Perceptions of and Adaptations to Climate Change, Determinants and Barriers Among Pastoralists in Inner Mongolia, Arid and Semi-Arid Region of China

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Perceptions of and adaptations to climate change, determinants and barriers among pastoralists in Inner Mongolia, arid and semi-arid region of China

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Abstract

Climate change is going to be one that presents major challenges facing pastoral system, especially in arid and semi-arid region. How pastoralists perceive and adapt has become increasingly important part in providing foundation for households and governments to develop adaptation policies. This article aims to investigate the pastoralists' perceptions on climatic change variability and impacts, in addition, to explore the pastoralists' adaptation strategies and determinants using a Multivariate Probit Model, as well as barriers and needs in the adaptive process. We collected questionnaires from the pastoral areas across four districts in Inner Mongolia. The findings revealed that pastoralists' perception of the inter-annual temperature variation is relatively coincide with actual meteorological data. This study found that 11 adaptation strategies have been commonly used by pastoralists, moreover, household production capital, risk-buffering capacity, and social network influenced the pastoralists' adaptations. However, barriers remain for pastoralists, such as inadequate capital and labor, lack of water, limited access to credit, technological knowledge, and timely weather information. Further, our findings indicated that pastoralists need hazard relief fund, improved pasture facilities, technical knowledge training, active weather-based information, integrated pest and disease management and off-farm employment opportunities. This combination of our findings potentially provides some support for developing appropriate and long-term specific policies to mitigate the adverse impacts of climate change.

Keywords: Climate change • Drought • Perception • Adaption strategies • Barriers

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Financial and Non-financial interests

The authors have no relevant financial or non-financial interests to disclose.

Availability of data and material

The datasets generated/analysed during the current study are available.

Author Contributions

Qi Wang, Huamin Liu and Lixin Wang participated in the conception and design of the study. Qi Wang collated the data, designed and developed the database, and carried out data analyses, Qi Wang and Huamin Liu produced the initial draft of the manuscript. Lu Wen, Dongwei Liu and Cunzhu Liang contributed to revised the manuscript critically for important intellectual content. All authors have read and approved the final submitted manuscript.

Ethics statements

This study was carried out in accordance with the approved guidelines. All the pastoralists have been informed and agree to verbally before the survey.

Consent for publication

Consent for publication was obtained from the participants.

1 Introduction

Global climate change is increasingly recognised as a serious, worldwide environmental challenge facing this century (IPCC 2007). The issue of climate change has received considerable critical attention, which will change temperature and precipitation patterns notably (Craine et al. 2012; Fay et al. 2010; IPCC 2014). In addition, one of the most abnormal and extreme events was drought, which occurred frequently (Briske et al. 2015; Easterling et al. 2000; Sheffield and Wood 2007) and its adverse impacts will be more common (IPCC 2014a; Stocker et al. 2014). Undoubtedly, such changes will continuously impact on natural resources, environment, and ecosystem that human rely on (Easterling et al. 2000; Pandey et al. 2017; Thornton et al. 2009).

China has the second largest grassland of the whole world (Zheng et al. 2018). The grassland is supporting the livelihoods of most pastoral communities, and most of which situated at the arid and semi-arid region. It has been suggested that communities are more vulnerable to climate change in dryland, which owns low capacity to adaptation and high dependence on natural resources sensitive to climate change (Callaway 2004; Fraser et al. 2011). Recent evidence note that their vulnerability has aggravated due to climate change is further compounded by other profound changes, including rapid growth of population (Kang et al. 2007), overgrazing (White et al. 2011; Zhang et al. 2018), changing land tenure, and unclear property right regimes (Briske et al. 2015; Bryan et al. 2013; Wang et al. 2013). Therefore, it is urgent to enhance adaptive capacity and strengthen the resilience to climate change in pastoralism.

Adaptation to climate change require they perceived the climate change firstly (Deressa et al. 2009), and several previous studies have revealed that the individual perception varied according to belief about climate change (Howe and Leiserowitz 2013; Niles et al. 2013; Niles and Mueller 2016). Although, individual perceptions and their understanding of climate change may be inaccurate or incomplete (Alessa et al. 2008; Li et al. 2014), it still makes an important contribution to understanding of response and adaptations (Niles et al. 2013).

As policy options, adaptation is a way to mitigate the negative effects of climate change (Adger et al. 2003; IPCC 2007). Several researchers have theoretically investigated adaptation initiatives associated with climate change from different nationalities. Farmers in Kenya, for example, may mix crop and

livestock production, diversify feeds, improve animal breed and migrate to other places (Silvestri et al. 2012). South Africa farmers changed stock number, purchased fodder, rent additional land and used hardier breeds (Clarke et al. 2012). Among rice farmers of Nepal, used fertilizer, changed in rice varieties and nursery date as adaptation options (Devkota et al. 2018). Farmers' adaptations in Southwest China have included adjusting planting and harvesting dates, changing crop species, and improving the irrigation facilities (Li et al. 2013). However, these findings have proved that adaptations are distinctly regional and extremely complicated in different geographical and socio-economic context (Ayers and Forsyth 2009; Below et al. 2012). Thus, a better understanding of existing adaptation patterns is essential for development of adaptation policies (Abid et al. 2019). In addition, several empirical studies on determinants of farm-level adaptations indicate that the educational background, gender, age of household head, household capital, landholding, tenure status, experience of farming, livestock ownership, credit availability, social capital, and regional climate influence farmers' adaptations (Al-Hassan 2013; Ashraf et al. 2014; Deressa et al. 2009; Hassan and Nhemachena 2008; Piya et al. 2013; Sarker et al. 2009; Tesfahunegn et al. 2016).

Although numerous studies have reported on various adaptation strategies to climate change, much work remains to be done to get insight into the barriers and opportunities for future adaptation. Furthermore, local government is also critical to climate adaptive policy development (Banerjee et al. 2013; Vogel and Henstra 2015). Therefore, it is essential that not only to improve local livelihoods and facilitate inherent adaptation ability for pastoralists, but to provide a foundation for governments to develop regional, and sustainable adaptive strategies to mitigate negative impacts of climate change and reduce vulnerability.

The major objectives of this study are to identify pastoralists' perceptions of climate change variability and what is the relationship between these perceptions and observations, how climatic change impacts on grassland ecosystem and local livelihood, in the case of drought. To explore adaptation strategies and recognize barriers and needs perceived under pastoralists' perspective deployed in rangeland in Inner Mongolia in arid and semi-arid zones of China.

2 Materials and Methods

2.1 Study sites

The study area for this research is the rangeland of Hulunbuir City, Xilingol League, Ulanqab City and Alxa League (Figure 1), with precipitation patterns vary from northeast to southwest. Eight Cities or Banners were selected, including Hailar City, Ergun City, Xin Barag Right Banner, Yakeshi City, Xilin Hot City, Abag Banner, Siziwang Banner, and Alxa Left Banner.

The inter-annual average rainfall in the study regions ranges from 150 mm to 350 mm, with precipitation conditions gradually decreased from northeast to southwest. The trend of mean annual temperature is obviously increased and the variability of rainfall patterns is extremely complex. Livestock includes sheep, goats, and cattle, and others, horses, donkey and camels.

2.2 Sampling and Data collection

In order to analyze the relationship between pastoralists' perceptions and historical climate trends, meteorological data on monthly precipitation and temperature were downloaded and analysed, including the period of 1981-2014 from 8 weather stations (Hailar City, Ergun City, Xin Barag Right Banner, Yakeshi City, Xilinhot City, Abag Banner, Siziwang Banner, Alxa Left Banner) from the website of China Meteorological Data Service Center (available at: http://data.cma.cn/en). Based on monthly data, inter-annual average precipitation, inter-annual average temperature, and Standardized Precipitation Evapotranspiration Index (SPEI) were calculated. The SPEI is a new ideal index for monitoring the trend of drought combining with sensitivity of PDSI to temperature and multi-temporal features of SPI (Vicente-Serrano et al. 2010). Classification of meteorological drought for SPEI given in Table 1. Using the Mann–Kendall nonparametric test, we analysed the data for time series trends (Smadi and Ahmed 2006).

Then, data were collected via face-to-face interview with respondents in June-October 2015. Livestock grazing is the major income of households in all these villages. The questionnaires data consist of (1) socio-economic characteristics of household, (2) perceptions of climatic change and its impacts, (3) pastoralists' adaptation strategies and (4) barriers and needs in the adaptive process.

We used a stratified sampling method to select households, and the number of chosen households is determined by the density of residents in the four survey districts. During the process of the fieldwork, one college student whose native language is Mongolian was recruited as a language interpreter to make sure questionnaires data are accurate. As a result, we chosen 38 Sumus and 64 representative villages, in addition, according to the population composition, 3–5 households were selected from each village randomly, 261 valid questionnaires collected from 279 households, finally. The numbers of households in each of the four regions are 22 in Alax League, 53 in Ulanqab City, 84 in Xilingol League, and 102 in Hulunbuir City.

2.3 Empirical Model and Explanatory Variables

2.3.1 Empirical Model

To analyse the determinants of farmers' adaptation strategies, a binary logistic regression and multinomial logit (MNL) models were used extensively, however, these two models cannot meet the requirements in this study, due to the households adopted several strategies simultaneously. Whereas, the assumption of practices are mutually exclusive is a disadvantage of MNL model (Shah et al. 2017), meanwhile, the binary logistic regression method fails to account for the correlation among the different adaptation measures.

Multivariate Probit (MVP) model address these problems, which allows respondents take more than one adaptation strategy simultaneously (Nhemachena and Hassan 2007). The MVP model is suitable when considering the relationship between dependent variables, overcoming the limits of the binary and multinomial logit models. Therefore, in this study, MVP model was selected to analyse the determinants of household adaptation strategies.

The MVP model used in this article consists of eight binary-choice equations.The regression model is as following:

$$Y_{ij} = \begin{cases} 1 & if \ X_{ij}\beta_j + \varepsilon_{ij} > 0; \\ 0 & otherwise \end{cases} \ i = 1, 2, \cdots, N. j = 1, 2, \cdots J.$$

Suppose Y_{ij} denote the adaptation strategy that taken values $\{0, 1\}$, where 1 represents that the

strategy has been chosen, and 0 represents opposite. X_{ij} denote the potential variables. β_j is the regression coefficient. Let i = 1, 2, …, N be the independent observations, j = 1, 2, … , J be the options of binary responses. $\mathcal{E}_{ij}$ are the error term.

With the method of simulated maximum likelihood (SML), the MVP model estimates probit models using Geweke-Hajivassiliou-Keane simulator (Geweke et al. 1997; Hajivassiliou et al. 1993) approach and STATA software.

2.3.2 Explanatory Variables of the Model

Facing the harsh realties of climate changes, and the first to be affected, are the pastoralists in pastoralism. Therefore, it is important to comprehensively understand the adaptation strategies to climatic changes and determinants of pastoralists, then, to diminish vulnerability and enhance the ability. Based on data available of questionnaires data and previous literatures, the independent variables including age, education and gender of the household head, household and labor member, and landholding as the socio-economic factors, institutional factors consist of credit availability, tenure status and enrolled in the project, in addition, social factor as the number of relatives living nearby. Principal component analysis (PCA) was used to derive independent variables for MVP model. The descriptions of explanatory (independent) variables in our study are presented in Table 2.

3 Results

3.1 Socio-demographic characteristics of respondents

The male gender of household was 78.9%, 46.3 is average age of the household head. Education information showed that 12.2%, 21.1%, 55.2%, and 11.5% of the respondents were illiterate, primary education, middle education, and secondary school or higher education level, respectively. The finding signifies that the respondents were not educated enough to understand the changing climatic variability. The average number of household members was 3.57. The whole mean number of household livestock was 385.22, and 64.4% of households have land tenure. The average area of household rangeland was 425.94 ha, and the mean number of households facilities was 2.57. Detailed figures are given in Table 2.

3.2 Trends of meteorological variables

The observations were analysed from meteorological stations evolved over 1981 to 2014. The results suggest that inter-annual average precipitation in Ulanqab, Alxa, Hulunbuir, and Xilingol was respectively 315 mm, 155 mm, 257 mm, and 343 mm. The inter-annual average temperature of Ulanqab, Alxa, Xilingol, and Hulunbuir was respectively 4.06 ℃, 9.11 ℃, 1.09 ℃, and −0.74 ℃.

Figure 2 shows inter-annual average temperature increased at a rate of 0.026 ℃ yr-1, 0.036 ℃ yr-1, 0.041 ℃ yr-1, and 0.046 ℃ yr-1 in Hulunbuir, Xilingol, Alxa, and Ulanqab from 1981 to 2014, respectively, which all was found to be statistically significant. The precipitation variability changes drastically, the inter-annual average precipitation of Hulunbuir and Xilingol shows a negative trend, on the contrary, the inter-annual average precipitation of Alxa and Ulanqab was increasing, but all was not statistically significant over the past 35 years.

Figure 3 presents the inter-annual average SPEI for the Alax, Ulanqab, Xilingol, and Hulunbuir. The overall SPEI trend on the inter-annual scale for the study area showed a decilning tendency from 1981 to 2014, with a rate of −0.029 yr-1, −0.030 yr-1, −0.026 yr-1, and −0.032 yr-1 in Xilingol, Hulunbuir, Alax, and Ulanqab. Results of Xilingol and Hulunbuir are statistically significant but not in Alax and Ulanqab. This finding demonstrates that the drought is became ever more frequent over the last 35 years.

3.3 Perceived Climate changes and its impacts of pastoralists

In Ulanqab, 72 percent of respondents reported that rainfall has declined, while 6% perceived no change. In the same region, 38 percent of pastoralists reported that temperature has increased, and 47% observed no change. In addition, most of pastoralists stated increase in frequency of drought (79%). The results for Alax show that pastoralists (50%) observed rainfall is increasing, 27% observed no change. In the same district, 45% of the respondents perceived increasing warmer temperature, 41% mentioned no change. Meanwhile, 41% of the respondents perceived no change in drought. 46% of the pastoralists in Xilingol stated that they perceived decreased in rainfall, 14% perceived no change. Approximately, 64% of pastoralists claimed that temperature has been increased as well as drought (56%). Districts as Hulunbuir (95%) have perceived increased in rainfall. Of all the respondents in Hulunbuir, 36% believe

that the temperature is increasing, while 40% mentioned no change. Compared to other regions, most of the pastoralists in Hulunbuir (68%) claimed that the frequencies of drought decreased in the past decades, only 7% mentioned increasing in drought (Figure 4).

The questionnaire investigated public perceptions that the pastoralists have experienced on impacts for climate change, in case of drought (Figure 5). Overall, the majority of households in each region, argued that there has been a decreasing grassland production, with proportion of 93%, 57%, 77%, and 100% of Hulunbuir, Xilingol, Alax, and Ulanqab, respectively. Correspondingly, pastoralists mentioned that the livestock production declined (44% of Hulunbuir, 26% of Xilingol, 68% of Alax, and 75% of Ulanqab), feeding cost has increased (86% of Hulunbuir, 61% of Xilingol, 59% of Alax, and 62% of Ulanqab), followed by income decreased (87% of Hulunbuir, 33% of Xilingol, 73% of Alax, and 98% of Ulanqab). While the respondents indicated that drought resulted in groundwater level dropped (14% of Hulunbuir, 50% of Xilingol, 18% of Alax, and 42% of Ulanqab), increased pests and diseases (26% of Hulunbuir, 37% of Xilingol, 18% of Alax, and 96% of Ulanqab). In addition, households observed soil desertification worsened (28% of Hulunbuir, 13% of Xilingol, 18% of Alax, and 98% of Ulanqab), and perceived the plant species decreased (27% of Hulunbuir, 55% of Xilingol, 18% of Alax, and 98% of Ulanqab).

3.4 Adaptation strategies and determinants

Then, major adaptation strategies of households were asked to deal with drought, and 11 major adaptation strategies (Figure 6) are widely used, and pastoralists take multiple adaptations simultaneously.

Figure 6 summarizes the adaptation strategies adopted by pastoralists in the study area, strategies as purchasing fodder (87% of Hulunbuir, 76% of Xilingol, 68% of Alax, and 19% of Ulanqab) and reducing livestock (61% of Hulunbuir, 43% of Xilingol, 50% of Alax, and 92% of Ulanqab) were the most commonly adopted strategies . In the case of grassland production declining, respondents (43% of Hulunbuir, 60% of Xilingol, 14% of Alax, and 25% of Ulanqab) chosen rent pasture. Survey data further revealed that the respondents (6% of Hulunbuir, 14% of Xilingol, 27% of Alax, and 70% of Ulanqab) migrated to other places where relatives living to mitigate the impacts of drought. It was also observed that there was 37% of Hulunbuir, 14% of Xilingol, 9% of Alax of households preventing disease for

livestock and drilling water (36% of Hulunbuir, 11% of Xilingol, 9% of Alax, and 8% of Ulanqab) to make sure the healthy livestock. In addition, purchasing insurance (43% of Hulunbuir and 9% of Alax) and improving livestock breed (21% of Hulunbuir, 20% of Xilingol, and 11% of Ulanqab) which were more resilient to the changing condition to minimize production loss. The least common adaptation strategies were off-farm work (4% of Hulunbuir, 1% of Xilingol, and 21% of Ulanqab), irrigating (1% of Hulunbuir, 14% of Alax, and 19% of Ulanqab) and planting artificial grassland (2% of Hulunbuir, 6% of Xilingol, and 27% of Alax), respectively.

According to the Kaiser normalization procedure, five components were extracted from 12 potential factors, which together explained 58.65% of the variance. Table 3 lists the variables with high load on the same components, illustrating that five components consist of the head demographics, household production capacity, household size, risk-buffering capacity, and social network.

We test the correlation between the 5 explanatory variables and 11 explained variables with pearson correlation analysis before we performed the MVP model, and 8 dependent variables in Table4 retained finally.

The likelihood ratio (Wald χ^2) of the MVP model for this study is statistically significant (P = 0.0000), indicating the model was explained sufficiently. Results show that all effect coefficients of head demographics were statistically insignificant, and demonstrate that head demographics were not significance in influencing adaptation, however, their signs suggest a particular pattern that old pastoralists tend to choose the migration to adapt to climate change, the older pastoralists are generally with low cultural level, they have less awareness of climate change so as to adapt to it, usually, they migrated as a traditional adaptation practice. In addition, more labor households have, the more stable they maintain their livelihoods. It was found that household size increases the likelihood of adopting the improving livestock breed, migrating, and purchasing insurance as adaptation practices rather than purchasing fodder, reducing livestock, renting pasture, and preventing disease.

Furthermore, in our research, the lower risk-buffering capacity is, households did not own land tenure, availability of credit, but enrolled in cooperation, the more likely people are to adopt strategies such as improving livestock breed, purchasing fodder and insurance, and renting pasture to maintain their

livelihood, and almost all effect coefficients were statistically significant. Results also showed that households with a larger social network are more likely to reduce more livestock, migrating and off-farm work rather than purchasing insurance and fodder, and renting pasture.

Finally, household production capacity is comprised of household's natural, financial and physical capital components. The greater the production capacity households have, the more likelihood of adopting purchase fodder, reduce livestock, migrate and rent pasture as adaptation measures, the less likelihood of adopting improving livestock breed and purchasing insurance.

3.5 Barriers and Needs for adaptation

There also has barriers for adaptation, some of which caused by climate change, and others may be natural, economic, social, or institutional (Adger et al. 2007), which may lead to limited awareness of climatic risks and constrained ability to adapt to it (Adger 2009; Moser and Ekstrom 2010). Thus, it is essential that identify the barriers for adaptation. Pastoralists were asked the limits and obstacles they faced in adopting strategies. As showed in Figure 7, they cited inadequate capital and labour as the major barriers to adaptation with the proportion of 47% and 46%, respectively. Lack of or limited access to credit and water was recognized by 32% and 23% of pastoralists. A small proportion of respondents (16% and 10%) also claimed that limited knowledge of adaptation measures and delayed weather information weakens their ability to better address the negative effects of drought.

It is crucial for enhancing their adaptive capacity by addressing the constraints above which impede adaptation process of pastoralists. Therefore, we attempted to broadly understand what are pastoralists needs for climate change adaptation (Figure 8). In our research, 84% of pastoralists stated that they need funding to relieve disaster, such as drought. Respondents (57%) expect that the government could help them improve livestock sheds and drill well facilities. Meanwhile, they indicated that they want receive technical knowledge training of adaptation practices and timely and accurate weather information in the process of adapting, with the proportion of 50% and 26%, respectively. In addition, 18% of the respondents considered that high income comes from good quality of livestock, the respondents claimed that implement the integrated pest and disease management by the government would prevent rather than control diseases. Further, a small proportion of pastoralists (4%) indicated that the local government

should increase off-farm employment opportunities, it will help them in diversifying their livelihoods.

4 Discussion

From our research findings, we concluded three main insights. First, the pastoralists observed changes in past decades, however, the perceptions not always correspond with historical climate trends. Second, with multiple and complex context, the adaptation strategies that households practiced were mainly depend on the capital and capacity of pastoralists. Third, adaptations of pastoralists remian have barriers and limits, which impede the ability to mitigation the impacts of drought hazard. It remains has a knowledge gap in terms of understanding the needs for adaptation of pastoralists in the decision-making process.

4.1 Perception of pastoralists and impact factors

Over the past three decades, the temperature was rising with low variability. Most of the pastoalists' perceptions of temperature correspond with historical climatic trends in all four regions. The finding is in line with a previous study (Li et al. 2014). The recorded data showed no significant increase and decline in precipitation. In addition, Drought with the characteristics of high frequency of Hulunbuir and Xilingol grassland in the past decades. Whereas more than 95% pastoralists in Hulunbuir claimed that rainfall has risen, and 68% noted that frequency of drought has decreased, while 73% pastoralists of Ulanqab perceived a decline in rainfall, and 79% perceived frequency of drought has increased past three decades. However, the actual data showed that the pastoralists' perceptions of precipitation are consist with the recent rainfall trends, whereas the pastoralists' perception of drought is seem to be related to the recent rainfall. It suggests that the perception of precipitation and drought is sensitive to short-term changes. It is consistent with a previous study that public perception of climate was linked to the strong variability of the climatic parameters (Rebetez 1996). As the previous study indicated, impacts on livelihood systems is highly specific in different ecosystems and regions (Morton 2007). The pastoralists-perceived climate change in four regions with precipitation patterns varies from northeast to southwest, there are four types of grassland, including the meadow steppe, typical steppe, desert steppe and desert, is also geographically specific in this article.

Meanwhile, through the interview, the pastoralists stated that the local government of Chenbarag Banner and Xin Barag Right Banner in Hulunbuir reserved part of grassland as the communal pasture. In the summer, pastoralists could be grazed as summer pasture and the same in the winter. The communal pasture was widely accepted by pastoralists because they could not only make full use of public grassland but also improved the production of their own pastures in autumn and reserved more fodder for the winter. Thereby, enhanced their adaptation capacity. Although the decreased trend of precipitation in Hulunbuir led to decrease of grass production, the pastoralists didn't aware the trend under the influence of appropriate policy, which proved that the implementation of policy affected the pastoralists' perception.

4.2 Adaptation strategies of pastoralists and impact factors

Furthermore, our result showed that adaptive strategies of pastoralists for drought involved livestock and pasture firstly, including buying fodder, selling livestock, and renting pasture, the other coping strategies were that of migrating, preventing disease, drilling water, purchasing insurance, improving livestock breed, off-farm work, irrigating, and planting artificial grassland. These adaptations were found in previous studies partly (Clarke et al. 2012; Mertz et al. 2009; Muller and Shackleton 2014; O'Farrell et al. 2009; Silvestri et al. 2012; Zhang et al. 2019). From the numerous studies showed that the socio-economic factors as age, education and gender, household and farm size, household farm income and off-farm income, institutional factors as access to credit, livestock ownership and tenure status, in addition, extension factors as access to farmer-to-farmer extension and local weather information are all influential in impacting on adaptation strategies to climate change (Deressa et al. 2009; Hassan and Nhemachena 2008; Mabe et al. 2014; Opiyo et al. 2015; Tazeze et al. 2012). Our findings suggest that the younger pastoralists would practice various adaptative strategies, household own more family members and more relatives, more willing they migrating to place where relatives living to grazing. In addition, pastoralists prefer to rent more pasture with more livestock, landholding, and facilities. Low risk buffering capacity household without land tenure and credit availability, they enrolled in cooperation to grazing together, and engage in off-farm work to earn other income to sustain their livelihood. The pastoralists have less insights into purchasing pastoralism insurance, and then, they did not tend to adopt it as an adaptation strategy.

4.3 Barriers and needs of pastoralists

Moreover, barriers are reducing the ability of farmers' adaptation for adaptation process (Antwiagyei et al. 2015), the results demonstrated that inadequate capital and labour, lack of water and limited credit availability and timely weather information, and technological knowledge of adaptation strategies are the main factors constraining pastoralists for adaptation. The pastoralists argued that they need hazard relief fund, improve pasture facilities, technical knowledge training, active weather information, integrated pest and disease management and create off-farm employment vista to relieve the negative effects of climatic change.

5 Conclusion

The perceptions of the variability of inter-annual temperature are relatively consistent with the observations, but perceived inter-annual rainfall and drought variability are not entirely consistent. Pastoralists are more sensitive to short-term rainfall as well as drought changes. Our findings highlight that pastoralists' perceptions are be linked to the strong variability of the climatic parameters and place-based, influenced by the implementation of policy. Therefore, consideration of the overall context of pastoralists' livelihood is necessary to identify the perception of climate changes.

Purchasing fodder, reducing livestock, and renting pasture, migrating, preventing disease, drilling water, purchasing insurance, improving livestock breed, off-farm work, irrigating, and planting artificial grassland are common adaptations. In addition, this study identified the determinants for adaptation strategies. Household capitals, risk-buffering capacity, and social network are all influencing adoption of adaptations. Protection projects for low buffering capacity communities, improving the exterior environment of the credit system, and developing partnerships among different households are likely to enhance pastoralists' adaptations. However, adaptations of pastoralists also have several barriers such as inadequate capital and labour, lack of water and limited credit availability and timely weather information, and technological knowledge on potential adaptation strategies.

Based on the observations of the needs of pastoralists, the local governments should provide supports for pastoralists to enhance the pastoralists' adaptation ability to climate change, such as hazard relief fund, improve pasture facilities, technical knowledge training, active weather information,

integrated pest and disease management and create off-farm employment vista. Overall, the findings provide the recommendations for government and policy-makers to develop appropriate, specific, and long-term adaptive strategies for household-level and government-level to enhance the ability to mitigate and cope with the adverse effects of climate change.

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Figures

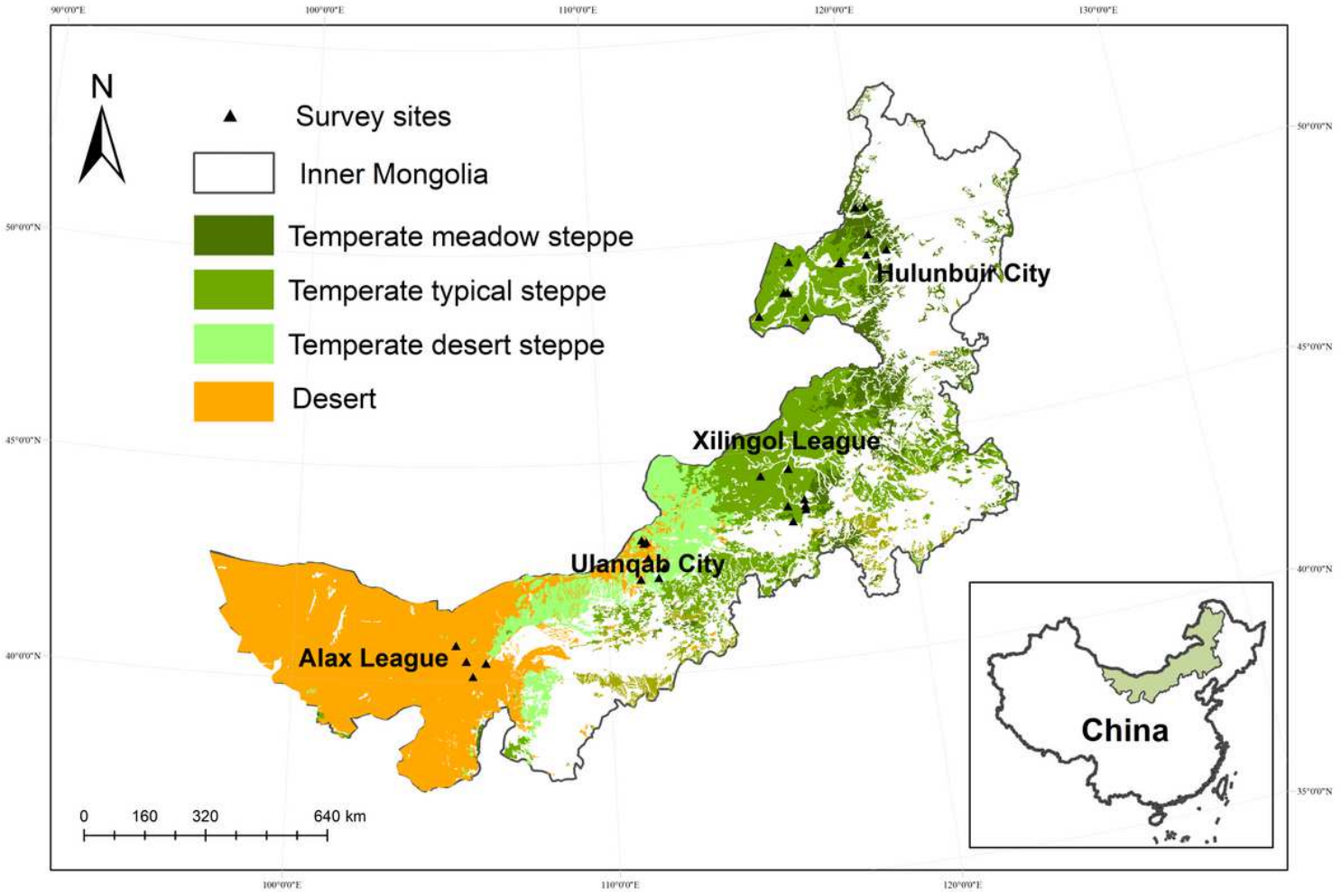

Figure 1

Location of the study area and the survey sites

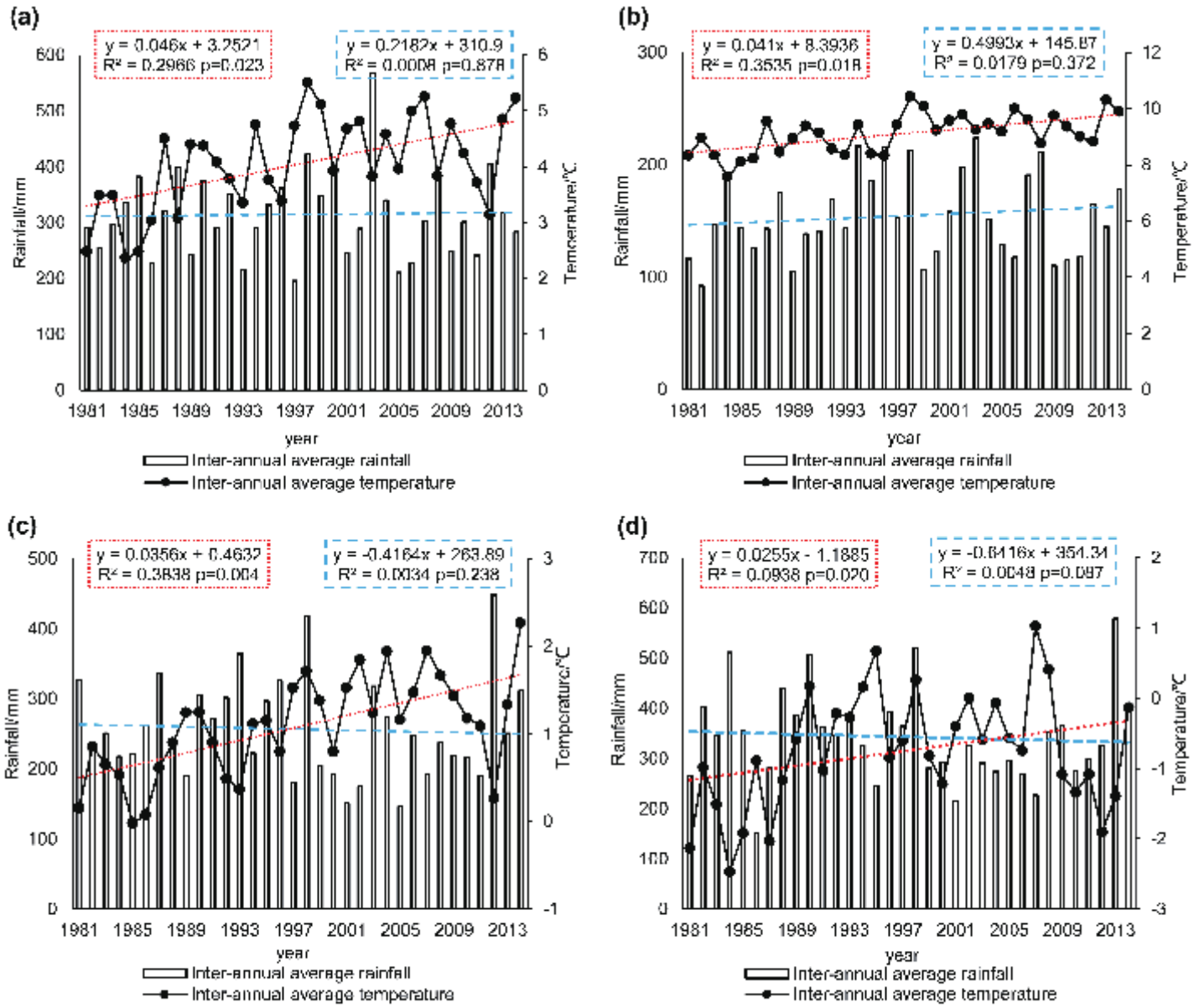

Figure 2

Trend of inter-annual average precipitation and temperature in Ulanqab (a), Alax (b), Xilingol (c), Hulunbuir (d) from 1981 to 2014

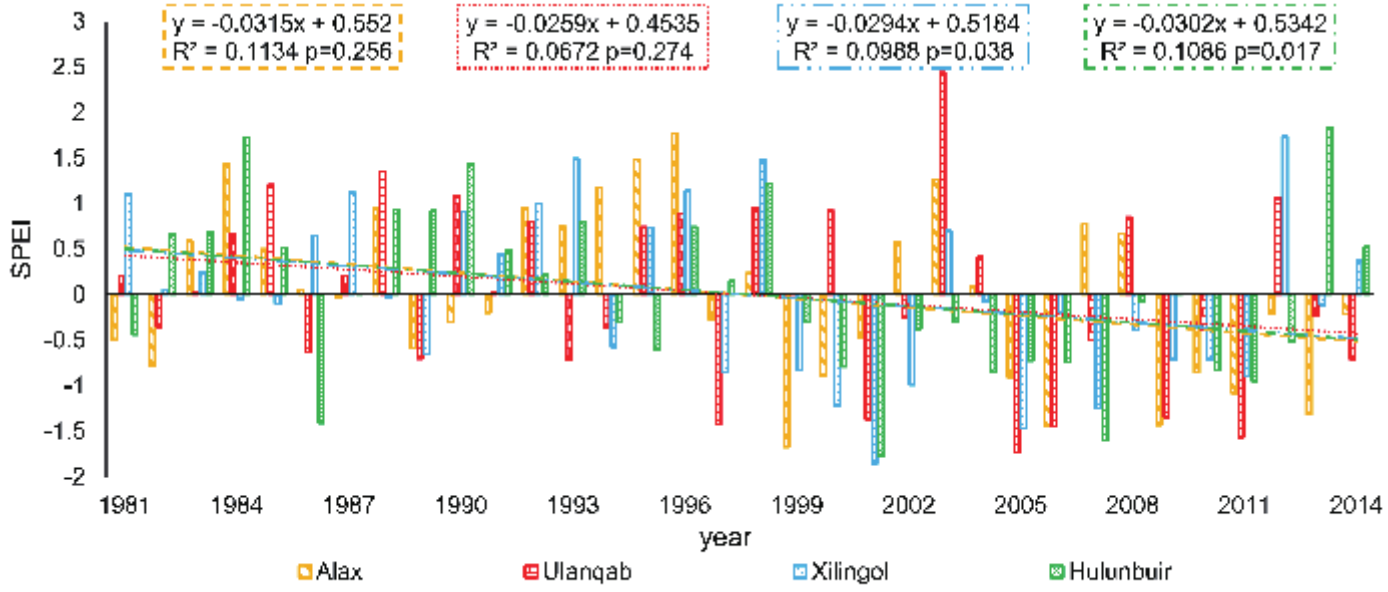

Figure 3

Trend of inter-annual average SPEI in the study region from 1981 to 2014

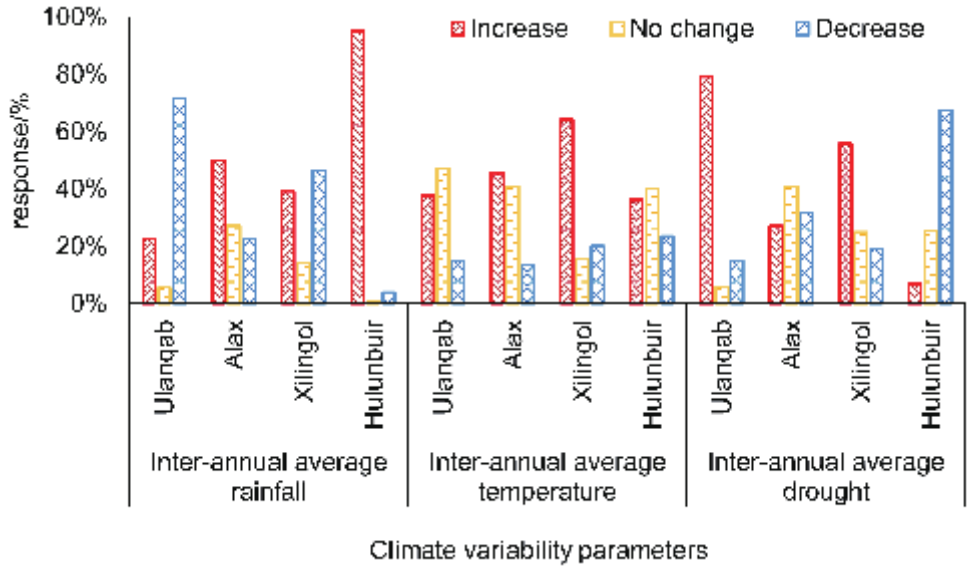

Figure 4

Perception of changes in inter-annual average rainfall, temperature and drought in the study region from 1981 to 2014

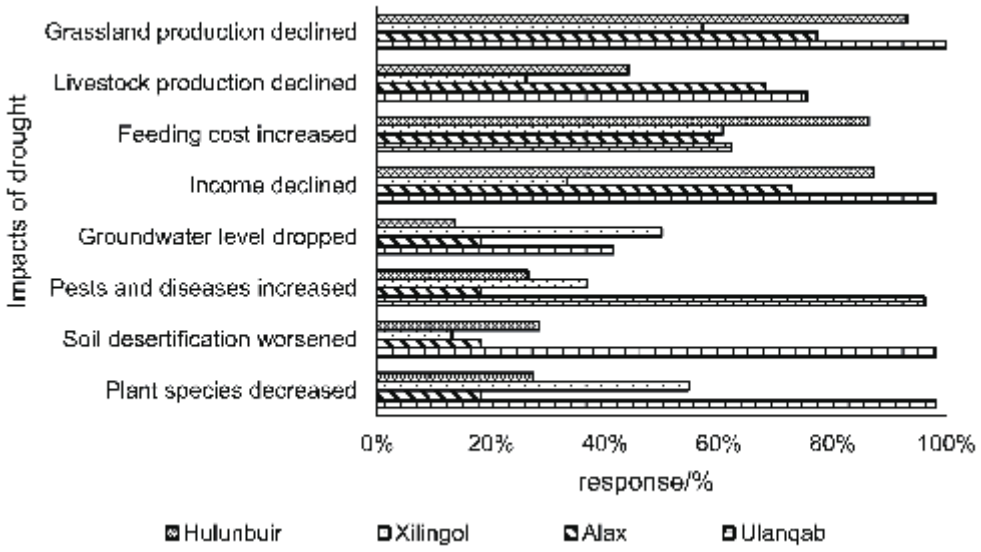

Figure 5

Pastoralists' perception of drought impacts in the study region

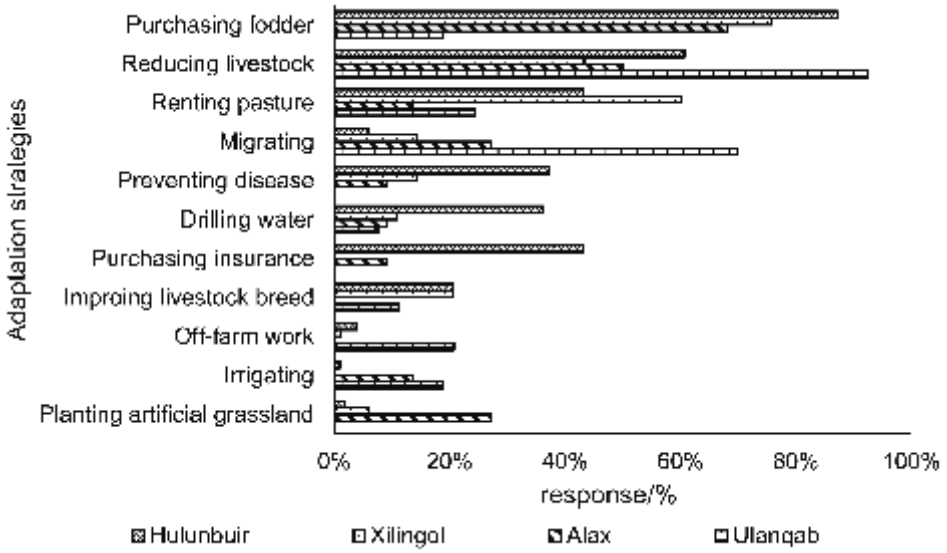

Figure 6

Pastoralists' adaptation strategies for drought in the study region

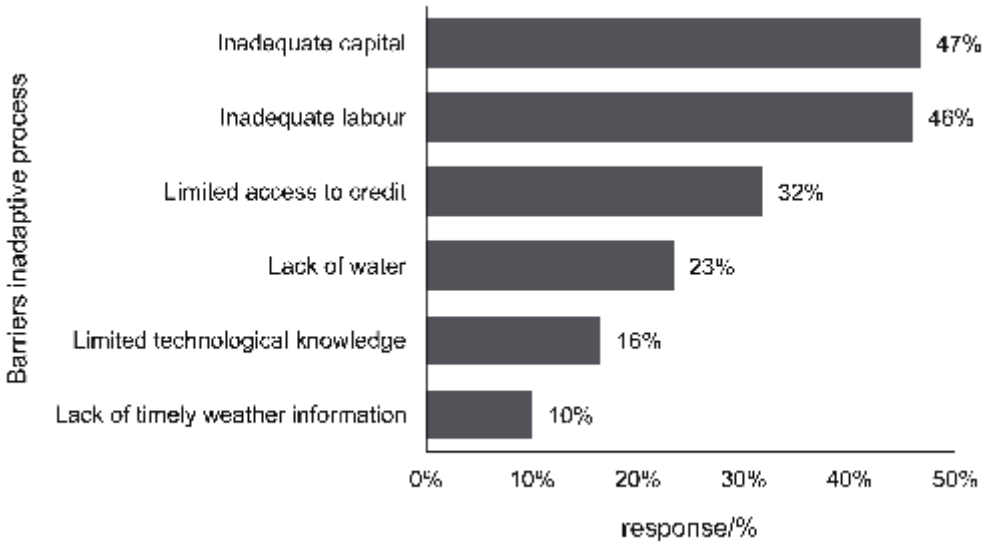

Figure 7

Barriers to pastoralists' adaptive process in the study region

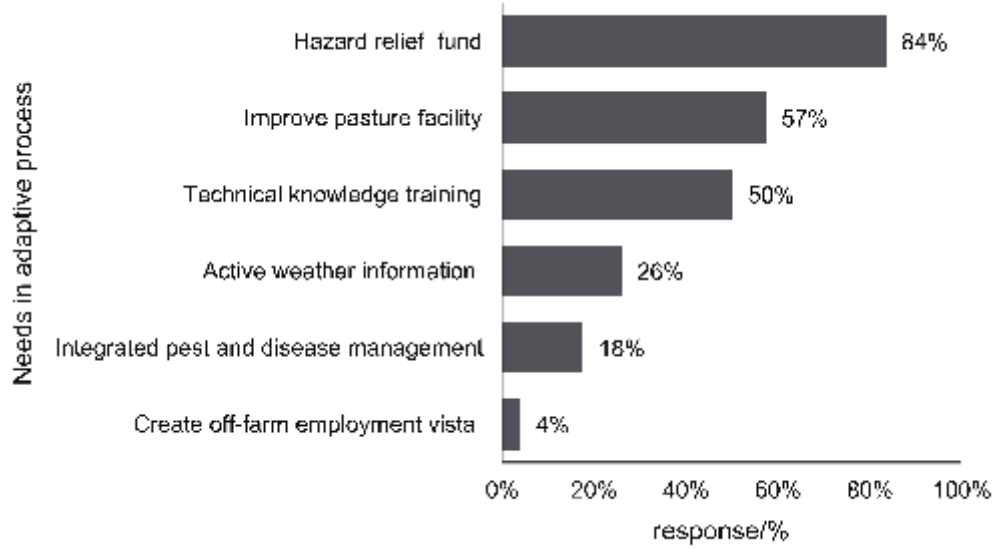

Figure 8

Needs of pastoralists' adaptative process under pastoralists' perspective

Supplementary Files

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