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Commodity Markets Outlook and Strategy

Nine billion bellies: Managing food, water, land, and air to 2050

Commodities

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- **Bringing home the breadcrumbs**: In December 2012, IRIN (a UN humanitarian affairs service) interviewed a 35-year old Kenyan woman. Her description of her occupation: breadcrumb seller. We and others instead see the founder and CEO of a vital small business that is succeeding where official aid programs have too often failed. She gathers unwanted and leftover bread from industrial bakers, then sells that product at half the fresh market price to people living in the slums of Nairobi who would otherwise not be able to afford a whole loaf of bread. Her venture spotlights several truths: (1) the ever-present difficulties of large populations to afford staple foods, (2) the rampant waste in the global food chain, and (3) the grassroots ingenuity and market-based solutions that promise to help surmount these very important problems.

- **One out of eight people in the world is undernourished**: In a 2012 report, the FAO estimated that 868 million people in the world were undernourished between 2010 and 2012, or about 12.5% of the global population. Within this group, 98% are located in developing regions, including Africa, Asia, Latin America and the Caribbean, and Oceania. As the US Census Bureau projects the world population to surpass 9.0 billion in 2042, human civilization faces the challenge of feeding an additional two billion people in less than three decades. The World Bank notes: "For the 70% of the world's poor who live in rural areas, agriculture is the main source of income and employment"—paradoxically, the people producing a large amount of the world's food are the ones who are still most hungry.

See page 14 for analyst certification and important disclosures.

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A problem of food distribution, not supply

In 2006-08, global food supply was more than 50% above the global minimum dietary energy requirement (MDER) of the total human population on the planet.

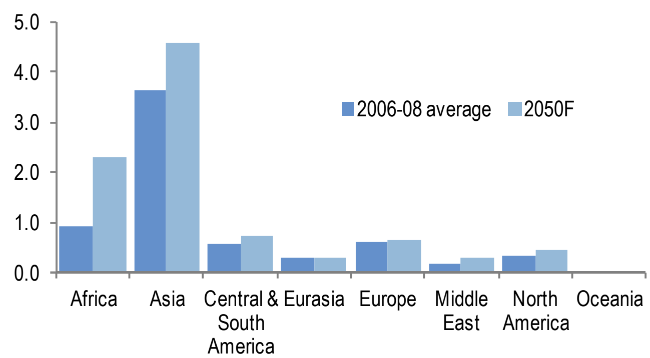
It is a self evident fact that human beings need to meet a minimum caloric energy requirement over time to survive. In assessing whether a person is undernourished, the FAO calculates an MDER per capita, taking into account gender, country, age, and activity levels of different populations. A global weighted-average of the component MDERs per capita suggests that on average a person needed to consume **1,850** kcal/day to avoid undernourishment between 2006 and 2008. As of 2008, FAO data show that world food supply available for human consumption is **2,829** kcal/person/day, suggesting that there is plenty of food on the planet to feed the total human population. Yet, almost one billion people are still hungry, while obesity is a booming trend in many parts of the developed world. These troubling facts suggest inefficient distribution networks, as well as unhealthy dietary habits among some consumers who are lucky enough to have regular and ample access to food.

An increasing global population, higher incomes in emerging economies, and changing diets are the main drivers of higher food demand in 2050.

According to the Population Reference Bureau (PRB), half of the additional 2.5 billion people in 2050, relative to today, will live in Africa and another 40% will live in Asia. Assuming that the proportion of undernourished people in the world remains at 12.5% due to a business-as-usual strategy, there could be **1.2 billion** hungry people by 2050, an increase of nearly 40% from the 2012 FAO assessment.

Exhibit 1: Global population distribution

Billion people

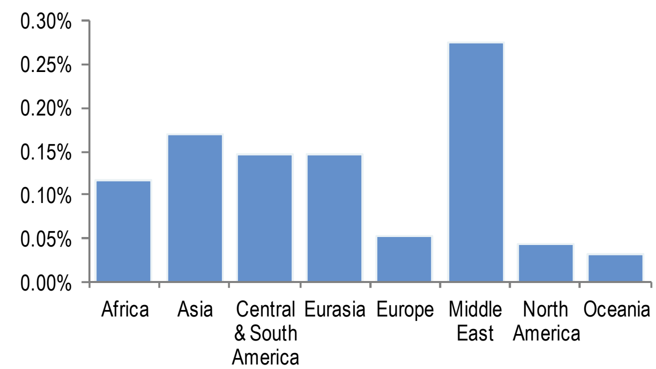


Source: World Bank, Population Reference Bureau, J.P. Morgan Commodities Research
Note: in this report, following sources, we group Mexico in Central &South America

Between 1990 and 2010, World Bank data show that the European Union and North American GDPs grew by a compound annual growth rate (CAGR) of 4.1%y/y and 4.7%y/y, respectively. The developing countries within East Asia, Latin America/Caribbean, the Middle East/North Africa, and sub-Saharan Africa have all experienced growth of more than 6.5%y/y over the same time period. Though the debt overhang in many developed countries suggests a drag on forward growth relative to history, we anticipate that population growth and infrastructure development will support reasonably strong income growth rates for emerging economies into 2050. On average between 1990/92 and 2006/08, the CAGR of the MDER was 0.04% across Europe, North America, and Oceania. Over this time period, the CAGR in Asia was 0.17% and 0.27% in the Middle East. We believe it is highly probable that growth in MDER in developed countries through 2050 will remain stagnant. In developing regions, it is feasible that that the MDER in 2050 could reach the current (2006/08) levels of MDER in developed regions. Based on these assumptions and PRB projections of population, we forecast the 2050 global weighted-average MDER will be **1,960** kcal/person/day, or nearly 6% above the 2006/08 level.

Exhibit 2: Growth rate (CAGR) of MDER between 1990-92 and 2006-08

Percent



Source: FAO, J.P. Morgan Commodities Research

Meat consumption in developing countries has been growing at a faster rate than consumption in developed countries. Chinese per capita pork consumption, for example, has increased from 8 kg in 1975 to 37 kg in 2011. As incomes rise further, an increasing share of the MDER in developing countries is likely to be met with meat, which implies greater resource intensity than alternatives. (Each pound of beef requires input of between seven-to-nine pounds of corn; each pound of pork requires about three pounds of corn.) If China reaches by 2050 the pork consumption intensity that Hong Kong already met in 2011, pork consumption will be 79 kg per capita, an increase of more than 100% from today. In that world, even in the very unlikely event the Chinese population plateaus at 1.3 billion, more meaty diets would demand an additional 54 mmt of pork production and 163 mmt of corn production to feed the pigs. The USDA says China harvested 208 mmt of corn last fall.

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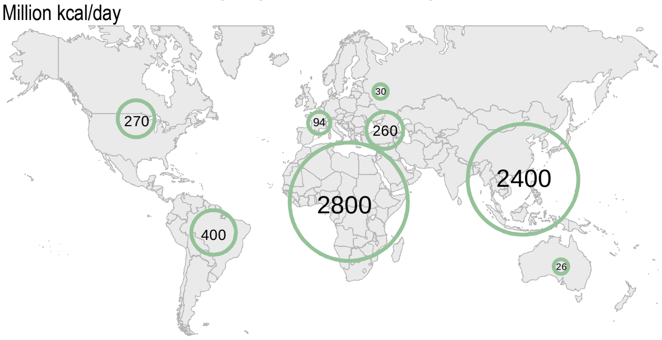
Exhibit 3: Forecasted change in total regional MDER between 2006/08 and 2050F, multiplied by regional population growth

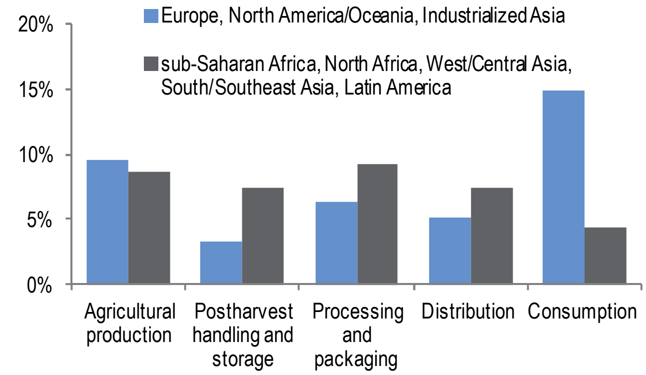
Million kcal/day



Source: FAO, World Bank, Population Reference Bureau, J.P. Morgan Commodities Research
Note that circle size is approximate proportion to the size of change, and Mexico is grouped with Central & South America.

Exhibit 4: Average food waste at different food supply chain stages

Percent



Source: FAO, J.P. Morgan Commodities Research

The challenge of feeding more than nine billion people will call on efficient use of distribution, storage, and risk management.

In order to get food supplies to where they are most needed, stakeholders are likely to focus on two key aspects. First, human civilization will need to acknowledge and address food waste. In developing countries, this will help farmers more efficiently produce and distribute food. This will also help preserve natural resources. Second, producer margins will likely need to move higher in order to support investment in equipment and technology. Freely-operating cash and futures markets are an important precursor, as they help facilitate returns to encourage and sustain investments.

Food waste likely depletes one-third of global food supplies

The reasons for food waste differ between developing and developed countries.

A 2011 FAO study estimates that about one-third of the world's food supply is wasted, equivalent to 1.3 billion tonnes. Food waste at the beginning of the food supply chain tends to be higher in developing countries, due to suboptimal production methods and lack of infrastructure for storage, transport, and processing. However, in developed countries, a much larger share of food waste is a result of consumer waste. One staggering finding is that North America and Europe waste 12% of their annual food use at the consumer level (e.g., purchasing food and throwing it away). Less than 2% of food produced in sub-Saharan Africa and South/Southeast Asia is lost this way.

In developing countries, food supply chains need to improve such that more food makes it to market.

Farmers and the agriculture industry as a whole in developing countries would likely be able to produce more food and reduce waste if given more access to credit to make necessary investments in mechanized production and storage infrastructure, such as refrigeration, transportation, and warehousing. Brazil offers a useful case study of infrastructure needs. Anecdotal evidence suggests that about 4% to 12% of Brazilian soybeans are lost between harvest and loading on to export vessels. Based on this range, we estimate Brazil will lose between 3.0 and 10.0 mmt of soybeans in this channel this year. In the US, the corresponding field-to-port loss figure is closer to 1%.

The vast majority of soybeans are moved by truck in Brazil and a significant portion of losses likely come from trucks that are traveling on poorly maintained roads. According to a November 2012 USDA report, only 16% of public roads in Brazil are paved. In the US, about two-thirds of public roads are paved. In addition to the physical losses of food products, the transport limitations in Brazil make moving products much more expensive than in other large producing countries. USDA data show that it cost $12/mt in 2Q2012 to move a truck-load of soybeans about 2000 kilometers from Minneapolis, MN to port at the U.S. Gulf. At the same time in Brazil, it cost $110/mt to move a truck-load of soybeans the same distance—from Mato Grosso (the largest soybean-producing state in Brazil) to the port at Santos. The higher cost for transporting soybeans cuts into farmer margin, in turn reducing capital available for investment in operations while also blunting incentives to pursue export markets.

Weaknesses at the storage points of food supply chains is particularly evident in India. According to a June 2012 Reuters report, the capacity of India's state-run warehouses is about 63.0 million tonnes of grains, but the country's combined stocks of grain stood at 82.4 mmt at that time. When warehouse storage is unavailable, wheat and other grains in India and elsewhere are stored outside in makeshift arrangements (i.e., maybe beneath a tarp). In such situations,

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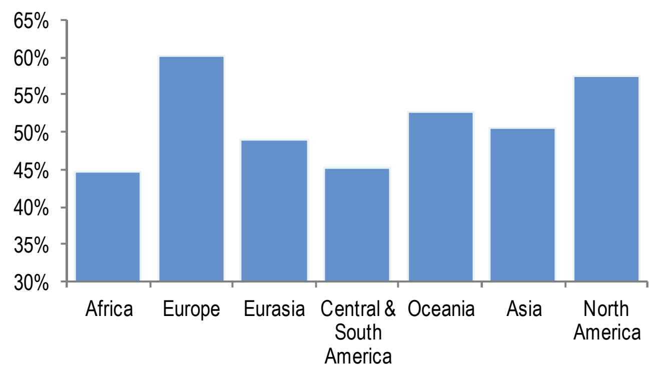
the grains are significantly more vulnerable to rodents and other pests and to the wet weather of the monsoon season. Stocks stored in this way lead to higher loss rates, lower stocks-to-use coverage ratio, and upward pressure on cash prices. However, in many developing economies, a typical policy response is to impose price or trade controls on the remaining stores in an attempt to stifle food price inflation. This strategy rarely, if ever, works as well as intended, as it immediately creates incentives for the creation of secondary cash markets, generates price volatility, and blunts or even eliminates the potential for investment in storage facilities.

In North America and Oceania, on average across food products, more than 20% of the food produced is lost in the consumption portion of the food supply chain.

Developed countries produce a higher percentage of excess food than do their developing counterparts. Overproduction of food in the developed world threatens harmful impacts on water supplies (as excess fertilizers and pesticides run off into bodies of water) and air quality (as landfill gas leaks into the air). While the rate of pollution per crop unit is lower in developed countries relative to developing nations, the absolute amount of pollution emitted is higher than it needs to be, as the system devotes precious resources to production that will not actually be consumed. This phenomenon is implicit evidence that prices are too low relative to personal disposable incomes to alert consumers to the waste in their choices, let alone to alter that behavior. One example of waste occurs in the grocer’s produce aisle as consumers are unwilling to buy “ugly” fruits and vegetables. A September 2012 article in *The Guardian*, citing the UK Soil Association, suggests that 20% to 40% in some UK produce channels is rejected before reaching stores, largely on appearance alone. This evidence also reveals gross price insensitivity, while also suggesting food prices may over time have to move higher if conservation becomes needed.

Exhibit 5: Excess food supply as a percentage of MDER in 2006-08
Percent



Source: FAO, J.P. Morgan Commodities Research

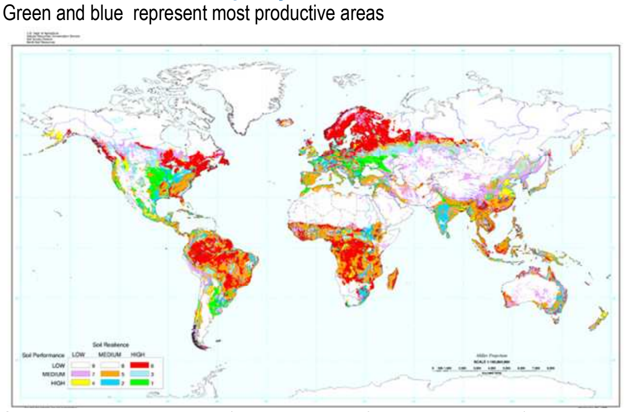
Will resource inputs support adequate food production capacity in 2050?

Arable land supplies are declining in some of the most productive regions, but planted acreage has potential to grow.

A 1999 study by Eswaran, Beinroth, and Reich (scientists for the USDA and the University of Puerto Rico) confirms that some of the most productive agricultural lands are located in the central US, central Europe, South America, and northern China. FAO data show that areas with some of the most productive lands (i.e., high yields) have been experiencing a trend of decreased arable land use—between 2001 and 2009, North American and European arable land and permanent crop land use in acreage units has decreased by 0.6% per year and 0.3% per year, respectively.

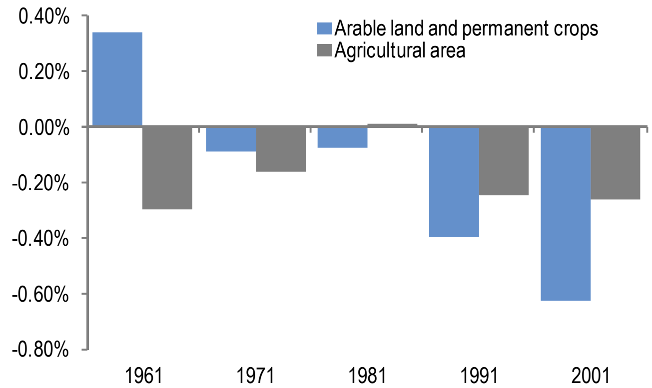
Yet, the FAO points out that its arable land statistics are not meant to include land that is "potentially cultivable". Increases in arable land use are indeed possible and will most likely be concentrated in parts of South America, the Former Soviet Union, and sub-Saharan Africa. Between 2001 and 2009, Africa has experienced the highest rate of increase in arable land and permanent crop use relative to the other regions of the world (1.3%y/y). We believe this trend is likely to be durable. In Brazil, additional crop land use in the short to medium term will likely occur through conversion of pasture land into crop land, a trend supported by the highest soybean prices in more than a half-century. Furthermore, Brazil is among the world's largest beef producers and could potentially increase its production efficiency. In 2011, the EU produced 104 kg of beef per hectare. As of 2011, Brazil produced 46 kg per hectare of pasture land. Argentina and China (also large beef producers) produced 22 kg per hectare and 14 kg per hectare, respectively. We see good potential for improving land use efficiency in alignment with consumer trends.

Exhibit 6: Inherent land quality assessment
Green and blue represent most productive areas



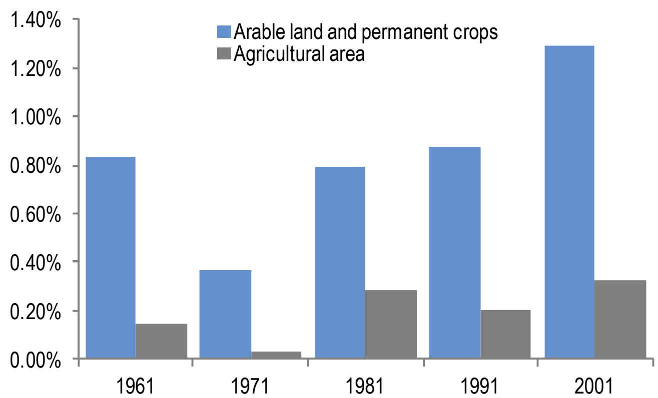
Source: Eswaran, Beinrot, Reich (American Journal of Alternative Agriculture). Photo courtesy of USDA NRCS

Exhibit 7: Compound annual growth rate of land use by decade in North America
Percent



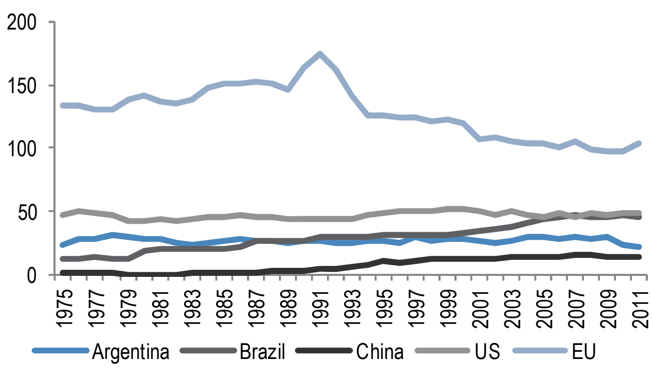
Source: FAO, J.P. Morgan Commodities Research
Note: Agricultural area includes arable land, permanent crop land and permanent meadows and pastures, data available through 2009.

Exhibit 8: Compound annual growth rate of land use by decade in Africa
Percent



Source: FAO, J.P. Morgan Commodities Research
Note: Agricultural area includes arable land, permanent crop land and permanent meadows and pastures, data available through 2009.

Exhibit 9: Beef production per hectare of permanent/temporary pasture land
Kg per hectare

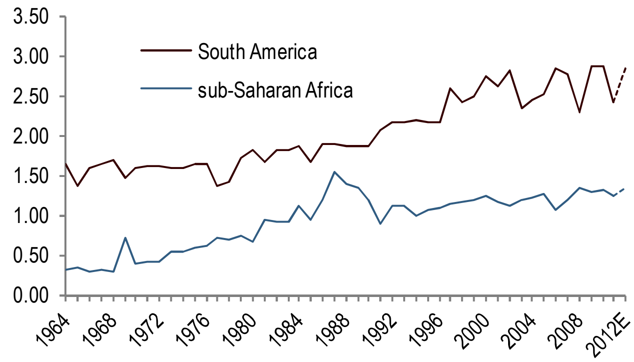


Source: FAO, USDA, J.P. Morgan Commodities Research

Yield improvements likely have greater potential to increase food production, especially as the largest increases in arable land use are being made where soil quality is suboptimal.

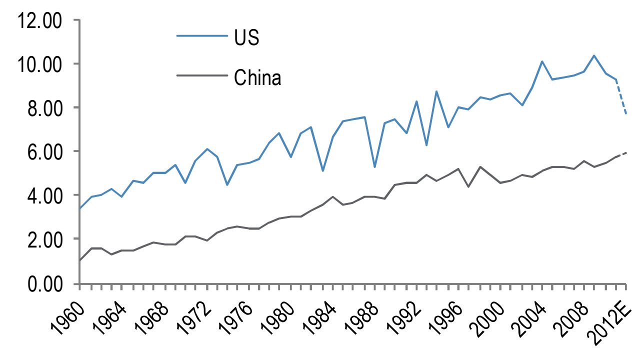
Globally, the yields of corn, soybeans, wheat, and rice have shown rising trends since the early 1960's. However, the differences in yields between countries with similar climates and/or soil qualities is drastic. Over the past five years, soybean yields in South America have been double those in sub-Saharan Africa, wheat yields in western Europe (using Germany as a proxy) have been 83% higher than yields in eastern Europe (using Poland as a proxy), and corn yields in the US have been 78% higher than those in China.

Exhibit 10: Soybean yields in South America vs. sub-Saharan Africa
MT/HA



Source: USDA, J.P. Morgan Commodities Research

Exhibit 11: Corn yields in the US vs. China
MT/HA



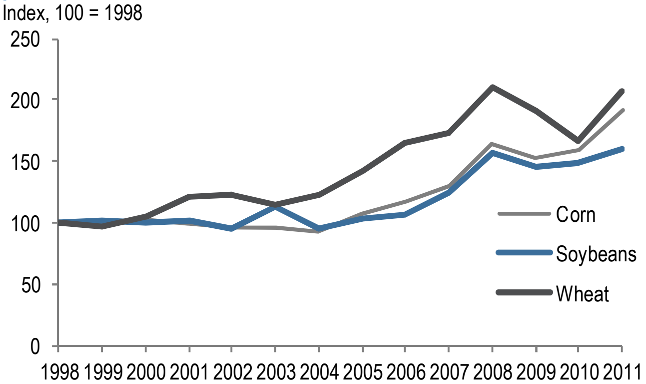
Source: USDA, J.P. Morgan Commodities Research

In order to build productive capacity to feed an additional 2.5 billion people, investments are necessary to increase yields.

There are many ways to improve yields and close the gap between current crop yields in Africa, Asia, and Eastern Europe and their productive potentials. These include using genetically modified seeds, increasing fertilizer use, rotating crops, planting higher plant populations per land unit, managing pests, more widespread farming education, and improving water management. However, in order to incentivize and finance these practices, farmers' received prices likely need to rise further in order to cover costs of input commodity prices that have already risen on their own global fundamentals (e.g., diesel fuel and natural gas) and to make reasonable returns attainable. Even in the Midwestern US, where soil is prime for agriculture, fertilizer is an expensive line item on the farmers' balance sheet. According to Iowa State University, in order to achieve a conservative corn yield (160 bu/acre), Iowa farmers will likely pay about $320/ha for their nitrogen, phosphate and potash needs for 2013/14 corn. For the sake of argument, assuming the same fertilizer cost per hectare in other parts of the world (which does not include seed, herbicide/pesticide, or any other inputs) results in an average production cost greater than the per capita income of Burundi in 2011, or more than 10% of the per capita income of Ukraine in 2011. In addition to working toward a more realistic assessment of current fundamental costs and the food prices that would be required to sustain farming, stakeholders are also likely to see value in educational and technology partnerships that lower barriers to entry for food production.

Exhibit 12: US crop production operating costs per tonne of production

Index, 100 = 1998



Source: USDA, J.P. Morgan Commodities Research

Water security is essential to food security

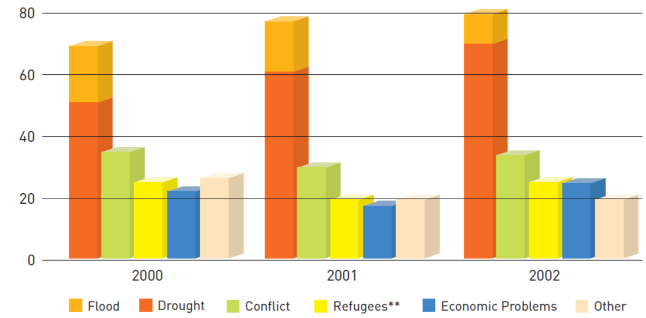
According to the World Food Program, drought is the most common reason for food shortages worldwide. The FAO reports that in 2002, around 70% of "food emergencies" in developing countries were partially attributable to drought. Coping with water stress is a necessary first step to alleviating mass undernourishment.

More than half of the world's population lives in countries with moderate to severe water stress.

Of the water on this planet, less than 1% is freshwater available for human use, according to the US Geological Service (USGS). Despite this small percentage, the planet is generally under low water stress, meaning less than 20% of renewable water resources are withdrawn each year. Moreover, the prognosis on water supply looks good: Earth would remain under low water stress even if human civilization were withdrawing more than two and a half times the current freshwater withdrawals, based on FAO data. As with land, it is ***distribution*** of water consumption and resources, moreso than supply tally, that is the key issue.

Exhibit 13: Causes of food emergencies in developing countries

Percentage of food emergencies*



Source: FAO.

* Total Excludes 100% because of multiple causes cited for many emergencies.

**Includes internally displaced people.

Based on our estimates from FAO and Pacific Institute data, in 2010 around 27% of the world's population lived in countries with severe water stress, defined as a country where greater than 40% of the country's renewable freshwater water resource is withdrawn per year. Another 28% lived in countries experiencing moderate water stress (between 20% and 40% of the renewable water supply is withdrawn), while under half lived in countries with little to no water stress (less than 20% of renewable water withdrawn). A country level analysis masks some of the basin-level stresses, particularly for large countries, and other analyses done on the water-basin level from industry researcher Growing Blue show even higher estimates for populations living under severe water stress.

Unsurprisingly, countries in the Middle East, North Africa, and South Asia are currently under the most severe water stress. Swaths of the south- and mid-western US, Eastern Europe, northern Mexico, southern Africa, and northeastern China are also at severely stressed levels, according to the OECD and Growing Blue basin-level analyses. Many of these countries are also some of the largest agricultural producers.

By 2050, demand for water resources will grow significantly.

Between 2000 and 2050, the OECD estimates that global water demand will increase by 55%. This will lead to 3.9 billion people likely living under severe water stress,

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including most of South Asia and the Middle East. Veolia Water suggests that this number could be as high as 4.8 billion under a business as usual scenario. In addition, China, the US, Mexico, North Africa, Eastern Europe and South Africa will be under significantly more water stress than the present situation.

Agriculture accounts for the largest share of freshwater withdrawals and consumption.

Agriculture accounts for 68% of freshwater withdrawals, domestic and other industrial uses account for 19%, power accounts for 10%, and evaporation from reservoirs accounts for the final 3%, according to Intelligence Community (IC). However, when looking at consumptive use, which reduces the quantity or quality of water returned to the environment, agriculture makes up 93% of all consumptive use, while domestic and industrial use is the other 7%. While a person requires 2 to 4 liters of drinking water daily, it takes 2,000 to 5,000 liters to produce their food for a day, according to FAO.

In agriculture, consumption occurs through evapo-transpiration, harvesting of the plant, and pollution, and the amount of water required depends greatly on the climate (sunshine, temperature, humidity, and wind speed). In addition, water requirements vary widely based on the local crop variety and farming practices.

Overall, improving water productivity is the key to reducing agricultural water use.

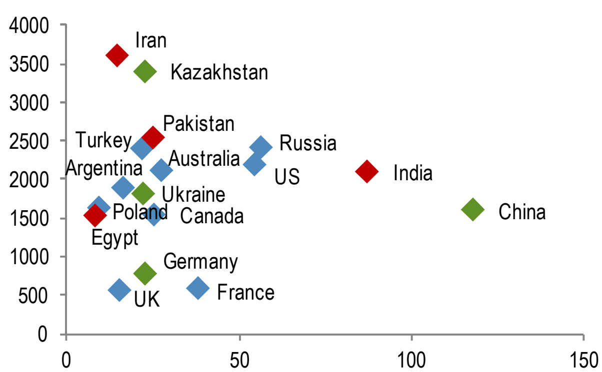
There are numerous methods for reducing water use in agriculture—reducing demand for water-intensive crops, reducing food waste, and optimizing where crops are grown. However, similarly to food, those that focus on improving yields, and thus the water required, will be most effective at boosting food supply for the growing population within the resource constraints.

Exhibit 14 shows the water footprint (water evaporated, incorporated into the product, or polluted) of a few key crops by top producing countries compared to production

Exhibit 14: Production of crops and water productivity (2011)

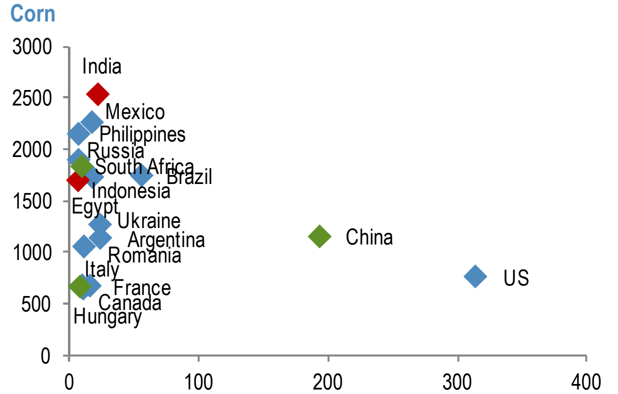
Production (x-axis, mmt); Water footprint *(y-axis, m3/metric tonne); Red=severe water stress** (>40%); Green=medium water stress (20-40%); Blue=Little to no water stress (0-20%).

Wheat



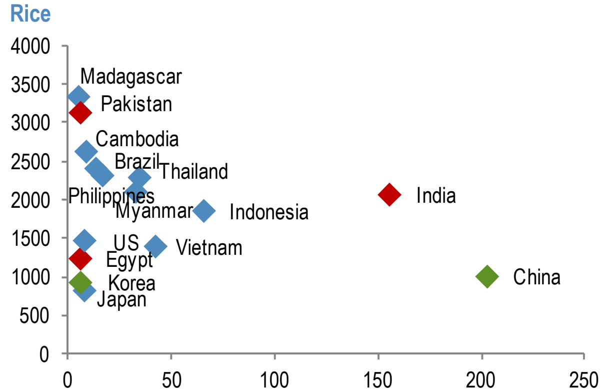
Note: Includes countries producing >8 mmt.

Corn



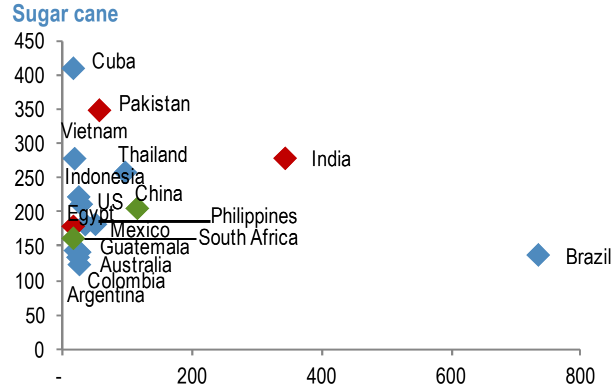
Note: Includes countries producing >6 mmt t, ex- Nigeria, for which there is no water data.

Rice



Note: Includes countries producing >5 mmt, ex-Bangladesh, for which there is no water data.

Sugar cane



Note: Includes countries producing >15 mmt.

Source: FAO; OECD; The Pacific Institute; M..M and Hoekstra, A.Y (2010) The green, blue,and grey water footprint of crops and derivative crop products, Value of Water Research Report Series No. 46, UNESCO-IHE, Delft, the Netherlands, http://www.waterfootprint.org/Reports/Report47-WaterFootprintCrops-Vol1.pdf; J.P. Morgan Commodities Research.

*Water footprint is a measure of freshwater appropriation by humans, defined as water volumes consumed (evaporated or incorporated into a product) or polluted. It includes blue, green and grey water. **Water stress is defined as the percent of total renewable water resource withdrawn.

of the crop. This consumption number includes blue water, the level of surface and ground water consumed, green water, the level of rainwater consumed, and grey water, the level of freshwater needed to absorb pollution to bring the water to ambient water quality standards. The figures also highlight the level of water stress for the countries.

As an example of efficiencies that can be gained from improving yields, Germany and western Poland have a similar climate, but wheat yields are significantly lower in Poland, likely as a result of smaller, less efficient farming. As a result, Poland uses more than twice the amount of water for every tonne of wheat produced that Germany does. If Poland were to reach the water productivity level of Germany, at current levels of production it would mean a reduction of 7.9 cubic kilometers per year used to grow wheat, more than the entire renewable freshwater resource of Jordan, Kuwait, Palestine, Oman, Qatar, Saudi Arabia, UAE, and Yemen, with a population of 80.9 million people combined as of mid-2012, according to the PRB. However, since Poland is not under water stress, this only helps other countries if it can increase its production and exports, and thus the "virtual trade" of water, which will be discussed later. In other countries, however, improved farming practices could mean helping to reduce its water stress levels overall.

Irrigation is both part of the problem and the solution to water scarcity.

We have already covered the potential growth in food production from yield improvements due to general farming practices, and effective water control and management is a part of the yield solution. In order to water crops, farmers can either rely on rainwater or irrigation. According to the FAO, 80% of agriculture is practiced on rain-fed land which produces around 60% of world production. Despite the prevalence of rain-fed agriculture, it is not always the most efficient. Irrigation can increase crop yields by 100% to 400% when compared to rain-fed agriculture, according to the FAO. There are numerous countries which have a small percentage of cultivated land equipped for irrigation (<5%), but are not facing water scarcity. Many of these countries, primarily in sub-Saharan Africa, also have limited precipitation and could benefit from improved water control systems. But crop prices received by producers must be sufficiently high and sustained to spur investment in such systems.

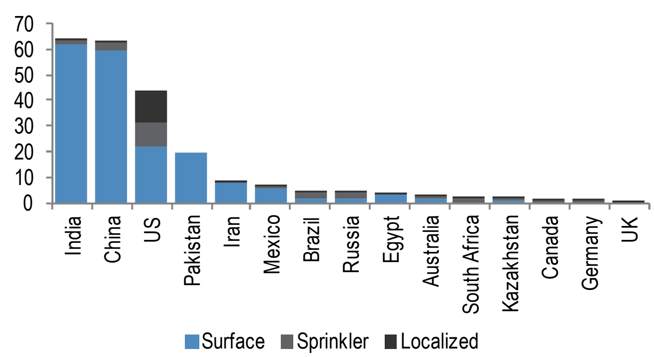
While irrigation is part of the yield solution for countries that are not water stressed, it is part of the problem for many others. Evapotranspiration from irrigated land is the largest driver of consumption of water in many regions, according to the FAO. Since irrigation most often draws on surface and groundwater, this leads to more blue water consumption than countries relying less heavily on irrigation (see Exhibit 15). Of the top five countries for area of irrigated land, four are under severe or moderate water stress—India, Pakistan, Iran, and China with 157 million hectares total under irrigation, according to the FAO's most recent data, or about the combined size of Texas, California, Nebraska, and Wyoming. Of the five countries, only the US is under low water stress nationally.

In some cases of widespread irrigation, countries are simply not endowed with plentiful precipitation—when ranking countries based on rainfall per area, nearly all of the severely water scarce countries are in the lowest 20%. Of large agricultural producers, Egypt, Pakistan, and Iran all have relatively low levels of rainfall. As a result, these countries have likely turned to irrigation in order to grow crops and therefore have a higher percentage of cultivated land under irrigation than countries receiving more rainfall on average. Nearly all of Egypt's cultivated land was equipped for irrigation as of the early 2000s, while about 94% of Pakistan's and 46% of Iran's cultivated land was equipped with irrigation capacity as of 2008 and 2009, respectively.

India is the only large agricultural producer of the severely water stressed countries that also has plentiful rainfall in comparison to the rest of the world. India receives more rainfall per area than the United States, China, and Germany, among many others. Even when ranking India based on the FAO's National Rainfall index, which takes into account seasonality of rainfall with respect to the growing season, India ranks above these countries. But as a consequence, only 22% of India's total land is equipped for irrigation, according to FAO and World Bank data. The comparable figures are 25% for Pakistan and 39% for Bangladesh. This exceptional reliance on the monsoon helps explain why India so frequently sees substantial swings in its domestic crop production as well as the corresponding price volatility.

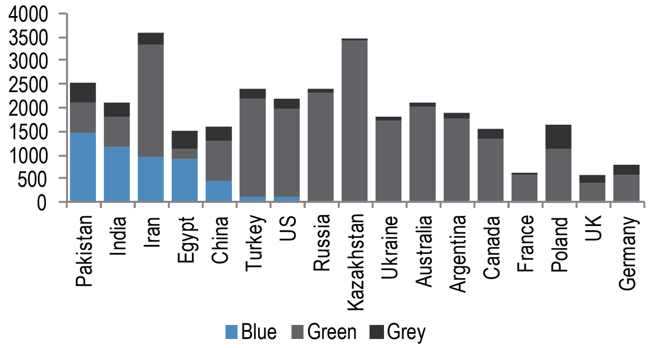
Exhibit 15: Approximate area equipped for full control irrigation by type

Million hectares



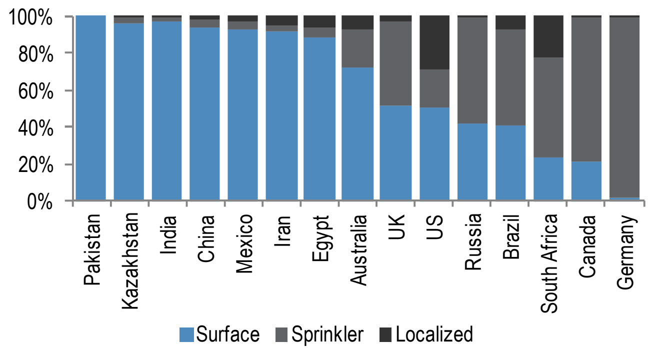
Source: FAO, J.P. Morgan Commodities Research. Note: Date of information varies, but is most recent data reported by FAO.

Exhibit 16: Consumption of blue, green, and grey water in wheat production
m3/metric tonne



Source: UNESCO, J.P. Morgan Commodities Research

Exhibit 17: Approximate share of total full control irrigation area by type of irrigation
Percent



Source: FAO, J.P. Morgan Commodities Research. Note: Date of information varies, but is most recent data reported by FAO.

All irrigation is not created equal. There are three main types of irrigation: (1) surface irrigation, whereby the water is moved over the land by gravity, (2) sprinkler irrigation, whereby water moves through pipe and is sprayed on plants, and (3) localized irrigation, where water is applied in small quantities directly to the plant. Localized irrigation has the lowest level of the consumptive evapotranspiration, though sprinkler irrigation is also an improvement over surface irrigation. Pakistan, Iran, India, and China, each have around double the US's share of agricultural land under gravity systems.

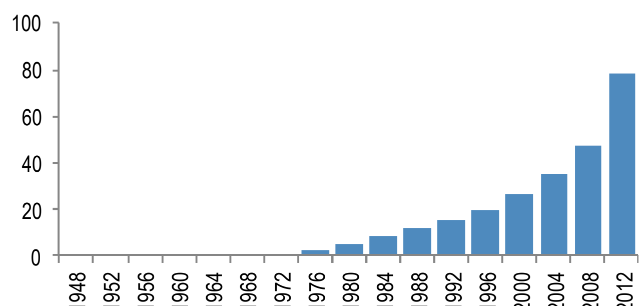
Since much of water use and stress is simply a condition of the climate, "virtual water trade" offers an opportunity to redistribute water around the globe.

Many countries do not have sufficient water resources to feed their entire population while also supporting industry and domestic uses in a sustainable manner. "Virtual water" is the water consumed in the production of a product and the "trade" of it is measured by the trade of that good. On a global level, the savings from virtual water trade are calculated by subtracting the water footprint of making the good in the exporting country from the water footprint of making the good in the importing country. Based on estimates by M.M. and Hoekstra, A.Y. (2010, UNESCO-IHE), **crops account for 76% of virtual water trade**. In addition to global water savings, each country that chooses to import food as opposed to producing it frees water for other uses.

As available water resources become more scare, countries will have to look toward unconventional solutions to the water supply shortage.

Unlike land, one can "make" more freshwater resources. Desalination technology, through membrane and thermal processes, converts saline water to freshwater, making the vast ocean resources available for human use. Currently, Global Water Intelligence estimates that there is 78.4 million cubic meters per day of desalination capacity in 150 countries around the world, two and a half times more than in 2002, or growth at a CAGR of 10% over the past decade. The International Desalination Association estimates that desalinated water supplies some or all of the daily needs of 300 million people, though installed capacity is still a miniscule fraction of total water withdrawals globally.

Exhibit 18: Cumulative installed desalination capacity
Million cubic meters



Source: The Pacific Institute, Global Water Intelligence, J.P. Morgan Commodities Research

However, the cost for desalinated water continues to be relatively expensive in most countries.

According to a Bloomberg report, groundwater supplies cost less than $0.20/m3 to supply, though that number likely ranges widely regionally. Desalination, on the other hand, can cost many multiples of that quote. For example, *The Economist* has reported that water from the Beijing Power and Desalination Plant, which began operation in 2010, costs about $1.30/m3 to produce, slightly more than industrial user tariffs, and 60% greater than household tariffs. The total cost of water, including the pipeline to deliver the water, from the Carlsbad Desalination Plant in California, expected to come online in 2016, will cost between

$1.63/m3 and $1.83/m3, according to the San Diego County Water Authority. Single-family water rates locally are currently between $1.13/m3 and $1.99/m3, depending on how much water is consumed, and agricultural rates are $1.31/m3.

Costs for desalination are closely linked to the cost of energy to produce the water. Israel, which has significant experience with desalination technology, focuses on reverse osmosis technology (which relies on membranes) as opposed to the more energy-intensive thermal technologies. In 2010, a study conducted by the Israeli Water Authority found that large-scale seawater reverse osmosis plants built between 1997 and 2010 had water costs between $0.50/m3 to $1.20/m3, with Israeli plants at the low end of the scale. The Authority estimate that water from the new Soreq desalination plant will cost $0.52/m3. In the country as of 2011, urban tariffs were between $2.50/m3 and $3.50/m3. Agricultural tariffs were $0.70/m3.

In general, given that water for agricultural uses is generally less expensive than domestic use, it is less likely that desalinated water would supply agriculture directly. By displacing domestic use as costs come down and demand necessitates, it may indirectly provide resources for agricultural use. Moreover, as water traditional resources become more stressed in some regions, tariff structures will have to adjust to incentivize the entrance of technologies that are relatively more expensive than the supplies being depleted.

There are numerous other measures to increase supplies in water-scarce regions.

With the well known Chinese water redirection project from the Yangzi River, the issue of water basin transfers has come once again to the fore. Other projects are moving forward in Brazil, Peru, and Greece. Interbasin transfers help resolve the distribution issue of water, but also come with other concerns, such as high costs, unsustainable withdrawals, and environmental impacts. Other measures to increase supply include increasing storage, reuse of drainage and wastewater, and reduction of pollution. All will likely be a part of the water shortage solution.

Improving food access by necessity means creating new markets

Transparent agricultural markets would allow buyers and sellers to get food to where it is needed.

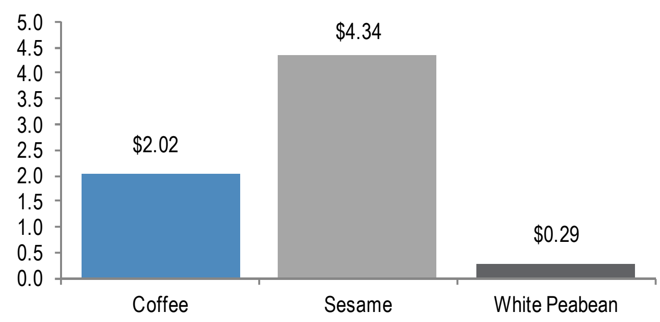
Dr. Eleni Gabre-Madhin, the founder of the Ethiopia Commodity Exchange, describes the problem of access to food in her native country of Ethiopia, in an interview with *The Guardian* in December 2012. She was baffled at how a famine in Ethiopia could occur in 1984 when there was a surplus of food available in the western part of the country. Her motivation for creating the Exchange was to eliminate food distribution problems by helping buyers and sellers facilitate contractually-enforced transactions and getting food from locations where there is plenty to locations where there is a deficit.

The Ethiopian Commodity Exchange began in April 2008. In a January 2013 interview with *The Financial Times*, Dr. Gabre-Madhin cites that prices received by coffee farmers increased from 38% to 65% of the final price after the exchange was established, as the gap between local markets prices and the exchange narrowed. Additionally, the spread of mobile technology has made it easier for farmers and consumers to call the exchange to find out the price of certain products. The ECX receives 1.2 million calls a month inquiring about market prices, 70% of which originate from rural areas. The opportunity to respond to fundamentally-rooted, market-discovered signals for more supply mean small farmers may receive higher prices for their products in resolving deficits as they emerge, potentially allowing greater investment in additional or improved production.

In areas where transparent cash markets have not traditionally existed, an exchange can also act as a guarantor that the quality and quantity needed will be delivered on time to the buyer, and that the seller will get paid.

The value of intermediation is a well established economic principle. In physical food markets, the involvement of the exchange helps to move crops from one place to another and does not necessitate personal relations between buyer and seller, ultimately lowering costs for each side of the transaction and improving society as those efficiencies are multiplied through economic channels. Transparent and fair pricing, in addition to legally-binding contracts, make farmers more willing and able to take production risk, efficiently invest, and to produce the food society needs.

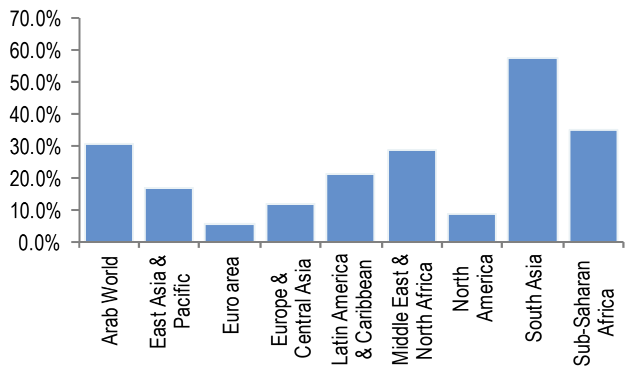
Exhibit 19: Open interest on Ethiopian Commodity Exchange
Million US$, as of 12-Feb-13



Source: ECX, J.P. Morgan Commodities Research

Exhibit 20: CAGR of mobile cellular subscriptions per 100 people between 2002 and 2011

Percent



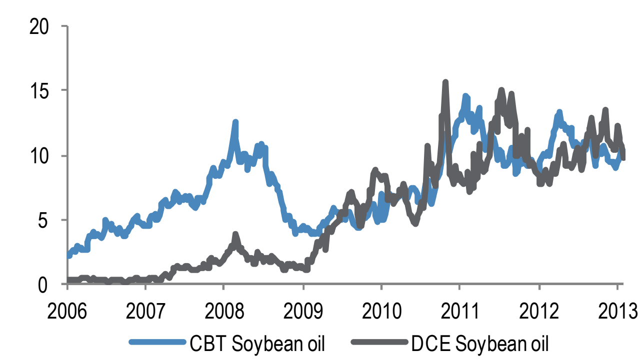
Source: World Bank, J.P. Morgan Commodities Research

New agricultural exchanges and hubs are likely to emerge with changing production, consumption and trade patterns.

In particular, as Asian and African agricultural production and consumption expand, we expect to see a shift in trading volumes as new cash markets emerge and futures contracts are offered on those basis markets. This pattern is already evident in China, as Chinese production and consumption of agricultural products has increased. The Dalian Commodity Exchange (China), for example, has active soybean oil and soybean meal futures markets. At times, open interest for these commodities in Dalian has surpassed the once-juggernaut contracts at the Chicago Board of Trade. As of February 15, 2013, soybean oil open interest at Dalian stood at $9.8 bn compared to $10.4 bn in Chicago. Soybean meal open interest at Dalian is currently $9.5 bn compared to $11.4 bn in Chicago. With China's dominant position as a producer, consumer, and now increasingly as an importer of corn, it is logical to conclude that corn open interest in Dalian (currently at $1.9 bn) will begin to erode market share from CBOT (currently at $42.9 bn). Overall, China's share of global grains and oilseeds futures open interest in USD terms increased from 9% in 2006 to 17% in 2012. In global softs and livestock futures contracts, China's share rose from 3% in 2006 to 13% in 2012 as the US lost market share. Earlier this month, wheat traders learned that on June 28, 2013, the Kansas City Board of Trade (chartered in 1876) will cease open-outcry trading of its storied wheat contracts, transferring all trading to CME Group's electronic platform. When assessing threats and opportunities in physical crop markets, or in setting policy, stakeholders must be careful to stay current with the actual stocks and flows of the 21st century and not assume that former market structures or rules of thumb still hold.

Exhibit 21: Total open interest of the CBT and DCE soybean oil futures

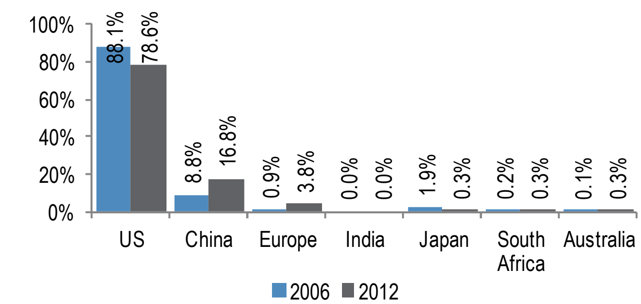
Billion US$



Source: CBT, DCE, J.P. Morgan Commodities Research

Exhibit 22: Grains & Oilseeds open interest by domicile region

Percent of global open interest on futures exchanges by domicile region



Source: CBT, DCE, J.P. Morgan Commodities Research

The mere establishment of a futures contract does not guarantee its success. In recent years, various governments' interventions in physical markets for grain—through export bans, production taxation, and marketing organizations—has depleted confidence in some physical markets and their associated futures contracts. For example, even as KCBT's hard red winter (HRW) contract formally joins the CME platform, other CME wheat contracts strike a note of caution. Consider the low liquidity of the CME Black Sea wheat contracts. As of February 15, 2013, the open interest of all of the available contracts was zero. Market participants appear wary about the risk of future wheat export bans, the most recent of which Russia implemented in 2010.

Conclusions

Two billion souls will join the human family by 2050. The world faces a tremendous challenge in figuring out how to feed this growing population with limited land and water resources. Reducing food waste and improving yields will likely be important factors toward meeting growing demand. This focus would not only have the effect of producing more crops per hectare, but would also minimize water use. Such a strategy is likely to be deemed especially important in countries that are already under moderate to severe water stress.

Futures markets have at least two important roles in providing enhanced food security. First, futures markets provide reliable and fair benchmarks price, whereby various physical basis markets can equilibrate to move supplies to where they are most needed and to discourage thoughtless waste. This service is of the utmost value to society generally, as it resolves imbalances dispassionately and efficiently. Second, futures markets also provide the significant benefit of reducing food price volatility from where it otherwise would be in a resource-constrained world. This is a counterintuitive fact for some observers, but it is why futures markets will become an increasingly important risk management tool in food markets as the demand of the growing population strains limited supplies.

In this regard, it is important to recognize that food prices have actually been way too low, relative to disposable incomes, to curb gross waste of food at the consumer level in the United States, Europe, and other developed nations.

All stakeholders should understand that prices need to be allowed to move freely to the levels that will encourage and sustain investment in food system infrastructure and constrain demand for food that will not actually be used, even if particular prices are painful for some consumers and producers in the short run. If farmers' margins are too small to allow for needed investment in new production, storage, and distribution facilities, necessary investment will not get made, and consumers will ultimately have to bear the consequences. Producers, especially small ones in rural areas in developing markets, would benefit from cheap (if not free) electronic access to accurate information on market fundamentals and prices, so that they can make informed decisions that benefit their local communities and the broader world. In the coming decades, many new pathways for production, consumption, and risk management will open up. Stakeholders will need to recognize and accept the fundamental origins of these changes, instead of making the mistake of concluding that "novel" means "broken".

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