Goldman Sachs

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CHINA AGRICULTURE

Addressing China food security — revolution of tradition

As food supply faces increasing challenges due to cyclical and disruptive factors, and structurally heightened risks from climate change, we view agriculture efficiency as an essential part of the long-term solution for food security. And for China, much can be done in revolutionizing the efficiency as smarter agriculture thrives and changes how grains and animal proteins are produced, for a more self-sufficient and resilient outlook. We map growth opportunities in modern seed breeding, animal health management, advanced feed additives, and precision farming practices that could ultimately drive the reduction of China's import reliance of major agriculture products by more than 80% from the potentially 90mn hectares in arable land equivalent.

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As food supply faces increasing challenges due to cyclical and disruptive factors, and structurally heightened risks from climate change, we view agriculture efficiency as an essential part of the long-term solution for food security. And for China, much can be done in revolutionizing the efficiency as smarter agriculture thrives and changes how grains and animal proteins are produced, for a more self-sufficient and resilient outlook.

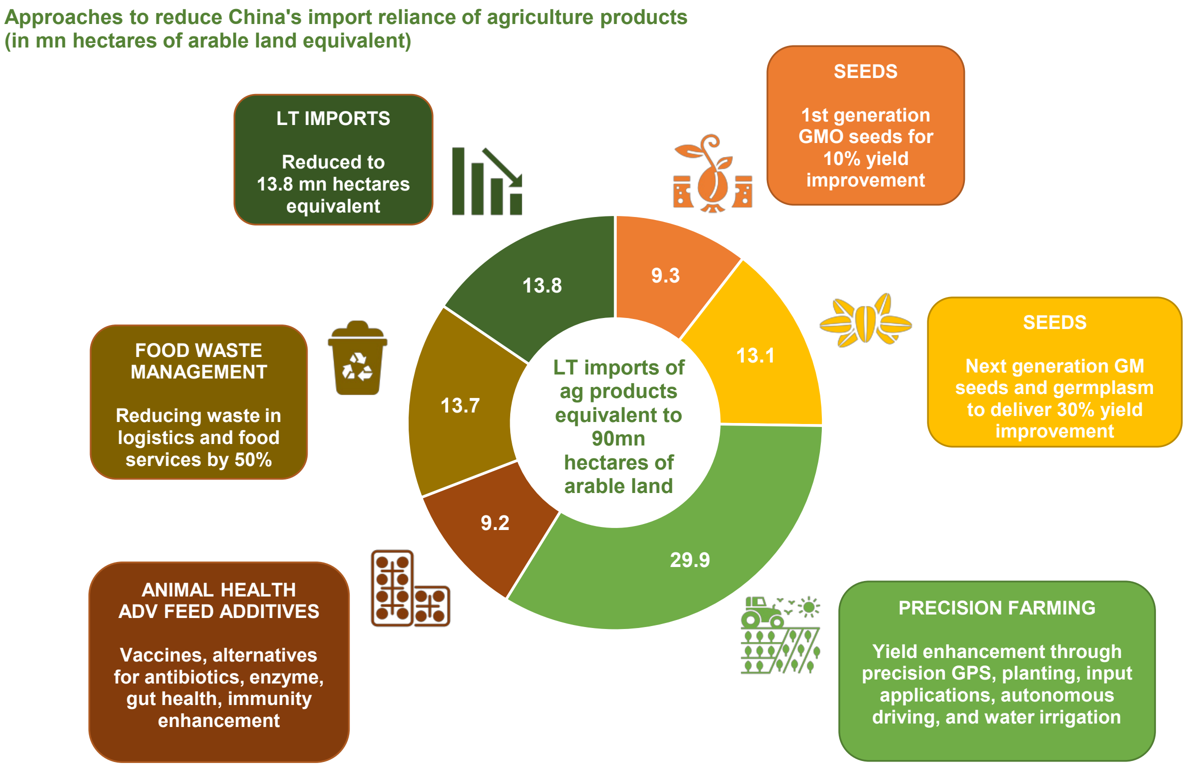
With 9% of the global arable land and 18% of the global population, China has managed to feed a population of 1.4bn mostly on domestic agriculture production.Yet, the intrinsic challenges on food security persist – China's import of major agriculture products, including grains and animal proteins, has been structurally moving up in the past 30 years. Translating the imports in terms of arable land equivalent, we estimate it has reached 71mn ha today, equivalent to nearly 68% of China's total arable land – a number that has been moving up by nearly 30% every 10 years since 2000, and could reach nearly 90mn ha or 90% in the next 10 years, by our estimates, as growing demand meets inelastic supply in this most traditional sector.

The long-term challenges for China agriculture supply are limitation of land and low efficiency. Arable land has been most stagnant in the past three decades, mostly in line with global trends.Yet, corn output per hectare in China is 40% less than in the US, and it takes 6%-26% more grains to produce 1 kg of pork or chicken. Grain production cost in China was in line with the US and Brazil in 2007, but is now twice as high, as a result of low yield, high use of pesticides and herbicides, the shrinking rural work force, and rising land costs. Climate change has also had a profound impact on agriculture resources in China. According to China's Ministry of Agriculture (MOA), the nation's average precipitation has been rising each year, with a northward shift of the rainfall belt, impacting winter wheat planting and leading to more unpredictable extreme weather. In addition, we estimate nearly 18% of the arable land has been affected by pests each year, and 12% by extreme weather.

However, we see China making a structural shift away from the traditional input-intensive approaches, ultimately reducing its import reliance, as adoption of modern seed breeding, animal health management, advanced feed additives, and precision farming practices rise. Specifically, we estimate improvement in seeds performance could lead to more grain output equivalent to 22.4mn ha of arable land in the coming years, while precision farming would further enhance the yield potential in the longer run, leading to 29.9mn ha equivalent of higher output. At the same time, animal health product penetration and advanced feed additives would not only drive safer food and higher supply sustainability, but also save grain consumption by an equivalent of 7mn ha of land. Combined with other factors such as improved food waste management, we estimate the potential efficiency gain would reduce China's LT food imports by over 80% to as low as 14mn ha, reversing the trend of the past three decades. Both government policies and advanced bio-technology and tools will facilitate and expedite the changes, in our view.

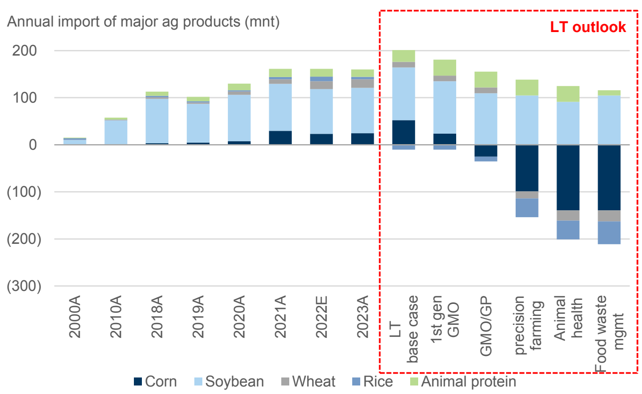
We note this report does not include details about addressing demand side shifts in food basket as incomes grow, but the analysis can be found in an earlier report – Feeding China's changing appetite. It also doesn't seek to address risks/the sudden impact of a change in government policy beyond the current trend. Lastly, while we discuss the critical role of precision farming development in China, our report doesn't seek to address investment opportunities in precision farming given the early stage of development, although we acknowledge the technology upgrade in China's machinery industry as one of the key drivers.

Exhibit 1: The road to ultimate food security – potential efficiency approaches to boost China's food supply self-sufficiency



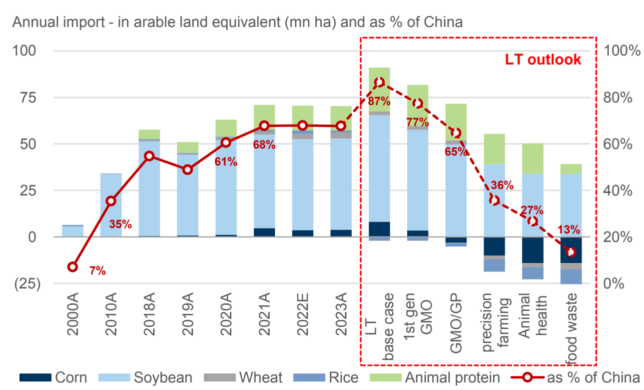
Source: Goldman Sachs Global Investment Research

Exhibit 2: China import of major agriculture products per annum = 2000-2023E, and LT outlook and scenarios



Source: NBS, MOA, FAO, USDA, Goldman Sachs Global Investment Research

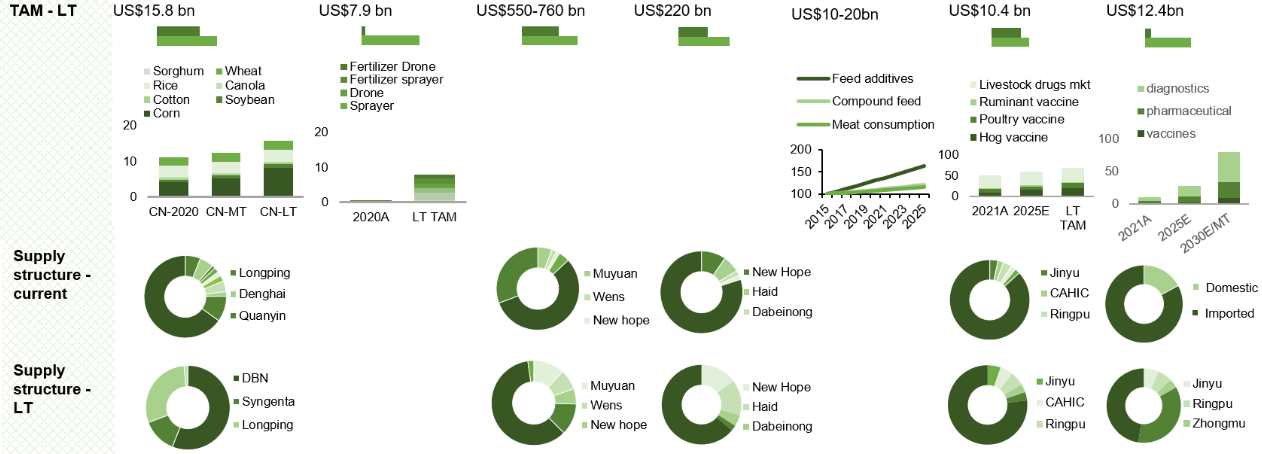
Exhibit 3: China import of major agriculture products in arable land equivelent = 2000-2023E, and LT outlook and scenarios



Source: NBS, MOA, FAO, USDA, Goldman Sachs Global Investment Research

Agriculture ecosystem

	SEEDS	PRECISION FARMING	LIVESTOCK FARMING	FEED	FEED ADDITIVES	LIVESTOCK HEALTH	PET HEALTH
Role in ag	The core of the agriculture sector. High quality seeds with optimized germplasm and traits deliver higher intrinsic yield and cost savings, and adapt to consumer food tastes and nutrition requirements.	Working with germplasm and biotech traits, precision farming drives the next phase of yield gains in agriculture food supply, reduces input, and contributes to climate change	Animal protein production	Animal protein production	Advanced feed additives address animal nutrition, improve feed efficiency for the production of animal protein, improve food safety, and contribute to carbon emission reduction,	Vaccination remains central in preventing and controlling infectious diseases in livestock.	The rise of pet ownership and higher adoption of basic healthcare services provide untapped growth opportunities.
Productivity enhancer	First-generation GM seeds in China could potentially bring a 10% improvement in yields for corn and 5% for soybean, a significant reduction in herbicides and pesticides costs, including weed management, and lower mycotoxin in the grain produced.	The early stage practices help Chinese farmers to reduce input costs, and increase crop yield. The upgrading of irrigation technologies reduces water consumption by 1/3.	Refining breeding system	Refining feed for farming stages	Advanced products include enzymes, probiotics/prebiotics, and other specialty products, replacing antibiotics, boosting feed efficiency, and reducing methane emission from livestock, and many others.	More effective vaccines and a higher penetration rate for major livestock diseases, leveraging advanced vaccine technologies.	Basic care products in China with rising brand recognition.
TAM and growth							
TAM-2020/2021A	US$11.2 bn	US$0.5 bn	US$500-700 bn	US$190 bn		US$8.0 bn	US$1.7 bn
TAM - LT	US$15.8 bn	US$7.9 bn	US$550-760 bn	US$220 bn	US$10-20bn	US$10.4 bn	US$12.4bn



Most attractive opportunities

	SEEDS	PRECISION FARMING	LIVESTOCK FARMING	FEED	FEED ADDITIVES	LIVESTOCK HEALTH	PET HEALTH
	Seeds prices to increase by 30-40% in the MT, Trait owners to benefit the most.		Top players as market consolidators	Top players as market consolidators	Advanced feed additives	FMD vaccine for the private market, ASF vaccines, vaccines for PRRS and PED	Pet vaccines to gain the highest growth at a 29% CAGR in the coming years

Source: MOA, NBS, Bloomberg, Company data, Goldman Sachs Global Investment Research

Seeds – maximizing yield potential

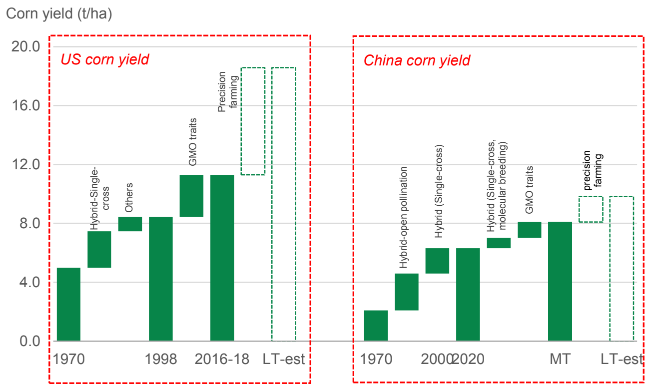
Seeds are the core of agriculture, and provide key supports to China's long-term food security. While bio-tech seeds are not the only driver for crop performance, the potential introduction of 1st generation bio-tech seeds in China will trigger a rapid industry restructure, and through higher seed prices, paving the way to incentivize and accelerate the development of better seeds that maximize crop yield potential and output in the long run.

We expect the first generation of GM seeds in China (most insect resistant and herbicide tolerant) to potentially bring an average improvement of 10% in yield for corn and 5% for soybean, significant reduction in both herbicide and pesticide costs including weed management, as well as lower mycotoxin in the grain produced. In the longer term, we estimate seeds can bring a potential 30%-60% improvement in Chinese corn yield from the current level, as bio-tech traits, germplasm, and precision farming work together to revolutionize the efficiency in grain production in China.

We also see the biotech development in seeds to accelerate the consolidation for the China seed industry and bring about stronger pricing power along the way. The prevailing trait advantage and economic benefit carried through seeds should enable rapid market share gains by top seed performers, and accelerate the elimination of the long tail end of the much fragmented industry supply. Nevertheless, we think the consolidation will be a lot more remarkable among the traits suppliers, while competition among the germplasm owners is likely to be more intense.

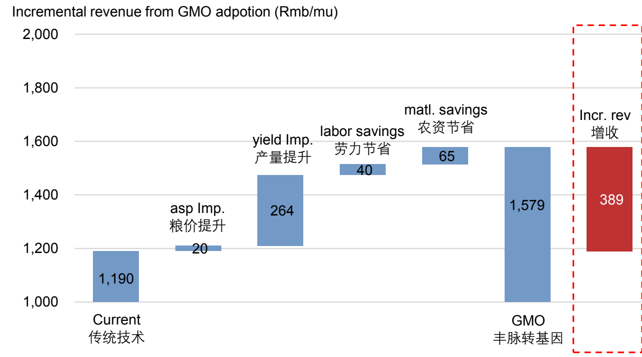
With the economic values created from seeds to farms and improved industry supply outlook, we expect 1st generation GM seeds to lead to 30%-40% of seed value appreciation, and potentially ~40%-80% in the long run, which would translate to attractive seed revenue growth for key beneficiaries including top bio-trait owners, and consolidating germplasm companies.

Exhibit 5: Corn yield change – US vs. China



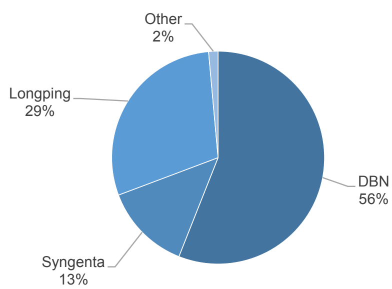
Source: USDA, FAO, MOA, Goldman Sachs Global Investment Research

Exhibit 6: Seed economics – DBN3601T for tropical corn in Southwest China



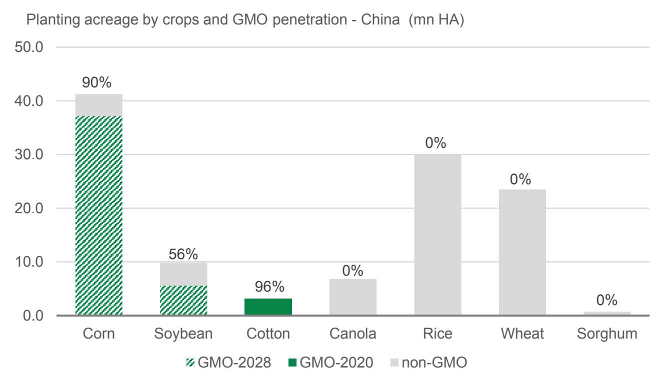
Source: Company data, data compiled by Goldman Sachs Global Investment Research

Exhibit 7: Market shares of corn GM traits – mid term, estimated based on weighted average of traits and regional approvals as of 1H22



Source: MOA, Company data, Goldman Sachs Global Investment Research

Exhibit 8: Planting area by crops and potential GM penetration – China



Source: MOA, Goldman Sachs Global Investment Research

Animal health - healthier and safer future

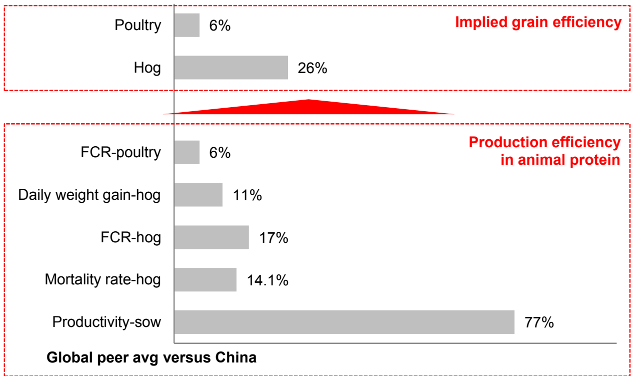
Animal health is about more efficient and safer production of animal protein.

China produced 225mnt of animal protein in 2021A, yet with 6%-26% lower grain efficiency in feed conversion, based on a simple comparison of Chinese hog and poultry production efficiency versus other countries. Should China produce major livestocks at the same efficiency as other countries, we estimate domestic grain consumption would decline by over 60mnt, all else equal, equivalent to 5%-12% of domestic grain demand.

This gap is driven by the health of livestocks, which needs to be addressed more in China given the higher farming intensity, and more frequent disease outbreaks in recent years. Globally, the focus to improve animal health is increasing on new vaccination strategies, improving animal nutrition, and refining the breeding system.

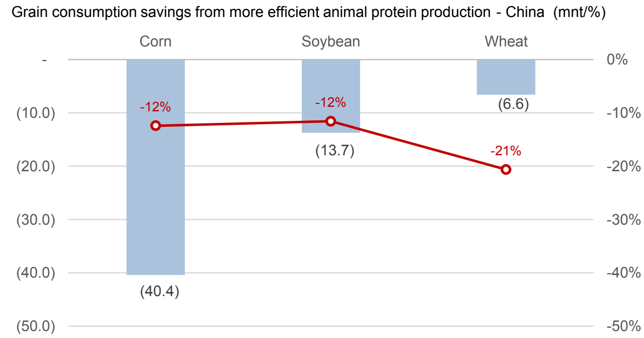
Specifically, vaccination remains central in preventing and controlling infectious diseases in livestocks. It also contributes in reduction of use of antibiotics in livestock farming, a key global trend to counter the risk of food safety and security. We see strong growth opportunities in livestock vaccines especially FMD and ASF with improved subunit and potential mRNA technology, as well as rising industry penetration on the farming side.

Exhibit 9: Efficiency gap of China vs. average global peers in animal protein production would translate into a 6%-26% improvement in grain consumption



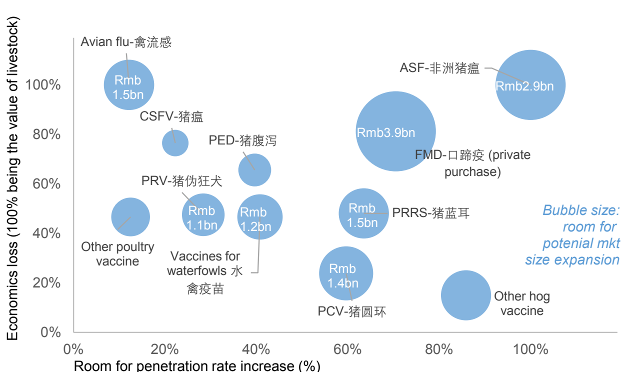
Source: AHDB, Wageningen Economic Research, Goldman Sachs Global Investment Research

Exhibit 10: Translation of higher efficiency in animal protein production into China grain demand (assuming 26% efficiency gain in hog and 6% in poultry)



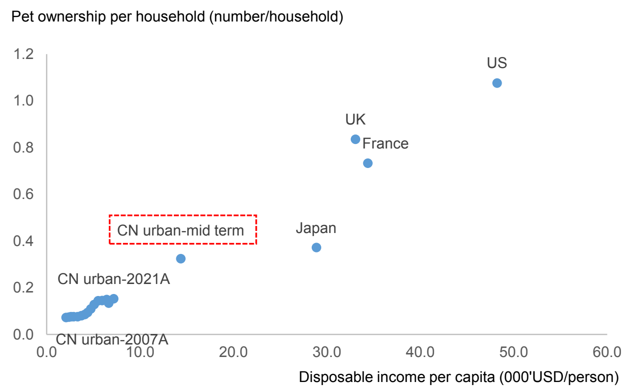
Source: MOA, China Feed Industry Association, Goldman Sachs Global Investment Research

Exhibit 11: Livestock vaccines – China: Economic losses, penetration, and room for future market expansions



Source: China Veterinary Drug Association, Company data, Goldman Sachs Global Investment Research

Exhibit 12: Pet ownership per capita – China urban versus peers



Source: OECD, American Veterinary Medical Association, Animal Health Europe, China Pet Industry White Paper, Goldman Sachs Global Investment Research

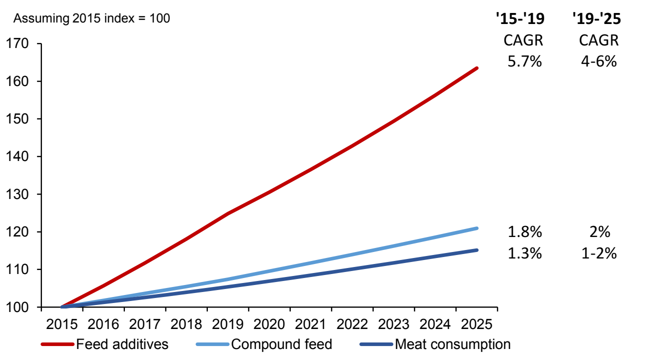
Advanced feed additives - green efficiency

We are optimistic on advanced feed products, from special enzymes to probiotics/prebiotics replacing antibiotics and improving grain efficiency, to additives that reduce methane emission from livestocks. Feed additives are no longer just about the essential products (vitamins, minerals and amino-acids). There is so much science and innovations that are going into more advanced animal nutrition products, bringing more efficient feed utilization for production of animal protein, higher food safety, and carbon emission reduction.

We expect a stronger growth outlook in feed additive demand globally and more for China, versus the growth of animal protein production and feed demand. DSM estimates the global feed additives market to grow at 4%-5% CAGR from 2019-2025E, driven by increasing inclusion rates and innovation in compound feed. We estimate the aggregated revenue in animal nutrition from key producers has been growing at an average of 5% in the past three years, and should persist at 5%-10% in the coming years.

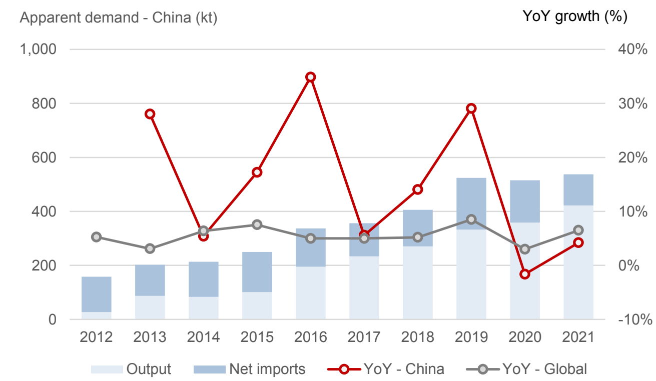
Advanced feed additives are relatively new in China, thus possess higher potential due to a lower penetration rate. This can be reflected in the stronger growth rate in methionine (a key feed additive) in recent years in China versus global. The ongoing increase in large commercial farming should also be an additional driver for growth.

Exhibit 13: Global feed additive demand should grow at 4%-6% in the coming years



Source: DSM

Exhibit 14: Apparent demand of methionine – China and global

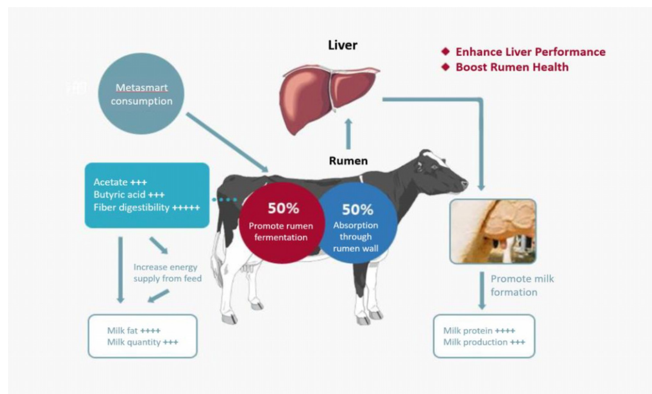


Source: GAC, Company data, Goldman Sachs Global Investment Research

Exhibit 15: DSM's Bovaer – specialized to surpress the enzyme in cattle for methane formation, leading to a 30% reduction in methane emission

Source: DSM

Exhibit 16: Metasmart from Adisseo: Designed for ruminants to be absorbed in remen directly, promoting rumen fermentation and milk production and quality improvement



Source: Adisseo

Precision farming – the next phase of yield gain

Early stages of precision farming have started to take place in China in recent years, mostly enabled by agriculture drones, autonomous driving technology and basic VRT (variable rate technology). According to China Air Transport Association (中国航空运输协会通航分会), agriculture drone sprayer working units have more than doubled each year since 2014, and reached 100k as of 2020A by estimate. Sales of autonomous steering on agriculture machinery have also reached 17,000 units in 2021, versus 5000 in 2019, according to MOA.

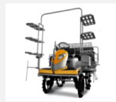
Based on the case study of FJ Dynamics, the latest precision farming equipment could help farmers to reduce the cost of inputs (chemical, fertilizer and seed), as well as increase crop yield. Specifically, the cases have seen 2%-25% savings in labor cost, 5%-20% savings in input cost, and 3%-15% in yield enhancement.

We expect the market penetration to continue growing in the coming years, given the improving economics and strong demand generated by labor shortages in rural China. Based on the current existing technology upgrade on the industry agriculture fleet, we estimate the annual market size of early stage precision farming in China could reach US$2.4bn by 2025E, or 2% of the current market size of agriculture machinery, and potentially US$7.8bn longer run.

In addition, water irrigation, an important part of precision farming, has also started its early stage upgrade in China, to address the water stress in selected regions. As of 2019, China's national average water stress level was 18%, yet can reach as high as 40%-60% in central north and northeast regions (globally, water-stress level is defined as water withdraw/total water resources, and a ratio above 20% is usually considered mid-high level of stress). Upgrading of irrigation technologies, to micro and tunnel irrigation, could reduce water consumption by 32%-36% at this stage. As of 2020, advanced irrigated land through spray, micro and tunnel irrigation reached 350mn mu, (equivalent to 23.3mn ha), or ~ 20% of total arable land, according to Ministry of Water Resource. Based on State Council's high standard farmland construction plan published in 2021, an additional 110mn mu, or 7.3mn ha of advanced irrigated land would be built nationwide by 2030.

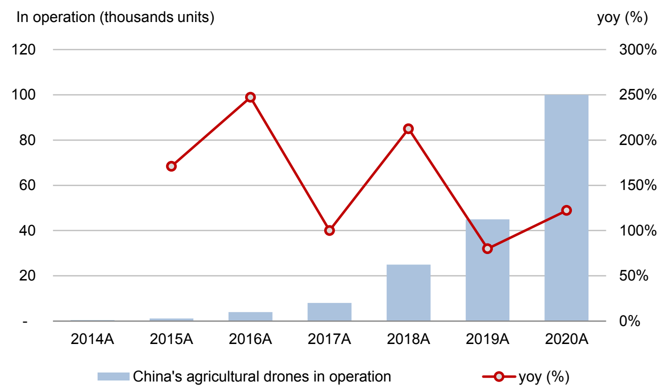
In the long run, precision farming practices will become more sophisticated in terms of more precised crop management, driven by field database collection such as mapped soil condition, weed identification, combined with algorithm/software, and integration with mechanical systems including the VRT technology. Working with ongoing improvement in seeds, better farming practices would provide the next stage of yield gain - in the US, advanced precision farming practices have created a potential market of US$56bn, and would potentially bring additional 70% yield gain in 2016A for corn, from 165 Bushels per acre to 281 Bushels per acre (or 10.4t/ha to 17.6/ha), according to GS US Machinery team, through precision fertilizer, irrigation, planting, spraying, etc.

Exhibit 17: Case study background – rice planter

Case study - FJ dynamics Location - Jiangsu Work - rice planting	 Conventional planter	 Precision planter
Labour required:	1 machine operator + 1 planter	1 planter
Efficiency	40-50mu/day	50-60mu/day
Cost saving:	Salary for conventional machine operator is Rmb600-700/day. Precision planter saved a total of Rmb10,000, equivalent to 15 days of a conventional machine operator	
Extra output:	10% increase in output through precise planting and efficient land use. Reduce cost of agricultural materials by about 10% including diesel, seeds, pesticides and fertilizers	
Cost saving details		
total area (mu)	1.0	1.0
mu/day per worker	25.0	60.0
number of worker	2.0	1.0
days	0.020	0.017
salary (Rmb/day)	700.0	700.0
Labor cost/mu	28.0	11.7

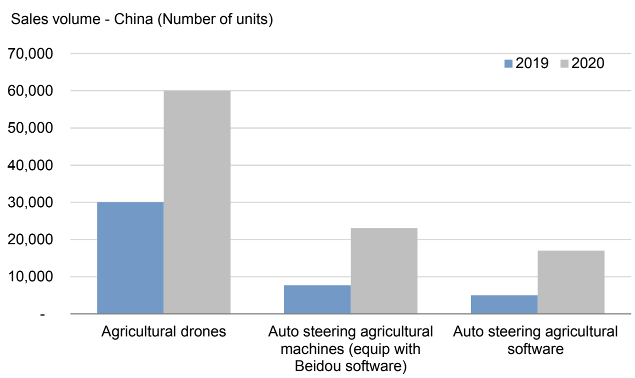
Source: FJ Dynamics

Exhibit 18: China's agricultural drones in operation



Source: China Air Transport Association

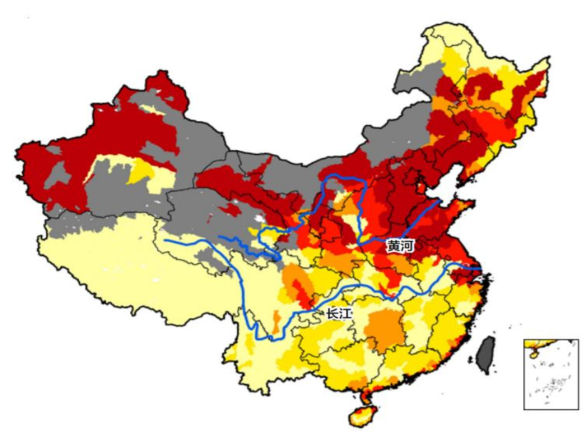
Exhibit 19: China's precision farming products sales volume – 2019 vs. 2020



Source: MOA, Goldman Sachs Global Investment Research

Exhibit 20: China water stress level – 2010

Red = high stress; yellow: low stress; grey: data not available



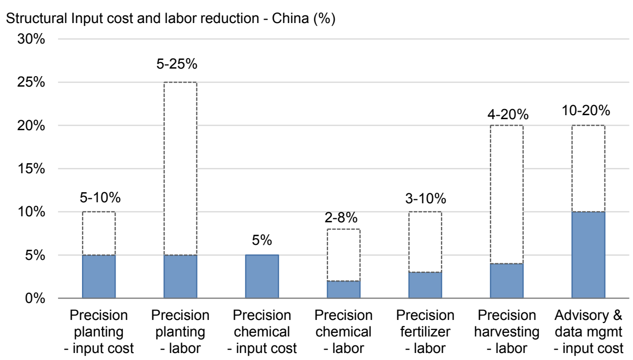
Source: Water Resources Institute

Specifically in North America where precision farming is in a more advanced stage, GS Machinery, Infra, Sustainable Tech team led by Jerry Revich highlights the precision ag focus is centered around creating a US$56 bn TAM centered on:

- Yield improvement. Precision planting solutions by Deere and AGCO deliver up to 5%-10% yield improvement. Self-correcting combine harvesters improve yield collection in the low single digits.
- Reducing the use of herbicides and pesticides. Deere's See & Spray product reduces the use of herbicide by 60%-80%, carries multiple different chemicals which reduce the cost of additional farming passes (labor & fuel), and has the potential to leverage the technology for other applications.
- Reducing the use of fertilizers. Deere has rolled out a product for applying nitrogen during planting, thereby reducing nitrogen run off and applying customized dosing to each part of the field.
- Reducing labor costs. At its analyst day, Deere outlined the path to a fully

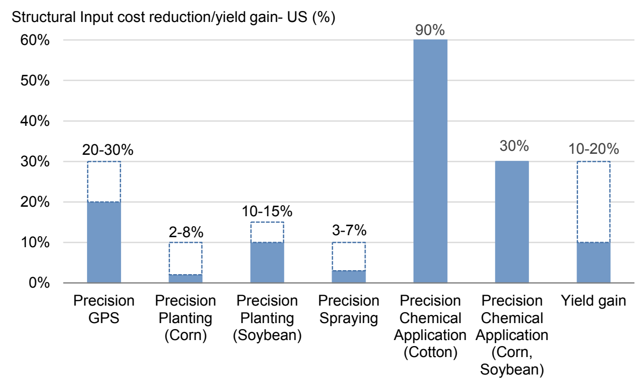
autonomous farm by 2030. As outlined in our autonomous tillage note, we estimate eliminating labor costs in tillage operations could yield US$7.50 per acre in cost reductions and US$2.50 per acre in revenue for precision ag suppliers.

Exhibit 21: Structural input cost reduction attributable to China's precision ag technologies



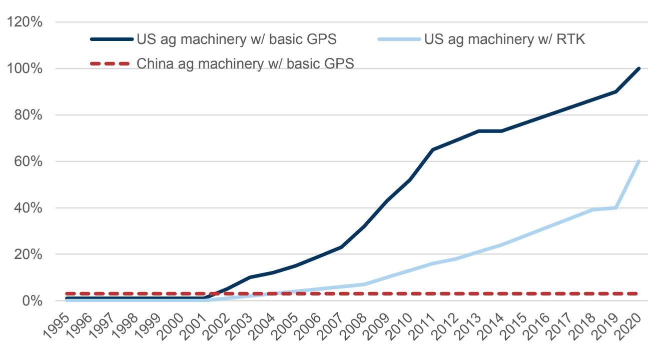
Source: Company data, MOA, WIND, NBS, Goldman Sachs Global Investment Research

Exhibit 22: Structural input cost reduction attributable to Deere's primary precision ag technologies



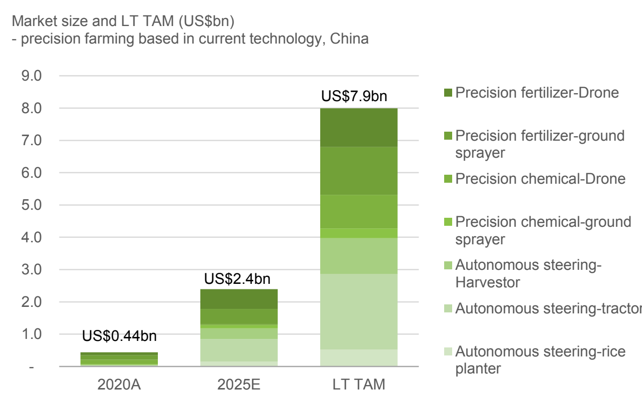
Source: Company data, Goldman Sachs Global Investment Research

Exhibit 23: Agricultural machinery with RTK and GPS systems – China vs. US



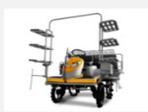
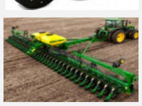
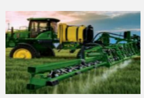
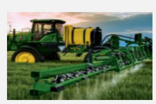
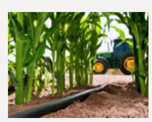
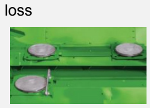
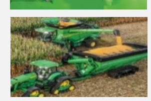
Source: Company data, Goldman Sachs Global Investment Research

Exhibit 24: Precision farming market size – China



Source: Company data, MOA, WIND, NBS, Goldman Sachs Global Investment Research

Exhibit 25: Ecosystem – conventional, early and advanced stages of precision farming – China and US

Planting stages	Planting 插秧	Plant protection 植保 - 农药	Fertilizer 施肥	Irrigation 灌溉	Harvesting 收获	Advisory & data mgmt 咨询和数据管理
Machineries employed	Rice planter, tractor 水稻插秧机, 拖拉机	Airplane, drone, tractor & sprayer 飞机、无人机、拖拉机和喷雾机	Tractor, sprayer & nozzles 拖拉机,喷雾机 和喷嘴	Hose & valve 软管和阀门	Combined harvester 联合收割机	Satellite, sensors, AI, and software 卫星、传感器和人工智能
China - Conventional farming						
Current	Traditional planter used for wetland; tractor + planter used for dryland 	Manual, still predominant; Some manned vehicle available but limited usage 	Manual or simple manned vehicle still predominant 	Mostly build as government infrastructure	Manned harvester 	n.a.
Key CN players	Zoomlion, Lovol Dongfeng, First tractor	Zoomlion	Mostly SMEs		Zoomlion, Lovol	
China - Precision farming						
Emerging precision farming	Autonomous planter & autonomous upgrade  	Autonomous ground-based sprayer; Drone  	Autonomous ground-based sprayer, drone  	Mostly build as government infrastructure	Auto-steering upgrade; Autonomous harvester  	AI platform using satellite & weather data etc. 
Realized function	Full autonomous driving or assisted driving for inexperienced drivers	Autonomous chemical spraying	Autonomous fertilizer application for early stage of planting	n.a.	Autonomous harvesting	Advise farmers according to climate data
Price per unit Yield enhancement Cost/inputs reduction	Rmb15k-30k 5-10% 5-10% in seed 5-25% in labor	Rmb20k-80k per unit 5% chemical 2-8% labor	Rmb40k per unit 3-10% labor 5-10% fertilizer		Rmb15k-30k per unit 4-20% labor	Rmb2k per year 5-15% 10-20% fertilizer
Key technologies GNSS: Sensors: Mechanical: Software integration:	 Basic Beidou	 RTK	 RTK Basic VRT		 Basic Beidou	 Fundamental Beidou Data analytics
Key CN players	FJ Dynamics XAG Baidu Apollo	FJ Dynamics XAG	XAG			iCanAg GaGo Group XAG
US - Precision farming	Deere ExactEmerge	Blue River (See & Spray)	Deere ExactApply	Subsurface Drip	Deere ActiveYield	Deere FieldConnect & Monsanto Climate Corp
Realized function	Prevent overlap and tramping. Plant with higher intensity in more fertile area.  	Specifically target and eliminate weeds, while protecting crop damage.  	Improve spraying consistency and minimize drift.  	2/3 less water as overhead irrigation; Improve crop yield. 	Record yield for each piece of land; Operation adjustment to working conditions and minimize loss  	Advise farmers according to weather, solid and field data. 
Price per unit Yield enhancement Cost reduction	US$29k/RTK, US$150/planter 5%+ 2-8% in corn 10-15% in soybean	 90% in cotton 30% in corn&soybean	US$50/unit 3-7%	US$1.2-1.5k/acre ~20% 2/3 water	US$9.8k + US$3.25k 5%+	US$399 + US$149/yr
Key technologies GNSS: Sensors: Mechanical: Software integration:	 RTK Soil sensors VRT Yield mapping	 RTK Soil/Weed sensors VRT Field monitoring	 RTK VRT (intelligent nozzle) Field monitoring	 Moisture sensors VRT Field monitoring	 RTK Yield/flow sensors Yield mapping	 RTK Various field sensors Data analytics
Global aggregators: Global enablers:	Deere, CNHI, Kubota, AGCO Deere, Trimble, Raven, Hexagon	Deere, CNHI, Kubota, AGCO Deere, Trimble, Equipment Tech, Hexagon	Deere, CNHI, Kubota, AGCO Deere, Hexagon, Monsanto	 Deere, Netafim, Toro	Deere, CNHI, Kubota, AGCO Deere	Deere CropX, Monsanto, Deere

Source: MOA, Wind, Bloomberg, Company data, data compiled by Goldman Sachs Global Investment Research

Precision farming technology

According to the USDA report in 2016, there were four major categories of precision farming functions being adopted between 1996 and 2013, namely yield mapping, solid mapping, guidance navigation and variable-rate input. Behind these functions, there were various technology enablers.

Global navigation satellite systems (GNSS): The heart of precision farming, it provides the latitude and longitude of a machine operating in a field. The satellite navigation system, such as GPS, Beidou, includes a constellation of multiple satellites orbiting the earth and broadcasting radio signals, and a receiver installed on the machine on the ground.

- *RTK (Real Time Kinematic, <2 centimeters accuracy)*: The RTK system consists of a local base station set up nearby the field of operation (within 10 km), together with a receiver on the vehicle. The base station monitors the constellation of satellites and continuously calculates a position, and the receiver sets highly accurate positions to about 2 cm. John Deere launched its RTK system in 2016.
- *China's Beidou based system (from meters to centimeters)*: In 2018, China Beidou started to offer more enhanced services with multiple levels of accuracy in ranges of meter, decimeter, and centimeter.

Sensor technologies: Used for planting decision and yield recording

- *Field data collection and planting decision-making*: Field information such as soil moisture, compaction, fertility, as well as crop conditions such as leaf temperature, plant water status insect-disease-weed infestation etc. Such data could be used to advise irrigation and spraying etc.
- *Yield mapping in harvesting*: A yield mapping system measures and records the amount of grain harvested using a yield monitor sensor on the harvester. Inputs can be adjusted to maximize the productivity.

Mechanical systems:

- *Variable rate technologies (VRT)*: VRT refers to mechanical systems that can apply various types of substances such as fertilizers, pesticides, seeds and waters on to planted crops. It consists of a controller of material flow, a position system, and a map of desired intensity of substance.
- *Continuous Variable Transmission (CVT) for tractors*: It consists of a computer-based intelligent control system that can automatically adjust engines according to working conditions as well as the functioning of Power Take off (PTO) units in the power trains. Deere's IVT system allows the engine to communicate 100 times a second with the transmission, and provides a seamless range of speeds between 0.03 mph (50 meter/hr) to 26 mph (40 km/hr) with no gaps and no clutching, enabling a more accurate plowing of uniform depth.

Software & information systems:

- *Autonomous-steering/Autonomous-pilot:* Besides saving labor cost, high accuracy auto-steering could also help improve efficiency e.g. more uniform planting patterns that maximize land utilization, avoiding overlapping of input usage, avoid ramping over crops thereby supporting crop yield.
- *Decision Support Systems (DSS)*: Using a big data system that examines weather, soil, and plant conditions and provides customized advice to farmers on optimal reactions.

Policy focuses - grain self-sufficiency, seeds and IP

The self-sufficiency of staple food and food security have been policy priorities for many years, and increasingly in focus since 2020. We highlight key recent policies of the Chinese government that addressed the definition of food security, seeds, grain imports, as well as food waste management – paving the way to improving output and self-sufficiency of China agriculture food supply.

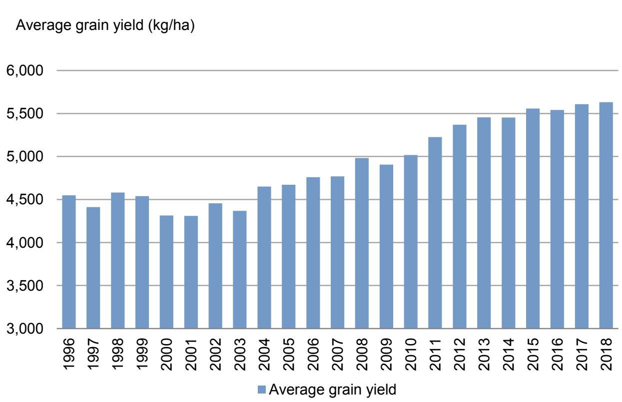
Key policies related to food security

The food security white paper (中国的粮食安全白皮书) published by the State Council in 2019, defined China food security in view of policies, in five major benchmarks:

1) Grain output - arable land, output, and yield. The policy stated that China's household food output was 470kg per capita in 2019, up 14% compared to its level in 1996, and above the global average during the same period. Average grain yield per hectare improved 25% over the period, and was higher or on par with global average. Nevertheless, the policy continues to promote further enhancement in grain output. Specifically, on arable land, the policy requires strict protection of arable land, higher mix of high-standard farmland, grain-specialized functional region, and improvement on efficiency of water utilization through advanced irrigation and water saving projects.

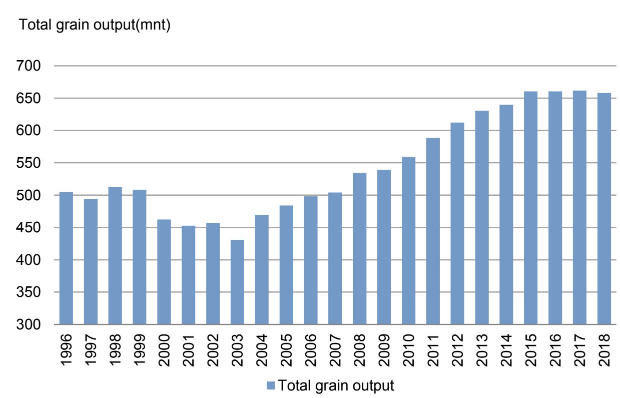
2) Grain self-sufficiency: China managed to maintain a self-sufficiency ratio of over 95% for major grains as of 2019, while maintaining its absolute self-sufficiency of staple grains (wheat and rice).

Exhibit 26: Average grain yield – China 1996-2018



Source: China State Council, NBS

Exhibit 27: Annual total grain output – China 1996-2018



Source: China State Council, NBS

Other key factors monitored are reserves and logistics (including the 670mnt of reserve storage capacity) and food for poverty – generally consistent with the UN's definition of food security.

The most important change is the recent seed industry revitalization plan ("种业振兴行动方案"). First promoted by President Xi in 2021, China's seed industry vitalization plan sets forth to urge efforts on achieving self-reliance within the sector through independent and controllable germplasm resources. Within the plan, the government highlighted the importance of local germplasm resources, aiming to consolidate the market by supporting 52 seed production counties and 100 regional breeding bases in selection with funding cap risen from Rmb1bn to Rmb2bn. In addition, the policy also stepped up its effort on IP protection through revised Seeds Law ("种子法"), introducing the concept of "essentially derived variety" (EDVs) to distinguish those originally developed varieties from derived ones. Under the stringent IP enforcement framework, infringement on plant variety would be punished by the strictest practice, according to the action plan.

China has long established a tariff-rate quota scheme for its corn, wheat and rice imports based on Interim Measures of Import Tariff Quotas of Agricultural Products ("农产品进口关税配额管理暂行办法") since 2003, aiming to protect its domestic grain industry. For 2022, China sets the quota at 9.4mnt of wheat, 7.2mnt of corn, and 5.3mnt of rice to be imported at 1% tariff, while any imports in excess of the quota would be applied at a 65% tariff instead.

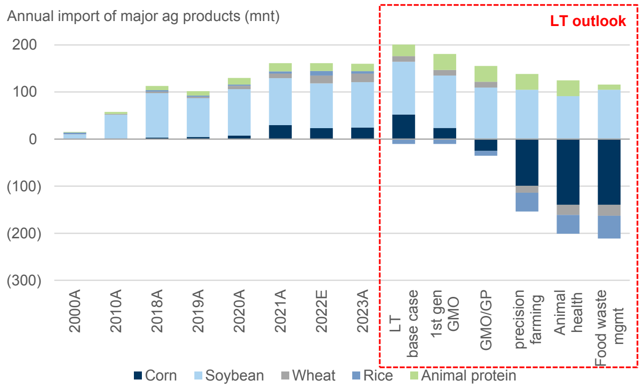
In terms of food waste management, China initiated the effort in 2013, with the Clean Plate Campaign (粮食节约行动方案/光盘行动). A comprehensive action plan was later introduced by the State Council in 2021, focusing on reducing food waste along the food supply chain, from grain production, storage, transportation, processing, to retail and wholesale consumption, including fines imposed on excessive waste of food. We estimate current food waste would account for 9% of meat consumption, and 13% of cereal in China.

Cyclical outlook in the near term

We expect Chinese import of corn and soy bean to remain elevated yet decelerating for the 2021/22 planting year, versus 2020/21, driven mostly by softened feed demand as lower hog feed will be partly offset by lower substitution of wheat. However, uncertainty in weather conditions and relatively lower inventory versus past years, continue to impose risks on grain balance in our view.

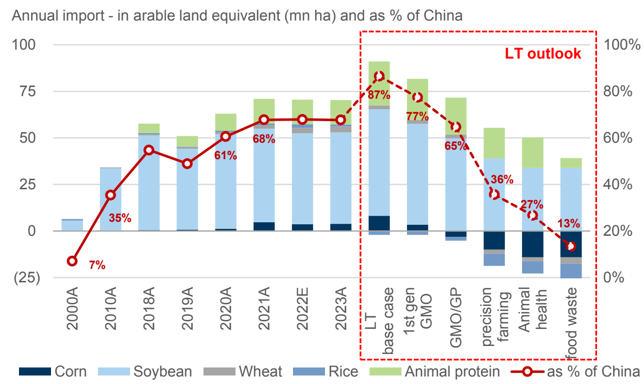
Based on forecast by China Agriculture Outlook Committee (CAOC) MOA, corn and soybean imports are expected to reach 20mnt and 93mnt in 2021/22 respectively, versus 30mnt and 113mnt a year ago. CAOC also forecasts the import would be 18mnt for corn in 2022/23, and 95 mnt for soybean. According to the July report by CAOC, the current growth condition of corn especially for the northeast region is better than a year ago, given meteorological conditions in most corn producing areas are generally better than the previous year. On soybean, uncertainties in meteorological conditions remain - the northeast region is seeing more rainfall, yet overall soybean growth conditions remain reasonable.

Exhibit 28: China import of major agriculture products per annum = 2000-2023E, and LT outlook and scenarios



Source: NBS, MOA, FAO, USDA, Goldman Sachs Global Investment Research

Exhibit 29: China import of major agriculture products in arable land equivalent = 2000-2023E, and LT outlook and scenarios



Source: NBS, MOA, FAO, USDA, Goldman Sachs Global Investment Research

Exhibit 30: Daily protein consumption pattern – China versus peers

Daily food consumption g/day/person (■ 2021 ■ LT)	China	Japan	Korea	US	Brazil	China (LT)
Animal protein						
Pigmeat	102	61	113	82	38	92
Poultry Meat	49	54	62	167	129	67
Fish, Seafood	106	133	145	59	30	123
Milk	105	206	88	746	381	171
Beef	21	25	51	105	92	33
Total grain-equivalent	671	713	981	2063	1444	844
Chgs versus 2019A (*vs 2018)	5.7%*	-0.5%	4.8%	1.2%	-5.9%	0.2%
Cereal						
Rice	209	163	172	19	80	183
Wheat	181	123	130	207	149	163

Source: FAO, NBS, Goldman Sachs Global Investment Research

Exhibit 31: Major agriculture products production and trade – global, China

		corn	soybean	wheat	pork	beef	chicken	v milk eqv
Global-2020	**mn t**	**1144**	**362**	**776**	**98**	**60**	**101**	**642**
Top producers								
United States	mn t	368	113	50	13	12	20	101
China	mn t	260	18	134	38	7	15	34
Brazil	mn t	110	133	6	4	10	14	
European Union	mn t	64	3	127	24	8	12	162
Argentina	mn t	49	50	18	1	3	2	
India	mn t	28	11	108		4	4	195
Russia	mn t	14	4	85	4	1	5	32
Global trade-2020	**mn t**	**186.0**	**168.5**	**203.3**	**10.8**	**10.4**	**12.0**	**58.8**
as % of production	**%**	**16%**	**47%**	**26%**	**11%**	**17%**	**12%**	**9%**
Top exporters								
United States	mn t	67.3	59.9	27.0	3.3	1.3	3.3	10.3
Argentina	mn t	34.0	7.0	11.5				
Brazil	mn t	39.0	85.0		1.2	2.6	3.9	
European Union	mn t			29.7	3.9		1.4	20.0
New Zealand	mn t					0.6		17.8
Australia	mn t			23.8		1.4		3.1
Ukraine	mn t	24.0		16.9				
Russia	mn t	3.1		39.1				
Paraguay	mn t		6.3					
Canada	mn t		4.2	26.4	1.5			
Chile	mn t				0.3			
India	mn t					1.1		
Thailand	mn t						0.9	
China import - 2020								
CN import demand	mnt	29.5	99.2	9.1	4.4	2.1	1.6	9.8
as % of global trade	%	16%	59%	4%	41%	20%	13%	17%

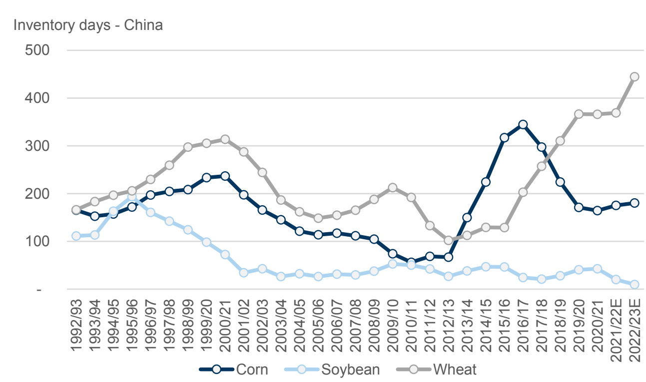
Source: FAO, Customs data, data compiled by Goldman Sachs Global Investment Research

Exhibit 32: China major grain S/D balance outlook

China corn S/D		15/16A	16/17A	17/18A	18/19A	19/20A	20/21A	21/22E	22/23E	23/24E	24/25E
Supply											
Domestic output	mnt	265	264	259	257	261	261	273	271	268	270
Import	mnt	3	2	3	5	8	30	23	31	34	37
yoy	*%*	*-42%*	*-23%*	*41%*	*30%*	*69%*	*289%*	*-22%*	*35%*	*10%*	*7%*
Total supply	mnt	268	266	263	262	268	290	296	302	303	306
Demand											
Feed	mnt	121	133	172	171	174	180	176	176	178	182
Hog feed	mnt	74	84	109	101	97	107	104	104	104	106
Other feed	mnt	47	49	63	70	77	73	71	72	74	76
Others	mnt	103	135	131	129	122	120	120	121	120	120
Total demand	mnt	224	268	303	300	296	300	296	297	298	301
Surplus/(deficit)	mnt	*44*	*(2)*	*(40)*	*(38)*	*(28)*	*(10)*	*-*	*5*	*5*	*5*
Inventory	mnt	*244*	*249*	*213*	*161*	*126*	*130*	*130*	*135*	*140*	*145*
as % of consumption	%	*109%*	*93%*	*70%*	*54%*	*43%*	*43%*	*44%*	*45%*	*47%*	*48%*
China soybean S/D											
Supply											
Domestic output	mnt	12	13	15	16	18	20	16	19	19	19
Import	mnt	83	94	94	83	99	100	95	96	97	99
yoy	*%*	*6%*	*12%*	*1%*	*-12%*	*19%*	*1%*	*-4%*	*1%*	*0%*	*2%*
Total supply	mnt	95	106	109	99	117	119	112	116	116	118
Demand											
Crushing demand	mnt	79	94	93	79	92	95	95	96	97	99
Others	mnt	14	16	16	17	18	20	19	20	19	19
Total demand	mnt	93	110	109	96	109	115	114	115	116	118
Surplus/(deficit)	mnt	*2*	*(3)*	*0*	*3*	*7*	*4*	*(2)*	*1*	*1*	*1*
Inventory	mnt	*12*	*7*	*6*	*8*	*13*	*14*	*11*	*11*	*11*	*11*

Source: FAO, USDA, MOA, Goldman Sachs Global Investment Research

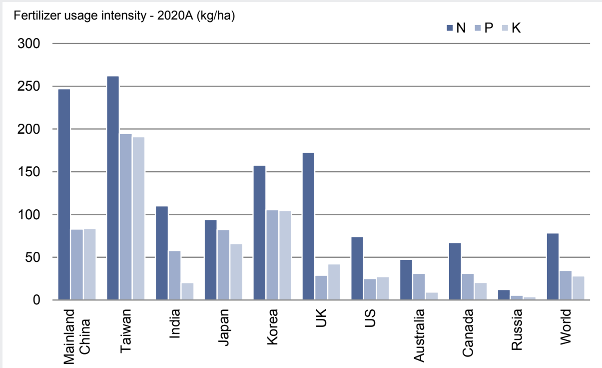
Exhibit 33: Inventory days of major grains – China
(inventory forecasts based on MOA and JCI)



Source: JCI, MOA, Goldman Sachs Global Investment Research

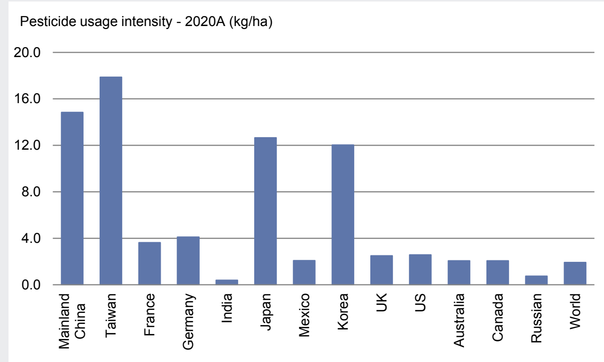
China agriculture supply – the inefficiencies

Exhibit 34: Fertilizer usage intensity – mainland China versus peers



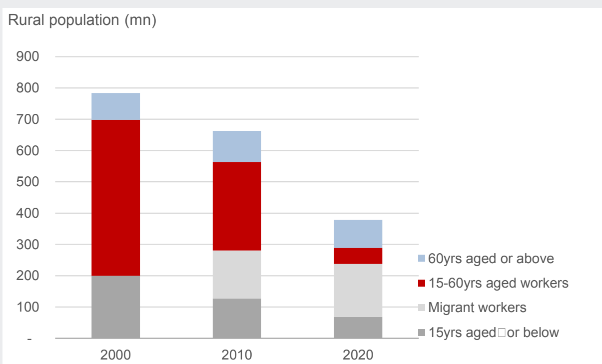
Source: FAO, data compiled by Goldman Sachs Global Investment Research

Exhibit 35: Pesticide usage intensity – mainland China versus peers



Source: FAO, data compiled by Goldman Sachs Global Investment Research

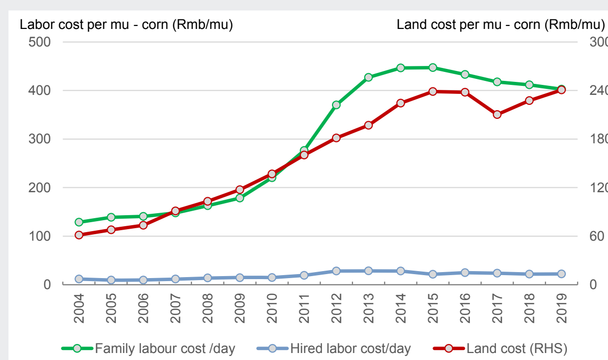
Exhibit 36: Shrinking work force in the rural population – China



Source: NBS, Wind, data compiled by Goldman Sachs Global Investment Research

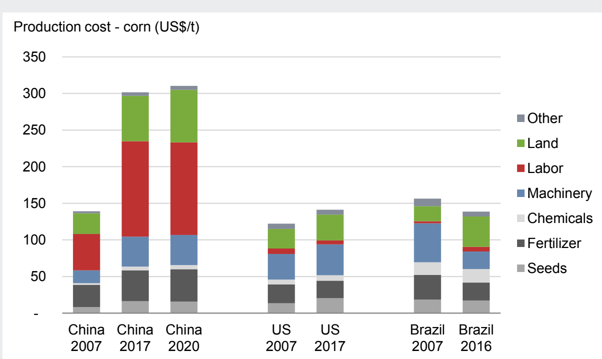
Exhibit 37: Cost inflation in labor and land – corn, China

Unit labor wages in farming rose nearly 4x in the past decade, similar trend in land cost



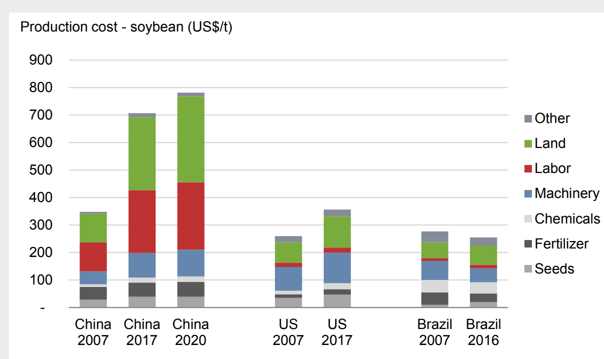
Source: MOA, Wind, data compiled by Goldman Sachs Global Investment Research

Exhibit 38: Production cost of corn – China versus peers



Source: NDRC, USDA, CONAB, data compiled by Goldman Sachs Global Investment Research

Exhibit 39: Production cost of soybean – China versus peers



Source: NDRC, USDA, CONAB, data compiled by Goldman Sachs Global Investment Research

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Reg AC

We, Trina Chen, Roy Shi, Christina Qin and Arthur Deng, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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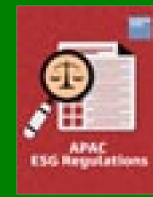

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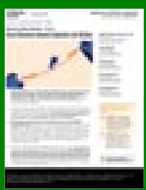

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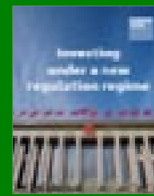

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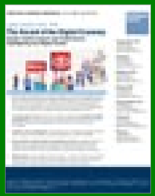

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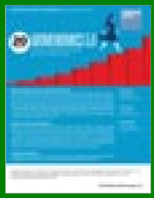

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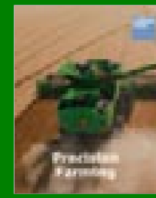

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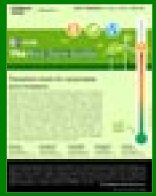

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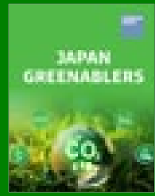

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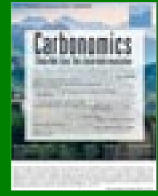

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