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Special Issue: China's Agricultural Boom, with Implications for California

China is reforming its agricultural economy, has joined the WTO, and is laying the foundation for increased competitiveness internationally. China's emergence as a major agricultural trading nation over the next few years will cause a series of changes in China's agricultural markets and in global markets.

Most researchers agree that China has an enormous potential for purchasing U.S. agricultural products, but that breaking into the "China Market" is difficult. Second, China, because of its location and factor endowments, can compete with many of California's most important commodities in world markets. Agribusiness leaders in California see the emergence of China into world food markets as posing perhaps the single most important challenge to California agriculture in the 21st Century.

Giannini Foundation researchers are examining many issues regarding China's emergence as a key competitor to California agriculture. This special issue features some of this work in three papers, each written by leading experts on China and agricultural issues. Scott Rozelle, Jikun Huang and Ruifa Hu suggest that China may soon become the first nation to begin commercial production of genetically modified rice. China's research program on rice biotechnology has developed varieties with resistance to key insects, tolerance to drought and resistance to herbicides. The authors' research suggests that adoption of GM-rice varieties reduces costs for China's producers and improves producer health, providing strong incentives for China to commercialize GM rice. They investigate the likely impacts of commercialization on world trade in rice, with particular attention paid to California's rice industry.

China is also an increasingly important competitor for California in the global markets for many specialty crops, including strawberries. Colin Carter, James Chalfant and Rachael Goodhue develop comparisons between strawberry production in China and California. China's strawberry production and exports have grown substantially, especially exports into markets that have been important for U.S. strawberries. The authors note that strawberry yields in China are limited currently by disease problems and inefficient production practices. Thus, they conclude that China has the potential to increase production even without increasing acreage.

Fredrich Karhl, David Roland-Holst and David Zilberman take a broad view of agricultural reform in China. They note that, although growth in the agricultural sector has been impressive, rural incomes are still low in many regions of the country and some current practices appear to be unsustainable over the long term. The authors examine the major inputs—labor, land, water and technology—into China's agricultural production and discuss the policy reforms that are needed to improve rural incomes, enhance food security and develop sustainable production practices.

Also in this issue.....

In the next issue...

Does the Internet Increase Farm Profits?

by Aaron Smith and Catherine Morrison Paul

Genetically Modified Rice in China: Effects on Farmers—in China and California

by

Scott Rozelle, Jikun Huang and Ruifa Hu

China is likely to soon commercialize a genetically modified (GM) major food grain. In this report, we track not only the implications for producers in China, but also discuss how the release of GM rice might affect the rest of the world, including California's rice growers. Ê

China has not commercialized genetically modified (GM) rice, but they are close and many observers believe the time is near when national leaders will "pull the trigger." After examining the state of biotechnology research on rice in the world, in general, we examine the implications for producers in China, the world's largest rice economy. To do so, we draw on our work that has appeared in *Science* and other media. While we come to the conclusion that China's producers will benefit, the consequences of the decision to commercialize GM rice, however, likely will be felt by millions, perhaps even billions, of people outside of China. Indeed, China's decision may start a domino effect that could cascade around the globe. It also could have direct consequences for California rice growers—both positive and negative. In the second part of the article, we will speculate on some of the far-reaching consequences of the commercialization of GM rice, especially considering how it might affect California's rice industry.

Stalled Out: The Record of GM Rice during the Past Decade

One of the early promises by the supporters of agricultural biotechnology was that it could make a major contribution to the reduction of world hunger. It is now 25 years since some of those early promises were made and a decade since genetically modified (GM) crops were first grown commercially. Unfortunately, the only way that biotechnology has contributed to the well-being of small, semi-subsistent producers is through higher incomes from the production of GM cotton. There arguably has been no benefit for poor, hungry consumers. However, China is currently on the threshold of starting to fulfill the promise of more food for the poor through the introduction of rice varieties that can resist important insect pests and diseases. One important question is if GM rice were to be released, could it begin to deliver on its promise?

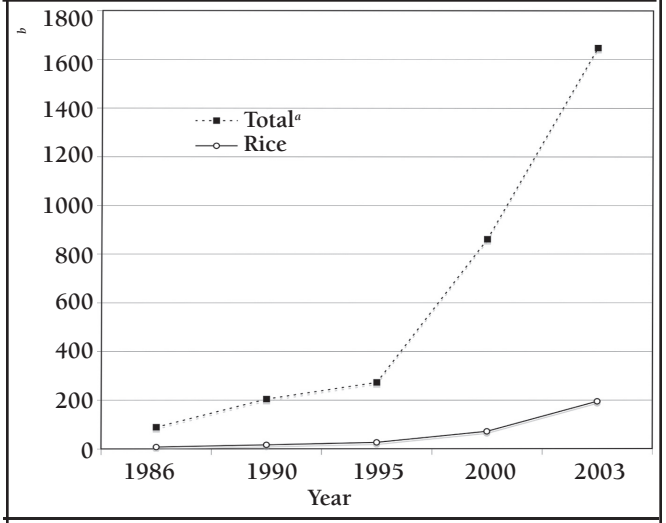
While most scientists believe that agricultural biotechnology can provide new sources of productivity growth and address some of the negative effects of conventional agronomic techniques for producers of rice and other basic food crops in China and other developing countries, at present GM varieties are primarily used for industrial crops, such as cotton, and feed crops for animals, such as yellow maize and soybeans. In the late 1980s and 1990s, government research in many developing nations—including China, often funded by the Rockefeller Foundation, began ambitious rice biotechnology research programs to develop new rice varieties that would increase yields and nutrition, reduce input use and make the rice plant, as well as other food plants, more tolerant to both biotic and abiotic stresses. This research led to a major increase in knowledge about the rice plant and rice genetics. Scientists in many of those countries—China, India, Costa Rica, to name a few—are currently conducting field trials for new GM varieties of insect and disease-resistant rice. However, due to government indecision, evolving biosafety regulatory systems, and a perceived resistance of consumers and traders, no country has yet approved GM rice for commercial use.

The difficulties of commercializing GM rice appear to be affecting the amount and direction of public and private biotech research. For example, government scientists in India are faced with increasing complications in finding locations for the trials of GM rice because of regulatory issues and pressure by anti-biotechnology groups on state governments. The private sector also is cutting back because of consumer resistance to GM products and the rising cost of commercializing new products. For example, Monsanto in the United States discontinued work on rice in the late 1990s and other companies, such as Syngenta and Bayer, have cut back on their rice research programs. California, too, has made it clear that it is not interested in trying to move forward on commercializing GM rice.

As a result, GM rice has not been commercialized anywhere in the world and little is in the pipeline in most countries. In fact, no GM staple-food crop is grown in developing countries except for Bt white maize in South Africa, where it is primarily grown by large, relatively wealthy farmers. Even in China, a country that aggressively commercialized Bt cotton and invested heavily into research on GM food crops, has not commercialized any major food crops despite the fact GM food crops have been in field trials since 1997.

One reason that commercialization may not have proceeded, especially in developing countries such as China, is that there has been little independent evidence on whether GM food crops would really improve the income and well-being of small, poor farmers. Often regulators and policymakers have to take the word of the government scientists and companies who developed and are promoting these GM products. In this article, we attempt to answer two questions: Does GM rice help reduce pesticides in the fields of farmers? Do the new varieties of GM rice increase the yields of farmers?

Figure 1. Public Research Expenditures on Agricultural Biotechnology in China: 1986 to 2003



[a] Total agricultural biotechnology spending includes spending on animals, plants and microorganisms.
[b] The official RMB-U.S. dollar exchange rate in 2003 was 8.277.
Source: Authors' survey.

China's GM Rice Research Program

China's modern biotechnology program, begun in the 1980s, has grown into the largest initiative in the developing world. A recent survey, by the authors, of agricultural biotechnology research investment in 2004 shows that the government's spending on agricultural biotechnology was US$199 million (at current exchange rates) and almost US$1 billion in purchasing power parity terms. (PPP is a method of calculating value figures that can make them comparable to those in other countries.) Rice scientists also have been provided with increasing financial resources. Although estimates of world spending on rice biotechnology are not available, given the low priority accorded by funding agencies to rice in nations with the largest biotechnology programs (such as the U.S. and the UK), it is almost a certainty that China's public investment into rice biotechnology exceeds that of any other nation.

Rice Technologies from China's GM Research Program

China's rice biotechnology research program has generated a wide array of new technologies that are at all stages of the R&D process. For example, many types of transgenic rice varieties have entered and passed field and environmental release trials and four varieties currently are in pre-production trials. Transgenic Bt rice varieties that are resistant to rice stem borer and leaf roller were approved for environmental release trials in 1997 and 1998. In experimental fields in Central China in 1999, a Bt rice hybrid yielded 28.9 percent more than its non-Bt counterpart in the presence of natural attacks of leaf roller and natural and induced attacks of yellow stem borer; scientists did not apply any pesticide on either variety. Two insect-resistant hybrids that contain the stem borer-resistant Bt genes entered pre-production trials in 2001.

Other scientists introduced the CPTi gene into rice, creating rice varieties with another type of resistance to rice stem borer and this product was approved for environmental release trials in 1999. One hybrid containing the CPTi gene, entered pre-production trials in 2001. Transgenic rice with Xa21 and Xa7 genes for resistance to bacterial blight were approved for environmental release trials in 1997 and one variety (with the Xa7 gene) entered pre-production trials in 2001. Experimental results from trials of an IRRI variety (IR72) that was transformed to express the Xa21 gene have shown that the new varieties give high levels of protection against bacterial blight. Interviews also found that although environmental release trials have not begun, field trials in China have been underway since 1998 for transgenic plants with herbicide tolerance and for varieties expressing drought and salinity tolerance in rice.

Table 1. Statistics of GM and Non-GM Rice Producers in Pre-Production Trials in China, 2002-03

	----------Mean--------	
	GM Rice[a]	Non-GM Rice
Pesticide Spray (times)	0.5	3.7
Cost of Pesticide (yuan/ha)	31	243
Pesticide Use (kg/ha)	2.0	21.2
Pesticide Spray Labor (days/ha)	0.73	9.1
Yield (kg/ha)	6364	6151

[a] GM rice includes 2 varieties: GM Xianyou 63 and GM II-Youming 86. *Source: Authors' survey*

Instead of moving ahead to commercialization, pre-production trials for the three insect-resistant rice hybrids have been expanded and, since 2001, have been carried out in at least 13 sites. According to regulations, the area for each pre-production trial should not exceed 1000 mu (or 66.7 hectares). Pre-production trials occur in both experimental station fields (and are run by technicians) and in farmer fields. Farmers in the pre-production trial sites are only provided seed and are cultivating GM rice without the assistance of technicians. The survey results in the next section come from a randomly selected sample of farmers who were enrolled in the pre-production trials.

GM Rice Adoption and Effects on Producers

In our analysis of producers who adopted GM rice, we found that the characteristics of rice producers and the prices in the markets received and paid for by households using GM rice and non-GM rice are nearly identical, and the main difference between the households is in the level of pesticide use. Specifically, when comparing GM rice and non-GM rice producers, there is no statistical difference between the size of the farm/plot, the share of rice in the household's cropping pattern, or the age or education level of the household head.

In contrast, there is a large difference between GM rice and non-GM rice production in the use of pesticides (Table 1). GM rice farmers apply pesticide less than once per season (0.5 times) compared to 3.7 times per season by non-GM rice farmers (a level which is statistically significant). On a per hectare basis, the pesticide use of non-GM rice production is more than eight to ten times higher than GM rice in terms of quantity and expenditures. GM rice farmers spend only 31 yuan per season per hectare on only 2.0 kilograms of pesticide for spraying for pests while non-GM rice users spend 243 yuan for 21.2 kilograms. Because of the reduction of pesticide application in GM rice, GM rice farmers reduced their labor use (less than 1 day/ha) compared to non-GM rice farmers (9.1 days). Although the pattern of pesticide reduction for those who adopt GM rice is similar to the reductions in the case of those who adopt Bt cotton, there is one important difference. While Bt cotton producers all continue to apply pesticides to control for a number of non-targeted pests, in the case of 64 percent of the sample GM rice plots, farmers did not apply pesticides at all. The results held up when we used more sophisticated statistical analyses.

In addition, statistical analysis also showed that GM rice outyielded non-GM varieties. As a result, the simultaneous rises in output and reductions of inputs mean that GM rice varieties have led to absolute rises in productivity. Profitability, at least for the initial adopters, is about 15 percent higher. Although there is still only a small set of farmers on which the studies are based, should the gains be similar elsewhere in China, the potential gains to China's economy could be as large as US$4 billion annually if GM rice were adopted by only 40 percent of China's rice producers. The benefit-to-cost ratio for investment into GM rice, assuming China ultimately commercializes it, will be extremely high.

Finally, the impact on farmers goes beyond productivity. In the same way that research on Bt cotton adoption showed that the productivity effects of Bt cotton were supplemented by positive health effects, according to our survey data, similar effects occur within the sample households. Among the sample farmers, there were no farmers who used all GM varieties who reported being affected adversely by pesticide use in either 2002 or 2003. Among those who cultivated both GM and non-GM plots, 7.7 percent of households in 2002 and 10.9 percent of households in 2003 reported adverse health affects from pesticide use; none, however, reported being affected after working on the GM plots. Among those who used only non-GM varieties, the health of 8.3 percent households in 2002 and three percent in 2003 was affected adversely. Although the study did not examine the effect on drinking water quality, interviews of farmers showed that many believe if pesticide use were reduced due to the adoption of GM rice, the quality of the local sources of drinking water would improve.

To Commercialize or Not: The Implications for California and Others

Although China is still struggling with issues of biosafety and considering the issues of international and

domestic acceptance, many competing factors are putting pressure on policymakers to decide whether they should approve commercializing GM rice or not, and the results in this study provide evidence that should encourage commercialization. The nation has already invested several billion U.S. dollars in biotechnology research and the development of a stock of GM technologies. Many of the new events have already been through several years of environmental and pre-production trials.

GM Rice (dark) grown in a checker-board pattern with non-GM Rice (light) in experimental fields that were infested with plant-hoppers without treatment of any pesticides, China, 2002
Photo Courtesy of Authors' Research Staff

As competitive pressures inside build in agriculture from the nation's accession to the World Trade Organization in 2001, and as leaders search for ways to increase rural incomes, there will be a continuing demand by producers for productivity-enhancing technology. The past success in developing technologies and high projected rates of return suggest that products from China's plant biotechnology industry could be an effective way to both increase competitiveness internationally and increase rural incomes domestically. Our analysis shows that in the pre-production sites, the costs of those farmers who adopt insect-resistant GM rice fall and their yields rise. Given that the farmers in the sample are small and relatively poor (the average per capita income of the households in the sample was US$0.74 per day at official exchange rates), leaders concerned with agricultural productivity and farmer income likely will back any decision to commercialize GM rice.

The implications of the commercialization of GM rice, should China decide to proceed, could far exceed the effect on its own producers and consumers. Robert Paarlberg, political scientist at Wellesley College, suggests that if China were to commercialize a major crop such as rice, it is possible that it would influence the decisions about the commercialization of GM crops in the rest of the world. For example, if China were to commercialize GM rice, it possibly would clear the way for the extension to GM wheat, maize and other crops inside China. If China, a large export market in future years, proceeded in this direction, this could encourage the large grain exporting nations, such as Canada, the U.S. and Australia, to recommit themselves to expand their programs in GM wheat and other export crops, since China is a likely target for their exports in the future. More importantly, the commercialization of rice and other crops may induce other developing countries, such as India or Vietnam, to expand their plant biotechnology programs. On the one hand, other developing countries might follow China in an effort to remain competitive. On the other hand, with a clear precedent, other leaders might be willing to adopt GM food crops to increase the income of their farmers as well as to improve their health. It is in this very real sense that the future of GM rice in China may have an important influence on the future of GM crops in the world.

The rice industry in California also is likely to be affected. Although speaking off the record, officials in South Korea have stated that they likely would not allow imports of rice from China if the nation were to commercialize GM rice. Japan could do the same. Interestingly, such an action has been hypothesized even though currently all GM technologies to date have been introduced into long-grain rice varieties, the type of rice that is produced in the southern region of the United States. There are no field trials of genetically modified varieties that include the use of short/medium-grain rice. So why would East Asian consumers (and importers), who only consume (import) short/medium-grain rice, not welcome China's non-GM short/medium-grain rice? In part, it could be that those in charge of importing would fear contamination of non-GM varieties by GM varieties. It could also be in anticipation that China would eventually move to introduce GM technology into all of their varieties. Finally, South Korea and Japan may also want to use this as an excuse for reducing imports.

So who would benefit? At least in the short run, California rice growers might be expected to gain. Throughout the world, there are only two nations that are able to produce significant volumes of short/medium-grain rice for world markets. If East Asian importers refused to import GM rice from China, they would have to rely almost entirely on exports from California. From this point of view, given the high likelihood of China's eventual commercialization of GM rice, California's reluctance to extend or commercialize GM rice may be the right move. California also might be able to capitalize on the (so far) small fraction of China's consuming population that would prefer to eat non-GM rice. Of course, California rice growers can easily understand that it does not take a very large share of China's population to make a large market for GM-free California short/medium-grain rice.

> ***"The implications of the commercialization of GM rice, should China decide to proceed, could far exceed the effect on its own producers and consumers."***

However, the decision to produce GM rice is potentially more complicated. It is possible that other factors could undermine or even offset any advantage that California might be expecting to gain. For example, if China could convince its East Asian neighbors (and its own wary consumers) that it could segregate the GM rice crop from the non-GM rice crop, China could ultimately have an advantage. With higher productivity in the long-grain rice-producing region of the country, growers in parts of the country that are able to produce either type of rice (that is, either long - grain rice or short/medium-grain rice) could move into short/medium varieties (which command a higher price premium in China's domestic market). With higher supplies of short/medium-grain rice, the price in China's domestic market could fall, allowing China to sell more competitively into export markets. In addition, it is possible that in the future the reluctance of consumers to buy GM food products could disappear. In this case, China's rice economy ultimately could be stronger since it would be a leader in GM technologies.

The current GM technologies are only scratching the surface of what biotechnology may be able to do for agriculture in the long run. At the very least, this means that even if in the short run California rice growers will not be using biotechnology, research in public and private research institutes should be encouraged.

For additional information, the authors suggest the following reading:

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China's Strawberry Industry: An Emerging Competitor for California?

by

Colin A. Carter, James A. Chalfant and Rachael E. Goodhue

China is becoming an important player in the world strawberry market. Although its yields per acre are much lower than California's, its costs per acre are much lower as well. China's production and exports are growing rapidly. For some countries, frozen strawberry imports from China are increasing while frozen imports from California are decreasing.

China is an increasingly important competitor for California in the global markets for many specialty crops, including strawberries. Strawberry production in China has grown substantially, because strawberries are a relatively profitable crop in that country. There are no official statistics reported in China's *Agriculture Yearbook* regarding the size of China's strawberry industry, but there is broad agreement that China's strawberry acreage has grown. Trade data indicate that China's strawberry exports have also grown rapidly in recent years. In this article, we discuss the Chinese strawberry industry, and provide comparisons to California's strawberry sector.

The actual dimensions of China's strawberry industry are not known with any certainty. While there is general agreement on China's strawberry acreage—roughly six times greater than California's—estimates of yields and, therefore, production differ widely. Table 1 reports three alternative estimates of China's strawberry acreage, yield and production, with comparisons to California's strawberry crop. One of the estimates reported in Table 1 puts China's annual production at twice California's level. The Market and Economy Information Department of China's Ministry of Agriculture estimates China's average yields to be nearly 40 percent of California's yields, and therefore estimates average annual production to be 3.39 billion pounds in China from 2001-2003, compared to California's production of 1.6 billion pounds. The other two estimates from China have substantially lower yields, and indicate that production there might be roughly the same as in California. The Chinese Strawberry Association estimates China's annual production to be 1.75 billion pounds, and researchers from Nanjing Agricultural University suggest a slightly smaller number, about 1.5 billion pounds.

As shown in Table 1, estimates of Chinese acreage do not vary much, and they suggest that China's strawberry acreage was over six times as large as California's average strawberry acreage from 2001 through 2003. Variation in annual production estimates is thus largely due to huge differences in yield estimates, which range from 8,675 to 19,109 pounds per acre. We obtained a fourth yield estimate from Mr. Zhang Lei, FAS Agricultural Specialist in the U.S. Embassy in Beijing, who indicated that field-produced strawberries yield about 10,000 pounds per acre, and greenhouse strawberries yield about 14,000 pounds per acre. All of these estimates are substantially below California's average yield of 56,800 pounds per acre. Even the highest estimate for China is only about one-third of California's yield.

China's strawberry production is less geographically concentrated than U.S. production. Strawberries are produced in many different provinces in China. Hebei, the top strawberry-producing province, accounts for about one quarter of China's total

Table 1. California's Annual Strawberry Production Compared to Estimates of China's Production

Estimate	Time Period	Land Area -acres-	Total Production --billion lbs--	Yield -lbs/acre-
California [1]	2001-2003	25,734	1.61	56,800
Chinese Strawberry Association [2]	2002-2004	166,066	1.75	10,554
China's Ministry of Agriculture [3]	2001-2003	168,514	3.39	19,109
Nanjing Agricultural University [4]	2001	172,900	1.50	8,675

[1] *California Agricultural Statistics Service.*
[2] *U.S. Department of Agriculture.*
[3] *Ministry of Agriculture, China.*
[4] *Yinghuang Zhou, Xianhui Geng, Liyue Huo, Feilun Du, Lv Chen and Jun Xiong (2001), "Chinese Strawberry Industry--Middle-term Report", Nanjing Agricultural University.*

Table 2. Strawberry-Producing Regions in China, 2001-2003 Average

Regions	Land Area --acres--	Production million lbs.	Yield lbs./acre
Hebei	29,652	782.5	26,322
Shandong	25,781	621.9	24,129
Liaoning	19,521	473.8	24,395
Jiangsu	17,297	260.9	14,937
Zhejiang	11,037	206.8	18,837
Anhui	11,029	147.6	13,381
Sichuan	8,237	111.3	13,418
Henan	7,742	132.5	15,858
Hunan	7,001	54.6	8,218
Shanghai	6,836	107.6	16,114
Others[a]	24,381	491.2	--
Total	168,514	3,390.7	19,109.3

Source: Ministry of Agriculture, China.
[a] "Others" aggregates acreage and production for all provinces and municipalities with less than 5,000 acres.

production. The top three production regions account for 55 percent of total production. In contrast, California alone accounts for 89 percent of U.S. volume, and the top three states (California, Florida and Oregon) account for 97 percent of U.S. volume. Within California, Ventura County accounts for just under 30 percent of California production, and the top three counties (Ventura, Monterey and Santa Barbara) account for 69 percent of California production.

Table 2 reports acreage, production and yield for the top ten strawberry-producing provinces in China, and Figure 1 shows their geographic location. The top three strawberry-producing provinces, Hebei, Shandong and Liaoning, are in northern China, which has favorable weather conditions for strawberry production. Hebei's production season is from November to mid-June. Good weather for strawberries, combined with superior growing techniques and varieties, means that northern yields are much higher than southern yields, as Table 2 shows. Jiangsu, which has the highest strawberry production of the southern provinces, has an average yield that is less than two-thirds of the average yields of the top three provinces. Jiangsu's production season is from mid-December through June. This regional yield difference is similar to differences in the United States, where Florida's average yield is about 40 percent of California's, and all other states have yields less than 60 percent of Florida's. However, Florida's growing season is shorter compared to California's growing regions, particularly those in the northern part of California. No such differences in length of growing seasons are apparent among China's strawberry-growing provinces.

Production

The majority of China's strawberry growers are small-scale family farmers who grow a variety of crops. The average grower cultivates less than 0.7 acres in total, and most growers do not hire labor. The use of hired labor is limited to the harvest season, if it is used at all. In other cases, neighbors might share labor during busy times. The daily wage for field labor is $1.20 to $2.40. Some farmers use methyl bromide to fumigate the soil before planting, but information on methyl bromide usage, and the usage of fumigants more broadly, is very limited. China's strawberry growers face significant disease problems, which fumigation with methyl bromide or other chemicals can reduce. Methyl bromide can be purchased in small enough quantities to be a viable option for small growers, so the use of the fumigant itself is not limited by the small size of the average grower's farm. However, other factors, such as knowledge of effective fumigation techniques, may be limited by scale considerations. If fumigation becomes more widespread in China, disease will become a less important factor and yields could increase substantially.

In California, the average strawberry grower has 63 acres of strawberries, although 70 percent of growers have less than 50 acres. Unlike in China, the typical California grower hires a substantial amount of field labor. According to University of California estimates, a strawberry grower requires 700 to 1,000 hours per acre of harvesting labor, depending on the production region, at a cost per hour of $9 to $10 (http://coststudies.ucdavis.edu). The majority of California's strawberry acreage is fumigated before planting, with methyl bromide or another fumigant, to control pests and diseases.

In China roughly 80 percent of the strawberries are produced in plastic-covered greenhouses, instead of in fields, as in California. Generally, field-grown strawberries are produced mid-season in China, when weather conditions are most favorable, and greenhouse production extends the season both earlier and later. There are three main types of greenhouses, with different costs and expected lifetimes. Wood-framed

Figure 1. Major Chinese Strawberry Production Regions

Only the provinces and municipalities with more than 1,000 acres of strawberry production are labeled. Shanghai and Chongqing are municipalities directly under the central government, similar to the District of Columbia in the U.S.

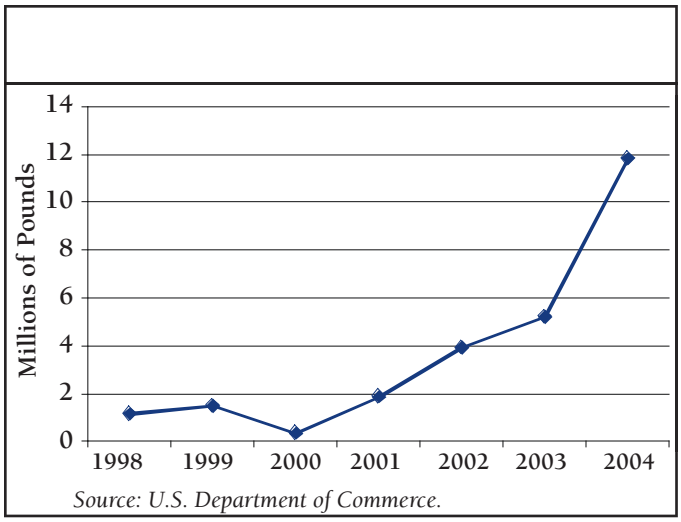
greenhouses are the cheapest, costing about $350, according to Jiangsu government officials. Wood-framed greenhouses last two to three years. Steel-framed greenhouses cost more, up to $1,200, but last significantly longer—nine to ten years. A less common type of greenhouse is the "sunshine greenhouse" used by some large growers. "Sunshine greenhouses" have three brick walls, with one plastic-covered frame wall. Although sunshine greenhouses are superior in terms of productivity and useful lifetime, they are fairly uncommon due to their substantial initial cost of $1,200 to $2,400.

One similarity between the California and China strawberry industries is the varieties grown. University of California varieties, such as Camarosa, are planted on about 60 percent of California acreage. Some of these varieties are also grown in China. Generally, strawberry varieties planted in China mostly originated elsewhere. Japan and the U.S. are the most important sources, although some varieties have been obtained from Europe. Imported varieties are sometimes then propagated within China. Unlike California growers, who buy certified disease-free and pest-free nursery plants every year, most growers in China propagate plants on-farm, or they may buy plants from other growers who do so. These grower-propagated plants cost $0.018 to $0.024 per plant, about one-fourth of what California growers pay for certified plants, and about one-fifth of what certified imported plants would cost in China. However, some growers in China do purchase certified imported plants, in order to meet quality requirements in production contracts with buyers such as McDonalds. The low-cost, grower-propagated plants are risky to use because grower-propagated plants may carry diseases and/or pests that can reduce both plant vigor and yields. This means that if growers in China increase their use of certified plants, they will be able to increase yields. Another possible avenue for increasing yields would be the development of more strawberry varieties specifically tailored to conditions in China's major production regions. China reportedly has an extensive breeding program underway.

Domestic Market

Domestically, China's demand for fresh strawberries is growing rapidly. As urban incomes have increased, and as consumers' consumption patterns have changed, the domestic demand for fresh strawberries has taken off. About 80 percent of China's production is consumed domestically as fresh strawberries. The fresh strawberry market in China is primarily a regional market, rather than a national one. Each production area tends to sell to nearby population centers. Prices therefore vary by production area. Within a season, prices tend to reach a maximum around the Chinese New Year, in January or February, and reach a minimum mid-season when volume is highest, regardless of the region.

For example, fresh strawberries from Hebei in the north are sold primarily in Beijing, Tianjin, Liaoning Province, Jilin Province and Heilongjiang Province. Fresh market prices range from $0.24 to $1.20 per pound, with a seasonal average between $0.36 and $0.55. From November through mid-April, Hebei strawberries are sold in the fresh market. From mid-April through the end of the season in June, they are sold in the processed market. There are many processing facilities in Hebei that produce canned strawberries, strawberry jam and strawberry wine, as well as frozen strawberries, the dominant processed product.



Source: U.S. Department of Commerce.

cessed berries in total production exports a hare of production, other things equal.

recent growth in China's exports of fresh and strawberries has been remarkable. Accordhe USDA, China's fresh strawberry exports 2.52 million pounds in 2004, a 54 percent over its 2002 volume. Hong Kong and the Kingdom are the two largest importers of 's fresh strawberries.

oximately 70 percent of China's frozen strawroduction is exported. Frozen strawberry are also growing rapidly: Exports totaled illion pounds in 2004, almost double the port volume of 76.9 million pounds. China its frozen strawberries to many countries. nd Japan are the largest importers, but Australia, Canada and the U.S. also import significant volumes. China has dramatically increased its frozen strawberry exports to the U.S. over the past few years, as shown in Figure 2. Within three years, volume increased from 2 million to 12 million pounds. Over the same time period, Canada and Japan substantially increased their imports from China as well.

China's increased exports contrast with a mixed picture for California's exports over the same time period. California's fresh strawberry exports grew substantially between 2001 and 2003, almost doubling, and then declined by about ten percent in 2004. Frozen exports declined by nearly 50 percent between 2002 and 2003, and then fell slightly (four percent) between 2003 and 2004. Canada buys over one-half of California's frozen strawberry exports, so the increase in China's exports to Canada could have a significant effect on California.

Continued on page 15

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ern production region, are sold primarily in Shanghai, Jiangsu Province, Zhejiang Province and Anhui Province. Fresh market prices range from $0.48 per pound to $1.20 per pound, with an average price of $0.72 per pound.

California's strawberry industry, in contrast, serves a national fresh strawberry market. All production regions ship across the country (and to Canada) during their fresh strawberry production season. As in China, the demand for fresh strawberries has been growing. About three-fourths of California's total strawberry production is marketed as fresh strawberries, and about 88 percent of fresh strawberries are consumed domestically.

Export Markets

China's strawberry exports in 2004 were 150 million pounds, or about nine percent of the China Strawberry Association's estimated average production volume for the 2002-2004 time period. In 2004, California exported about 12 percent of its total fresh production and five percent of its total frozen production.

In China, the importance of exports varies by production region. Hebei exports about nine percent of its production, while Jiangsu exports about one-quarter of its annual production. This difference may be due in part to the differences in growing conditions, which lead to lower berry quality in the south, particularly later in the season. Lower-quality berries are used for processing, so given that the vast majority of exports are processed berries, a region with a larger share


Strawberry production in China is often on small plots that are integrated with production of other crops. Photo by Wensi Zhang.

New Horizons for Rural Reform in China: Resources, Property Rights and Consumerism

by
Fredrich Kahrl, David Roland-Holst and David Zilberman

We present a reform agenda to alleviate rural poverty and improve environmental sustainability in China. It focuses on labor reform, suggesting reductions in the work week and providing incentives aimed at encouraging exit from farming, trading in land and water rights, and adopting and developing new technologies. Ê

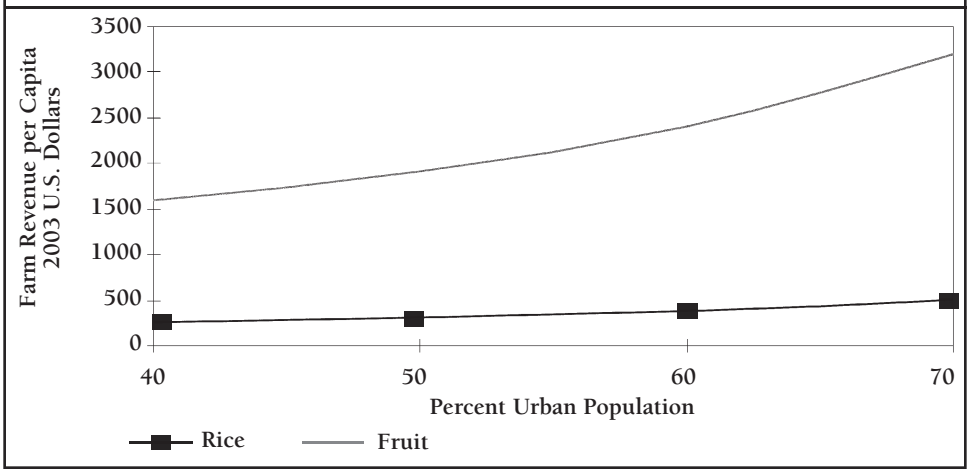
China's agricultural development in recent decades is impressive. Its farmers continue to feed the world's largest population and China's crop yields are well above global averages. Yet rural incomes have been stagnating, with wide and growing geographic disparities. Overall, China's median net per capita rural income is low, estimated at US$317 in 2003. Nevertheless, Chinese agricultural development faces other challenges. In China's northern region, for example, water use appears to be on an unsustainable trajectory. The chemical intensity of Chinese farming is high by global standards and is a growing source of public health risk. Technologically, China could benefit from advances in biotechnology and irrigation science, but the successful deployment of these technologies will also depend on well-functioning institutions.

In this article, we introduce a reform agenda to address China's rural poverty and sustainability challenges, based upon an assessment of the primary resources used in China's agricultural sector: labor, land, water and technology. The reform agenda we present is unconventional, but we believe it opens new opportunities for meeting China's objectives for rural and national economic growth, water and environmental sustainability, and food security.

Labor

Labor has been a comparative advantage for the modern Chinese economy, yet labor markets pose a longer-term conundrum for policymakers. Rural labor mobility has provided a perennial resource of competitiveness, yet continued migration requires high economic growth to sustain labor demand. From the opposite perspective, population density in the agricultural sector could seriously constrain long-term efforts to alleviate rural poverty. In 2005, only 40 percent of the Chinese population is urban. Even under the government's more aggressive migration projections, implying anywhere from 50-50 to 40-60 rural-urban population percentages by 2020, our estimates indicate the average Chinese farmer could remain below the World Bank's threshold for poverty ($2/day). Figure 1 illustrates this point, displaying per capita farm revenue that would result from current Chinese yields marketed at current U.S. prices.

Figure 1: Estimated Farm Revenue per Capita for Chinese Crops at U.S. Prices



The average amount of land per farmer is only 0.47 hectares. Figure 1 shows that total rice production on this land, valued at California farm gate prices (the highest in the U.S.), would yield only about US$244 per capita, while tree fruits and nuts would be much more lucrative ($1,589). Given these extremes, crop composition will clearly be important to the distribution of farm incomes, yet extensive staple crops are expected to

dominate domestic production acreage for the foreseeable future, and this will exert a significant drag on per capita income growth.

A sustained commitment to poverty alleviation in China must address the issue of farm population density. To meet income targets of US$1,500 per farm worker annually, using present technologies, roughly 75 percent of current farmers would have to switch to other activities, implying a need for 234.4 million jobs. This would require massive job creation in urban areas, in addition to growth in off-farm employment in rural areas. Since the late 1970s, China's rural township and village enterprises have made significant contributions to the country's economic growth, creating nearly 110 million rural non-farm labor jobs since 1985. These rural enterprises will have to substantially expand to absorb a surging labor supply.

Some of the new urban jobs required to absorb migrants from rural areas can be partially created by a more drastic reform of current labor laws. China's 1995 Labor Law mandates an eight-hour workday, a six-day workweek and a minimum wage. But these standards are seldom enforced and many Chinese workers have an 80-hour workweek. A labor-leisure reform could dramatically alter both labor markets and consumption patterns in China. Reducing the workweek without reducing pay would marginally lower China's competitive advantage, but would dramatically stimulate demand and urban job growth. Similarly, hours worked in excess of 50 could be compensated with overtime pay. We estimated the aggregate effects of imposing a 50-hour workweek on China's urban labor force, assuming different prior levels of weekly work commitment. For example, reducing the urban workweek from 75 hours to 50 hours would increase urban employment by 50 percent, thereby translating into 125 million new jobs. The increased leisure would also increase domestic consumption.

Currently, the Chinese population is saving about 30 percent of its earnings, as compared to much less than ten percent in most of the developed nations. One reason for the high savings rate is China's long workweek. Consumption activities require time. A shorter workweek would lead to the development of a leisure culture, thereby increasing consumption and creating new jobs. For example, most of the employment and earning in the U.S., as well as many developed countries, is driven by domestic demand. China's current export-driven model of growth will not in and of itself create sufficient jobs to absorb hundreds of millions of farmers into the wage labor force. Creating a vibrant domestic market would instead be the key toward sustaining China's economic growth over the longer term. From a labor-market perspective, employment to offset the declining workweek would create new urban demand and increase the cities' capacity to absorb rural migrants. In turn, this rural outflow would stimulate rural wages and marketed-food demand. Furthermore, as farm residents become urbanites, this greater demand for goods in cities would increase industrialization in rural areas and buffer the migration process.

Land

Many of China's rural policy challenges stem from existing land and demographic conditions. Sixty percent of China's population currently resides in rural areas, 312.6 million of whom were officially registered as "farm laborers" in 2003. Average farm size in China is roughly 0.13 hectares (0.32 acres) per household, dipping to 0.04 hectares in Guangdong Province. While Chinese farmland has shown remarkable capacity, the yield increases needed to keep pace with evolving food demand will require renewed commitment to investments in technology, improved genetic material and more efficient scale of production in extensive food staples. Current farm size contributes to a low degree of mechanization, high costs of input use and marketing, limited access to credit and subsequently low investment. Overcoming scale constraints will require establishing clear land-property rights and incentives for expanding the leasing of land.

The virtues of leasing rights are many. Migration in China to date has been varied. While some rural-urban migrants leave villages to take up permanent residence in mega-cities like Beijing and Shanghai, more often migration has been temporary, focused away from major cities, and a boon for rural economic growth, as migrants send remittances and return to their villages to establish small enterprises. Leasing provides a means for farmers to diversify income sources as they make a stepwise transition into other sectors of employment.

At present, China is undergoing a transition in rural property rights, including secure tenure arrangements atop ambiguous state ownership. China's central government has long advocated some degree of land transfer, with "leave the land but not the village" directives beginning in the 1980s. However, while the legal basis for land leasing has significant precedent,

in many areas leasing remains a taboo, possibly because of uncertainty about enforcement of leasing rights and lack of functioning markets.

Land reform can play an essential part in raising rural incomes and stabilizing rural populations, but only if it facilitates a smooth transition to more labor-efficient production systems. Providing farmers with the legal and market institutions to lease their land is a key component in encouraging labor migration and increasing profitability of farming.

Water

China's water resources are unevenly distributed. The five municipalities and provinces of the North China Plain—Beijing, Tianjin, Hebei, Henan and Shandong—produce approximately 25 percent of China's total agricultural output and 24 percent of its GDP, with only five percent of its water resources. Thirty-five percent of the country's total planted area, and 40 percent of northern China, is irrigated. With rapid expansion of agricultural capacity, irrigation has increased in both its scope and intensity. In major watersheds in northern China, this has led to sustained imbalances between water demand and supply, as in the case of the Yellow River (Figure 2). Northern China has a high degree of groundwater dependence—accounting for 64 percent of total water use in the North China Plain—and aquifers in many areas are under stress from rising water demand. Agriculture remains by far the largest use of water in China, accounting for 65 percent of water use in 2003. Nevertheless, competition for water is expected to intensify with the pace of urban migration, both from residential and industrial water needs.

Expanding water supply and controlling demand can address the water imbalance. Supply expansion includes the current proposed south-to-north water transfer and other proposed water projects, but they are costly and have negative environmental effects. Demand can be reduced by conservation activities, improved water productivity and improved conveyance. Policy reforms are needed to induce conservation and to improve water management. To promote conservation, water-pricing reforms were passed in 2003, yet implementation has been slow and uneven.

The Chinese government's official objective is to increase national average water efficiency for irrigation systems from 45 percent to 55 percent. While increased water-use efficiency will come through public and private investment in conveyance facilities and new application technologies, the key to more sustainable water use in China is efficient pricing. However, water pricing remains a subject of contention, due to its impact on farmers' incomes. All of these considerations have to be incorporated into water reform with the following elements:

• *Mechanisms for efficient investment in water infrastructure:* A formal procedure should be introduced to evaluate the economic impacts of proposed projects. Its outcomes should avoid wasteful projects.

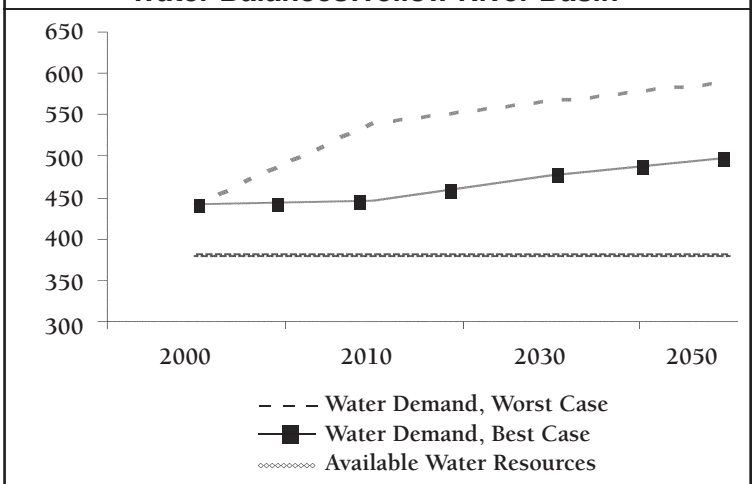
• *Water management institutions:* These institutions include: 1) Water-user associations (WUAs) and water-service organizations (WSOs) that are effective in maintaining and improving conveyance and facilitating water trade. 2) Groundwater-management districts that should control overdraft. 3) Water-quality boards that will monitor and enforce water-quality standards. China now has more than 500 WUAs, and their experience in promoting improved management has been promising.

• *Water rights and trading*: Water ownership should be clearly defined and an institutional framework to support trading in water rights should be established. Efficiency is likely to increase when water users have water rights and trading is allowed.

Technology

The crop-breeding sector has supplied Chinese agriculture with diverse and productive genetic materials.

Figure 2: Current and Projected Water Balances:Yellow River Basin



Worst case scenario: *Small decrease in irrigation constant (water consumption per unit agricultural land), large irrigated area.*

Best case scenario: *Large decrease in irrigation constant, small irrigated area.*

Maintaining and improving private and public capacity to enhance genetic materials using traditional breeding should continue to be a priority. However, China should also continue to invest in alternative methods of improving its genetic materials. China can take advantage of new tools of molecular and cell biology and develop genetically modified varieties.

Bt cotton illustrates the potential of transgenic varieties in China. Bt cotton had nearly a 50 percent adoption rate in 2001, five years after its introduction. It increased yields by 10 percent, decreased pesticide use by 70 percent, and improved profitability and workers' health. China has not taken full advantage of available transgenic traits. Transgenic-rice varieties can save pest-control costs and improve farmers' health. Herbicide-resistant varieties—internationally the most widely adopted transgenic varieties—can almost eliminate the time spent on weeding. Experiments with Bt maize in China show yield increases of 23 percent and insecticide savings of more than 50 percent.

Agricultural biotechnology is still in its infancy. New transgenic traits currently in the experimental stage will extend the shelf life of vegetables, increase the nutritional value of animal feed and fortify grains with valuable nutrients. China can benefit from new technologies that improve the precision of agriculture, increase yield and reduce residues, and improvements in livestock production that increase efficiency, and especially reduce public and environmental health risks.

Technological change in agriculture will require investment in research development and industrial facilities. Expansion of the Chinese agricultural research and education system will be essential, since agricultural technologies need adaptation to local conditions, and some of the problems of China are unique and will not be sufficiently addressed elsewhere. The educational system in China tends to be centralized, and much of the research capacity is in the major cities. Some decentralization of research capacity will be needed to produce the knowledge base for technological changes in agriculture. Since much of the agricultural research products (seed varieties, pollution control strategies) have public good properties, the public sector may need to invest in much of this research. Less than three percent of China's GNP is spent on public education, and that must increase to continue growth. The public sector will also need to invest, or provide incentives for investments in infrastructure that reduce transportation and communication costs to the farm sector. That includes improved and well-maintained roads, and the infrastructure for modern information technologies.

Concluding Remarks

China's remarkable economic attainments inspire both admiration and concern. It has made unprecedented progress in poverty alleviation and economic advancement, yet major regions of China still suffer from rural poverty and unsustainable environmental situations.

The only avenue to substantially improve rural income levels is to establish policies that will provide incentives to drastically reduce employment in farming. They include urban labor-market policies that would enforce existing work rules, reducing the average workweek significantly. This would contribute to more off-farm employment and more efficient scale in agriculture, both of which could raise rural incomes substantially. It would also stimulate domestic demand though increased leisure, reducing China's reliance on external demand when this is an increasing source of international controversy.

The proposed reform agenda also includes the establishment and protection of land and water rights and removal of barriers to water trading and land leasing. It suggests the establishment and strengthening of institutions for the management of shared natural resources and generation and dissemination of new technologies.

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One potentially important difference between China's exports and California's exports is that California's exports of fresh strawberries are more important than its exports of frozen strawberries, in terms of volume and share of production. In contrast, frozen exports are much more important in China. The California Strawberry Commission's Processor Task Force has concluded that China's processed strawberry exports are a potential threat to the California industry. Alternatively, the Task Force found that China is not currently a threat to California's fresh markets. Indeed, because fresh strawberries are not available in China from July until production begins again in November or later, the Task Force sees an opportunity to export fresh strawberries to China during this market window. However, strawberries are not currently approved for import into China, by China's State General Administration for Quality Supervision, Inspection and Quarantine.

One market where China's strawberries have proven to be competitive is in Japan, which is an important export market for California. In 2003, China replaced the U.S. as the largest supplier of frozen strawberries to Japan. California's exports to Japan have declined, while China's exports have increased. In 2004, California's exports to Japan were roughly one-quarter of the 2002 level of exports. Because frozen strawberries from China cost roughly one-half as much as frozen strawberries from the U.S., this trend of an expanding market share for China and a declining market share for the U.S. and California is projected to continue.

In conclusion, China is becoming a more important competitor for California strawberries. Although estimates of the size of the strawberry industry in China vary, by all accounts it is growing rapidly. To the extent that its current yields are limited by disease problems and production techniques, China has the potential to increase production even without increasing acreage. China's share of exports of processed strawberries to third markets historically important to the U.S. has been increasing, while the U.S. share has declined. All indications suggest that China will become an increasingly important competitor for the California strawberry industry.

For addition information,
the authors suggest the following resources:

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