FEATURE ARTICLE

Surf and Turf

Environmental and Food Safety Concerns of China's Aquaculture and Animal Husbandry

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In the summer of 2005, China's largest pork-producing province, Sichuan, experienced an unprecedented human outbreak of the pig pathogen Streptococcus suis. *The 215 cases totaled more than all of previous human cases worldwide (Greger, 2007). A year later,* The Economist *reported how hundreds were sickened in Shanghai from eating pork doctored with fat-reducing chemicals or injected with water to raise the weight of the carcass ("An Old Worry," 2007). In the summer of 2007, the Jiangsu government banned hairy crab farming in and around Yangcheng Lake, for excessive nutrient production from the farms had created algae blooms that were threatening Suzhou's drinking water (Yan, 2007). In the village of Cang Dong, Hainan, the stench of a pig farm of 10,000 animals prompted protests when it was built only two miles from the village (Greenhouse, 2006). These stories all touch on health and environmental problems stemming from raising animals in high-density conditions. The emergence of livestock factory farms, known as concentrated animal feeding operations[1] (CAFOs), and intensive aquaculture production are integral parts of China's livestock revolution that began in the late 1970s to meet the demands of the country's growing population. China's poorly regulated "protein factories" pose considerable environmental and human health dangers from the relative ease of pathogenic and bacterial contamination between animals raised and slaughtered in dense quarters, the fragmentation and lack of transparency of the market, and the waste they generate. The growing Chinese food safety scares—both domestically and internationally—are catalyzing new regulations and more opportunities for international cooperation, which could help address environmental and health problems stemming from China's aquaculture and CAFOs.*

UNANTICIPATED OUTCOMES OF THE LIVESTOCK REVOLUTION

Food security has long been a challenging priority facing China, as the country with the highest population, but only 7 percent of the arable land and a quarter of the per capita freshwater resources globally. The household responsibility system, initiated in 1979 under the free market reforms, was one of the earliest Chinese government experiments to address this problem. It granted farmers a right to make profits on food produced after fulfilling grain targets for the state. These reforms aimed to encourage greater agricultural output to feed the country and helped catalyze broader economic reforms. Output of grains, fruits and vegetables boomed, fueled increasingly by heavy application of pesticides and fertilizers. To meet the growing demand for meat, dairy, and eggs in China, both central and local governments began to encourage livestock factory farms, or CAFOs. By the mid-1990s, China's CAFOs supplied 15 percent of the country's pork, 40 percent of its chickens, and 25 percent of its eggs (Lei, 2006). In the past two decades CAFOs have helped supply the 200 percent increase in China's per capita meat consumption, which in turn has sparked more industrialization of its production. Not surprisingly, livestock farming is now China's fastest growing sector in agriculture.

In the 1980s, aquaculture became a major target of rural development. Of China's total seafood output, 64 percent comes from aquaculture, making

TABLE 1: Percent of China's Meat and Animal Products from CAFOs

	2003	2004	2005
Pork	28.39	32.86	37.22
Eggs	59.87	63.32	68.24
Chicken	74.23	72.96	75.22
Beef	27.58	27.83	30.82
Milk	53.33	52.90	54.36
Mutton	43.58	39.78	41.38
Total % of all Animals Raised on CAFOs	47.83	48.28	51.21

Note: In this chart, a CAFO is defined as a farm having an output of greater than 50 pigs, 500 egg-laying chickens, 2,000 meat chickens (broilers), 10 beef cows, 5 milk cows, or 30 sheep. This data was gathered through a September 14, 2007 interview with Professor Bingsheng Ke, director of the Research Centre for Rural Economy in Beijing.

it the only country in the world where aquaculture outstrips wild catch ("China Industry," 2006). Since 1978, China's aquaculture production has increased 490 percent, making it the largest producer of farmed seafood in the world, accounting for 57 percent of global output ("Development plan," 2003; "Farming fish," 1994).

This development has not come without costs. In fact, pollution from China's CAFOs and aquaculture production poses a major threat to water, soil, and air quality, which in turn represent major threats to human health and agricultural production. Factory farms and aquaculture hold the promise of great profits, but the emergence of severe acute respiratory syndrome (SARS) and avian influenza, as well as the increasing human infections of *Streptococcus suis,* raise concerns about how extreme densities of animals could enable such diseases to mutate rapidly and spread to human populations.

SLIPPERY MENACE

China has a 2,000-year history of cultivating fish, making it the first civilization to do so. Thus, seafood is already a staple in the Chinese diet and domestic consumption is projected to rise 40 percent by 2020 ("China industry," 2006). Aquaculture—including a wide variety of freshwater and saltwater finfish, shellfish, crustaceans, and aquatic plants—is a vibrant industry. Carp is the main cultivated freshwater species, and within mariculture (a.k.a. saline aquaculture) shellfish are the dominant market. Local governments promote aquaculture as a poverty alleviating industry and have therefore subsidized production of lucrative species such as tilapia. China supplies 70 percent of the tilapia imports to the United States and is also its fourth largest supplier of shrimp (Bean & Wu, 2006). Statistics on aquaculture production focus on output rather than on farm structure and numbers, but the sector is spread throughout the country, with particular density in the southeast, and is predominantly made up of small fishponds run by private individuals.

Due to the ability of fish to retain pollution in their flesh, food safety has become a major challenge for Chinese aquaculture. International concern about food safety has cost China's aquaculture dearly, as countries ban species they discover to be contaminated. Two major cases include the 2005 eel bans in Japan and the 2003 shrimp bans in the European Union—both devastated these important aquaculture sectors in China. In 2007, the industry was hit again by a U.S. ban on 5 types of Chinese seafood.[2] Chinese consumers also are increasingly concerned about the safety of the fish they eat due to water pollution, dangerous farming practices, and poor processing in the aquaculture industry. In terms of ecological impacts, the rapid development of China's aquaculture industry has seriously polluted rivers, lakes, and coastal waters and the huge demand for fishmeal is driving stock depletion in the oceans.

FEARSOME FARM ANIMALS

With many other attention-grabbing industrial pollution accidents and scandals, waste from China's 14,000 pig, cattle, and poultry factory farms that hold 1,000-plus animals each, go largely unnoticed in the news media. The size of China's animal farms varies widely, but farms remain predominantly small scale.[3] Nevertheless, much of the meat and animal products consumed in China come from CAFOs, even if they make up a small percentage of the total farms. For example in 2003, only 4 percent of China's farms produced 50 or more pigs per annum. However, that 4 percent produced 28 percent of the country's total pork output (Li, 2005). Even more impressively, 4 percent of Chinese broiler chicken farms produced 84 percent of chicken output in 2003 (Li, 2005). In 2005, 38 percent of China's pig output came from farms with 50 or more, and 75

percent of broiler chickens came from farms with an output of 2,000 or more birds.[4] Table 1 provides insights into an increasing dependence on CAFOs, which are now the fastest growing sector in China's agriculture.

In 2003, it was estimated that 90 percent of the animal farms in China lacked any kind of pollution controls and less than 10 percent had conducted an environmental impact assessment (EIA) (Wang, 2003). China's CAFOs produce 40 times more nitrogen pollution and 3.4 times the solid waste of industrial factories. Due to high-stress conditions forced upon the densely populated animals, veterinary compounds, such as antibiotics and sometimes heavy metals, must be applied to keep animals alive and growing. Much of these find their way into soil, human drinking water, and meat.

China's CAFOs also have global implications, as their numbers swell worldwide. First, there is evidence that the conditions of animal farms help spread diseases, such as avian influenza. Since 1983, China has been exporting live animals as far away as the Middle East, sending 1.5 million live animals to this region in 1996 alone. Thus, pathogens in China's farms are of grave concern to world health. Second, China's weak meat and regulations affect international markets through exports. For example, 35 percent of China's pork production went to Hong Kong in 2003, tying the city's tourism industry and food safety to the quality of China's farms (Li, 2005). Third, CAFOs contribute increasingly to global warming. Dense populations of animals generate large quantities of greenhouse gases, such as nitrous oxides, carbon dioxide from daily respiration, and methane from meal digestion, exacerbated by the grain diets of CAFO-raised animals. According to the FAO, in 2004 China produced 12.19 million tons of methane through enteric fermentation (herbivore digestion) and manure, as compared with North America's 8.44 million tons (Steinfeld et al., 2006). In addition, large quantities of chemical fertilizer manufactured in China, used primarily to produce grain consumed by confined animals, account for 20 percent of industrial energy consumption in China derived from coal. For example, in Chongqing alone (a municipality producing approximately 5 percent of China's fertilizer), fertilizer production uses 1 million tons of coal annually, "resulting in the emission of nearly 2 million tons of carbon dioxide and thousands of tons of sulfur oxides, nitrogen oxides, and particulates" ("Clean power projects," 2007).

ENVIRONMENTAL HEALTH IMPACT OF ANIMAL PRODUCTION IN CHINA

CAFOs impact human health from the facility to the table, both as a result of consuming the product and by simply being nearby. CAFOs pollute soil, water, air, food, and livelihoods with organic, inorganic, and pathogenic pollutants. Within China, animal husbandry practices that compromise human health have been particularly rampant due to the structure of production. Although animal density per square kilometer of agricultural land in China is considered high by OECD standards, few individual facilities hold as many animals as those in the United States.[5] Most of China's animals are raised by millions of medium-scale family operations that are difficult to manage and monitor effectively. Such farms often feed what is necessary—including industrial compounds and manure—to their animals in order to reap the highest profit with little knowledge of post-production consequences. For example, the OECD reports that in locations where there is no latrine "…human excrement, food waste and waste from other animals is often disposed of in the pigsty, where it will be consumed by the pigs" (OECD, 2007, p.100). In June 2007, *China Dialogue* reported 80 percent of chickens that die of disease in China's CAFOs end up in the human food chain, either directly through vendors and food processors, or through pigs that are fed the diseased birds (Jiang & Tang, 2007). According to anecdotal evidence from Sichuan, one of the provinces with the highest pig densities, farmers often simply medicate sick pigs to make them look better and then sell them immediately to slaughter.[6] Such corner-cutting practices are all too common because the government provides little insurance or compensation strategies for farmers who lose stock or market share from diseased animals.

CAFOs and Inequity

Economic Effects and Poverty

The consequences of the above examples of dangerous lapses in food safety and pollution do not fall evenly across China's population. The poor and migrant workers tend to frequent very cheap street vendors, and are therefore the most likely to consume animals that were sick or died of natural causes prior to slaughter. Air pollution from CAFOs impacts nearby villagers, particularly sensitive groups such as children and the elderly.

Ammonia emissions are one such air pollutant, with emissions rising from 9.7 teragrams (Tg) to 11.7 Tg between 1990 and 1995 (Steinfeld et al., 2006). China's limited arable land means soil degradation from CAFOs has a massive economic impact on poor farmers. High levels of nutrients, particularly nitrogen, released from CAFOs acidifies the soil, causing plants to divert more energy to absorbing nitrogen than growing, thus reducing crop yields of poor farmers. The FAO estimates that 23.6 percent of agricultural land in Asia, mostly in eastern China and around major Asian cities, is overloaded with nutrients from chemical and organic fertilizers and thus unable to absorb the prodigious amounts of waste produced by CAFOs (Steinfeld et al., 2006). Airborne nitrogen—95 percent of the nitrogen in manure exposed to air—settles onto ground as far as 80 to 160 kilometers from a CAFO.

The growing level of organic pollution from CAFOs and aquaculture ponds is also partially to blame for the toxic marine algae blooms, called red tides, which have affected much of the east coast of China since the 1990s. The *People's Daily* reported as of the year 2000, the country had suffered $240 million in direct damages from red tides ("China closely," 2000). Other types of algae blooms also proliferate with the increased nutrient content of the water, creating vast "dead zones" in lakes, rivers, and coastal waters where almost nothing can survive in the low levels of dissolved oxygen. Aquaculture farmers and fisherman suffer disproportionately from such environmental disasters. Government clean-up efforts often are equally damaging to the poor. For example, when the Jiangsu government banned hairy crab farming on Yangcheng Lake, as mentioned at the beginning of this paper, no compensation was offered to the farmers (Yan, 2007). In August of 2007, *Xinhua* announced that by the end of 2008 all fish farms would be removed from China's three largest lakes—the Dianchi, Chaohu, and Taihu—to prevent reoccurrences of economically damaging and toxic algae blooms ("Central China," 2007). Notably, when the government culls herds of livestock to contain disease, the animal owners are seldom compensated, which discourages them from reporting the outbreaks.[7]

Health Impact on Farm Workers

Employees are another group vulnerable to CAFO pollutants. Air emissions from CAFOs contain several airborne pollutants, such as hydrogen sulfide, ammonia, and endotoxin, which pose threats to workers within the facilities and to surrounding communities. CAFO workers in the United States face at least a 25 percent chance of getting respiratory diseases such as asthma, bronchitis and acute lung infection, and a 30 percent chance of pulmonary mycotoxicosis, an acute, but not fatal, respiratory illness (Donham et al., 2007). They also face the possibility of death from asphyxia or respiratory arrest. Studies conducted in the United States show that community residents within a two-mile range of a CAFO experienced greater risk of respiratory diseases ("Iowa concentrated," 2002).

Indirect Impacts on Vulnerable Groups

In rural areas, 300 million Chinese lack access to safe water and runoff from agriculture and animal production are major sources of this problem. The next section discusses direct impacts of CAFO waste on water, but contamination also stems from the inputs into CAFOS—namely feed stock and water. China is the world's second largest producer and consumer of corn, with 93 percent of it going to animal feed (Li, 2007). Currently, China is an enormous importer of animal feed, especially corn. Yet, as animal production rises in China, the profits from producing corn also rise, encouraging Chinese farmers to divert precious land resources from human food production to resource intensive animal feed production, thus threatening food security. Shallow-rooted monoculture corn production requires heavy pesticides, fertilizers (particularly nitrogen), and water applications, which increase toxic soil runoffs and create algae blooms in lakes (Steinfeld et al., 2006).

Water wastage and pollution from cleaning and processing CAFO animals is another indirect impact on the environment and communities near the facilities. China's growing water scarcity, with only one-quarter of the world's per capita average, should encourage researchers to consider water conservation and recycling options for CAFOs, particularly in the urban northeast. In addition to supplying the animals with drinking water, water is required for washing carcasses, cooling facilities, cleaning animal pens, and liquefying waste to compost it. According to Danielle Nierenberg (2005), author of *Happier Meals: Rethinking the Global Meat Industry,* eight ounces of beef can require up to 25,000 liters of water. Poultry processing tends to be even more water intensive per unit of weight than red meat, as water is used for defeathering as well. FAO estimates one bird requires an average of 420 gallons of water (Steinfeld et al.,

> **In Guangdong, swine farms alone are estimated to produce 72 percent of the nitrogen and 94 percent of the phosphorus emissions in the province's waterways.**

2006). Animals raised in industrialized systems can require as much as seven times the water as those raised in extensive or free-range systems, for animal feeds have much less water content than wild forage (Steinfeld et al., 2006).

Organic Pollutants

Organic waste is an unavoidable part of animal husbandry; however, with high animal density, this waste can become dangerously concentrated. Consumption of organic waste in contaminated food or water can lead to fatal bacterial infections and diseases, such as *E. coli* and *Salmonella*. Bacteria are concentrated in manure, and are especially common in CAFO manure because of the animals' high levels of stress and high carbohydrate diet. A study found grain-fed cattle, such as those confined in feedlots, shed significantly higher numbers of virulent *E. coli* than animals that ate roughage (Gilbert et al., 2005). These pathogens can be passed to humans when untreated manure is applied to vegetable crops or when fecal matter contaminates meat during slaughter, as will be discussed under the food safety section below. This is particularly likely in a CAFO setting due to higher than normal levels of bacteria in the intestines of the stressed animals and the high volume and speed of slaughter. According to the Hebei CDC, *Salmonella* accounts for 97 percent of China's 300 million cases of food-borne illnesses (Hebei CDC, 2006).

Organic Water Contamination

Only about five percent of animal waste is treated in China (Lei, 2006). Excess waste from over-saturated fields, with naturally high levels of nitrogen and phosphorus, ends up primarily in water, where it poses a number of human and environmental health risks. When untreated animal waste is applied to fields, 40 to 60 percent of the nitrogen leaches out of the soil and into water (Steinfeld et al., 2006). Heavy rains or accidents can cause lagoons where liquefied animal waste from CAFOs is stored to eventually break or leak into the surrounding soil and watersheds, releasing dangerous levels of trace heavy metals and bacteria into drinking and irrigation water. In Guangdong, swine farms are estimated to produce 72 percent of the nitrogen and 94 percent of the phosphorus emissions in the province's water systems (Steinfeld et al., 2006).

Health affects from nitrogen leaching into wells and surface water include increased the risk of some types of cancer, miscarriage, and "blue-baby syndrome," an often fatal type of congenital heart disease in infants. Animal waste runoff in drinking water can expose humans to bacterial infections, such as *Escherichia coli (E. coli)*, *Salmonella*, *Campylobacter* (the leading cause of diarrhea), *Clostridium botulinum*; animal to human viral diseases; and livestock intestinal parasites, such as *Giardia* (Steinfeld et al., 2006).

Runoff of uneaten food and effluent from fish farms also represents a growing problem in China. In the past, freshwater fish fed off naturally occurring organic material in ponds. As farming has intensified in China manufactured feed has become necessary, leading to more uneaten food, effluent and pollutants. One study cited by the U.S.-based NGO Food & Water Watch estimates that 155 square miles of shrimp ponds in Thailand produce more phosphorous waste, an organic compound in waste and decomposing feed, than three million people ("Suspicious shrimp," 2006).

Eutrophication, or high nutrient concentrations in an ecosystem, and algae blooms, which strip the water of oxygen necessary for life, made the news in 2007 as China's three largest lakes—Dianchi, Chaohu, and Taihu—became unsafe for drinking because of toxic blue-green algae outbreaks. Before this crisis, agricultural runoff—including CAFO waste—was responsible for 70, 60 and 35 percent, respectively, of the pollution in those lakes (Lei, 2006). Waste from CAFOs is also severely impacting the water quality of the Yangtze River, which accounts for 35 percent of China's total freshwater resources ("Report: Yangtze," 2007). The resulting mass die offs of oxygen starved fish and plants throughout China's freshwater ecosystems exacerbate biodiversity losses and food insecurity (Wang, 2003). Moreover, nutrient runoff from CAFOs into the South China Sea is wreaking havoc on sensitive coastal ecosystems such as mangroves, sea grass, and coral reefs (Steinfeld et al., 2006).

BOX 1. Major Food Safety Scares in China and the United States

United States or U.S. Products	Year	China or Chinese Products
August: Castleberry canned food recalled for possible botulism contamination, which can cause paralysis and death.[12]	2007	July: Chinese spices blamed for 54 cases of salmonella in the United States.[13]
July: China bans chicken and pork imports from several U.S. companies for various contaminants including salmonella, a feed additive Ractopamine, and anti-parasite drug residues.[14]		April 30: *The New York Times* reported that melamine scrap, believed to have sickened 14,000 U.S. pets, is commonly used in fish feed in China.[15]
February: Peter Pan and Great Value peanut butter recalled after being linked to a salmonella outbreak, affecting 628 people.[16]		April 26: U.S. Wal-Mart stores remove Chinese catfish due to antibiotic contamination.[17]
February: 52,650 pounds of chicken breast strips contaminated with potentially fatal *Listeria monocytogenes* recalled. [18]		March: The Ministry of Health reported in that 196 people died of food poisoning in China in 2006.[19]
December: *E-coli* contamination on iceberg lettuce sickens 71, including 53 hospitalizations and 8 cases of kidney failure.[20]	2006	November: 11 out of 15 samples of Mandarin fish from China tested positive for malachite green in Hong Kong.[21]
September: *E-coli* tainted baby spinach sickens over 200 and kills 3, including a 2-year old.[22]		November 22: Carcinogens (chloramphenicol, malachite green, and furazolidone) found in turbot in Shanghai. Turbot sales were subsequently banned or suspended in Shanghai, Beijing, Shenzhen, and Taoyuan. Turbot is a species of flatfish with low disease resistance that requires considerable and careful veterinary input; 100 percent of the Shanghai fish tested positive.
September: Bolthouse Farms Carrot Juice linked to 4 cases of botulism poisoning.[23]		October: Taiwan bans imports of hairy or mitten crabs from China due to traces of carcinogens.[24]
August: Carcinogenic bromate levels in Wegmans bottled water found to be double U.S. allowable levels.[25]		September: 330 people sickened by clenbuterol—a steroid that promotes weight gain in animals—on pork in Shanghai[26]
December: *Listeria monocytogenes* found on strawberries used to make smoothies in California.[27]		August: 87 people diagnosed with meningitis after eating raw or undercooked Amazonian snails in Beijing.[28]
September: *Listeria monocytogenes* contamination in 18,510 pounds of Allison's packaged barbeque beans with beef and chicken salad recalled.[29]	2005	256 food poisoning incidents reported to the Ministry of Health, 7 percent of which involved more than 100 people.
April: *Listeria monocytogenes* recall of turkey, pork, sausage, and salmon after regular USDA sampling found contamination.[30]		Malachite green found in Chinese farm- raised eels. China's three main eel export markets of South Korea, Japan, and Hong Kong (totally $860 million in 2004) suspend their imports.[31]

September: Recall of 59,000 pounds ground beef by Wisconsin company after contamination with *E. coli.*[32]	**2004**	The Chinese Ministry of Agriculture reported that between 20,000 and 40,000 people fall ill from food poisoning in China every year, which some Chinese experts believe is only 10 percent of the real number.[33]
August: Recall 406,000 pounds ground beef by Illinois company after contamination with *E. coli.*[34]		171 babies in Anhui Province became malnourished from fake milk power; 13 of these babies died. [35]
May: 13 million pounds of almonds recalled, 22 people infected with salmonella.[36]		The Chengdu Quality Inspection Department released figures stating that less than 23 percent of pickled vegetables in Sichuan met provincial regulations for pesticides residues. Some factories were spraying 99 percent strength of the pesticide dichlorvos on the pickled vegetables every two to three days to prevent pest damage while in the processing plants.[37]
February: 700 sickened, 4 deaths linked to *E. coli* contamination of Jack-in-the-Box hamburger.[38]	**2003**	Chloramphenicol found in Chinese frozen shrimp shipments to the United States.[39]
April: ConAgra ground beef contaminated with E. coli, 19 million pound recall. 29 people sick in 8 states.[40]	**2002**	Discovery of chloramphenicol, a potent antibiotic and source of aplastic anemia, in Chinese shrimp and crayfish results in an EU ban.[41]

Organic Soil Contamination

Animal manure is an excellent source of fertilizer. The Alaska Cooperative Extension Service says that the organic matter in animal manure increases water holding capacity, lessens erosion, "…improves soil aeration, and has a beneficial effect on soil microorganisms and plants" (Purser , 2000). While CAFO waste tends to contain higher levels of pathogens and other additives, many economic and environmental gains could be realized through better integration of animal husbandry and other agricultural sectors, such as using animal waste as organic fertilizer for corn, or using free-range chickens to control pests on crops.

Yet such integration has been slow to progress due to three factors. First, most agricultural land is divided into small plots, whereas CAFOs produce bulk amounts of manure; too much for a single farm to use. Second, location of farms is another constraint to integration, 80 percent of the large- and medium-sized CAFOs are located near major cities in the demand centers of the east coast, rather than in rural areas where manure could be spread on land more efficiently. The combination of the first two factors provides strong incentives for large CAFOs to store their waste, rather than distribute it to small farms because of the comparative cost of transportation and low volume of sales. Third, anecdotal evidence suggests that local Ministry of Agriculture's extension services have invested heavily in chemical fertilizers and pesticides, and thus push sales of them to farmers.[8] Thus, costs and overwhelming volume, combined with the ready availability of cheap chemical fertilizer, result in low utilization of CAFO waste.

Whatever the reason, most Chinese farmers today depend on chemical fertilizers as opposed to animal manure. According to a report from *China Watch*, in Zhejiang Province only 6.2 percent of manure from CAFOs is applied to farmland. There are 437 animals per square kilometer in China, and each animal's waste requires approximately three acres of farm land to be safely absorbed, thus a large amount of chemical fertilizers could be replaced by CAFO waste (Nierenberg, 2001; OECD, 2007, p.103).

Inorganic Pollutants and Harmful Additives

Raising carnivorous species, such as salmon and shrimp, tends to produce some of the most

detrimental environmental impacts because of the amount of antibiotics and waste they produce. All animals require carefully manipulated diets to survive, let alone grow, under high-density conditions, particularly since confined animals cannot select their own food based on their nutritional requirements. These man-made diets can include harmful additives such as antimicrobial drugs; fungicides (for fish); low quality protein (such as the coal-based melamine found in pet foods); and cosmetic components (such as carcinogenic Sudan Red, a dye to make egg yolks darker, and arsenic or mercury, which makes meat redder). When farmers and feed producers cut corners to reduce costs, these kinds of potentially harmful substances can enter the food chain.

Duck farm in China's Sichuan Province, in which ducks are raised completely and entirely on raised platforms with net floors with no access to water for swimming. Photo Credit: Humane Society and Compassion in World Farming

Antibiotics and Hormones

The practice of feeding antibiotics and hormones to stock animals is well established in the West as preventative medicine and to increase weight gain. There is ample evidence that these additives remain in meat and animal waste, leaching into soil and water surrounding these facilities. In China, however, growth hormones and antibiotics are banned in pork and poultry, the biggest waste producers. Bingsheng Ke, director of the Research Centre for Rural Economy in Beijing, maintains small farms do not use antibiotics due to the prohibitive cost and the largest farms avoid them for quality control reasons.[9] Despite the ban, antibiotic resistance is a huge problem in China because of past excessive use of antibiotics and, potentially, current infringements. The U.S. Embassy in Beijing commented in 2001 that "China feeds 6,000 tons of antibiotics each year to its livestock, with Chinese animals receiving a much higher per-head dose than their developed country counterparts" ("Beijing environment," 2001). In August 2007, China announced it would be producing special hormone-free pork for all Olympic athletes to prevent false-doping cases at the Olympics, calling into question the supposedly hormone-free nature in the rest of China's meat supply (Buckley, 2007).

Compared to terrestrial farms, antibiotics in aquaculture are relatively well documented. These substances—either applied directly to the water or passing through the animals' digestion systems—are not biodegradable and persist in the surrounding environment threatening wild fish stocks and drinking water ("Suspicious shrimp," 2006; "Drugs used," 2007). When humans regularly consume antibiotics with their meat or in their water, drug resistant strains of bacteria appear in communities. In 2007, *Environmental Health Perspectives* published 2 articles on drug resistance from CAFOs. The first proved that antibiotic-resistant *Campylobacter*, a type of bacteria that in rare cases can be fatal, persists in poultry meat, even after factories had ceased using the antibiotic (Price et al., 2007). The other article demonstrated how antibiotic-resistant *Enterococci*, a type of bacteria responsible for various infections including meningitis, remained in swine waste in the local waterways (Sapkota et al., 2007).

Heavy Metals

Animal farm manure produces a considerable amount of heavy metals, including copper, zinc, selenium, cobalt, arsenic, iron and manganese, which potentially threaten food and environmental safety. These are generally added to the animal's diets to increase weight gain and reduce disease; however significant amounts go through the animals and into the surrounding environment. Arsenic, a carcinogen, is of particular concern. The metal is traditionally fed to animals, especially poultry and swine, to enhance the red coloring of the meat, help control disease, and increase weight gain. One study of pig farms in the Beijing area, conducted by Yan-xia Li and Tong-bin Chen, predicted that pig manure alone could potentially raise the levels of arsenic in Beijing's topsoil to the maximum permissible level within 93 years (Li & Chen, 2005). In their study of 29 CAFOs surrounding Beijing, all had some level of arsenic in the manure, with two producing more than the legal limit of 75 mg/kg. Once applied to

soil, the carcinogenic arsenic in manure converts to its inorganic water-soluble form and regularly seeps into drinking water. Thus, even before the arsenic exceeds emission standards it could threaten human health and the environment.

Food Safety

In March 2007, the Ministry of Health reported that 196 deaths from food poisoning in China in the year 2006, but because of underreporting, the true number is likely to be much higher (Luan, 2007). Regulation of food safety has long been a problem in China due to weak monitoring capacity, strong local government protectionism of industries, and few consumer protection watchdogs. CAFOs pose special threats to food safety via including waste contaminating crops on surrounding land, unsafe inorganic compounds persisting in the meat, and contamination from processing or improper storage. Aquaculture in particular is challenging because of a strong preference for live and undercooked fish in China, increasing the risks to consumers and highlighting the need for timely monitoring and testing (Bean & Wu, 2006).

Further, heavy metals persist in all meat, but particularly in fish. Mercury from China's coal-fired power plants is a high-profile example of how water pollution links to food safety. Consuming fish is the most common way to ingest mercury because it accumulates in the flesh of the animal. Mercury exposure can cause miscarriages, harms brain development and damages the endocrine system, kidneys and other organs. Statistics on mercury in Chinese fish are scarce, but Chinese coal is believed to be responsible for mercury contamination in fish as far away as the western United States, pointing to a strong possibility of mercury contaminated fish within China ("China's mercury," 2006).

Another worrisome additive is melamine, an industrial compound made from coal. This contaminant in pet food was responsible for pets falling ill and swine culls in the United States at the beginning of 2007.[10] In China, this industrial compound made from coal was commonly added to stock, including fish and swine, animal feed because it is a cheap way to increase the nitrogen reading of the food, making it appear to have more protein. In 2007, international pressure caused China to ban melamine additives ("Animal feed," 2007).

In the processing stage, meat can become contaminated with organic material, such as *E. coli*. When many animals are slaughtered in one location, bacteria and fecal matter can get onto the meat, even in the comparatively hygienic facilities in the United States. As mentioned above, CAFO-raised animals have unusually high levels of pathogenic bacteria, which can potentially contaminate meat.

China's State Food and Drug Administration was established in 2003 to combat the considerable governmental inefficiency in regulating food and drug safety. After 2003, the central government began passing more regulations on food quality monitoring and hygiene licensing, especially of exports.[11] Under the Eleventh Five-Year Program (2006-2010) the State Council issued the "National Food and Drug Safety Plan" that aims to establish a food safety guarantee system in China. Nevertheless, food safety rests essentially in the hands of local government enforcers, which in the case of aquaculture, often lack the motivation or capacity to strictly monitor. According to Lei Jilin in an interview with *Xinhua*, the local government agencies entrusted with monitoring fish-related food safety are either doing their jobs poorly or not at all ("Cancer-causing," 2006). The Shanghai food quality inspections appear to be the most successful, as they are often the first to discover large safety mishaps. Further complicating the food safety issue and eroding consumer trust is the fact that, while investigations are publicly announced, the findings of the investigations of farms and market studies are often not publicized.

Epidemic Disease

Disease, and fear of disease, is a huge driving force behind CAFO reform around the globe though results of CAFO safety research are still debated, particularly with regards to avian influenza. One 2004 estimate, estimated farm animal disease is costing China over $23.8 billion annually (Li, 2005). In China and elsewhere, the desire to improve disease prevention and monitoring of CAFOs caused the industry to move away from small-scale, integrated, more environmentally sound animal husbandry, to large CAFOs with few high-value breeds. For example, in response to bird flu outbreaks, the Chinese government has mandated all poultry be confined, which essentially eliminates small-scale farms and family chicken coops—hurting many rural poor. Promoting large CAFOs is based on the theory that confined animals are better monitored and their owners better informed on safe animal management.

The opposing view—supported in part by the fact that only 6 of the 48 Chinese farms hit by avian

influenza were small scale—is that large CAFOs actually play an active role in both the development and the spread of pandemic human diseases such as avian influenza (Li, 2005). While the FAO initially condemned untraceable small-scale farms, in September 2007 they declared "excessive concentrations of animals" were contributors, if not catalysts, for pandemic disease. Dr. Michael Greger argues in his book, *Bird Flu: A Virus of Our Own Hatching* (2006), that the dense, heavily-medicated factory farms encourage viruses to mutate into more dangerous varieties, some of which can infect humans.[42]

The practice of shipping live animals facilitates the rapid spread of disease across the world. Some of the first global avian influenza scares revolved around the disease's appearance in the Middle East, a live animal export hub for China. Further exacerbating the problem are poor farming practices such as feeding animal waste and by-products to other animals. Qinghai Lake, the migratory bird gateway between Europe and Asia where thousands of migratory birds fell ill in 2005, also happens to be the home of several large carp farms and feed manufacturing facilities that may have used or produced poultry litter-based fish feed (Feare, 2006). Signs of these disease-spreading phenomena in China are particularly visible in the swine industry, where a recent nationwide outbreak of the highly pathogenic "blue-ear syndrome" caused record losses to the swine industry. (See Box 2).

Streptococcus suis, bacteria that cause meningitis both in pigs and their human handlers, is one of particular importance in China. In one publicized case, 40 people died of *Streptococcus suis* in rural Sichuan Province in 2005, an outbreak which Deputy Minister of Commerce Huang Hai said "was found to have direct links with the foul environment for raising pigs" ("China drafts," 2005). Rural citizens are mainly impacted by CAFO waste and they are the most vulnerable due to limited resources to afford the often substandard healthcare available.

In addition to these high profile disease outbreaks, dense populations of animals pass other microbial diseases to farmers on a regular basis. For example, one study states that farmers have a 35.3 and a 13.8 percent chance of catching H1N1 and H1N2 influenza from swine, respectively (Donham et al., 2007). Part of the concern related to the spread of disease is the use of antibiotics in CAFOs to increase weight gain and reduce stress-related deaths among livestock. Many studies have shown that significant amounts of antibiotics pass through the animals and into the surrounding environment.

EFFORTS TO CREATE A NEW KIND OF LIVESTOCK REVOLUTION

Current politics in China view CAFOs as the solution to land constraints and rising demand for protein. As proof of the central government's commitment to the industry, the State Council endorsed the Ministry of Agriculture's "Propositions on Accelerating the Nation's Animal Husbandry Industry" in 2001. The Chinese government's priority for food security has led it to commit considerable resources to agricultural and fish research that has produced some promising new options for feeds, fish species, and farming practices. Such research holds the promise of promoting ecologically safer farms that may also help protect human health. The growing food safety problems with China's exports is spurring more attention to better monitoring and regulating of all food production sectors, which could help improve the quality of CAFO and aquaculture management and lessen their environmental impacts. Strikingly, aside from the animal waste to biogas sphere, there are not many international efforts to address environmental and health consequences of China's multiplying CAFOs and aquaculture, which makes them a highly promising area for collaboration.

Domestic Policies Targeting CAFOs and Aquaculture

Similar to other policy areas in China, there is political overlap with insufficient coordination between the Ministry of Health, the Ministry of Agriculture (MOA) and the State Environmental Protection Administration (SEPA) in the sphere of animal husbandry and aquaculture regulation.

China's MOA began providing loans to farmers in the 1990s to promote cleaner production in CAFOs. Moreover, MOA also has carried out various demonstration projects on eco-agriculture, biogas from animal waste, and promotion of organic fertilizer. Confusingly, in 1998, the responsibilities of rural and agricultural environment management were transferred from MOA to the smaller and less well-funded SEPA. In 2000, SEPA set up the Division of Rural and Agriculture Environment, which has a mandate over pollution from livestock operations. Although it was not achieved, the

A pig looks out the window of a Beijing CAFO. It takes approximately 3 months for a pig of this variety to meet the 100kg slaughter-weight on a highly manipulated diet. Photo Credit: Humane Society and Compassion in World Farming

Tenth Five-Year Plan for environmental protection included the ambitious goals to utilize 70 percent of China's livestock and poultry waste as fertilizer by the end of 2005 (Gao, 2003).

In 2003, SEPA issued "Discharge Standards of Pollutants for Livestock and Poultry Breeding" that specify the minimum distance between CAFOs and residential areas and water supplies (Wang, 2003). The standards focus on chemical oxygen demand (COD) and biochemical oxygen demand (BOD) emissions and odor control, but neglect the issue of trace metals in the manure (Li & Chen, 2005). Another law (GB284-84) limits the arsenic concentration in sewage applied to farmland to 75 mg/kg (Li & Chen, 2005). Farming zones are now an increasing trend in China. In order to discourage small and decentralized farms, the government instituted animal farm zones or parks areas where government subsidies encourage large agriculture to develop. In 2003 alone China constructed 20,000 such zones (Li, 2005).

Most promising is China's first Animal Husbandry Law, which went into effect in 2006. This law focuses on encouraging large-scale farming, maintaining genetic integrity, ensuring product safety, and protecting the environment through zoning laws ("Important legal," 2006). Following the law, the government has taken steps to address rising concerns about food safety including allocating $1.16 billion in August 2007 to address food safety monitoring infrastructure, which could strengthen the regulation of CAFOs and aquaculture (Juan, 2007).

Biogas

The development of biogas—energy derived from the methane inherent in animal waste—in China promises to deal with the major pollution from CAFOs while also providing much-needed energy and a safe form of fertilizer. A biogas digester is a cost-effective waste treatment facility that cleans liquid runoff with secondary products: clean energy and safe solid fertilizer. Biogas projects range from small initiatives promoted by international and Chinese NGOs in poorer rural areas to more extensive national and provincial government programs.[64] In China there are growing biogas projects conducted privately by the owners of CAFOs in reaction to public outcry. Some of these are subsidized by the MOA or local governments. Such facilities could offset costs by using the methane energy to power the facility; but the low cost of energy in China does not make this a strong incentive for companies.

Hainan Island has become one of the more progressive provinces, using subsidies to encourage the development of animal biogas processors to limit the growing problem of water and air pollution from CAFOs while also supplying energy to its poor rural areas (Greenhouse, 2006). MOA has helped encourage this development under its National Plan for Rural Biogas Construction (2003-2010). *Xinhua* reported that nationwide 18 million processors had been built through government subsidies by the end of 2005 ("More methane," 2007), yet this incentive policy neglects large-scale animal operations near urban areas, which are the primary source of animal methane.

New programs and investment into large biogas infrastructure could be developed out of China's membership in the international Methane2Markets (M2M) Partnership. M2M is an international initiative advancing cost-effective, near-term methane recovery and use as a clean energy source. The members of this partnership—which include national governments, private sector entities, development banks, NGOs, and financial and technical experts—are catalyzing methane capture projects from agriculture (animal waste management); coal mines; landfills; and oil and gas systems.

One significant project partially linked to M2M is FAO's Livestock Waste Management in East Asia Project (LWMEAP, 2004), conducted in partnership with the governments of China, Thailand, and Vietnam. This project was created in 2004 to develop policies to balance the location of livestock operations with land resources and to encourage

BOX 2: The Case of the Disappearing Fire Pig: Boom in Hi-Tech Farms, But Where Have All the Pigs Gone?

Hong zhu nian kuaile! Happy year of the fire pig! Pork is the staple of Chinese cuisine, with each of China's 1.3 billion people consuming a fifth of a pound of pork a day.[43] Even the character for home, *jia* (家), is a roof over a pig. However, 2007—the year of the fire pig—has not been auspicious either for pigs or the people that depend on them.

Panic erupted in Hong Kong in late 2006 when pig carcasses floated down the Pearl River and the mainland government remained suspiciously silent. In mid-summer of 2007, the rising price of pork led to fears of social instability. China's official news media has linked the high prices to a new and highly pathogenic form of a relatively common pig ailment, "blue ear syndrome" (i.e., porcine reproductive and respiratory syndrome). Blue ear killed over a million pigs in 2006 in China and more than 18,000 in the first five months of 2007, excluding the tens of thousands culled to prevent the spread of the disease.[44] By July of 2007, pork prices were 85.8 percent higher than the previous year and were blamed for overall inflation in China.[45]

FRAMED?

However, for all the hype, the impact of the epidemic remains unclear. Based on the 2006 USDA estimate for the number of pigs in China—678 million animals—and the rather high *China Daily* death estimate of over a million, blue ear killed a grand total of 0.15 percent of China's pigs last year.[46] Confusingly, the *China Daily* reported that the number of live pigs in stock dropped 15 to 20 percent in May 2007 alone.[47] Even assuming that the number of reported blue ear victims is close to accurate, there still would appear to be another reason for the decline in pork.

Insisting that the disease is contained, the Chinese government has refused to provide samples to international health organizations. This secrecy could be because the disease is worse than reported, or simply that the state fears losing patents to a vaccine that could be worth $265 million next year.[48] Blue ear and other diseases are probably not the only causes for the rising prices. In 2006, low prices of pork combined with rising prices of feed and veterinary medicine encouraged farmers to decrease their stock. According to *The New York Times*, the price of feed has risen one-quarter since 2006, possibly due to demand from biofuel.[49]

While the overall number of blue ear deaths may not be that great, they could be decimating the livelihoods of vulnerable rural farmers. One recent *Reuters* report described how one Chinese farmer's herd of 45 animals was culled (after the government issued vaccines did not work) with no compensation, leaving the farmer in debt.[50] Throughout China, a total of 175,000 animals were culled in the first 8 months of 2007; if all of them were from similarly small farms, nearly 4,000 farms may have been ruined.[51] Perhaps it is the permanent loss of such small- and medium-scale farmers who in 2005 managed 70 percent of China's pigs that has produced the current crisis. It also may not be far fetched to blame the drop in pork availability to a failure in the government-distributed vaccines.

It is also possible that a different disease is frustrating veterinary know-how, and blue ear is simply a convenient scapegoat. Much of China, particularly Sichuan Province and the east coast, carries extreme densities of pigs where diseases can form, mutate and spread rapidly. China's farms have bred and hosted many other crippling pig diseases in recent years including an outbreak of *Streptococcus suis* type II, a bacterial meningitis-like disease with no visible symptoms in pigs, that killed 39 people in China in 2005. Blue ear is a relatively common disease in pigs but it seldom infects humans,[52] however such diseases can mutate. For example, in 2004, the Harbin Veterinary Research Institute presented some disturbing evidence that avian influenza was found in China's pigs.[53]

THE GOVERNMENT'S PROGRESSIVE RESPONSE

The Chinese government has taken creative measures to combat blue ear disease, including offering insurance for sows and subsidies for raising pigs, in addition to supplying $36.5 million to offer free vaccinations.[54] Inspection teams comprised of officials from 7 central ministries were organized to monitor the disease and work with farmers to develop policies that would encourage them to produce more.[55] Towards the end of August 2007, the government printed 600,000 blue ear informational handbooks that 251 experts dispersed during rural visits to educate farmers on the disease. Moreover, the central government passed a law to punish farmers for not reporting outbreaks or refusing to vaccinate their animals.[56] According to *The Washington Post*, the Chinese government has been making regular public announcements since 2006 reporting on the spread of the disease.[57]

So important is the price of pork in China that there is even a strategic pork reserve of frozen and live pigs that Ministry of Commerce holds to release in times of scarcity—a safeguard that has not yet been used. In 2007, China's central government moved to phase out corn-based ethanol programs within five years, reverting instead to crops such as cassava and sweet potato, to protect prices of feed stock staples.[58]

The Chinese government is sensitive to rising pork prices, for this meat is the primary source of protein for low-income Chinese, and rising prices have the potential to spur unrest in the country. The *Asia Times* reflected that spikes in food prices occurred in 1989, just preceding the Tiananmen Incident.[59] Thus, local governments are subsidizing pork for low-income urbanites, and the Ministry of Education called on schools to subsidize pork prices on campuses (some canteens are cutting quantity to maintain stable costs). Moreover, central officials are responding quickly to quell consumer fears on the safety of pork, which is a real danger due to the high incentives for farmers to market sick pigs.[60] On 15 August 2007, the Ministry of Commerce reported that pork prices had finally come down 1.5 percent from the previous week due to the diligence of the government and producers.[61]

"So important is the price of pork in China that there is even a strategic pork reserve of frozen and live pigs that the Ministry of Commerce holds to release in times of scarcity.

IMPACT ABROAD

As of yet, the scarcity of pork in China does not directly affect the tables of the United States, but blue ear disease could spread rapidly, affecting global supply. It has already appeared in Vietnam and Myanmar.[62] Spreading inflation, and resulting social instability, is another concern domestically and abroad, with Chinese food prices accounting for all but 0.9 percent of the drastic August 6.5 percent year-on increase of China's consumer price index.[63] As the China scrambles to slow the climbing prices domestically, the price of exports is creeping up. China is the fourth largest exporter of pork, so continued increases in its export prices are eventually likely to affect world prices for pork.

integrated farming practices to reduce environmental impact (Steinfeld et al., 2006). This $24 million, five-year project—supported by the Global Environment Facility (GEF), the World Bank, and the U.S. Environmental Protection Agency's AgStar program—is in the planning stages. The project will include conversion to biogas and integration of fishponds and CAFOs.

Development of Safer and More Environmentally Friendly Feeds

Feed is a major source of concern and an integral part of intensification. In aquaculture, the feed is added directly to the water and thus pollutes it with extra nutrients and additives, including antibiotics and fungicides to protect fish from disease. In July 2007, *The Washington Post* reported that Traditional Chinese Medicine was sometimes used on fish struggling to survive in China's polluted waters (Cha, 2007). New feeds may help lower some of the waste emissions on fish farms and lessen the industry's unsustainable consumption of fishmeal from the high seas. Some new feeds being developed include:

- *Yeast-based feed.* Chinese researchers have been experimenting with a yeast-based protein supplement to replace more than half the fishmeal in aquaculture feed preparations ("Farming fish," 2004).
- *Soy-based feed.* As of 2007, China's aquaculture industry uses 4.5 to 5 million metric tons of soy meal a year ("US soymeal producers,"2007). Some species, such as tilapia, one of China's staple fish, can tolerate 50 percent soy in their diets ("US soymeal producers," 2007). Other high value fish can tolerate only 10 percent soy. Even a small reduction in fishmeal dependence will relieve some stress on global oceans.

The U.S. Department of Agriculture currently is working with MOA and the American Soybean Association on a three-year (2006-2008) soybean-based fish feed pilots within the watershed of Lake Tai, which in the summer of 2007 was plagued by a toxic green algae, caused in part by agricultural and CAFO runoff.

Genetically modified (GM) feed grains are another potentially useful, if controversial, innovation. In September 2007, the Chinese Academy of Agricultural Sciences released a corn genetically modified to produce the enzyme phytase for field testing. Phytase helps animals, particularly pigs, digest phosphorus, a common pollutant of CAFOs. In addition to reducing nutrient pollution, a member of the research team claimed that commercializing this corn could save up to 450 million Yuan ($60 million) per year in energy costs because it would eliminate the need for industrial production of phytase to add to animal feed, an energy-intensive endeavor (Jia, 2007).

A shed of egg laying hens in a CAFO in northeast China. Photo Credit: Humane Society and Compassion in World Farming

A safer feed change would be to increase the ratio of forage to grain in the diet of confined animals. Forage, such as alfalfa and hay, is easier for pigs and especially cattle to digest and therefore produce less waste and healthier meat.

Better Farming Methods and Integration

Polyculture

Farming integration can potentially lessen the pollution of CAFOs in a major way. One method to better integrate farms is to place them in rural areas where there is more land to spread the manure. Polyculture—such as combining aquaculture with other CAFOs to help process waste—is another means to better structure farms. Agricultural experts have demonstrated that herbivorous fish species are fully capable of safely processing waste from pigs, cattle and poultry by ingestion.

Integrated polyculture systems between fish species and crops, once the norm in China, are a more sustainable solution to aquaculture in general. One living example is the rice-field carp of Qingtian, Zhejiang. In Qingtian, terraced rice patties were stocked with carp by naturally flowing river water. In recent years farmers have intensified carp production

with the addition of manufactured fish feed and by erecting concrete barriers to deepen their ponds. The damming of such rivers to create carp pools has led to problems of eutrophication, interrupted water supply to farms and communities, and diseased fish (Edwards, 2007). In order to encourage a return to a more environmentally friendly integrated polyculture system, the government could develop new certifications for organic rice-patty carp, which could help the Qingtian farmers create lucrative markets in the nearby tourist centers of Hangzhou and Suzhou.

Free-Range Systems

Allowing farm animals to roam free in China is only a partial solution to China's animal husbandry problems. China lacks vast land resources for grazing animals and the government has thus far proven ill equipped in guiding the many medium-sized free-range family farms to safe practices. Moreover, if not properly managed, free-range animals are sources of different types of environmental damage such as increased soil erosion and desertification—a major problem in the ecologically fragile grasslands in China's north, which are also threatened by over extraction of water for agriculture, industrial pollution, and mining.

Increasing free-range animal production could vastly improve food and environmental safety. Free-range animals, especially chickens, can thrive on non-arable land, such as rocky hillsides, that are not suitable to growing crops. Further, if well managed, free-range animals are healthier and less susceptible to disease, thus requiring fewer feed additives. In terms of environmental impacts free-range animals require less water for cleaning, spread their manure naturally over the land, and require less feed as they can forage for part of their diet. This type of animal production is most successful with native species, so as not to be reliant upon imported species of reduced gene pools. Dr. Peter Li of the University of Houston has noted that Chinese, particularly in the south, have a taste preference for free-range animals and native species, allowing farmers to ask higher prices for animals requiring fewer inputs (Li, 2005).

Such free-range systems must be carefully monitored to prevent excessive environmental damage. A land rotation system is important to allow vegetation to grow back so that soil erosion is reduced and manure absorption is maximized (Li, 2005).

Some research points to health benefits to humans from eating free-range animals. One study comparing the nutrition of free-range chicken eggs to industrial eggs found that the former had: one-third less cholesterol, one-quarter less saturated fat, two-thirds more vitamin A, two times more omega-3 fatty acids, three times more vitamin E, and seven times more beta carotene (Long & Alterman, 2007). Obviously, there are advantages to a country where obesity is expanding rapidly to consume less cholesterol and fat. In addition to these health benefits, such free-range chickens eat insects that might otherwise become pests.

Other Possibilities

Building a streamlined manure distribution infrastructure is key to mitigating the impacts of CAFOs. Part of the challenge to distributing manure is that farm land is often divided into small parcels making distribution to each farmer tedious and expensive. Animal farmers would be able to increase their profits if they could promote and distribute manure as fertilizer to rural farmers at a fraction below the cost of chemical fertilizers. For such a strategy to work, local government agricultural extension offices would have to be brought on board, for today they generally still prioritize the selling of chemical fertilizers (Hamburger, 2002).

Instrumental to making such a manure distribution system work would be moving animal farms further away from east coast city centers and closer to mass rural transportation routes where manure can be distributed to agricultural land. However, this increased distance between major markets and meat production can be risky. Either the meat will be transported live—which apart from being inhumane can increase the chances of contaminating the meat during butchering, facilitate pathogens rapid movement across the country—or it will be transported butchered on China's under developed cold-chain system, introducing potential bacteria contamination. In both circumstances, greater amounts of fossil fuels will be necessary for the transportation. Additionally, farms moved into the countryside are less scrutinized by the urban civil society, and thus perhaps more environmentally damaging and prone to unsanitary practices.

Another way to improve CAFOs environmental records would be to process and treat waste, perhaps by running it though sewage treatment plants. This is only possible if current water pollution control laws are fully enforced, which to date has rarely been done vis-à-vis CAFOs.

Better Species Selection

Identifying and cultivating high-efficiency species with higher survival rates and faster growth rates is another area of research that may reduce the need for chemicals to sustain profitable production. This has proved challenging, due to a question of the meaning of "high-efficiency." Large farms tend to use species that cope well with being confined and grow fast, which are usually the same disease prone species cultivated in CAFOs globally. With regards to aquaculture, local governments have encouraged high-value species that can claim a higher price per pound, such as turbot and eel (although African tilapia continues to be the most cultivated fish in China). Emphasizing herbivorous fish species, shellfish, and seaweed cultivation is a way to reduce the need for feed inputs in aquaculture.

It would be prudent for researchers to explore some native chicken and pig species that tolerate local conditions and require less water, as water is so scarce in many parts of the country. In addition, the local species are not as susceptible to many of the common contagious diseases that affect stock all around the world. Currently, MOA highly values the China's native species of domestic animals and has taken measures to document and protect their genes. In 2003, native species of livestock and poultry comprised 74 percent of China's agricultural output, but 41.9 percent were threatened by extinction ("Report on domestic animal," 2003, p.12). Native species can contribute to better animal products in a variety of ways including high fertility, as in the case of the Hu Sheep and the Taihu Pig; leaner or tastier meat, as in the case of the Weijin Pig and the Beijing You Chicken; and low input requirements, such as the Tibetan Pig ("Report on domestic animal," 2003, p.19). Much research is being conducted on crossing native species with those adapted to confined living with positive results, but the real value of these species is their ability to live free-range in a sustainable way due to their adaptation to the local conditions.

Food Monitoring a New Priority

In 2007, the government pledged $1.2 billion to address food and drug safety. By the end of 2007, county and township governments are required to have food emergency response systems in place. In June of 2007, 180 food factories were shut down by the General Administration of Quality Supervision, Inspection, and Quarantine for producing contaminated and unsafe products (Ang, 2007). China's numerous small farms, vast and fast-paced distribution system, and cash-and-carry economy pose hefty challenges to regulators. Although China faces many difficulties in ensuring the safety of its food supply, the government has set up a coordinating committee under Vice-Premier Wu Yi to examine strategies for improving food safety. In recent months, the government also has issued a five-year food and drug safety plan and a food safety white paper, as well as carried out campaigns to close unsafe food processors. Chinese food safety regulators are reaching out to international partners—particularly the United States, as its largest food export market—to discuss issues of mutual interest. The needs of both the United States and China to strengthen their food inspection and regulatory systems underscore the ample opportunity for collaboration between the governments and private sector companies (Ellis, 2007).

One example of increasing government prioritization occurred in Shanghai 2006, when 100 percent of turbot fish tested in the city were found to contain carcinogens. The 3 farms discovered to be responsible were highlighted by name in the Chinese news media and were subsequently fined and ordered to suspend sale ("Fish farms," 2006). Now, in an effort to revive the market, the government is experimenting with a promising branding scheme. The new agreement involves a product identification code on each fish package, doubling prices, but enabling the consumer to request information from the supplier on the particular fish purchased (Deng, 2007). If this project works for turbot, it could be a solution to many of the problems of unaccountability in China's fragmented meat and aquaculture industries.

The Nexus of Food, Farmer, and Environmental Safety

The current CAFO system, based primarily on the U.S. model, is devastatingly polluting to China, and increasingly dangerous to ecological and human health as demand for meat increases. The long-term trend shows that demand for meat will continue to increase; factory farms will spread, particularly in grain-producing areas; and the market share of pork will shrink and be replaced increasingly with beef. The incentives for local governments to encourage economic growth at the cost of the environment have meant regulation of CAFOs and aquaculture is generally weak. Significantly, the recent highly-publicized food safety problems in China's exports have helped shine a light on some of the regulatory

shortcomings of domestic meat and fish production, as well as food processing. The concern for protecting food exports appears to be catalyzing some crucial political reforms and creating opportunities for international aid and assistance.

Currently, the Chinese government is targeting end products through certification and monitoring to ensure food safety. Notably, China could benefit from more "upstream" improvements to promote better agricultural practices. This is the way the United States ensures food safety, by holding farmers themselves accountable for the safety of their products. Although there are many challenges to such a system in China, the creation and enhancement of existing farmer and producer associations is one way to initiate change at this level. Such organizations would help educate farmers to safe handling practices and enable them to market goods as safe.

As Box 2 highlighted, domestic food security problems emerging from outbreaks of diseases in pig and chicken CAFOs have caused prices to rise and led farmers to cut production and off load potentially diseased animals on the market. This situation underscores another crucial area needed to promote safer and more ecologically friendly meat and fish production—farmer security.

The Chinese government has stepped up efforts to protect farmers and encourage them to increase production, such as subsidizing vaccines and insuring sows in the event of epidemic disease. This is an area where more effort could produce exponential benefits. Stronger and reliable insurance for farmers would reduce the incentive for unsafe practices, such as butchering and selling sick animals.

China is already a water- and land-scarce country, so the soil and water contamination stemming from CAFOs and aquaculture could actually limit the growth of this sector. Domestic and international NGOs have a role to play as not simply watchdogs and whistleblowers of the animal husbandry industries, but also as trainers for safer and more humane farming practices. The international and increasingly middle-class Chinese consumers also must play a role in pushing sustainable alternatives to these polluting enterprises.

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NOTES

1. "CAFOs" sometimes refers to *confined* animal feeding operations; however, we use concentrated to indicate the density of the animals in confinement.

2. The five banned fish are catfish, basa, dace, shrimp and eel. Before this ban, China was the United States' fourth greatest source of shrimp ("Beijing will inspect," 2007).

3. Based on an interview with David Brubaker, October 29, 2007.

4. These data are from an interview with Bingsheng Ke, director of the Research Centre for Rural Economy on September 14, 2007.

5. In 2005, China had an average of 437 animals (sheep equivalence) per km^2 of agricultural land, while the United States had only 191 animals per km^2 according to OECD statistics. Sheep equivalence was calculated based on manure produced: 1 horse = 4.8 sheep; 1 pig = 1 sheep; 1 goat = 1 sheep; 1 hen = 0.1 sheep; 1 cow = 6 sheep.

6. Based on information provided by Fred Gale at the USDA Economic Research Service, November 2, 2007.

7. In one example, provided by Fred Gale at the USDA ERS based on research from Dr. Hu Dinghuan of the Chinese Academy of Agricultural Sciences, a farmer received 150 Yuan from the government as compensation for a hog that had to be slaughtered. This amount did not cover the cost it took to raise the 120 kg hog and normally, he would have made a 100 to 200 Yuan profit.

8. Based on interviews with Carl Pray, Rutgers University on April 5, 2007.

9. Based on interview with Bingsheng Ke, director of the Research Centre for Rural Economy on September 14, 2007.

10. Estimates for the number of pet deaths in 2007 due to melamine range from 16 to 300 animals. In order to determine with certainty whether the animal died from the pet food, tissue tests have to be conducted, thus the low number is the number who tested positive, and the high number is reported probable cases.

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FEATURE BOX

Greening China's Banks

By Christina Larson

As every developer and local mandarin knows, it is all too possible to build new factories without living up to the letter of China's environmental laws. But it is not possible to build without money. With pollution statutes poorly enforced, China's environmental officials are now turning to unexpected allies, the country's banking regulators, to devise new ways to force environmental compliance on the front end. Their aim is to have banks review companies' environmental records before writing checks. In July 2007, a front-page headline in *China Daily* announced: "To Fight Pollution, China Takes Capitalist Route." At present, "green banking," a relatively new idea in the west, is more aspiration than reality in China. Yet such efforts may in the future help curb pollution emissions in China, and around the globe.

Because China needs an increasing supply of mineral, timber, and energy resources to maintain economic growth, its banks have been more active since 2001 in promoting extractive industries in Asia, Africa, and Latin America. Between 2001 and 2005, Chinese funding for new large-scale foreign infrastructure projects jumped twenty-fold to $18.4 billion. That total exceeds comparable 2005 spending by the United States ($8.7 billion), Japan ($5.9 billion), and every country in Europe. According to estimates prepared by the U.S. Export Import Bank, China's portfolio is expected to grow to more than $40 billion by 2010, surpassing even World Bank financing (about $25 billion). China is already the largest lender in Africa, and will soon be the world's top financer, bar none. Already China's influence is being felt. European Investment Bank president Philippe Maystadt last year told the *Financial Times*, "Chinese banks have snatched projects from under the EIB's nose in Asia and Africa, after offering to undercut the conditions it imposed on labor standards and environmental protections."

MAKING BANKS ACCOUNTABLE

The idea of holding banks responsible for the impacts of projects they finance has evolved in the west over the last two decades. Calls for "socially responsible investment" first emerged in the late 1980s, when shareholders forced many western banks to divest from projects in apartheid-era South Africa. Following the 1992 U.N. Earth Summit in Rio, banks increasingly faced pressure to become more environmentally responsible. In 2002, a group of leading financial institutions, including Barclays and Citigroup, met in London to develop social and environmental guidelines. The result was the Equator Principles, standards modeled after World Bank benchmarks for projects in developing countries. Requirements include environmental impact assessments, "free, prior, and informed" consultation with affected communities, grievance mechanisms, and independent reviews. Over forty banks—mainly in North America and Europe—have since adopted the framework. Implementation lags behind principle, but the ideal of sustainable banking continues to gain ground.

In China, during those same years, the banking sector embarked on a series of momentous reforms, beginning the transition from a socialist system into a modern competitive industry. To prepare for the country's 2001 entry into the World Trade Organization, China's major financial institutions overhauled procedures for corporate governance, public disclosure, financial supervision, and risk management. The central government infused massive capital and offloaded many bad loans. A series of recent public offerings enabled foreign investors to purchase minority shares in several leading Chinese banks. For instance, the Royal Bank of Scotland is now a strategic investor in the Bank of China, as Goldman Sachs is in the Industrial and Commercial Bank of China. International banks, seeking access to China's lucrative market, have in

several instances agreed to provide domestic banks with expertise in management, technology, and risk assessment techniques.

INKLINGS OF GREEN BANKING IN CHINA

These trends, together with piqued grassroots interest in the environment, came together in 2004 to produce the first inklings of green banking in China. In the same year that China's State Environmental Protection Administration (SEPA) wielded a new environmental impact assessment law to suspend 30 major construction projects and banking regulators began to remind financial institutions that projects approved for loans should comply with regulations, including pollution controls. More recently, the China Regulatory Banking Commission (CRBC) encouraged banks to consult lists of approved and blacklisted projects prepared by SEPA.

In January 2007, SEPA and the People's Bank of China unveiled plans to make these environmental records more accessible. China's central bank was already at work compiling the first nationwide credit database, a key risk-management tool, when it announced that it would also include records of legal actions against companies for environmental infractions since 2003. The CRBC has reportedly begun formulating a "green credit" policy to link this environmental performance data with loan eligibility.

SEPA Deputy Minister Pan Yue is advocating new financial strategies to fight pollution, for years of fines, bans and orders to closer polluters have failed. Pan Yue argues that SEPA sees the need to use economic leverage to "make companies feel it would be costlier to break the law than to abide by it."

Pan Yue's support of such strategies was greeted with special enthusiasm by a number of green nongovernmental organizations (NGOs) that had recently begun to advocate for Chinese banks to adopt standards similar to the Equator Principles. In December 2006, several of China's most established environmental NGOs, including Green Watershed and Friends of Nature, helped organize a "Workshop on Finance, Environment, and Harmonious Society in China" at Beijing's Red Wall Hotel. Attended by dozens of nonprofit leaders and a handful of government officials, the three-day conference introduced the concept and history of green banking. As Green Watershed's Dr. Yu told me, "China's NGOs are beginning to learn an advocacy role." In addition to prompting scrutiny of domestic banks, the conference gave environmentalists ammunition to hold western banks operating joint ventures in China accountable to higher social and environmental standards.

The extent to which China's financial sector will, in practice, prioritize environmental compliance remains a question. "It's a bit early to tell about what ultimate impacts will be," said Michelle Chan-Fishel, Green Investments Program coordinator for Friends of the Earth-U.S. She is also the lead author of a 2007 report, *Time to Go Green: Environmental Responsibility in the Chinese Banking Sector*. She was somewhat more optimistic about the prospects for China implementing "green credit" than the recently suspended "green GDP," an initiative that would have linked cadres' political promotions with environmental indicators. Unlike green GDP, a wholly new innovation, there are established green-banking models to follow. Further, Chan-Fishel believes that international banks providing technical expertise to Chinese banks have a unique "role and responsibility to download good environmental loaning practices."

In at least one instance, a major Chinese bank will be forced to meet international standards. In May 2007, the China Export-Import Bank (China Exim) signed a memorandum of understanding with the World Bank to cooperate on select energy and road construction projects in Africa. For those projects, China's state-controlled export credit agency must adhere to World Bank procedures. For sensitive proposals, environmental impact assessments must be made public and developers must consult affected communities before construction begins. "These are not procedures that China Exim would normally follow," says Peter Bosshard, who has been monitoring the bank's activities for the International Rivers Network. Although China Exim is not expected to adapt its own standards in the near term, staff will gain experience in environmental compliance that may be meaningful in the future. Unlike western banks, China Exim has no environmental-compliance division. Continued multilateral and private bank collaboration with Chinese banks will be crucial, for Chinese banks will finance an increasing number of pipelines, rigs, roads, dams, and mines across the globe.

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