Diversified Livelihoods in Changing Socio-ecological Systems of Yunnan Province, China

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Key messages

- Government policies play a key role in shaping the extent to which rural households are able to adapt to climate change and climate hazards.
- Economic reform and shifts in property regime have weakened rural institutions and collective action in water resource management.
- Local people's exposure to risks induced by climate change has decreased due to the rural transformation brought about by the open market period and off-farm income opportunities.
- The various biophysical and socioeconomic conditions in the study sites generate differing degrees of exposure to natural hazards and climate-induced risks and diverse options for adaptation.
- Agricultural intensification depends on large quantities of chemical fertiliser inputs, and this might cause maladaptation as well as greenhouse gas (GHG) emissions.

Introduction

The study examined adaptations and responses in three locations in Yunnan, China. It also studied how state policies and local institutions have shaped the capacity of the rural population to respond and adapt to climate change and climate-induced risks. This paper highlights how external interventions can help strengthen the functioning of rural institutions and innovations relevant to adaptation.

In many parts of Yunnan Province, China, mountain farmers have responded to threats from climate variability for decades now and centuries in the past. Climate change may increase the expected magnitude, frequency, and intensity of such threats. The success of adaptation practices developed by rural farmers depends on the nature of prevailing state policies, formal and informal institutions, and financial investment in risk-reducing infrastructure.

Over the past half century, rural farmers in China have faced uncertainties in the transformation from a centrally planned and collectively managed agrarian economy to a market-driven one. At the same time, they have faced climatic uncertainties and change. These two processes, climatic and economic, both affect the short-term responses of farmers to climate risks and change, which in some cases leads to maladaptation or unsuitable responses.

Study sites

This case study was conducted in three villages that represent different topographic, altitudinal, and agro-ecological zones in western Yunnan, China. Yunnan Province covers 394,000 sq.km, and includes the headwaters of Asia's six largest rivers that sustain over 600 million people within the basin boundaries. It is home to 46 million people, most of whom dwell in the mountain regions.

The mountain geography creates a mosaic of settlement patterns, land use, and livelihood practices. Local people, including 25 distinct ethnic minority groups, have adapted in ways that demonstrate their local ecological knowledge and intimate relationship with the environment and climate.

The three villages are located in Longyang District, Baoshan Municipality, which is famous for its high production of grain (almost 1 million tonnes in 2007) and intensive cultivation of cash crops, including coffee, sugarcane, off-season vegetables, tobacco, and walnuts. The three sites have distinct wet and dry seasons with precipitation mainly concentrated in May-October due to the influence of the Indian monsoon. Daojie and Taokong are in the Salween River watershed; Baicai is in the Mekong River watershed (see Figure 5).

- Daojie village is in a low, dry-hot valley with little precipitation (~ 740 mm) and very high evaporation. Its climate is suitable for tropical cash crops like off-season vegetables, sugarcane, and coffee.
- Taokong village is at a mid-elevation, which has moderate precipitation (1,000 mm). It sits in a wide valley suitable for intensive agriculture and tobacco and it has good access to Baoshan City, with markets for farm produce.
- Baicai village is in the highlands with high precipitation (almost 2,000mm). Its inhabitants depend on forest products, NTFPs, and livestock production.

Political change – from People's Commune to Household Responsibility

Rural institutions in Yunnan differed greatly in two historical phases: the People's Commune phase before 1978 and the Household Responsibility System since 1979. This transformation brought a significant change in land use decisions, property rights, tenure arrangements, and the role of markets in production planning. The shift in governance affected the capacity of communities and households to adapt to climate change.

The People's Commune phase – In the 1950s, the central government collectivised all assets (lands, machinery, and livestock). For almost 30 years, it planned land use and allocated a quota for grain production to each People's Commune. Labour was organised collectively for farming and infrastructure development. The government could mobilise massive numbers of people to construct large reservoirs, irrigation channels, drainage systems, and terraces. It responded to population growth in rural China by constructing large-scale water infrastructure to support food self-sufficiency and disaster prevention. Government technicians or the communes maintained water facilities including dikes, gates, and pumping systems. In this rural mountain region, the central government heavily subsidised large infrastructure construction.

Household Responsibility System (HRS) – Since 1979, the communes have been dissolved gradually to introduce the HRS. The government allocated farmland to individual households according to the size of the family and availability of land. Individual households now make their own decisions on agricultural production and selling their products in the market. Although some large infrastructure facilities have been privatised, most are still owned by local government or collectively, but are managed through contracts with private agents.

Climate – change and uncertainty

Regional climate change studies show that the change of surface temperature in Yunnan province (0.015°C per year) from 1901~2005 has been slightly higher than the global average and a little less than the averages for the Northern Hemisphere and China (Cheng and Xie 2008). However, temperature changes at the three sites present a complex picture.

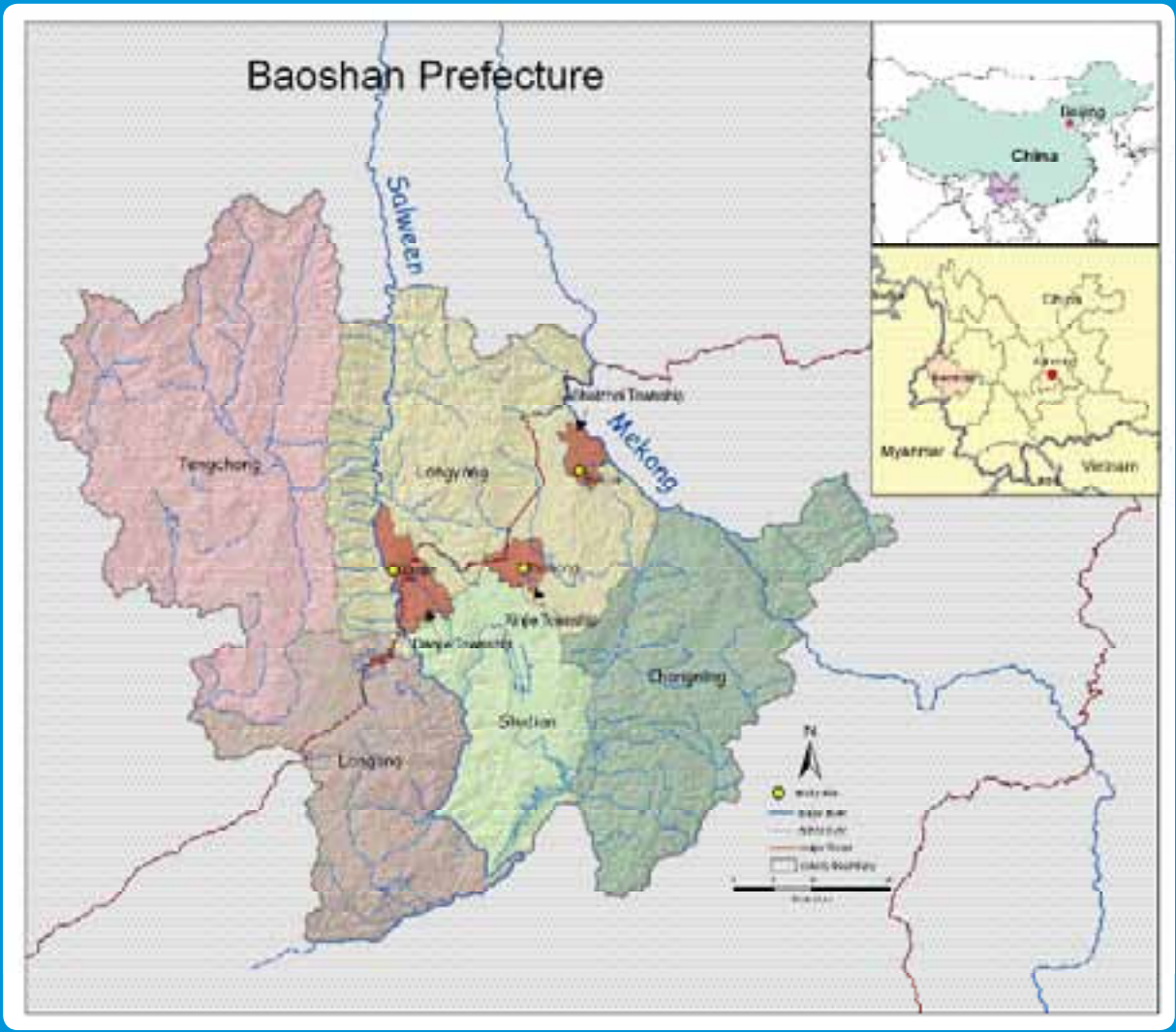
Since the 1980s, temperatures in Daojie (the arid valley site) have gradually decreased by 0.5°C. In the other two sites at higher elevations, temperatures have increased by almost 1°C over the same period. Throughout the past few decades, inter-seasonal, inter-annual, and spatial variability in rainfall trends has been dramatic at all meteorological stations in Baoshan, with both increasing and decreasing trends (see Figure 6).

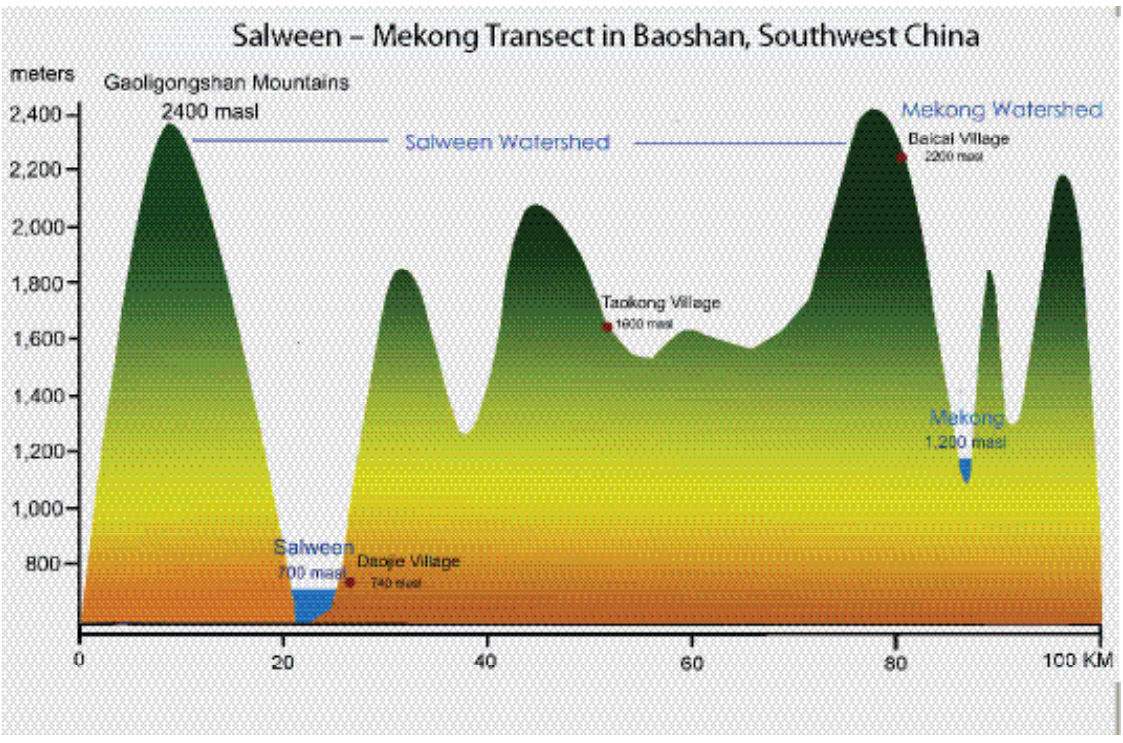
Ma et al. (2008) found that the monthly rainfall in Longyang District increased during the past 50 years by 43.1% and 54.9% in May and September and decreased by 27.6% and 14.4% in June and July, respectively. The increase in May rainfall suggests an earlier onset of the monsoon. The change in monthly rainfall from May to September indicates monsoonal variability and less water availability during the main summer crop-growing season.

Impacts of Water Stresses and Hazards

The impacts of changes in water supply and climate in the studied locations vary greatly depending on elevation, environmental conditions, and on the socioeconomic situation of rural inhabitants.

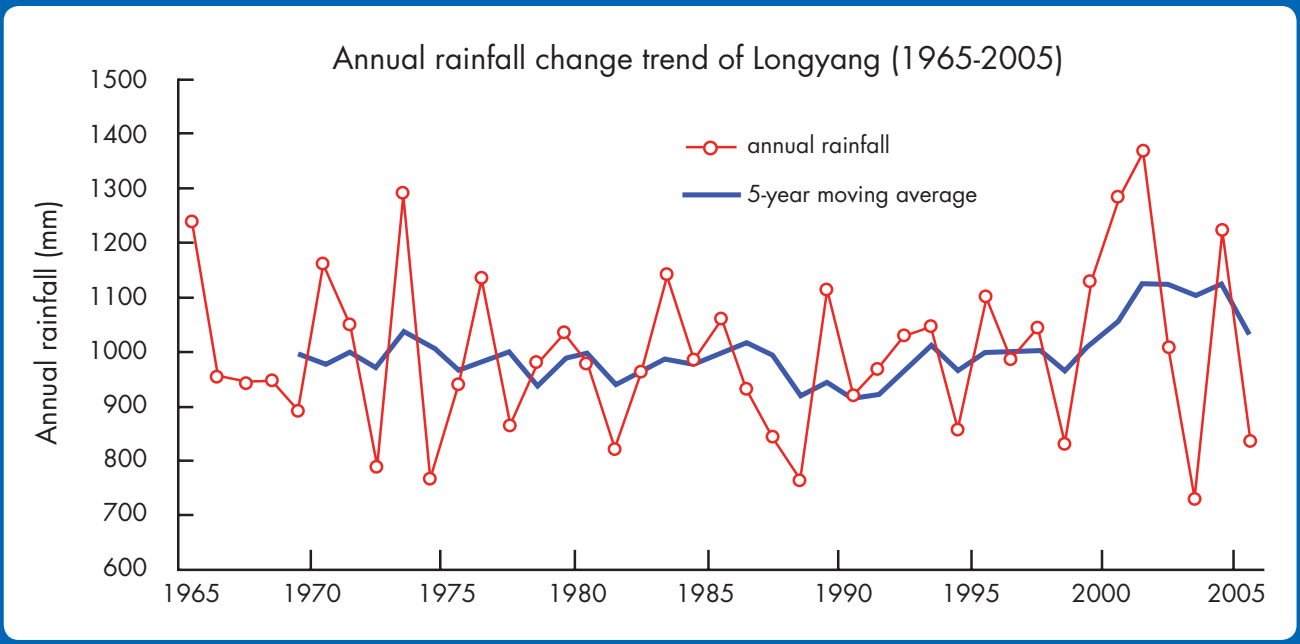
Figure 5: **Location of study sites in Yunnan Province**





Source: Centre for Mountain Ecosystem Studies, Kunming Institute of Botany

Figure 6: **Inter-annual variability of rainfall trends in Longyang District, Baoshan**



Daojie – floods and droughts at low elevation

In Daojie, several serious floods and droughts were recorded in the 1970s, 1980s, and 1990s. Floods destroyed some farming land in the past. Market forces have caused cropping patterns in paddy fields to change from rice and cotton to sugarcane and off-season vegetables. This shift requires more water for irrigation particularly during the dry season.

Since most arable land is rain-fed, variability in precipitation and shifts in the monsoon pattern have triggered severe water shortages. Farmers reported decreasing water supplies in both irrigated and rainfed fields. They estimated that since the 1980s there has been a 30% decline in water flows in irrigation channels during the spring season, though the reasons for this are not clear.

Although Daojie is located on the Salween river, the river water is not accessible for either agriculture or drinking due to the steep, deep gorge. Thus, water brought from a distance in irrigation channels is crucial for the Daojie villagers' domestic use and agricultural production.

Increased winter vegetable production has worsened water resources by increasing demand. Overuse of chemical pesticides and fertilisers is common so water pollution also limits access to safe water.

During the rainy season, floods have often washed away farmlands near the riverbank. However, especially from January to April, almost all farmers experience water shortages due to reduced rainfall and increased competing demands for water resources from upstream villagers. Their drinking water is also poor quality due to the high alkali concentration in water sources – caused by limited quantities and poor quality of construction and maintenance of irrigation canals.

Taokong – competing demand for limited water at mid-elevations

In Taokong, villagers do not get enough water due to insufficient precipitation. Even though they have an irrigation system, the reservoir now has reduced water storage capacity because of sediment build up since its construction during the 1950s collective period.

Film used for reducing evaporation from the soil in Daojie village, Yunnan Province, China

There is increasing demand for water for agricultural intensification in the valley and urbanisation in Baoshan City. The largest reservoir used to provide water mainly for irrigation but now provides more for drinking water. The quality of the drinking water is deteriorating from being mixed with irrigation water and from the heavy use of chemicals in agriculture. Another impact of climate variability is that strong monsoon circulation has increased hail events, which destroy tobacco and other crops.

Baicai – Living with flash floods and landslide risk at a high elevation

Baicai is located on steep upland slopes and in the past villagers were exposed to flash floods and landslide risks. They were often concerned about rainfall intensity and duration, which could trigger landslides. The village leader initiated afforestation that limits exposure to landslide risks and improves livelihoods. Unlike in the lower study sites, the warming of the climate has been beneficial as it may increase the yield of food crops if there is good access to water. According to a village leader, 'A drier and hotter year is good for us, but it is not good for our downstream neighbours.'

Responses to Water Stresses and Hazards

During different periods, people at these three study sites have used both short- and long-term responses to cope with recurrent water stresses and hazards due to climate variability and change. The responses in these three villages have depended on the shifting socioeconomic and political contexts during the communal and HRS periods and thus differed at the individual and community levels. The main responses by individual households and community organisations have involved afforestation, irrigation, crop selection, and changing cropping patterns.

Individual responses since initiation of HRS in 1983

During the communal period, individual households could not respond because land use and labour decisions were

Small field-based water tanks store water for irrigation during the winter in Daojie village, Yunnan, China.

planned collectively. Since the start of HRS, individual households could respond to water stresses by adjusting farming and livestock management decisions and doing off-farm work. However, these common responses may vary depending on the impacts felt, the consequent responses, and the individual household's socioeconomic situation. The following strategies have evolved over time to address water availability.

Changing crop variety and cropping patterns – In Taokong, villagers plant maize, yam, or bean instead of paddy rice in the summer cropping season when water availability was low – even though this caused some reduction in income. Villagers also replant, postpone planting, or replace crops if the rains come late (after early June).

In Daojie, responses to water shortage and market forces changed after the communal system was disbanded in 1983. The changes to cropping patterns are shown in Table 4.

Water-saving farming technologies – Farmers have adopted dry seeding of paddy rice and begun using plastic sheeting on vegetables to retain moisture and maintain consistent temperatures. They are also using techniques for improving water retention of upland maize.

Improved irrigation methods – In Daojie, the high clay soil content of some fields can hold water longer, so the villagers make small water tanks and channels along their fields to store extra water during the winter irrigation season. The channels enable them to direct water to the roots of the crops for water saving. Some better-off households with fields near the Salween River have purchased water pumps to draw water from the river. Poorer households will sometimes have to rent the pump if there is a severe water shortage.

Single earth dam built by an individual household for irrigation of paddy in Taokong, Yunnan, China

Coping mechanisms by poor households – Poorer households are more vulnerable to climate impacts on livelihoods because they often lack alternative income sources. During serious droughts in both Daojie and

Table 4: **Village interviews, 2009**

Time	Cropping Patterns		
	Paddy field (irrigated land)	**Irrigable land**	**Rain-fed dry land**
Before 1983 (communal system)	Early rice + late rice	Maize	Cotton
1983-2005 (change to HRS)	Midseason rice (MR) + sweet potato MR + tobacco MR + vegetable (small area)	Maize + tobacco Maize + sweet potato Maize + vegetable Sugarcane Longan	Sugarcane Maize (1 season/year)
After 2005 (expanded market)	Irrigated: MR+ vegetable Lack of water: maize (quit rice) + vegetable (80%)		Maize + beans (less)

Taokong, poorer villagers borrow grain or cash and raise fewer pigs because they have less maize to feed them.

Leaving for off-farm work – As the incidence of droughts has increased, respondents said that more villagers are leaving for longer periods of seasonal migration for off-farm work. For example, in Taokong, most families have at least one member involved in off-farm work. If there is a drought, two or more family members might go out for off-farm work for a longer period and may travel to further destinations in search of work.

Collective action

When water shortages occur, individual households might adopt immediate coping mechanisms that prove to be insufficient, competitive, or contrary to the needs of other households. Greater organisation and cooperation in the wider community is required to make long-term adjustments to change. At the village level, communities respond in the following ways.

Distribution rules for irrigation – In Daojie, when there is not enough irrigation water, the village committee (VC) implements a system of irrigation water distribution and rotation among village groups. Villagers from each group also watch over the main irrigation channels to ensure the water distribution is fair. The water fee is three times higher when water supply is low, due to increased costs of guarding the water facilities. As a result, villagers' costs for agriculture are increased.

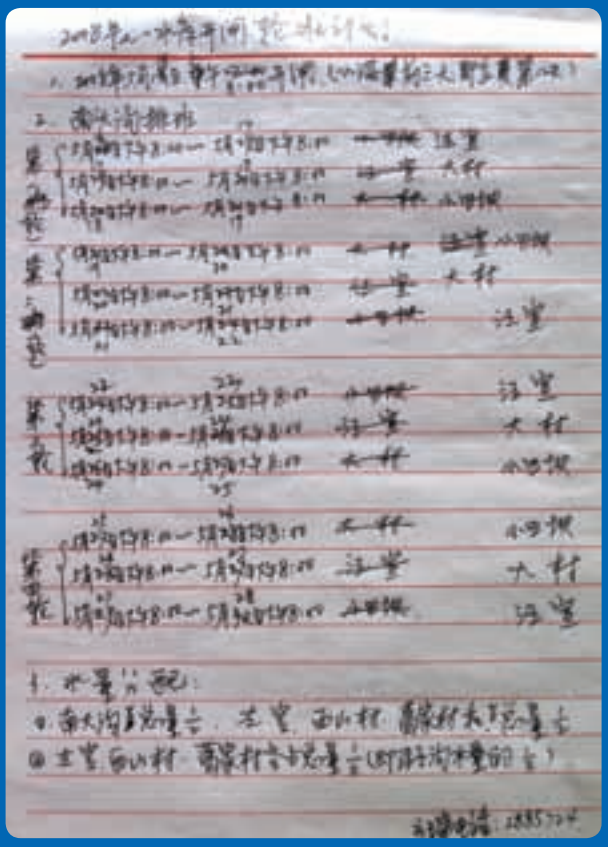
Hiring contract managers is a common practice to manage irrigation water in villages with water shortages. In Taokong, village leaders hire the contractors to be in charge of water pumping and guarding the pump stations. In Daojie, the contractors are selected by an open bidding process to manage the distribution of both irrigation and drinking water. However, the VC or village groups still manage the irrigation system maintenance. The capacity of these community organisations determines the ability of communities to maintain and improve the irrigation systems.

Drinking water management – In Daojie, each household has drinking water piped to their house since 1994; however, the water quality remains poor. Originally, the water was provided free, but in 2003, the VC established drinking water regulations to limit the use of drinking water for farming purposes and to improve water use efficiency. It has also implemented water fees and, in 2006, a water quota of 2 tonnes/person/month. If a household uses more water than the quota, the VC imposes a fine six times higher than the water fee. Most households have built small water tanks to store water for use during the dry season, which is very convenient for women's household chores.

Increasing role of women in water distribution – Recently, women have become more involved in guarding water. In Taokong, only men were involved in guarding water until a few years ago. With more men away for off-farm work, women are now involved, which has reduced physical fights among the men. Both men and women are supporting the further involvement of women.

Afforestation – In Baicai, afforestation programmes initiated by village leaders have significantly increased forest cover. The gradual process of afforestation over a long period has dramatically reduced land degradation, landslides, and soil erosion. Villagers are getting more income directly from timber, fuelwood, NTFPs, and fruit, which is improving their livelihoods dramatically.

Rotation schedule for Daba reservoir in Taokong village, agreed at the annual meeting called by the township government to discuss the distribution of irrigation water from the main reservoir.



Maladaptive responses

Despite existing water shortages, villagers are planting cash crops with low drought resistance. Technical improvements, overuse of pesticides and fertilisers, and the application of frost resistant chemicals on vegetables have impacts on water and human health, and increase dependency on the market. The local government has implemented hail prevention measures that protect against loss of tobacco, but reduce rainfall, which has an adverse effect on other food crops.

Factors Influencing Local Adaptation

The study documented specific factors that enable adaptation and factors that constrain it. However, some factors, such as the community organisation during the communal period, can in some instances enable adaptation and in others constrain appropriate and sustainable responses.

Enabling factors

Communal period infrastructure and institutions – During the communal period, local institutions and collective actions governed the community to help ensure that all villagers had equal access to resources, irrigation, and infrastructure. Although resources were not always used efficiently, both large and small irrigation facilities constructed during the communal period still benefit people by providing physical infrastructure for their adaptation responses.

In both Daojie and Taokong, past investments in irrigation infrastructure enable villagers to cope relatively well during droughts. During droughts, the management of irrigation systems adjusts to reflect the limited water supply and to attempt to minimise agricultural losses. The communal system was an enabling factor that allowed villagers to make adaptive responses at the village level. However, the ability of individual households to respond to climate risks and impacts was constrained in this system.

Local leadership can be an enabling factor – For example, in Baicai, a village leader initiated afforestation activities to cope with serious landslides and soil erosion. Later, these activities evolved into a long-term adaptation strategy. In Taokong, some village groups have better irrigation infrastructure than others as a result of strong leadership.

Governance systems – The transformation to the HRS has enhanced the ability of people to choose their own autonomous individual responses to risks and stresses. In all study sites, individuals have more incentive to innovate or respond since the introduction of the HRS.

Government policies allowing markets, rural reforms, poverty reduction, and environmental protection have provided opportunities for local adaptation. The villages and households have good access to technology, markets, information, and government programmes, such as techniques for agricultural water saving, employment opportunities outside agriculture, and measures for environmental improvement (e.g. Sloping Land Conversion Program). These policies are a key to strengthening community and individual households' adaptive capacities.

Government environmental protection programmes such as Natural Forest Protection Program, Sloping Land Conversion Program, and Grain for Green Program; have contributed to reducing landslide events in Baicai. With compensation payments from the central government for converting sloping farmland into forest, villagers are able to do more off-farm work and to invest in cash crops, animal husbandry, and fruit trees.

Improved management of irrigation water at the local government level – Since the HRS was introduced in Taokong in the early 1980s, new water management rules were established. These included a schedule for distribution of irrigation water and a rotation system to respond to increasing water demand. However, these rules only help with the equal distribution of irrigation water to a certain extent, because the township government is not directly involved in the enforcement of the rules to avoid conflicts.

Government aid and technological responses are being used to mitigate disasters – Historically, hail, landslides, and crop diseases had impacts on livelihoods; but various technological measures are now used to reduce the damage. For example, agricultural technology stations at the village level provide support to ensure that crop diseases or insect pests are reported and prevented in a timely way. There is government compensation for extreme disasters, such as providing water pumps when there is a drought. In Taokong, the government established a hail prevention station to protect against hail, especially for tobacco, but the technique reduces rainfall, affecting the farmers' other crops.

These factors enabled people in these three villages to change cropping patterns, improve farming technology, intensify agricultural practices, change irrigation methods, and diversify livelihoods. In Daojie and Taokong, once a drought occurs, the extent to which households are able to cope depends on the extent to which they are engaged in diversified agricultural practices and off-farm income generation.

Constraining factors

During the communal period, individual households did not have discretionary power for decisions on land use. This affected their ability to adapt to changing biophysical and socioeconomic conditions. For example, people in a dry, hot valley were forced to plant cash crops without consideration of climate there, so often agricultural production efforts failed.

Inappropriate technology might cause maladaptation – All three villages have access to technology, which allows villagers choose varieties of crops needing more chemical fertilisers and pesticides. These have negative impacts on water quality and human health, which many villagers do not yet realise, but which are likely to increase in the future.

Lack of governance for maintenance – Old water infrastructure is still the basis for irrigation and drinking water supplies in the communities, but the lack of maintenance of these systems is currently causing water shortages. For example, in Taokong, an irrigation channel from the reservoir built in 1956 is now filling with sediment. The dam has also developed physical weaknesses. In part, these problems reflect the relative lack of governance for the management of these infrastructures.

Bias in government extension agendas may not benefit the majority of farmers – Local level governments depend on fiscal revenue from taxes on certain cash crops, such as tobacco and sugar cane. Consequently, the delivery of extension services is biased towards tobacco and sugar cane producing areas. For example, in Taokong, the government responds immediately to hail disasters because it receives revenue from tobacco crops. The local officials are responsible to higher ones for ensuring tax income from tobacco.

Limited financial support for functioning institutions – The management of existing water infrastructure is problematic in many areas of Baoshan. Currently, the government promotes the establishment of water user associations in areas that have recently received infrastructure investments. However, it does not support improved management of existing water infrastructure. Although Flood and Drought Management Coordination Committees exist, they appear to be providing only limited support to rural areas, mostly of which is post-disaster relief.

Conclusions

- Chinese government policies play a key role in shaping the extent to which rural households and villages have the capacity to adapt to climate change-induced risks. Adaptation may not occur without enabling policies and institutional arrangements. However, the Chinese government has often implemented differing, and sometimes contradictory, policies that affect local adaptive capacities.
- Economic reform and shifts in property regimes have weakened rural institutions and collective management of water resources. Large-scale water infrastructure developed during the collective period has been poorly maintained due to ambiguity in property rights and financial support since the introduction of the HRS. Farmers face challenges to adapt to both climate change and China's changing socioeconomic conditions.
- Rural transformation and off-farm opportunities reduce exposure to risks induced by climate change. The thirty-year process of economic reform has helped a large population to come out of poverty. Urbanisation is creating more opportunities for off-farm jobs and niche products for rural farmers. The remittance economy enables villagers to invest in protected farming, such as greenhouses for vegetables, and diversified livelihoods, like livestock.
- The diverse biophysical and socioeconomic conditions at the three sites present varying degrees of exposure to natural hazards and climate-induced risks and offer diverse options for adaptation. Villagers at the three sites encounter different climate change-induced risks at varied elevations and socioeconomic conditions. A shift in monsoon patterns has triggered both more frequent landslides in high elevation areas and water stresses in low elevation areas. Women and elders in rural areas are exposed more directly to climate risks. Water poverty occurs mainly in the highlands and the dry-hot valley due to inadequate water-harvesting

infrastructures. It can be less severe in the mid-elevation plain valleys due to the construction of reservoirs.

- Agricultural intensification (off-season vegetables in dry-hot valley, tobacco in the middle, and high-yield corn in highlands) depends on inputs of large quantities of chemical fertiliser, which might cause maladaptation and GHG emissions. Smallholder farmers are using more fertiliser, which is causing nitrogen to leak into underground water, watersheds, reservoirs, and lakes. Nitrate water pollution and eutrophication are becoming major threats to water resources and human health. According to our first estimates, improving fertiliser application practices and lowering current rates of fertiliser use by 50% can reduce fertiliser emissions by 0.8 tonnes CO_2/ha.

Recommendations

Based on the three study sites, the field team suggests the following recommendations to manage climate change induced risks in mountain regions of Southwest China.

- Utilise regional climate science to facilitate stakeholder dialogue on local adaption. Utilise the availability of historical hydro-meteorological trend data to interpret local climate patterns. This information can illuminate dialogues among different stakeholders including local farmers, resource managers, government officials, and planners, who often have their own knowledge systems and understanding of climate change. Integrating local and scientific knowledge can achieve better adaptation planning.
- Incorporate state afforestation efforts (Grain for Green Program) into local watershed/disaster-risk management. Due to its location at the headwaters of major rivers, Yunnan Province has received large-scale state funding for afforestation and ecosystem restoration. If these tree-planting efforts involve local participation in species selection and site planning, they can benefit local villages by controlling landslides and soil erosion in the uplands.
- Improve small-scale infrastructure. Some mountain hazards, such as flash floods, happen due to precipitation, but their impact may depend upon the banking of rivers, drainage, proper retaining walls, and terracing of fields. Water stresses, such as droughts, can be mitigated by water storage, particularly during the planting season in the early monsoon. Investing in appropriate small-scale water infrastructure (with or without links to large water infrastructure) is a good option for addressing the accessibility of water in mountain regions.
- Revive village institutions. Village institutions and local leadership are necessary for households and social groups to deploy specific adaptation practices. There is an urgent need to develop the capacity of community-based organisations, such as water resource associations and vegetable cooperatives. This can be done through legal, financial, and technical support from government agencies, such as civil affairs, line agencies, and the Communist Party. Village institutions should adopt more market-oriented approaches, such as organic farming and payments for environmental services.
- Provide support to improve farming systems. There is an urgent need to develop climate-resilient crop varieties, early warning for weather forecasting, cropping pattern adjustments, and conservation agriculture with high water use efficiency and low-carbon emissions. Two options for securing food production are extension services for rural livelihood diversification and social insurance for climate risk reduction.
- Promote participation by local people in developing adaptation plans. China is a growing economic power that is able to develop efficient top-down National Adaptation Plans for climate change. However, this approach can only be implemented effectively with the active participation of local people in planning, monitoring, and evaluation.
- Integration of climate change policy. Climate change and climate change adaptation are emerging as new explicit policy domains in China, where the government is superimposing them onto existing sectoral and regional development policies. A great opportunity exists to integrate climate science into sectoral policies at a higher level and for it to inform plans for local level actions. There is also a need to undertake further studies to evaluate the extent to which policies promote or hinder adaptation to climate change in a wider variety of contexts. Both political reform and climate science call for synergy among all government sectors to develop an integrated climate change policy.