

Expansion of agricultural oasis in the Heihe River Basin of China: Patterns, reasons and policy implications



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ABSTRACT

The Heihe River Basin (HRB) is the second largest inland river basin in the arid region of northwestern China. An agricultural oasis is a typical landscape in arid regions providing precious fertile soil, living space and ecological services. The agricultural oasis change has been one of the key issues in sustainable development in recent decades. In this paper, we examined the changes in the agricultural oasis in HRB and analyzed the socio-economic and climatic driving forces behind them. It was found that the agricultural oasis in HRB expanded by 25.11% and 14.82% during the periods of 1986–2000 and 2000–2011, respectively. Most of the newly added agricultural oases in HRB were converted from grassland (40.94%) and unused land (40.22%). The expansion in the agricultural oasis mainly occurred in the middle reaches of HRB, particularly in the counties of Shandan, Minle, Jinta and Jiuquan city. Changes in the rural labor force, annual temperature and precipitation have significant positive effects on agricultural oasis changes, while the ratio of irrigated agricultural oases has significant negative effects on agricultural oasis changes. The agricultural oasis expansion in HRB is the combined effect of human activity and climate change.

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1. Introduction

Arid and semi-arid regions cover more than 30% of the land on the earth's surface (Okun et al., 2006) and 22% of the land area in China (Bai et al., 2014). An oasis is a unique intrazonal landscapes existing within arid and semi-arid regions, which allows flourishing vegetation and human settlement due to a stable water supply (Ling et al., 2013). Although an oasis covers less than 5% of the total area in arid and semi-arid regions in China, it holds more than 90% of the population and 95% of social wealth in these regions (Wang et al., 2008). An oasis not only provides precious fertile soil and living space for human beings in the barren desert, but also regulates the regional climate by the vegetation and water resources within it. Therefore, the oasis ecosystem directly influences the environmental and social security in arid and semi-arid regions. The oasis change has been one of the key issues in the sustainable development in recent decades (Cheng et al., 2006).

An agricultural oasis is defined as cultivated land that can be irrigated by human activities (Bai et al., 2014). Since an agricultural oasis can provide the necessary grain for population growth, it plays a vital role in sustainable social development. After the

foundation of the People's Republic of China in 1949, as well as the implementation of reform and the opening-up policy in 1978, the economy in China developed rapidly, inducing the evolution in agricultural oases. The evolution of agricultural oases has two opposite processes: oasisification and desertification (Li et al., 2006; Su et al., 2007; Zhang et al., 2003). Agricultural oasisification usually means the expansion of an agricultural oasis, i.e. converting the desert to an agricultural oasis under the combined effects of human activities and climate change (Xie et al., 2014). Desertification usually means the degradation of an agricultural oasis, i.e. converting an agricultural oasis into a desert (Chen et al., 2014; Liu et al., 2010b; Pan and Li, 2013; Zhang et al., 2008).

The expansion of an agricultural oasis can increase the total crop yields and promote humans' well-being to some degree. However, the scale of an agricultural oasis is not necessarily "the larger the better" (Ling et al., 2013). Water is a vital limiting factor for sustainable crop production and social development in arid and semi-arid regions (Jia et al., 2004). The expansion of an agricultural oasis will inevitably increase the water demand due to irrigation (Jiang et al., 2015; Ma et al., 2015). When the scale of an agricultural oasis exceeds the carrying capacity of water resources, the stability of an agricultural oasis will be challenged, inducing severe ecological and environmental problems (Lu et al., 2003; Zhang et al., 2003). The decline of several ancient agricultural oasis

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civilizations (e.g. ancient Babylon) is partly related to the irrational expansion of agricultural oases. Therefore, examining the changes in agricultural oases and discerning the driving forces behind them are urgently needed for controlling irrational expansion of agricultural oases.

Currently, research related to oasis change has focused on four aspects: analyzing the land use patterns in oasis agricultural region (Bai et al., 2014; Guo et al., 2008; Hu and Li, 2014; Wang et al., 2014), discerning the relationship between agricultural oasis change and water resources (Misak et al., 1997; Siebert et al., 2007), assessing the ecological effects of agricultural oasis changes (Su et al., 2007; Zhang et al., 2014), and discussing the suitable scale of an agricultural oasis (Ling et al., 2013). Although great efforts have been made in the field of oasis change, less attention has been paid to identify the factors driving oasis change. In the limited literature that analyzes the driving forces of agricultural oasis change, a qualitative analysis has been frequently adopted but it cannot accurately identify the key driving forces.

To fill the knowledge gap, we examined the changes in the agricultural oasis in the Heihe River Basin (HRB), the second largest inland river basin in Northwest China, and quantitatively discerned

the driving forces behind them using a panel data model. To be specific, the aims of this paper are to: (1) examine the spatial-temporal patterns of agricultural oasis changes in HRB from 1986 to 2011; (2) identify the conclusive factors driving agricultural oasis changes; and (3) discuss the feasible policies controlling the irrational expansion of agricultural oasis.

2. Study area and data sources

2.1. Study area

HRB is located in northwestern China (38°N–42°N, 98°E–101°E), covering an area over 143.29 thousand kilometers (Fig. 1). HRB is a typical arid region in China. The annual average precipitation is about 37 mm, 45 mm and 55 mm according to the monitoring result of local meteorological stations of Ejin, Guazihu and Dingxin in HRB, while the annual average evaporation exceeded 3000 mm (Xiao et al., 2015).

The Heihe River is the second longest inland river in the arid region of northwestern China. The total length of the Heihe River reaches 821 km (Huai et al., 2014). According to the location of

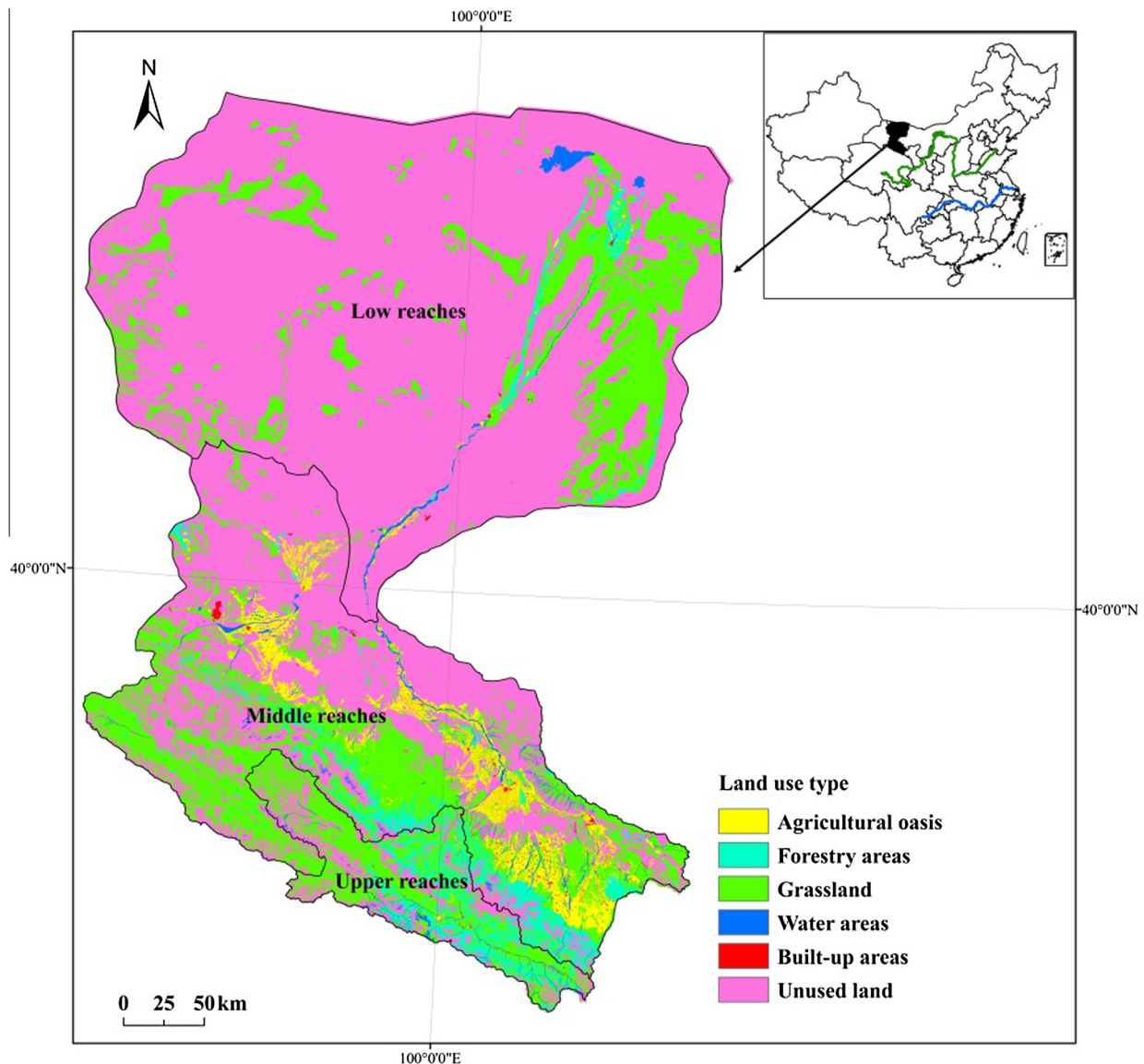


Fig. 1. The location and land use patterns of the Heihe River Basin in 1986.

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