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China, Factor 2

China: Water Scarcity and Inland Aquaculture

With approximately 1.34 billion people, China is the most populated country in the world. (Beijing Official Website). China also has one of the fastest growing economies in the world, recently passing Japan to become the second largest economy, after the USA (China GDP). This growth is resulting in an increasing demand for high quality food. Due to the country's growing population as well as recent strains on food production, due to factors such as widespread drought affecting much of its agricultural areas, China must currently rely on food imports, including corn and soybeans, to supplement its own food production (Mayer). In addition to the increasing demand for the quantity of food, the stronger Chinese economy is resulting in the increasing demand for a better quality of food, with people having more money to spend on higher quality, high protein foods such as dairy, meat, and fish (China GDP).

With China's growing economy, total calorie and protein consumption have both been increasing (Table-Food Calorie Consumption). Protein consumption has risen from an average of 67 grams/day in 1990 to 89 grams/day in 2007 (Daily Protein Per Capita). Fish have been an important source of protein in China, providing about 16% of the protein in the average diet in 1998. In 2003, fish consumption in China was 25.8 kg per person annually, compared with 16.5 kg per person in other countries(Agricultural Outlook).

At the 2005 World Food Prize symposium, Dr. Norman Borlaug, Nobel Peace Prize laureate and World Food Prize founder, said "In the future, I expect that aquaculture will play a much bigger role in the world's food supply" (Hesser, 2006). Improvements in aquaculture, the breeding of fish on farms for food, could help China meet its increasing demand for larger quantities of high protein food (Output of Aquatic Products). However, the aquaculture industry, while having a long history in China, will first need to overcome significant challenges in order to meet this goal of increased production. One of the aquaculture industry's main requirements is the availability of a clean and reliable water supply. Currently, much of China is experiencing a water shortage, due to both increasing drought and a lack of adequate water infrastructure. This significant challenge of water scarcity will need to be adequately addressed in order for aquaculture to play a larger role in feeding the increasing population of China (Zhang).

The size of the Chinese population has been partly controlled by the government's "one child policy", begun in 1979 to try to limit overpopulation. In most Chinese families, sons have been preferred over daughters, with the thinking that sons could work better on family farms as well as better support their parents in retirement. There have been some exceptions to this "one child policy", such as farm families being allowed to have a second child if the first child is a female. Despite the "one child policy", however, it is estimated that the population of China will increase by at least 10 million people per year, putting further pressure on water and food supplies (World Fact Book).

Farming is becoming a less common career choice, with more and more young people migrating to cities in search of better jobs. In 2007, about 40% of the Chinese population lived in cities. As of 2012, the population was split almost evenly between city and country (World Fact Book) and by 2040 the percent of all people living in cities is expected to reach 75%. More than 100 cities in China have populations of over one million people, compared with only 9 cities in the U.S. Although there is a great amount of construction occurring in China, there are still many problems with housing, sanitation, water, power, and jobs for people living in Chinese cities (Schneider).

With more people moving into the cities, the farm labor population in the countryside has been decreasing. In 1996, about 75% of the rural working people were farmers. This number decreased to 70.8% in 2006. Most family farms in China are small, ranging from 0.3 hectares (about 0.75 acres) for small rice farms to 0.6 hectares for combined rice and vegetable farms. A 2005 farm survey showed about 2.5 full time family workers on these small farms. Small farms growing rice only earned 2626 yuan (about 350 US dollars) per year. Farms growing both rice and vegetables were more profitable, earning as much as 31,339 yuan per year (Table Food Calorie).

Adding to the recent issues of fewer farm workers, only 15% of China's land is farmable. Seventy five percent of that land is used for food crops. Chinese farmers near cities are also trying to increase production of non-grain food crops such as vegetables and milk. Rice is the main grain crop of China and is mostly grown in the southern provinces. Wheat is the second most important grain crop in China. It is grown in most parts of the country, but especially on the North China Plain, the Wei and Fen River valleys on the Loess plateau, and in Jiangsu, Hubei, and the Sichuan provinces. Also, corn and millet are grown in Northern and Northeast China, and oats are important in Inner Mongolia and Tibet. Other crops include sweet potatoes in the South and white potatoes in the North. Cotton, vegetables, hogs, poultry, and cattle are raised throughout the country (Agriculture-Crop Cultivation).

With so little of China's land being suitable for farming, aquaculture may be an attractive alternative for feeding China's growing population and increasing the availability of high protein food. Aquaculture is the fastest growing type of protein production in the world according to a 1990-2002 study by the United Nations Food and Agricultural Organization (FAO). One reason that aquaculture is growing so rapidly is that it is an efficient way of converting grain into animal protein. Fish have a low feed conversion ratio (known as the "FCR"), which is the ratio of pounds of food fed to an animal compared to the pounds of protein produced from the animal. Beef has an FCR of about 8, meaning that it takes 8 pounds of feed to be converted into 1 pound of beef. Pigs and poultry have FCR's of 3 and 2, while different types of fish have FCR's of 1.5-2.0. Farming fish therefore has a big advantage in protein production, especially when feed supplies are limited and the population needing protein is large (Salmon).

In 2004, the total world fish production was 140 million tons, and 1/3 of this was from aquaculture. The value of aquaculture production in 2009 was $86 billion. While the recent growth rate of ocean-caught fish has only been 0.5%, recent aquaculture production has increased 10.2% per year (Aquaculture). About 90% of world aquaculture comes from Asia, with the majority of that coming from China. In 2005, about 32.4 million tons of fish were obtained through aquaculture in China (Led by China). In comparison, the USA is 10th in the world for aquaculture, producing 0.61 millions of tons of fish per year, although aquaculture production is growing in the USA as well (Aquaculture).

Aquaculture plays an important role in the Chinese economy and in the economic well-being of the Chinese farmer. About 4.49 million people are involved in aquaculture, an increase of about 25% between 1999 and 2004 (FAO Fisheries). In China, aquaculture is currently practiced both in ponds in the interior of the country as well as also along the coastal regions (Beijing Official Website). Marine (salt-water) aquaculture accounted for about 40% of fish and aquatic plant production in China in 2004, an increase of about 35% from 1999. Shellfish including oysters, clams and razor clams, mussels, shrimp, and scallops accounted for 77.8% of this total, with other important marine farmed products including seaweed, crustaceans, sea cucumber, sea urchin, and jellyfish. The leading provinces for marine aquaculture production in 2004 were Shandong, on the eastern edge of the North China Plain, followed by Fujian on the southeast coast and Guangdong on the southern coast (FAO).

Inland aquaculture in China is thought to have started as early as 3500 BC. Even in ancient times, fish were found to grow well in ponds that occurred after flooding of rice paddies. In recent years, the land

used for aquaculture has significantly increased. Since much of inland aquaculture occurs in the countryside, the growth in aquaculture has helped rural development. Of 5.664 million hectares of land used for aquaculture, 42.9% is in ponds, 29.8% is in reservoirs, 16.6% is in lakes, and 6.7% is in rivers. In addition, another 1.63 million hectares of land are used for both rice and fish production (FAO). The combination of aquaculture with crop farming can be financially good for the small farmer, generating up to a 25-150% return on investment (Tremblay). Fresh fish are preferred by Chinese consumers, and therefore the major inland aquaculture regions are close to large cities in the middle and lower Yangtze valley and the Pearl River delta (Aquaculture). Leading aquaculture provinces, with at least a million tons of production each year include Guangdong, Hubei, Hunan, Anhui, and Jiangxi. However, every province in China has at least some aquaculture production, making aquaculture important for food and economic security throughout the country.

Carp are the most commonly farmed inland fish, making up about 74% of inland aquacultural production. The advantages of carp include the fact that it is a omnivorous fish, eating zooplankton, insects and larvae, mollusks, soybean and cereal meal, rice, and aquatic vegetation. Feces from livestock such as chicken and hogs have also been used as a food for carp. Unlike salmon which are carnivorous, carp do not require fish meal or fish oil in their diet. Carp also tolerate a wide range of weather conditions, and can be grown in both ponds and reservoirs. As a bottom-dweller, carp can also coexist with other species which are grown at the same time, known as polyculture (FAO Fisheries). Carp also has a very good food conversion ratio that has been estimated to be as low as at 1.5. This makes carp farming an efficient source of animal protein production. Other cultivated species include tilapia, bream, crab, shrimp, catfish, eel, and turtle (FAO Fisheries).

However, one of the greatest problems confronting inland aquaculture in China is the limitation of water quantity and quality. All forms of aquaculture rely on a reliable supply of clean water. China has long had a relative water shortage compared to the rest of the world, with China having 17% of the world's population but only 7% of its fresh water. China's water supply per capita is only 31% of the world average (Tan). This overall water shortage is made worse by the distribution of available water in the country. Geographically, water shortages have generally been the worst in Northern China. In 2009, the Chinese government declared a state of emergency in Northern China due to drought, threatening inland aquaculture in those regions (Zhang).

Because of the water shortage in Northern China, the Chinese government has begun a massive engineering project to divert water from Southern and Central China to the North. Three separate routes are planned, with construction estimated to take fifty years, costing $62 billion. There has also been a drought in Southern and Central China, with precipitation along the Yangtze River at its lowest level in 50 years. The drought has prompted unplanned release of water from the Three Gorges Dam to provide more water for drinking supplies, irrigation, shipping, and electricity production (Hook). Future weather extremes could make this water shortage even worse. Some scientists are predicting extremely dry weather or flooding because of global warming (Feng). Both further drought and flooding could damage aquaculture production.

The other major water-related problem in China is poor water quality. It is estimated that the groundwater of 90% of cities and 75% of rivers and lakes is polluted. About 700 million Chinese people drink contaminated water every day. The Pearl River, which supplies and drains some of the most important inland aquacultural areas, is one of the world's most polluted rivers (Made in Britain). Water pollution is caused by increasing industrialization as well as expansion of agriculture, with an estimated 43% of current river water pollution in China due to contaminants from agriculture (Tremblay).

General measures to increase the overall amount of fresh water available in China may help inland aquaculture. China has the world's most active cloud seeding program, although this is controversial. The government and Chinese industry are effectively developing desalination technologies to improve the

supply of fresh water (Tianyang). Other important efforts include the development of drought-resistant crops and fertilizers, allowing more water to be shifted away from agriculture and to other uses such as aquaculture (China Agritech). There are active efforts to decrease water pollution in China, with a target of an 8% reduction in chemical oxygen demand (a measure of water pollution) in the latest 5-year plan of the Chinese government (Schneider).

Specific measures of water management may also help inland aquaculture. Relatively low technology approaches to water conservation in inland aquaculture include the use of a smaller number of larger-volume ponds as well as covers to reduce evaporation. However, these measures may result in the need for more pond aeration, as well as synthetic liners to decrease water loss from the sides and bottom of mud-lined ponds. The more advanced use of specialized "raceway" and "D-ended" tanks may provide better water quality and better water conservation than using round tanks. Although round tanks may be less expensive to build initially, raceway tanks can be built without the need for special construction experience and may take up less land than round tanks. These factors might make raceway tanks a good option on small Chinese aquacultural farms (Dillard).

More advanced technological developments include the use of Recirculating Aquaculture Systems (RAS). These closed systems have 3 main components: a culture tank, a settling tank, and biological filters, which remove fish waste and uneaten food, allowing clean water to recirculate into aquaculture tanks. The filtered waste and food products can be used as compost for crop production (Aquaculture). These systems also decrease the discharge of waste products which may contaminate local water supplies. New RAS technologies, including the use of denitrifying bacteria grown on biodegradable polymer carriers to reduce nitrate wastes, are being developed in China. Pilot commercial RAS projects have been implemented successfully in Zhejiang and Guizhou provinces, and could be scaled up and installed elsewhere in China (Tan).

Another option which may help improve the amount of clean water for aquaculture in China is the use of Integrated Multi-Trophic Aquaculture techniques (IMTA) (Chopin). In IMTA, waste from one species is used as a food source for other species. A simple version of IMTA has actually been practiced for a long time on Chinese farms. Chicken cages are suspended above aquaculture ponds, allowing chicken waste and uneaten chicken feed to serve as a food source for carp production. It is estimated that the manure from one chicken can support up to 6-8 kg of fish production a year (FAO). Although such carp farming can result in problems with silt dispersion, excess waste accumulation, and poor water quality, these problems can be limited by rotating use of land for fish and duck production with alfalfa and rice cultivation (FAO). More complex forms of IMTA may include cultivation of aquatic plants such as seaweed and shellfish that can extract waste from water and can be harvested for food as well as shrimp or fish cultivation. Co-cultivation techniques have also been developed where fish are grown with aquatic ferns, producing organic fish with a 30% return on investment, improving economic security for low income, small farms (Turkish). Additionally, new computerized "expert systems" have been devised to better monitor and manage water quality in aquaculture ponds (Wang).

Although there are multiple water-related challenges facing inland aquaculture in China, there are a number of steps that local and national governments, academic institutions, non-governmental organizations, and corporations can take to address these issues:

(a) Academic institutions could conduct research into fish biology, breeding, infectious disease, and pathology, better production techniques, and water purification and conservation. The development of drought-resistant varieties of crops through academic research could also increase water availability for aquaculture production.

(b) Non-governmental organizations could assist by continuing to collect and publish data concerning water availability, water quality and aquacultural production. Non-governmental organizations could also work with governmental agencies, academic institutions, and businesses to share new information with small farmers about improved aquaculture and water conservation techniques. Microfinance programs sponsored by these organizations could help farmers start or expand fish production using these new techniques.

(c) Businesses could work with academic institutions, non-governmental organizations, and governments to fund research into areas including fish biology and disease, as well as more efficient and environmentally friendly aquaculture techniques. Businesses could then develop and market appropriate and affordable products and services to farmers and governments, and help educate farmers and governments about these products and services. Businesses could also play a major role in scaling up commercial aquaculture operations such as the new RAS systems described above.

(d) Governments could develop policies and regulations to safeguard water quality and pursue ways to increase fresh water availability. Industrial and agricultural pollution of rivers, lakes, and reservoirs could be carefully monitored and corrective measures taken. Releasing reservoir water and pumping underground water in times of particularly bad drought could help ensure food and economic security for the small farmer. The government could support the academic research efforts listed above. The government could also support the education of scientists and veterinarians dealing with fish biology and disease. Extension efforts where governmental agencies and academic institutions work together to share scientific advances with fish farmers could be important, as well. The government could try to support businesses dealing with aquaculture, water purification, water recycling, and pollution control and correction. In addition, the government could provide low-interest loans to help small farmers afford the costs of pond-liners and tanks, as well as initial fish stocks and production supplies.

With these efforts, inland aquaculture may play an increasingly important role in meeting the increasing protein needs of the growing Chinese population. Advances in aquaculture occurring in China could possibly support the development of aquaculture in other countries as well as help to address hunger and food security challenges around the world.

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