The Relevance of Chinese Agricultural Technologies for African Smallholder Farmers:

Agricultural Technology Research in China

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CENTRE FOR CHINESE STUDIES

List of Acronyms

AIDS	Acquired Immune Deficiency Syndrome
CAAS	Chinese Academy of Agricultural Sciences
CADFund	China-Africa Development Fund
CASS	Chinese Academy of Social Sciences
CDB	China Development Bank
EXIM Bank	Export-Import Bank of China
ERS	Economic Research Service
FAO	Food and Agriculture Organization of the United Nations
FOCAC	Forum on China-Africa Cooperation
GDP	Gross Domestic Product
GFDI	Grassland Fire Danger Index
GM	Genetically Modified
GMO	Genetically Modified Organism
HIV	Human Immunodeficiency Virus
HS	Harmonised System
IAED	Institute of Agricultural Economics and Development
ICCCA	Impacts of Climate Change on Chinese Agriculture
IFPRI	International Food Policy Research Institution
IMAR	Inner Mongolia Autonomous Region
IPM	Integrated Pest Management
MDGs	Millennium Development Goals
MOA	Chinese Ministry of Agriculture
NATESC	National Agro-Tech Extension and Service Centre
OECD	Organisation for Economic Co-Operation and Development
PPPs	Public-Private Partnerships
PSE	Producer Support Estimate
R&D	Research and Development
SADC	Southern African Development Community
TFP	Total Factor Productivity
TRQ	Tariff Rate Quota
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
WTO	World Trade Organisation

Summary and conclusions

The economic miracle of China is well known. In particular, China's dramatic economic growth over the last thirty years is just one more example of the growth paths exhibited by several Asian economies over the last fifty or sixty years, albeit with some road-blocks such as the Asian crisis of the mid 1990s. In general, the successful recipe for this success has been: to open markets to facilitate sensible price signals but at the same time to operate trade and exchange rate policies that favour exports over imports in at least the initial stages; to provide a sound and stable government that inspires investment and secures property rights (including land tenure security); and to develop large-scale physical infrastructure. Given this, rural migration provides the labour force that drives the growth in manufactured products (exported to the final market of the US) and consequently agriculture becomes an increasingly small component of the economy. The key to achieve the same success as nations such as China is to have all of these factors operate in a coordinated manner, as they are mutually reinforcing.

The Asian growth miracle reflects the above trends. Meanwhile, much of Africa is generally regarded by the world as an open-cast mine for resource extraction in a series of often dysfunctional countries emerging from colonial domination and largely governed by incompetent and/or corrupt leaders that have exhibited little or no economic growth over the last forty or so years[1].

While China has classically followed this Asian growth miracle pathway, it has differed in one major respect. That is, the rural sector; while supplying much surplus labour to the manufacturing sector, has become an internationally competitive sector in its own right, despite operating with largely small holder farmers. With less than nine percent of global arable land, China has succeeded in providing food security for 20 percent of the global population and largely lifted its citizens out of abject poverty.

How has the development in the agricultural sector been achieved? The first component of the agricultural package is the functioning of the overall political-economy package, as outlined briefly above. This in turn has fostered investment. But the real issues for the rural sector are twin paths that have been followed in the sector, with the second pathway initially lagging behind but now catching up.

The first, the traditional agricultural pathway, was driven by technology. This has mainly involved the adoption of new plant varieties, also augmented by the associated increases in the use of other inputs that are a necessary part of their success. Augmenting these technologies to ensure that this success happened has also been an extension service of over one million staff dedicated to getting the technology right through to virtually the last farmer.

[1] This is of course a sweeping generalisation, as the southern African country of Botswana, for example, has rivaled Asian growth.

In assessing the relative effectiveness of the technology/extension combinations we developed a 'yield frontier/gap' question approach to Chinese experts, during field research conducted in China. This postulates that an index of 100 represents best experimental crop yields, and that actual farm levels will be below this. The general response was that this farm level index was something around 70 points (i.e., 30 percent below the potential). Opinions varied as to whether the level was closing (perhaps measuring effectiveness of the extension service) over time. Meanwhile this frontier itself has been moving upwards by around two percent annually to date. The end result has been that since around 1980 when China was producing some ten percent of the global fruit, vegetables and meat it now produces over 35 percent of the global fruit and vegetables and around 28 percent of global meat production. Examining this production increase in more detail shows that yield increases have largely been the contributing factor, as China is actually steadily losing agricultural land to urban encroachment and infrastructure development.

The second and uniquely Chinese rural pathway has been the village industrialization or the setting up of township enterprises that provide employment opportunities for rural populations. These light manufacturing firms and other forms of development to the rural sector have been set up to mitigate the migration surge to the cities. Furthermore, it is difficult to get a feel for what or who exactly a small holder farmer in China is, as the communal sense still seems to bind the Chinese in a manner that enables the community to move in 'lock step' to the beat of a central drummer. This has greatly facilitated many aspects of China's recent development and sets this country aside from Africa.

A lifetime would have to be spent to really assess exactly what parts of the actual technological package are the most crucial, as this is an ever-evolving process. The challenge for Africa is to operationalise technologies in the absence of much of the necessary flanking support (policies, prices, infrastructure, agricultural credit etc). But what are these actual technologies? Sometimes it is hard to assess as to whether the technologies are Chinese developed or imported – but this should not matter. The crucial question is – what has worked for China that could be applicable to Africa?

Rapid advances in new plant varieties have been a major factor in China's crop production increases. Yet Africa with access to equally successful new crop varieties that are being developed through international cooperation has not seen similar increase in productivity. To date China has not released GMO food crop varieties. Although intensive research is underway in research centres, Bt cotton remains as the only GMO crop where seed has actually been released.

The study team considers that water and soil related technologies offer the best Chinese examples for transfer to Africa. Africa is generally a water-challenged land, and soil degradation is a problem. Here China offers packages that can be applied, especially when focusing on small-scale farmers. This includes water saving and augmenting techniques, tillage and planting methods, soil enhancing methods such as mulching, and the maximisation of fertilizer usage by soil testing and application techniques. For the purposes of this research we have not studied mechanisation techniques, and only touched upon rural energy sources, but consider there are some lessons here to be learned. Similarly, we feel that Chinese aquaculture has much to offer Africa.

Overall, China considers that it has largely solved the problem of feeding 20 percent of the world's population and lifting most of its citizens out of abject poverty. The country is therefore turning away from the agricultural imperative of increasing production and instead seeking ways to improve product quality and pursue a more responsible approach that emphasizes lower fertilizer, pesticide and insecticide usage. Africa has not reached that stage of development.

Report outline

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Preamble

This report documents the dramatic growth in Chinese agriculture, and portrays how this growth has been fuelled by a package of measures that includes technological change. The wider measures concentrate upon the policy and infrastructural environment and include changes to land ownership; a relaxing of prices, both output and input, to move closer towards a free market regime; an associated relaxing of border controls and restrictions to similarly move towards a relatively free global market regime; a large improvement in rural infrastructure such as roading and distribution; a dramatic rise in fertilizer, insecticide and pesticide usage; an even more dramatic increase in rural electricity usage; a modest rise in irrigation usage; a modest, by Asian development standards, change in rural labour numbers; and improvement in agro-processing and storage procedures. The technological changes include a more efficient use of irrigation water; genetically modified plant varieties (and other plant variety changes), changes in soil management and changes in fertilizer related issues. In addition, there have been dramatic changes in the spread and technological development of aquaculture in small plots. The literature documents these 'big-picture' factors very well, as considerable research has been undertaken on this subject area.

The objective of this study is to examine where technological changes in Chinese small holder farming can be transferred to small holder African farmers. To address this research question, however, it is of great importance to first understand how much of the increases in Chinese agricultural production is actually determined by technological change. And, similarly, how much of the technological change is relevant to small holder production and therefore of interest to Africa?

Note that this research has been conducted concentrating largely on crop (including vegetable) production, However, we provide some information on small-scale animal production, aquaculture and agricultural trade patterns in a series of Annexes.

The report starts by examining the role of agriculture in development, a role that has traditionally concentrated upon both feeding the population and providing a supply of surplus labour to the cities for the manufacturing workforce[2]. We know that this path has been followed in China but suggest that Africa should in the same way utilise the surplus workforce from the rural sector. Next a background to China's geography and its agricultural sector is provided to put the sector in perspective. This includes a description of the land tenure system, including its changes and its limitations. This is followed by an outline of the main products from the sector before moving on to the crops sector developments. The

[2] In development economics, the "Dual Sector Model" explains the economic growth of developing countries by the movement of labour (surplus labour) from the rural agricultural sector to the urban industrial sector. The model is based on the assumption that a certain amount of farm workers in the agricultural sector do not add to agricultural output (marginal productivity of these farmers is zero) as land is a fixed input and as there are diminishing marginal returns. Hence, these additional farmers are termed as surplus labour, given that the shift of the farmers from the labour-intensive agricultural sector, to the industrial sector will not have any (adverse) impact on production in the agricultural sector.

aggregate technology picture is then given, followed by an introduction to the agricultural extension service.

This is followed by the real objective of the paper, namely the study of what technology is exactly driving Chinese agriculture. This includes crop varieties, water and water related issues, fertilizer and related issues, and an introduction to energy issues. The main part of the report concludes with a look at the status of the main official China-Africa partnership programme.

Annexes are given for the livestock sector, aquaculture, a review of some of the major problems related to the lack of coherent agriculture policies in Africa, and then finally a section placing China's agricultural trade in perspective.

1 The role of agriculture in development

The role that agriculture plays in the development of an economy is clearly set out and enunciated in the World Bank's 2008 report "*Agriculture for Development*". The first role is that of agriculture in its own right. Specifically, given that agriculture usually employs around two-thirds of the population in a developing country and that the agricultural sector generally has more people in poverty than the urban sector, any meaningful effort towards development must involve increasing productivity and therefore incomes in this sector notwithstanding agriculture's generally low and declining direct contribution to GDP. Traditionally, this first role then links to the second role for agriculture, of providing its surplus labour for the industrial sector, whose growth drove the so-called East Asian miracle. In the short term, productivity as usually defined can be lifted by reducing labour (the main input). The longer term must involve a technological revolution, and nowhere is this better demonstrated than in China over the last thirty or so years.

Conversely, nowhere is the need for this transformation more acute than in Africa. Yet we cannot stress enough the need to have an 'enabling framework' in the manner of a well-balanced set of policies to have this transformation occur – there has been much debate about whether this environment is state or market driven. We feel that it is the 'correct balance' of both, but that market signals must be the key drivers although probably within state-driven aspects of both overall policies and the provision of public goods to give the overall 'enabling framework'. But to achieve the right mix of incentives is the key lesson from China, combined with providing the relevant technologies to farmers.

2 China: the background[3]

2.1 China's geography

China is the world's fourth largest country by area but the largest by population with some 1.33 billion persons. Its terrain is mostly mountains, high plateaus and deserts in the west and plains, deltas, and hills in the east. Although the country is endowed with various natural resources including coal, iron ore, petroleum, natural gas, mercury, tin, tungsten, antimony, manganese, molybdenum, vanadium, magnetite, aluminium, lead, zinc and uranium, land is a constraint. Some 16.7 percent of the land is arable or in permanent crops, but with around nine percent of the world's arable land and water resources per capita at perhaps as low as one quarter of the global average, there is considerable pressure on this land and the scarce water resources.

By 2007 the Ministry of Agriculture (MOA) reports that China had 121.78 million hectares of cultivated land, with another 11.82 million hectares in gardens, orchards and plantations, 261.93 million hectares of grassland and 25.54 million hectares in 'other agricultural uses'. Around one quarter of the farmland is irrigated and the rest dry land. Importantly, this land is facing environmental and sustainability challenges for the agricultural sector. Since 1978 China has been losing almost half a million hectares of its farmland annually, although this decline seems to have stabilised in the two to three years through to 2006, as China becomes aware of the problems associated with declining farmland and increasing populations. This latter relationship is highlighted by the declining farmland per capita in China since 1978; from 0.139 hectares per capita down to 0.093 hectares per capita in 2006. In short, China, following centuries of cultivated farming to feed its population, has virtually no 'new' land available. This is not the case in at least some African countries.

The geography of China is important, as this makes it difficult to directly compare this large country even with a continent such as Africa. The temperature of course generally increases moving north to south in China. In the southern parts of the middle and lower Yantze River the accumulated temperature is between 5,000 to 7,000 degrees Centigrade annually. The warmer weather permits up to three crops a year to be grown. Also, in the southern parts of the Nanling Mountains the warmer temperature permits year-round cropping. Moving north to the colder North China plain and the northern parts of the middle and lower Yantze River the accumulated temperature is lower (between 4,000 to 5,000 degrees) and this permits two crops a year, while in the colder northeast and northwest China the lower average temperature with its severe winters only permits one crop. The country also suffers from both periodic droughts and floods.

[3] Most of this section is taken from 'Agriculture in China', published by the Ministry of Agriculture, People's Republic of China, January 2007.

2.2 The agricultural background

There is little doubt that in recent years China has achieved most of its 'big picture', right and enabling framework for agriculture. This is undoubtedly a key lesson for Africa and others in the developing world. In late 1978, leadership began moving the economy from a sluggish, centrally planned economy to a more market-oriented system. During this period agricultural production rose sharply, rural industries absorbed a large part of farm labour, poverty fell dramatically, and the level and quality of food consumption improved significantly. The commune system was replaced by one where individual families lease land from the collectives, ensuring that almost all rural households have access to land and are, at the minimum, food self-sufficient.

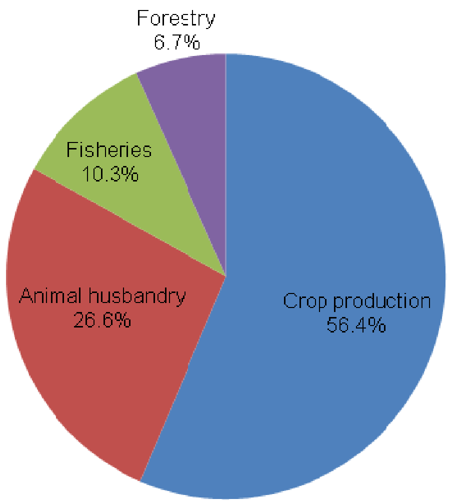
China's agricultural development has resulted in the country comfortably feeding around 20 percent of the world's population on less than nine percent of the world's arable land. This resulted from supply and demand that has been adjusted to market forces; science and technology which has led to China closing the gap between its production and top world levels (and sometimes now even setting these world levels); township enterprises which have assisted in keeping both farmers near the land and increasing rural prosperity; international trade in both technology and agricultural products that has increased dramatically; and in general, as a result, rural China has leapt from largely subsistence to generally (but not always) relatively well-off communities. More recently, in recognition of the potential environmental problem facing China, emphasis has been placed upon improving food quality through better plant breeding, better storage and processing operations and critically looking at fertilizer, pesticide and insecticide usages.

China's average land allocation per farmer is just 0.65 hectares, with many of these allocations consisting of several tiny and separated plots. Limited arable land and a large rural labour force mean that, in general, China tends to have a comparative advantage in the production of labour intensive crops (fruits and vegetables) and a disadvantage in the production of land intensive crops (grains and oilseeds).

Agriculture is still the most important economic activity even though its share of GDP is declining with development. In 2006 the Ministry of Agriculture reports that agriculture is providing a livelihood for over 63.9 percent of the labour force for the country and that agriculture contributed 11.8 percent to GDP[4]. Crop production accounted for 56.4 percent of the agricultural value-added in 2006 (down by 20.6 percentage points from 1978), animal husbandry 26.6 percent (up by 8.6 percentage points since 1978), fisheries 10.3 percent (up a dramatic 8.3 percentage points since 1978) and the remaining small balance is forestry.

[4] This latter figure has steadily declined from 30.1% in 1980 (although there are variations in this figure) according to the Ministry of Agriculture.

Figure 1: Composition of Chinese agricultural value-added in 2006



Source: Ministry of Agriculture, 2006

Total employment in agriculture is a difficult figure to actually pin down, as it is subject to definitional variations. Again, the Ministry of Agriculture reported that in 2005 China had some 252 million households, with a rural working population of 503.87 million. Of the latter figure, some 299.76 million (9.5 percent) were engaged in agriculture, forestry, animal husbandry and fisheries, while the remaining 204.12 million were engaged in non-agricultural sectors like industry, construction, transport, trade and catering services. MOA also reports that "in addition to agriculture, farmers have moved to diversified operations", and that the absolute number of workers in agriculture began to decrease from what seems to be a peak of some 340 million as late as 1992.

Conversely, the urban population increased from 172 million in 1978 to 577 million in 2006, with perhaps 150 million rural labourers moving into urban areas over this period. In 2003 total rural households comprised of (a) farm households (19 percent), (b) farm households partly engaged in non-farming operations (48 percent), (c) non-farm households partly engaged in farming operations (29 percent) and (d) rural non-farm households (4 percent). The big feature of the rural landscape over the previous few years has been the decline in the percentage of purely farm households from around 55 percent in the 1996 census to the 2003 figure of 19 percent, while the second and third categories rose by around 40 percent in total. Farmers have shifted from purely farm work to multiple operations. These changes are driven by the 'township enterprises' concept.

From 1978 through to 2006 the annual increase in the inflation-adjusted net income per capita of Chinese farmers was a remarkable 7.04 percent (although the rural GDP per capita still lags the comparable urban

GDP, but the rural index has increased faster and the gap is closing). By almost all measures, farmers are now much better off than they were at the start of the reform period. However, despite the large improvement in agricultural production in several commodities and the increasing average incomes the prevalence of undernourishment has still been estimated at 12 percent of the population, with most of this in the poorer western regions.

Chinese agriculture must be put into perspective. A crucial part of the rural landscape is the role of peasant labour in the Chinese economic miracle. The time-honoured development pattern over the last half century in Asia has been for the labour force to be withdrawn from the rural areas to augment the urban labour force in developing the new industrialisation (with the resultant goods from this mostly light manufacturing being exported to the US).

While this has happened in China, the Chinese model has concentrated as much or more on trying to move light manufacturing and secondary industry to the countryside. Rozelle reports that in 1980 only 4 percent worked full time off the farm, but by 2000, 45 percent of the rural labour force had employment off the farm, and more than 80 percent of households had at least 1 person working off the farm[5]. The Chinese Ministry of Agriculture similarly reports that in 2006 over 124 million of the rural labourers had employment in cities or towns (with about 43 percent of these folk working outside of their own provinces. This change is dramatically demonstrated by Table 1, which shows the changes by age and gender of the rural workforce engaged in some off-farm work over the two periods of 1990 and 2000. Especially striking is the large increase in the female workforce engaged in some off-farm work, with the emphasis on the younger age groups. Equally dramatic has been the Ministry of Agriculture's reported data on literacy rates; from 35.5 percent 'illiterate or nearly illiterate' in 1983 down to 6.87 percent in 2005, with most of this decline taking place over the 1983 to 2000 period.

Table 1: Percentage of workforce off-farm, by age and gender (poor areas)

Age range	1990 Male	1990 Female	2000 Male	2000 Female
16-20	15.8	8.8	68.3	69.8
21-25	39.6	5.4	70.3	40.4
26-30	38.0	4.1	67.3	31.7
31-35	35.8	2.3	64.1	17.1
36-40	26.9	2.7	61.0	14.4
41-50	26.9	2.4	52.1	10.3

Source: Rozelle, New Zealand Treasury Seminar, 7th March 2006

[5] Scott Rozelle, "China's Rural Economy and the Path towards a Modern Industrial State", Seminar to the New Zealand Treasury, 7th March, 2006. Rozelle, from the University of California at Davis and Stanford University, is the best known western expert on reforms in Chinese agriculture.

3 Land reform in rural China

Since 1949 there have been three major farmland reforms in China. The first was the revolution in the early 1950s whereby land was expropriated from landlords and distributed to peasants. Next, the collectivisation of the mid-1950s, whereby land was owned by the collective followed. Production activities were carried out by all commune members. This production was then sold through the government monopoly system, and all profits were distributed among the commune. The system was preceded with the household responsibility system in the mid to late 1970s reform period, when China introduced the family-based contract system.

Incentives for agricultural production by farmers were encouraged through a freedom of land use rights and decision-making. This, along with the wide-spread package of reforms that included price reforms provided the catalyst for the growth in Chinese production, although there are limitations in the system such as the continued fragmentation of plots and complex village ownership patterns that continue to distract from the benefits that full and unfettered land ownership is generally considered to confer. The household responsibility system maintained egalitarianism but was not the complete answer for economic efficiency, as no real provisions for land ownership through a market approach exist. Consideration is being given to means of improving the system, and the Property Law adopted in 2007 strengthened farmers' legal rights.

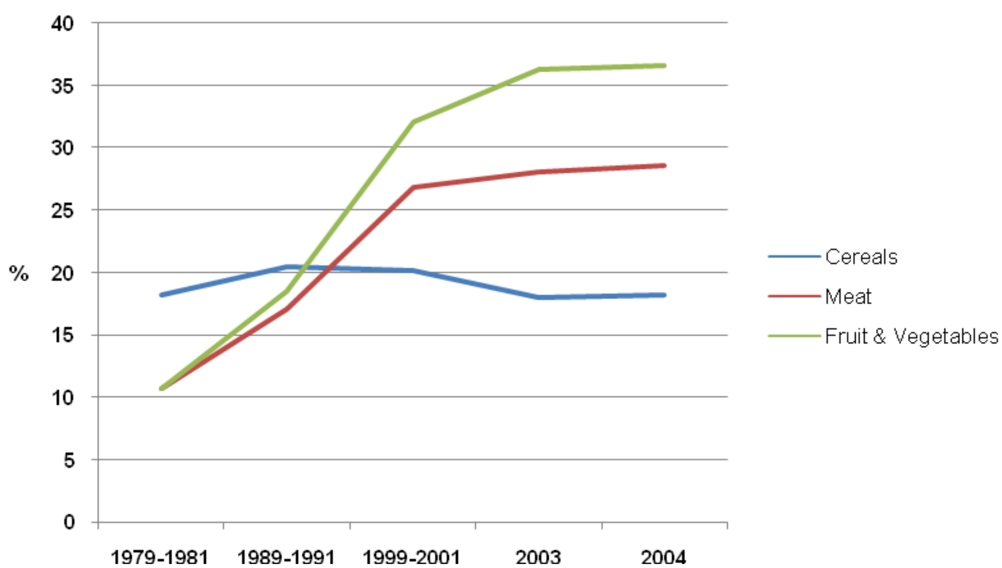
The ownership of land in rural China is by farmers collectively rather than individually, but the land use right is granted to farmers as individuals on 30-year contracts. Thus property rights become unclear. In theory, farmers should have an exclusive use right which should mean the freedom to consume, to obtain income from and to alienate the use right at their will. In practice, however, farmers' land use rights are still insufficient in areas such as transferability – land fragmentation remains intractable, and peasants are unable to cash in on their land's market value for investment or moving to town. Conversely, the current system does allow for migrant workers to return home to their land (an important factor in today's global recessionary environment). Urban land, in contrast, though state-owned, is readily traded, with far longer leases. Chinese economists agree about the need for further clarification of land property rights, but not on how this should be done.

4 China's agricultural achievements

The FAO reports[6] that the main agricultural products are rice, vegetables, maize, sweet potatoes, wheat, potatoes and watermelons, with China being the world's biggest producer and consumer of products such as cereals (in total), potatoes, garlic, onions, apples, pears, duck and goose meat, eggs, honey, pig meat, and sheep and goat meat. China is also a large producer of fish, and inland aquaculture is becoming increasing important to the rural community. Agricultural imports have grown at an annual rate of 13.6 percent from 1995 to 2005, with soybeans the main imported agricultural commodity, followed by cotton lint, palm oil, wheat and soybean oil. Over the same period, agricultural exports have grown by nine percent annually, with prepared food, prepared fruit, prepared vegetables, chicken meat and tea being the main agricultural exports.

Examining the FAO data clearly highlights the dramatic rise in Chinese production of fruit and vegetables and meat since the beginning of the reform period. This is shown in Figure 2, with the three periods of 1979-1981, 1989-1991, and 1999-2000 given along with the most recently available 2003 and 2004 data. The data is expressed as a percentage share of the world total production. Data above 19.8 percent indicates that China is producing more than its comparable share of world population[7].

Figure 2: Chinese agricultural production relative to global production, % (1979-2004)



Source: FAO data

[6] Food and Agriculture Organization of the United Nations, see ftp://ftp.fao.org/docrep/fao/010/ah994e/ah994e00.pdf.

[7] As at July 2008, the American CIA reported that China's estimated population of 1.33 billion was 19.8 percent of the total world population. Therefore data above this level shows that China is producing a share of the agricultural produce that is above its population share. Source: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html

Clearly shown is that cereal initially rose marginally but has since declined to around the starting level, while both fruit and vegetables and meat have increased dramatically; from just over ten percent to over 35 percent for fruit and vegetables in particular. Note that the time scale and the last two observations need to be looked at carefully, as the first three points are for three year averages at ten year intervals while the last two points are annual data to be benchmarked against the 1999-2001 average data.

In a comprehensive analysis of Chinese agricultural policy and performance the OECD[8] reports that much of the relative change in the importance of fruit and vegetables and meat against cereal resulted as the government relaxed the policy measures that had forced farmers to produce grains at a time when price signals (for both domestic and potential export) should have been encouraging fruit and vegetables and meat production. The OECD also reports that traditionally most of China's meat was produced by small and part-time 'backyard' operations, but in recent times full-time household operations ('specialist households') and commercial operations have grown rapidly. By 2003 the latter's share of pork production was 32 percent, poultry production 67 percent and egg production 57 percent. This has in turn been responsible for much of China's increased imports of feed grains as the more technically efficient commercial operators replace the backyard use of potatoes, sugar beet tops etc that have been residuals from plot farming.

4.1 Specific crops

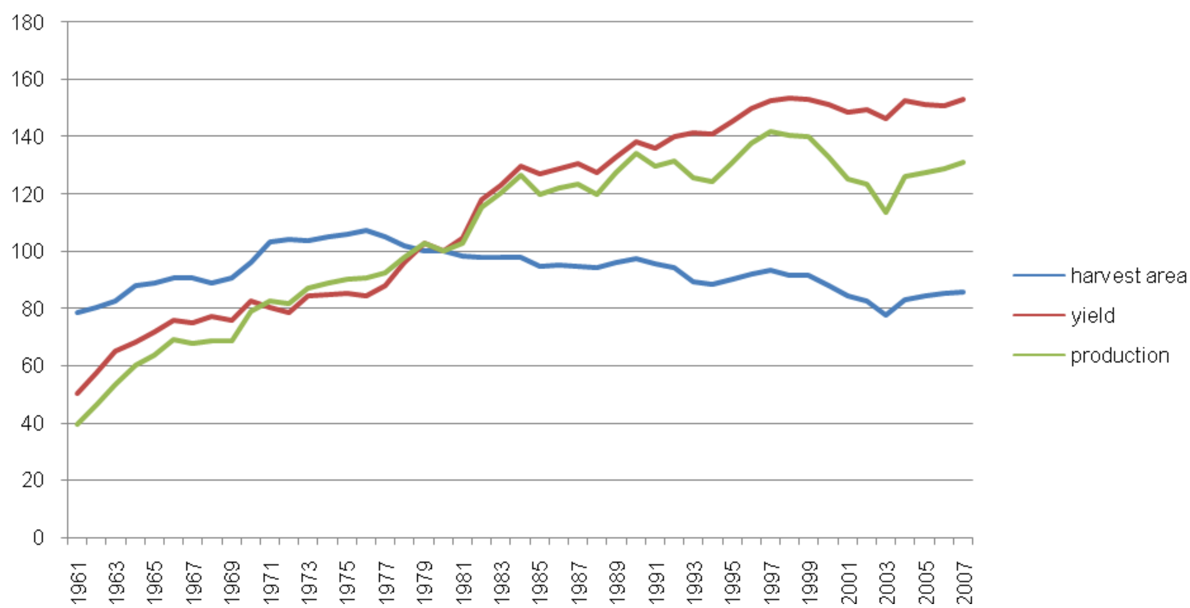
A striking picture emerges when we examine recent changes to specific crop production, acreage and therefore yields. This section starts by looking at rice, maize and wheat, the three most important crops in China. A clear pattern emerges. The increases in production have been driven by increases in yields. This of course is rather self-evident, as China, with its land and water constraints and following many centuries of intensive cultivation, can only increase this production to the extent shown in the following graphs through yield increases. This has not been the case in southern Africa, where increases in production have largely come from increases in acreage[9].

Figure 3 shows the harvest area, yield and total production for **rice** in China since 1961, again with the data indexed to 1980=100. This clearly shows (a) a steadily increasing rice yield per hectare (although perhaps flattening somewhat since 1997), (b) a harvest area that has steadily reduced since around 1976, but an overall production line that increased to a peak around the 1997 period when yields peaked and then declined, becoming more unstable from 1997. Given that rice is the main crop grown in China, the technological change associated with rice production has been crucial from at least 1970. However, note also that there had been a steady increase in production prior to the reform period of the late 1970s,

[8] 'OECD Review of Agricultural Policies, China.' Organisation For Economic Co-Operation And Development (OECD), Paris, 2005
[9] Vink, Nick; Sandrey, Ron; McCarthy, Colin; Zunckel, Hilton, 2006, "Promoting Agricultural Trade and Investment Synergies between South Africa and other SADC Members"; tralac Working Paper, November

indicating that caution must be taken in attributing credit to the various factors driving increasing crop production in China. For example, China may have been benefiting from the 'green revolution' rice varieties developed through an international programme that crossed a Philippine variety with a Chinese variety[10].

Figure 3: Chinese rice harvest area, yield and production data (1961-2007)



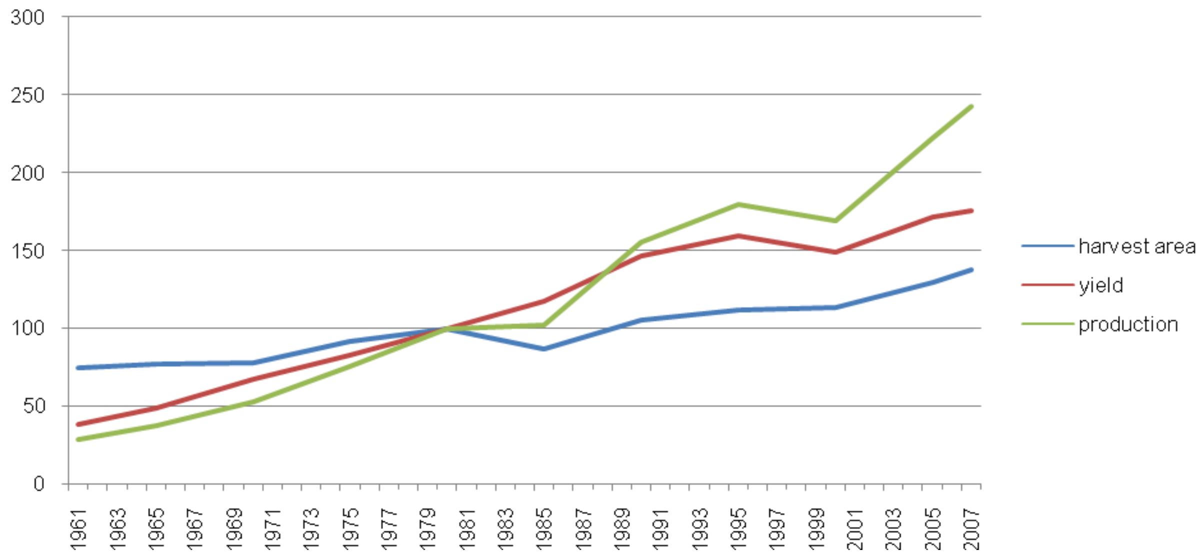
Source: FAO data

A similar pattern (not shown) is observable in wheat production where the area harvested was steady through to 1998 before declining. At this point production declined for about five years until the area harvested stabilised. Continued strong and consistent increases in yields put production back to the near record levels of 1997.

The picture for maize is a little more complex, as shown on Figure 4. The area harvested increased modestly through to around 1980 before stabilising and increasing again around 1995. The average yield and overall production remained in lock-step through to around 1995 before the yields stabilized but production increased albeit in an erratic manner that generally mimicked the most recent period of harvest area increases.

[10] IR8, the first widely implemented high yielding variety (HYV) of rice to be developed by the International Rice Research institute (IRRI), was created through a cross between an Indonesian variety named "Peta" and a Chinese variety named "Dee-geo-woo-gen". http://en.wikipedia.org/wiki/Green_Revolution

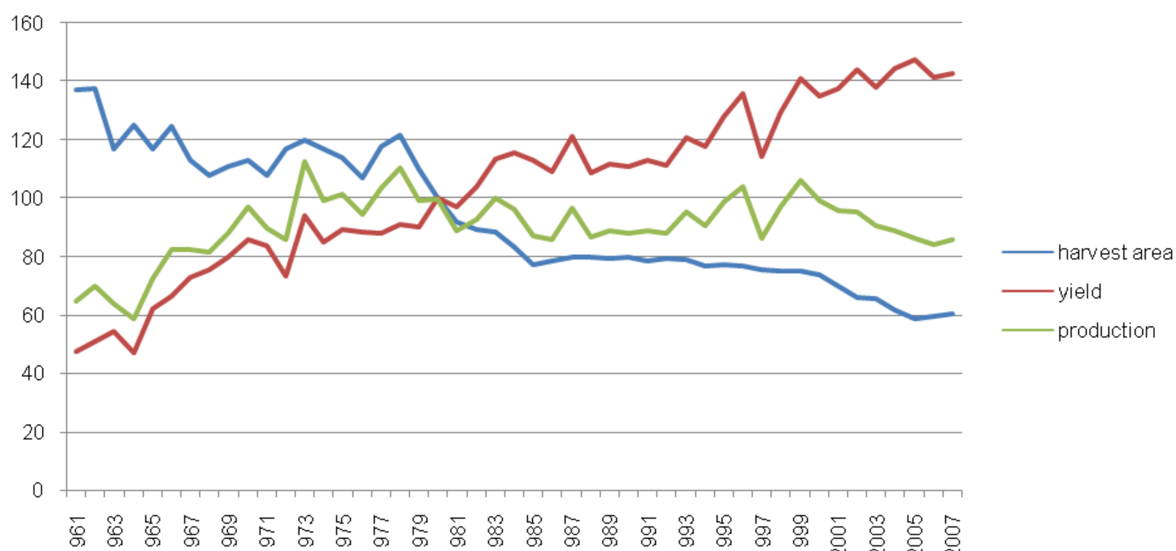
Figure 4: Chinese maize harvest area, yield and production data (1961-2007)



Source: FAO data

Sweet potatoes are the main vegetable grown in China when total value is used as the measurement (coming behind rice, 'other vegetables', hen's eggs, maize and wheat). Figure 5 shows a consistent downward trend in the harvest area and, from 1980 a consistent level of production until around the turn of the present century. Compensating for the declining area has been an increasing yield to ensure this relatively stable production. One could speculate that new varieties, more fertilizer and perhaps increased irrigation may have been the technological factors at play here.

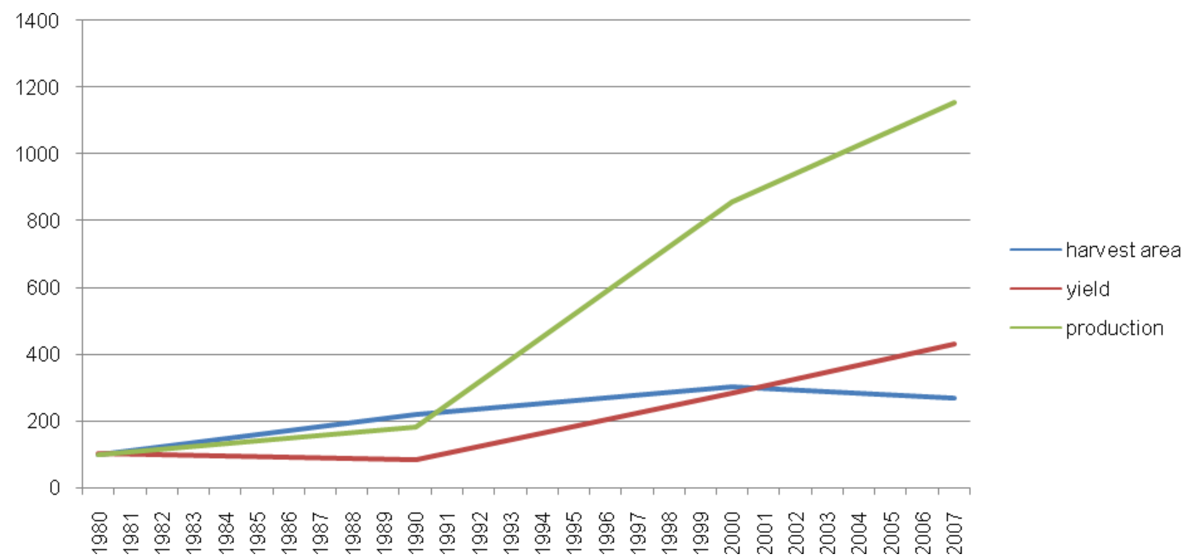
Figure 5: Chinese sweet potatoes harvest area, yield and production data (1961-2007)



Source: FAO data

Perhaps even more dramatic has been the increase in apple production in China since 1980. Figure 6 shows the index values (where 1980 = 100) for the harvest area, yield and total production of apples in China through to 2007. Since the early 1990s apple production has increased spectacularly, albeit with a steadying period in the early years of this century. The yields have clearly been driving these changes, as the harvest area has declined since the mid 1990s.

Figure 6: Chinese apple harvest area, yield and production data (1980-2007)



Source: FAO data

China is by far the world's leading apple producer with just over 25 million metric tonnes (mt), some six times that of the second placed US. South Africa, the only significant African producer, ranked much further back (number 16) with a production volume of 778,630 mt. China's apple production has been on a dramatic increase since 1995, while during the same period apple production in South Africa increased marginally from about 510,000 mt in 1995 to over 750,000 mt in 2004 before declining again. Similarly, China is by far the leading producer and exporter of apple juice, followed by Poland in both production and exports. Germany, the fourth largest producer, is a massive consumer of apple juice with large imports balancing the low supply and large consumption (in direct contrast to China's massive production and export and very low consumption).

5 Agricultural technology: the aggregate picture

A key focus of this report is to examine the technologies that have driven the dramatic increases shown above. The FAO reports that China has significantly improved its agricultural technology since 1978 by introducing high-yield crops, increasing its use of fertilizers, pesticides, agricultural machinery, and expanding irrigation. Rural electricity use has increased more than six fold. The food industry has also introduced new technologies for food storage, processing, preservation, and distribution that have reduced post-harvest losses – although the FAO considers that there is still a great potential for further technological modernisation in this sector. Recently the Chinese government has given priority to advanced research in molecular biology, plant genetics, biotechnology, and related fields. While the emphasis on research to date has been aimed at increasing crop yields and livestock productivity, this study has learned that the current thinking in China, now that the country has effectively solved the problem of feeding its vast population, is changing to increasing food quality within a more sustainable management framework that emphasizes lower pollution with a more responsible approach to lower fertilizer, pesticide and insecticide usage.

It is important to appreciate that **production increases in Chinese agriculture have come through a package that includes the policy framework, infrastructure and technology.** The introduction of high-yield plant varieties in combination with moderately expanded (but more efficient) irrigation and a massive increase in the use of chemical fertilizers and pesticides has significantly improved crop yields. This, combined with the economic reforms of the late 1970s, led to the spectacular increase in food production. The use of chemical fertilizers (nitrogenous, phosphate, potash, and compound fertilizers combined) increased from 0.08 to 39.81 million tonnes between 1952 and 1997, while the total arable land declined slightly. Conversely, the supply of organic fertilizers only increased from some 5.8 to about 17.7 million tonnes over a similar time period. This meant that the use of chemical fertilizers increased from 0.6 to about 213 kg per hectare between 1952 and 1993, while the application of organic fertilizers increased from about 41 to 120 kg per hectare. By 1982 Chinese farmers were applying more chemical than organic fertilizers on their fields, but by 1993 they were using almost twice as much chemical than organic fertilizers.

Other changes have seen the irrigated area increase from 45.0 to 51.2 million ha between 1978 and 1997; the total power of agricultural machinery increase from 117.5 million kW in 1978 to 420.2 million kW in 1997; the number of large and medium-sized agricultural tractors increase from 557,400 to 689,100 units; the number of mini-tractors increased almost eightfold from 1.37 to 10.49 million over a similar period; and the number of trucks for agricultural use increase almost twelve-fold from 73,800 in 1978 to 875,600 in 1997. Similarly, the use of electricity in rural areas of China demonstrates that large technological changes have been made since the late 1970s; consumption increased from 25.3 billion kWh to 198 billion kWh in 1997. This was also paralleled by a significant improvement in transportation technology.

However, the FAO considers that productivity in China's agricultural sector could increase substantially if existing conventional technologies were implemented more widely. There are huge **regional** differences in crop yields and livestock productivity, and post-harvest food processing and the logistics of the Chinese food system would benefit from modern transportation and processing technology. In assessing the Chinese technologies the problem lies in firstly ‘unpacking’ this technological revolution and then secondly assessing what may be applicable to Africa. For example, the research and development of high yielding crop varieties is not an exclusively Chinese operation, as much of this work such as the ‘green revolution’ in rice and wheat varieties predated the Chinese work. For Africa therefore, many of the high yielding (usually hybrid) crop varieties are available from other sources. But what puts the Chinese agricultural scene apart from almost all other examples is the integrated approach; from policy reforms through to intensive research backed by a far-reaching extension service that combined into a comprehensive effort that endeavored to ‘leave no farmer behind’.

Table 2 summarizes these input changes from 1980, but from a different source (ERS of USDA rather than FAO). It outlines again the modest increase in employment in the primary industry (different to actual farm labour, discussed in Section 2.2), cultivated land and overall irrigation area in the first part of the table before highlighting the dramatic increases in fertilizer and pesticide use, rural electricity consumption and the total power of agricultural machinery.

Table 2: Cumulative changes in Chinese agricultural inputs (% change from 1980 to 2005 unless different)

Input	Change	Period (if different)
Agric employment (primary industry)	17%	to 2006
Cultivated land area	23%	to 2006
Irrigated area	23%	
Irrigated area by mech/elec pump	42%	
Fertilizers:		
Compound fertilizer	4691%	
Nitrogenous fertilizer	139%	
Phosphate fertilizer	172%	
Potash fertilizer	1315%	
Total fertilizer consumption	275%	
Pesticide use	91%	1994 to 2005
Rural electricity consumption	1264%	
Total power of ag machinery	364%	

Source: Economic Research Service of the US Department of Agriculture (ERS of USDA)

Despite these changes relative labour productivity in agriculture remains low. The OECD reports that calculating this labour productivity as the ratio of share of GDP over share of employment shows the secondary sector to have labour productivity levels from five to seven times that of agriculture and services to also have levels about three and a half to four times that of agriculture. This is of course because Chinese agriculture is still very labour-intensive. Reducing the share of labour is the fastest way to increase productivity in the sector, but this would be at the cost of social upheaval if done too quickly. Thus, agriculture remains labour-intensive despite many sectors such as dairy and chicken production moving to large scale production.

Looking to the future, many observers consider that it is unlikely that China can sustain its agricultural productivity growth. Exports of course provide opportunities, and China is already a major agricultural exporting country. However, potentially available land is very limited and current productivity levels are high, water is scarce, and the increasing use of fertilizers, insecticides and pesticides contributes to the growing environmental problem that faces China. Further growth is likely to come from an increased emphasis on higher-valued products (but fruit and vegetable production has already increased substantially), the wider application of new biotechnologies that are receiving considerable research attention in China, and labour-replacement technologies. This latter aspect of agricultural productivity suggests several problems related to urban-rural migration and alternative employment for displaced workers.

5.1 Extension services

A key feature of the Chinese agricultural change has been the reformation of the extension service. During the Cultural Revolution period (1966-1976) the old system was effectively disbanded and the staff was sent to the countryside as part of that Revolution. From the ‘spring’ period of the late 1970s to the early 1980s the new extension system was set up that combines:

- technology experimentation;
- demonstration;
- extension;
- training; and
- commercial services.

It operates under (a) the umbrella of the Ministry of Agriculture, and is structured down through (b) the Provincial Departments of Agriculture to (c) the Municipal Departments of Agriculture to (d) County Departments of Agriculture and finally to (e) the Township Government (literally, the ‘grass roots’). This ‘grass roots’ level includes technical staff, individual farmers, demonstration farm/households, farmer’s associations, and individual households.

The mandate of the extension service is to:

i. extend new technology to farmers;
ii. improve farmer incomes;
iii. provide technical training;
iv. assist in the event of disaster (e.g., unusually bad snowstorms, grasshopper plagues); and
v. at times even become involved in village dispute resolution.

The approach at the 'grass roots' includes assessing what farmers want from agents/government by conducting interviews in a very demand-driven participatory approach; use modern communication techniques such as TV and the computer (web-based approaches) to provide advice; use the demonstration approach through both research/extension farms and farmers' own plots; direct delivery contracts between agents and village people; and all kinds of training through site training, meetings, fostering interaction directly between scientists and extension agents, farmer associations and mass media. The current extension emphasis is on new plant varieties; non-pollution approaches; new technologies such as mini green house development, anti-drought techniques such as shading; new micro irrigation techniques; nursery growth and direct sprouted rice seedling plantings in place of the old planting techniques; storage systems; and non-tillage cultivation techniques.

Even by Chinese standards the size of this extension service is impressive, with some 830,000 staff in total. Some 760,000 of these people are at the 'grass roots' level, with possibly 50,000 direct extension agents servicing around 1,000 to 1,500 farmers/households each (it is unclear as to how many of the total persons are direct support staff and how many may be 'honouree' or part-time operators at the farm level). Around 40 percent of the total emphasis is on crop farming, and there is a degree of specialisation for extension agents.

There is no doubt that this extension effort has been a contributor to the Chinese agricultural performance in recent years – although just how much of a contributor remains uncertain. It is a key lesson that African countries must study.

Two other aspects of the extension service must be emphasized. One is that extension agents have been encouraged to operate commercially in selling chemicals, seeds and other inputs. This has benefited both parties, as the agents have a direct knowledge in matching supply of inputs to farmer needs (we stress however that this system is not without its critics, and does carry some inherent risks). This is being extended into assisting farmers with contracts for both inputs and output marketing with the private sector (the Company plus Extension plus Farmers model). The other aspect of the extension service worth considering is that extension has focused on women in agriculture. There are around 450 million persons in the wider rural labour force, and some 70 percent of these or 320 million persons are directly engaged in farming. Of the latter figure, some 66 percent are estimated to be women as many males have found work in towns and cities leaving women on farms. These women have been trained in not only direct farming techniques but also in employment opportunities allied with or associated with farming and the land.

There are three major challenges associated with modernising small holder agriculture. The first is that it is hard to generate commercial surpluses; the second is that it is hard for small holder farmers to justify mechanisation or obtain access to new inputs and technologies; while the third is that literally millions of small farmers potentially make extension service delivery a challenge. China has made impressive strides in overcoming these challenges. Furthermore, we are also cautious in defining exactly what a small holder farmer is, given that there are still elements of the communal system operating in China that are not features of African agriculture. We may in fact be dealing with farming cooperatives rather than several clearly defined individual farmers.

Finally, as noted above, there is some uncertainty as to how effective the extension service is. Proponents of course argue that it has been essential, while others suggest that despite the veritable army in the field the practitioners 'on the ground' are not well resourced. Some supporting evidence of this, at least in its early years, is provided by Yang Xuedong and Auerswald[11]. They examined the effectiveness of 'the last kilometer' in the extension chain in the 1990s and found that many township-level information centers lacked much of the necessary equipment such as digital cameras and scanners; others could not pay their phone bills; many operators were not familiar with either computers or agriculture; and, following from the last point, the consultants were not able to answer many specific questions. We explore aspects of this and a more detailed analysis of technological changes in the next section.

5.2 The drivers of Chinese agriculture

In a discussion with an expert Dr Liu from the Institute of Agricultural Economics and Development (IAED) section of the Chinese Academy of Agricultural Sciences (CAAS), Dr Liu outlined the twelve key technologies that have driven Chinese agriculture over the past three decades[12]. These are:

- new seed varieties;
- fertilization technology;
- irrigation technology;
- insect control through plant breeding, new insecticides and integrated pest management (IPM);
- planting technologies in the field;
- soil improvements such as mulching and desalination;

[11] Yang Xuedong and Phillip Auerswald, "How to Avoid Stumbling in the Last Kilometer: The Case of Quzhou Agricultural Technology 110: An Innovations in Technology and Governance Case Study". NJ110 ITG Case Study.
[12] Interview with Dr Liu Heguang, Institute of Agricultural Economics and Development (IAED) section of the Chinese Academy of Agricultural Sciences (CAAS), Beijing, March 2009

- mechanisation;
- tissue culture technologies;
- animal grazing and management technologies;
- feed and nutrition changes for animals;
- animal disease controls; and
- aquaculture technologies.

These themes repeatedly were echoed from other observers, and we concur with this general listing.

The Ministry of Agriculture outlines the four major restructuring aims of the government since 1999. These are:

1. A coordinated improvement in crop farming;
2. Development of animal husbandry and aquaculture;
3. Improving the quality and safety of farm produce; and
4. The concentration of production in climatically optimal growing areas where this is practical.

More specifically, the Ministry of Agriculture suggests that science and technology's contribution to the growth in China's agricultural output has increased from around 20 percent to the current 48 percent generally (but a lower 42.4 percent for crop farming specifically). The main features of the crop technologies have been:

- new crop varieties, including the 'super' rice;
- planting techniques to maximize the use of the land;
- operational techniques such as mulching, plastic film nursing, dry land nursing of paddy rice and rice seedling throwing for paddy transplanting; and
- fertilizer applications and the associated soil testing.

Many of these techniques will be discussed in more detail later in this section.

Perhaps the best known western researcher in this area is Scott Rozelle, from the University of Davis in California and Stanford (cited in section 2). He shows that of the almost ten percent annual growth in China (total) over recent times some six percent is due to increased inputs with the residual of almost four percent being total factor productivity (TFP). Decomposing this TFP he argues that one percent annually has been in industrial productivity, around 0.75 percent in rural productivity and the balance in what he defines as the 'shift effect'. The latter is the effect of taking a poor, underutilised young son/daughter of a farmer and moving him/her into a factory. This shift follows the classic development patterns of the earlier 'Asian tiger' economies.

Rozelle's thesis is that after 1984 the contributions to productivity were mostly to technology, with a bit to market emergence and education but nothing to neither extension nor decollectivisation. In the few years leading up to 1984 (from 1978) around half of the contributions to productivity were attributed to property rights reform, about the same to technology and the remaining small bit to extension and education[13]. Demonstrating the growth of productivity and its associated technology Rozelle shows how the 'yield frontier' or the increasing potentially obtainable crop yields of rice, wheat and barley at the research field stations is moving upwards at around two percent annually. Over time, this cumulative effect is impressive.

In discussions with Chinese researchers we asked how farmers relate to this benchmark frontier. A somewhat mixed response to this question was received. This 'yield frontier' and the subsequent 'productivity gap' are measured by the difference between the 100 Index of the frontier and the index of where average farmers were actually at. The Deputy Secretary General of the China Agricultural Association for International Exchange, considered that farmers were generally somewhere between 50 and 70 on the Index[14]. When asked about what research currently being developed in the labs was likely to contribute to this Index, he considered 'more than ten percent'. This is consistent with Rozelle's data. The team then asked the Deputy Secretary General to look even further into the future, and here he considered that more emphasis was now being placed upon other factors such as environmental issues including better fertilizer and water usage, drought, pest resistance and food quality rather than yield *per se*. China has, in effect, demonstrated that it can feed itself while at the same time lifting most of its farmers out of abject poverty. It is now looking further ahead to a 'cleaner greener' future, although increasing emphasis also is being placed upon attention to the lower yielding regions.

During a field trip by the research team to China's Henan Province (the agricultural heart of China – where Ministry of Agriculture and Henan Agricultural University officials were interviewed) and with visits to the Chinese Academy of Social Sciences (CASS) we explored this 'productivity gap' further with senior officials. The Ministry of Agriculture confirmed the general pattern from above, where the average rice yield of perhaps 550 kg per mu[15] is around 70 percent of the Index value of 800 kg under research conditions. This frontier has been moving upwards at a rate of perhaps one to two percent a year, and encouragingly they considered the productivity gap to be closing. Almost all of the advanced farmers have access to the new varieties upon release or within two years, and around 99 percent of the crops are planted with the new varieties within three to five years. This suggests that the extension service system is effective.

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[13] Perhaps a note is needed to conjecture that Rozelle is negating the impacts of the extension service because he is looking at the situation through US eyes. In the US the "John Deere" or large-scale farmers are very aware of recent advances in technology and therefore do not need the Chinese extension model.

[14] Interview with Mr Cao Haijun, Deputy Secretary General of the China Agricultural Association for International Exchange, Beijing, March 2009

[15] Where the mu, the common farmland unit of measurement, equates to one fifteenth of a hectare.

However, a slightly less rosy picture was provided to the team in that yes, the productivity gap is around 70 percent, yet no, this gap was not closing (with a more measured view of the extension service in that it 'needs improving'). There is a general consensus that the frontier was flattening over time though, with one reason being that an emphasis was being placed on sustainability and food quality factors rather than just the frantic yield improvement effort to ensure China could feed itself as discussed above. Perhaps a flattening may be a good thing if the other factors are addressed, and this seems to be moderating the GMO emphasis.

A strong message was also delivered from the Vice President of the Henan Agricultural University on the four steps in the Chinese experience. Firstly China had the policy reforms which were secondly, quickly followed by investments. Thirdly are developments in science and then, fourthly the associated extension/education service emphasis. In his view Africa badly needed to address the first step of policy reforms before any subsequent ones could be taken. New seed varieties can, and indeed have changed the world, but this must come after the first two steps have been taken (we must concur with this view, and note that new seed varieties have been available to Africa for some decades now). His view on the latter two steps of the relative importance of science and extension is consistent with Rozelle: in the early period extension was important, but now science 'is number one'. This supports a closing of the 'technology gap'.

5.3 Plant varieties: the impact

There is no doubt that new seed varieties have had a dramatic impact on agricultural production, but only when these seeds are part of and wrapped in the 'complete package'. This cannot be overstressed. In the past few years Chinese researchers have developed a large number of new crop varieties (as well as improved livestock, poultry and aquatic varieties). This included the dwarf-rice varieties that increased rice yields per hectare of around 50 percent. This was in turn augmented by firstly the hybrid technologies that increased yields by another 20 percent and more recently the super-rice varieties that has brought yields to a potential of at least 12 tonnes per hectare. While this laid the foundations for the rice revolution, these technologies had to be transmitted to farmers. At the same time, the research and extension services also developed and promoted the hybrid corn (maize) varieties, dwarf-sterile wheat, transgenic Bt cotton and other seed technologies that improved the productivity of staple crops in China.

We will not endeavor to go into details on the actual seed varieties and their relative impacts. This is a job for the specialists. Rather, we will lead into the next generation of technology, that of genetically modified crop varieties. In recent years the Chinese government has given high priority to advanced research in molecular biology, plant genetics, biotechnology, and related fields, which is aimed at increasing crop yields. Genetically modified (GM) foods are made from crops that have been given specific traits through genetic engineering. Unlike crops developed through conventional genetic modification that have been accepted and have been consumed for years, GM foods were first put on the market in the early 1990s. Typically, genetically modified foods are plant products: soybean, corn, canola, and cotton seed oil. The US, Argentina and Brazil are the main users of GMO crops, with South Africa the only African country permitting release.

The methodology behind GM technology is complex. A gene that governs a desirable trait is identified and isolated from another organism. Then a recipient plant is selected and the gene is inserted and incorporated into its genome. Once part of the recipient plant, the newly inserted gene is indistinguishable from the plant's native genes and will be used by the plant like any other gene. Genetically engineered crops and foods are controversial. Debate commonly focuses on the long-term health effects for those who consume GM foods, environmental safety, labelling and consumer choice, intellectual property rights, ethics, food security, poverty reduction, environmental conservation, and potential disruption or even possible destruction of the food chain. Thus, critics believe it to be a potential or actual health or ecological disaster, whereas proponents claim the technology to be a boon for the human race[16].

Huang and Wang[17] reported a few years ago that even in the early part of this century attention was placed on GMO research in China. Bt cotton is the most successful story of agricultural biotechnology in China, when in response to rising pesticide use and the emergence of a pesticide resistant bollworm population commercial use of GM cotton was approved in 1997. Other transgenic plants with resistance to insects, disease or herbicides, stress tolerance, or plants with improved quality had even then been approved for field release, and some remain ready for commercialization. These include transgenic cotton lines resistant to fungal disease, rice resistant to rice stem borer or bacteria blight, diseases, herbicide, and salt tolerance, wheat resistant to barley yellow dwarf virus, maize resistant to insects and with improved quality, soybeans resistant to herbicides, and transgenic potato resistant to bacterial disease or Colorado beetles. Progress had also been made in soybean nodule nitrogen-fixing bacteria for rice and corn.

But despite the considerable research being done on GMOs in China, to date the only release remains the celebrated Bt cotton variety. Scott Rozelle and his colleagues[18] consider that although genetically modified (GM) crops are being grown on increasing large areas in both developed and developing countries, with few minor exceptions, there has been almost no country that has commercialized a GM major food crop. One reason may be that it is unclear how the commercialization of GM crops will help poor, small farmers. They reported on the results of an economic analysis that uses three years of data

[16]Taken from Wikipedia, at http://en.wikipedia.org/wiki/Genetically_modified_food
[17] Jikun Huang and Qinfan Wang, 2002, "Agricultural Biotechnology Development and Policy in China", *AgBioForum*, 5(4): 122-135. AgBioForum.
[18] Jikun Huang, Ruifa Hu, Scott Rozelle and Carl Pray, 2008, "Genetically modified rice, yields, and pesticides: Assessing farm-level productivity effects in China", *Economic Development and Cultural Change*, Vol. 56: 241-263

from a series of quasi-experimental areas (preproduction trials) in China's GM rice programme that were carried out in the fields of small and relatively poor producers in two provinces in China. The use of GM rice by farmers in these trials allowed farmers to reduce pesticide use and labour input, but the effect on yields was less clear as the findings suggested very little if any yield effect. This is perhaps in slight contrast to some of Rozelle's other comments, where he considered that the performance of GM rice in field trials reduced pesticide usage by 40 to 50 percent, reduced labour input by around six to nine percent, but increased yields by some six to eight percent[19].

Looking further ahead, Rozelle and his colleagues argue that there are three vital ingredients in the continued progress of China's agriculture which have not received adequate attention. They are the development of a functioning agricultural research and development system, including the capacity to produce novel and productivity-enhancing biotechnology breakthroughs; improvements in agricultural commodity markets; and increasingly functional land rental markets. Technology-driven total factor productivity (TFP) growth has become one of the main means (if not the main mean) of raising the returns in agriculture. China's agricultural R&D system has become more than capable of generating new conventional technologies and those created by GM biotechnology. Meanwhile, Chinese commodity markets have become remarkably integrated across regions: between the coast and inland and between county market seats and villages, even in remote areas. And finally, although the emergence of land markets has been fairly recent, they are developing quickly and have been having beneficial effects in terms both of allocative efficiency and equity. Land across China is shifting to households that still specialize in farming and away from those in the migrant labour force through rental markets.

5.4 Water and water related issues

China has access to the sixth largest amount of renewable fresh water annually of any country[20]. While this relates to just over five percent of the global total, China supports almost one person in every five (20 percent) that lives on the planet. Generally the precipitation varies from year to year, season to season and region to region. The southern part of the country is both warmer and wetter, and in general the summer and autumn periods are wetter than the winter and spring. In addition to the increasing shortage of water, there are simultaneously critical issues looming for China on the quality of its water resources. Given its long history as a major world power and its patterns of intensive agriculture, much of the available water resources have been harnessed for usage. Droughts and floods are a feature of China's geography, and Table 2 above showed that the increase in irrigated land over the agricultural expansion of the last thirty years has been modest. In order to face the reality of the decreasing farmland base and

[19] Rozelle, Seminar to New Zealand Treasury.
[20] Based on FAO data. This ranks China just below Canada, the US and Indonesia. http://www.mapsofworld.com/world-freshwater-resources.htm

expanding population, China must continually make maximum use of its available farmland and water resources.

This is being achieved through a combination of factors that included some limited increases in the irrigated land, but more especially through more efficient water utilisation technologies on both the dryland and irrigated lands. These technologies include more efficient irrigation techniques such as drip irrigation, small-scale water storage techniques, plant breeding for varieties better able to cope with water stress, new cultivation techniques such as direct seeding rather than deep plowing, and soil water enhancing techniques such as mulching and plastic water retention methods, decomposition and recycling of plant residues, crop rotations, and more attention to fertilizer applications. In general, the new plant varieties come associated with a package that calls for more intensive nutrient requirements. This accentuates the increasing burden on China's water requirements for both irrigated and dryland farming. But these challenges are being met; for example, the Ministry of Agriculture reports that in field trials in northern China grain yields per millimeter of rainfall has increased from 0.3 to a range of 0.6 to 1.2 kg by using the comprehensive package outlined above in general terms. This section will turn to examining the water related technologies in detail for both irrigated and dry land farming, as we believe that these technologies have much to offer Africa.

During an interview with a Chinese agricultural expert, Prof Wang, it was reported that emphasis was being placed upon a drought tolerant dry land rice variety that had many combinations of both paddy and upland rice varieties[21]. Traditional lowland rice with continuous flooding in Asia has relatively high water inputs, but there is a need to develop alternative systems that require less water. "Aerobic rice" is a new concept of growing rice: it is high-yielding rice grown in non-puddled, aerobic soils under irrigation that combines aspects of both paddy and upland rice. In 2008 around one percent of Chinese rice was from the 40 or so varieties of aerobic rice. It is targeted at water-short areas, and both yield and socio-economic comparisons must include water-short lowland rice and other upland crops rather than high producing paddy rice yields. Combined with a seeding and planting technology, and shortening of the growing season this aerobic rice can reduce its fertilizer usage by around 30 percent. Importantly, based upon his African experiences, Prof Wang foresaw that given its reduced fertilizer demands and drought tolerance there was considerable potential for these varieties in Africa.

Note in particular that the concept of irrigated and dry land farming in China becomes a little blurred, as at least some of the techniques are applicable to both. Irrigation technologies include the mini-construction of water harvesting cisterns, fertigation[22]– a technique largely imported from Israel but also extensively used in South African horticulture, drip-irrigation and spindle-irrigation. The emphasis is on water

[21] Interview with Professor Wang from China Agricultural University, Beijing, March 2009.
[22] Where fertigation is a fusion of fertilizer and irrigation and is named because it combines irrigation with the measured release of plant nutrients.

management and soil composition to better enhance the available water rather than exclusively water technologies. Dry land farming techniques include terracing; the use of technologies such as conservation farming, deep plowing, impacting the soils, zero tillage, and the use of big furrows and ditches farming; the mulching techniques of plastic or straws cover; and the agronomic cultivation techniques such as cropping rotation and green manure planting.

The use of terracing is a traditional practice in China (and indeed many other Asian countries), and its advantages are well known. More recent techniques on flatter to gently sloping land include the use of big furrow tillage, whereby this furrow is really a shallow ditch where the ridges are high and wide and the grain is planted in the shallow ditch to both utilise every drop of rain and minimize soil erosion. This technique can increase yields by 30 to 40 percent. Another dry land/irrigation technique is the development of small water cellars that generally hold 50 cubic meters of excess water runoff. This either supplements irrigation or can be used as a stand-alone system on dry land, and is very effective for improving yields in small-scale labour-intensive plots. It is an extension of more traditional technologies such as runoff ponds and retention walls.

In summary, small-scale irrigation techniques are becoming more sophisticated in China, and especially when combined into an integrated package. Water-saving techniques such as drip irrigation combined with tillage and planting techniques, water storage such as cellars and the use of both plastic and straw mulch can be used to obtain the maximum benefit from available water. In higher-value crops and orchards the drip system is being extended to fertigation, where the optimal combinations of water and fertilizer can be applied. While possibly still at the research stage, the use of agro-chemical soil absorbent polymer and fulvic acid drought resistant conditioner are being investigated. These conditioners absorb and retain water to be released later. On a wider scale, the Chinese government has made a large investment in water related infrastructure such as dams, reservoirs and deep wells, and an effort has been placed on cementing water channels to eliminate seepage.

5.5 Fertilizer and related issues[23]

Table 2 showed the increases in synthetic fertilizers in China over recent years. These are predominantly the three primary ingredients of nitrogen (N), phosphorus (P), and potassium (K), known as N-P-K. Earlier national studies from around 1960 found that while soils in China were often suffering from an insufficient supply of N and that while the responses of P application were obvious in southern paddy soil and perhaps even some northern soils, the response to K was not obvious in most of the soils in China. A second major nationwide investigation carried out around twenty years later (1980-83) found that the

[23] Parts of this section were drawn from a presentation to the team by Dr Youguo Tian, Senior Agronomist & Division Chief, Quality Testing for Soil and Fertilizers Division, National Agro-Tech Extension and Service Centre (NATESC), Ministry of Agriculture (MOA), China, Beijing, March 2009

response of N application is decreased in some crops, the response of P decreased in southern paddy soil but increased in corn and wheat in northern regions, and that K was becoming more and more important in the south in particular. More recently there has been a great emphasis placed upon the detailed soil sample analysis to firstly test soils and secondly advise farmers on the correct application.

Over the last fifty years the patterns have been that in the 1950s organic fertilizer or manure was widely used due to the limits of production and input of fertilizer, but by the 1960s farmers started to understand the importance of N fertilizer. Through 1970s and 1980s, N fertilizer application rapidly increased, and by the 1990s the applied N fertilizer rates were the highest in the world. This was similar for both P and K fertilizers, as their applications increased from the 1980s. Chinese fertilizer consumption amounted to about 58 million tonnes in 2006, accounting for 37.1 percent of the total world consumption. This has been raising concerns about the environmental sustainability of such a high usage.

Data from the US Department of Agriculture shows that US farmers today are using fertilizer nutrients with the greatest efficiency in history. Between 1980 and 2005, US corn production increased by 74 percent. Over the same period farmers' adoption of best fertilization practices, including placement near roots and timing of application, improved consumption efficiency. Consequently, in the US the use of nitrogen on corn increased by a minor three percent, while use of phosphate and potash fertilizers fell by 20 and 24 percent respectively. Perhaps China is starting to move down this pathway in its recent research and technologies. Current research is showing that by using just one third of typical fertilizer amounts, farmers could obtain the same or even improved results growing corn, rice and wheat – the main staple crops. The key is applying the fertilizer to seedlings rather than adding it to soil while planting. Experimental rice yields were marginally higher when these used less fertilizer, but fertilizer that was optimally applied. Similarly, wheat yields were some 300 kg/ha even when using less than half the current practices[24].

Meanwhile, as the commercialization of the fertilizer industry continues apace in China, there are more than 5,000 enterprises operating in the country. Their production includes the N-P-K of nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer, and an increasing emphasis on newer approaches such as compound fertilizer, organic fertilizer, organic-inorganic compound fertilizer, micronutrient fertilizer, humic acid soluble fertilizer, amino acid soluble fertilizer, biofertilizer and other new specialist products that incorporate features such as slow release of the nutrients.

What are the lessons for Africa? Certainly the large increase in fertilizer usage has been a factor in the dramatic increase in crop production in particular, but it must be viewed as a component of a package that includes newer seed varieties, better irrigation and soil management techniques, and an

[24] Personal comments from Professor Ju Xiao-Tang of China Agricultural University, March 2009.

understanding of the correct application rates and timing of these rates. And, although Africa is a long way off China's usage, this increased usage in China may not be environmentally sustainable. Meanwhile, the recent emphasis placed upon the soil testing and advisory programmes adopted in China to ensure that fertilizer is applied appropriately is impressive.

5.6 Energy related technologies

Two energy related technologies must be examined in more detail. These are solar power and bio-gas production. While solar power generation is of course being examined by numerous experts globally under a dedicated international effort to promote alternative energies, the Chinese concept of a low-cost approach may offer more opportunities to sunshine rich but financially poor African farmers.

China's conventional electricity prices are currently very low. However these are expected to rise over the next few years as the price for conventional electricity does not reflect the actual production costs. Coal has been subsidized for many years, and unless support for renewable energy sources is offered on a similar basis there are limited incentives to develop solar energy. In particular, the external costs resulting from burning fossil fuels are also not included in current electricity prices, and these costs have both a local and a global component.

5.6.1 Biogas[25]

Biogas is a combustible mixture of gases produced by micro-organisms when livestock manure and other biological wastes are allowed to ferment in the absence of air in closed containers. The major constituents of biogas are methane (CH_4, 60 percent), carbon dioxide (CO_2, 35 percent), small amounts of water vapour, hydrogen sulphide (H_2S), carbon monoxide (CO), and nitrogen (N_2). Biogas is mainly used as fuel, like natural gas, while the digested mixture of liquids and solids "bio-slurry" and "bio-sludge" are used as organic fertilizer for crops. While using fecal matter as an energy source may be taboo in some societies, it has gained wide acceptance and utilisation in China and has become a feature of the new Chinese small-scale agricultural technologies.

Six million digesters were set up in China in the late 1970s and early 1980s using the "China Dome" digester which is still used to the present day, especially for small-scale domestic use. By 2006 there were biogas pits being used by 22 million households in rural areas, and more than 5,200 large and mid-sized biogas projects were based around livestock and poultry farms. The typical eight cubic meter biogas pits are able to provide 80 percent of the cooking energy for a four-member family. Farmers from Yunnan Province are now experimenting with a "four-in-one" biogas plant that incorporates a pigpen and

[25] This section draws heavily from David DuByne, on http://www.sciencealert.com.au/opinions/20080905-17301.html

a household latrine to provide feedstock, then uses methane to heat a greenhouse for growing vegetables and raises carbon dioxide within the greenhouse to boost plant yield.

5.6.2 Solar power

Solar power is universally recognized as being able to solve many of the problems associated with energy provision. It can be easily installed in remote and rural areas, and it is the ultimate in environmentally-friendly power generation as it is non-polluting and sustainable. The challenge though is one of economics and the relative costs of solar versus other forms of energy, despite recent advances in technology. Solar systems are particularly suitable to remote rural areas where costs of traditional electrical supply are high. At the end of 2006 there were still 11 million people in China without access to electricity. Solar energy would provide a power supply for most of these people.

While the research team did not study solar power in China, we would expect that China's contribution to solar energy may well be in the manufacture of small-scale and potentially cheap generation techniques that may or may not be originally developed in China.

5.7 Agricultural machinery

Farmland mechanization in China has improved remarkably. Even through to 1949 agricultural production mainly depended on human and animal labour, with minimal mechanization. By the end of 2003, the mechanized ploughing area has reached 60.943 million hectares, the mechanized sowing area had reached 40.714 million hectares, and the mechanized harvesting area has reached 27.36 million hectares. This related to percent levels for ploughing, sowing and harvesting of 46.8 percent, 26.7 percent and 19 percent respectively. Since the scale of operations is small for Chinese farmers, it is neither economical nor necessary for every farmer to buy agricultural machinery. Thus, to the Chinese emphasis has been on developing a socialized service of agricultural machinery. For example, since 1996 Chinese agricultural machinery operations have progressed into market-oriented but still socialized services that are taking advantage of the time difference of wheat harvesting from south China to north China. The actual usage time of combine harvesters has increased from 7 to 10 days to more than one month a year. In 1994, there were only around 60,000combine harvesters, but in 2003, there were 360,000 combine harvesters. The machine harvesting rate of wheat improved from 47 percent in 1995 to 82 percent in 2004.

There are several small-scale cultivation, tillage and harvesting machines that would potentially be applicable to Africa, but this report has not studied them in detail. What is apparent though is that the Chinese approach to a combination of communal operations within a market-based structure has enabled the use of mechanization to develop quickly. This may be a more important lesson for Africa than the actual technology. An analysis of the Chinese export data reveals that there have been some exports of small 'pedestrian controlled tractors' to Africa over the last few years, with these exports reaching some 4,412 units in 2008 at an average value of US$ 938. Exports of other agricultural machinery to Africa during 2008 included ploughs to the value of US$ 3.76 million, disc harrows at US$ 2.25 million, and seeders and planters at US$ 0.6 million.

5.8 Pest and disease control

The generic term used increasingly in China is integrated pest management (IPM). Again, this is the recognition and practice of the 'package' approach to agriculture rather than a single pest control method. Researchers, extension agents and farmers who advocate and practice IPM follow a four point approach of (a) setting an acceptable threshold for a particular pest that establishes when it becomes an economic threat, (b) monitoring and identifying insects, weeds and other organisms that may require control, (c) using prevention as the first line of defense by perhaps cultivation and rotation techniques or the use of pest-free rootstocks and resistant varieties, and (d) a proper evaluation of alternative control measures to control the problem at minimal economic and environmental costs once control becomes necessary. Thus, the 'M' of management becomes important, as the objective is not usually to kill all pests but to manage the problems in an integrated approach. It combines the traditional Chinese approach of taking a holistic view of the world with the modern desire to recognize the local, national and global problems associated with environmentally unsustainable farming practices.

Pest-resistant transgenic crop research represents the frontier of IPM in China and elsewhere, and as noted above, outstanding success has been in the Bt cotton to manage the serious threat of cotton bollworm. Since the 1970s the widespread use of chemicals resulted in the pesticide-resistance of cotton bollworm with an associated decline in yields, but since the widespread release of the Bt cotton in 1998 bollworm has effectively been controlled. Most of China's cotton is now Bt cotton, and the benefits from greatly reduced pesticide application and enhanced yields has been dramatic. Importantly, there does not seem to be any evidence of bollworm resistance to the Bt cotton despite this being seen as a potential down-side to the Bt cotton. Meanwhile, research on transgenic insect–resistant rice to suppress insect pests such as leafrollers and brown plant hopper is well advanced in China, as is similar research on wheat, soybeans, maize and other crops.

So far, although research has not shown any significant security threats, no release of transgenic food plants has been approved in China as the nation takes a very conservative 'wait and see approach'. Increasing resistance to several control measures and the increasing openness and exposure of Chinese agriculture to foreign imports and potentially pests means that IPM will similarly increase in importance.

5.9 Soil management

Soil management is another essential part of the overall package that is driving Chinese agriculture. Enhancement of soil quality has been accompanied by improvements in planting systems such as inter-planting and relay inter-planting of grain-oil crops, grain-cotton and grain-vegetables, and the 'vertical planting' patterns of multi-crop and multi-layer cultivation. In crop cultivation technology, new advanced operational techniques that have been disseminated include plastic film nursery, mulching[26], greenhouse cultivation, dryland nursing of paddy rice, light transplanting and rice seedling throwing for transplanting. Overall, these techniques have increased grain production, lowered farm costs, improved fertilizer regimes and promoted sustainability in Chinese agriculture.

Soil tillage techniques to preserve rainfall are widely used, and here deep plowing is a key. Another technique that is becoming increasingly important is the quick decomposition of crop residues by using chemical decomposition agents, microbe cellulose or fermenting bacteria to aid the decomposition process. This provides a quick fertilizer of high quality in a relatively simple operation that also assists in building soil structure. Chinese farmers are increasingly using mulching techniques to conserve moisture, increase the ground temperature and enhance soil quality. These techniques include both plastic and straw mulching. The plastic mulching in particular is very common, and when used in conjunction with micro-furrowing techniques and planting techniques to match the mulching cover can be very effective in increasing yields. Even pulverized corn and wheat straw residues are being used to provide coverage and protection for water retention in the subsequent crop. Inter-cropping and inter-planting of complementary crops such as wheat and peas, maize and peanuts, or maize and potatoes is becoming increasingly used to promote water conservation and soil quality. These techniques, and especially when used in some combinations, are being supplemented with the emphasis that is being placed on breeding drought resistant crop varieties. We feel that many of these techniques are directly applicable to African conditions.

Soil warmth is an important factor in lengthening the growing season in the colder parts of China. During the field trip to Henan the research team explored medium-scale, relatively low cost plastic-roofed greenhouses and observed vegetables and flowers growing under cold conditions. These appeared to be very efficient, and many such greenhouses dot the Chinese landscape. There is also a considerable evidence of just a simpler plastic coverage of plants in evidence for enhancing and/or enabling growth during the winter periods. While extremely efficient for the colder areas of China, their application may be more limited for warmer African conditions.

[26] Mulching is basically returning either the crop residues or special green grass and/or nitrogen fixing plants back to the soil, usually after a chopping or chemical process to aid decomposition in the case of residues. This increases nitrogen levels and water retention, leading to increased (and sometimes earlier maturing) harvests. It can also refer to the use of biodegradable plastic sheets to enhance water retention properties of the soil.

Technology development in China also benefits from international cross-fertilization of ideas. Canadian scientists have been promoting soil conservation techniques in the Inner Mongolia Autonomous Region (IMAR)[27], a region of China that suffers from soil erosion and dust storms. Constraints and problems in the IMAR region include (1) the need for tillage for weed control, (2) the removal of crop residues for domestic fuel and for livestock fodder and bedding leaves which then leaves too few residues on the land for erosion control and maintenance of soil quality, (3) the lack of appropriate mechanization for seeding and harvesting, (4) uncontrolled grazing of crop stubble, (5) the lack of forages in the cropping systems to supply feed and improve soil quality, (6) insufficient technology transfer on conservation tillage and (7) the economic challenges of the small farming units and the lack of alternative sources of energy. The objective of the Canadian project was to demonstrate how Canadian prairie conservation tillage production systems can be modified for and applied to the small dryland farms of IMAR, and in particular stressing the need for appropriate crop residue management. The project showed that it is possible to have appropriate best-practice conservation tillage for the small farms without large requirements for capital and the need to incur much risk when changing to conservation tillage. These techniques may well be valuable in Africa.

5.10 Climate change and weather forecasting

Globally, agriculture is facing a new set of challenges from climate change. While many aspects of this phenomenon are uncertain, and indeed perhaps not even universally accepted, is it generally understood that agriculture is facing a future that is likely to be drier and warmer. This is likely to be crucial to China, where there is virtually no new agricultural land and the available land and water resources are farmed virtually to their limit. Regional climate and crop modelling scenarios are being modelled to assess the degree of change facing rural communities. One example is a project 'Impacts of Climate Change on Chinese Agriculture' (ICCCA) that combines scientific research with practical development policy advice. Since 2001, the project has led the way in understanding how climate change can be expected to affect rural China. Led by the Chinese Academy of Agricultural Sciences in collaboration with leading UK climate change researchers, Phase I (2001–2004) of the project sought to understand how climate change will affect Chinese agriculture overall, while Phase II (2005–2008) built on this work. It is a cooperative project linking science of climate change with the views of local people to develop responses to climate change.

Other examples that may be applicable to Africa include the development of a Grassland Fire Danger Index (GFDI) for north China. These fires do a lot of economic and environmental damage in arid and semi-arid areas, but can be largely eliminated by early warning technology. The GFDI was developed

[27] Guy Lafond, B.G. McConkey and M. Stumborg, 2008, "Conservation tillage models for small-scale farming: Linking the Canadian experience to the small farms of Inner Mongolia Autonomous Region in China", Soil and Tillage Research, 5 December

using remotely sensed images and weather station data. Seven basic indicators, relative humidity, temperature, wind velocity, precipitation, degree of grassland curing, fuel weight and grassland continuity were selected to calculate the GFDI, and the GFDI is classified into low, moderate, high, very high and extreme levels.

5.11 Markets and infrastructure

In its 2009 publication '*Agricultural policies in emerging markets*' the OECD reviewed China's recent policy developments[28]. The report found that agricultural support is dominated by market price supports and input subsidies. Although as a percentage of the agricultural value-added these supports are not high, but the sheer size of the agricultural sector means that in terms of the national GDP these supports are significant. However, the report also considered that the manner in which China allocates it supports, means, that only a small part of the supports are received by farmers and they are therefore not an efficient way of making transfers to the rural sector. Furthermore, China's reaction to the most recent 2008 global food price spike may have been accentuated by the country's various measures taken to restrict exports (especially in rice) when in late 2007 to early 2008 the government removed grains and soybeans and their derivatives from VAT rebates and imposed provisional export taxes and export licensing management on these products.

Analysis of the OECD data shows that market supports accounted for some CNY 79,700 million of the CNY 378,600 million supports (around 21 percent), with even more (CNY 180,200 million or 48 percent of the total) provided in the form of payments based on input use. Most of this market price support is provided through tariffs, tariff rate quotas and state trading, as well as minimum guaranteed prices for rice and wheat. Similarly, general support to infrastructure of CNY 43,200 million or 11.5 percent of the total is provided to the sector, primarily for irrigation and drainage facilities.

While the previous state pricing structure and associated state procurement system for grains was largely relaxed from 2004, the government continues to regulate and micro-manage the grain market through the national grain stock, minimum prices, state trading and border measures such as tariff quotas and export taxes. However, in a clear break from the past, centrally fixed prices are only in operation for tobacco, and the tobacco sector remains under a strict state monopoly for production, marketing and trade.

Minimum prices are set for wheat and rice, but these prices have remained below both world and domestic prices in recent times. Linked to this pricing structure is China's grain reserve system where around three to five months of overall usage for both human and animal consumption is held. Similarly,

[28] More details on the actual policies and their associated supports to the sector are provided in the Annex. This section concentrates on the market supports.

while the cotton and sugar markets are largely liberalized, a reserve system and targeted loans are operating to partially stabilize supply and therefore prices for both products. In addition, since 2004 a direct payment support system has been operating in parts of the main grain producing provinces to encourage this production, but as the OECD calculated that it contributed perhaps 2.3 percent of grain grower's gross revenues in 2007 its impacts are rather limited. Finally, until the end of the 1990s farmers paid various taxes and fees, but these have all been progressively discontinued since the start of 2006.

Another interesting area where Africa is recognized as having major infrastructural problems is the internal and cross-border transportation costs of produce. Rozelle[29] has studied this issue in China using the benchmark US internal transport costs as his reference point. He concluded that interregionally China's agricultural commodity markets are fairly well integrated. His analysis to arrive at this conclusion consisted of comparing the average percentage change in corn, rice and wheat prices for every 1,000 km distance from the port in China and the port of New Orleans for the same produce in the US. Using 2000 data for China the reductions per 1,000 km were -3 percent for corn, -4 percent for soybeans and -7 percent for rice. These findings were compared with 1998 data for the US where the figures were -5 percent for corn, -3.5 percent for soybeans and 8 percent for rice (rice is transported away from New Orleans and not towards it, as it is not produced in the Midwest of the US).

[29] Seminar to New Zealand Treasury, cited above.

6 The current and future prospects for Chinese agricultural technology transfers to Africa

Our views on the appropriateness of Chinese fertilizer and related soil management technologies for Africa's agricultural sector development have been mirrored by a team from the Gates Foundation developing China-Africa partnerships to support African smallholder agriculture[30]. While examining a concept similar to this current study, the team evaluated through a Chinese lens the extent to which Chinese companies may prosper commercially in Africa through exporting technologies under the agreements of the Forum on China-Africa Cooperation (FOCAC) summit. They highlighted the three areas of crop cultivation, water harvesting and water-saving irrigation that we have discussed in this report, and added a fourth of 'others' that includes raising fish in the rice paddies, micro tractors, methane generation and application, and spray technology of pesticides.

The report goes on to discuss where some Chinese companies have ventured into Africa recently but have found commercial operations difficult. Through the application of detailed studies such as the current one supported by the Rockefeller Foundation and the Gates Foundation study, in line with the climate of political cooperation that is developing between China and the African continent, we foresee that Sino-Africa technology transfers specific also to the agricultural sector will increase.

6.1 FOCAC commitments and agricultural cooperation

According to research by the Gates Foundation, to date the Chinese Government's efforts on transferring agricultural engineering have been small-scale and uncoordinated; although some 500 Chinese agricultural experts have gone to Africa, they have only worked in seven countries with 60 percent of them going to Nigeria. The funding for these projects has been limited, and mostly from African countries or third parties such as the FAO.

For the last five decades, however, since the forming of diplomatic relations with numerous African states in the mid 1950s, China has extended assistance *inter alia* to Africa's agricultural sector. Shelton and Paruk[31] report that since 1960, about 200 agricultural cooperation programmes have been implemented in more than 40 African states, including demonstration centres and agro-technology programmes. Mostly regarded as aid at the time, these projects spanned from the DRC to Uganda, to Niger, Guinea and Mauritania. During this time period, and contrary to the above, more than 10,000 agricultural experts and technicians have also been reported to be dispatched to African countries to train local African farmers.

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[30] Jane Chao and Frank Ge, McKinsey and Company, per com, 17 March 2009, Beijing.
[31] Garth Shelton and Farhana Paruk, 2008, "The Forum on China– Africa cooperation A strategic opportunity", Monograph 156, Institute for Security Studies, December

This included friendship farms such as in Zambia, or support from the agricultural institute in China's Hubei province to establish a Chinese farm in the DRC.
While the effectiveness of these aid projects has been questioned in terms of assisting the development of the agricultural sector in key African economies, commitments to further boost agricultural cooperation have been extended, as portrayed in this section.

Following the conclusion of the 3rd Ministerial Meeting and the 1st Heads of State Summit of the Forum on China-Africa Cooperation (FOCAC) in November 2006 (the 3rd summit of its kind), China's current and potential role as a development partner for Africa cannot be dismissed. This was reiterated by President Hu Jintao's opening address at FOCAC November 2006 where China's support for Africa's sustainable development and the unveiling of a multi-billion dollar development package to help boost the continent's initiatives was reaffirmed. The development assistance package, which includes a range of commitments, is underpinned by major projects in the infrastructure and agriculture sectors. These two sectors (infrastructure and agriculture) have also been dubbed the two underlying pillars of focus for the upcoming FOCAC summit in Egypt, November 2009. Generally, agriculture cooperation in the Sino-African relationship is expected to become an even greater focal point in future.

This echoes China's African Policy, a White Paper released in January 2006, reflecting the Asian country's objectives on the continent. Amongst these, agricultural cooperation is highlighted, with focus on "cooperation in land development, agricultural plantation, breeding technologies, food security, agricultural machinery and the processing of agricultural and side-line products". A commitment to intensify cooperation in training and provision of practical agricultural technologies, including demonstration centres and technology projects was also made in the White Paper, in order to "speed up the formulation of China-Africa Agricultural Cooperation Programme"[32].

Key agricultural cooperation commitments have been made at the 2nd FOCAC Summit in December 2003, Addis Ababa, and 3rd FOCAC Summit in November 2006, Beijing, the following are included[33]:

Areas of support for the agricultural sector as part of the Addis Ababa Action Plan:

- Agro-infrastructure development
- Farming, breeding & aquaculture
- Food security
- Exchange and transfer of applied agricultural science & technology
- Skills transfer & technical assistance

[32] See China's African Policy, January 2006, http://english.peopledaily.com.cn/200601/12/eng20060112_234894.html
[33] See Edinger, H., 2008. ""How China delivers rural development assistance to Africa", presented at the 6th Brussels Development Briefing entitled "New Drivers, New Players in rural development", organized by the Technical Centre for Agricultural and Rural Cooperation (CTA), Brussels, Belgium, 2nd July

- Manufacturing of farm machinery
- Processing of farm produce

Areas of support for the agricultural sector as part of the Beijing Action Plan:

- Send 100 senior Chinese agricultural experts to Africa
- Set up 10 agricultural demonstration sites in Africa
- Send 300 young volunteers to support education, agriculture, sports & health-related projects

Yet, longstanding friendships and rhetoric of cooperation aside, examining the Chinese presence in Africa under the China-Africa agricultural cooperation agreement as at early 2009, the Gates Foundation research found that to date China's agricultural centres are focusing on seed technologies. Of the African countries where projects are being initiated, only the one in Madagascar is in operation. Here Chinese experts have been working on the two hectare centre for rice technologies since 2006. The status of the other centers as at early 2009 is[34]:

- Benin, contract signed in March 2008;
- Cameroon, contract signed in November 2008 and a working committee set up in early 2009;
- Congo, contract signed in March 2008;
- Ethiopia, contract signed in April 2008;
- Liberia, construction not yet commenced;
- Mozambique, contract signed in November 2008;
- Rwanda, construction commenced on 4 April 2009
- South Africa, contract signed in 2008;
- Sudan, field visit by Chinese company in October 2007;
- Tanzania, field visit by Chinese experts in 2007;
- Togo, construction commenced on 22 October 2008;
- Uganda, contract signed in June 2008; and
- Zambia, visit by Chinese experts in December 2008;
- Zimbabwe, contract signed in 2008.

A research team from the Centre for Chinese Studies recently visited Mozambique and Uganda, to evaluate, among other things the delivery and implementation of certain commitments made at the 2006 FOCAC summit. This included visits to the envisaged agricultural demonstration sites. In Mozambique, the agricultural demonstration centre, which will be located in Boane, just west of Maputo, was signed in November 2008, when 52 hectares of land were made available for this project. As of late, this land is currently being cleared and prepared for the site. 10 Chinese technicians will be overseeing construction

[34] Based on Gates Foundation report as well as on in-house research by the Centre for Chinese Studies.

of the demonstration centre and the training programmes of the centre, with some of these technicians already having arrived in Maputo. However, despite this progress being made, the first crops are only expected to be planted in the next 3-5 months. Chinese technicians will also be testing the Mozambican climate for various seeds, including maize, rice, vegetables and fruit. Expertise in the areas of seed development, multiplication and farming methods are expected to increase yields in the current badly underperforming agricultural sector of the country.

In Uganda, an aquaculture demonstration centre is being constructed in the Kampala area. A feasibility study by a Chinese team, dispatched in the country in 2008, has been completed and a Chinese contractor is expected to complete the buildings of the demonstration centre within 12 months from the commencement of construction. The demonstration centre is envisaged to generate knowledge for fish farmers, fishers and researchers in the country.

African governments have also been competing to attract investment and financing from China. In the agricultural sector, Tanzania recently put forward an appeal to the Chinese government to assist the country with the setting up of an agricultural bank, as a joint venture between the two countries. While the establishment of such a bank might not be the case in the near future, Chinese policy banks, such as China Development Bank (CDB) and the Export-Import Bank of China (China EXIM Bank) have been important actors in extending agriculture related financing, export credits and investment to the African continent[35]. Most recently, Angola has been in negotiations with CDB to secure a US$ 1 billion loan to boost the country's agricultural sector, specifically focusing on the production of cereals and processing of agricultural products[36]. In early April 2009, China also made a significant contribution of US$ 30 million to the FAO trust fund of US$ 50 million, aiming to improve African agricultural productivity and thus farm production over the next three years, in order for African states to better meet the Millennium Development Goals (MDGs)[37].

Yet, to date the political pronouncements and rhetoric on both sides have not been matched by reality and performance from either partner. Africa is littered with failed aid projects and efforts must be made by all players to ensure that these research centers do not join them.

6.2 CADFund initiatives on agricultural investment and technology transfer

One of the eight measures announced by President Hu Jintao at the third and most recent FOCAC

[35] Refer to section 6.2 re China Development Bank's assistance through the China-Africa Development Fund to Africa.
[36] See "Angola: Head of State, Chinese Bank Discuss US$ 1 billion grant", 13th March 2009, http://allafrica.com/stories/200903130499.html; A CCS research team focusing on China-Angola relations, that visited Luanda in March, has not received any confirmation on the status of this proposed loan.
[37] See "China and FAO sign historic $30 million deal ", FAO, 25th March 2009, http://www.fao.org/news/story/en/item/10802/icode/ and "FAO launches trust fund to improve agriculture in Africa", *Business Daily*, 1st April 2009, http://www.bdafrica.com/index.php?option=com_content&task=view&id=13781&Itemid=297

Summit, in November 2006, was the creation of the China-Africa Development Fund (CADFund) – an independent commercial equity fund to facilitate Chinese companies investing in Africa. The fund was created with the assistance of China Development Bank (CDB), one of China's three policy banks and the main shareholder of the fund, who provided the first tranche of financing. Officially launched in June 2007, the fund had an initial starting capital of US$ 1 billion to be extended to a total US$ 5 billion over the next few years. A recent report by the *Financial Times*[38], that the fund would extend its resources by US$ 2 billion was confirmed by the fund in March 2009[39].

The CADFund is the first global fund specifically aimed at African development, with the underlying purpose of accelerating the economic and trade cooperation between China and Africa in more market-orientated ways. By promoting investment and providing capital for Chinese firms to invest in Africa, the fund reflects Beijing's foreign policy and strategic intention towards the African continent.

A key focus of the fund has been the sectors of agriculture, manufacturing, infrastructure (especially power infrastructure), extractive industries and special economic zones. It is reported that to date more than US$ 400 million has been dispersed across about 20 projects on the continent in these key areas. This has supposedly mobilised a further US$ 2 billion in direct investment from Chinese companies on the continent. The agricultural sector has been identified as crucial for investment in order to boost African countries' economic recovery and development, underpinning the enhancement and strengthening of these countries' development competencies.

To this extent, more than US$ 20 million had been committed across 10 agricultural projects by March 2009[40]. This includes projects in forestry, animal husbandry, fishery, planting, processing, agricultural machinery, and agricultural trade promotion, among other things, to improve the livelihood of African people and to "bring in practical Chinese technology and skills" to African farmers. Examples of these projects include cotton planting and processing projects in Malawi, Mozambique and Zambia (in cooperation with Chinese companies such as Colored-Cotton (Group) Co., Ltd., and Qingdao Ruichang Cotton Co.) as well as an Ethiopian leather processing project established together with Heitian Mingliang Leather Manufacturing Company, which looks at effectively driving stock breading and improving the processing skills in the industry.

Related to the agricultural sector, in the machinery manufacturing sub sector, CADFund has also proposed a further US$ 20 million across 10 projects on the continent. This includes projects for the

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[38] "China to add US$ 2 billion to African Investment Fund", *Financial Times*, 16th March 2009, http://www.bloomberg.com/apps/news?pid=20601116&sid=a5nfF0p6UF6M&refer=africa#

[39] Based on comments made by Mr Liliang Teng, CADFund representative to Southern Africa, at the presentation entitled "China's First Equity Investment to facilitate the African Continent", 26th March 2009, presentation presented at the Gordon Institute of Business Science, Johannesburg.

[40] Liliang Teng, 2009, "China's First Equity Investment to facilitate the African Continent", China-Africa Development Fund, 26th March, presentation presented at the Gordon Institute of Business Science.

"introduction of advanced and applicable Chinese industrial technology" including machinery for agricultural projects and the cooperation with companies like China No. One Tractor Group in some African countries for agricultural and project machinery, and generally, the supply of cheaper agricultural machinery including tractors.

The fund recently opened its first representative office on the continent in Johannesburg, South Africa, servicing the southern African region in identifying investment opportunities in countries including Botswana, Comoros, Lesotho, Madagascar, Mauritius, Mozambique, Namibia, South Africa and Zimbabwe. A further four offices in eastern, central, western and northern Africa respectively will be established in the near future. With the fund looking to expand its resources and investment footprint on the continent, there is scope for African projects, specific to agriculture and agricultural technology transfers, to tap into financial support and funding from the CADFund, in cooperation with Chinese state-owned enterprises and private investors.

7 References

Angola: Head of State, Chinese Bank Discuss US$ 1 billion grant, 2009. *Angola Press*, 13th March, Available [Online]: http://allafrica.com/stories/200903130499.html

China's African Policy, 2006. January. *People's Daily*, Available [Online]: http://english.peopledaily.com.cn/200601/12/eng20060112_234894.html

China to add US$ 2 billion to African Investment Fund, 2009. *Financial Times*, 16th March, Available [Online]: http://www.bloomberg.com/apps/news?pid=20601116&sid=a5nfF0p6UF6M&refer=africa#

DuByne, D., 2008. "Biogas? China size it". *Science Alert*, 9th May. Available [Online]: http://www.sciencealert.com.au/opinions/20080905-17301.html

Economic Research Service of the US Department of Agriculture (ERS of USDA), 2009. http://www.ers.usda.gov/Data/China/NationalForm.aspx

Edinger, H., 2008. "How China delivers rural development assistance to Africa", presented at the 6th Brussels Development Briefing entitled "New Drivers, New Players in rural development", organized by the Technical Centre for Agricultural and Rural Cooperation (CTA), Brussels, Belgium, 2nd July

Fan, Zhang, and Zhang, 2002. "Public Investment: Its Impact on Rural Growth and Poverty Reduction", International Food Policy Research institution (IFPRI)

Food and Agriculture Organization of the United Nations, 2007. Selected Indicators of Food and Agricultural Development in the Asia-Pacific Region 1996-2006. RAP Publication 2007/15. Available [Online]: ftp://ftp.fao.org/docrep/fao/010/ah994e/ah994e00.pdf

FAO, 2009. "China and FAO sign historic $30 million deal", 25th March, Available [Online]: http://www.fao.org/news/story/en/item/10802/icode/

FAO launches trust fund to improve agriculture in Africa, 2009. *Business Daily*, 1st April, Available [Online]: http://www.bdafrica.com/index.php?option=com_content&task=view&id=13781&Itemid=297

Games, D., 2006, "A Missed Opportunity: A Three-Country Study of African Agriculture", Brenthurst Discussion Paper 7/2006

Gates Foundation, 2009. "Developing China-Africa Partnerships to Support SSA Smallholder Agriculture".

Gulati, A., and Fan, S., 2008, "Learning from Agricultural and Rural Reforms in China and India", IFPRI Issue Brief 49, July

Huang, J., Hu, R., Rozelle, S., and Pray, C., 2008. "Genetically modified rice, yields, and pesticides: Assessing farm-level productivity effects in China", *Economic Development and Cultural Change*, Vol. 56: 241-263

Huang, J. and Wang, Q., 2002. "Agricultural Biotechnology Development and Policy in China", *AgBioForum*, 5(4): 122-135.

Lafond, G., McConkey, B.G. and Stumborg, M., 2008. "Conservation tillage models for small-scale farming: Linking the Canadian experience to the small farms of Inner Mongolia Autonomous Region in China", Soil and Tillage Research, 5 December

Ministry of Agriculture, People's Republic of China, 2007. "Agriculture in China", January
Organisation for Economic Co-Operation and Development (OECD), 2009. "Agricultural policies in emerging markets", Monitoring and Evaluation, Paris

OECD, 2005. "Review of Agricultural Policies, China." Organisation for Economic Co-Operation and Development, Paris

Martin Ravallion, 2008, "Are there lessons for Africa from China's success against poverty?", World Bank Policy Research Working Paper 4463, January

Rozelle, S., 2006. "China's Rural Economy and the Path towards a Modern Industrial State", Presentation at a Seminar hosted by the New Zealand Treasury, 7th March

Sandrey, R. and Nick, V., 2008, "Regulation, Trade Reform and Innovation in the South African Agricultural Sector", OECD Journal: General papers Volume 2008/4

Shelton, G. and Paruk, F., 2008. "The Forum on China–Africa cooperation: A strategic opportunity", Monograph 156, Institute for Security Studies, December

Teng, L., 2009. "China's First Equity Investment to facilitate the African Continent", China-Africa Development Fund, 26th March, presentation presented at the Gordon Institute of Business Science.

Tian, Y., 2009. "Quality Testing for Soil and Fertilizers Division", Presentation at the National Agro-Tech Extension and Service Centre (NATESC), Ministry of Agriculture (MOA), China, March

United States of America, Central Intelligence Agency (CIA), Downloaded from https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html

Vink, N., Sandrey, R., McCarthy, C., Zunckel, H, 2006. "Promoting Agricultural Trade and Investment Synergies between South Africa and other SADC Members", tralac Working Paper, November. Available [Online]: www.tralac.org

World Bank, 2008. "World Development Report 2008: Agriculture for Development". Available [Online]: www.worldbank.org/wdr2008

Yang, X. and Auerswald, P., 2003. "How to Avoid Stumbling in the Last Kilometer: The Case of Quzhou Agricultural Technology 110". An Innovations in Technology and Governance Case Study, NJ110 ITG Case Study.

Annexes

i) Supports to Chinese agriculture

During the course of the field trips and interviews in China, the research team was alerted to references to direct supports provided to the agricultural sector. It is important to put these supports in perspective. The OECD, the acknowledged experts in this area, recently reviewed and updated these supports for several developing economies[41]. Compared to the OECD average, the report estimates that the level of support to Chinese agricultural producers using the accepted Producer Support Estimate (PSE) remains low, but has increased since 2000. The structure of support continues to be dominated by market price support and input subsidies, the least efficient and most trade distorting ways of providing agricultural assistance. OECD analysis shows that only a small part of this type of support is effectively received by farmers. Moreover, the overuse of fertilizers, partly resulting from input subsidies, has made agriculture the main source of non-point water pollution in China.

Using the PSE, support to Chinese farmers increased from three percent in 1995-97 to nine percent in 2005-07. This is still considerably below the OECD average of 26 percent in 2005-07. Prices received by farmers were on average four percent higher than those observed on the world markets in 2005-07, while they were just one percent higher in 1995-97. As a result of the overall subsidies (including the input subsidies) farm receipts were ten percent higher than they would have been at world prices in 2005-07 compared to three percent higher in 1995-97. Transfers as a share of commodity gross farm receipts are the highest for cotton, sugar, maize and sheep meat. Total support to agriculture as a percentage of GDP increased from 1.60 percent in 1995-97 to 2.23 percent in 2005-07, and this is higher than the OECD average of 0.97 percent.

There are several channels for delivery of this support to farmers, ranging from direct payments through to taxation and border tariff measures. This report has discussed the rapid uptake of new seed varieties in China, and this is helped by subsidies that were introduced in 2002. Output supports are provided to grain production through minimum price support and grain storage supports, while all farmers benefit from input subsidies on many items such as fertilizers[42]). Other supports are more general, and these include the provision of electricity and general infrastructure, taxation advantages and general on-farm investment incentives. Interestingly a careful study of the OECD report does not reveal that the considerable extension service discussed in this report constitutes a significant support to farmers. Perhaps this is because although the service employs around one million persons on the Chinese scale this is not significant in fiscal terms.

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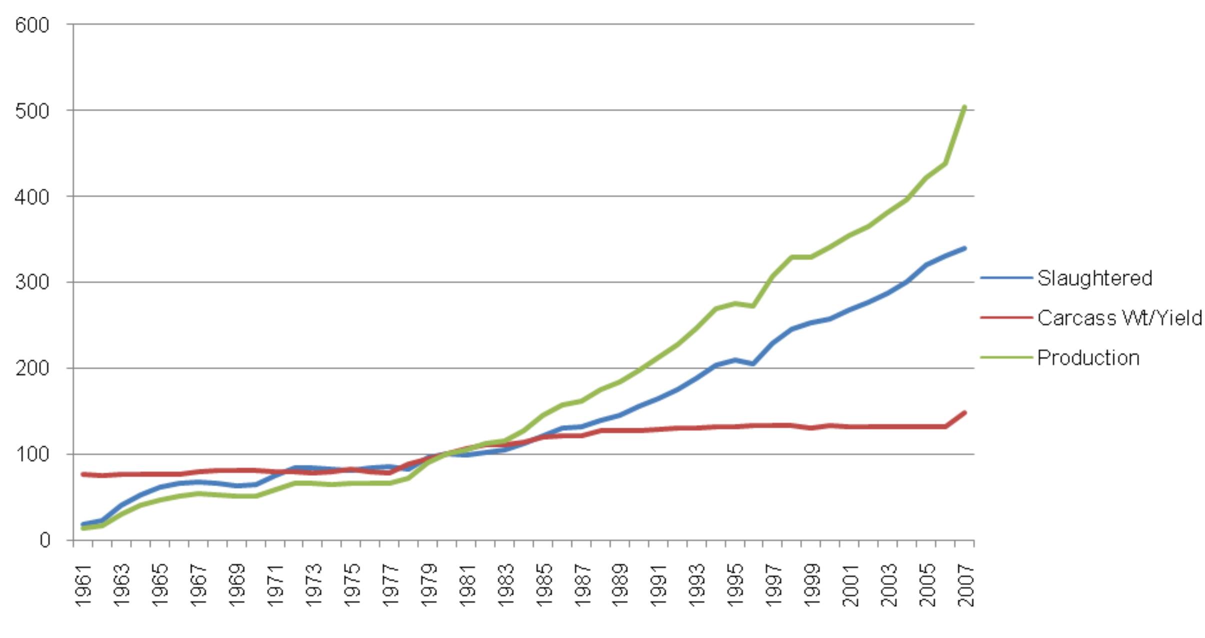
[41] 'Agricultural Policies in Emerging Economies 2009: Monitoring and Evaluation', OECD, Paris, 2009.
[42] Here the OECD notes that the overuse of fertilizers is perhaps between 20 and 50 percent in China, a concept noted above in this report.

ii) Livestock production

Over the last two decades China has emerged as the largest global producer of livestock products. Traditionally China has been a big producer of pig meats, but over the last few years both poultry and beef production has increased. The structure of the livestock industry is changing, but despite more specialisation taking place in the industry much of the production remains sideline business for small farmers[43]. However, it is the specialisation of livestock (including chickens and aquaculture) that is driving the large increases in soybeans and soybean products into China.

Figures 7 and 8 examine the relationships between the total production, numbers slaughtered and average carcass weight/yield for Chinese pig meat and poultry meat respectively. We would expect the carcass weight/yield trend line to represent technological progress in factors such as better breeding, feeding and management technologies. However, while this data (indexed to 1980 = 100) has increased for pig meat, and especially through the early 1980s, the poultry meat index has not changed much. Over the period 1961 to 2006 pig meat yields increased by 1.6 percent on average while poultry meat increased at a lower 1.0 percent. Indeed, Figures 7 and 8 strongly show that the big increase in production for both pig meat (6.5 percent) and poultry meat (an even higher 9.1 percent) has been driven by the numbers slaughtered (a growth of 4.9 percent for pig meat and 8.1 percent for poultry).

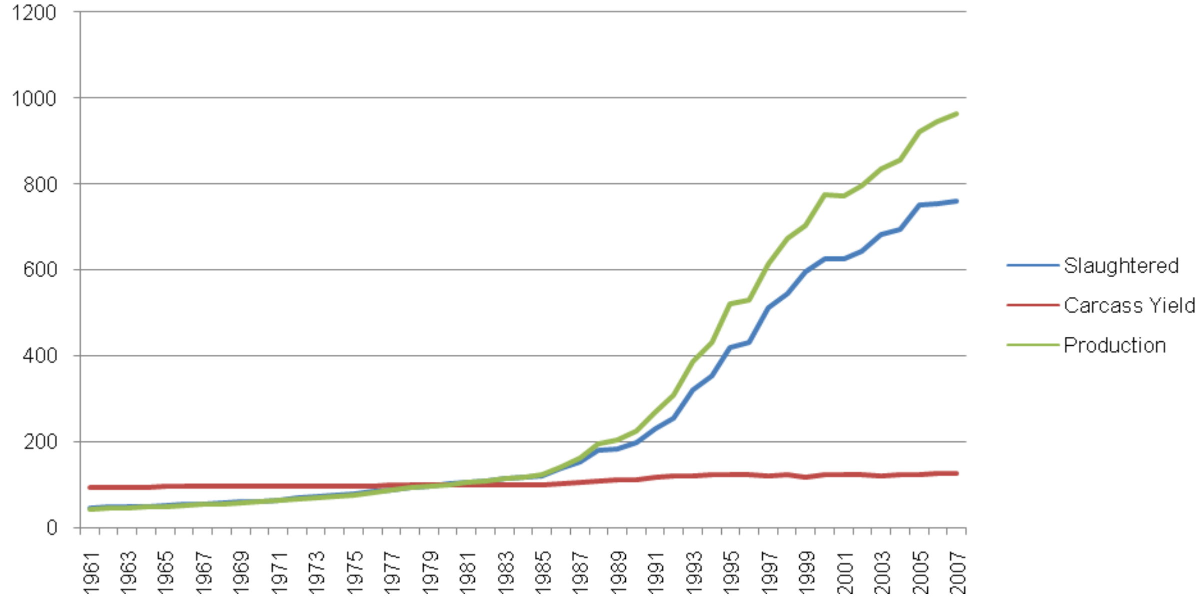
Figure 7: Chinese pig meat production (1961-2007)



Source: FAO data

[43] 'Agriculture in China: developments and significance for Australia', Australian Bureau of Agricultural and Resource Economics (ABARE); March 2006, Canberra.

Figure 8: Chinese poultry meat production (1961-2007)



Source: FAO data

Livestock production and its associated technologies were not a focus of this study. Even so, we see limited lessons that may be applicable to Africa, as the Chinese emphasis is on moving towards large scale production and imported feedstuffs.

iii) Aquaculture

FAO reports that aquaculture is developing, expanding and intensifying in almost all regions of the world, except in sub-Saharan Africa. Global population demand for aquatic food products is increasing, the production from capture fisheries has levelled off, and most of the main fishing areas have reached their maximum potential. Sustaining fish supplies from capture fisheries will, therefore, not be able to meet the growing global demand for aquatic food. Between 1950 and 2006 the total landed catch from open- and inland-sea fishing grew from around 20 million to about 95 million metric tonnes, and this proved to be unsustainable as resources are becoming overfished and depleted since harvests peaked in the late 1980s. In the 1970s, farming accounted for six percent of the fish available for human consumption. By 2006, the most recent year for which figures are available, this has risen to 47 percent[44]. This is the 'Blue Revolution' of aquaculture: firstly in China, but now in many other parts of the world. Aquaculture yields have increased from around two million metric tonnes in 1950 to almost 50 million metric tonnes in 2006 (Figure 9). China now accounts for around two thirds of total aquaculture production worldwide by weight

[44] Economist magazine, 2nd March 2009

and roughly half by market value. Aquaculture appears to have the potential to make a significant contribution to the increasing demand for aquatic food, and this is being demonstrated in China.

Fish farming in China is an ancient activity, where the combination of rice production with fish farming made good ecological and economic sense in densely populated China. Putting aquaculture in perspective, a cow requires around seven kg of feed grain for each kilogram of meat, while a carp requires around three kg or less. Chinese scientists have both improved the efficiency of aquaculture and revolutionized the range of species that can be farmed. Aquaculture of fishes such as carps, tilapia and catfish, is vastly more sustainable than current open-water harvesting. Even so, it still poses ecological challenges, but better aquaculture technologies are evolving rapidly to face these challenges. The industry continues to grow throughout the world with the exception of sub-Saharan Africa, and one important question that this current study can highlight is 'why is aquaculture not important in Africa?' The success of rural aquaculture must be an area where lessons for Africa should be relevant.

The FAO reports[45] that China's aquaculture production now exceeds its fish capture landings, and fisheries have become one of the most vital support industries and economic activities in rural development. Technical innovations, especially mass seed production of aquatic organisms, design and construction of commercial fish bases, expansion of coastal aquaculture and sea-farming, and intensive and high-yield aquaculture technologies have stimulated this rapid increase in production. The capacity of workers to apply the scientific approach to fish farming has been vastly improved through technological research, demonstrations, and extension and training courses. Both central and local governments have invested a tremendous amount of funds to establish a national aquaculture technical training and extension network at the central, provincial, prefecture, county and village levels. Technological systems for pond fish culture are basically traditional Chinese fish farming technology refined and improved through knowledge and experience gained from research and development efforts of the last five decades. The system has the following outstanding features:

- ***Rearing short food-chain fish***: Fish reared in China are largely herbivorous or omnivorous. Their food chain is very short, and fertilizer, grass and wastes from farm products processing industry can be used as fish feed. This ensures that culture cost is low.
- ***Self-sufficiency in seed production***: Over 20 species are being artificially bred, and seed of all the major culturable species are available in almost all rural areas where aquaculture is an important activity. Carp species are however dominating the harvest.
- ***Mixed and polyculture with high density***: Building on traditional Chinese methods different species of fishes can be cultured in the same pond according to their biological characteristics,

[45] www.fao.org/docrep/003/x6945e/x6945e05.htm and www.fao.org/DOCREP/003/AB412E/ab412e19.htm

food and feeding habits, and the water column inhabited by different species, so as to fully utilize the water space and the available natural feed to maximize production per unit area.

- ***Integrated culture***: Pond fish culture can be integrated with other farming activities such as livestock rearing (chicken/duck/pig/cattle etc.) and/or crop cultivation/horticulture (vegetables, mulberry, fruits etc.). It is a comprehensive and integrated method of production with fish culture as the main activity and growing different kinds of crops, cash crops, grass as feed, and raising livestock and poultry on and around the pond banks. Fermented waste of farmed animals can be used as fertilizer or as fish feeds, the sludge from the pond bottom can be used as quality fertilizer for crops on land, and crops and grass can be used as feed for farmed animals and fish.
- ***Water quality management***: For healthy growth of fish, the pond water quality is maintained at the optimum level by balancing the pond ecosystem. This is done through carefully managing the feeding regime, water inflow and outflow, and aeration.

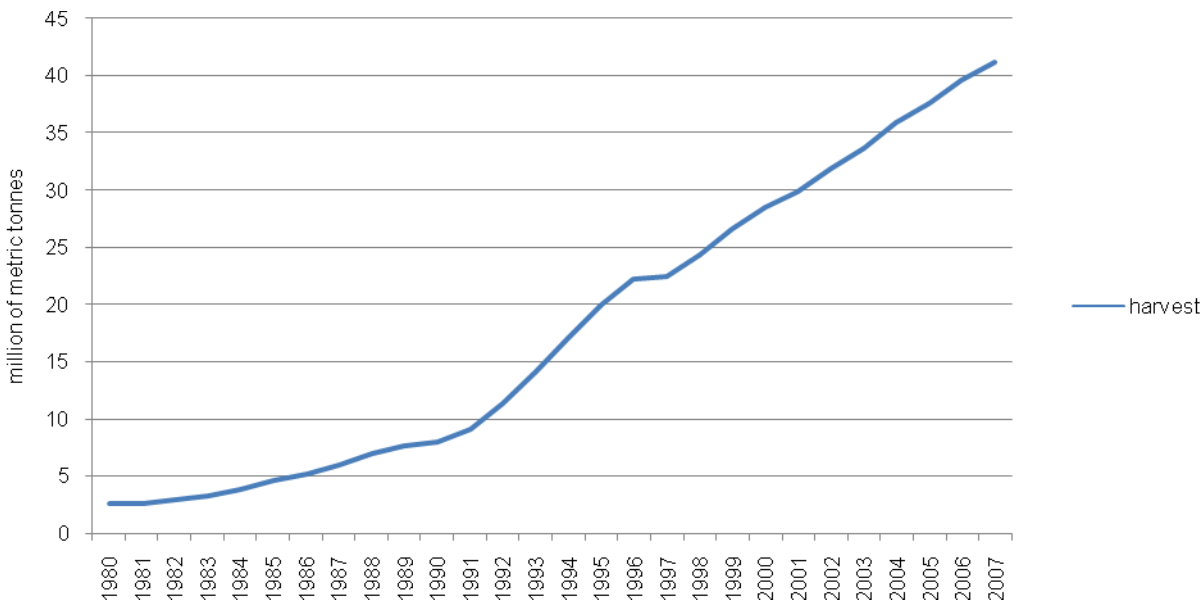
China exploits ponds, lakes, reservoirs, rivers, rice fields and other water areas, with pond culture the most important as it accounts for some 70 percent of total inland culture output. In recent years, rice fish farming has started to grow from small-scale production and by 2003 the paddy areas for fish farming were expanded to 1.56 million hectares with a total output of 1.024 million tonnes. The benefits for the rural sector from the fisheries sector are relatively higher than other sectors of agriculture. Again, the FAO reports that in 2004, fishermen's net annual income was US$ 660 per person, significantly higher than the US$ 355 of farmer's net annual income per person. About 4.3 million rural workers are directly employed in aquaculture. Development of fisheries, in particular aquaculture development, has attracted more people to stay in rural areas, and has had a positive effect on rural development. The sector is not without its problems, as aquaculture diseases have led to significant losses. Promoting healthy aquaculture production technology would decrease the huge economic loss, and could further increase aquaculture output.

In all sub-Saharan African countries, except South Africa, aquaculture is promoted under the relevant Poverty Reduction Strategy papers. This indicates that governments throughout the region recognize the potential of the sector particularly for rural development. With the exception of Kenya and Uganda, the aquaculture specific legislation and regulatory frameworks in almost all countries are either non-existent or weak. The sub-Saharan Africa region continues to be a minor player in aquaculture despite its natural potentials. Even aquaculture of tilapia, which is native to the continent, has not developed to a large degree. Nigeria leads in Africa with 44,000 tonnes of catfish, tilapia and other freshwater fishes reported. Indeed, the Economist[46] reports that the FAO consider that the future increase of production is predicted to be greatest in Africa. Growth rates in Africa are already high, albeit from a low base (in 2006 the continent produced less than 1 percent of the world's farmed fish). Between 1995 and 2005,

[46] Economist magazine, 2nd March 2009

production rose by 11.4 percent a year in sub-Saharan Africa and 21.9 percent in north Africa, with much of the growth being supported by outside injections of investment and expertise. This growing commercialisation of African aquaculture offers tremendous potential for the continent.

Figure 9: Chinese aquaculture yields (1980-2007)



Source: FAO data

iv) African agricultural policies (or lack thereof)

A damming report by the Brenthurst Foundation[47] on African agricultural policies in Malawi, Zambia and Tanzania considers that to understand why Africa has not realised its potential in the world economy one only has to look at the state of its agriculture. As the backbone of almost every African economy, the sector employs about 80% of the population and accounts for a major share of gross domestic product (GDP) in every African country. And yet there is no country on the continent, with the possible exceptions of South Africa and pre-2000 Zimbabwe[48], where agriculture has reached anywhere close to its potential. African heads of state make regular appeals in international forums for increased market access for African agricultural products, but back home they have, on the whole, failed to put in place policies and practices that will ensure the growth of market-oriented agricultural production despite considerable rhetoric. Meanwhile, even with considerable donor aid and expertise millions continue to starve and/or rely on food aid.

[47] Dianna Games, 2006, "A Missed Opportunity: A Three-Country Study Of African Agriculture", Brenthurst Discussion Paper 7/2006
[48] The recent disaster of Zimbabwean agricultural policies are well known, and even in South Africa Sandrey and Vink recently wrote for the OECD that technological change in South African agriculture in recent years has been notably absent.

Agriculture is one of the critical factors that will enable Africa to achieve the poverty reduction targets of the Millennium Development Goals (MDGs), yet per capita agricultural production has fallen by five percent over the past 20 years. Meanwhile populations are growing despite the AIDS pandemic, increasing demand for food and resources. Few African governments prioritise agriculture in their policies, spending or attention. Even where they have, they have failed to effectively tackle the persistent problems in agricultural development. Leaders 'talk the talk' but are incapable of 'walking the walk'.

The Brenthurst Foundation considered that the three southern African countries of Malawi, Tanzania and Zambia highlighted many of the problems that cause the lack of success of African agriculture. The problems in the three countries examined (which are common to most African countries) are in stark contrast to Chinese agriculture policies and include:

- poor implementation of good policies, where they exist;
- a lack of commitment to official spending in this sector;
- an over-reliance on donors funding and aid;
- a lack of infrastructure, including rural infrastructure, which constrains access to markets;
- an inability to make the required shift in mindset from subsistence agriculture to market-based agriculture, both among farmers and politicians;
- a socialist hangover in the approach to the private sector;
- poor leadership and an attitude that agriculture is something that 'takes care of itself';
- a lack of extension services and technical support;
- a reliance on traditional methods, with little technological innovation;
- no long-term planning and an attendant inability to deal with persistent, but not necessarily regular, crises such as droughts;
- a lack of empowerment of farmers, who are, as a result, not in a strong position to articulate their needs to governments;
- a lack of credit and financing options, particularly small loans and long-term finance;
- land tenure issues, which affect title to land and collateral for loans to farmers;
- a lack of value addition, making raw exports dependent on variable world prices;
- a lack of water management and animal disease control;
- a high incidence of disease in rural areas, particularly HIV/AIDS, which is depleting labour resources and productivity;
- government interference in the growing and pricing of strategic crops such as maize, creating shortages;
- a lack of understanding of markets, both local and international, and poor access to them;
- high entry levels and non-tariff barriers in developed markets; and
- onerous transport and business costs, which make locally produced goods uncompetitive regionally and internationally.

Yet, despite this absence of good agricultural policies in Africa, there are some wider lessons that others consider Africa can learn from China. We can only highlight the importance of a cohesive policy framework to stimulate growth, a lesson that China has learnt from a succession of Asian economies that have travelled the growth path over the last half century or so (Japan, Korea, Taiwan Province of China and Malaysia for example). Unfortunately, with the possible exception of Botswana, no African nation has found this growth pathway. There is important information in these broad conclusions.

Ravallion[49] promotes two lessons: the first is the importance of productivity growth in smallholder agriculture (although he does not provide details), and the second is the role played by strong leadership and a capable public administration at all levels of government that provides political stability. China and Africa contrast markedly in the latter lesson! Arguably the single best policy reform that started the Chinese growth was the dismantling of the rural collectives and the allocation of this land to individual peasants (through a lease system) that enabled them to react to the new market signals.

Ravallion's research also highlights how the dramatic growth in China impacted on poverty levels; in 1981 around 66 percent of Chinese lived below about US$1 per day, compared with a lesser 40 percent of the African population. By 2004 the African percentage remained the same while in China it had dropped to below ten percent. Put another way, by 1984 some 500 million fewer Chinese lived below the accepted poverty level than 1981, while conversely in Africa 130 million more did. To place these figures in perspective around ten percent of Chinese people are still as poor as the poorest 40 percent of Africans, with most of the Chinese poor living in rural areas with few absolute poor in urban areas as China's growth favoured coastal areas over remote rural areas. In contrast, sub-Saharan African rural and urban poor percentages are similar, with high dependency rates caused by increased mortality combined with continued high fertility rates contributing to Africa's woes. A development strategy for Africa that concentrates on agricultural and rural development as the Chinese reforms did in their early days can bring an initial impact on poverty levels in Africa – and Ravallion considers that China is in a good position to help Africa with its agricultural research and extension services.

Fan et al.[50] from the International Food Policy Research institution (IFPRI) found that China reduced rural poverty enormously since 1978 as a result of institutional and policy reforms, technical change, and increased efficiency in the agricultural sector induced by government investment in agricultural research, education and infrastructure improvements. They found that:

- Education is the best way to reduce rural poverty and the second-best way to increase agricultural growth.

[49] Martin Ravallion, 2008, "Are there lessons for Africa from China's success against poverty", World Bank Policy Research Working Paper 4463, January

[50] Fan, Zhang, and Zhang, 2002, "Public Investment: Its Impact on Rural Growth and Poverty Reduction", International Food Policy Research institution (IFPRI)

- Agricultural research is the best way to increase agricultural growth and the second-best way to reduce poverty.
- Investing in infrastructure (especially roads) is the third most important way to both increase agricultural production and reduce rural poverty.
- Spending on irrigation does not have a major impact on growth and poverty reduction.

Their research findings also indicate that additional investments in the less-developed interior regions are more effective than investments in the more-developed coastal areas in further reducing poverty and achieving regionally equitable patterns of development. Several types of investments in these underdeveloped areas now yield the highest productivity returns and the greatest poverty reduction and regional equity in development compared to more-developed areas.

A second IFPRI paper[51] posed the question of what India could learn from China. Here the authors consider that the correlation between initial conditions and post-reform achievements in poverty reduction and growth in China makes a convincing case for stepping up government investments in rural infrastructure and social services. In India, the decline in rural public investment as a result of fiscal profligacy and rising subsidies on fertilizers, power, water, and price support is regarded as one of the primary causes of slower growth after 1997.

The authors cite other IFPRI studies that have found spending on agricultural research, education, and rural roads is more effective in promoting agricultural growth and poverty reduction than spending on fertilizer or irrigation subsidies. There are also significant opportunities for public–private partnerships (PPPs) in agriculture in the areas of funding, research, and extension. Encouraging the more efficient use of water resources by targeting investments, reforming existing water systems, and improving crop yields is particularly crucial. In both China and India, water-use efficiency can be vastly improved through institutional and management reforms of existing water systems. China's experience shows that providing incentives to irrigation systems managers to improve use efficiency has a positive effect on crop yields, groundwater tables, and cereal production. Improving crop yields can also lead to a more efficient use of scarce water resources in agriculture, though inputs other than water such as credit and agricultural research on water saving and yield-improving technologies will need to be deployed.

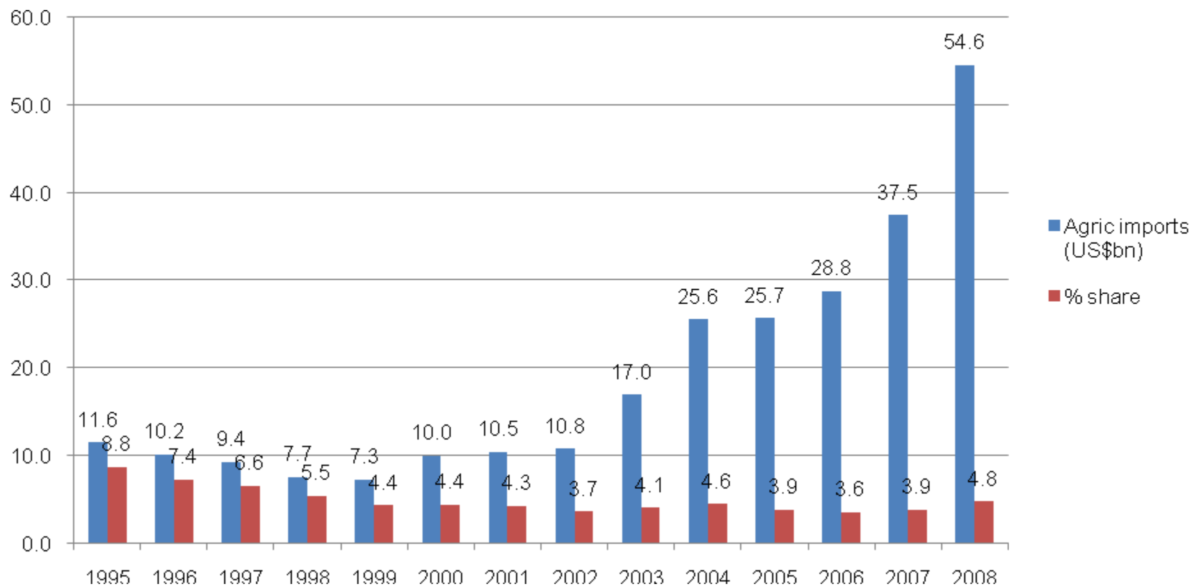
v) Chinese global agricultural trade

Figure 10 shows Chinese agricultural imports over the period year ending December 1995 through to 2008. The data is expressed in billions of US-dollar for imports (top columns) and percentage share of

[51] Ashok Gulati and Shenggen Fan, 2008, "Learning from Agricultural and Rural Reforms in China and India", IFPRI Issue Brief 49, July

total Chinese imports in the lower columns. The definition of 'agriculture' is that used by the WTO[52]. Imports were stable in dollar terms through to around 2002 before steadily climbing to just short of US$ 55 billion, while agriculture's percentage share of total Chinese imports had been consistently around four percent for most of the past decade before rising to 4.8 percent during 2008 as a result of the global agricultural price increase (an increase in part fuelled by China's own rising imports).

Figure 10: Chinese agri imports, % of total imports and US$ billions, annual data



Source: World Trade Atlas

Table 3 provides more information on the top ten imports at the aggregated HS code level. During 2008 these imports were 4.8 percent of total Chinese imports, the highest figure since 1998. By value, total agricultural imports were US$ 54.6 million during 2008, up from US$ 37.5 million during 2007. By product, the main imports were soybeans (US and Brazil), palm oil (Malaysia and Indonesia) and cotton (US and India) and. Soybean and soybean oil made up 46.1 percent of the agricultural imports and the top ten imports make up 75 percent of the total agricultural imports during 2008. Note that four of the top five products (cotton, palm oil, wool and soybean oil) are products that are under tariff rate quota (TRQ) regimes into China and therefore potentially restricted.

[52] This definition includes traditional food and beverage products (except fish and fish products), and a range of other products such as raw textiles like wool and cotton, hides and skins, live animals, and some manufacturing products such as caseins that are derived from animals or plants.

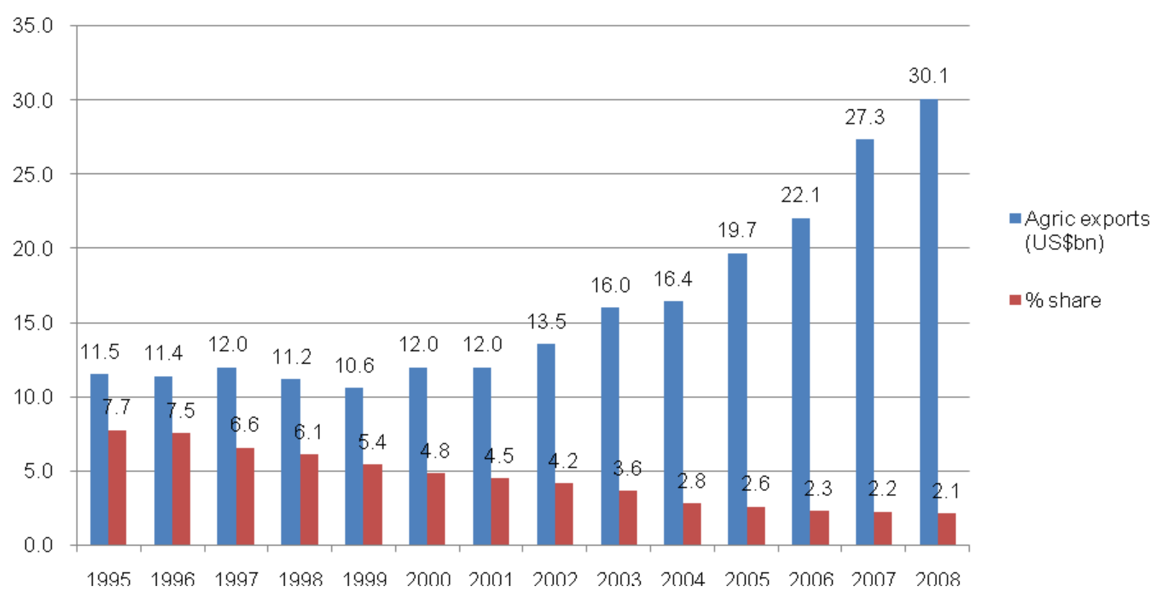
Table 3: Chinese agricultural imports, 2008, US$ million and % growth

HS	Description	2008	Growth	Sources of imports 2008		
		$ mill	%	First	Second	Third
Total agri imports $m		**54.6**	**9.8**	**USA**	**Brazil**	**Argentina**
1201	Soybeans	21,816	41.9	USA	Brazil	Argentina
1511	Palm oil	5,218	12.1	Malaysia	Indonesia	
5201	Cotton	3,494	7.7	USA	India	Uzbekistan
1507	Soybean oil	3,334	6.2	Argentina	Brazil	USA
5101	Wool	1,686	8.7	Australia	New Zealand	**RSA**
2301	Fish meal	1,436	9.6	Peru	Chile	US
4101	Hides & skins	1,412	13.6	USA	EU	Australia
0207	Chicken cuts	1,087	20.6	USA	Argentina	Brazil
1205	Rape seed oil	755	21.6	Canada		
2410	Tobacco	703	23.2	Brazil	**Zimbabwe**	USA

Source: World Trade Atlas

Figure 11 shows the similar profile for Chinese agricultural exports as shown in Figure 10 for agricultural imports. While the dollar value (top columns) has been steadily climbing during this century, the percentage share of Chinese exports (lower columns) is consistently trending downwards. Thus, while agricultural exports are increasing, they are not really contributing to the dramatic overall Chinese export explosion of recent times.

Figure 11: Chinese agri exports, % of total exports and US$ billions, annual data



Source: World Trade Atlas

Table 4 provides more information on the top ten exports at the aggregated HS code level. During 2008 these exports were 2.1 percent of total Chinese exports, a figure that has been steadily declining since

1995 as shown above. By value, total agricultural imports were US$ 30.1 million during 2008, up from US$ 27.3 million during 2007. By product, the main exports were other fruits and nuts (with peanuts the main individual line) with the US and EU the main destinations, followed by fruit juices (mainly apple) with again the US and EU the main destinations. Overall the main destinations for agricultural exports were Japan (16.6 percent), EU (15.5 percent), US (10.4 percent) and Hong Kong (10.0 percent). Note that China imported considerably more agricultural products (US$ 54.6 billion) than it exported (US$ 30.1 billion) during 2008.

Table 4: Chinese agricultural exports, 1995-200, US$ millions, growth & destination

HS	Description	2008	Growth	Destination of exports 2008	
		$ mill	%	First	Second
Total agri exports $m		**30,108**	**7.2**	**Japan**	**EU**
2008	Fruit, nuts (peanuts)	1,809	13.3	US	EU
2009	Fruit juice (apple)	1,259	30.3	US	EU
1602	Prep meat (chicken)	1,003	11.5	Japan	Hong Kong
0712	Vegetables	929	5.1	Japan	EU
2309	Animal feed	919	17.8	US	EU
0808	Apples & pears	914	16.7	Russia	Indonesia
2005	Vege other (mixed)	892	8.0	Japan	EU
0504	Animal guts	843	6.0	EU	US
0713	Dried legumes (kidney)	826	3.5	EU	Japan
2002	Prep tomato (paste)	801	21.1	EU	Russia

Source: World Trade Atlas

vi) China-Africa agricultural trade

During 2008 Africa provided some 1.7 percent of Chinese agricultural **imports**, with a value of US$ 906.6 million – a figure that has declined from a relatively stable three to five percent from 1999 through to 2006 and a high of 14.4 percent in 1995. This figure shows an average growth of 12.4 percent since 1995, below the average growth in total African imports of 26.9 percent over the same period. . By the more disaggregated HS 6 lines cotton represented over one third (34.8 percent) of these imports, followed by tobacco (16.6 percent), sesame seeds (13.6 percent), cocoa beans (10.6 percent) and wool (7.3 percent).

The top five HS 6 lines represented 82.8 percent of the total agricultural products imported into China from Africa during 2008, showing that the trade is highly concentrated. Even more concentrated is the product profile from individual African countries. South Africa is the main source from Africa (US$ 152.8 million), with US$ 78 million of this wool, hides another US$ 34 million and fish meal (not really an agricultural product) some US$ 13.1 million. The concentration in the next four Chinese agricultural import sources in Africa is even more apparent: US$ 121.1 million in tobacco accounting for most of Zimbabwe's trade of US$ 130.1 million; cotton of US$ 82.3 million from Benin accounting for all of the agricultural imports from this country; imports of cocoa beans of US$ 71.25 million accounting for most of Ghana's US$ 78.5 million; and cotton of US$ 62.47 million accounting for virtually all of the trade from Burkina Faso.

Agricultural **exports** to Africa over 2008 were a larger US$ 1,445.9 billion. This was 4.8 percent of Chinese agricultural exports, but a lesser 2.8 percent of total Chinese exports destined to Africa. Over time agricultural exports to Africa grew at 13.5 percent year, below the 22.5 percent growth in total exports to Africa. By detailed HS 6 lines green tea was the main item (18.6 percent of the total agricultural exports), followed by tomato paste (15.1 percent), rice (13.7 percent), kidney beans (6.1 percent) and animal guts (3.4 percent). By destination South Africa (US$ 203.7 million) ranked first. The republic was followed by Nigeria (US$ 150.9 million), Morocco (US$ 144.4 million), Algeria (US$ 132.7 million) and Egypt (US$ 127.7 million).

Profile of the Centre for Chinese Studies, University of Stellenbosch

The Centre for Chinese Studies (CCS) is the first institution devoted to the study of China on the African continent. The CCS promotes the exchange of knowledge, ideas and experiences between China and Africa. As Africa's interaction with China increases, the need for greater analysis and understanding between our two regions and peoples grows. The Centre fulfils this role.

Housed at Stellenbosch University in the Western Cape Province, the CCS is a joint undertaking between the Governments of South Africa and the People's Republic of China having been agreed to at the South Africa-PRC Bi-national Commission held in June 2004.

The Centre conducts analysis of China-related research to stakeholders in Government, business, academia and NGO communities. The CCS produces a monthly electronic publication, The China Monitor, with themes focusing on various aspects of China-Africa relations.

The Centre is active in delivering business strategy content to academic and business audiences at the Stellenbosch University Business School, as well as private sector corporates.

The CCS hosts visiting academics and Government officials within the China Forum that provides a platform for discussion and debate on China-Africa related subjects. China Forum events are often organised in collaboration with other institutions.

The CCS has co-operative linkages with key Chinese universities and institutions pursuing both research collaboration and exchange undertakings. The CCS has exchange agreements in place with Xiamen University, the Institute of West Asian & African Studies within the Chinese Academy of Social Sciences, the Shanghai Institute for International Studies and the Development Research Council, State Council.

The Centre for Chinese Studies is also home to the Confucius Institute, the first of its kind in South Africa. Through the Confucius Institute, the CCS is projecting Chinese language and cultural studies in the Africa region. The CCS thus serves as the foremost knowledge bridge between China and the African continent.

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