Food Security and Biofuels Development: The Case of China

Fengxia Dong

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Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

Fengxia Dong is an associate scientist in the Center for Agricultural and Rural Development at Iowa State University.

Questions or comments about the contents of this paper should be directed to Fengxia Dong, 571 Heady Hall, Iowa State University, Ames, IA 50011-1070; Phone: (515) 294-0470; Fax: (515) 294-6336; E-mail: fdong@iastate.edu.

Executive Summary

Biofuels production is expanding rapidly all over the world, driven by rising crude oil prices, the desire of countries to be energy independent, and concerns about climate change. As developed countries, especially the United States, are expanding biofuels production, developing countries are expanding their biofuels industries as well, to power their growing economies. However, developing countries must address the food security issue when they develop biofuels. As China is a developing country with rapid economic growth, population growth, significant demand for fuels, and food security concerns, it serves as a good example for studying the opportunities and challenges faced by developing countries under current conditions. This study analyzes the background, history, and current situation of biofuels development in China. Some implications for developing countries are also provided.

Keywords: biofuels, food security, China.

FOOD SECURITY AND BIOFUELS DEVELOPMENT: THE CASE OF CHINA

Biofuels production is expanding rapidly all over the world, driven by rising crude oil prices, the desire of countries to be energy independent, and concerns about climate change. As developed countries, especially the United States, are expanding biofuels production, developing countries are expanding their biofuels industry as well, to power their growing economies. Biofuels have been proclaimed as the alternative fuel of the future, offering cleaner energy and new opportunities for farmers in developing countries. However, developing countries face different situations than do developed countries. They must address the food security issue when they develop biofuels. The large and rapid expansion of ethanol worldwide has affected virtually every aspect of food markets and prices in both domestic and international markets, ranging from the allocation of acreage among crops to exports and imports. As more food grains will be used to produce biofuels, food grain carryover stocks will remain tight, and average grain prices will increase. Moreover, these price increases also increase the feed cost for livestock. Consequently, most food prices are affected. As production of biofuels and food are closely related, the question arises: How should developing countries respond to biofuels development when food security is an issue?

Because China is a developing country with rapid economic growth, population growth, significant demand for fuels, and food security concerns, it serves as a good example for studying the opportunities and challenges faced by developing countries under current conditions. China is the third-largest producer and consumer of ethanol, behind Brazil and the United States. Unlike Brazil, the United States, and some other developing countries, though, China has the largest population in the world and limited arable land, and thus food security is an issue. While the competition between food and fuel for grain exists in many developing countries, the problem is more acute in this country because of the low per capita availability of cultivated land (0.23 acre per capita in 2006) to feed its enormous population. In addition, China is reluctant to import a large proportion of crops. Government policy supports food self-sufficiency for the sake of national security. Although China has these unique characteristics, its development of a biofuels industry can still provide some experiences and lessons for other developing countries.

The following sections give the background and history of biofuels development in China. Then, the current biofuels production situation is analyzed. Discussion of opportunities and challenges of future expansion will follow. And finally, some implications for developing countries will be discussed.

Background of China's Biofuels Development

China produces two types of biofuels, fuel ethanol and biodiesel. China's government has been putting more emphasis on fuel ethanol development, as China is lacking in suitable sources for biodiesel production. China is a big net importer of all the major edible vegetable oils, and it lacks the land for crops production for biodiesel. Currently most of China's biodiesel production is produced from animal fat or waste vegetable oil from oil crushing plants or restaurants. And biodiesel plants are small, ranging from 100 to 20,000 metric tons (mt) of production (FAS-USDA, 2007). In contrast to fuel ethanol production, which has government support policies, strict production standards, and regulations, biodiesel production is provided with fewer incentives for development in the near future. Therefore, the following sections focus on fuel ethanol development in China.

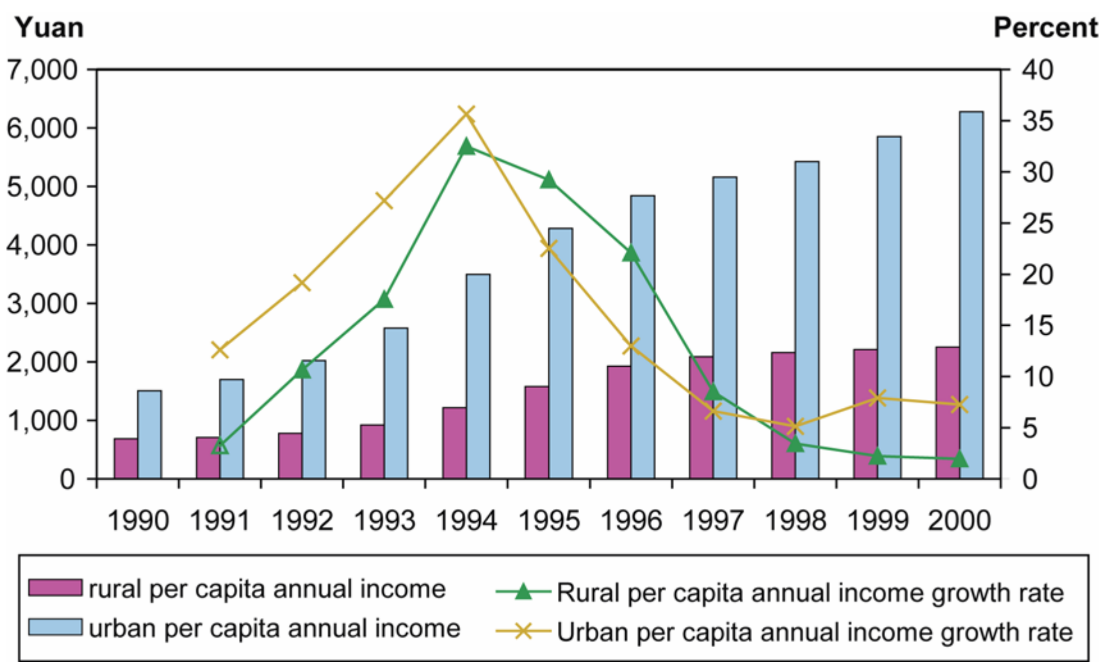
China's incentives for developing fuel ethanol production include not only those common to other countries, such as rising oil prices, energy independency, and environmental issues, but also some unique concerns, such as having stale grains in the national grain reserve system.

Motives for Developing Fuel Ethanol Production

1. Excess Reserved Grains and Slow Growth of Rural Income

For the sake of national security, China's government advocates food self-sufficiency and has a national grain reserve system. About 17%-18% of grain produced every year is reserved in case of poor harvest or natural disaster in coming years. The bottom amount of reserved grain is 135 million mt, of which 20%-30% is substituted by fresh grain every year (Li, 2007). Crop harvests were large in 1996 and 1999. Annual crop outputs stabilized at 500 million mt in four consecutive years (*China Statistics Yearbook*), and almost all grain barns of the reserve system across the country were full. For example, in 2001, reserved wheat in Henan province, the largest wheat producing province in China, exceeded 25 million mt. This resulted in an increase in the central government's total cost—up to 2.8 billion yuan—to administer and maintain the grain reserve, and thus the reserve became a burden to the government (Li, 2007).

With these increases in grain production, grain prices plunged. In Jilin province, the price of corn was at the lowest level in 25 years (Liu, 2005). Moreover, between 1998 and 2000, rural per capita income growth lagged behind urban income growth, and the income gap between urban and rural residents increased faster (see Figure 1). The average income for urban residents grew 2.73 times faster than that of rural residents in 2000. Finding a way to stabilize grain prices and increase farmers' incomes is always at the top



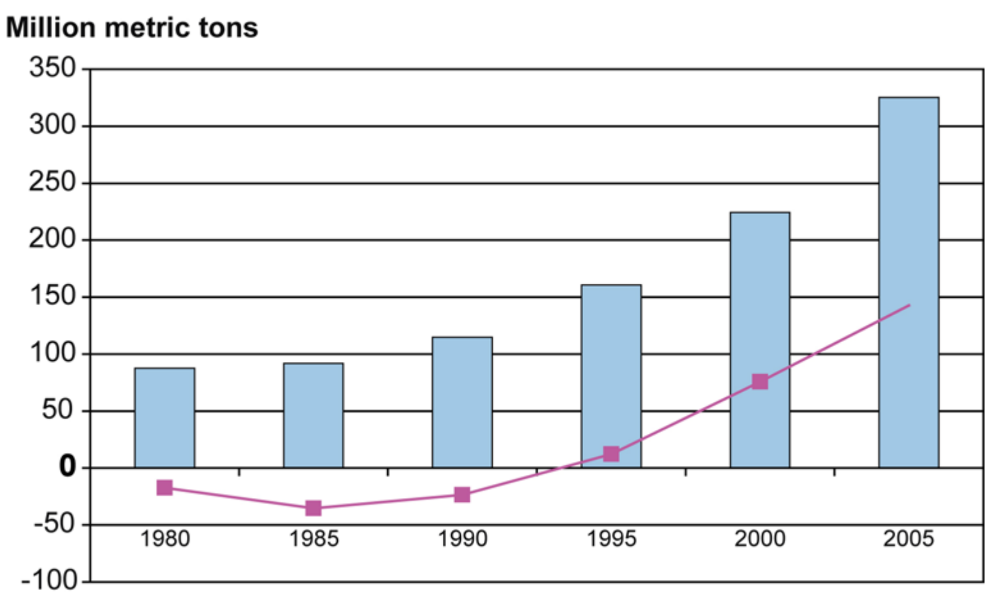
Source: *China Statistics Yearbook*, various.

FIGURE 1. China's rural and urban per capita annual income and growth rate

of the government's agenda. Developing the fuel ethanol industry seemed to be a way to support the transformation of grains such as corn and wheat and increase the efficiency of grains' utilization. Thus, this could help form a stable and controllable grain consumption market and protect farmers' benefits.

2. Increasing Dependency on Imported Crude Oil and Deteriorating Air Pollution

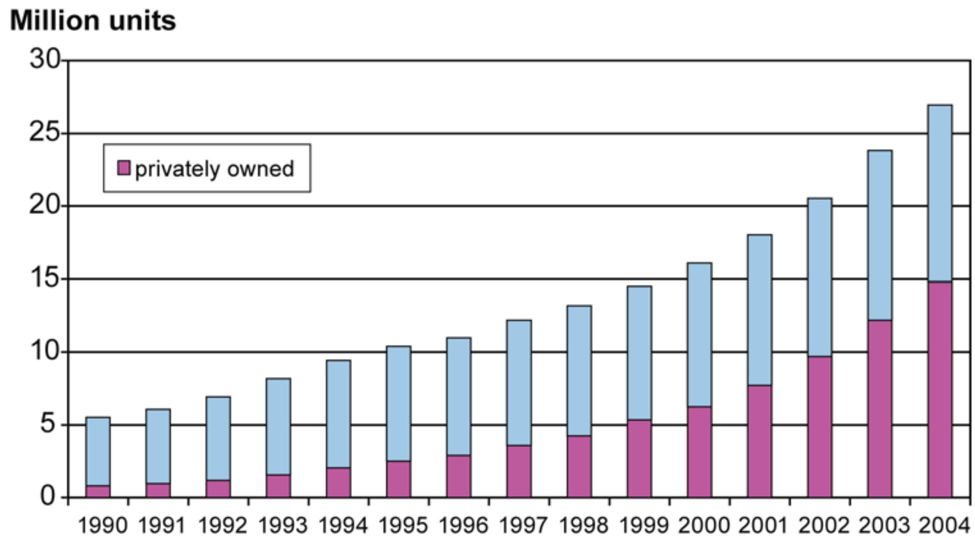
China's energy consumption is increasing significantly to fuel its fast economic growth. Total consumption of energy doubled, from 987 million standard coal equivalent (SCE[1]) in 1990 to 1.97 billion SCE in 2004. While the percentage of energy provided by coal decreased, that of crude oil increased 6% and accounted for 22.7% of total energy consumption. Petroleum consumption increased from 87.57 million mt in 1980 to 325.35 million mt in 2005 (see Figure 2). Next to industry use, transportation use ranks second in petroleum utilization and is growing very fast, because of the rapid growth in vehicle numbers (see Figure 3). In Beijing alone, 1,000 cars are added to the city's roads every day (FAS-USDA, 2006). As disposable incomes increase, more and more Chinese people



Sources: China Statistics Yearbook, Petroleum Balance Sheet.

FIGURE 2. China's petroleum consumption and net imports

[1] 1 kilowatt of electricity=0.1229 kg SCE.



Sources: China Statistics Yearbook, various.

FIGURE 3. Possession of civil vehicles in China

are purchasing privately owned vehicles. With relatively limited oil resources in China, oil production cannot meet the increasing demand, and thus oil imports are increasing and are accounting for more and more of domestic oil consumption. In 1995, petroleum imports accounted for 7% of consumption. This number increased to 34% in 2000 and 44% in 2005 (see Figure 2). In the meantime, world crude oil prices increased significantly. This challenged China's energy security goals and motivated the country to look for alternative energy sources.

The other issue arising with the expansion of the vehicle fleet is the deterioration of air quality. The country's greenhouse gas emissions reached 5.6 billion mt in 2004, of which 5.05 billion mt were CO_2, compared with U.S. emissions of 7.12 billion mt for the same year, according to the U.S. Department of Energy. And China will probably soon become the biggest greenhouse gas emitter, according to the International Energy Agency. Because biofuels in cars discharge less exhaust and are more environmentally friendly, China is motivated to develop this green energy.

Development of Fuel Ethanol

Concerned about excess old stocks in the grain reserve system, rural poverty, and the issues of rising dependency on oil imports and increasing greenhouse emissions, China's government began developing its plan for biofuels development, especially the fuel ethanol industry. In April 2001, standards for “Denatured Fuel Ethanol” (GB18350-2001) and “Bioethanol Gasoline for Automobiles” (GB18351-2001) were released (FAS-USDA, 2006). The China Petroleum and Chemical Corporation (also known as Sinopec) set up a series of enterprise standards on fuel ethanol’s blending, storage, and delivery. And in June 2001, according to the “State Scheme of Pilot Projects on Bioethanol Gasoline for Automobiles,” three cities in Henan province (Zhengzhou, Luoyang, and Nanyang) and two cities in Heilongjiang provinces (Harbin and Zhaodong) launched pilot projects on mandatory utilization of fuel ethanol in all vehicles for a year. Sinopec was responsible for setting up a fuel ethanol blending facility in three cities in Henan province to blend and deliver fuel ethanol locally. The China National Petroleum Corporation (CNPC) was assigned to build blending facilities in the two cities in Heilongjiang province. The pilot projects achieved success in management of fuel ethanol’s supply, delivery, marketing, and service. In the meantime, this helped consume a considerable amount of stale grains. For example, 1.05 million mt of stale grains in the reserve grain system were used to produce 30,000 mt of fuel ethanol in Henan. The consumption of 1.05 million mt of stale grains in the reserve grain system saved Henan province 200 million yuan in subsidies (Henan Tianguan Group).

Given the success of the pilot project, on February 10, 2004, the National Development and Reform Commission (NDRC), along with seven ministries, announced the “State Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles” (hereafter referred to as SSEPP) in order to further adjust China’s national energy consumption structure, explore substitutes for crude oil, improve air quality, and promote agricultural production and sustainable development. According to the SSEPP, extensive pilot projects were launched in five provinces (Heilongjiang, Jilin, Liaoning, Henan, and Anhui), in nine cities in Hubei province, seven cities in Shandong, six cities in Hebei, and five cities in Jiangsu (see Figure 4 for more details). By the end of 2005, according to the SSEPP, bioethanol gasoline was to substitute for other gasoline, with an exclusion for utilization by the army and state/special reserve gasoline in the named regions. Purchase or sale of other gasoline at gas stations was illegal. Original #90, 93, 95, and 97 unleaded gasoline were mandated to switch to #90, 93, 95, and 97 bioethanol gasoline.

Notes: Provinces and cities included in the Extensive Pilot Projects on Bioethanol Gasoline for Automobiles in 2004 are five provinces: Heilongjiang, Jilin, Liaoning, Henan, and Anhui; nine cities in Hubei province: Xiangfan, Jingmen, Suizhou, Xiaogan, Shiyan, Wuhan, Yichang, Huangshi, and Ezhou; seven cities in Shandong province: Jinan, Hezhe, Zhaozhuang, Linyi, Liaocheng, Jining, and Taian; six cities in Hebei province: Shijiangzhuang, Baoding, Xingtai, Handan, Changzhou, Hengshui; and five cities in Jiangsu province: Xuzhou, Lianyungang, Huaian, Yancheng, and Suqian.

FIGURE 4. Provinces/cities in China included in the Extensive Pilot Projects on Bioethanol Gasoline for Automobiles in 2004

As indicated in the SSEPP, fuel ethanol production and distribution are under strict control. All denatured fuel ethanol must be produced by plants that are authorized by the government, and all bioethanol gasoline is distributed by Sinopec and CNPC. The SSEPP is under the leadership of the NDRC, cooperating with Sinopec and CNPC, as well as seven other ministries.

So far, only four ethanol plants have been authorized by the government to produce fuel ethanol from grains: Jilin Fuel Ethanol Co. Ltd., Anhui Fengyuan Biochemical Co.

Ltd., Heilongjiang Huarun Ethanol Co. Ltd., and Henan Tianguan Group. All of them are located in the main corn and wheat producing areas (see Figure 5) and use mainly these grains to produce ethanol. In the SSEPP, 1.02 million mt of denatured fuel ethanol is involved, including 300,000 mt (the first phase) from Jilin Fuel Ethanol, 300,000 mt from Henan Tianguan Group, 320,000 mt from Anhui Fengyuan Biochemical, and 100,000 mt from Heilongjiang Huarun Ethanol. In addition, 100,000 mt of fuel ethanol from Jilin province would be consumed in the province and the other 200,000 mt would be distributed in Liaoning. Of the 300,000 mt of fuel ethanol produced in Henan, 130,000 mt would be consumed locally and 170,000 mt would be distributed to 13 cities in Hubei and Hebei. Of the 320,000 mt of fuel ethanol produced in Anhui province, 100,000 mt would be sold in the province and 220,000 mt would be delivered to 14 cities in Shandong, Jiangsu, and Hebei. All 100,000 mt of fuel ethanol produced by Heilongjiang Huarun Ethanol would be distributed in local areas. In addition, the settle price between fuel ethanol plants and Sinopec and CNP was calculated by multiplying the shipping

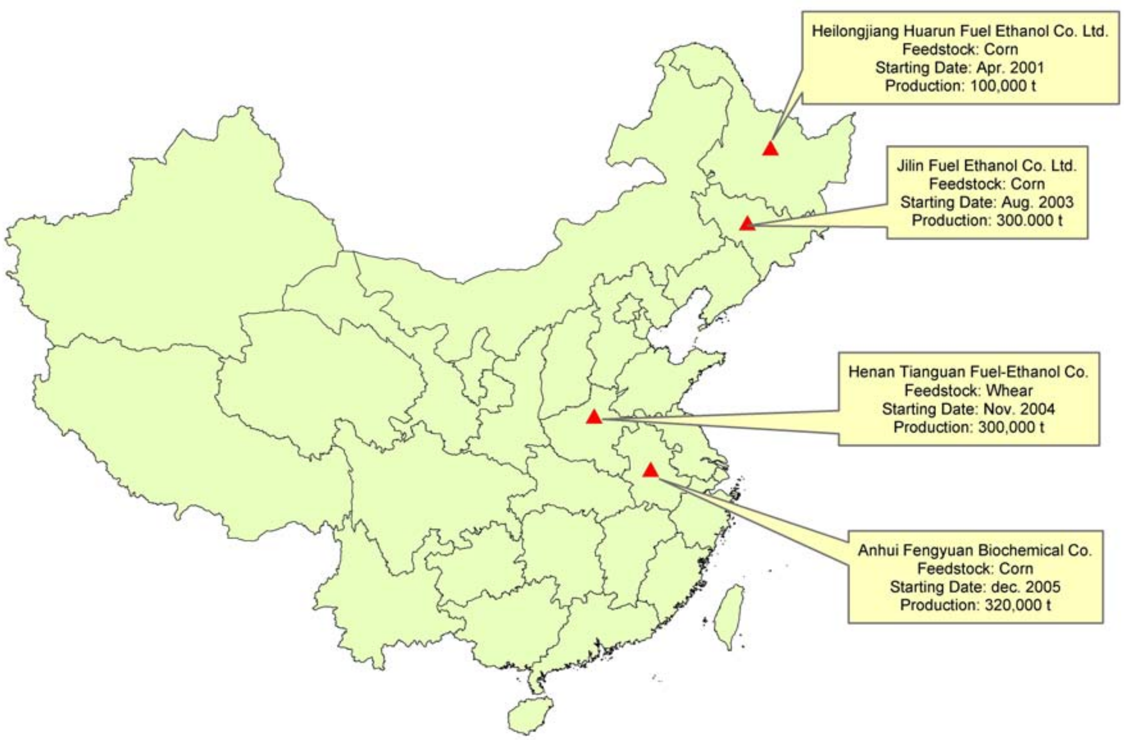


FIGURE 5. Authorized fuel-ethanol plants in China

price of the #90 gasoline published by NDRC by a factor of 0.9111. The bioethanol gasoline price was based on the #90 normal gasoline price published by the NDRC and adjusted according to the market but in the range allowed by the government.

Because the production cost of ethanol is around 3,500 yuan (China Ministry of Agriculture, 2007), still relatively high, and production is not very profitable, to encourage the development of fuel ethanol production, ethanol production is subsidized by the government. Every mt of fuel ethanol produced by the four authorized plants can get a subsidy, set at 1,883 yuan in 2005, 1,628 yuan in 2006, 1,373 yuan in 2007, and 1,373 yuan in 2008. In addition, the ethanol plants are exempt from the 5% consumption tax and are able to get refunds of the value-added tax. Moreover, the four plants can get a stale-grain subsidy by utilizing stale grains in denatured fuel ethanol production. Since 2002, the total tax benefits for the four fuel ethanol plants have reached 190 million yuan, and subsidies from the central government have reached 2 billion yuan to compensate for their deficiency (*People's Daily*, 2006).

Current Situation

After several years of development, China has become the third-largest ethanol producing and consuming country, following Brazil and the United States. China's current Five-Year Plan sets the goal of using biofuels for 15% of the country's transport fuels by 2020. By the first quarter of 2006, five provinces and 27 cities that were included in the scheme of extensive pilot projects had basically realized the substitution of bioethanol gasoline for the normal unleaded gasoline. With increasing demand for ethanol in both domestic and world markets, ethanol prices started to increase and the ethanol industry became very attractive for many investors. According to the NDRC, the production capacity for fuel ethanol or for non-grain biofuels planned for construction had exceeded 10 million mt.

Food Security Concerns with the Expansion of Biofuels Production

Corn and wheat are the major feedstocks used by the four authorized fuel ethanol plants to produce fuel ethanol. Although the government encourages efforts to make ethanol from non-grain sources, Chinese producers continue to make ethanol from grains because the mass planting of non-grain feedstock such as cassava and sorghum has yet to be implemented on a large scale. In 2005, 0.7 million mt of reserved wheat and 2.87 million mt of reserved corn were used to produce fuel ethanol (Li, 2007). The stale grain in the grain reserve was almost used up after several years of development of ethanol, and more and more new crops are being used (Liu, 2005).

As demand for corn increased significantly, the price of corn was pushed higher. Higher corn prices in the last year have changed the allocation of acreage among crops in some major crop-producing provinces. For example, in Jinlin province, corn planted area increased by 264,000 acres from last year, while soybean planted area decreased by over 165,000 acres, and planted area for other crops also decreased (China Food Industry Net). In the nine months preceding June 2007 in the Dalian Commodities Exchange, domestic corn prices increased 30% as a result of more corn being processed into ethanol. Because corn is the main feedstock for hogs, the price of pork has gone up by 43% as of mid-May compared with the same period last year (although a disease that killed hundreds of thousands of hogs has also been blamed). The jump in pork prices caused quite a stir in Chinese society, as the Chinese people consume more pork per capita than consumers in any other country except Germany. On April 19, 2007, the China Statistics Bureau announced that domestic food prices increased 6.2% in the first quarter compared to the same period last year.

The crop price increase can raise rural incomes, which is one of the initial goals of China’s biofuels development. As food prices increase, however, those poor and net-food-purchasing urban and rural households are the most adversely affected. High prices can cause social unrest and threaten the government’s stability. Worried over surging food prices—which might affect social stability—and food security as well as the resulting inflation, last December the Chinese government stated that biofuels production should not be undertaken by utilizing arable lands and grains, and should not pollute environments, though it had promoted the production of the environmentally friendly gasoline additive for years. The government stated that all construction of new fuel ethanol plants would have to be approved by the state investment administration and financial department. Constructions violating rules or without approval would not get tax benefits for fuel ethanol production. Those producing and supplying fuel ethanol using unauthorized ethanol plants or purchasing fuel ethanol from unauthorized fuel ethanol plants would not only get no financial subsidy but would also be punished. A short time later, another urgent announcement declared that all ethanol production projects in the pipeline would be suspended; projects on construction or proposed would be rectified; and the four authorized fuel ethanol plants could not increase producing capacity without the approval of the government. These actions indicate that China cannot use food for fuel because food security is more important than energy and because food is politically more important. Wang Xiaobing, an official in the Ministry of Agriculture’s Crops Cultivation Department said, “In China the first thing is to provide food for its 1.3 billion people, and after that, we will support biofuel production” (*Asia Times*, 2006). Another official, Yang Jian, director of the Development Planning Department under the Ministry of Agriculture, said, “We have a principle with biofuel. It should neither impact the people’s grain consumption nor should it compete with grain crops for cultivated land” (*Asia Times*, 2006).

Development of Non-grain Ethanol Production and Challenges

With rising food prices and concerns over social stability, strategies based on the short-term goal of elimination of the burden of grain stocks seemed unsuitable for the long-term development of China’s biofuels industry. Although China’s government continued to advocate development in biofuels, it had to switch its strategies from using main staple grains to using other non-grain crops or crop by-product sources. Crops currently receiving the most attention include cassava, sugarcane, sweet sorghum, and sweet potatoes. Crop by-products that have attracted interest are mainly crop stalks. According to the NDRC, northern China should focus on ethanol from sweet sorghum, the middle region is best suited for sweet potatoes, southeastern China should focus on cassava, and the very southern tier should focus on sugarcane for feedstock. One appealing aspect of sweet sorghum is that it is drought tolerant and well suited for saline and alkaline soils that are no longer able to produce grain. Most saline soil is located in North China, amounting to 23.6 million acres in the northern 13 provinces. The current conversion rate is approximately 16-18 mt (outputs from about 0.66 acres in North China) or less of sweet sorghum stalks to produce 1 mt of ethanol (China Ministry of Agriculture, 2007). A pilot project in Heilongjiang province produces 5,000 mt of fuel ethanol from sweet sorghum each year. Cassava production is mainly distributed in Guangxi, Guangdong, Hainan, Fujian, Yunnan, Hunan, Sichuan, Guizhou, and Jiangxi provinces. Currently, about 7 mt of cassava can produce 1 mt of fuel ethanol. In 2005, yield per acre of cassava was only 6 mt. China has the largest sweet potato production in the world. The output in 2005 exceeded 10 million mt. About 8 mt of sweet potatoes can produce 1 mt of fuel ethanol. The planting area of sugarcane was 3.3 million acres and the output was 86 million mt in 2005 (China Ministry of Agriculture, 2007).

As China's arable lands are limited, the current supply of cassava and sugarcane cannot meet the demand of expanding ethanol production. Therefore, some people suggest that China use saline and alkaline soils, wasteland, uncultivated land, and vacant lands in winter to plant non-grain feedstocks. Moreover, farming by-products like straw and corn stalks, or even forest residues which contain cellulose, could offer a long-term solution. These could provide an option without creating concerns about food security and land requirements.

These suggestions seem very promising for the expansion of fuel ethanol production in China. However, before biofuels production from these feedstocks can play a significant role in China's fuel supply, there are some obstacles that must be overcome.

First, policies on ethanol production should be reformed to support fuel ethanol production from non-grain feedstocks. Although China's government is promoting the use of non-grain feedstock to produce fuel ethanol, current policy does not do so. Fuel ethanol from non-authorized plants cannot go into the fuel market and cannot get government subsidies. Current production costs of fuel ethanol from non-grain feedstocks are higher (about 4,000 yuan) than those from corn or wheat, so without policies to support the non-grain resources for ethanol production at its infancy stage, development will be impossible.

Second, difficulties in collecting and transporting the feedstock from the field to the ethanol plant can be serious. Given that a large share of the land in China that is not suitable for crop planting lies in remote and mountainous locations, it is very costly to transport the feedstock from producing areas to ethanol plants or to transport ethanol instead of feedstock to consumers if the ethanol plant is located near the producing areas. Large investments in infrastructure (such as road construction) in producing areas are necessary.

Third, there are logistical problems associated with the storage of non-grain feedstocks. Sweet sorghum, for example, must be processed soon after harvest in order to ferment the stalks while sugar and moisture content is high. If stalks are stored wet, they will begin to ferment in an uncontrolled manner, potentially rendering them useless for ethanol production. Unless the storage issue is resolved, the ethanol plants may be affected by the seasonality of feedstock supply and would be in production for only a few months out of the year, making these feedstocks economically unfeasible.

Fourth, the yield of non-grain feedstocks in China is very low, as previously described. This may restrict supply of feedstocks and thus the capacity of ethanol plants. Better seeds and technology will need to be brought in to increase the yields of non-grain feedstocks for the expansion of ethanol production.

Fifth, the technology of cellulosic ethanol production is still at “pilot” and “commercial demonstration” scale and will take years to commercialize. Production of ethanol from cellulose is more costly than that of corn-based ethanol. Scientists are still working on plant enzymes to offer new properties for producing ethanol more efficiently. China has a demonstration plant engineered by SunOpta Inc. and owned and operated by China Resource Alcohol Corporation that is currently producing cellulosic ethanol from corn stover (stalks and leaves) continuously, 24 hours per day.

And sixth, biofuel production requires intensive use of natural resources, mostly water, which restricts the location of biofuel plants. Because China is also facing a water shortage problem, this issue will inhibit the expansion of biofuel production in some regions where water supply is an issue. The alternative is to set up biofuel plants in regions where water supply is abundant, but if the location is far from the feedstock supply areas, transportation issues, as just discussed, may arise. In addition, water quality and the maintenance of genetic resources must also be addressed.

Conclusions

Fuel ethanol production from non-grain feedstocks appears unable to commercialize on a large scale for at least the next few years because of the absence of policy support; the low yields of non-grain feedstocks; difficulties with collection, storage, and transportation of some non-grain feedstocks; and the slow development of production technology and equipment as well as sluggish construction of the non-grain-sourced ethanol plants. Some fuel ethanol facilities using non-grain feedstocks are in construction (like the one in Guangxi, which uses cassava for fuel ethanol, and Fengyuan Biochemical Co., which uses cellulose). Government support of research on high-yield seeds of non-grain feedstocks, enzymes for ethanol production, storage technology for non-grain feedstocks, and investment in infrastructure and facilities in producing areas would seem essential. Besides depending on their domestic efforts only, introducing advanced technology from other countries such as the United States and Brazil could be an easier and faster way for China to develop its biofuels industry (for example, the technology imported from SunOpta Inc.). Investing in other countries that have a sufficient supply of feedstock is becoming a way for some of China's biofuel companies to procure more raw materials and expand biofuels production. For example, a Chinese agricultural firm, Nanning Yong Kai Industry Group Co., plans to set up three ethanol facilities in the Philippines this year using sugarcane or cassava feedstocks, with a total investment of $105 million (www.agra-net.com/SL).

Although China has some unique characteristics, its experiences and lessons in biofuels development are still instructive for developing countries.

First of all, developing countries should evaluate the relationship between food security and biofuels expansion. They should develop an analytical framework that takes into account the diversity of their situations and specific needs (FAO, 2007). The strategies for biofuels development should consider not only short-term goals but also take into account long-term objectives. Inconsistent policies on biofuels development such as those based only on short-term goals will not only hinder that development but will also mislead agricultural markets. In addition, policymakers must take care to ensure that biofuels development will not adversely affect poor and net-food-purchasing households, which are vulnerable to rising food prices.

Second, government support is necessary at the starting stage of biofuels development, including subsidies, tax benefits, investment in technology and facilities, and mandated-use targets. Companies may not be profitable at the initial stage, so government inputs and investments are critical for biofuels development. In addition, importing technology or cooperating with more advanced countries would also be a good way to develop a domestic biofuels industry. If second-generation technologies based on lignocellulosic feedstock such as grasses, wood, crop and forest residues, and municipal wastes become economically viable, they could reduce the demand for food and feed crops for the production of biofuels and mitigate the competition of food and energy.

Third, one way of mitigating the food-versus-energy competition is to grow crops on degraded or barren land not suitable for food production. Besides the support of new technologies that can increase efficiency and productivity in crop production, some varieties and hybrids of crops that are suitable for barren lands must be bred. This can help poor and marginal farmers benefit from biofuels development, making that development pro-poor. The expansion of biofuels production could contribute significantly to higher incomes for farmers through higher feedstock prices and new employment opportunities to the benefit of rural areas, an outcome that is quite desirable for developing countries that generally have large rural populations.

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