals. However, the natural capital has a significant positive impact on farm livelihood strategies, whereas the financial capital presents a significant positive correlation with non-farm livelihood strategies (see Fig. 4 and Table 6). Sensitivity analysis shows that the probabilities of farm livelihood strategies are multiplied by 22.4% and 83% respectively as natural and human capitals increase by one unit, and those of non-farm livelihood strategies increase by 2.131, 286.480 and 1.449 times respectively as physical, financial, and social capitals increase by one unit.

As shown in Fig. 4, the most striking feature of the sensitivity curve is that the slope of the financial capital is very steep. The sensitivity of the non-farm livelihood strategy to the financial capital is approximately 300 times as large as that to the physical and social capitals. Owing to the remoteness of the high-mountain settlement, one possible explanation is that households of the high-mountain settlement have extremely limited financial resources (e.g. low savings, high debt, and high incidence of poverty), compared with those in the river valley and semi-mountain settlements. This evidence points to the importance of the financial capital. The access to the financial capital helps farmers relax their liquidity constraint, and may be able to invest more into production. Indeed, the gradient effect of family income has been explained by Fang et al. (2012).

Fang et al. (2012) argues that there are flat areas of arable land in the semi- and high-mountain settlements, but the non-farm income is less. Therefore, conventional farming practices insure the stable source of income for rural household. The majority of the poor are concentrated in this area, where their livelihoods depend on farmland and smallholder agriculture. Additionally, most of households in the high-mountain settlement have limited access to the social web (e.g. social capital) and public services (e.g. physical capital). These challenges reflect the fact that such inequality is a different degree of access to key resources such as capital in different types of mountain settlements. Some efforts (such as ecological migration, agricultural production subsidies, and TV networks construction), however, have been made by the government during recent years. Poverty alleviation and regional development has not a significant multiplier effect. Therefore, there is an enormous demand for developing integrated institutional and policy frameworks concerning livelihood capital improvement, and the option of livelihood strategies.

3.4. The resettlement area

Looking at the resettlement area, the proportion of farm households is 55.3%, whereas the proportion for non-farm households is 44.7%. Table 5 shows that natural, human and physical capitals have positive and significant effects on farm livelihood strategies. By contrast, it is clear that financial and social capitals have seriously negative effects on farm livelihood strategies. In sensitivity, Fig. 5 reveals that the slopes of sensitivity curves are similar to those of the semi-mountain settlement. The probabilities of farm livelihood strategies increase to 0.556, 0.503, and 0.622 times respectively as natural, human, and physical capitals increase by one unit, and those of non-farm livelihood strategies increase to 1.336 and 1.001 times respectively as financial and social capitals increase by one unit (Table 6).

Ecological migration provides an option for reducing ecological insecurity and poverty although it cannot constitute a long-term solution to rural poverty. In order to speed up the reconstruction in earthquake-prone areas and provide assistance in an orderly manner, a mechanism for aid partnership was set up in China in 2008. In this context, some settlements located in the high- and semi-mountain areas have been transferred to the river valley (Fang et al., 2012). The resettlement area is an important initial

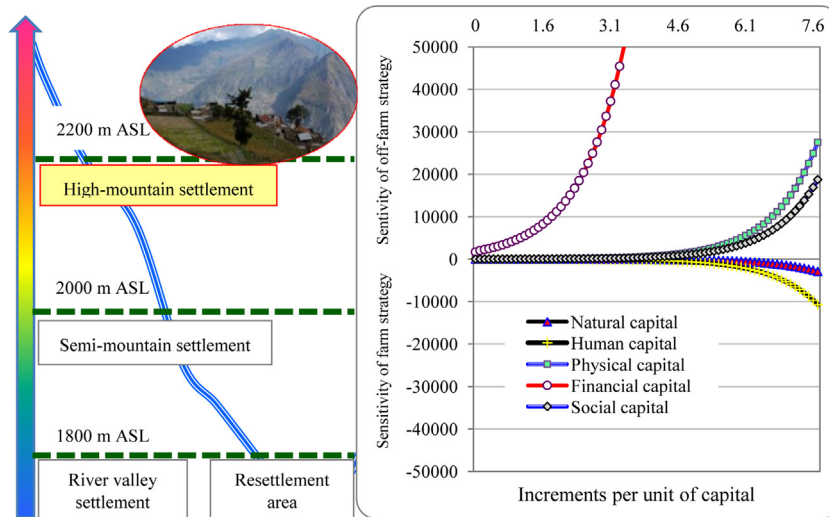


Fig. 4. Sensitivity of livelihood strategies for the high-mountain settlement.

part of the recovery and reconstruction program. Although the government-led resettlement could be an effective approach to building the future resilience of households to rural poverty, with the amount of farmland available per person declining dramatically after the influx of migrants, they have less access to productive assets, such as land. Therefore, off-farm strategies play a central role in maintaining sustainable livelihood for migrants. Fig. 5 and Table 6 illustrate the quantification of the sensitivity of farm and non-farm strategies to five types of capital. Clearly, the main constraints faced by households in the resettlement area are lack of financial, social, natural and human capitals, especially financial and human capitals. Therefore, for the resettlement area, the priority must be on maintaining and improving the transfer capacity of the rural labor to non-farm sectors. Furthermore, the long-term professional development and skill training are increasingly important.

3.5. Livelihood strategy implications

Regarding the status of the aforesaid mountain settlements, harsh environmental conditions, remoteness and frequently difficult access hamper the development in mountain regions.

Mountain residents frequently face social and economic marginalization and lack access to livelihood assets. Compared with livelihood improvement in other areas of China, mountain residents are still suffering from low livelihoods and income inequality. Western Sichuan, as the most biologically diverse and also the poorest area, could typically illustrate mountain settlements' sustainable livelihood. Indeed, the livelihood strategies in the area need strong and urgent external interventions. Due to specificities in mountain areas, specific and targeted livelihood strategies need to be taken.

3.5.1. Farm livelihood strategy implication

Agriculture and animal husbandry are important both as sources of food and cash income regardless of the high-mountain settlement or the river valley settlement. Agriculture is considerably more important to local resident's livelihoods in the area than any other livelihood strategies. By their admission, settlements in the study area are highly dependent on natural resources for a host of day-to-day needs, including fuelwood/energy, building materials, food and water. Therefore, the emphasis on natural and physical capitals is an important means for improving farm livelihood strategies. In fact, much of literatures highlights the importance of farm

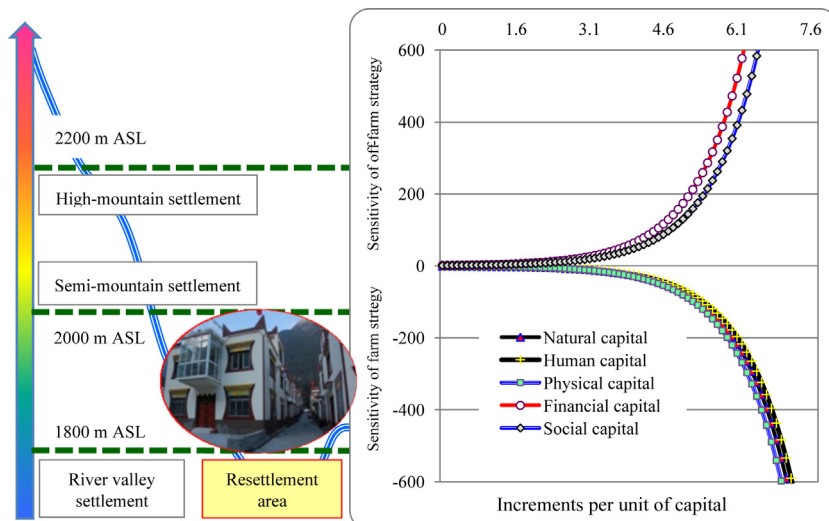


Fig. 5. Sensitivity of livelihood strategies for the resettlement area.

strategies for household economic and food security (Reardon et al., 2000; Shackleton et al., 2007; Alary et al., 2011; Christiaensen et al., 2011; Hogarth et al., 2013; Soltani et al., 2012). The dependence on agriculture demonstrates the importance of rural settlements to improve production conditions and adjust land-use strategies. Improving irrigation conditions (fight a drought), soil fertility (productivity), and infrastructure (access to public services) as well as increasing subsidies of agricultural production (policies intervention) from central and local governments are not only being promoted as potential benefits for agricultural production. They are also touted as a way for subsistence households to effectively use farmland resources.

3.5.2. Non-farm livelihood strategy implication

Although the impact factors of the farmers' income for different settlements are quiet different from each other, there is an increasingly recognition that the expansion of non-farm jobs is the most effective way for poverty alleviation and increase income of household (Barrett et al., 2001b; Lanjouw and Feder, 2001; Haggblade et al., 2002; De Janvry et al., 2005; World Bank, 2009; Haggblade et al., 2010; Jacquelyn, 2010). The key to enhancing non-farm strategies will be in finding opportunities to build up the financial, social, human and physical assets of the settlements to make them less reliant on natural resources and farm livelihood. In practice, this means a greater emphasis on professional training in more efficient and sustainable farming and animal husbandry activities to gain greater productivity from fewer natural resources. This also means the development of a more educated, healthier and energetic population able to diversify into non-farm livelihood activities. In addition, this means the provision over time of transport, communications and market infrastructure to invigorate local economies and create further opportunities for growth.

3.5.3. Mixed livelihood strategy implication

The mixed livelihood strategy is an approach for capturing the diversified means of raising household income. In practice, rural households have all attempts to diversify their sources of income, although the motivations for doing so vary (Ellis, 1998; Barrett et al., 2001b; Jansen et al., 2006; Tiftonell et al., 2010). The interaction between livelihood capitals and outcomes defines what livelihood strategies households will pursue. The opportunities for involvement in multiple livelihood strategies are not equally distributed across the mountain settlements. The involvement in multiple livelihood strategies depends on many factors such as natural and human resources, and the economic and social background of residents also determines the participation in multiple livelihood strategies. Therefore, policy-makers need to understand the nature and regional differences in livelihood strategies to enable them design appropriate policies. Nevertheless, there is a clear demand for more field studies to better understand the mixed livelihood strategy and its effect on other mountain settlements.

4. Conclusions

Limited accessibility to capitals is identified as a universal challenge faced by rural households in mountain areas. However, livelihood capitals are likely to have a significant effect on the livelihood option although the effect on different types of settlements varies. In general, natural and human capitals have obviously positive effects on farm livelihood strategies, while financial and social capitals have a positive impact on non-farm livelihood strategies.

For non-farm livelihood strategies, there is increasingly empirical evidence that financial and social capitals contribute significantly to off-farm activities. The probabilities of non-farm livelihood strategies increase by 286.480, 2.704, 1.485, and 1.336 times respectively as the financial capital increases by one unit.

Based on the sensitivity of social capital, the river valley settlement ranks the top, followed by the high-mountain settlement and then the resettlement area. This implies that improving access to financial and social capitals is one of the pillars of livelihood strategies.

For farm livelihood strategies, natural and human capitals are positively correlated with farm strategies. The sensitivities of farm livelihood strategies to nature capital are 0.619, 0.556, 0.224, and 0.057 respectively (the semi-mountain settlement, resettlement area, high-mountain settlement, and river valley settlement in a descending order). Similarly, the sensitivities of farm livelihood strategies to human capital are 0.880, 0.830, 0.770 and 0.503 respectively (the river valley settlement, high-mountain settlement, semi-mountain settlement, and resettlement area in a descending order).

In the past couple of decades, rapid urbanization and industrialization have made a significant contribution to speeding up the process of transferring rural labor forces. Although the approaches vary, improving livelihood transition from farming to non-farm activities is as important as increasing income and alleviating poverty. However, a livelihood strategy depend the efforts of livelihood capital portfolios for different mountain settlements. Thus, understanding of this issue is important, because the increasing pressure of population in agriculture has been considered as one of the important problems in the mountain areas of China. Therefore, lessening the pressure of population in agriculture by diverting farm based individuals toward non-farm activities has been the policy agenda of the central and local governments. In recent years, many concrete initiatives, such as poverty alleviation, ecological migration, grain for green, and infrastructure construction, are already being pursued by governments. Most of rural households have enjoyed the benefits from these initiatives. In practice, no size fits all the solutions to livelihood issues, and only livelihood capitals will be helpful in the long term if they are complemented by relative policies that enhance capital capacity as well as increase access to capitals. When considering policies for the promotion of non-farm sectors, governments should consciously differentiate the river valley, the high-mountain, the semi-mountain, and the resettlement area. Professional education and public investment, as another important dimension of livelihood capitals, are one of the key determinants of livelihood strategy transformation from farming to non-farming sectors. Most importantly, these initiatives need to be coordinated with activities based on different types of mountain settlements.

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