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Agricultural Situation

Water Situation in the North China Plain

2008

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Report Highlights:
Water resources play a major role in China's incredible economic growth and rapid development. Over the last 20 years, the speed in which this growth has taken place has led to the current crisis facing China: the overexploitation and pollution of water resources. In the North China Plain, groundwater overexploitation is the most pressing problem because it is unsustainable. It is difficult to say with exact certainty how agricultural production will be impacted by water scarcity and pollution. Most likely, agricultural imports will be needed. The type and volume of goods that will be imported depend on the policy initiatives implemented by the government.

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Introduction

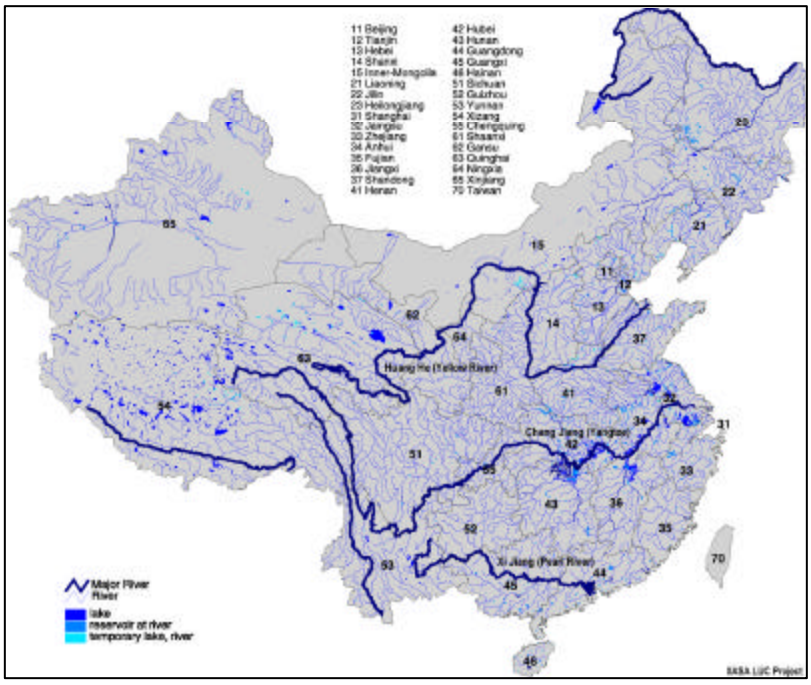
Water resources play a major role in China's incredible economic growth and rapid development. Over the last 20 years, the speed in which this growth has taken place has led to the current crisis facing China: the overexploitation and pollution of water resources. In agriculture, the issues of water availability and quality have serious ramifications for production levels. This report will focus on the water-scarce, agriculture intense North China Plain. The North China Plain includes three provinces and the municipalities of Beijing and Tianjin. The focus of this report is on how the water scarcity and pollution issues in the plain will impact agricultural production in this region.

Overview of China's Water Situation

Boats in the South, Buses in the North

China's total water supply is the fifth largest in the world; however, as it is needed to supply the world's largest population, per capita water supply in China is among the world's lowest. The annual water resources available in China are 2,800 billion m^3, or approximately 7 percent of total world supply. However China which represents 20 percent of global population, produces more food – 20 percent of global production - than any other nation in the world. This relatively low water supply is further stressed by its uneven distribution. Most of China's water resources are located in the south. According to the Ministry of Agriculture, southern China has 80 percent of the country's total water supply but only 36 percent of the total farmland. In contrast, northern China has less than 18 percent of the total water supply, but 64 percent of the country's farmland, and a population of approximately 500 million (37 percent of total). The unbalanced distribution of water resources results in a very tight supply in northern China (see Figure 1). China currently has approximately 140 million hectares of cultivated land compared with the U.S., which has 165 million hectares of arable land (CIA, 2008). This arable land area is decreasing however, as a result of increasing industrial development including transportation networks, expanding urban areas, and spreading desertification.

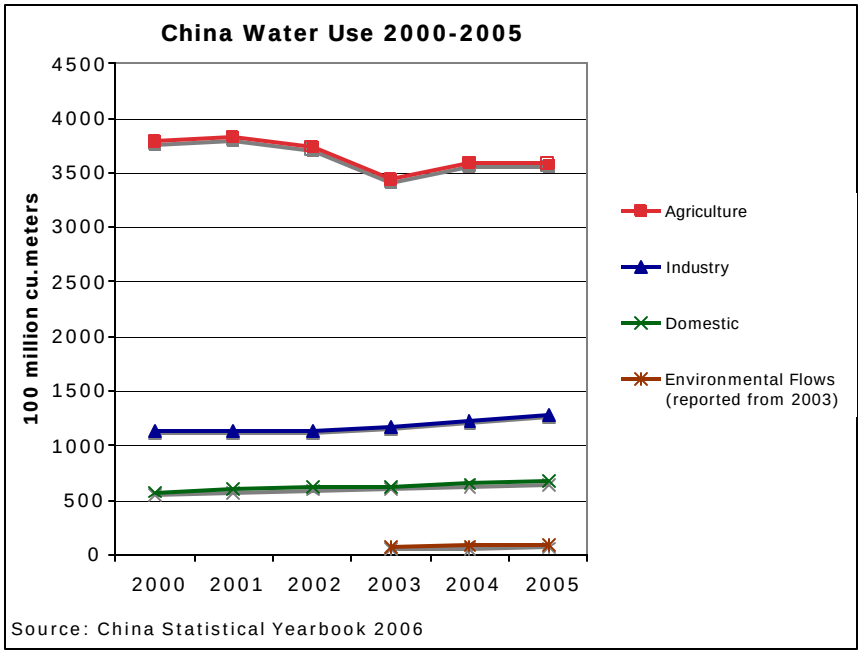
Figure 1: Map of China's Surface Water Resources



Source: International Institute for Applied Systems Analysis, 1999

Northern China has less water than southern China but a greater percentage of arable land and is therefore, the area where most of the corn and wheat are produced. Rice, the largest grain crop, is produced in the south due to the available water resources. The majority of this agricultural production occurs with the aid of significant irrigation. In the past, agriculture received priority for water resources due to the government's food security policy. However, a rapidly growing urban population and an expanding industrial sector, aided by an industrial growth policy supported by the government, have changed the dynamics of water usage. Urban and industrial consumers are rapidly increasing their water demands. This has led to increasing disputes regarding the allocation of the tight water supply amongst the main water consumers in northern China: agriculture, industry, and the domestic sector (see Figure 2).

Figure 2:



Growth in water demand, more frequent droughts (attributed by some to global warming), and a stagnant water supply, all contribute to the overexploitation of water resources of both ground and surface water. This overexploitation of water resources in northern China has led to concern of a pending water crisis.

This potential water crisis coupled with the gradual decrease in water allocated for agriculture may have serious consequences for China's most productive agriculture region for wheat and corn production, the north. Within northern China, the North China Plain is the most productive agricultural area and the most water stressed.

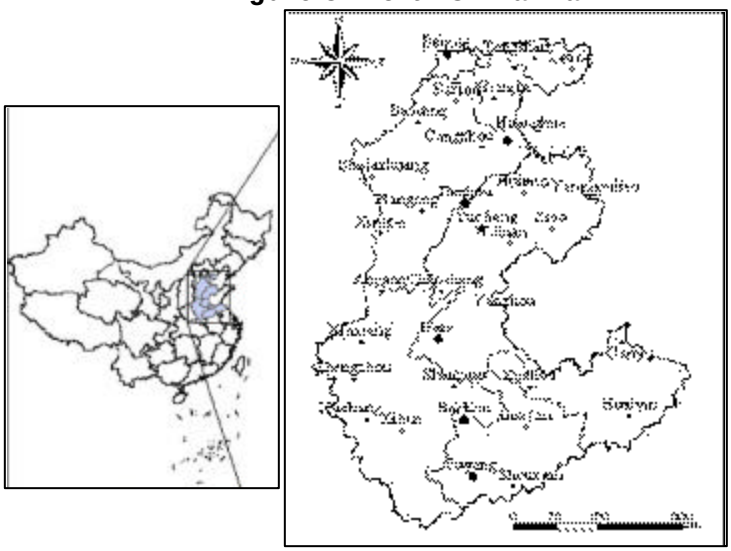
REGIONAL FOCUS: North China Plain

China's Breadbasket

The North China Plain (NCP) covers an area of 320,000km^2, roughly the size of New Mexico, and is inhabited by 200 million people (New Mexico: 2 million) (Kendy, 2003). The NCP area includes: Heibei, Henan, and Shandong Provinces and the municipalities of Beijing and Tianjin (see Figure 3). In the NCP, there are several water resource problems. Groundwater overexploitation is the most pressing because it is unsustainable. There is also surface water overexploitation, water pollution generated from heavy industrialization and agriculture production, and, in certain areas, salt water intrusion in aquifers and land subsidence due to groundwater withdrawal. The NCP has restricted rainfall, depends on groundwater for 60

percent of its water supply (an unsustainable level), and is one of the most densely populated and developed areas of China. Together, this has resulted in continually increasing demands on the already highly constrained water supply. The NCP has the most severe water depletion in China and will continue to face severe water scarcity issues if the government does not act quickly to secure water efficiency gains where possible in agricultural and industrial water use.

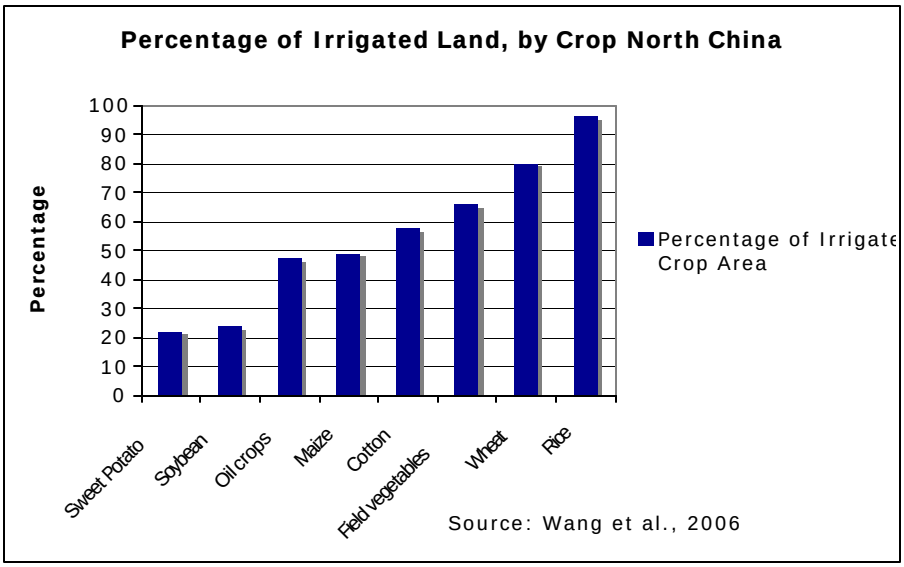
Figure 3: North China Plain



A. Agriculture Background

Agricultural production in the North China Plain region includes grains, cotton, and a variety of vegetables, fruits, and cash crops (e.g., peanuts and fresh flowers) (WB, 2000). Agricultural production in the NCP is the main support for China's food self-sufficiency policy with 50 percent of wheat, more than 50 percent of vegetables and fruit, and 33 percent of corn grown in the plain. The majority of these crops depend on irrigation, which means that pending water scarcity issues must be addressed or the production of these crops will be severely compromised. The percentage of land that is irrigated is shown below in figure 3 by type of crop. Sweet potatoes and soybeans are the only crops where significantly less than 50 percent of the field area is irrigated.

Figure 3:



In order to meet the growing demand for grains and improve their incomes, farmers in the NCP rely on irrigation to double crop. Double cropping includes an irrigated winter wheat crop harvested in early June followed by a corn or cotton crop harvested in early September. In addition to the double cropping, farmers also inter-crop. Typically, they plant a second crop within their wheat crop field, usually a more profitable cash crop such as peanuts, in order to diversify production and increase overall income (see Figure 4). Farmers are also producing higher value fruit and vegetable crops, often using more efficient drip and sprinkler irrigation systems where groundwater is available[1]. These are often produced in simple green houses to maximize yields. Without irrigation, farmers would be unable to double-crop or produce enough fruits and vegetables to justify the additional fertilizer and labor expenses.

Figure 4: Example of inter-cropping

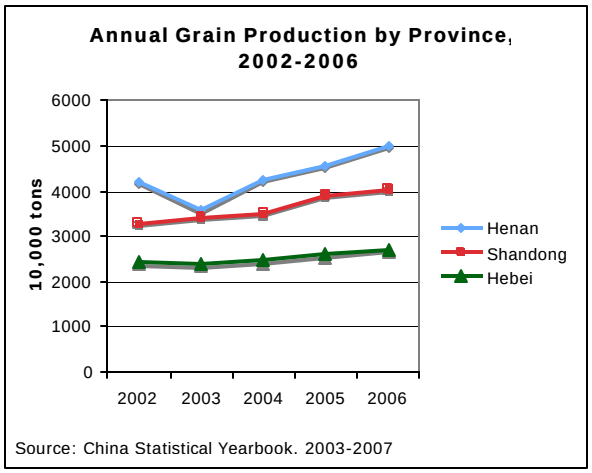
Source: Field Visit, Hetao Irrigation District, Inner Mongolia May 2008

The impact of water scarcity has not *yet* affected aggregate agricultural production.

[1] Drip and sprinkler irrigation systems are difficult to use with the way surface water is allocated for irrigation in China

The three provinces in the North China Plain have not seen a decrease in grain production over the period 2002-2006. As the most heavily irrigated crop, wheat production in the North China Plain is entirely dependent on irrigation and thus, any water shortages would most likely be seen through lower grain output figures (see Figure 5) (Lohmar and Wang, 2002).

Figure 5:



Source: China Statistical Yearbook. 2003-2007

B. Water Resources

The North China Plain averages 18.9 in (480 mm) of annual precipitation but this can vary from 300 to 1,000 mm. The majority, 60-80 percent, of annual precipitation falls in the summer months. Due to variable rainfall patterns and recent droughts, a large share of the cropland for most types of crops grown in the NCP is irrigated (see Figure 3 above). Corn is typically rainfed but in drought years it is irrigated with either ground or surface water. Consequently, ground and surface water are the most common sources of irrigation water during 'normal' years. As in the rest of the nation, the NCP faces increasing competition for its tight water supply. Beijing and Tianjin are two of the fastest growing cities in the nation and their water demands are growing at an equally rapid pace.

Two-thirds of the total water supply in China is used for agricultural production (see Figure 2). In the North China Plain, groundwater[2] is the mostly widely used water source. Reflected in Figures 6 and 7 below, China as a whole has a more abundant supply of surface water (Figure 6), but in northern China groundwater is in greater supply and thus, provides a much larger share of the water used for irrigation (Figure 7). This has led to the overuse of groundwater, which is proving to be unsustainable. Many Chinese officials within the North China Plain reference the forthcoming South-to-North water transfer project as a solution to the pending crisis. The middle route is expected to begin delivery of 13 billion m^3 of water in late 2008 for municipal and industrial use in Beijing, Tianjin Municipalities, Hebei, Henan, and Hubei Provinces from the Yangtze River in the South (MWR, 2004). However, the cost of the water is too high for agricultural users. To remedy this situation, officials have suggested that it will free available water for agricultural uses. Due to the rapidly expanding demands of the cities and municipalities in the North China Plain and the overexploitation which is currently occurring in the region, Post does not anticipate that the water supply from the South-to-North water transfer project will significantly increase the water available for agricultural use.

[2] Water within the earth especially that which supplies wells and springs (Merriam-Webster, 2008).

Figure 6:

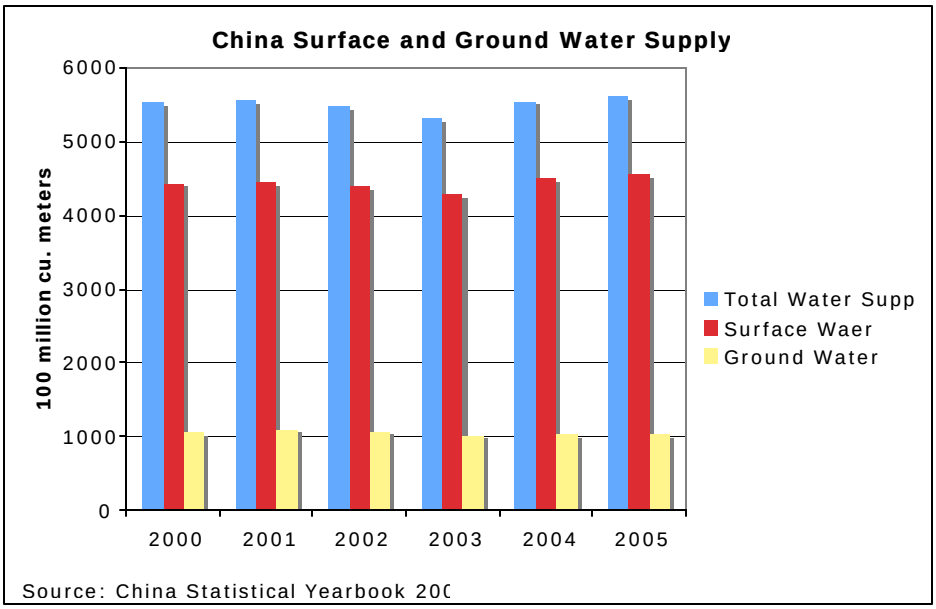
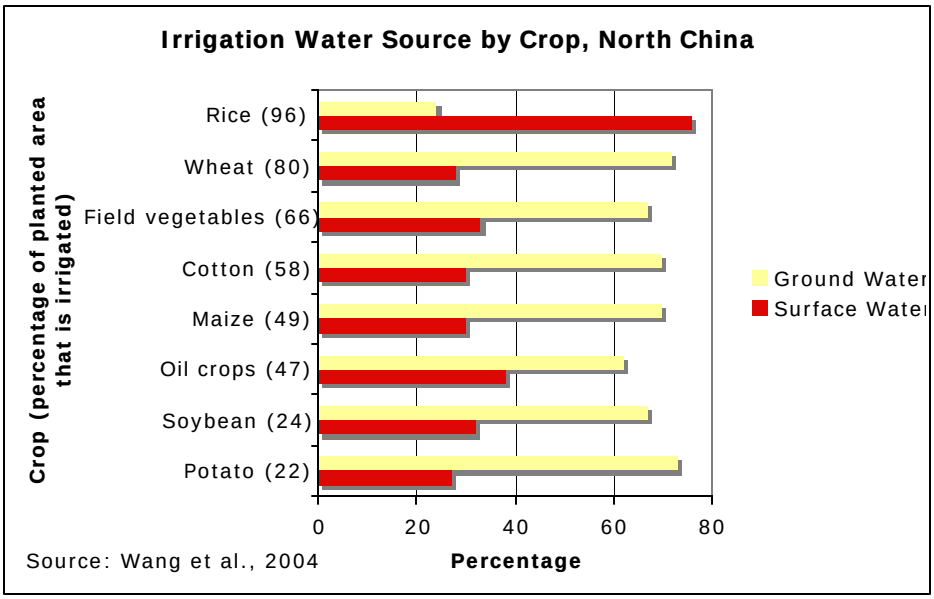


Figure 7:



1. Ground Water

Groundwater is an available source of water for irrigation in the NCP. Farmers prefer ground water for irrigation because this allows them to double crop their land. Wells are typically dug by farmers themselves though private operators have become increasingly present because of the growing costs associated with drilling deeper and deeper wells. The deeper wells are necessary as the more shallow aquifers are running dry as a result of unregulated withdrawal by urban and industrial consumers. The cumulative effect of farmers digging deeper wells and urban dwellers consuming larger amounts of water have reduced the amount of time available for the groundwater to recharge. In many areas of the NCP, groundwater tables are dropping at a rate greater than 1 meter per year, which many water specialists have extrapolated to be an unsustainable rate. The impact of overexploitation is not limited to a decrease in available water, however. Falling water tables also cause land

subsidence and water quality problems. Moreover, certain areas near the coast face salt water intrusion as the water tables fall below sea level.

2. Surface Water

Surface water resources on the NCP flow from three river basins: the Hai River in the North, Huai River in the South, and the Yellow River in the middle. Within the NCP, the supply of water from these rivers is distributed through irrigation districts. Farmers are charged by the quantity of mu irrigated (15 mu is equivalent to one hectare), not by the volume of water received. The NCP is the downstream region for the three rivers and as demand has increased on the upstream portions, rivers flows have decreased leading farmers in the NCP to exploit available ground water supplies even more heavily.

C. Irrigation Water Use

The majority of farmers in the NCP do not use water efficiently for irrigation. Many factors contribute to this inefficient water use including: inefficient water delivery methods, the low cost of water, the high cost of drip and sprinkler systems, and a lack of education. Surface water is delivered through canals running alongside fields where, during the irrigation season, water is available 4-5 times. Farmers use a flood irrigation method when water is delivered through canals (see Figure 8). This is a highly inefficient method of irrigation. However, the design of this canal system makes it very difficult for farmers to adopt more efficient irrigation techniques such as drip or sprinkler systems. These technologies would require off-stream storage for the water in areas where very little, if any, land is available. With water only available 4-5 times during an irrigation season and having little knowledge on irrigation best practices, farmers simply take all that is available to them when there is water in the canal. Also, farmers are charged for surface water irrigated, not for the volume of water applied, which further discourages efficient water application.

Figure 8: Flood Irrigation

Source: Field Visit, Hetao Irrigation District, Inner Mongolia May 2008

Groundwater for irrigation use is different than surface water. Ground water is delivered when farmers need it which allows them, if funds are available, to purchase more efficient drip or sprinkler irrigation systems to apply water according to their crop requirements. Farmers pay the cost of electricity or diesel used to pump groundwater, not the true cost of water. However, the price does take into account its scarcity because pumping costs increase with the depth of the wells. According to a survey conducted by the Center for Chinese Agricultural Policy and the University of California, Davis in Hebei Province, as water tables fall, the share of cash crops planted increases. The survey showed that a drop in the water table depth from 4.7 to 79 meters resulted in the share of cash crops increasing from 13 to 41 percent (Wang et al., 2007). This demonstrates that farmers alter their production decisions based on higher water prices (in the form of higher electricity/diesel costs

associated with pumping from deeper wells). Cash crops also provide greater income and allow farmers the opportunity to purchase the more efficient drip and sprinkler irrigation systems. It is encouraging that farmers are responding to price incentives but this is only occurring in small areas of the NCP and does not mitigate the overexploitation of water resources.

The inefficient use of water leaves considerable room for water production gains. If these inefficiencies were addressed, farmers would have a more reliable water supply. A more reliable water supply might compensate for reductions in total water supply as far as impacting agricultural production. The NCP is home to millions of poor farmers with little education so the initiative to support changes in irrigation water use will have to come from the government.

D. Water Quality Issues

The pollution of China's water resources is a critical issue. Untreated industrial and municipal water are the main sources of pollutants that are severely affecting China's major rivers and, in some areas, ground water supplies. Agricultural inputs, such as fertilizers and pesticides, along with human and animal waste also contribute to polluted water. These pollutants have the greatest impact on humans causing cancer, birth defects, and spreading water borne diseases (Larmer, 2008).

Water quality in China is measured by a Grade system, I-V. Grade I represents drinking water and Grade V is unfit for any use without treatment, provided treatment is possible. Among the 27 lakes and reservoirs monitored by the Ministry of Environmental Protection in 2004, none met the Grade I standard, only two met the Grade II standard, five met the Grade III standard, four met the Grade IV standard, and 6 met the Grade V standard (3 of which were large lakes) (WB, 2007). It is important to note that irrigation water for many crops (vegetables are the main exception) can safely be irrigated with Grade III and, depending on the crop, Grade IV water. Thus, agricultural users have more water resources available compared with municipal users. Despite the greater available water resources, annual agricultural losses due to water scarcity and water pollution are still very large. Estimates of the losses range from $8.2 billion (Chinese news media estimate) to $24 billion (World Bank estimate) (Turner, 2006).

The government has begun taking pollution seriously with a recent pledge to allocate $200 billion annually towards the environment. An important element in its new efforts must be the enforcement of existing laws against industrial polluters; this may dampen economic growth but water is a nonrenewable resource. Without it, economic growth would be challenging.

E. Water Management

Water is difficult for all nations to manage simply due to its nature; it is difficult to monitor and measure use, complicated to assign usage and/or ownership rights, and neither supply nor demand remains static. In China, at the *national* government level alone there are 6 separate agencies involved in different aspects of water: policy, development of resources, irrigation, groundwater levels, environment, and price-setting. There is an even greater number of agencies involved at the provincial, city, and village levels. In the case of irrigation, the Ministry of Water Resources (MWR) and the Ministry of Agriculture (MOA) work together to develop local delivery plans and disseminate water saving technology. The MWR is also responsible for the creation and execution of water policy, including the pricing and allocation of water resources (Lohmar et al., 2003). The management of water also differs by type - surface versus ground water.

Surface water is allocated and delivered to villages by irrigation districts (IDs). The IDs are allotted their total water supplies through the major river conservancy commissions, which have 'control' of the entire river flow as it passes through all provinces. The price of water for irrigation is very low and is determined by Local Price Bureaus under the guidance of the National Price Bureau. At such a low price, the IDs are under funded and thus,

irrigation infrastructure is not well maintained. Furthermore, the irrigation districts have little incentive to improve delivery times and volume because they have no control over fees (Lohmar et al., 2008). Improvements in surface water management would best be made at the local level where potential efficiency gains are the largest.

Ground water is managed at the village level with no communication between consumers in different villages or towns who are all withdrawing from the same aquifer. In the past, all pumps were owned collectively. However, over the last twenty years, the number of privately owned wells has increased with little repercussions as, technically, all water is state-owned (Lohmar et al., 2008). Essentially, this means that there is no control over ground water pumping. With ground water tables falling rapidly, the owners of privately owned wells may pump themselves out of a market unless the government decides to take countervailing action soon.

Impact on Agricultural Production and Trade

There are a number of factors that will influence how water scarcity impacts agricultural production in the future, including China's policies regarding water, the environment, and food security, commodity market prices, production costs, and science. China has a history of remarkable achievements; its incredible economic growth over the last thirty years is the most recent example. Thus, it is difficult to say with exact certainty how agricultural production will react to the various factors. China may be able to mitigate the anticipated water crisis and its impact on agricultural production.

It can, however, be said with certainty that agricultural production inputs, such as arable land and water, are becoming increasingly scarce and the quality increasingly lower. While recovery is possible, to a certain extent, demand is continually increasing and applying constant pressure to the food supply. Most likely, agricultural imports will help relieve this pressure. The type and volume of goods that will be imported depend on the policy initiatives the government implements. Global market prices for commodities and input prices (oil, water, labor) will also influence China's production. And finally, science has a major role to play in China's future agricultural output. There remain many efficiency gains possible with the prudent application of agricultural inputs and a commitment to agricultural research and development.

A. Policy

In 1994, the Chinese government raised grain support prices, which shifted production away from soybeans. As a result, soybean production decreased, demand continued to increase, and China shifted from being a net exporter to a net importer of soybeans (Brown, 2001). The U.S. was able to fill the unmet demand and in 2007, U.S. soybeans exported to China totaled over $4 billion. Government policy decisions have a significant impact on China's agricultural production and due to the large population and growing demand for food, their decisions also impact the world agricultural trade market.

Grain production is currently being encouraged through minimum support payments to support the food security policy. Grains require large amounts of water to produce. If government policy restricts irrigation water use due to increasing scarcity they may also remove the minimum support payments and relax the food security policy. Production would shift to alternative crops which may include fruits and vegetables. On the global market, this would result in an increase in the demand for grains. The added fruit and vegetable production might be absorbed by the growing domestic demand or increase global market supplies.

Environmental concerns are rising and fertilizer is a pollutant that is contaminating water resources. Fruits and vegetables require greater amounts of fertilizer than grains. If the government implements a policy to restrict fertilizer use, there might be a shift toward the production of less fertilizer intensive crops such as grains. This would increase the production of grains and world market supplies.

B. World Prices and Input Cost

World grain prices significantly influence production decisions. Grains are water intensive and thus, very expensive to produce in China when the *true* value of water is incorporated into the costs of production. However, if world grain prices continue to increase, the high domestic cost of producing grains, including the cost of water, may justify the continual domestic production of grains.

The cost of water as an agricultural input has increased for those farmers who use ground water drawn from deep wells. These farmers have reacted by shifting production to higher-value crops such as fruits and vegetables (see the section entitled "Irrigation Water Use" above). If the government implements policies to increase the cost of water for irrigation, this would suggest that an even larger number of farmers would shift their production to higher-value crops thus, creating a demand on the world market for grains. As many farmers currently face very low water charges, a price increase of as little as 10 percent may cause a significant and swift reaction in production decisions.

C. Science

Science has the potential to play a major role in preventing the water scarcity crisis predicted to hit China. There are vast water productivity gains possible in agriculture, the largest water consuming industry, with on-time irrigation water application, more efficient irrigation systems, use of higher yielding and drought-resistant seed varieties, and improved knowledge of water and fertilizer use on the part of the farmer. In order to secure these productivity gains, the government has to invest a significant amount of resources to build infrastructure and provide farmers with more efficient irrigation systems, investment in scientific research and development, and education extension programs.

On-time irrigation water application would allow farmers to apply water when needed and in the volume required to maximize plant growth. The current surface water distribution system is not set up for this type of irrigation. It would require investment in infrastructure at the village level, investment in research and development to determine optimal water application volumes for plant varieties grown, and investment in the education of farmers on optimal water use. Many farmers, particularly those using the flood irrigation method, irrigate with excessive amounts of water. A reduction on this over-use would significantly reduce overall irrigation water use and increase yields, as plants would be receiving optimal quantities of inputs. Currently, Chinese yields are lower than the rest of the world so improvements in production technology that do not require an increase in inputs may improve yields.

The development of higher yielding, drought resistant crops could reduce agricultural production losses expected from increasing water scarcity. International researchers have recently started to develop new strains of corn, rice, canola, and other crops through genetic engineering (GE) and conventional breeding, which can produce high yields even under drought and water-stressed conditions (Pennisi, 2008). China has also been investing heavily in GE crop research; research is being conducted on GE rice, wheat, corn, and soybeans. This is in spite of the fact that current government policy does not generally allow the production of transgenic food plants (Mahr, 2008). If the government approves the use of the genetically engineered varieties of these crops, a 10 to 15 percent yield increase could be expected.

Pollution caused by fertilizer, pesticide, and herbicide applications can also be dramatically reduced through the dissemination of information on optimal application quantities. Farmers in the North China Plain over-use water, fertilizer, pesticides, and herbicides.

Conclusion

China's water resources are currently being stretched beyond a sustainable level. Water shortages in the NCP will significantly affect agricultural production in the type of

commodities grown and the volume and value of production. The falling ground water tables and the decreasing volume of available surface water are enough for certain observers to predict a pending water crisis. The agriculture industry faces increasing competition for these limited water resources from industrial and urban consumers. While government policies implemented to prevent further water pollution by industry may slow growth, increasing demand from urban consumers is expected to increase dramatically. During the past 20 years, China has undergone the largest urbanization in human history with more than 572 million people living in urban areas and another 428 million people expected to migrate by 2030 when urban population will reach an unprecedented 1 billion (Woetzel, 2008).

The Chinese government will soon be forced to make difficult decisions in order to address the pending crisis. However, it is difficult to predict the impact on Chinese agricultural production and potential new markets for U.S. exporters. If the government maintains their grain self-sufficiency policy, this will put extreme pressure on the NCP's water resources. If the government aggressively pursues pollution control in the industrial sector, economic growth may decrease. If the government continues to support the policy to increase rural incomes without land reform, economies of scale in agricultural production and maximum yields will be difficult to attain. If the government fully supports science-based initiatives to address water scarcity, water productivity gains may be achieved, yields may increase, and agricultural production may not shift significantly. There are also external factors such as the cost of inputs, which are not limited to water but also include labor (increasing as urbanization expands) and oil (used for transportation and fertilizer).

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