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Original Research

Vulnerability and Adaptation of Livestock Producers to Climate Variability and Change

Vahid Karimi [a,*], Ezatollah Karami [b], Marzieh Keshavarz [c]

[a] Former Graduate Student, Department of Agricultural Extension and Education, College of Agriculture, Shiraz University, Shiraz, Iran
[b] Professor, Department of Agricultural Extension and Education, College of Agriculture, Shiraz University, Shiraz, Iran
[c] Associate Professor, Department of Agriculture, Payame Noor University, Tehran, Iran

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ABSTRACT

Rangeland-based animal husbandry has been frequently exposed to the vagaries of weather. While the current rates of climate variability are unprecedented in arid and semiarid regions, climate change is expected to put further pressure on rangelands with medium- and poor-quality forages and increase the vulnerability of households who mainly depend on livestock production. Therefore, it is imperative to ensure that livestock producers increase their resilience to climate variability or change. However, few field-based studies have focused on simultaneous investigation of both vulnerability and adaptation of livestock keepers to climate-related risks. To fill this gap, a field-based research study was conducted in southwest Iran. A survey of 274 herder families, selected using a cluster sampling technique, revealed low, medium and high levels of vulnerability, which were principally distinguished by various degrees of exposure, sensitivity, and adaptive capacity. Further, this study identified the main adaptation strategies employed by the herders of this region (i.e., purchasing fodder; rotational grazing; raising a mixed-herd, on-farm occupation; and postharvest grazing). Results indicated that most herder families applied traditional adaptation strategies in response to climate variability. Findings revealed that herders had to reduce their livestock due to low adaptability. Loan term, purchasing insurance, level of exposure, income, experience, response efficacy, and knowledge were the major determinants of the herders' adaptation decisions. To increase the resilience of livestock producers against climate change, restructuring traditional livestock production systems, producing participatory knowledge and information for sustainable management of rangelands, and designing or redesigning effective adaptation strategies are required.

Introduction

Rangelands comprise 52% of Iran's total land area and provide about 67% of the feed requirements for domesticated livestock (FRW, 2016). Although 89.7% of Iran's rangelands support medium- and poor-quality forages,[1] they are of particular importance to the livelihood of nearly 16% of rural families (FRW, 2016). Nevertheless, rangeland-based animal husbandry is one of the sectors that has been exposed the most to climate variability and change. The effects of climate change, such as rainfall variability, have become increasingly apparent over the past decades in Iran. Also, it is expected that the frequency and intensity of extreme weather events (i.e., drought) will increase in the future (IPCC, 2014). These changes will significantly reduce the productivity of rangeland resources and livestock systems that are essential for the livelihood of herder families (Moore and Ghahramani, 2013; Zhang et al., 2013). As a result, with its arid and semiarid geographical profile, livestock production systems of Iran will be highly vulnerable to climate change. Moreover, vulnerability to climate change is an outcome of complex interactions between climatic and anthropogenic dynamics (Boero et al., 2015). Growth in population, coupled with increased urbanization, leads to rising incomes and higher per capita consumption that will increase the demand for livestock products (FAO, 2011). Natural resource scarcity and deterioration of rangelands through heavy grazing will reduce the productive capacity and will aggravate vulnerability to climate change. In Iran, the current stocking rate is about 2.2 times the grazing capacity of the rangelands, which poses a significant challenge for natural resources management (FRW, 2016).

Although true understanding of both local-level vulnerability and adaptation to climate change is imperative (Moser and Luers, 2008), most of the studies have dealt with adaptation of herders to climate variability or change (e.g., Banerji and Basu, 2010; Ifejika Speranza, 2010; Butt, 2011; Fu et al., 2012; Hou et al., 2012; McDowell and Hess, 2012; Rivera-Ferre and López-i-Gelats, 2012; Silvestri et al., 2012; Joshi et al.,

* Correspondence: Vahid Karimi, Dept of Agricultural Extension and Education College of Agriculture, Shiraz University, PO Box 71441-65186, Shiraz, Iran.
E-mail address: vakarimi69@gmail.com (V. Karimi).

[1] Medium forage value designates plants that provide adequate nutrients; however, they are not preferred by animals or do not produce abundant forage. Also, low or poor forage value denotes a plant that simply does not provide adequate nutrients to the grazing animal.

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2013; Lavrillier, 2013; Wang et al., 2013; Zhang et al., 2013; Alary et al., 2014; Turunen et al., 2016; Yu, 2016) and few field-based studies have investigated the vulnerability to climate variability or change, globally (e.g., Galvin et al., 2001; Tyler et al., 2007; Nettier et al., 2010; Funberg et al., 2011; Fang et al., 2015; Mogotsi et al., 2012; Sulieman and Elagib, 2012; Wang and Zhang, 2012; Moore and Ghahramani, 2013; López-i-Gelats et al., 2016; Seekao and Pharino, 2016). Moreover, most existing studies have focused on crop producers' adaptation to climate variability and change (e.g., Koocheki and Nassiri, 2008; Morid and Massah Bavani, 2010; Moradi et al., 2013, 2014; Keshavarz et al., 2014), and knowledge about the current process of adaptation and vulnerability of herder households is still limited in Iran. To address the knowledge gap, this study aims to identify and examine the vulnerability and adaptation of livestock producers to climate variability and change. The findings of this research are expected to reflect the current vulnerability and adaptive capacity to climate variability and also preparedness of herder families to reduce climate change impacts. This information may also assist policy makers to develop more effective adaptive strategies for reducing vulnerability to climate variability and change.

This paper first briefly addresses the key issues of Iran's vulnerability to climate variability and change. After that, potential adaptations of livestock producers are explained. The focus then shifts to the description of the study area and survey data, followed by an analysis of results and concluding remarks.

Vulnerability of Iran to Climate Variability and Change

Since the concept of vulnerability roots in various fields, there is no generally accepted and precise definition. However, two different types of vulnerability are defined in the climate change — related literature: 1) the extent of potential damages to the production system caused by climate variability and change (i.e., biophysical vulnerability; Jones and Boer, 2003) and 2) an internal state of a system before it encounters a climatic event (i.e., social vulnerability; Allen, 2003). Biophysical vulnerability deals with the ultimate impacts of natural climatic hazard with a focus on its frequency and severity (Turner et al., 2003). However, social vulnerability is considered as an inherent property of a system arising from its internal characteristics and influenced by various political, economic, and social factors (Adger and Kelly, 1999; Cutter et al., 2000). The literature on climate change has recognized examples of such factors to be inequality in access to resources and institutional services, ineffective coping strategies, poverty, and food insecurity (Kelly and Adger, 2000; Ribot et al., 2009). Furthermore, a large number of scholars believe that vulnerability is context specific and can be influenced by nature-society interlinkages (i.e., an integrated approach) (IPCC, 2013). In other words, an integrated approach emphasizes the double essence of vulnerability as a socially and naturally produced phenomenon (Ribot, 2011). To understand the impacts of climate variability and change on Iranian herder families, the integrated approach is adopted.

Three constituent elements of integrated notion of vulnerability are 1) exposure to climate variability and change, 2) sensitivity to a specified natural climatic hazard, and 3) adaptive capacity of the system to cope with and adapt to the impacts of those conditions (Adger et al., 2007). Exposure is defined as the "duration, extent and frequency of climatic perturbations" (Adger, 2006) affecting the livestock production systems. Sensitivity is "the degree to which a system is affected, either adversely or beneficially, by climate variability or change" (Adger et al., 2007). Adaptive capacity is "the degree to which a system can adjust its practices, processes, or structures to moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate" (Schneider et al., 2001).

Exposure and sensitivity of Iran to climate variability or change are subject to this section. Long-term average annual precipitation of Iran ranges from 224 to 275 mm/yr, which is about 70% lower than the worldwide average of 990 (mm/yr) (Semsar Yazdi and Labbaf Khaneiki, 2007). Furthermore, there is a great spatial and temporal variation in the distribution of rainfall in Iran. About 70% of the annual precipitation falls between November and March while June through August are often rainless, in this country. Also, the highest rainfall occurs in Rasht (1337.5 mm/yr), Yasuj (823.3 mm/yr), and Sari (789.2 mm/yr), and the lowest rainfall is received in Yazd (59.2 mm/yr) and Zahedan (89.3 mm/yr) (IRIMO, 2017).

As indicated in Figure 1, several periods with underaverage precipitation have occurred since 1900 (e.g., in the periods 1944 — 1945, 1973 — 1974, 2000 — 2002, and 2008 — 2010), but some positive anomalies were observed in 1957 and 1972. The average temperature in Iran is approximately 18°C, ranging from 7.49°C (winter) to 26.8°C (summer). Figure 1 shows the increase of the mean temperature over the period of 1998 — 2012. The largest warming rates were observed in 2001 (19.02°C) and 2010 (19.42°C). Overall, a general tendency toward warmer and drier conditions can be found in the past decades for Iran (see Fig. 1).

Figure 2 illustrates the dimensions of resource sensitivity (i.e., internal water resources and number of livestock). Internal renewable water refers to the water resources that are generated within boundaries of Iran. Figure 2 shows that the per capita volume of internal renewable water resources has declined significantly from 4 883 m^3/yr in 1958 — 1962 to 1 624 m^3/yr in 2008 — 2012, which equals to 3 259 m^3 loss. Thus, Iran is currently notorious for water stress according to the Falkenmark (1995) definition. It seems that climate variability or

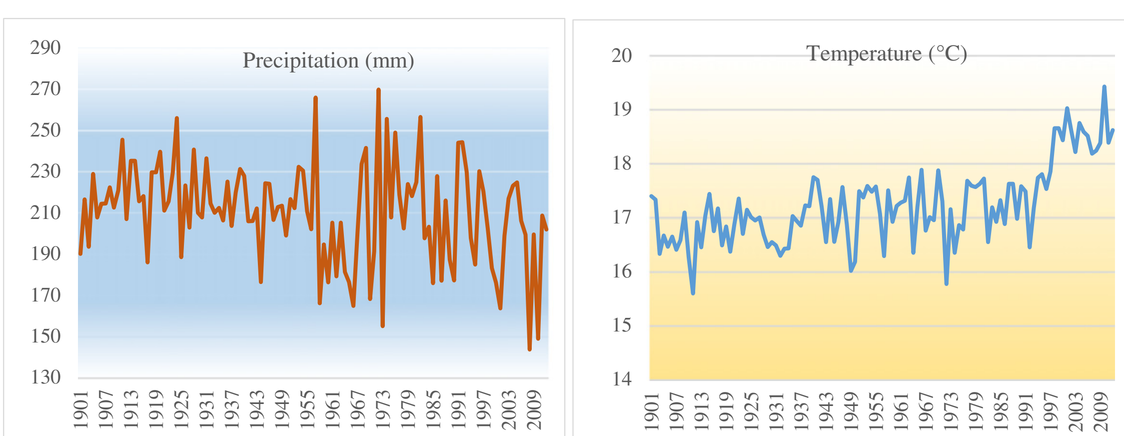

Figure 1. The temporal variability of annual mean temperature and precipitation in Iran between 1901 and 2012 (own representation based on World Bank, 2016).

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