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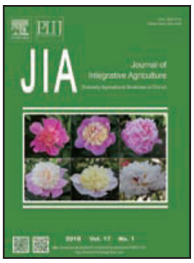

REVIEW

Climate change and agriculture: Impacts and adaptive responses in Iran

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Abstract

The impacts of climate change on agriculture are still shadowed with uncertainty. However, climate change is expected to adversely affect Iran's agricultural practices through changes in precipitation, temperature and carbon dioxide fertilization. Therefore, adaptation of this sector to the increasing weather events is imperative. This study is aimed to document the likely impacts of climate change on Iran's agriculture and the current adaptation efforts made by government and farmers. The review of literature shows that changes in rainfall and water endowments will have significant impacts on crop yield, crops' water requirements and income and welfare of farm families. The extent of the changes in yield depends on the crop type, assumptions related to the CO_2 fertilization effect, climate scenarios and adaptation abilities. On adaptation, the government's efforts have been distinguished in the improving agricultural productivity and irrigation development based on current technology, developing new technologies and policy reforms. Farmers' adaptive responses have also been identified. Some conclusions and recommendations are offered to increase the adaptive capacity of farmers and reduce negative impacts of climate change.

Keywords: climate change, agriculture, impacts, adaptation, Iran

1. Introduction

Despite the remaining uncertainty, it is widely accepted that climate is changing. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, the atmospheric concentrations of the greenhouse gases, i.e., carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), have increased to unprecedented levels in the last 800 000 years (IPCC 2013). An increase in the levels of GHGs (greenhouse gases) can lead to greater warming, which, in turn, can influence the world's climate, leading to the climate change (VijayaVenkataRaman *et al*. 2012). While causes of climate change can be divided into two categories, namely, natural and man-made causes (Karami 2012), there is a strong evidence that most of the observed warming (of 0.1°C per decade) over the last 50 years can be attributed to human activities (Ravindranath and Sathaye 2003) such as the burning of fossil fuels and changes in land use (IPCC 2013). For instance, in 2009, agriculture directly accounted for 14% of global GHG emissions in CO_2 equivalents and indirectly accounted for an additional 17% of emissions when land use and conversion for crops and pasture were included in the calculations (IPCC 2013). Without additional efforts to reduce GHG emissions, the global average surface temperature will be very likely to rise in 2100 from 3.7 to 4.8°C compared to pre-industrial

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levels (IPCC 2014).

Under the Kyoto Protocol, most developed countries made binding commitments to modest — but not insignificant — net reductions in their emissions of six GHGs in the period of 2008 to 2012. Even if this goal is achieved through stringent worldwide mitigation actions to stabilize global GHG concentrations, some impacts will remain, at least in the short and medium terms, making adaptation imperative to reduce vulnerability and enhance resilience (Isoard 2011). Some areas such as northern Europe might benefit to some extent from climate change, in the short and medium terms, e.g., by increasing crop yield, forest growth and increased tourism demand (Isoard 2011). However, the negative impacts of climate change will be so severe in arid or semi-arid areas such as Iran (Parry *et al*. 2004).

Iran is one of the world's water-scarce regions and is extremely vulnerable to the impacts of climate change due to its high dependency on climate-sensitive agriculture (Nassiri *et al*. 2006). Iran's per capita freshwater availability was about 2 000 m^3 per capita per year in the year 2000. However, it is predicted that it will reduce to 1 500 m^3 per capita per year by 2030 due to the population growth (Yang *et al*. 2003). Therefore, it seems that the occurrence of probable climatic changes in this region has a disruptive impact on water resources. In addition, Iran has a broad spectrum of climatic conditions across regions with significant rainfall (Abbaspour *et al*. 2009). While the northern part of the country is quite wet with frequent costly floods, the southern part is dry with large water scarcity. One of the largest climate changes is a decrease in precipitation that has occurred in northeastern Iran (Evans 2009). Changes in the timing of the maximum precipitation in northeastern Iran will affect the growing season and lead to adverse effects, in the long-term.

Climate change is expected to have different impacts on rainfall and temperature patterns across different regions and consequently on the spatial and temporal distributions of the various components of water resources. However, it is estimated that if the CO_2 concentration doubles by the year 2100, the average temperature in Iran will increase by 1.5–4.5°C. In turn, it will cause significant changes in water resources, energy, agriculture and food production and forestry sectors (Amiri and Eslamian 2010) and aggravate current environmental challenges. It is therefore imperative for Iran to adapt to climate change.

As the major water consumer, agriculture is one of the most water vulnerable sectors to climate change in Iran. Despite the fact that the impacts of climate change on agriculture are still shadowed with uncertainty, there is a general consensus that Iran's agricultural sector will be influenced significantly (Nassiri *et al*. 2006). Climate change is expected to greatly affect agricultural practices through changes in precipitation, temperature, carbon dioxide fertilization, climate variability and surface water runoff. Moreover, dramatic population growth, associated with the reduction of productive land area and water resources, exerts extra pressure on the Iran's agricultural sector. Therefore, there is a concern about the potential for climate change to disrupt Iranian farmers' livelihoods and prevent the country from achieving sustainable development. To ensure sustainability of agriculture, studying the possible climate change impacts on this sector and adaptive responses are essential. This paper aims to review and analyze current understanding of climate change impacts on Iran's agriculture and the present adaptation strategies employed by the government and farmers. Based on the literature review, discussions are provided and research gaps are addressed in order to fill these knowledge gaps in future studies.

2. Study area

Iran is located between 25° and 40°N and 44° to 63°E and has a total area of 1 648 000 km^2 (Abbaspour *et al*. 2009). This country contributes to a relatively heterogeneous climate. The area coverage of different types of climate in Iran is 35.5% hyper-arid, 29.3% arid, 20.2% semi-arid, 5% Mediterranean and 10% wet (of the cold mountainous type) (Amiri and Eslamian 2010). Therefore, about 85% of Iran's territory is dry with significant water shortage, frequent droughts and a large reliance on groundwater resources.

Temperature varies between –20°C and +50°C while annual precipitation varies from less than 50 mm over the uninhabitable Eastern deserts to 1 800 mm over the Western Caspian Sea coast and Western highlands. However, Iran's average rainfall is 250 mm, which is less than one-third of the global average (860 mm). This sparse precipitation is also unfavorable with respect to time and location. So that, most parts of the country receive less than 100 mm of rain per year (Madani *et al*. 2016).

Approximately 37 million hectares of Iran's total surface is arable land. Of this, 18.5 million hectares are devoted to horticulture and field crop production (Keshavarz *et al*. 2005). Also, about 47% of the arable land is irrigated using various traditional and modern techniques while the other 53% of the land is rain-fed (Salami *et al*. 2009). The major crops cultivated in Iran are wheat, barley, corn and rice. Wheat as the core commodity of Iranian food is grown on nearly 60% of the arable land. The average yield of irrigated and rain-fed wheat is approximately 3.0 and 0.95 tons per hectare, respectively (FAO 2016).

Iran is currently experiencing serious water problems. This country uses a considerable amount of groundwater for irrigation to compensate surface water deficit. Currently,