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Chapter 1 : CiteSeerX â€” Citation Query Who Will Feed China. Wake-up Call for a Small Planet

*Working Paper No. 56 What Will Make Chinese Agriculture More Productive? by Jikun Huang Justin Y. Lin** Scott Rozelle*** August, * Professor Jikun Huang, Center for Chinese Agricultural Policy, Chinese Academy of Agricultural.*

Total factor productivity, or TFP for short, is positive when one of the following conditions holds: However, the substantial structural changes in production agriculture and the institutions that serve it make it difficult to gauge the nature and sources of productivity growth in Chinese agriculture. Agricultural research spending at times has remained stagnant. Policies to encourage the importation of foreign technologies have been applied unevenly. Structural adjustment policies also triggered wrenching changes in the sector. Horticulture and livestock production has boomed; while the output of other crops, such as rice, wheat and soybeans, has stagnated or fallen. Somewhat surprisingly perhaps, little effort has been devoted to assessing the productivity performance of Chinese agricultureâ€”especially in the past decade. Because our analysis examines TFP growth on a crop by crop basis, we focus primarily on technical efficiency and are not able to assess changes to allocative efficiencies, or those efficiencies that would arise by adjusting crop structure or crop mixes. Economic Factors, Structural Change and Productivity The pace of TFP growth is influenced by investments in agricultural research and extension and other factors. Moreover, changes in technologies can have differential impacts on the rate of measured productivity over time. Yields of Chinese-bred rice, wheat and maize varieties were comparable to the yields that were being produced by varieties in some of the most productive agricultural economies in the world Stone After the economic reforms in the late s and early s, a nationwide reform in research was launched in the mids Rozelle, Pray, and Huang The reforms attempted to increase research productivity by shifting funding from institutional support to competitive grants, support research useful for economic development, and encouraged applied research institutes to be more self-supporting by commercializing the technologies they produced Fan, Zhang, and Qian Funding was greatly increased for plant biotechnology, although Bt cotton is the only genetically engineered crop that has been commercialized to any significant extent Huang et al. The extension system in China was once known as a system that was effective in moving technology from the experiment station to the farm and for giving farmers advice in combating diseases and insects. With the publicly funded system, there were extension agents at the county and township levels. After the mids, however, fiscal pressures at all levels of government induced local officials to commercialize the extension system. Extension agents had their salaries reduced by half or more. The extension systemâ€”focused on supplying technology and other information to farmersâ€”almost collapsed completely. Surveys found that most cropping farmers rarely, if ever, saw extension agents. Likewise, livestock and horticulture farmers received little support from the formal extension system. In the early reform period, output growthâ€”driven by increases in yieldsâ€”was experienced in all subsectors of agriculture, including grains. However, after the mids, the area sown to rice and wheat production has fallen, as has the domestic production of these two staple food crops. The contraction in grain supply was preceded by a reduction in demand as increasing per capita incomes, rural to urban migration and a reduction in government marketing controls shifted the pattern of consumption away from staple food grains. Like the grain sector, production of cash crops in general and specific crops, such as cotton, edible oils and vegetables and fruit, also grew rapidly in the early reform period. The growth in livestock and fishery output outpaced the growth in output from the cropping sector, in total and in most crop subcategories. Livestock production increased by 9. Dairy production also is rising extremely rapidly Fuller et al. Inputs, Outputs and Productivity Before After the rapid growth in output and the decline in inputsâ€”involving mostly labor that shifted to off-farm activitiesâ€”during the early s McMillan, Whalley, and Zhu ; Lin , policy-makers became increasingly concerned about the slowing pace of agricultural output growth. In fact, our data suggest that these concerns were justified in the case of some crops but not others. For these four crops, input use actually increased by 1. In contrast, during the same decade, production of

wheat and maize grew by 2. While pre data for cash crops and livestock production are limited, the record of output and input trends also varied among commodities. Widespread problems with cotton pests meant cotton production contracted by 0. Inputs used in hog production also grew faster than output, whereas output grew faster than inputs for beef production. TFP Performance before TFP analysis demonstrates that policy concerns regarding the relatively poor performance by Chinese agriculture during were justified Figure 1, Lower Panel. For early and late indica rice and soybeans, our estimates indicate that TFP during this period grew by a relatively modest rate compared with the early s. The growth rates of TFP were even smaller for wheat and maize. Japonica rice productivity actually fell by 0. The record is mixed during this period for nongrain crops. Although the research system helped stem the fall by producing some new conventional cotton varieties, production efficiency declined; TFP trends in the hog sector followed a similar path. Hitherto information has been lacking on the pace of productivity growth for the major grain crops for the decade after In addition, there has never been a systematic analysis of the productivity performance of rapidly emerging agricultural sectors, such as horticulture, poultry and dairy. Outputs and Inputs after Agricultural output growth for most commodities rebounded during the period Figure 2, Top Panel. For 20 of the 23 commodities, for which we have more-complete data, output grew at a faster rate than inputs. This was so for all the grain crops as well as soybeans. Other sectors within agriculture showed similar trends. Cotton production expanded by 2. Most likely, the widespread uptake of Bt cottonâ€”which allowed farmers to dramatically reduce pesticide use and labor for spraying while increasing yieldsâ€”is a large part of the story. With the exception of the specialized milk sector that is mostly made up of large commercial dairies, the livestock sector also saw output growing faster than inputs during The horticultural sector has a more mixed record Figure 3, Top Panel. The pace of output growth exceeded the pace of growth in input use for five of the horticultural crops, namely capsicum, field cucumbers, greenhouse cucumbers, greenhouse tomatoes, and mandarins. In contrast, the opposite held for eggplants, field tomatoes, and oranges. The fact that greenhouse tomatoes and other greenhouse vegetables experienced faster output growth relative to input growthâ€”compared with less favorable output-input trends for field tomatoes and some other cropsâ€”might reflect the greater farming abilities of those commercial farmers who adopted greenhouse technologies. It also appears that TFP growth accelerated between the late s and Some of the highest rates of TFP growth have been in the livestock sector. If one considered the fact that domestic investment into livestock productivity-enhancing research during the s and s was relatively low this might seem surprising. It could be, however, that foreign technologies have played a role in the rapidly increasing TFP growth in the livestock sector after Figure 4. During the s, China encouraged the importation of large amounts of new genetic material for the hog, beef, poultry and dairy industries. Conclusion Our analysis shows that agricultural TFP in China grew at a relatively rapid rate since for a large number of commodities. The rate of increase in agricultural TFP in China over the quarter century, , was high by historical standards and compared with corresponding rates of TFP growth reported for many other countries around the world. We ascribe much of this TFP growth to changes in the technologies flowing to and being used by these sectors. Both domestic and foreign technologies have played a role. Rapid TFP growth is important for the competitiveness and national food security in China in the coming years. It is also important to keep China from putting too much pressure on international markets. These demands mean that large increases in production will be needed to feed China. Simulation modeling has shown that continued rapid growth of the economy and slow productivity growth would result in extremely large demands for imports. Being such a large country with access to foreign reserves, international prices would feel upward pressure. For More Information Fan, S. Too Little, Too Late? International Food and Policy Research Institute. Production and Productivity Growth in Chinese Agriculture: New National and Regional Measures. Economic Development and Cultural Change, 50 4 , Food Policy, 31 3 , Plant Biotechnology in China. Productivity, Efficiency, and Technical Change: Journal of Productivity Analysis. Rural reform and agricultural growth in China. American Economic Review, 82 1 , Journal of Political Economy, 97 4 , Department of Agricultural Economics, Rutgers University. Managing Pest Resistance in Fragmented Farms:

Freeman Spogli Institute, Stanford University. Agricultural Research Policy in China: Testing the Limits of Commercialization-led Reform. Comparative Economic Studies, 39 2 , Developments in Agricultural Technology. China Quarterly, , Scott Rozelle Rozelle stanford. We thank Julian Alston, Ruifa Hu, Hengyu Ma, Philip Pardey and the anonymous reviewers for valuable comments that have improved the quality of the paper.

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Chapter 2 : Climate Change and Chinaâ€™s Agricultural Sector by ICTSD - Issuu

1 What Will Make Chinese Agriculture More Productive? Jikun Huang, Justin Y. Lin and Scott Rozelle I. Introduction The international community has long recognized China's effort to produce.

Any opinions expressed here are those of the author s and not those of the Centre for Economic Policy Research. Research disseminated by CEPR may include views on policy, but the Centre itself takes no institutional policy positions. The Centre for Economic Policy Research was established in as a private educational charity, to promote independent analysis and public discussion of open economies and the relations among them. It is pluralist and non-partisan, bringing economic research to bear on the analysis of medium- and long-run policy questions. These Discussion Papers often represent preliminary or incomplete work, circulated to encourage discussion and comment. Citation and use of such a paper should take account of its provisional character. We explore that possibility bearing in mind that, even if producer prices of some land-intensive farm products fall, prices of other labour-intensive farm and non-farm products could rise. The Paper concludes with some policy suggestions for alleviating any pockets of farm household poverty that may emerge as a result of WTO accession. O19, O53 and P31 Keywords: For further Discussion Papers by this author see: The usual disclaimer applies. During those negotiations, China was continually opening up and reforming its economy, and further reforms will be introduced over the next few years to fulfill the legal obligations China has committed to in its WTO Protocol of Accession WTO That underscores the importance of first analyzing the likely distributional consequences of the reforms themselves, and then considering what complementary policies are needed to provide adequate safety nets for potential losers. However, while imports of numerous land-intensive farm products may well increase, reduced protectionism may also boost output and exports of some labor- intensive farm products in which China still has a comparative advantage. Those changes, together with the promised increase in a wide range of agricultural imports, will allow China to exploit more fully its strong comparative advantage in unskilled labor-intensive products â€” both farm and non-farm. Even the direction, let alone the magnitude, of some of the effects cannot be discerned from theory McCulloch, Winters and Cirera , so we use the numerical simulation model known as GTAP to address these issues. So too is the possibility that China itself may use quarantine measures to limit its imports of farm products. The paper concludes by drawing out implications for Chinese policy makers wishing to pre-empt any increases in food insecurity or rural poverty. More recently policies have favored some agricultural industries, while others remain discouraged. Table 1, which shows new estimates by Huang, Rozelle and Chang of nominal protection rates for key agricultural commodities, suggests rice, meat, fish and fruit and 3 See Sah and Stiglitz and Anderson Maize and cotton also enjoyed export subsidies in amounting to one-third and one-tenth of f. As well, producers of major crops may continue to be affected by commodity-specific policies of government procurement of a portion of the crop at lower than market prices as in the past â€” see Sicular or at higher than market prices as in â€” see Huang What will those reforms mean for agricultural trade? Yet net food import growth has not yet happened, at least not in a sustained way, and China has continued to be a net exporter of meat, fish, fruit and vegetables. Indeed on occasions in the latter s, China also was a net exporter of grain and cotton. How much of that is due to government policies that constrained domestic demand, including occasional export subsidies, is a moot point. The import market access commitments China has made to WTO members look substantial on paper. The quota volumes are to grow over the next three years at annual rates ranging from 5 to 19 per cent. A further commitment by China is that monopolies previously held by state trading enterprises will be weakened except for tobacco: Tariffs will be cut on accession and further cuts will be phased in by with just a few exceptions. Furthermore, for industrial products, China will reduce significantly its non-tariff measures and eliminate all quotas, tendering and import licensing on non-farm merchandise by no later than Commitments to open up services markets in China also have been made. Over the s the average scheduled tariff rates for manufacturing initially exceeded but fell

more than for agriculture, and by the manufacturing average will be well below that for agriculture a simple average of 9 per cent, versus 16 per cent for agriculture â€" see WTO , Appendix Table IIB. That does not give a true indication of the extent of change in protection 5 that is taking place, though, because in the s many manufactures have been entering China at reduced or zero tariffs via duty drawbacks, to encourage foreign investment in processing of imported intermediate goods for subsequent export. Some agricultural products also have entered at less than the scheduled rate, including through smuggling. For present purposes the data base is aggregated to 25 sectors and 20 regions and projected forward first to and then to , using World Bank projections of population, income, and endowments of productive factors agricultural land, other natural resources, unskilled labor, skilled labor, and other capital. The initial base case assumes China retains its protection policies as of and Taiwan 4 The GTAP Global Trade Analysis Project model is a multi-regional, static, applied general equilibrium model based on neo-classical microeconomic theory including full employment of all factors of production, constant returns to scale and perfect competition. For a discussion of the prospect of greater unemployment during the accession period, see Zhai and Wang The numeraire is the world price of exports. See Hertel for comprehensive documentation. The Version 5 data base is described at www. For key agricultural import policies these remaining reform commitments are assumed to shift nominal rates of protection NRPs from column 3 to column 6 of Table 1. As well, the export subsidies in place in 34 per cent for maize, 10 per cent for cotton are eliminated, and we assume no new farm production subsidies are introduced. Tariff cuts are from applied rates to post-accession bound rates or zero if the latter exceed the former. In this application the aggregate trade balance and government tax revenue are both assumed to remain a fixed share of GDP. Sensitivity of the results concerning the first two categories are explored in the results section. If this reform were to require a movement of unskilled labor out of farm activities, three impediments need to be kept in mind. One is that those farm workers would be less than perfect substitutes for those already in non-farm pursuits. Econometric work by Sicular and Zhao suggests that restraints on mobility could be approximated via a CET function with an elasticity of transformation of 1. Another impedime nt to off-farm migration is that urban social welfare benefits such as subsidies to housing, food, education and health care are not available to non-urban people, except by purchasing a residence permit, or hukou Zhao These latter two impediments have contributed to the persistence of a large gap in farm versus non-farm returns to unskilled labor. The closure adopted is a long-run one in which, in addition to the above assumptions about unskilled labor, we assume agricultural land is mobile between industries within the agricultural sector, and skilled labor and capital are mobile within and between sectors. It keeps the aggregate trade balance and government tax revenue as a fixed share of GDP with little 7 In a subsequent analysis, Sicular and Zhao provide estimates of 2. Ianchovichina and Martin conduct sensitivity analysis on the implications of changes in these parameters, and find the results are not altered greatly. What do the results show? The core WTO accession scenario To begin with the bottom line of the main scenario before revealing the details, the core empirical results suggest WTO accession will increase farm-nonfarm income inequality. The main reason for this is that the relative producer prices of farm products are projected by the GTAP model to fall more than the prices of labor intensive non-farm products following the completion of WTO accession reforms Table 2. There is in addition a lower cost structure in unskilled labor intensive manufacturing activities, for three reasons: As a result, the quantity of unskilled non-farm labor demanded is greater by 0. However, lower farm product prices mean the quantity of unskilled farm labor demanded is less by 1. Meanwhile, the real wages of skilled labor increase by 0. Together these results suggest the owners of non-farm capital gain almost the same in proportional terms as unskilled laborers in non-farm employment, but the latter do better than skilled workers. Hence on balance income inequality may improve slightly among non-farm households dependent mainly on labor income. For farm households entirely dependent on earnings from agriculture type A in Table 3 , income would fall 1. This would differ little across the country since product shares for farm output â€" when fish products are ignored â€" are reasonably similar in western, central and eastern provinces; however, if we look at northern and southern provinces in China, differences

could be larger since wheat, maize, soybean and cotton are planted primarily in northern China while rice, horticulture, livestock and 11 Wages of skilled workers might increase more than suggested here as we do not capture the endogenous productivity growth resulting from the substantial liberalization of the service sectors. For a recent study that does incorporate that effect using a dynamic version of the GTAP model, see Ianchovichina and Walmsley For farm households earning 30 per cent of their income from nonfarm unskilled work, however, that income fall is only half as large 0. Real consumer prices relative to the CPI are lowered most by WTO accession for motor vehicles, oilseeds and sugar and for beverages and tobacco, although if China was using import taxes on those items as a form of consumption tax and their decline were to be matched by an increase in domestic sales taxation, those price declines may not materialize. They are also lowered for textile products and to a lesser extent clothing. Among the farm products, consumer prices are raised slightly for livestock products, somewhat more for grains, and significantly for cotton plant-based fibres. Producer prices also shown relative to the CPI fall more than consumer prices because of a uniform consumption tax of 1. They are down more for farm products than for most other products except autos though. Also, farm output is down for all but cotton and meat. Moreover, feedgrain exports shrink by three-quarters and cotton exports by half with the abolition of export subsidies. But the extent is really quite minor: The above results depend as always on the assumptions in the model. To check the sensitivity of some of those assumptions, two alternative scenarios were run to compare their results with those in the base accession scenario: An additional GTAP simulation was run and the differences for factor rewards are not huge in aggregate but they would be in the direction of worsening income inequality: These changes would attract only another million workers from farms. But while agricultural incomes would be lower, farm household income would not fall if at least 60 per cent of its income came from wages of non-farm unskilled labor see row 8 of Table 3. Domestic production of grains, sugar and cotton would be less though, and domestic consumption greater, so self-sufficiency in those products would be slightly lower. Such an import increase would be within the tariff rate quotas for those items with the possible exception of maize depending on the extent to which other feedgrains that are not TRQ-restricted, such as barley, are substitutable for maize. The changes are not great though, even though these products account for nearly 40 per cent of the value of food and agricultural output in China. As can be seen by comparing columns 1, 2 and 3 of Table 3, they would involve about as much improvement in income distribution as the previous alternative scenario would worsen it. This case involves a 3 per cent larger national economic welfare gain than the core case bottom row of Table 3. Conclusions and policy implications Our initial analysis suggests rural non-farm incomes will rise on average absolutely and possibly even relative to urban incomes in the case of households depending just on labor income assuming urban laborers are more skilled. However, some farm households facing increased import competition may be worse off in this case, ceteris paribus, if they are: The first alternative scenario shows that this situation would be exacerbated slightly if the TRQ-protected items grains, sugar and cotton were to become even less protected than we initially assumed. By way of contrast, the second alternative scenario suggests the situation could be made slightly less extreme by removing the negative protection affecting rice, meats, vegetables and fruits. But both of these alternatives only involve small changes to the magnitudes of effects, rather than altering the sign of those effects, and both add only a small amount to the aggregate gains from trade liberalization. National self-sufficiency in farm products would decrease slightly, particularly for feedgrains and cotton as demand for livestock products grows with income gains from trade reform and as production of natural fibre-based textiles and clothing expand. But overall, most of the declines in domestic agricultural production as a consequence of the remaining reforms that are required following WTO accession are relatively very small in magnitude, especially when compared with the growth in farm output that would occur as a result of normal economic growth compare columns 1 and 5 of Table 4. What they underscore is that whether a particular group gains or loses from a shock such as WTO accession in the long run depends heavily on their sources of household income and their capacity to adapt to the changed economic circumstances. Rather than arguing against trade reform, first-best ways should be sought for

dealing with those concerns and with any transitory unemployment that might follow reform. First, the government might consider further investments in basic rural education and health services to reduce the adverse effect of trade reform on poverty incidence and perceived food security. In addition to those longer-term benefits, there could also be an immediate poverty alleviating effect if the governme nt were to cut basic school fees and make up the shortfall with a bigger direct grant to rural primary and middle schools. Second, improvements in rural infrastructure such as roads and rail mean that a larger share of the price eventually received at the end of the marketing chain for farm products can be passed back to farmers. Such improvements also lower the barrier for off-farm work by members of farm households, making it easier for them to take advantage of expanding employment opportunities in rural townships. A boost in agricultural productivity could significantly offset 15 the per cent drop in agricultural production that is estimated in the core scenario to result from WTO accession.

Chapter 3 : CiteSeerX â€" What Will Make Chinese Agriculture More Productive?

By Jikun Huang, Justin Y. Lin, Scott Rozelle This paper reviews China's development strategies in agriculture, the reforms that it has pursued in the past for achieving its current level of food security, raising agricultural productivity and augmenting farm income.

While it receives considerably less attention, the agriculture sector is not an insignificant source of emissions. Excessive fertilizer use is not only fueling a major portion of the nitrous oxide emissions but also is raising alarm about water pollution from agriculture. Given the myriad challenges facing Chinaâ€"developing the economy, eliminating poverty, mitigating the emissions of greenhouse gases and adapting to climate change, and ensuring long-term food securityâ€"it is deserving of such specific consideration. By comparison, total U. Economic studies show that climate change will affect not only agricultural production, but also agricultural prices, trade and food self-sufficiency. The research presented here indicates that producer responses to these climateinduced shocks will lessen the impacts of climate change on agricultural production compared to the effects predicted by many natural scientists. The change in relative prices in domestic and international markets will in turn impact trade flows of all commodities. The magnitude of the impact on grain trade in China will equal about 2 to 3 percent of domestic consumption. The effect of climate change on rural incomes in China is complicated. The analysis shows that the average impact of higher temperatures on crop net revenue is negative, but this can be partially offset by income gains resulting from an expected increase in precipitation. Moreover, the effects of climate change on farmers will vary depending on the production methods used. Rain-fed farmers will be more vulnerable to temperature increases than irrigated farmers, and the impact of climate change on crop net revenue varies by season and by region. In recent years, China has made tangible progress on the implementation of adaptation strategies in the agricultural sector. Efforts have been made to increase public investment in climate change research, and special funding has been allocated to adaptation issues. An experiment with insurance policies and increased public investment in research are just two examples of climate adaptation measures. Beyond government initiatives, farmers have implemented their own adaptation strategies, such as changing cropping patterns, increasing investment in irrigation infrastructure, using water saving technologies and planting new crop varieties to increase resistance to climatic shocks. China faces several challenges, however, as it seeks to reduce emissions and adapt to climate change. Fertilizers are a major component of nitrous oxide emissions, and recent studies indicate that overuse of fertilizer has become a significant contributor to water pollution. Application rates in China are well above world averages for many crops; fields are so saturated with fertilizer that nutrients are lost because crops cannot absorb any more. Changing fertilizer application practices will be no easy task. Many farmers also work outside of agriculture to supplement their income and opt for current methods because they are less time intensive. An Overview of Impacts, Adaptation and Mitigation mitigation strategies for some farmers. To combat low fertilizer use efficiency in China, the government in recent years has begun promoting technology aimed at calibrating fertilizer dosages according to the characteristics of soil. In addition, conservation tillage CT has been considered as a potential way to create carbon sinks. Finally, extending intermittent irrigation and adopting new seed varieties for paddy fields are also strategies that have been supported and promoted as part of the effort to reduce GHG emissions. An Overview of Impacts, Adaptation and Mitigation 1. Introduction The scientific community widely agrees that climate change is already a reality. Over the past century, surface temperatures have risen, and associated impacts on physical and biological systems are increasingly being observed PRC, Climate change will bring about gradual shifts such as sea level rise, movement of climatic zones due to increased temperatures, and changes in precipitation patterns. Climate change is also likely to increase the frequency and magnitude of extreme weather events such as droughts, floods and storms. While there is uncertainty in the projections with regard to the exact magnitude, rate and regional patterns of climate change, its consequences will change the fates of generations to come. While climate influences virtually all

aspects of life, the impact on agricultural production is likely to be particularly important. Moreover, since China is a large, important producing and trading nation, the impact of climate change on China will likely also affect the rest of the world via international trade. However, these figures may overestimate changes in yield, as they do not account for the adoption of new technologies or changes in policy in response to climate change. As agreed by many scientists, climate change is mainly driven by the emission of greenhouse gases, such as carbon dioxide, methane and nitrous oxide IPCC, Among all sources of emissions, agriculture is one of the most important contributors. Methane emissions from agricultural activities mainly from ruminant animals and the cultivation of paddy rice amounted to These emissions are impor1 tant; when comparing the consequences of different ICTSD - IPC emissions, the temperature-increasing potential from nitrous oxide methane is times 23 times that of carbon dioxide. While agriculture is one of the most important sources of emissions of greenhouse gases, the sector is increasingly being recognized for its potential to be part of the solution. This recognition of the positive role that agriculture can play is timely. In this vein, China is currently undergoing some fundamental changes to its climate change strategy. It is beginning to formulate a set of plans to deal with adaptation and mitigation issues by aiming at improved public access to information, stronger enforcement of laws, and higher accountability for emitters. An Overview of Impacts, Adaptation and Mitigation However, in order to improve its adaptive capabilities and realize its mitigation targets, China must first examine several key questions. Within agriculture, where are the primary sources of emissions? What are some of the ways China is currently under- the sector can adapt going some fundamental and what efforts are changes to its climate change already underway? It is beginning to What are potential formulate a set of plans to mitigation measures deal with adaptation and and policies that mitigation issues by aiming could be promoted in at improved public access the agricultural sector to information, stronger in China? In order to realize this goal, we have the following specific objectives. First, we will synthesize the likely impacts of climate change on agricultural production crop yield and cropping systems , farmer income and agricultural trade imports and exports in China. Second, we will review adaptive responses to climate change that could potentially be made by the government and by farmers. Third, we will review some potential mitigation measures and policies that could be promoted in the agricultural sector. The remainder of this paper is organized as follows. Section 2 briefly reviews the observed scientific evidence on climate change in China. Section 3 synthesizes the impacts of climate change on crop yields and cropping systems according to scientific estimates; the discussion in this section is based primarily on various biophysical modeling efforts. Section 4 reports the impacts of climate change on agricultural production, trade and farmer income. These results are based on research carried out by authors using economic models. The final section provides some overall conclusions. An Overview of Impacts, Adaptation and Mitigation 2. The average surface air temperature across China increased 0. The upper end of this range is higher than the global average during the same period PRC, a. Moreover, there is evidence that this process is accelerating; most of the temperature increase took place over the past 50 years. There is also a regional dimension, which shows that the warming trend was more significant in areas north of the Yangtze River. The seasonal distribution of the temperature changes shows that the most significant temperature increases occurred in winter; warmer than average winters were observed 20 consecutive years nationwide between and Ren, There are also signs that rainfall patterns are changing. Although in the past years there have been no statistically significant shifts in the trend of annual precipitation across China, there are considerable variations among regions. At the same time, however, precipitation significantly increased in southern and southwestern China. In contrast, national average rainfall across all of China decreased 2. Droughts in northern and northeastern China have become more severe, and flooding in the middle and lower reaches of the Yangtze River and southeastern China has intensified PRC, Although the average annual precipitation in most years since has been higher than normal, the pattern has been dipolarâ€"heavier rains in the South and more severe droughts in the Northâ€"which seems to correspond to the more frequent weatherrelated disasters Ren, The China has intensified. It is estimated that by , the annual temperature will likely increase 1. Precipitation in China is also expected to

change, and scientists predict an overall increase of rainfall nationwide in the coming years Ren, Specifically, rainfall across China is expected to increase 2 to 3 percent by and 5 to 7 percent by With rainfall, as with temperature, there are regional disparities and concerns about more frequent extreme weather events. It is probable that the arid area in western China will become larger, and the risk of desertification would subsequently increase Ren, ; Zhang and Wang, An Overview of Impacts, Adaptation and Mitigation 3. Within the agricultural sector, significant structural changes have taken place. In the meantime, the more labor-intensive and less land-intensive horticulture, livestock and fishery sub-sectors have expanded rapidly. While agricultural production was growing rapidly, agricultural trade grew even faster. Agricultural trade both imports and exports nearly tripled from to Huang and Yang, During this time, exports rose more quickly than imports. Since the early s, China has been a net food exporter. In general, net exports of land-intensive bulk commodi4 ties such as grains, oilseeds and sugar crops have fallen or imports have risen. At the same time, exports ICTSD - IPC of high-value, more labor-intensive goods such as horticultural and animal including aquaculture products have risen. Grain exports, which comprised nearly one third of In general, net exports food exports in the of land-intensive bulk mids, fell to commodities such as less than 10 percent grains, oilseeds and sugar of those levels during crops have fallen. Since the the next decade. Since late s, horticultural, the late s, hortianimal and aquatic prod- cultural, animal and ucts have accounted for aquatic products have about 70 to 80 percent of accounted for about food exports. Although grain exports have been decreasing in their relative share of total Chinese food exports, China remains self-sufficient in rice, wheat and maize. As Annex Table 1 indicates, China was a net exporter of rice and maize in percent self sufficiency in rice means production was one percent higher than demand , and wheat production was able to fully meet domestic demand. In the north- gated, and because of the east and northwest common practice of multiareas of the country, cropping on this land, 54 only one crop a year percent of all sown area is is normally planted. However in regions along the middle and lower reaches of the Yangtze River and South China, planting three crops a year is possible. Farmers use various cropping systems based on local weather and resource conditions: Irrigation is one of the major factors contributing to high productivity of farmland. The share of irrigated land varies significantly across regions due to diverse environmental conditions, ranging from more than 70 percent in the East to only about 20 per cent in the Northeast. Water shortages, particularly in the North China Plain and the northwest part of the country, have become more acute over the last two decades. With intensified farm and non-farm uses of water, the water table has declined rapidly in northern China, and many rivers stop flowing during the dry season Wang et al, b. Due to differences in climate and physical features, the particular crops under cultivation can vary widely across regions in China. An Overview of Impacts, Adaptation and Mitigation crop produced and is grown in southern and central China. Other major crops in this region include oilseeds, vegetables and sugarcane. North and northeastern China are the main production areas for wheat, maize, soybeans and cotton.

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Alan de Brauw, Jikun Huang and Scott Rozelle source of, and returns to, incentive reforms (studied in the past by, for examÂ- ple, McMillan et al., ; Lin,) and market liberalization initiatives (our.

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