

John P. Woog, Student Participant
Mayo High School
Rochester, MN

The Impact of Water Scarcity on Biofuel Production in Hebei Province, China

Introduction

China is the most populous country in the world, with a current population of approximately 1.32 billion. China has a very rapidly growing economy. Its GDP (Gross Domestic Product) is growing at a rate of 10.7 percent (2006 estimate), making China's economy the fastest growing in the world. China also has a very high greenhouse gas production rate of 14 percent, an increase of more than one-third over the past decade. China will likely overtake the United States as the world's leader in greenhouse gas production in 2007 or 2008.

China uses an exceedingly large amount of fossil fuels and energy. It is currently the third-largest producer of energy in the world accounting for 10.6 percent. It is also the second-largest energy consumer, consuming 10.8 percent of total world energy, and energy use is expected to grow at approximately five percent per year through 2020. China is the second-largest oil-consuming country in the world and currently accounts for approximately seven percent of the world's total oil consumption. By 2030, China may have to import more than 80 percent of the oil it consumes annually. China obtains only about three percent of its energy from natural gas and ranks 17th in natural gas production. Which is 1.3 percent of the world's total gas production. China currently has plans for quadrupling its natural gas production by 2010 and for the importing of liquefied natural gas from Australia. China has showed that as of January 2005, it had about 125 billion tons of recoverable coal and as much as four trillion tons in potential reserves. China is currently the world's largest producer of coal and is responsible for about 30 percent of the world's total annual production of coal. China is also the world's largest coal consumer, consuming 28 percent of the world's total annual coal consumption. Two-thirds of China's total energy use is accounted for by coal. The coal demand is projected to increase by 20 million short tons yearly over the next five years and China plans to increase the production of coal by 17 percent. As an electricity generating country, China is currently rated second and makes and consumes more than 11 percent of the world's total annual electricity generation. The demand for electricity in China is predicted to increase by about 4.3 percent yearly through 2025. China's large production of coal accounts for about three-fourths of its electricity production, but China plans to incorporate other energy sources such as hydroelectric, natural gas, and nuclear sources and there is also a growing interest in biofuels as a future energy source as well.

Geographically, Hebei Province is located in the North China Plain, which is in North East China. It is bordered on the east by the Bohai Sea. It includes the capital city, Beijing, and as well as Tianjin, a large port city. The Taihang Mountains rise in the western part of Hebei Province, and the Yan Mountains lie in northern Hebei. The Great Wall of China runs through northern Hebei from east to west. At the end of 2005, the total population of Hebei province was calculated to be 68.5 million.

Hebei Province is composed mainly of plains which are used for growing crops such as wheat, cotton, corn, paddy, tobacco, peanut, sesame, walnut, persimmon, and date. The main cereal crop is wheat. Hebei Province experiences periods of intense heat and frequent droughts as well as monsoons and floods. Average annual rainfall is 400-800 mm. Concerns have been raised recently about the water supply in Hebei Province. Traditionally, much of the population has been composed of subsistence farmers who live in densely populated villages. Because of the water scarcity and droughts in Hebei and the importance of subsistence farming there, I thought it would be interesting to look at the impact of water scarcity on potential biofuel production in Hebei Province.

Demographic Summary of Hebei Province

It is difficult to get exact information concerning the number of subsistence farmers and related activity in Hebei Province. Recent publications appear to be focused more on commercial farming and agricultural exports from China than about subsistence farming. In general, about 45% of the working Chinese population is employed in agriculture, compared to about 14% of the working US population employed in farming as of 2002. Available information from the China 2000 Census reveals that the average family in Hebei Province consists of three to four residents; the majority of households contain members of two generations. The majority of the population ranges from 15-64 years of age. The amount of living space is usually 20-30 sq. meters (approximately 200-300 square feet) per person, compared with approximately 721 square feet for the average American. Annual income per household is 2000-3000 yuan or about \$250 to \$375. Approximately 40% of per capita income is spent on food, compared with approximately 10% of disposable income in the United States in 2005. The diet is largely wheat-based and includes steamed bread, potatoes, corn, soybeans, other vegetables, meat including pork, beef, and mutton, poultry, and eggs. Most vegetable, hog, and chicken farming is done on a small scale. Although the rural population of China spends relatively little in absolute terms on food (approximately \$107 annually per capita in 2003, compared with approximately \$5,000 per capita in the US in 2002), the population is generally not malnourished, with a daily average caloric intake of 2600 calories. During recent years there has been a trend for increased purchasing of food by rural Chinese households as opposed to consumption of self-produced crops. Subsistence farming seems to be gradually fading. Farmers are growing more cash crops and livestock for sale, or migrating to the city to earn money, which they send home to their families, in the country. Data from the China National Bureau of Statistics suggests that farmers are selling a larger proportion of the grain, which they are producing. In terms of education, the illiteracy rate is quoted at five to ten percent in 2000 with improvement noted from the 1990 census.

Main crops grown in Hebei province include cereals such as wheat, maize, millet, and sorghum. Cash crops include cotton, peanuts, soybeans, dates, and sesame. Interesting data are available about cotton farming, in Hebei province. According to 2001 data, China is the world's biggest producer of cotton, and the Yellow River region (which encompasses Hebei province) produces the most. In the Yellow River region, about 70% of farmland is planted with two crops per year. Winter wheat is often double-cropped with cotton. Cotton farms in the Yellow River region are the most likely to grow genetically modified strains such as Bt cotton. Data published by CIRAD (the Centre de cooperation internationale en recherche agronomique pour le développement) in 2006 indicate that most cotton farms are relatively small, 0.3-0.6 hectares (0.7-1.5 acres) in size, and are farmed by families. Although as noted above, the average farm family may include three to four individuals, men often have jobs outside the farm and much of the farming is done by women. While household income is lower for farm residents than for urban residents, the standard of living for farmers has been improving.

A number of factors may affect farm productivity and income in Hebei province. These include varying crop prices, the labor intensive nature of family farming, limited access to new farm technologies, and water-related issues including flooding and drought. In the next section I will focus on water scarcity and its impact on agriculture in Hebei province.

Water Scarcity and Agriculture in Hebei Province

Water scarcity is a worldwide problem. A technical paper from UN-Water recently summarized issues associated with water scarcity, and noted that a major 2007 study showed that one third of the world's population may face water shortages due to either physical scarcity of water or economic barriers to obtaining water access. Problems associated with water scarcity include increasing water pollution, decreasing groundwater and river levels, and unequal allocation of water resources between competing water users.

While China has approximately the same amount of total exploitable water resources as the United States (2,800 billion cubic meters per year), due to China's larger population the per capita water supply is only one-fourth that of the US. Also, water resources in China are unevenly distributed geographically, with 90% of the water in Northeast China and in parts of China south of the Yangtze River. The agricultural regions of the North China Plain have only one-tenth of world per-capita water levels. The Chinese Ministry of Agriculture has classified 70% of farmland in China as dryland. Although flooding is also a problem in China, economic losses from drought are greater, totaling approximately \$35 billion per year in the 1990's compared with losses of \$10 billion from flooding. The area affected by drought has increased steadily from the 1950's through the 1990's.

As noted before, Hebei province is subject to both flooding and droughts. Water resource availability in the northern dryland area is said to be only one-fifth of the average for China. Amounts of precipitation are lower in the northern part of China. Groundwater levels are dropping, and concerns have been raised regarding water pollution and water quality. Nearly one-third of China is said to be desertified. Severe dust storms originating in the deserts of Inner Mongolia and occurring approximately ten times yearly may affect the Northern plains, contributing to increasingly sandy soil which is not well suited for agriculture.

In view of the relatively low precipitation in Northern China, agriculture has been dependent on extensive irrigation. The total area under irrigation in China increased from approximately 45,000,000 to 55,000,000 hectares from 1980 through 2005. Although as of 2001 there was no definite evidence that water scarcity has affected agricultural output, several potential concerns have been raised for the future. Both China's industrial economic output and related water use have been growing significantly. The value of water in industrial use is greater than that in agriculture, and this creates a potential for competition for water resources. Evidence of impending water scarcity includes the reduced water flow in the three major river systems serving the Northern plains: the Yellow, Huai, and Hai Rivers. There has been a marked reduction in the number of lakes in Hebei province from over 1,000 to less than 100. Water table levels in the Northern plain area, including Hebei province, are dropping due to over-pumping of water. The number of wells drilled to provide water has increased significantly over the past 20 years, and in Beijing it is sometimes necessary to drill wells 1,000 meter deep to reach fresh water. Use of water from the deep aquifer under Hebei province, which is considered non-replenishable, is thought to have contributed to an average 2.9 meter drop in the level of this aquifer in 2000. Increasing expenses associated with deep well drilling and pumping, as well as competition with industrial users may limit the availability of water for agricultural purposes in the future. In 2001 it was estimated that an annual water deficit (defined as the excess of consumption over sustainable resupply) as high as 40 billion tons might exist. The author of this study suggested that this might result in the inability to continue high-yield irrigation-dependent agriculture in the North China plain by the year 2010, with a subsequent return to lower-yield rain-dependent agriculture.

As summarized above, current issues in terms of water scarcity and water quality raise questions regarding the future continuation of irrigation-dependent crop production in Hebei province. Production of some biofuels such as ethanol requires abundant water supplies, with approximately 4 gallons of water required per gallon of ethanol produced. Some rural communities in the United States have declined to pursue ethanol plant construction due to concerns regarding water utilization. In terms of Hebei

province, development of biofuel programs which require large amounts of water might result in additional problems for conventional subsistence and cash crop agriculture, which is already under stress due to water scarcity and quality issues as noted above. Another concern relates to the cost of cereals used for food production. The United Nations Food and Agriculture Organization indicates that the demand for biofuel crops has pushed the cost of cereal crops higher over the past year, and that similar increases are expected from 2007-2008. If farmers in Hebei province are no longer self-sufficient in cereal crop production, they may have to pay higher prices to buy cereal crops from other sources for food purposes. On the other hand, it is possible that payments received from biofuel-related crops may be higher than for other crops, resulting in higher incomes for the farmers. In general, though, improving water availability and quality in Hebei province would protect and allow further growth in conventional agriculture and might also allow development of biofuel crop production.

Options for the Future

Several suggestions have been offered regarding how to address water scarcity issues affecting agriculture in the North China plains. First, there can be increasing application of techniques of dryland farming. These include terracing of hilly farmland, planting trees on terraced land, and planting grass at the base of terraced land to decrease fertile topsoil erosion and improve water retention and conservation. Furrow drilling is another technique which can help with moisture retention; this has been associated with crop yield increases of 40-50% in northern Hebei province. Water cisterns can be built to allow rainwater to be used for supplemental irrigation. Mulching with plastic film or residual crop materials can decrease moisture evaporation and improve crop yields. Other options include deep tillage and use of new drought-resistant strain seeds and/or seeds coated with a drought-resistant agent. Improved soil fertilization including increased planting of legumes and oilseeds as well as intercropping and crop rotation techniques may also be helpful. The replacement of annual (single-season) crops with perennials with large root systems, in particular, may allow maintenance of rich fertile soil with better water and carbon retention and associated reduction of carbon dioxide (a greenhouse gas) levels in the air.

Another option to address water scarcity in Northern China would be to redirect water from parts of Southern China where there is a more abundant supply. This, however, would be very expensive and would result in significant population dislocations. Shifting the production of some food crops from Northern to Southern China might also be a possibility. Other options would include improved industrial and household water usage and conservation which would stretch the overall water supply. Another choice would be for China to increase its imports of grain from producers in other parts of the world with larger water supplies. This is essentially equivalent to importing water, as it has been said that it takes 1,000 tons of water to produce one ton of grain.

The development of biofuel crops which require less water is of particular interest. These may include sorghum, sweet potato, and jatropha. Jatropha is a forest shrub with seeds containing a liquid which can be made into biodiesel. It can be grown in many areas without the use of much water or fertilizer. In India, there is interest in growing jatropha on poor quality land which would not be suitable for cultivation of food crops. This would hopefully decrease any disruption of food production which would be associated with jatropha cultivation. Sweet sorghum can often be grown in the setting of water scarcity and more saline soil, as may occur in the setting of poor irrigation and drainage. Dr. Bryan Lohmar, an agricultural economist with the US Department of Agriculture specializing in Chinese agriculture, recently returned from a research meeting in Beijing where these issues were discussed. Dr. Lohmar indicates that right now the plan in China, is to proceed conservatively with biofuel plants using sorghum or, more likely, sweet potato in Inner Mongolia and Hebei, although concerns have been raised about long-term effects on soil quality. Other biofuel sources may be pursued in Southern China where water is more abundant.

Possible Corporate, Governmental, and Non-Governmental Organization Activities

Corporate, governmental, and non-governmental organizations could help address the challenges discussed above in a number of ways. Non-governmental organizations such as the World Bank and United Nations agencies including the Food and Agriculture Organization and UN-Water may help by continuing to sponsor research into the problem of water scarcity and its effects, publicize the results of this research, and co-sponsor meetings where these issues may be discussed and approaches to these problems suggested. China's national and regional government and educational institutions could play an important role in co-sponsoring these meetings, and in formulating and enforcing policies based on solutions suggested there. In specific, China's government might make more efficient water use, water conservation, and adoption of dryland farming techniques a priority. The government might also consider encouraging increased agricultural production in Southern China, food crop imports from other countries, as well as the planting of biofuel crops such as jatropha, which require fewer land and water resources. Agricultural scientists in universities and corporations could help by developing and making available at affordable prices new food crop seed (including perennial crops, as discussed above) and biofuel crop seed which may be cultivated with the use of less water.

Conclusion

China has the world's largest population, with a rapidly growing economy and energy requirements. China is adopting a broad-based strategy in meeting its energy needs, and there is great interest in pursuing biofuel production as part of this strategy.

Hebei Province in the North China plain has been one of the most agriculturally productive areas of the country. While in the past subsistence farming on small family-owned farms has been dominant in this region, more recently there has been a shift towards commercial agricultural production of cereal and non-cereal cash crops. Hebei Province possesses limited water resources, and crop growth is largely dependent on intensive irrigation. The continued agricultural productivity of this region is threatened by increasing water scarcity. This water scarcity is the result of droughts from low rainfall, dropping aquifer levels, increased costs of deep well drilling, and increased competition for water from other industries.

In view of water shortage issues in Northern China, the main biofuel crops of interest, at present, are those which require less water than corn-based ethanol, such as sorghum, sweet potato, and jatropha. Additional biofuel crop production may be pursued in areas of Southern China with more abundant water supplies. The ideal biofuel crops will add to fuel supplies while minimizing additional stress on water supplies. Agricultural scientists at universities and corporations, the Chinese government and representatives of other governmental agencies such as the US Department of Agriculture, and non-governmental organizations such as the World Bank and the United Nations will hopefully be able to work together as partners to promote biofuel development in China and elsewhere while taking measures to ensure continued availability of an adequate food supply.

Bibliography

1. "China population clock." Chinability. 3 Sep 2007. 3 Sep 2007 <<http://www.chinability.com/China%20population%20clock.htm>>.
2. "China." CIA-The World Factbook. 16 Aug 2007. 20 Aug 2007 <<https://www.cia.gov/library/publications/the-world-factbook/print/ch.html>>.
3. "China economy." Economywatch.com. 20 Aug 2007 <http://www.economywatch.com/world_economy/china/>.
4. Collier, Robert. "A warming world." SFGate.com. 5 Mar 2007. 20 Aug 2007 <<http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/03/05/MNG18OFHF21.DTL>>.
5. "Energy summary of China." CSL Forum. 7 Dec 2007. 20 Aug 2007 <<http://www.cslforum.org/china.htm>>.
6. "World Biofuels Symposium-China." 3 Sep 2007. 3 Sep 2007 <<http://www.worldbiofuelssymposium.com/>>.
7. "Hebei Province." Wikipedia. 20 Aug 2007. 3 Sep 2007 <<http://en.wikipedia.org/wiki/Hebei>>.
8. "Hebei 2005—The Year in Review." China.org.cn. 8 Aug 2007 <<http://www.china.org.cn/english/features/ProvinceView/167819.htm>>.
9. "Hebei Province." People's Daily. 20 Aug 2007 <<http://english.peopledaily.com.cn/data/province/hebei.html>>.
10. "China Atlas of Population and Environment (2000) 7-12: Changes in Groundwater Level." China Data Online. 20 Aug 2007 <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=255>>.
11. McColl, Robert W. "Understanding the Geographies of China." Education about Asia. 4.2 (1999) 20 Aug 2007 <<http://www.aasianst.org/EAA/mccoll.htm>>.
12. Gale, Fred. Senior Economist, China Team, US Department of Agriculture, Economic Research Service, "Re: Subsistence Agriculture in China." E-mail to the author, 13 Aug 2007
13. "United States Farm and Farm-Related Employment, 2002." Economic Research Service. United States Department of Agriculture. 1 March, 2005. 8 Aug 2007 <http://www.ers.usda.gov/Data/FarmandRelatedEmployment/ViewData.asp?GeoAreaPick=STAUS_United%20States>.
14. "China Atlas of Population and Environment (2000), Housing and Consumption Level of Population, 3-2: Domestic Households." China Data Online. 8 Aug 2007 <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=187>>.
15. "China Atlas of Population and Environment (2000), Population and Health, 2-3: Age Structure." China Data Online. 20 Aug 2007 <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=170>>.

16. Rector, Robert E. and Johnson, Kirk A. "Understanding Poverty in America." The Heritage Foundation. Jan 5, 2004. 20 Aug 2007 <<http://www.heritage.org/Research/Welfare/bg1713.cfm>>.
17. "China Atlas of Population and Environment (2000), Housing and Consumption Level of Population, 3-4: Rural Per-Capita Residential Space." China Data Online. 2 Aug 2007. <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=189>>.
18. "Americans Spend Less Than 10 Percent of Disposable Income on Food." Salem-News.com. 19 Jul 2006. 8 Aug 2007 <http://www.salem-news.com/articles/july192006/food_prices_71906.php>.
19. Ramankutty Navin, Olejniczak Nicholas, Foley Jonathan. "Croplands of the Earth". 20 Aug 2007. <<http://www.sage.wisc.edu/download/potveg/CropPoster.pdf>>
20. Gale Fred, Tang Ping, Bai Xian Hong, Xu Hui Jun. "Commercialization of Food Consumption in Rural China." Economic Research Report Number 8 from the Economic Research Service, USDA, July 2005. 18 Aug 2007. <<http://151.121.68.30/publications/err8/err8fm.pdf>>
21. "Illiterate Population." China Data Online. 20 Aug 2007 <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=310>>
22. "Hebei Province Economy." Wikipedia. 20 Aug 2007. 3 Sep 2007 <<http://en.wikipedia.org/wiki/Hebei#Economy>>
23. Hsu Hsin Hui, Gale Fred. "Regional Shifts in China's Cotton Production and Use." Nov 2001. 18 Aug 2007 <<http://www.ers.usda.gov/Briefing/Cotton/PDF/Chinacotton.pdf>>
24. Fok Michel, Liang Wei Li, Xu Nai Yin. "Cotton in China--a giant with intensive sustainable smallholdings run by women." 2006. 21 Aug 2007. <http://www.cirad.fr/dossiers_en/content/download/1359/7756/file/Cotton_China.pdf_2006>
25. Zhu Yu. "China's Dryland Farming and Practices". 3 Sept 2007 <<http://www.lanl.gov/chinawater/documents/zhuyu.pdf>>
26. UN-Water. Coping with World Water Scarcity. 2007. 21 Aug 2007 <http://www.unwater.org/wwd07/>_downloads/documents/escarcity.pdf>
27. Lohmar Bryan, and Hansen James. "Interactions Between Resource Scarcity and Trade Policy: The Potential Effects of Water Scarcity on China's Agricultural Economy under the Current TRQ Regime." United States Department of Agriculture, June 2007.
28. "Water-level Changes of Groundwater." China Data Online 20 Aug 2007. <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=255>>
29. "Water Quality Type Along Major Water Systems." China Data Online 20 Aug 2007. <<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=247>>

30. "Pollution of Groundwater." China Data Online 20 Aug 2007.
<<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=256>>
31. Fratini G, Da Canal S., Valentini R. "Dust storms and rural development in North China". 21 Aug 2007.
<http://www.unccd.int/publicinfo/events/docs/dust_storms.pdf>
32. "Frequency of Sandstorm." China Data Online 20 Aug 2007.
<<http://chinadataonline.org/member/atlas2000/ybtableview.asp?ID=275>>
33. Lohmar Bryan, Wang Jin Xia. "Will Water Scarcity Affect Agricultural Production in China?" 15 Aug 2007. <<http://www.ers.usda.gov/publications/aib775/aib775o.pdf>>
34. "China Agricultural and Economic Data: National Data Results". 15 Aug 2007.
<<http://www.ers.usda.gov/Data/China/NationalResults.aspx?DataType=6&DataItem=125&StrDatatype=Agricultural+inputs&ReportType=0>>
35. Brown, Lester. "Worsening Water Shortages Threaten China's Food Security." 18 Aug 2007
<<http://www.earth-policy.org/Updates/Update1.htm> 2001>
36. Reidy, Susan. "BFJ.com EXCLUSIVE: New Research Paper Finds Water Availability Critical to Growth of Ethanol Industry." 18 Aug 2007
<http://www.grainnet.com/articles/BFJ.com_EXCLUSIVE_New_Research_Paper_Finds_Water_Availability_Critical_to_Growth_of_Ethanol_Industry-38850.html>
37. "World Food Reserves Threatened by Ethanol Production." 19 May 2007. 3 Sept 2007
<<http://www.inteldaily.com/?c=135&a=2059>>
38. Mou Hai Sheng. "Rainwater utilization for sustainable development in north China." 1995 Waterlines 14(2): 19-21 18 Aug 2007 <<http://trophort.com/002/682/002682220.html>>
39. Glover Jerry, Cox Cindy, and Reganold John. "Future Farming: A Return to Roots." Scientific American August 2007 pages 82-89.
40. Lohmar, Bryan, China Team, US Department of Agriculture, Economic Research Service. E-mail to the author re: "Water Scarcity and Chinese Agriculture" dated 9 Aug 2007.
41. Lohmar, Bryan, China Team, US Department of Agriculture, Economic Research Service. E-mail to the author re: "Water Scarcity and Chinese Agriculture" dated 3 Sept 2007.
42. Barta, Patrick. "Jatropha Plant Gains Steam in Global Race for Biofuels." Wall Street Journal, August 24, 2007.
43. " Hebei Province". Chinese Business Worldcom 19 Sept 2007
<http://www.cbw.com/general/gintro/hebei.html>