



Original Articles

Farmers' livelihood adaptation to environmental change in an arid region: A case study of the Minqin Oasis, northwestern China

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ARTICLE INFO

Keywords:

Adaptation strategies
Livelihood
Government policy
Adaptive capacity
Environmental change
Adaptation outcome

ABSTRACT

Adaption to global environmental change is a focus of sustainability research. Farmers face multiple environmental and social pressures due to global environmental change. Effective livelihood changes must be taken to decrease asset losses and to adapt to current or future environmental challenges. However, there are few studies that systematically understand and assess farmers' livelihood adaptation. We developed an integrated analytical framework for livelihood adaptation and explored the relationships between adaptive capacity, adaptation outcomes, and farmers' adaptation strategies. We applied this framework to a case study of the Minqin Oasis in China and assessed the livelihood adaptation of farmers facing environmental change and water scarcity. Household surveys and semi-structured interviews were used for data collection. We found that (1) farmers' livelihood adaptation choices were limited due to current government policies and their own resources and (2) livelihood adaptive capacity (such as land, water resources, and social networks) and policy reform (water resource fees, and cultivated land compression) had a key impact on farmers' adaptation. The factors representing a poor livelihood strategy and adaptation outcomes of the farmer include the following: (1) a low level of livelihood awareness among farmers (such as passive farmers), (2) a lack of livelihood assets, (3) government focus on environmental recovery, and (4) a weakened role of the market. To improve the adaptation of farmers' livelihoods to environmental change, these measures must balance the relationship between environmental restoration and farmers' livelihoods, consider a variety of key forces, and guide farmers to adopt effective strategies. This study facilitates the development of livelihood adaptation analysis methods for global change studies. Case-based research results can be used to improve local decision-making and can provide an assessment reference method for farmer adaptation to regional and global environmental change.

1. Introduction

The impact of global climate change has drawn the attention of the international community over the past decade (Adger et al., 2005; IPCC, 2014; John Smithers, 1997; Turner et al., 2003). The aggravation of drought and the scarcity of water resources have become primary reasons to restrict the sustainable development of populations, especially in arid and semi-arid regions. Water scarcity is expected to be a major challenge for most people in Asia in the future (IPCC, 2014). Northwestern China is a sensitive area in the global ecological environment and is susceptible to climate change. The frequency of extreme drought events has increased significantly in recent years (Zhang et al., 2015). With the arid geographical environment and the scarcity of resources, the rural area of northwestern China has become a region that is highly vulnerable to climate change. At the same time, the

activities of human beings (such as excessive reclamation, excessive extraction of groundwater, etc.) in the past have exacerbated environmental degradation in arid regions of northwestern China (Danfeng et al., 2006; Feike et al., 2017) and have increased desert expansion, groundwater depletion, water quality degradation, deforestation, biodiversity loss, and natural disasters (Zhang et al., 2010). In the process of environmental degradation, land and water resources were reduced, resulting in negative impacts on the agricultural economy. Rural development has been seriously hampered, especially threatening farmers' livelihoods and sustainable growth. Adapting to arid environments and a lack of water resources have become a core issue in many areas of developing countries, including northwestern China, which is also related to the sustainable development of local rural communities.

Livelihood issues have been central to rural development and

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practice over the past decade (Khayyati and Aazami, 2016; Oberlack et al., 2016; Scoones, 2009). Rural areas occupy the vast majority of arid regions in northwestern China. As the basic livelihood unit in rural society, farmers bear multiple risks resulting from climatic (environmental) changes and socio-economic policies. Drought, land desertification and other risks of disturbance will undoubtedly increase the vulnerability of farmers' livelihoods. In rural communities, where access to income is limited, various agriculture-related activities, which strongly depend on soil and water, can contribute significantly to livelihood security (Khayyati and Aazami, 2016). Therefore, drought and water resources scarcity become the main influencing factors restricting the livelihood maintenance of farmers and threatening social welfare (Alam, 2015).

Due to its location in the desert and the temperate continental arid climate, Minqin County is a typical arid region in China. With the disruption of global climate change and human activities, the runoff flowing into the Minqin Region decreased. Because water resources are scarce and the groundwater is massively pumped, a large area of natural vegetation has been destroyed causing the desert to extend to the oasis (Yin et al., 2016). The original fragile arid environment has sharply deteriorated, which seriously threatens local food production, water security, public health, natural resources, and biological diversity. More than 70 thousand people and 120 thousand livestock have great difficulty accessing drinking water. More than 200 million m² of farmland have already been abandoned, leading to severe challenges to the survival and livelihood security of farmers; furthermore, some farmers have become "ecological refugees" in the region (Zhang et al., 2011; Zhao et al., 2015). Therefore, it is of urgent practical significance to mitigate the risks of climatic and environmental change impacting farmers' livelihoods.

Although current studies focus on the adaptation and vulnerability of climate change in developing countries, most of them concentrate on the field of global impacts, human adaptation, and socio-ecological vulnerability of climate change (Adger et al., 2003; Fazey et al., 2010; Polsky et al., 2007; Snorek et al., 2014). Research on livelihood adaptation in the face of environmental change is still limited at the household level (Abid et al., 2016; Khayyati and Aazami, 2016) (especially the contradiction between the restoration of the ecological environment and the maintenance of farmers' livelihoods in arid environments). Global climate change not only has a direct impact on the biological environment and natural resources but also indirectly derives a series of social problems, such as livelihood poverty, social inequality and competition for resources. Therefore, this study combines sustainable livelihoods with adaptation to propose a conceptual framework. This framework uses case studies to explain the adaptation of farmers facing risks in complex livelihood systems. It will focus on the livelihood adaptation of farmers to environmental change and water resource scarcity; the findings of these typical case studies may provide valuable references to mitigate farmers' livelihood risks and to promote scientific policy-making by decision-makers. The research objectives can be divided into four areas:

- What are the impacts of environmental change on farmers, and which adaptive strategies have been adopted by farmers?
- What are differences in the adaptive capacity of farmers for different adaptation strategies?
- What are the outcomes and perceptions of farmers' livelihood adaptation?
- What are the impacts (effects) of the adaptive capacity of farmers and local government policy actions on farmers' adaptation results?

2. Analytical frameworks

2.1. Restrictions of current framework

In the 1980s, sustainable science began to understand the

interaction of the coupled human-environment system from the perspective of vulnerability, resilience and adaptation of systems (Adger, 2006; Holling, 2001; Smit and Wandel, 2006). Among them, combined study of resilience and adaptation shows that the promotion of adaptive capacity in a system enhances the adaptation of the system subject confronting external changes and then promotes the resilience of the damaged system amidst the disaster or environmental risk (Nelson, 2011). Therefore, adaptation (including adaptive capacity) plays an important role in buffering the human system coping with the vulnerability to climatic and environmental changes. International institutions and scholars (e.g. Chen et al., 2014; Grothmann and Patt, 2005; Shinn, 2016; Butler et al., 2014; Li et al., 2014; Perry et al., 2010) have carried out much research and practices. Analyses of adaptation to changing climatic conditions have been undertaken for a variety of purposes, such as recovery from natural disasters, policies responding to climate change in a region and society, resource adaptation management, etc. (McCubbin et al., 2015; Pandey et al., 2011; Turner et al., 2003).

With the accumulation of research and practical observations of adaptation, a series of methods and analytical frameworks for adaptation have risen. However, due to the dependence of climate change adaptation on the theory of resilience and vulnerability and differences in the definition of adaptation, it is difficult to separate and form a unified research framework. Existing research methods and analytical frameworks (see Dessai et al., 2005; Parry and Carter, 1998) have been fundamentally considered from complex human-environmental systems or based on a top-down approach to analyze the potential risk impacts and to develop adaptive measures through downscaling model calculations. Owing to the systematic analysis guide of the impact of climate change, the research scale has focused on the global, national, regional level, and complex integrated systems. In recent years, there have also been a series of different adaptive analyses frameworks and methods in agricultural systems, resource systems, and disaster assessment research based on the background of climate change (Chen et al., 2016; Kalaugher et al., 2013; Pandey et al., 2011; Warrick et al., 2016), while inadequate attention has been paid to the micro social systems adapting to the risk.

Actor-based analysis looks at adaptation as the decision-making process (Nelson et al., 2007). The ultimate goal of adaptation research is to determine how humans (such as households, inhabitants or farmers, etc.) adapt to changes in order to improve resilience to the environment and disasters. Accordingly, research into the adaptive behavior and decision-making characteristics of humans needs to be further strengthened, especially the adaptive capacity of the community and on the farmers' scale. Table A.1 in Appendix A presents a summary of previous studies on livelihood (human) adaptation. The initial study of human activity adaptation focused on proposing a framework for understanding human adaptation to climate events or risk disasters (John Smithers, 1997; Mortimore and Adams, 2001; Smit et al., 1999), but the quantitative analysis of livelihood adaptation is not very operational. Subsequent research on adaptation also focused on the impact of social factors on the farmers' livelihoods adaptation (Carr, 2008; Osbahr et al., 2008; Thomas and Twyman, 2005). However, many studies lack systemic thinking and focus adaptation analysis only on the social structural elements. At present, under the background of environmental (climate) change, research on farmers' adaptation is mainly based on the adaptive behavior and strategy selection (Alauddin and Sarker, 2014; Reed et al., 2013). Researchers tend to use qualitative research to understand the adaptive behavior of households and analyze influencing factors (Hoque et al., 2017; Nicholas and Durham, 2012), ignoring the inherent logical relationship between adaptive capacity and adaptive outcomes. Many studies still follow the Sustainable Livelihoods Framework established by the DFID (Department for International Development) (2000) (Khayyati and Aazami, 2016; Motsholapheko et al., 2011). Therefore, current studies lack a comprehensive research framework, combined with livelihood options, in

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