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Addressing the dual challenges of food security and environmental sustainability during rural livelihood transitions in China

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ABSTRACT

Ensuring national food security without decreasing environmental quality is essential for China's agricultural sustainability. This paper proposes an analytical framework that integrates the influence of rural livelihood transitions and the constraint of local resource availability to explore possible approaches for addressing the dual challenges of food security and environmental sustainability. Using data from land-use images, farmland quality investigations, household surveys, and plot surveys, this framework is applied within a catchment in Taojiang County, which is a key commodity grain base location in China. The results indicate that the combined effects of local livelihood transitions, farmland allocation systems and the current subsidy policy resulted in a higher environmental cost per unit rice output. The results also suggest that the "one-size-fits-all" policy that favors large-scale double cropping rice is problematic. Local decision makers need to develop contextually sensitive policies that promote moderate-scale farm households and cropping patterns that are consistent with farmland grain-planting suitability.

1. Introduction

Over the past two decades, the rapid development of the social economy and accelerated urbanization have caused significant changes in China's expansive rural areas (Liu and Liu, 2016; Tian et al., 2016). The changes have largely reshaped rural culture, restructured land-use patterns and reformed agricultural technology (Siciliano, 2012; Long and Liu, 2016). During these processes, the traditional small-scale household economies that dominated China's agricultural production for centuries have gradually disintegrated, while, driven by various agricultural policies, diversified livelihood strategies have formed among rural households (Bilsky, 1990; Wang et al., 2010; Zhang, 2015). These livelihood transitions include various new elements such as the increase of non-agricultural employment, the decrease of rural population, the promotion of market instruments and agricultural industrialization, all of which have had profound impacts on the patterns of agricultural production across the country.

Because China has approximately one-fifth of the world's population but only 7% of its total cultivated area, national food security has always been a cornerstone of maintaining China's social stability. Therefore, national grain self-sufficiency has been one of the top priorities for the central government of China in response to high national grain demand and high uncertainty of global markets (Simelton, 2011; Qiang et al., 2013). Due to pressure from population growth and human dietary shifts[1], maintaining national grain self-sufficiency means that grain output must continue to increase (Qi et al., 2015a). However, the agricultural labor force, in terms of both quantity and quality, is declining significantly owing to unfavorable market conditions for rural households that are engaged in grain production (Qin, 2010; Xie and Lu, 2017; Xie, Cheng, & Lu, 2018). As a result, utilization of more chemical and machinery inputs (i.e., intensive production patterns) has become a major approach to increasing grain output over the past two decades (Vitousek et al., 2009; Chen et al., 2011).

The intensive grain production pattern in China has doubled the per-hectare grain yields in many areas (Vitousek et al., 2009) and led to a continual increase in grain production for 12 years (Song et al., 2016). This increase has significantly reduced the risk of national food insecurity (Qi et al., 2015a). However, the considerably greater amounts of chemical fertilizers and pesticides associated with intensive grain production patterns have also resulted in serious damage to the environment upstream and downstream of the agricultural sector and on farms (Vitousek et al., 2009; Lu and Xie, 2017).

With the continuous deterioration in environmental quality, China's agricultural sustainability faces great risks unless environmental costs

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[1] Human dietary shifts are moving more towards meat and less towards grain, with more grain fed to animals.

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can be reduced during agricultural production. In response to these risks, the Ministry of Agriculture of China promulgated two programs in 2015 (Ministry of Agriculture of China, 2015) that aim to achieve 'zero growth' in both chemical fertilizer and pesticide inputs by 2020. Achieving this ambitious objective of ensuring national food security without substantially decreasing environmental quality depends on farm households that work directly in grain production. Some scholars have suggested that the application of dynamic subsidies to leave cultivated land fallow, to adjust cropping pattern and to facilitate eco-agriculture could improve environmental quality and achieve sustainable land use (Zhao et al., 2010; Qi et al., 2018; Xie et al., 2018). However, the primary uncertainty related to China's efforts to address the dual challenges of food security and environmental sustainability lies in the rapid socio-economic transformation of Chinese rural society (Li et al., 2014), which involves the transition of diverse rural livelihood strategies that influence patterns of agricultural production and the efficiency of fertilizer and pesticide use (Liu and Liu, 2016).

To date, studies on China's rural livelihood transition have covered a wide range of issues. Some scholars have analyzed the diversification of rural livelihoods, which focused on the selection of livelihood strategies such as participation in non-farm activities, adjustment of cropping patterns, expansion/reduction in farmlands and increase/decrease in production inputs (Wang et al., 2010; Liu and Lan, 2015; Liu and Liu, 2016). Other studies have focused on the driving factors behind livelihood transition. These factors can include education level, household size, health status, transport means, savings, living expenditures and social position (Wang et al., 2010; Bhandari, 2013; Fang et al., 2014; Qian et al., 2016). The consequences of livelihood transitions have also been an important research topic. One line of inquiry investigates the environmental aspect which examines the impacts of these transitions on natural resources, biodiversity and ecosystems. Particular attention has been paid to the decrease of ecological land, the loss of biodiversity, soil erosion, non-point source pollution and so forth (Ediger and Huafang, 2006; Wang et al., 2010; Lu and Xie, 2017; Xie et al., 2017; Yuan et al., 2017). The other examines the human aspect which focuses on the vulnerability of rural households. Various studies have indicated that the changes in rural households' social, natural and financial capacity, which are associated with their livelihood transitions, could expose themselves to risks from external shocks such as climate change, policy intervention and economic recession (Paavola, 2008; Ding et al., 2014; Huang et al., 2017). Overall, previous studies on the rural livelihood transition in China have mainly discussed its manifestation, processes and implications; however, few studies have simultaneously examined food security and environmental sustainability against the background of rural socio-economic transformation.

As two intrinsically interconnected issues, food security and environmental sustainability have been extensively studied. Recently, relevant studies have often addressed the challenge of ensuring food security with lower environmental costs by analyzing the use of new technologies and advanced crop and nutrient management measures (Ju et al., 2009; Fan et al., 2012; Zhang et al., 2013; Chen et al., 2014). Although their results were notable, most rural households are unable to adopt these highly precise and contextually sensitive strategies in the short term because few households have access to these technologies or management measures, which are only applicable under certain soil properties and climate conditions. Moreover, rural livelihood transitions usually lead to an increase in non-farm activities and the reduction of the agricultural labor force (Barrett et al., 2001; Qin, 2010; Liu and Liu, 2016); as a result, many households may not be enthusiastic about these thorough, time-consuming and/or costly strategies. In addition, the successful implementation of these new technologies and measures requires a series of policy instruments that not only consider rural livelihood strategies but also are compatible with local resource availability that constrain the capacity of agricultural production. However, most previous studies were unable to provide effective policy recommendations owing to the inadequate examination of rural households and local resource availability.

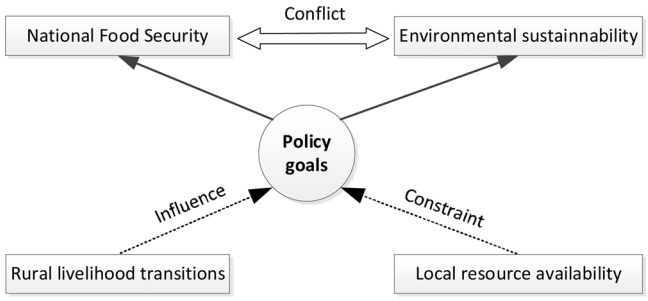

Fig. 1. A framework for analyzing the dual challenges of food security and environmental sustainability.

In summary, limitations in the existing literature have hindered the development of effective policy instruments to address the dual challenges of food security and environmental sustainability during rural livelihood transitions. To address this research gap, this study provides an operational framework that integrates the influence of rural livelihood transitions and the constraint of local resource availability. We apply this framework in the context of China and explore approaches that might address the conflict between food security and environmental sustainability.

2. Methods and procedures

2.1. Analytical framework

Fig. 1 illustrates our proposed analytical framework, which contains two major policy goals. One policy goal is to ensure national food security[2]. In the next decade, population growth and dietary changes are expected to result in a continuous growth in food demand (Simelton, 2011; Qi et al., 2015a), which will require an increase in grain production to ensure national food security. The other policy goal is to achieve environmental sustainability, which requires lower chemical inputs for grain production. Traditionally, farmers expect a higher net income through a greater grain output; while an increase in grain output depends on a greater input of chemicals. To achieve a new paradigm of sustainable agricultural development, the inputs-outputs of grain production[3] needs to be balanced and the conflict between food security and environmental sustainability needs to be addressed.

These two policy goals are subject to the influence of rural livelihood transitions and the constraints of local resource availability. From the perspective of farm households, these households make diverse land-use decisions (e.g., expansion/reduction in cultivated area, adjustment of crop types, and increase/decrease in chemical inputs) during livelihood transitions. These decisions directly influence grain production and environmental quality. In addition, resource availability refers to the degree to which local geological, physical and chemical characteristics could support agricultural production. The compatibility between local cropping patterns and resource availability determines the environmental costs of grain production. To effectively utilize the potential of agricultural production with lower environmental costs, the impacts of local resource availability on the design and implementation of policy instruments need to be taken into consideration.

Based on this framework, we propose a three-step analysis approach. First, the household types are identified, and their transition trends are clarified to estimate the impact of rural livelihood transitions

[2] China's central government requires local authorities to be responsible for maintaining a certain amount of grain output (which varies by region). If the grain outputs in all regions could meet the requirements, then national food security can be ensured.

[3] For the purpose of analytical simplicity, in this paper, the inputs-outputs of grain production mainly refer to fertilizer and pesticide (inputs) as well as yield and net income (outputs).