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Gendered Responses to Drought in Yunnan Province, China

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Vulnerability to and perceptions of climate change may be significantly affected by gender. However, in China, gender is rarely addressed in climate adaption or resource management strategies. This paper demonstrates the relevance of gender in responses to climate change in the mountainous province of Yunnan in southwest China. Based on surveys undertaken during a record-breaking drought, the paper explores how women and men in a village in Baoshan Prefecture differ in their perceptions of and responses to drought, and how the changing roles of women and men in the home and the community are influencing water management at the village level. Our results show that despite the increasingly active role of women in managing water during the drought, they are excluded from community-level decision-making about water. The paper argues that given the importance of gender differences in perceptions of and responses to drought, the lack of a gender perspective in Chinese policy may undermine efforts to support local resource management and climate adaptation.

Keywords: *Drought; gender analysis; climate change; responses.*

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Introduction

Climate change is expected to increase the incidence of climate hazards in mountain areas (Kohler et al 2010). Mountain people's vulnerability to these hazards is mediated by their exposure and sensitivity to specific hazards, their access to resources, and their capacities and opportunities to respond and adapt (Neumayer and Plümper 2007). Since these factors may all be strongly influenced by gender relations, there may be differences in the vulnerability of men and women to climate hazards. Through an analysis of gendered responses to drought in a mountain community in Yunnan Province in southwest China, this paper demonstrates the relevance of understanding gender-differentiated perceptions of and responses to droughts as an approach to developing gender-sensitive adaptation strategies.

Physical and social vulnerability to climate change in mountain areas

Mountains have important effects on global climate and hydrological cycles (Beniston et al 1996). Physical characteristics such as elevation, latitude, and topography shape mountain climates and ecosystems differently in different locations. Topographical variability and lack of sufficient physical observations are major impediments to reliable projection of climate change impacts in mountain areas (Rangwala and Miller 2012). However, available evidence suggests that the incidence of extreme climate events is likely to increase in many mountain regions (Kohler et al 2010; Field et al 2012).

The physical features of mountain regions also shape socioeconomic processes that affect mountain people's vulnerability to the impacts of climate hazards (Jodha 2005). Their relative remoteness increases the cost of access to physical goods and information, socioeconomic marginality may limit their access to income generation opportunities, and limited control of resources may increase resource scarcity. Mountain peoples' vulnerability to climate hazards is a product not only of biophysical processes but also of economic, cultural, and social relations (Neumayer and Plümper 2007). Therefore, in addition to improved understanding of biophysical processes associated with climate hazards, it is vital to evaluate related social processes (Adger et al 2005).

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Gender, climate change, and climate hazards

The importance of gender's impact on vulnerability to climate hazards and on adaptive capacity is increasingly recognized (Paolisso et al 2002; Nelson and Stathers 2009; Olsson et al 2014). Social structures and norms and unequal gender power relations lead to gender-differentiated vulnerability: for example, where women have limited access to resources and a limited role in decision-making, their responses to climate stresses are constrained (Jin et al 2015). Previous studies have found that women are therefore often more vulnerable to the negative effects of climate change than men (Neumayer and Plümper 2007; Olsson et al 2014).

Women's greater vulnerability and more limited response options give them different perspectives on adaptation. The decisions women make to cope with climate changes, the risks they take, and the climate-related information they seek differ from those of men (Nursey-Bray 2015). This is related in part to gendered differences in access to support networks, information, and participation in decision-making, which are constrained by the often unequal power dynamics between men and women (Carr 2008).

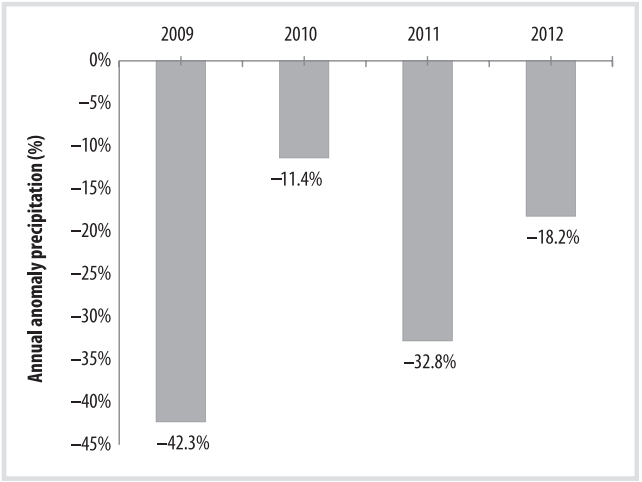
In particular contexts, gender may also interact with other markers of identity and dimensions of inequality, such as age, ethnicity, or social class, so women's experiences of climate stresses are not homogeneous (Carr and Thompson 2014; Olsson et al 2014; Bhattarai et al 2015). For example, poor women are especially vulnerable to climate impacts, because of their dependence on natural resources for their livelihoods and because they often face difficulties in accessing shelter and health care.

Because women in mountain areas also face different climate-hazard-related challenges and response options, better understanding of mountain women's responses to climate variability and climate change and the effects of gender on responses to climate hazards is important for developing gender-sensitive adaptation strategies in mountain areas. Although gender awareness plays a role in participatory approaches to disaster mitigation and preparedness (Sohrabizadeh et al. 2014), gender is not widely used as an analytical approach to conduct disaster research. Without an in-depth study using gender as a central analytical element, differentiated responses to hazards (Stehlik et al 2000) and gender-differentiated roles in household and natural resource management will not be discernable (Dankelman and Jansen 2010).

Drought in China

The frequency of drought in China has increased over the last 50 years (Yu et al 2015). It is projected that climate warming will increase drought frequency and duration in many parts of the country due to evaporation, with the highest risk in the mountain areas of southwest China

FIGURE 1 Annual anomaly precipitation in Kunming (2009–2012). (Data source: China Meteorological Data Service Center, http://data.cma.cn/site/index.html).



(Wang and Chen 2014). Yunnan Province, where 94% of the land area is classified as mountainous, was affected by a persistent drought from fall 2009 through 2012, with an estimated return period of greater than 80 years (Wang and Meng 2013). According to the data from the China Meteorological Data Service Center (CMDSC 2016), precipitation from 2009 to 2012 in Kunming, the provincial capital, was substantially (from about 11.4% to 42.3&) below the long-term average (Figure 1). By the end of 2012, the drought had affected millions of people and livestock, and there were about 4.2 billion RMB of agricultural losses in Yunnan (Lü et al 2012; Zhou and Yang 2013). Anomalies in atmospheric circulation patterns were among the direct causes of decreased precipitation and increased evaporation during the drought period (Lu et al 2011; Lü et al 2012). In response to the tangible effects of climate change and the likelihood of more extreme weather events in future, national and provincial governments have announced new policies and governance mechanisms for drought response (Xinhua Net 2012) and for climate change adaptation (NDRC 2013; YDRC 2016). None of these gives special consideration to gender.

Gender in rural China

Off-farm employment and large-scale short- and long-term migration from rural to urban areas have been major drivers of economic growth in rural China (Zhang and Song 2003). While men and younger women often work off-farm, many middle-aged women remain in rural areas (Mu and Van de Walle 2011). In mountain communities in China, short- and long-term migration has made significant contributions to household income growth. Increasing off-farm employment may also be related to low levels of investment in agricultural infrastructure (Liu and Ma 2006). Simultaneously, agricultural labor has become increasingly feminized, and

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overwork has been found to impact women's health and welfare (Mu and Van de Walle 2011). Despite their increasing share of agricultural labor input, women receive a lower share of crop sale income than men, and their decision-making power in household farming enterprises and in community resource management remains limited (De Brauw et al 2008). Additionally, despite the important role of women in water management for household and agricultural use, rural water management policies pay little explicit attention to gender (Lu 2009; Tong et al 2017), and water management often remains male dominated (Lu 2008; Ge et al 2011; Tong et al 2017). The effects of changing gender roles in agriculture may further be exacerbated by the relative inaccessibility of social services and lack of infrastructure investment in these areas (Lu and Cai 2009; Wu et al 2015). As a consequence, gender is an important contextualizing factor that is rarely explicitly addressed in Chinese national policies and plans related to agriculture, water management, or climate change.

Gaps in gender analysis on water shortage responses

Understanding vulnerability to extreme events and developing strategies to support adaptation can be promoted through gender analysis (Cannon 2000; Demetriades and Esplen 2008). In particular, studying local perceptions of climate change and how they are embedded in cultural and socioeconomic contexts, including gender, can improve understanding of the impacts of climate events on particular categories of people and the factors that influence different social groups' responses to these events (Berkes and Jolly 2002; Byg and Salick 2009). Documenting local perceptions of climate change can also help policy-makers understand the experiences of mountain people and their needs for support in responding to risks posed by climate variability and climate change (Laidler 2006).

In this paper, we explore gender-differentiated perceptions of, impacts of, and responses to drought in Yunnan, with a focus on agricultural practices and household water use. We explore gendered roles at the household and community levels and their influence on men's and women's responses to water scarcity. We argue that understanding gender-differentiated perceptions of and responses to drought is key to developing gender-sensitive strategies for adaptation to climate change in Yunnan.

Study area

Yunnan Province is topographically, ecologically, and ethnically diverse and spans temperate, subtropical, and tropical climatic zones. Over 56% of Yunnan's 47.4 million people (including 26 ethnic minority groups) are rural dwellers, and more than 53% are employed in agriculture (YDHRSS and SBY 2016). Yunnan is home to the second-largest poor population in China, with more than 5.74 million people living below the national poverty line at the end of 2014 (Yunnan Net 2015) and an average per capita GDP of US$ 4611 in 2015 (SBY 2016).

Yunnan's topographic diversity and its location at the junctions of the East Asian and South Asian monsoons results in a complex climate. Although it has the third largest endowment of water in China, its water resources are unevenly distributed, with several highly populated areas classified as water-scarce (Li and Li 2012). Since the late 1980s, the frequency of spring and summer droughts in Yunnan has increased, and since 2000 there has been a decreasing trend in precipitation across the province (Cheng and Xie 2008). The 2009 drought was preceded by another major drought in 2005, which was estimated to have a return period of 50 years (Cheng and Xie 2008).

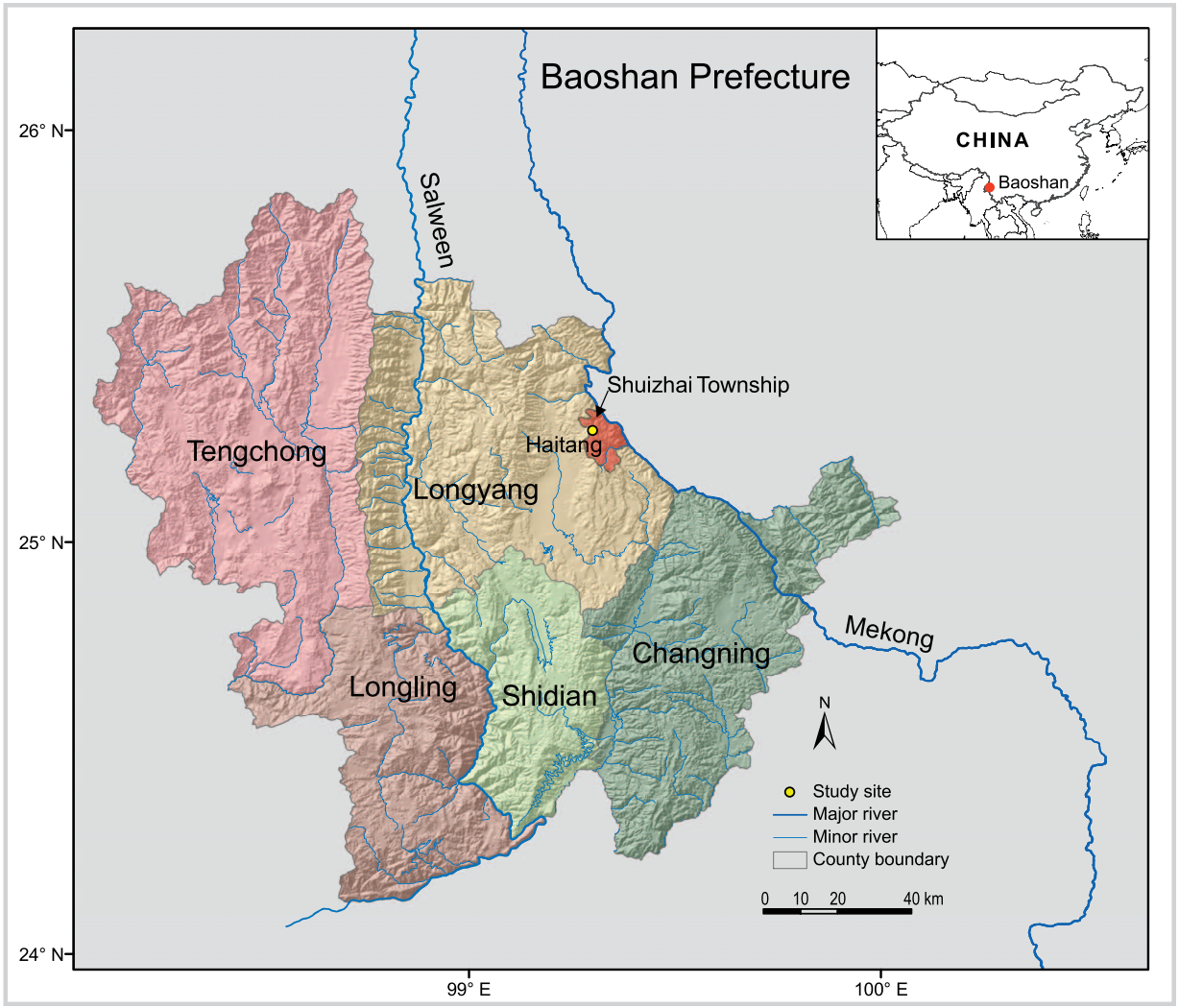
As part of an international research project on water management and climate change in the Himalayas (Pradhan et al 2012), this paper uses data from Haitang village (Figure 2) and is based on field surveys conducted in 2012 after 3 consecutive drought years.

Haitang village lies at 2473 m (N 25.27, E 99.30) and has an average temperature of 12.2°C and average annual rainfall of 1200 mm. As of 2014, it was home to 365 households with a population of 1581 (808 men and 773 women), divided into 6 villager groups (Yunnan Digital Village Network 2014). The mountains surrounding the village have high forest cover (1105 ha), and forest products (eg matsutake mushrooms, timber, pine nuts, and walnuts) are important sources of income, along with Sichuan peppers, tobacco, livestock, and off-farm work. Per capita arable land is very limited (0.073 ha/person); corn and barley are mainly used as livestock feed and for domestic consumption. Since agriculture in Haitang is rain-fed and thus less productive than in other areas, many households have diversified their livelihoods, and men in particular have become more engaged in seeking off-farm work. Over 70% of men engage in migrant labor, returning during the farming season or for festivals or important family events. Haitang is 11 km from the nearest market by gravel road and an hour by car from the prefecture seat in Baoshan.

Haitang is governed by a village committee and a village party committee. The village committee is elected directly by villagers and is led by a director with 1 deputy director and 5 members, of whom one is a woman. The village party committee is led by a director and a deputy director, who are nominated by the party members and report to the township government. There are 72 party members, of whom 11 are women. All the heads of the villager groups are men. There is a women's group in the village, but they are not involved in community decision-making. All data came from these study participants.

There are 2 major water resources in Haitang: Dragon Pond and Xiangshui Pond. Two of Haitang's 6 villager

FIGURE 2 Map of the study site. (Map by Mingcheng Wang and Huafang Chen at Kunming Institute of Botany, Chinese Academy of Sciences)



groups are located upstream of the village's water sources, so they depend more on timber and non-timber forest products than on agriculture for their livelihoods. The rest are downstream and focus on tobacco and grain production.

Water for agriculture

Haitang has very few irrigation facilities; 92% of agricultural land is rain-fed. While the village receives sufficient rainfall during the monsoon season (June–October), it experiences annual water shortages during the dry season (February–May). Some villagers have small ponds and streams near their fields, which fill during the rainy season and can be used for watering crops or trees (manually or using pumps) during spring cultivation, but these have been drying up quickly after October since the 2009 drought, which affected agricultural production. Therefore, some households, especially from the 2 upstream communities have planted walnut and alder, as well as a medicinal plant called dry grass, as these do not require much labor, are drought tolerant, and are fairly lucrative. Beyond these, only a few agricultural crops are planted in Haitang due to the area's limited water availability.

Water for domestic use

In the past, during the dry season, women (and less often men) would fetch drinking water for use by villagers and their livestock. It would take them 10–40 minutes with the distance to the nearest water source varying from 0.5 to 3 km, depending on the location of the household. But by 2007, with support from government and a Hong Kong company, Haitang had built 9 tanks to supply drinking water. As a result, most households have piped water and small water tanks in their homes, which has saved a great deal of labor, especially for women. This has afforded

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some women the time and water resources to grow extra vegetables and cash crops in home gardens and on nearby land. Some households have also installed flush toilets and solar-heated showers. Sanitary conditions have therefore improved, and some women even use washing machines rather than washing clothes by hand in local ponds. However, in recent years, households have experienced shortages in water for domestic use, and they once again have to fetch water during the dry season.

Water management

There is no water management system in place for agriculture, as there are very few irrigation channels. There is, however, a domestic water system, and the heads of the villager groups (all of whom are men) are responsible for its management and repair. With nearly 100 households each, both of the 2 upstream groups have hired an extra person—both men—to help manage the water system.

The upstream villager groups pump and store water in tanks before piping it to individual households. In 2005, during the dry season, the village was able to release water once every other day. From 2006 to 2009, this was reduced to once every third day, and during the following 3 years to once every fourth day. However, downstream households got their water first, meaning they were able to take and store more water while people upstream were left with shortages, leading to conflicts. Therefore, even if water is provided according to availability during the dry season, the group heads oversee daily water allocation to try to ensure that people do not misuse water. The village committee also plans to build a larger tank to increase water storage capacity.

Methodology

The fieldwork conducted in 2012 assessed and documented gender differentiation in (1) perceptions of the causes of water shortages, (2) water use, (3) the impacts of water shortage on livelihoods and domestic water use, (4) responses to water stress, and (5) the role of local and government institutions in helping community members address their water-related concerns. It aimed to understand the processes that make different sections of the community more or less vulnerable to water stress and the manner in which they do or do not respond to it. The assessment was mainly qualitative (eg focusing on people's perceptions and narratives), but it was complemented by quantitative data wherever possible.

First, a semistructured in-depth questionnaire was used to conduct 31 individual interviews (with 14 women and 17 men) in different households. The questionnaire focused on water availability, access to and management of communal water resources, conflicts over water, perceptions of recent changes in climate and water resources, possible causes of drought, the impact of water stress on household water consumption and agricultural practices, and actions taken to mitigate water stress.

Second, 2 focus group discussions were held, one for each sex. The women's group included the leader of the village's women's group, a representative of the village committee, and 4 farmers from different villager groups. The men's group included the village committee leader, the head of a villager group, and 6 farmers from different villager groups. Each focus group discussion began with participatory mapping of water resources in the village, followed by discussions of challenges related to water collection and management for agricultural and household use.

Third, key informant interviews were conducted with the head of the women's group of Haitang and the water manager of 1 of the villager groups. These interviews focused on water management in the community, which included a specific focus on government support, common issues, and the role of women in village-level decision-making.

Statistical analysis was performed on questionnaire responses using a permutation test, where dependent values were shuffled 1000 times in relation to independent variables and the distribution of a test statistic under a null hypothesis was generated. The P value was obtained based on the ranking of the real test statistic among the shuffled test statistics. All possible independent indicators and questions were tested using the R 3.0.1 software environment for statistical analysis (R Core Team 2014). This method of analysis allowed us to generalize key results despite a small sample size.

Results

Gendered perceptions of water availability

Water shortages in Haitang were experienced before the 2009–2010 drought. As one water manager said:

> *I think the problem of water shortage was not so serious in 2005 [also a drought year], but the situation has continuously deteriorated since 2006. The recent 3 years [2009–2011] are the worst years since I started work. In 2005, the village could release water every other day and the situation was not so bad. From 2006 to 2009, water could generally be released once in 3 days. However, in last 3 years, we could only release water every 4 days.*

About three-quarters of the interviewees also stated that water availability was declining. This trend meant that villagers had to travel farther to access water for manual irrigation of crops and trees. Most farmers interviewed in 2012 estimated that these water sources would only suffice for 4 months, and that tap water had been sufficient for a mere 6 months in the previous year. The rest of the year, household members had to collect

TABLE 1 Expectations regarding future drought.[a)]

Expectations	Men ($n = 17$)	Women ($n = 14$)
Less drought	0%	14%
More drought	59%	29%
Uncertain	41%	57%

[a)]Source: 2012 field survey.

water from the nearest water source to supplement the limited tap water.

Concerning the likelihood of future drought, in general, women were more optimistic than men (Table 1). Men and women saw a range of reasons for declining water availability (Table 2). About a quarter of women and a third of men attributed it to decreased rainfall during the monsoon season. Women were more likely than men to note changes in the number of rainy days and the timing of rainfall, and members of both groups attributed it to human activities in the mountains. (About a quarter of women pointed to the construction of a railway line that cut across the main water stream serving the village, and one man noted that road construction in the village had silted up several small ponds and streams.) About a quarter of women and a fifth of men blamed nearby tobacco cultivation, as cloud seeding has been employed to reduce rain and prevent hail from damaging the crop. Thus, water shortages were attributed not only to natural factors such as decreased rainfall, but also to human activities affecting the mountain environment.

Agricultural water use

As mentioned earlier, there is no irrigation management system in Haitang because there are no permanent water sources for irrigation. Men and women made similar estimates of the impact of water shortages on agricultural production, with about half of each noting a decline in yields and changes in crop types.

Men and women in Haitang reported using different strategies to cope in the short term with the shortage of water for agriculture during the drought in 2009–2010 (Figure 3A). Just under half of men reported simply waiting for the rain, and just under a fifth reported transporting water to water their crops. For women, the preferences for coping strategies were reversed. Just under half reported that they transported water to their crops, and under one fifth claimed to be simply waiting for rain. Some women, but no men, reported changing their farming arrangements, such as decreasing the cultivated area and adjusting the timing of planting. In general, women actively engaged with more immediate responses to drought than men.

As the drought continued, men and women showed further differences in their longer-term responses (Figure 3B). After successive low crop yields, 15% more women considered shifting into forestry and animal husbandry. Both men and women considered engineering measures to enable crop irrigation, but more men considered digging ponds or wells, while more women considered building water tanks and renting or buying pumps. Seventeen percent more men still said that they had no plan for adaption; 6% more men than women sought government support.

Changes in cropping patterns and reduced production due to the drought meant smaller harvests and less produce available for sale. Most young men and a few young women thus turned to seasonal migration for work as their main income source. Men's outmigration indirectly affected the women who stayed behind. It increased their share of agricultural work, including

TABLE 2 Perceptions of the causes of water shortages.[a)]

Main causes	Detailed causes	Men ($n = 17$)	Women ($n = 14$)
Environmental changes	Less rain	32%	22%
	Limited water source	9%	11%
	Deforestation and land reclamation	3%	0%
Human activities	Railway construction in lower area	9%	26%
	Road construction in the village	3%	0%
	Nearby tobacco plantation	18%	26%
Socioeconomic changes	Population growth	15%	7%
	Livestock increase	3%	0%
Physical conditions	High elevation of villages	9%	7%

[a)]Source: 2012 field survey. Drought is a complex issue that may have many contributing factors; therefore, individual respondents reported one or more causes of drought.

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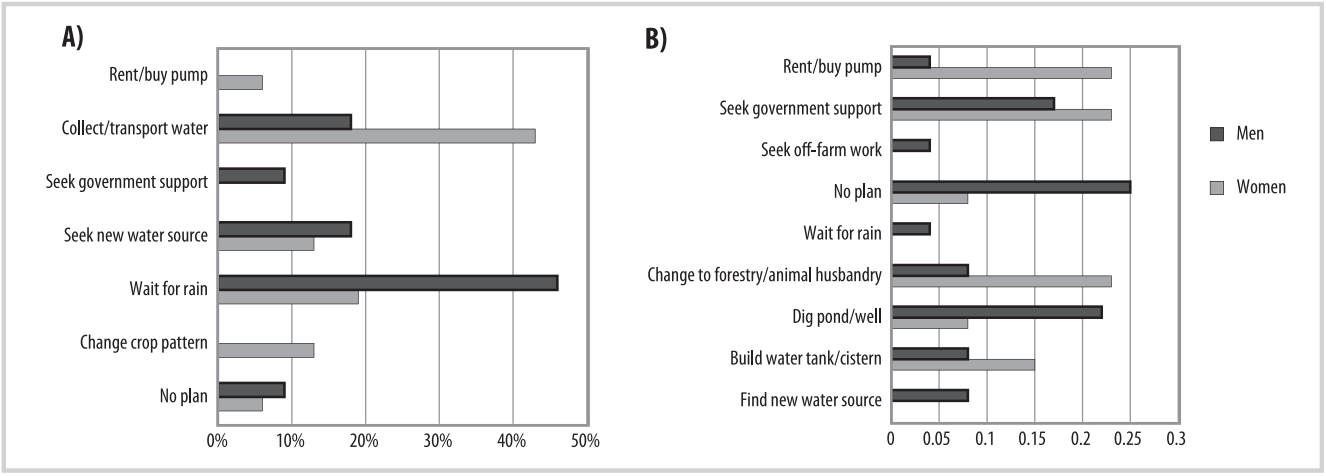
FIGURE 3 Responses to shortages of water for agricultural use: (A) short term; (B) long term.



manual irrigation of crops, adding to the burden on their time and energy. Failing agricultural production also made women more dependent on remittances from migrating household members.

Domestic water use

All women stated that the element most affected by the drought was drinking water. As one woman said: "If there is no water for the land, we can survive with remittances from our husbands who work as migrant laborers outside the village. But how can we survive without drinking water?" In focus group discussions, women collectively agreed that collecting drinking water is difficult almost half of the year (February to July), and fetching water takes more than 20 minutes at a time. Women estimated that on average they carried 6 buckets of water each day from the nearest source to meet household demand.

Both men and women (more than half) stated that collecting water was their immediate response to lack of drinking water. However, men and women differed in terms of who they believed was responsible for responding to water shortage on a daily basis (Table 3): more men saw it as a man's job to respond by gathering additional water, and more women saw it as a women's job. More detailed discussions revealed that traditional gender roles were perpetuated in the way that "gathering water" was defined in each focus group. Men understood gathering water to mean looking for new sources of water as old sources dry up, which is their main responsibility, while the actual carrying was primarily women's responsibility (Figure 4A). In this situation, the men believed that they were the person responsible within the household for coping with a domestic water shortage; however, women's daily labor increased more substantially than men's although they were not seen as the person responsible for the additional task. However, as the distance to water sources increased, women needed help to fetch water. Men would provide this assistance, carrying water on motorcycles, mules, or trucks. Women whose husbands and sons were working outside the village depended on support from neighbors and relatives to collect water for domestic use. About half of the men indicated that men dominated household decision-making, while only about one fifth of the women confirmed that this was the case. In general, over 50% of both men and women stated that transporting water was their preferred coping strategy. All other strategies received less than 15% support.

As the drought continued, a variety of longer-term responses were adopted. Engineering responses, including constructing larger water tanks, ponds, wells, pipes, and water-harvesting facilities, were reported by about a third of men and women. The government provided funds or materials to several households to implement these measures. More women than men mentioned nonengineering responses, such as water transportation, while a few men and women reported taking measures to

TABLE 3 Perceived responsibility for collecting water.[a)]

	Men ($n = 17$)	Women ($n = 14$)
Men	51.7%	16%
Women	24.1%	58%
Both men and women	17.2%	21%
Relatives	3.5%	0%
Sufficient water, no collection activities	3.5%	5%
Total	100%	100%

[a)]Source: 2012 field survey.

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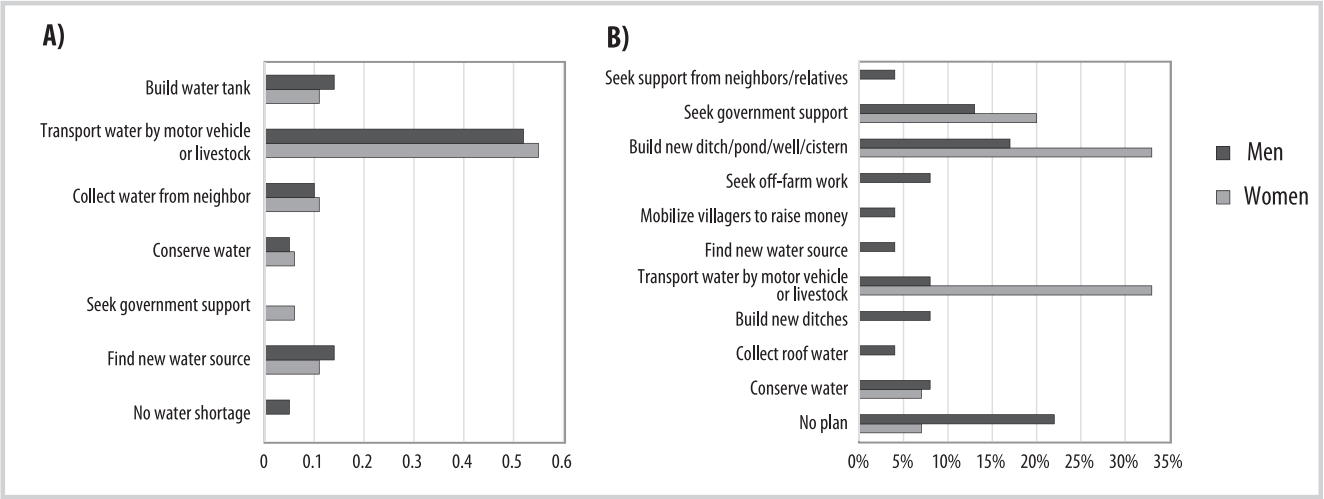
FIGURE 4 Responses to shortages of water for domestic use: (A) short term; (B) long term.



save water. About a fifth of the men, but fewer than one tenth of the women, still reported having no specific plan to address the domestic water shortage (Figure 4B).

Community-level water management

Water managers are selected by the villager committee and approved by a meeting of the villagers' representatives. They are mainly responsible for water tank and pipe maintenance and for domestic water allocation at the village level. Although both women and men can serve as managers, no women have been selected as managers in the past. Both men and women said that this was due to the skills and physical strength needed to repair pipes and water infrastructure, as well as a perception that it fell outside women's traditional domestic roles. However, as water scarcity continued, conflicts over water allocation became more frequent, and both men and women acknowledged that women have become increasingly active in monitoring water allocation along with water managers in order to reduce the risk of fights among the men. Women are seen as able to solve these conflicts and ensure equal distribution through negotiation rather than physical fighting.

Considering future options, focus group discussions with both men and women emphasized that the construction of a water tank uphill would reduce water stress. Both groups stated that villagers were ready to collectively contribute and that they were also seeking support from the local government. The village head said, "it takes a lot of effort to convince the government to budget for it, but we hope to showcase the tank construction by starting it without waiting for the government support." In contrast to these discussions on the improvement of physical infrastructure, the (female) head of the women's group in Haitang advocated strengthening women's role in implementing long-term strategies to address domestic water scarcity by conserving and recycling water. She stressed that "it is necessary to encourage women to plant more cash crops and trees through the village women's group. In addition, I think women and children can play a vital role in educating villagers to save [and recycle] water."

Discussion

Gender-differentiated perceptions and impacts of climate change are context-specific and depend on the involvement of men and women in agricultural production, socioeconomic status, location, and gendered differences in access to and control of key assets (Roncoli et al 2001; Carr 2008). Access to support networks and information and decision-making power are all subject to traditional gender roles and are important influences on gendered responses to climate hazards (Carr 2008). Engagement in agricultural production is partly shaped by gendered features of migration (Hunter and David 2011). Therefore, in cases like Haitang, where women and men have very different roles in water collection, use, and management, they also have different experiences of drought. Our results also show that they choose different coping and adaptation strategies: for example, women were more likely to adapt to agricultural water shortages by using different farming techniques and were more willing to consider shifting to other activities such as forestry and animal husbandry. Women and men also played different roles in community-scale water management: our results show that women in Haitang are active in informal ways in water management and conflict prevention. However, despite the increasingly active role of women in managing water during the drought, cultural attitudes still exclude them from decision-making.

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Attention to the gender dimensions of climate change is relevant to the Chinese context in several ways. Off-farm work, including large-scale seasonal and permanent migration to urban areas, has been a major contributor to economic growth, including in the mountain areas of Yunnan (Zhang and Song 2003). Many men and younger women from rural areas have migrated to urban areas, leaving many middle-aged women behind in rural areas (Mu and Van de Walle 2011). Agricultural production has become increasingly feminized, and many women take on multiple roles in addition to their responsibilities for care of children and the elderly (Mu and van de Walle 2011). In Haitang, off-farm wage labor outside the community had for some years been an important income-generating strategy. As the drought continued, more men and some younger women migrated, and women assumed more responsibility for agricultural production. Water scarcity has forced women to travel farther to collect water for agricultural and domestic use, and men have helped them transport water from more distant sources. This has limited women's ability to pursue other livelihood activities and has made them more dependent on men. Outmigration (primarily by men) and its adoption as a drought response strategy thus frame the impact of drought on women in Haitang. Other studies of gendered impacts of water shortages caused by climate change also confirm these findings (Denton 2002; Neumayer and Plümper 2007; Nellemann et al 2011; Jin et al 2015).

Although formal water management policies in rural China may help farmers meet their practical needs, little explicit attention has been paid to gender-specific needs, and no regulations have been put in place to ensure women's participation in formal institutions and in water management institutions (Lu 2009). Traditional gender roles remain dominant, especially in mountain areas with strong cultural traditions, and these can prevent the meaningful participation of women in community-based water management (Ge et al 2011). This is despite many women's participation in additional labor as a result of water scarcity, both in domestic work and in agricultural production.

Men and women in Haitang suggested that women's participation may help to reduce conflicts during drought and strengthen water management at the community level. However, because neither government policy nor village structure explicitly addresses gender issues, the potential for women to contribute in these areas is wasted. The relevance of gender issues for policies to address drought and other climate risks is not widely recognized, and in general there is a lack of information on the topic.

There is therefore a need for mainstreaming gender awareness in relevant policies and institutions. Indeed, there has been almost no assessment of the gender impacts of climate change and climate variability in China. Thus, government-supported adaptation responses may not be tailored to women's priorities and needs, may not fully benefit from women's active contribution to water management, and may further marginalize rural women in public affairs.

Conclusion

In mountain communities, women and men experience vulnerability to water shortage differently and have different capacities and roles in responding to water shortage. As a mountainous region with an economy dominated by agriculture that is subject to significant water stresses related to climate change, Yunnan Province is an important site for examining these different perceptions, impacts, and formal and informal channels for responding to water stresses. This study found that women who are engaged in agricultural production in Haitang are increasingly exposed to the impacts of drought. This is largely due to the changing roles of men and women due to outmigration and to increasing water shortages, which may be linked to climate change. Our results show that men and women are affected by and respond to water shortages differently, with women being more likely to actively change their agricultural management techniques. However, despite the increasingly active role of women in managing water during droughts, they are still excluded from formal decision-making about water management at the community level.

Formal water management policies in rural China do not address gender issues and do not ensure women's participation in formal water management institutions (Lu 2009; Tong et al 2017). These may therefore fail to align with the priorities and needs of women, who are increasingly responsible for agricultural management.

Current climate change adaptation policies in China also focus more on natural ecosystems than on socioeconomic issues (Peng et al 2015), and there are no gender-related items in the National Strategy for Climate Change Adaptation. By understanding culturally specific gender roles in household economies and natural resources management (Dankelman 2002), research can generate insights to inform the development of targeted measures to support women in coping with longer-term changes in climate and climate variability (Nelson et al 2002).

This case study has demonstrated that attention to gendered impacts of and responses to climate hazards are relevant in the Chinese context. In particular, promoting gender equality and focusing on greater participation of women in decision-making are key to supporting sustainable development in mountain communities where outmigration of men is high and women take on many roles in household and agricultural management. Further research into the gender-differentiated impacts of and responses to climate hazards in mountain areas, where people are especially vulnerable to natural and social

stresses, can therefore inform the development of policies aimed at meeting the particular needs of different social groups in those areas.

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