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Structural change and carbon emission of rural household energy consumption in Huantai, northern China

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ABSTRACT

Huantai, a typical high-yielding agricultural county in the northern developed region of China and as a microcosm of China's rural area, is chosen as a case study to analyze the structural change and carbon (C) emission of rural household energy consumption. During the last 30 years, the per capita consumption and emission increased from 329 kg standard coal equivalent (kg ce) and 783.6 kg CO₂ to 638.4 kg ce and 1582.5 kg CO₂, with the average annual growth rates of 3.2% and 3.5%, respectively. Among four activities (lighting, cooking, heating, and recreation), cooking and heating account for > 70–95% at different times, and recreation is the fastest-growing activity. The current annual growth rates for recreational consumption and emission are 133.3% and 115.5%, respectively. In the context of energy structure, the proportion of nonrenewable energy increased from 15.7% in 1980 to 87.7% in 2009. Increase in income and changes in lifestyle are the two key factors affecting energy consumption and C emission. And this trend is endangering the sustainable development of rural areas and further China's development. Thus, it is necessary to develop new renewable energy strategy and explore new low-C developing mode both for local and central governments. At the level of Huantai county, appropriate strategies include improving use-efficiency of straw, developing large and medium-sized biogas digester, and harvesting solar energy. At the level of central government, developing biomass, rural biogas industry and solar energy have large potentials. It is necessary to continue to promote energy-saving stoves and small energy facilities, such as small wind power and hydropower stations in rural areas. But how to realize high-speed development and low-C emission in the process of urbanization is a major challenge in China at present and in the future.

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1. Introduction

Climate change may strongly impact the human society, economy and the environment. Consequently, development of low-carbon(C) fuel sources is gaining momentum globally [1–3]. In the “twelfth five-year plan”(the most important plan designed and completed by the government) of China, low-C and green development are emphasized and will become important components of its economy. Towards an effort to develop a low-C society, there is a growing focus on cities and industry. Nonetheless, low-C villages and towns must also be taken into account, especially in China. There are > 940 million rural residents in China, among which about 750 millions keep permanent residency status in villages and their daily life is also an integral part of the low-C society [4–6]. In the past, the quantity of rural energy consumption was drastically less than that in the cities. The majority of rural households were mainly dependent on traditional biomass (i.e., crop residues/straw and firewood) as household energy source. Thus, C emission from fossil-fuels was low, and emissions from rural households were often neglected. With the rapid development of the economy, however, the structure of household energy consumption has greatly changed and rural C emissions are progressively increasing. Indeed, non-renewable and commercial energy sources constitute a considerable proportion of total energy use in some developed rural areas [7–9]. Thus, it is necessary to analyze the structural change and emission of rural households at spatial and temporal scales, to identify basic principles and trends, and adopt corresponding measures to prevent rural areas from becoming a major C source.

This manuscript is a case study of the Huantai county of Shandong province, a typical agricultural region in developed area. It is based on an analysis of representative rural household survey and diverse sources of aggregate statistics. It explores the structural change and C emission of household energy use from 1980 to 2009. The results presented can be used as an important reference for other regions of northern China, which are also in the process of rapid modernization. The data presented are also

important to identify researchable priorities to balance the energy supply and demand, formulate energy policy, and create eco-environment in rural northern China.

2. Materials and methods

2.1. The study area

Huantai county is located in the center of the Shandong province, which is part of the North China Plain (NCP), located between 36°51'50" and 37°06'00"N, and 117°50'00" and 118°10'40"E (Fig. 1). The study covers an area of 520 km², and ~0.5 million people, consisting of 0.41 million in rural communities. This region has a typical continental monsoonal climate, characterized by an average annual temperature of 12.5 °C, with long cold winters. The soil parent material mainly consists of mountain diluvium and Yellow River alluvial deposits, which developed into loam soils classified as Calcaric Fluvisols [10]. This region is the primary food-producing area of China. More than 80% of agricultural land use between 1990 and 2010 comprised of the cropping system involving winter wheat (*Triticum aestivum* L.) and summer corn (*Zea mays* L.). Agronomic productivity in 1990 was > 15 Mg/ha of grains across the entire region. Thus, Huantai became the first grain county in northern China, and earned the title of “Granary of North Lu”. Modern, intensive livestock breeding is also widely practiced, while sporadic, personal livestock breeding is rapidly diminishing [10]. Along with the rapid development of industry and agriculture in recent years, there are many employment opportunities for rural laborers, created by local town and village businesses and the construction industry. Consequently, rural per capita net annual income increased from 88 RMB (Chinese Yuan) in 1978 to 9745 RMB in 2010. Yet, the contribution of agriculture to the total GDP decreased from 49.4% in 1983 to < 5% in 2009, and > 80% of peasant's income is derived from non-agricultural industries [10].

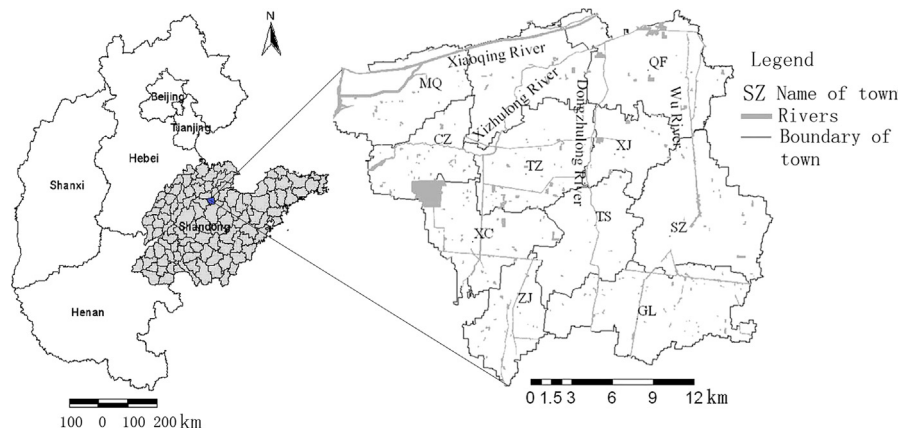


Fig. 1. Geographic location of the study area in Huantai County. Abbreviations: CZ—Chengzhuang town; GL—Guoli town; JJ—Jingjia town; MQ—Maqiao town; QF—Qifeng town; TS—Tangshan town; XC—Xingcheng town; XJ—Xingjia town; ZJ—Zhoujia town.

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