Sustainable Food

Challenges and Opportunities in Global Food Production

Prepared with support from the Morgan Stanley Institute for Sustainable Investing by the Smith School of Enterprise and the Environment, University of Oxford

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SUMMARY FOR INVESTORS

Global food production faces immense ecological sustainability challenges. With population growth coupled with the emergence of a global middle class, both absolute and per capita demand growth for agricultural goods – food crops, livestock products, and seafood – is accelerating.

o Meanwhile, the environmental footprint of the global food production system is already enormous, and ever greater quantities of inputs to production will be required to sustain yields on a relatively inelastic supply of fertile land.

o Key ecological risks to sustained food production include climate change, water scarcity, sustainable energy needs, and scarce fertile land. Moreover, many of these risks are interconnected.

o Key risks posed by food production on the environment include its contributions to climate change, water scarcity, and biodiversity loss. Demand growth for protein foods (i.e. meat, dairy, eggs, and seafood) will have the greatest proportional impact on sustainability.

While the themes above are consistent across the world, the landscape of risks as well as opportunities varies from region to region. Therefore, this report adopts a comparative geography perspective in Part II.

o **North America** is an agricultural powerhouse: both the US and Canada are major producers and exporters of agricultural products. To sustain its competitiveness, the region will need to invest in climate-resilient agriculture, and to overhaul immigration policy in order to meet demand for farm labour.

o **Latin America and the Caribbean** currently contribute 13 per cent to world food trade – but there is high potential for this to increase substantially.

o The **European Union** is the world's largest importer and exporter of agricultural products, exporting US$55.6bn of goods. Meanwhile, a number of European countries have been transitioning to greater market orientation and private ownership of farms and agri-business.

o All of the countries in the **Middle East and North Africa** region face moderate to high degrees of food insecurity, with threats from water scarcity and climate change set to grow over time.

o Agriculture accounts for at least a quarter of **sub-Saharan Africa's** GDP and provides two-thirds of the population with full-time employment. Yet the region remains highly dependent on food imports, and the proportion of people living with chronic hunger in the region hasn't changed over the last 20 years.

o In **Asia,** China and India have been called 'new food superpowers' given the size of both their exports and their rapidly growing domestic markets.

o **Australia and New Zealand** both aim to capture a greater share of Asia's food imports. But both countries face ecological constraints – especially freshwater availability – to expanding production.

Chronic under-investment worldwide is a major bottleneck to sustaining production. The World Business Council for Sustainable Development puts the size of the investment opportunity at an estimated $10 trillion to 2050. While the investment universe contains a wide range of possibilities, we outline four of the greatest classes of opportunities:

o Investors can have the most direct exposure to food production by investing directly in farmland. Doing so sustainably, however, requires a long-term perspective and a 'stewardship' mentality.

o Investment in R&D and technological innovation will be crucial for the sustainable intensification of yields – particularly in less developed parts of the world.

o Investment in human capital – the knowledge, skills, and capacity of the world's food producers, at least nine-tenths of whom are small-scale family farmers – is urgently needed yet under-appreciated.

o Finally, investors can support efforts to provide long-term price guarantees for producers, whose business needs are currently under-served by existing forward pricing arrangements such as futures trading.

Part I

Overview of Sustainability Challenges to Global Food Production[8]

8 Adapted from McGill (2013)

INTRODUCTION

Global food production faces immense ecological sustainability challenges. With population growth coupled with the emergence of a global middle class, demand growth for agricultural goods is accelerating. The UN Food and Agriculture Organisation (FAO) projects that demand for food will grow by 70 per cent by 2050, and even more intensive energy, water, and fertilizer inputs will be required to sustain yields on a relatively inelastic supply

Yet already the environmental footprint of the global food production system is enormous. Humanity now cultivates 40 per cent of the earth's land area, and agricultural production accounts for one-third of global greenhouse gas emissions – much of it through deforestation and the manufacture of fertilizers – and 70 per cent of freshwater withdrawals.

Given the scale, scope, and complexity of the entire system of global food production, distribution, and consumption, our focus here is primarily on productive agriculture. While research and awareness of challenges facing all stages of the supply chain is still needed, we believe that particularly wide scope remains for presenting the risks and opportunities associated with production up to the harvest stage to the investment community. Perhaps surprisingly, even many of the largest and most sophisticated food multinationals lack even a basic knowledge of their 'upstream' supply chains: the very farms and fisheries that supply them with their inputs, through an increasingly complex and opaque global network.

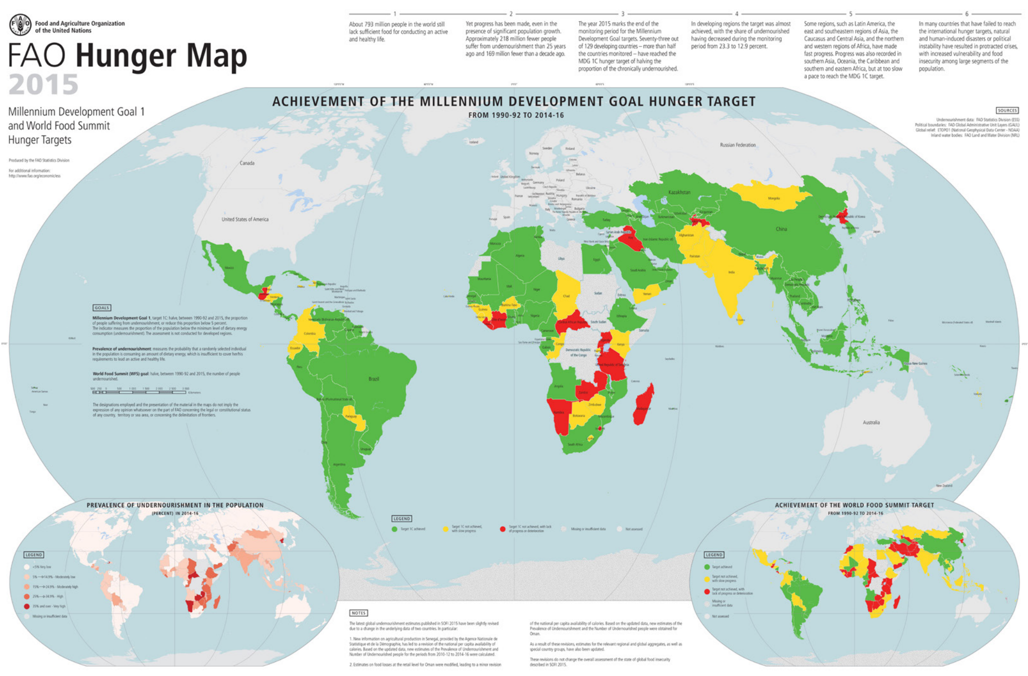
Meanwhile, hunger, malnutrition, and poor diet remain huge challenges worldwide. It is true that the proportion of global hungry had dropped by 17 per cent since the beginning of the 1990s, and the first of the UN Millennium Development Goals – to halve global hunger by 2015 – now appears to be attainable. On the other hand, roughly one-eighth of the world's population – 842 million people – is estimated to be suffering from chronic hunger (FAO et al. 2013). The FAO further estimates that about three billion people do not eat well – a figure that includes the overweight and obese, as well as those with micronutrient deficiencies. In other words, at the same time as the problem of malnutrition persists, overconsumption is increasingly contributing to high levels of obesity and associated diseases such as diabetes in middle-income countries.

Box 1: Fast food

Fast foods are increasingly an important component of diets in many parts of the world. One in four Americans eats fast food every day. Meanwhile, obesity is a growing issue in Latin America and the Caribbean (LAC), and has been linked with the expansion of multi-national fast-food chains into the region; dietary habits across the region have shifted to include more fast foods and less nutrient dense foods. LAC is regarded as the new growth area for fast-food franchises – the market grew 15 per cent over 2012 in Peru alone (Quigley & Altstedter, 2012) and is expected to experience an average growth rate of at least 6 per cent throughout the region (Euromonitor 2014).

Correlations between obesity rates and the prevalence of fast-food outlets have been found in the US – and this links obviously to poor health outcomes and rising healthcare costs (Cummins and MacIntyre 2006). Diabetes is a particular problem: it is the second-leading cause of death in Mexico (Ferdman and Phillips 2013), seventh-leading cause of death in both the US and Canada (CDC 2011). A growing number of countries are passing taxes and other regulations against fast foods, in an attempt to steer people away from high-sugar, high-calorie foods and thus ward off the negative consequences for population health and associated government spending (Guthrie 2013). This may reduce expected long-term growth in the fast food sector.

Figure 1: FAO Map of Global Hunger 2014



Source: FAO 2015

In the face of these challenges, equitable distribution of existing resources is as important as increasing production levels. The UN calculates that current levels of food production are more than sufficient to meet the world's present basic nutritional needs (World Food Programme 2011). If this is accurate, then much current food 'scarcity' is an issue of distribution: as much as one-third of current production is wasted at some point along the supply chain. This may be due to a number of reasons, ranging from post-harvest losses due to poor storage and transport infrastructure (see Box 1) to – taking a broader definition – unequal distribution resulting in over-consumption and post-consumption waste in more affluent regions. Improvements to the institutions and infrastructure that ensure access to food are therefore at least as urgent as the need to expand existing production. While not the primary focus of this report, it is therefore crucial to think not only in terms of food production but more broadly in terms of the entire food system – the 'processing, distribution, preparation, and consumption of food' – and the environmental impact of each step (Carleton 2013).

Chronic under-investment worldwide is a major bottleneck to sustaining production.

The World Business Council for Sustainable Development puts the size of the investment opportunity at an estimated $10 trillion to 2050.

The concept of food security is most often deployed to denote an ideal situation in which 'all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life' (FAO 2009a). The great challenge, therefore, will be to transform the global food system into one that meets the nutritional needs of all in an ecologically sustainable manner.

Against this backdrop, the aim of this report is twofold:

First, in Parts I and II we paint a picture of the state of global food production: in particular, the key demographic and environmental impacts not only on food production, but also in turn by food production on the environment. In doing so, we rely on the latest world-class academic and policy research as well as our own expertise and insights as scholars of financial markets and environmental sustainability. Given the scale and scope of the global food production system, this overview is by necessity a broad-brush one. However, we have taken care to the most pertinent and urgent sources of risk and uncertainty, and to take a more granular view where we feel our points are particularly worth accentuating.

Second, in Part III we point the way to investable solutions to these challenges. We seek not just to describe a series of problems, and so the report fulfills this second aim by presenting a selection of potential sustainable investment opportunities in food production. Given the complexity and scale of the challenges to global agricultural systems, here again we can only hope to curate what we judge to be among the most salient opportunities: not only in terms of the urgency of the issues they seek to address, but also insofar as they represent the 'low-hanging fruit' in this investment space.

Ecological risks facing key classes of food products

Food crops

The Green Revolution has brought with it a number of extraordinary achievements: it has ensured that agricultural productivity gains far outpaced population growth, tripling cereal yields over 70 years while using only 30 per cent more land area. However, industrial agriculture has been blamed for a host of socio-environmental ills, including biodiversity loss, soil nutrient depletion, water and atmospheric pollution, high greenhouse gas emissions, and the destruction of smallholder livelihoods. These conditions are in turn placing great strain on existing production. Along with demand growth, further pressures on current and future supply include competition from other land uses, such as urbanisation and the cultivation of biofuel crops; and the effects of climate change, including droughts, floods, and other extreme weather events.

Box 2: Fertilizers

Current crop production levels cannot be sustained without inorganic fertilizers, which are manufactured from phosphate rock, potash, and nitrogen from natural gas. In the wake of the 2008 commodity price spike, when the price of phosphate rock shot up by 800 per cent, fears of 'peak phosphorus' were widely discussed (Cordell et al. 2009; Cordell 2010). Supplies are in fact adequate to meet demand for several centuries, but we have exhausted most high-grade reserves. 90 per cent of remaining reserves are concentrated in just five countries. Moroccan deposits account for at least half of remaining reserves, and Morocco currently accounts for about one-third of global phosphate and derivative products, a figure that is set to increase over the next decade (OCP Group 2011). Reserves of potash, the price of which rose by 1000 per cent in 2008, are projected to last for up to 1000 years but are even more geographically concentrated than phosphate, with Canada and Russia the top producers.

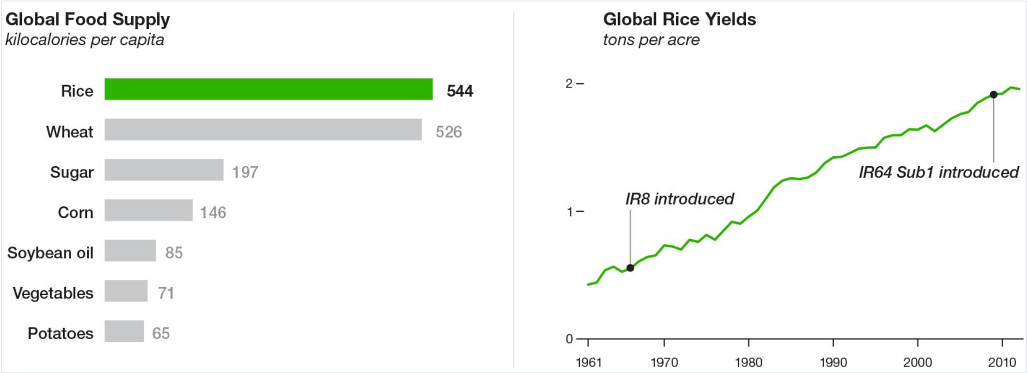
All of these pressures on supply have placed upward pressure on prices as well as contributing to price volatility. The food price increase of 2006-08 is estimated to have pushed 105 million of the world's marginal poor[2] back below the poverty threshold (Ivanic and Martin 2008), while the 2011 food price rise resulted in a net increase of 44 million people living below the extreme poverty line (Ivanic et al. 2011). The presence of financial investors in commodity futures markets is suspected by many market participants and observers to play a role in accentuating short-term price movements. While controversial, this issue has provoked the concern of policymakers, and new regulations governing commodity derivatives have been proposed in the US and the EU. In general, increases in the world market price are transmitted to consumer prices only with a lag of a few months and to a limited degree. By the same token, price volatility has relatively little effect on consumer welfare, although it does have negative implications for producer incomes.

That said, although the food crisis of 2008, in which the World Bank food price index rose by 60 per cent, has been proclaimed as a 'perfect storm' of supply shocks and so is unlikely to recur in the short term, it is considered indicative of what may become a more common occurrence in a 'business-as-usual' scenario. Supply-side disruptions may encourage producers to restrict exports, as occurred in over 30 countries in 2008. Higher prices in developing regions may also lead to civil unrest, as occurred in 61 countries in 2008 (Evans 2010).

One of the key controversies surrounding future crop production concerns which methods offer an optimal balance between ecological and economic sustainability: those typically employed in industrial agriculture, or alternative cultivation methods such as organic farming or agro-ecology. There are increasing concerns about the cumulative shift toward larger, specialised farms and away from family farms. Doubts have been raised about potential impacts on the environment from monocultural cropping and CAFOs, as well as potential impacts on livelihoods of smallholder farmers (Union of Concerned Scientists 2014). Although there is little consensus on the merits of smallholder agriculture for more sustainable production increases, encouraging evidence from China and India strongly suggests that investment in R&D in less-developed regions with smaller average farm size is beneficial for economic growth and poverty reduction (Foresight 2011a, 120). This is a hot-button issue for environmental and political reasons alike. The 'simple' answer is that we will need a blend of both types of technique – though of course, finding that ecologically and socially optimal blend will pose immense challenges.

2 I.e. those living below the World Bank's benchmark daily income of $1.25.

Figure 2: Global food supply and rice yields

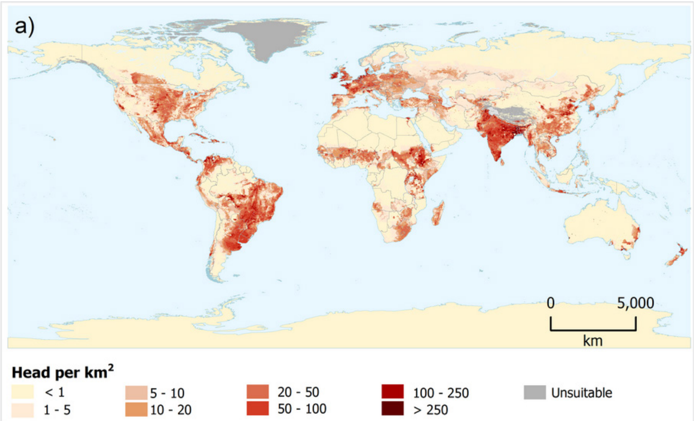


Source: National Geographic http://www.nationalgeographic.com/foodfeatures/green-revolution/

Livestock

Population growth coupled with increasing affluence is increasing demand for meat and dairy products, which are orders of magnitude more input-intensive than crops. Production of meat is projected to more than double by 2050 from its 1990 levels, while that of milk will grow at nearly the same rate. In total, an additional 200 million tonnes of livestock products will need to be produced annually by mid-century (Bruinsma 2009 cited FAO 2012b, ix). Much of this demand growth – up to 80 per cent - will be met by confined animal feedlot operations concentrated animal feeding operations (CAFOs), or 'factory farms' (FAO 2006). However, it is estimated that the impact of both the meat and dairy sectors upon land, water, and atmospheric resources will need to be reduced by half merely to avoid environmental damage beyond present levels (LEAD 2012). This is particularly true of CAFOs, which additionally contribute to the spread of both human and animal

Figure 3: Global distribution of cattle



Source: Robinson et al. 2014

The effects of climate change have placed additional pressure on livestock. For instance, in 2012, a heatwave in the United States resulted in severe drought conditions; many cattle producers were forced to liquidate their herds due to water shortages, while the effects on grassland and feed crops meant that total farmer expenditures on feed increased by $9.1bn (Ray and Schaffer 2011). Such extreme weather events have longer-term negative implications for both food supply (and by extension, consumer prices) and for producer livelihoods (due to higher input costs).

Yet there have been very few credible public policy proposals for curbing meat consumption, given its social and cultural significance. Although 'in vitro' meat grown in laboratories has garnered a great deal of media attention, its current price alone, at $240/lb, makes it far from a viable substitute in the nearer term (van der Weele and Tramper 2014).

Aquaculture and fisheries

85 per cent of the world's fisheries are already overfished or harvested at their maximum sustainable rate, with over half facing shrinking stocks (Costello et al. 2012). The picture is worse for some species than others: stocks of bluefin tuna have declined by up to 96 per cent in some areas (ISC 2012), for example, while those of cod collapsed or came close to doing so in the 1990s and 2000s (NOAA Fish Watch 2013). Here again, the root of the problem is mismanagement, as quota systems such as the EU Common Fisheries Policy are either inadequate or poorly enforced. The recent creation of several marine protected zones may help to alleviate the problem to some degree.

Aquaculture is projected to meet the majority of global demand for seafood in the coming years. While aquaculture as a sector is already growing at an annual rate of 6.1 per cent, it is feared that this will not be sufficient to meet the projected 25 per cent global demand growth for fish to 2030. Further, fish farming is not without its own environmental concerns, including high energy consumption, waste management, and the spread of parasites and diseases. Given controversy over which method of seafood production is most sustainable, the need for a second 'blue revolution' in the sector is clear.

Food-resources nexus: Key ecological risks from food production

Food-energy-climate nexus

Increasing agricultural yields will require greater inputs of fossil fuel-based energy, placing additional strain on these resources and further contributing to climate change.

The entire global food system consumes approximately 4 per cent of available fossil fuel energy resources – but it accounts for up to 30 per cent of total anthropogenic greenhouse gas (GHG) emissions (Foresight 2011b). While estimates of livestock's contribution to GHG emissions range widely[3] there is no doubt that meat and dairy production is a sizable driver of the problem of climate change.

As mentioned, biofuels are already competing with scarce arable land and other resources for food crops. Widely promoted as a form of (literally) green energy only a few years ago, biofuels are now regarded as an additional strain on scarce agricultural production resources that fail to offer net clean-energy benefits.

3 The most widely cited figure is 18% (FAO 2006), but any estimate is highly dependent on assumptions made about deforestation to make way for pasture or feed crop cultivation (Foresight 2011b, 5).

On current trends, biofuel crops could take up 2.5-3.8 per cent of available arable land by 2030 (Cotula et al. 2008). By competing with food crops for land area, water, and fertilizers, biofuels have also placed further upward pressure on food prices. Second-generation biofuels, which are derived from a variety of organic waste products, remain far from being technologically and economically viable alternative energy sources. Yet largely for domestic political reasons, generous subsidies for first-generation biofuels remain in place in the US and EU.

One often overlooked effect of climate change on food availability comes via the effects on crop pollinators, including certain bird species, bees, and other insects. The total annual global economic value of natural pollination is estimated at €153bn (US$213bn), or 9.5% of the total value of food produced in 2005 (Gallai et al. 2009). While land-use pressures from an expanding and urbanising population are already placing stresses on the habitats of these pollinators, once again, changes in mean temperatures and precipitation further threaten their populations.

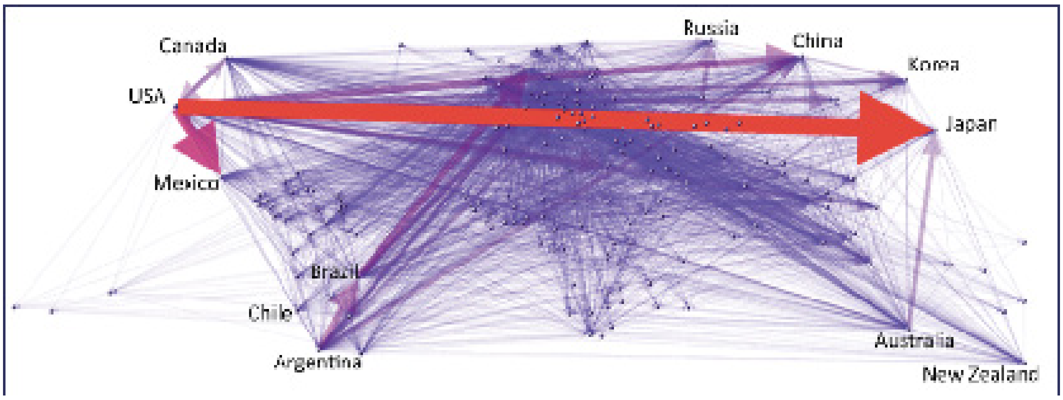
A 2009 survey of farmers by Oxfam revealed that their greatest concerns about climate change were related to changes in natural cycles – not temperature increases. For example seasonal changes have become more unpredictable, which has disrupted farmers' planting schedules (Jennings and Magrath 2009).

Freshwater scarcity

Water scarcity ranks alongside climate change as the great sustainability challenge of the 21st century, and food production is one of the most threatened sectors.

Existing stresses on water resources will also be further exacerbated by efforts to increase yields. Food production already accounts for 70 per cent of global 'blue water' (surface water) withdrawals, and agricultural demand for water is expected to increase by 30 per cent by 2030 (2030 Water Resources Group 2011). In arid regions, unsustainable water withdrawals have depleted aquifers and resulted in high levels of salinity in remaining water resources. Coupled with the effects of climate change on the hydraulic cycle and competing demands from industrial and domestic uses, water is currently the greatest limiting factor to agricultural production.

Figure 4: Map of weighted and directed global virtual water trade network in agriculture



Source: Konar et al. 2011

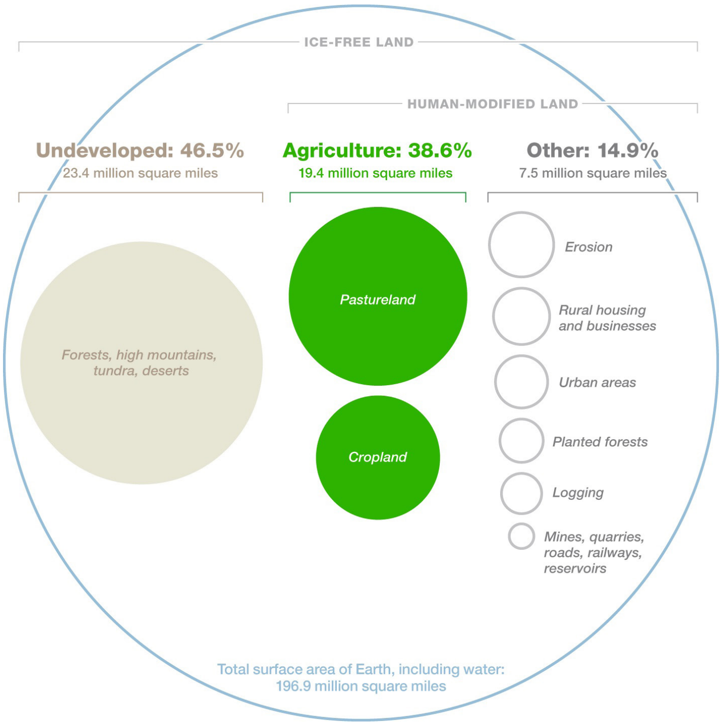
The runoff of phosphate- and nitrogen-based fertilizers poses an additional threat to the world's water resources, as it causes eutrophication (algal blooms) in both freshwater and seawater. If sufficiently large, these algal blooms can deprive other organisms of oxygen, leading to 'dead zones' such as that in the Gulf of Mexico and hypoxic areas in the Chesapeake Bay and Baltic Sea.

Fertile land availability

Along with water availability, the greatest challenge facing food and other types of crop production is a limited supply of fertile land. Yet experts believe that there remains little scope for expanding the earth's existing supply of agricultural land.

Soil erosion remains a longstanding problem in many parts of the world and has a number of drivers, including deforestation, intensive cultivation, and over-expansion of existing agricultural land. Degraded soils require increasingly costly (and, if not managed properly, polluting) fertilizer inputs and endanger future productivity levels. Meanwhile, competition from other types of land uses – many of them associated with growing levels of urbanization – is already placing pressure on existing arable land.

Figure 5: Map of weighted and directed global virtual water trade network in agriculture



Source: National Geographic 2014

The past several years have seen a dramatic rise in the number of land deals in which finance-rich, resource-poor nations – such as various Gulf states, South Korea, and Japan – lease or buy large tracts of land from resource-rich, finance-poor nations – typically in Africa, Latin America, South and Southeast Asia, and the former Soviet Union – and grow food for re-export to the investing country. Various European companies have concluded similar deals to grow biofuel crops in order to meet stringent EU clean-energy targets.

Biodiversity and habitat loss

Through the expansion of cultivated land, monocultural and plantation cropping, and the use of pesticides and herbicides, industrial agriculture also contributes to biodiversity loss. Livestock production in particular tends to encroach on natural ecosystems in many regions. For example, well over 70 per cent of deforested land in the Brazilian Amazon is used for grazing or for growing feed crops such as soy. By the same token, the risks posed by aquaculture to biodiversity include the introduction of invasive species, disease, contamination of the local fish gene pool, and eutrophication of local ecosystems. The destruction of biodiversity, in turn, decreases ecosystem resilience and therefore negatively impacts agricultural production.

Related concerns surround genetically modified organisms (GMOs), which have been shown to affect species- and gene-level diversity as well as entire ecosystems (see Box 3). While it will take many years to assess the long-term effects of biotechnology on biodiversity, much research has suggested that the risks are already evident in the relatively short term, and many countries have taken a precautionary approach by banning imports of GMO products.

Box 3: Genetically Modified Foods

Genetically modified (GM) crops were first grown commercially in 1994, and now comprise roughly 10% of all planted lands. While genetic modification promises to increase yields, investment in genetically modified food carries significant regulatory and reputational risks, particularly over the long-term where uncertainty is greatest. Potential risks include the creation of new or more vigorous pests and pathogens; irreparable loss or changes in species diversity or genetic diversity within species; harm to non-target species and the disruption of ecosystems; and adverse health effects on humans.

Because genetic alterations to organisms or food supplies can readily be traced back to the original intellectual property developer and current owner, the future potential for reputational damage and costly litigation is extensive. Some 64 countries have GM bans or labeling restrictions, and this number is steadily climbing. Retailers and manufacturers are also getting in on the act. For instance, Whole Foods, a supermarket for the rich, plans to introduce GM labeling for all products by 2018, and Ben & Jerry's, a Vermont-based maker of ice-cream, now sources all of its products with non-GM ingredients.

Part II

Regional Summaries

NORTH AMERICA

North America is an agricultural powerhouse: both the US and Canada are major producers and exporters of agricultural products. To sustain its competitiveness, the region will need to invest in climate-resilient agriculture, and to overhaul immigration policy in order to meet demand for farm labour.

1. Current trends in supply & demand

Food crops

The US and Canada are major global producers and exporters of grain: the US is the world's largest corn produer. The most productive agricultural sector in the US is through the Midwest, or 'Corn Belt' (Hatfield 2012). In Canada, agricultural lands are concentrated in the southern portion of the country, the Prairies region (Veeman 2010); in Mexico, predominantly in the north. There is, however, expected to be a downturn in the next few years in agricultural crop exports from this region due to lower prices for bulk commodities and lower global demand.

Livestock

North America is both a leading exporter and importer of animal products, including cattle, pork, and poultry. There is expected to be an increase in livestock, poultry and dairy exports from the region as a whole due to higher global prices, as well as larger volume demand (USDA December 2014).

There is some granularity within the sector, however. For instance, over the past twenty-five years the US cattle industry has been in decline, while the Canadian and Mexican cattle industries have expanded. Most US cattle exports are now destined for Mexican and Canadian markets; the biggest export markets outside of NAFTA include Japan and South Korea (USDA ERA 2014). Both Canada and the US are major exporters of pork products. However, the region has a declining share of the world poultry export market, due to increasing share taken by China and Brazil (Adcock 2006).

Fisheries and Agriculture

The US is the fourth largest exporter of fishery commodities in value, at US$12bn. However, the country is a net importer, with the world's second-largest imports by value (US$21.3bn). Aquaculture has experienced more or less steady growth since the mid-1980s. Although fisheries contribute less than 1 per cent to overall GDP, this sector is the principal economic base for many coastal areas.

Canada is a net exporter of fish

(FAO 2005), although fishery catches have steadily declined over the past decade. Most fisheries are fully developed, so production gains will only come from improvements to fleets. Aquaculture is well established, contributing 16 per cent of total production; but with the potential for growth. Canadians consume 21.3kg of fish per person per annum, significantly higher than the world average.

Mexico's fisheries sector was dominated by anchovy catches until these stocks collapsed in the early 1980s. Aquaculture is minimally developed, relying mostly on inland fisheries. Fisheries contribute only 0.8 per cent of GDP, and this is expected to continue to decline as a result of overexploitation of fisheries in the area (FAO 2003).

2. Historical performance indicators

While there has been an absolute growth in yields experienced throughout North America, there is a declining proportional growth rate, since the same yearly absolute increase is a smaller percentage of the growing base (Veeman 2010). US agricultural output in 2009 equaled only 170 per cent of the 1948 output – an average annual growth rate of 1.63 per cent, which is not very high given the significance of this industry to the region (Yglesias 2012b).

Farms in the USA and Canada have been declining in contribution to the region's national economies since 1935 (Statistics Canada 2014)[4]. Recently there has also been a decline in agricultural trade, as shown in Figure 6 below.

Figure 6: US Agricultural trade, fiscal years 2009-15

Item	2009	2010	2011	2012	2013	2014	Forecast fiscal year 2015	
							Aug.	Nov.
	Billion dollars							
Exports	96.3	108.5	137.5	135.9	141.0	152.5	144.5	143.5
Imports	73.4	79.0	94.5	103.4	103.9	109.2	117.0	116.0
Balance	22.9	29.6	43.0	32.5	37.1	43.3	27.5	27.5

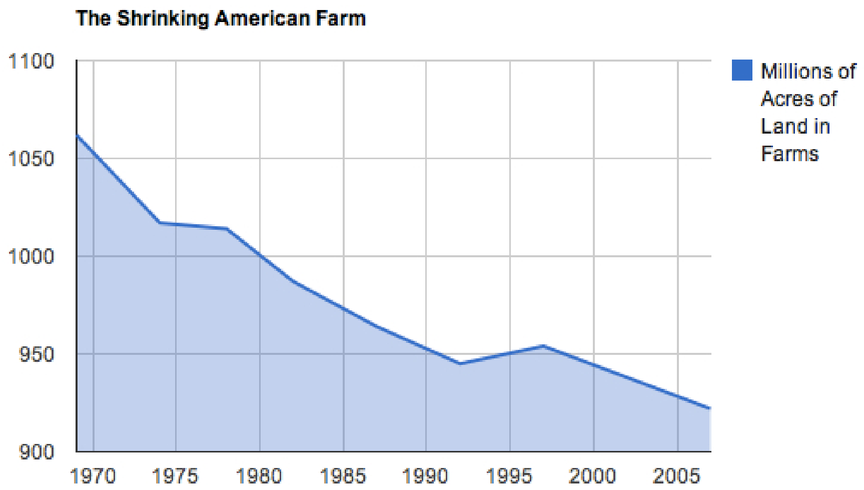
Reflects forecasts in the November 10, 2014, *World Agricultural Supply and Demand Estimates* report.
Source: Compiled by USDA using data from U.S. Census Bureau, U.S. Department of Commerce.

Source: USDA 2014

4 In 2012, agriculture accounted for 1.3 per cent of USA GDP, for 1.5 per cent of Canada GDP, and for 3.5 per cent of Mexican GDP (World Bank 2014).

Moreover, there has been a long-term decline in the quantity of farmland. Over the past 40 years, approximately 125m acres have gone out of cultivation (Yglesias 2012a), which can be seen in Figure 6 below. Less than 1.5 per cent of the total population in the US was employed in agriculture in 2012 – and by 2022, it is expected decline further to less than 1.2 per cent (US Department of Labor 2013). This is largely due to production being concentrated in specialised larger farms rather than mid-sized family-style farms – average farm size has doubled since 1935 (USDA 2014).

Figure 7: Decline in quantity of land under cultivation, USDA Census data



Source: Yglesias 2012a

Although there is an overall trend to larger farm sizes, local produce and direct marketing is increasingly more popular in North America. This has provided smaller farm operations with a more secure market and greater financial security (USDA 2010).

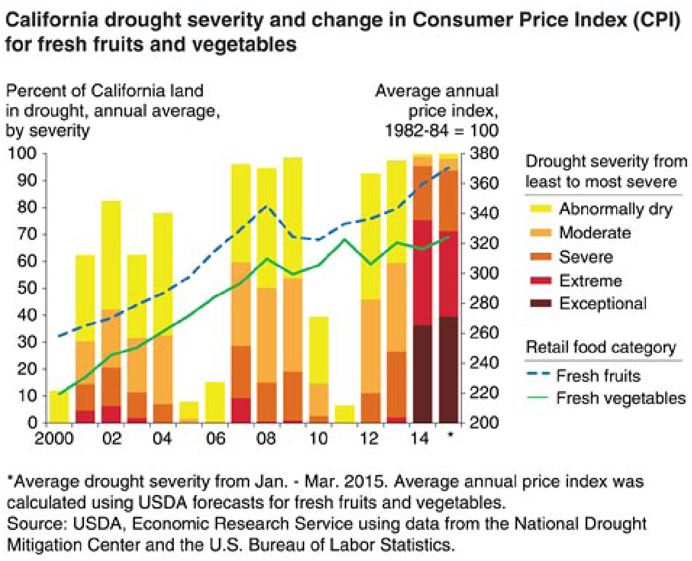
Recent slow productivity growth can be partly attributed to a decline in agricultural R&D spending. Spending has shifted instead to other priorities, including food safety and the environment (Veeman 2010). This shift is partly attributable to public pressure on the farming industry to be more environmentally conscious.

Physical risks

Climate change is a key concern; it will result in unpredictable weather patterns across the US (Resilience 2010). There is evidence suggesting that temperature changes from 1980 to 2008 – potentially as a result of climate change – have reduced crop productivity significantly enough to offset yield gains from technology. Ongoing temperature effects as a result of climate change are expected to have further negative impacts on annual yield.

In particular, the droughts experienced in the USA over the past five years affected more than 80 per cent of agricultural land, severely impacting crop and livestock production. The 2012/13 droughts cost the state of California US$1.5bn and 17,000 jobs, with similar socio-economic effects felt throughout the country. The losses to California's agricultural output as a result of drought in 2014 was $2.2 bn – and in 2015, it's expected to rise to $3 bn. There was a decline of 11% in acres planted in 2014, particularly in corn, rice and cotton. A major new study has predicted that the Great Plains and south-west regions of the USA are facing a decade-long drought far worse than anything experienced until this point, with its foundation in climate change (Cook 2015). This will fundamentally transform agriculture in the region, making it impossible for farmers and ranchers to continue using current production methods.

Figure 8: California drought severity and change in Consumer Price Index (CPI) for fresh fruits and vegetables



Source: Cook 2015

Water unavailability has also been exacerbated by the over-exploitation of aquifers[5]. Water variability is the most important factor affecting agricultural yields, and is a concern for both crop irrigation and animal husbandry (Resilience 2010).

A **declining bee population** has negative effects on crop pollination and may significantly decrease crop output (Grossman 2013).

Competing land uses from urban sprawl in the USA has meant that 23m acres of agricultural land have been urbanised since 1982. This is an on-going threat to small and family farms, which are being driven out of production by this trend (American Farmland Trust 2013).

Regulatory Risks

Agriculture is a highly **subsidised sector**, particularly in the US, with both direct aid payments and insurance subsidies. This is expected to cost US taxpayers over $90bn through the next decade (Lynch 2013). Implications from this include overproduction of certain crops to gain advantages from subsidies, lower prices due to this overproduction and the driving of smaller farms out of business as a result of lower prices making farms unprofitable. Moreover, subsidies are often collected by large industrial farms and do not go to the intended recipients: a study found that 73 per cent of subsidies – US$120.5bn – in the US were collected by 10 per cent of subsidy recipients (Steenblink 2012). This will not promote agricultural or overall economic growth.

Overfishing is a problem facing all of the coastal areas, despite multiple catch limitation plans in place. Management plans in progress should result in the long-term rebuilding of stocks in the US and Canada[6] , although reliable scientific data is required for long-term conservation and management of this sector.

One of the greatest overlooked risks to the competitiveness of the agricultural sector in North America is in the area of labour markets. In particular, there have been some calls for changes in immigration policies, particularly in the USA, to allow a greater number of temporary workers to come into the country from South America. . Seasonal migrant workers make US farms much more cost-effective – and indeed have been described as 'vital' for the industry (Goodman 2014).

5 The Ogallala aquifer, the main underground water source for central USA, is being drawn at rates 1.3tn gallons faster than it can be replaced.

6 For a list of fishery management plans in the US by region, see: http://www.nmfs.noaa.gov/sfa/domes_fish/FMPS.htm

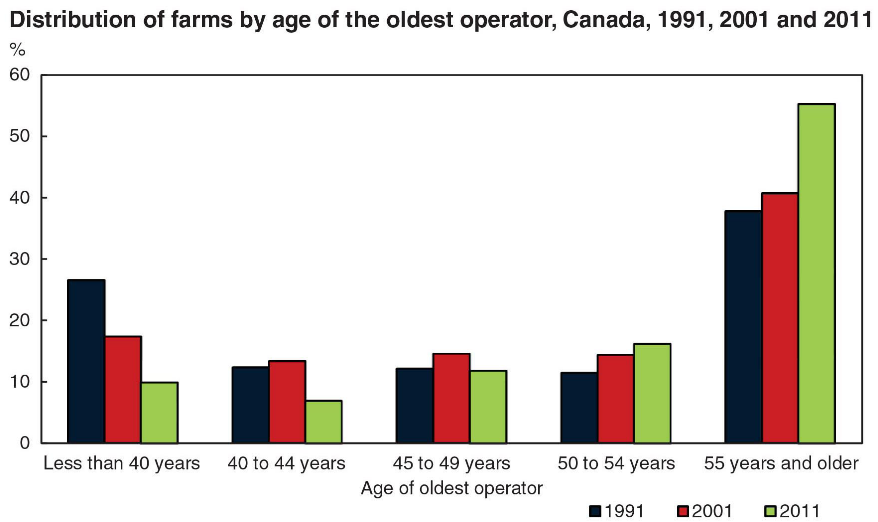
For a list of fishery management multiple plans in Canada by region, see: http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/index-eng.htm

More restrictive immigration policies that are being debated in Congress could thus have serious negative effects on farm output (Associated Press 2011). Labor accounts for 17 per cent of the sector's variable production expenses – though this can be up to almost 50 per cent for fruit, vegetable and nursery farms. Significantly, over the past 15 years, almost half of the workers employed in US crop agriculture were unauthorized migrants, overwhelmingly from Mexico (Zahniser et al. 2012). The National Milk Producers Federation has advised that without its immigrant labor force, milk retail prices would rise by up to 61 per cent. As to arguments about the pressure on social services of migrant workers, the Congressional Budget Office advised that the past 20 years has seen tax revenue generated by immigrants exceeding the cost of services they utilize (Goodman 2014).

Infrastructure risks

There are increasing concerns about the cumulative shift toward larger, specialised farms and away from family farms. Doubts have been raised about potential impacts on the environment from monocultural cropping and CAFOs, as well as potential impacts on livelihoods of smallholder farmers (Union of Concerned Scientists 2014). Changing farmer demographics will mean significant shifts in the long-term future of the agriculture industry (Beaulieu 2014 and US EPA 2013). The farming population in the region continues to age, while those who retire are not being replaced with younger farmers. Moreover, this trend is not always fully reflected in models forecasting agricultural productivity trends. Figure 9 below shows the ageing trend in farming in Canada, which reflects trends in the US as well.

Figure 9: Distribution by age of farms accross Canada



Source: Beaulieu 2014

4. Key Opportunity to Watch: Trade Agreements

Ongoing international trade liberalization will do much to improve the competitiveness of the region's agricultural products in a global market. NAFTA legislation established a free-trade area, which substantially integrated North America's markets, including those for agricultural goods (Zahniser 2015). On-going Trans-Pacific Partnership (TPP) and Transatlantic Trade and Investment Partnership (TTIP) negotiations may create new trade agreements that could be more effective than NAFTA in enhancing intraregional trade, with positive effects on the value of agricultural products. Canada does, however, have high tariff rate quotas on import of foodstuffs outside of North America, with, for example, dairy products facing a 247 per cent tariff (Audet 2013). This has raised prices within Canada and limited international trading.

LATIN AMERICA AND THE CARIBBEAN

LAC currently contributes 13 per cent to world food trade – but there is high potential for this to increase substantially (World Bank 2013).

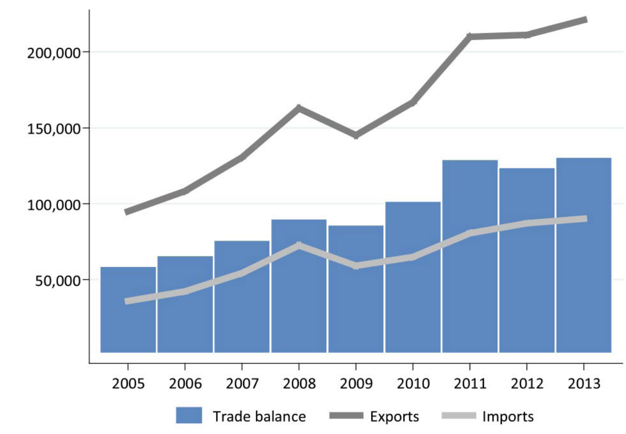
1. Current trends in supply & demand

For the past decade LAC has been a net agricultural exporter, with high levels of both intraregional and global trade. The EU and US account for nearly half of the region's agricultural exports – but even this represents a declining share of LAC's export markets. Not surprisingly, exports to emerging economies are growing in its place (Ziegler 2014), with Asia accounting for a fifth of trade (Hwang 2012). This diversification means that LAC will be better placed to deal with fluctuating global commodity prices.

Figure 10 below shows the increasing trend in food production in the LAC since 2005. If the region maintains its current 2.67 per cent per annum Total Factor Productivity growth rate[7] , as presented in Figure 11, it will be able to meet food demand in the region by 2030, as well as expand export volumes (Ziegler 2014). World Bank forecast models show LAC substantially increasing its share in global agricultural trade by 2050, supplying half of the oilseeds, a third of the meat, and a third of the fruit and vegetables traded worldwide (World Bank 2013).

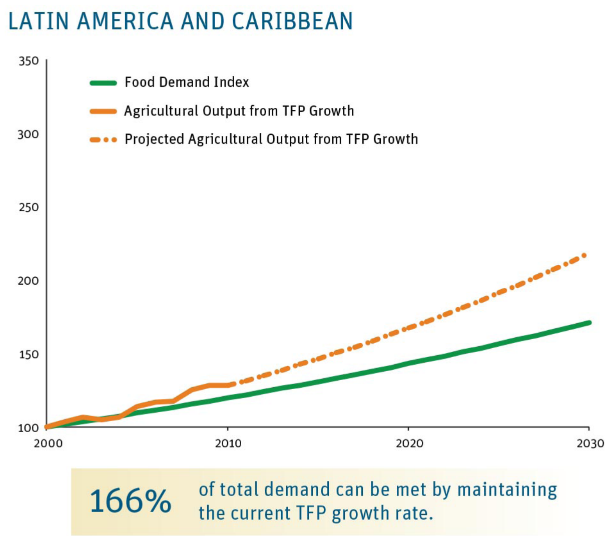
7 TFP is a broad measure of agricultural productivity that accounts for all land, labour, capital, and material resources utilised in agricultural production. It compares these resources with the total output of crops and livestock. When total output is growing faster than inputs, this is an improvement in TFP.

Figure 10: Evolution of agricultural trade in LAC, 2005-2013 (millions of dollars)



Source: FAO 2014d

Figure 11: Total Factor Productivity Growth Rate in LAC



Source: Ziegler 2014

Food crops

LAC's top four crops (in terms of harvested area) are soyabeans, maize, sugarcane, and wheat. The region produces a major fraction of the world's total supply of sugarcane (54% of world's total), coffee (58% of world's total), soybeans (42% of world's total) and beans (29% of world's total). In 2011, LAC accounted for 20 per cent of the world's soybean exports. Brazil is the region's – and the world's – largest beef exporter over the past decade, and this accounts for 27 per cent of the country's agricultural GDP.

Livestock

Livestock farming accounted for 45% of GDP from agriculture in the LAC in 2009 and represented 13% of global livestock production (CEPAL 2009). South America is the global leader in beef exports, at 43% in 2008 – predominantly from Brazil, Argentina and Uruguay. The region is expected to supply up to 60 per cent of the global market for beef by 2020 (Ziegler 2014). There is also rapidly growing demand for livestock products across LAC: for example, pork and poultry both expected to see over 100% absolute increase in annual consumption by 2030.

Fisheries and aquaculture

The fishing industry in LAC is relatively small and oriented predominantly toward the domestic market. The Pacific coast is where the industry is primarily located, with anchovies, tuna, and crustaceans as major products (MBendi 2015). However, though smaller in volume, the Caribbean island countries do derive important foreign currency earnings from their catches (Salas 2011).

Across LAC, coastal areas have considerable livelihood dependency on small-scale fisheries, which are very vulnerable to fluctuating trends in fish stocks. Unfortunately, there has been a decline in catches since the mid-1990s in the LAC region – and many LAC countries are considered to be at their maximum level of exploitation of fish stocks. Increasing coastal populations and demand for fish, coupled with immature governance regimes and poor oversight for fisheries has led to development of an unsustainable fishing industry (Salas 2011).

2. Historical performance indicators

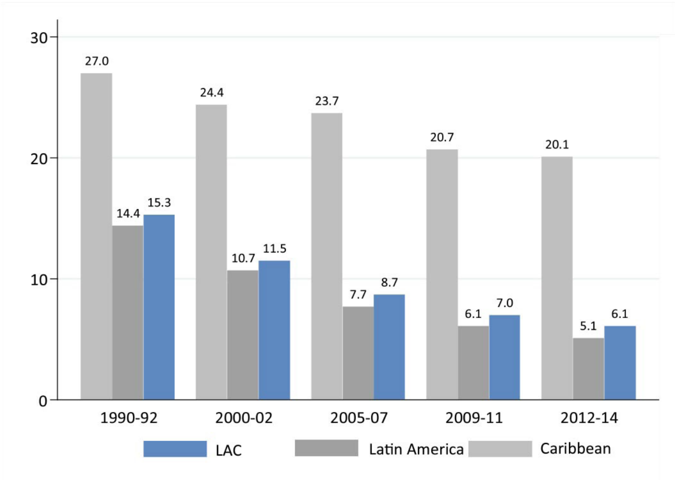
Agriculture in LAC has had slow growth in productivity, with an annual rate of only 1.9 per cent in total productivity between 1961–2007 – compared with 2.4 per cent in OECD countries (IDB 2015).

Total land area under cultivation has grown by a third since 1961, with high potential for further expansion (FAO 2014e). LAC contains 28 per cent of the world's arable land that has been classified as medium to high potential for expansion of cultivation, although it must be noted that 64 per cent of that land is over six hours' travel time to a market (Ziegler 2014).

There are 14m smallholder farmers, who produce over half of the region's food. Family farms account for 80 per cent of all farms in the region, and generate 64 per cent of total agricultural employment (Ziegler 2014).

LAC is the only region of the world to achieve the Millennium Development Goal for hunger – it has halved its proportion of undernourished people since 1990, as seen in Figure 12 below. Only 6.1 per cent of the population, 37.5m people, still suffer from hunger – a 60.3 per cent drop from 1990 levels (FAO 2014d). On the other hand, there are significant differences between Latin America and Caribbean countries in levels of food security. Caribbean nations have much higher proportion of the population still undernourished at 20.1 per cent, compared to Latin America's 5.1 per cent. The only country to have gone backwards in hunger reduction is Costa Rica, from 5.2 per cent in 1990 to 5.9 per cent in 2014 (FAO 2014d).

Figure 12: Prevalence of hunger in LAC



Source: FAO 2014d

3. Risks

Physical risks

Climate change is anticipated to have four main effects on food production in LAC. First, it will exacerbate the climate variability that is already endemic in the region[8], making planning by farmers more difficult and yields less predictable. Second, higher temperatures will result in loss of soil humidity and fertility. Third, changed rainfall patterns and lower overall precipitation will reduce water availability[9].

8 LAC's agricultural sector has two endemic risks – climate variability and price volatility; research has determined that climate factors have a greater impact on economic capital than price volatility (Castro 2014).

9 The shrinking of glaciers, a major source of water for agriculture in some areas, in the region due to climate change has been extensively documented.

Already an on-going drought in Central America has hit hundreds of thousands of people with food shortages and higher prices (Ziegler 2014). Finally, significant loss of biological diversity will impact crop and livestock productivity[10]. The absence of climate-smart agriculture and risk management schemes means that the LAC may suffer mitigation costs of up to 137 per cent of current regional GDP by the end of the century (Ziegler 2014).

Although LAC has the largest area of tropical forest in the world, extensive deforestation has been documented. Latin America has already lost approximately 40 per cent of its original forests, which are critical to reducing climate change effects and preserving biodiversity (IDB 2015). This has been driven mainly by increasing affluence and per capita consumption of resources, leading to expansion of land under cultivation for export-oriented agriculture as well as for soy production, much of which is used in animal feed. Some countries in LAC have been successful in slowing deforestation rates, notably Brazil, which has seen rates of deforestation drop by 18% over 2014 to the lowest rates measured since 1988 (Associated Press 2014).

10 See part I for an explanation of the link between biodiversity and food production.

This is promising, but has to be replicated throughout central South America to have a greater, more lasting effect.

There are concerns for negative effects on the natural resource base as a result of expanding production (particularly by large commercial agricultural ventures) and use of fertilisers, pesticides, and other potentially ecologically disruptive inputs into sensitive marginal lands.

Regulatory risks

The LAC region has demonstrated stability in the political, economic and civic sphere, and has more infrastructure than other developing regions (Ziegler 2014). However, weak institutions have plagued the region for years, and have allowed for widespread corruption and escalating crime rates (Hwang 2012). Increasing murder rates and robbery numbers trebling over the past 25 years, coupled with minimal trust in the justice system, may lead to an upsurge of instability in the future (The Economist 2014). This could have negative effects on agriculture through increasing theft risks – but may also mean that investors shy away from investing in the region's agriculture.

Land tenure regularisation will be important for gaining productivity from small-scale farms. Moreover, the trend of movement of multinational corporations to LAC to make use of a low-wage labour force that is predominantly women will have to be addressed, in order to avoid reputational risk (Timmons Roberts 2013). **Land grabbing** has become an increasing concern in LAC, and is carried out through mechanisms of food security initiatives, fuel/energy security initiatives, and climate change mitigation methods. This is concentrating land and capital into the hands of large single companies and commercial plantations and farms, and away from small-scale and family agriculture (Saturnino 2012).

There are multiple **barriers to markets** participation by family farms – they lack technical know-how, the financial capacity to purchase necessary equipment and inputs, and the capacity to deal with risk. They are also are hindered by poor national infrastructure. Low investment in agricultural R&D and direct subsidies are further obstacles to developing family farms' potential in the region.

Infrastructure risks

The LAC region is responsible for 6 per cent of global post-harvest losses – which amounts to 15 per cent of the available food in the region – due to poor market infrastructure. This waste is enough to satisfy the needs of more than 30m people who are currently undernourished (FAO 2014b).
Improving agriculture-related infrastructure is key to making LAC more competitive; logistics costs are up to 25 per cent of the food product in many countries, compared to 9 per cent for OECD countries (World Bank 2013).

4. Key Opportunity to Watch: Insurance for Climate-Resilient Agriculture

There have been a number of recent developments in the insurance industry with the overall aim of helping Caribbean countries adapt to climate change. By implementing innovative solutions to reduce losses, these initiatives can also build local knowledge and expertise in the insurance industry. For example, Munich RE Group has established a weather-related insurance scheme in the Caribbean, the Munich Climate Insurance Initiative (MCII). This seeks to address vulnerability to climate change through implementation of a risk management insurance system based on a weather index. There are products aimed both at low-income individuals and at lending institutions, to reduce poverty and vulnerability to extreme weather events. There is potential for this approach to be expanded to other parts of the region as well as other areas of the developing world (MCII 2015).

EUROPE[11]

The EU is the world's largest importer and exporter of agricultural products, exporting US$55.6bn of goods (Foresight 2011a). Meanwhile, a number of European countries have been transitioning to greater market orientation and private ownership of farms and agri-business.

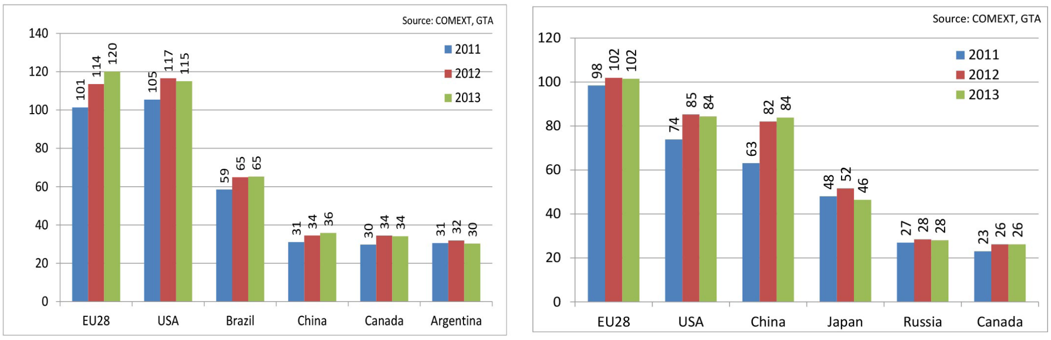
1. Current trends in supply & demand

The EU is one of the world's largest producers of cereal crops. Wheat makes up almost half of total cereals grown, one-third is maize, and one-third is barley. The EU is also a net cereals exporting region (Alexandratos and Bruinsma, 2012), the majority of which are utilised in livestock feed. Europe and Central Asia together accounted for 40 per cent of world's wheat production in 2011 (FAOSTAT, 2014). Russia is a major barley exporter, accounting for 16 per cent of the global export market in 2011, but this is expected to decline in coming years due to drought conditions. For a significant volume of other agricultural goods, Russia has traditionally been a net food importer, and in 2010 had an agricultural trade deficit of US$26bn (FAO 2012b).

Figure 13: Europe as top global importer and exporter

Graph 1: Top 6 world agricultural exporters (€ billion)

Graph 2: Top 6 world agricultural importers (€ billion)



Source: EC Map 2014-01

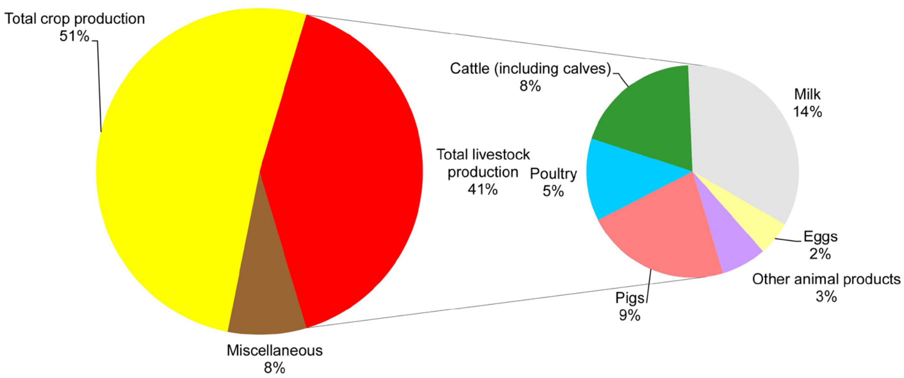
Livestock

Livestock production in the EU accounts for 41 per cent of all agricultural production by value (€169.5 bn). The sector has shown a clear trend over the past 20 years of scale enlargement: fewer but larger farms, also with more animals per farm.

11 For the purposes of this report, we include the member-states of the European Union, and Russia.

There are, however, significant differences between northern and southern Europe, with for example the UK average number of cattle per holding at nearly nine times that of Portugal (FEFAC 2013). Figure 13 overleaf shows the proportions of livestock production by sector in the EU in 2013.

Figure 14: Breakdown of the value of agricultural production in 2013



Source: FEFAC 2013

Livestock production in the EU accounts for 41 per cent of all agricultural production by value (€169.5 bn). The sector has shown a clear trend over the past 20 years of scale enlargement: fewer but larger farms, also with more animals per farm.

Increasing livestock production in Russia was one of the major priorities of the State Programme for Development of Agriculture 2008-2012. The aim of this program is to increase food security particularly through weaning Russia off livestock food imports (FAO 2012a), in part by creating a widespread subsidy program that shares taxes from grain and crop producers as a form stimulus support to livestock ranchers.

Livestock consumption is falling in this region, and per capita meat consumption has been stable since the 1990s; most of the growth in the livestock sector is currently taking place in developing and emerging economies. It is expected that this will not change significantly, as unemployment, stagnant economic growth, and higher meat prices continue to influence meat consumption (European Commission 2013). Projections are that the EU will see only a 3 per cent increase in per capita meat consumption to 85 kg in 2020 (Alexandratos and Bruinsma, 2012).

Fisheries and aquaculture

Production levels in fisheries industry are falling, but the aquaculture sector in the region is growing. Capture fisheries output fell by 3 per cent between 2010 and 2011 to 13.7 million tonnes. This still represents 14 per cent of global production, however. Meanwhile aquaculture grew by 6 per cent. Aquaculture in the region accounts for only 3 per cent of global output (FAOSTAT, 2014), but 20 per cent of fish production in Europe (Environmental Indicator Report, 2014). Russia is the top fishing nation in the region, accounting for nearly a third of the region's production.

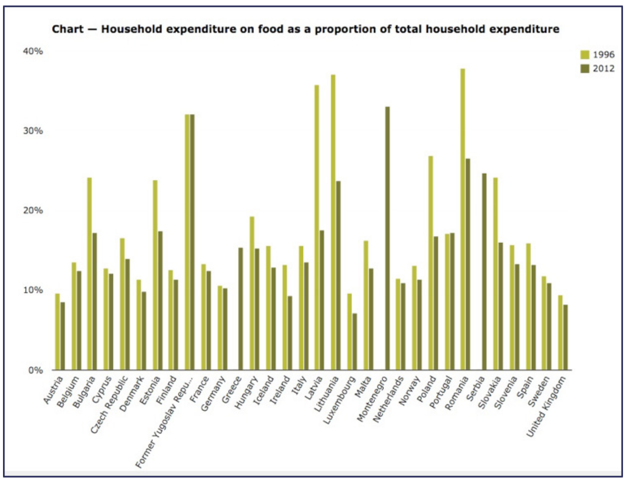
2. Historical performance indicators

Agricultural land has become scarcer over the last 50 years in the region as urbanization increases. European farm policy has sought to respond accordingly to these changes in a variety of ways over time, but the focus is now on economic and ecological competitiveness.

An increasing trend of food imports to the region indicates that most of the environmental impacts related to food consumption in Europe are felt outside the region. Farming in the region has shifted from low to high intensity, threatening loss of biodiversity and increased amounts of greenhouse gases (GHG) being emitted across the food supply chain.

In both Russia and the EU, there has been a decrease in household expenditure for food, as shown in the chart below. This is due to the considerable slowdown in 2012/13 in global economic development affecting disposable income in the EU and Russia. On-going political uncertainties in the Eurozone will influence both demand and supply of agricultural products, given changes in employment and income, as well as availability of agricultural credits and exchange rate changes (European Commission 2013).

Figure 15: Household expenditure on Food in 1996 and 2012



Source: European Environment Agency 2014

3. Risks

Physical risks

Droughts have increased significantly in number and intensity in the EU over the past 30 years, with 20 per cent more people being affected, and at a total cost of €100 bn. Exacerbating this is that at least 40 per cent of water is wasted across the EU due to inefficiency. Agriculture is the primary focus of sustainable water management, as abstraction for irrigation accounts for 24 per cent of total water abstraction in the EU – and can be up to 80 per cent in some southern European countries. Reduction of water availability would negatively affect agriculture across the EU (European Commission Directorate D, 2012). Russia is experiencing similar extremes of weather, and suffered a severe drought in 2012 that ruined small-scale farmers across the country. The government has few plans to put mitigation or adaptation plans into place, with negative implications for Russia's future food security (Oxfam 2013).

As a result of the above, **competition for water** may be exacerbated. Agriculture is a major water consumer, and exports that from the country as 'virtual water' in agricultural products. This will increase pressure on underground aquifers alongside industrial and municipal uses. This has already been happening in southern Spain, and could potentially spread to other areas of the EU (Godfray and Garnett, 2014).

The effects of **climate change** will include significantly more extreme weather events across the EU and in Russia. Northern Europe is predicted to become wetter, and southern Europe drier; Russia will become pronouncedly warmer. This will impact agriculture by shifting the areas in which certain crops can be cultivated, and making agricultural production less predictable. Russia will in fact likely benefit from this change, as more territory will become suitable for crop farming – although more vulnerable to heat waves (Rutten 2012).

Climate change is also likely to reduce fish catches across the region by more than 50 per cent (Caldecott et al, 2013). Aggravating this is the planned expansion of livestock farming across Russia, as this will contribute to greenhouse gas emissions. The EU is aware of this risk, and is taking steps to reduce GHG emissions from livestock – a 2014 European Commission study predicts a reduction of 6.8 per cent in emissions by 2020, with largest decreases expected to take place at beef meat levels (European Commission JRC, 2010).

Regulatory risks

The EU's **Common Agricultural Policy** (CAP) is the major regulatory risk in the EU in a number of ways. It makes up most of the EU's agricultural budget, and moreover nearly 40 per cent of total EU spending is allocated to it. It ensures that EU crops and livestock production is highly subsidised, with two potentially negative results. First, the value of farmland in the UK has tripled over the past 10 years as a result of land subsidies, driving small-scale farmers off the land as it becomes increasingly expensive (Monbiot 2013). Second, subsidies have in past years acted as disincentives to efficient food production, with rising consumer prices as a consequence. This has specifically been an issue in the fisheries sector, where poor management and policy enforcement of the Common Fisheries Policy has led to overfishing and exploitation of fish stocks in the EU (Foresight 2011a).

However, the CAP has recently been revised, with targets in the 2014-2020 policy to provide greater support for family farms. This would be achieved through a redistributive payment for market price support to smaller farms. However, adoption of this policy is optional for member states, and has so far seen limited uptake (Matthews 2013).

There is **high price volatility** of agricultural products in the EU that has been increasing over time. This is demonstrated in the table below, where prices in Germany are representative of prices in the EU, compared to the rest of the world. Such volatility is partly the result of successive CAP reforms that have liberalised trade with countries outside the EU and also reduced market price support. It is also partly the result of volatility in global crude oil prices, and low global stocks particularly in cereal crops (REAS 2010) leading to increased speculation.

Table 1: Coefficient of variation in EU and World prices for various commodities over three periods

	1983-1992		1993-2004		2005-2010	
Commodity	Germany	World	Germany	World	Germany	World
Common wheat	5.56	15.09	10.49	20.53	33.53	25.99
Maize	6.35	17.73	10.98	20.94	26.01	20.23
Sugarbeet	1.08	30.17	4.38	19.49	3.08	27.68
Cattle	4.53	6.93	7.89	15.25	4.85	5.15
Rapeseed	11.82	24.14	14.09	21.19	22.13	25.34
Sunflower	18.36	15.91	8.89	21.08	19.97	42.73

Source: REAS 2010

Russia's recent accession to the **World Trade Organisation** could potentially impact EU trade through tariffs and trade barriers imposed on agricultural imports.

It has recently banned some German meat and dairy product imports as not adhering to a number of Russian standards. As well, there are also high tariffs still in place for cereals, oilseeds, and dairy and meat products (European Commission 2013).

Approximately 65 per cent of vegetable oil production in the EU is used as feedstock for biofuels. The EU is expected to become a major global player, with total biodiesel use projected to reach 24 bn litres by 2019. EU legislation requires that renewable fuel should increase to 10 per cent of total transport fuel use by 2020 (Caldecott 2013). However, the sustainability of expansion of growth in biofuels has been questioned, with concerns about displacement of food crops and effects on the environment and climate change – and it is increasingly accepted that of all oilseed crops, only sugar cane ethanol will play a significant role in future transport fuel mix (OECD/IEA 2010).

Second-generation biofuels are therefore gaining more attention, given the benefits that can be reaped from consuming waste residues, making use of abandoned land, and thus promoting rural development. Some research is taking place on this in the EU, but it has been limited; greater investments should be made in R&D, and partnerships with non-OECD countries should be created as well (OECD/IEA 2010).

Infrastructure and other risks

Farming across the EU is carried out by an increasingly older population, and is declining in popularity as an employment sector. In the UK, the entry rate from 2000-05 was only 2 per cent, while the exit rate was nine times higher, at 18 per cent. The uncertainties of farming and attractive returns in other sectors are cited as reasons for younger generations not becoming farmers. This will have negative long-term implications for farming across the EU (DEFRA 2004).

In Russia and in the former Soviet countries, however, a major infrastructural problem is **ageing farming machinery**. Small-scale and family farmers do not have enough capital to purchase new equipment, so rely on very old machinery – or even human and animal power (Recknagel 2013).

4. Key Development to Watch: Climate-Smart Agriculture

Europe already has a highly productive food system with a well-developed infrastructure. The focus of policymakers is now on agricultural innovation to adapt to and mitigate climate change, under the rubric of climate-smart agriculture.

This will be key to maintaining competitiveness of the region's agricultural products in the global arena.

Four areas of research have been selected as critical to the future of agriculture in the EU: genetics of animals and plants to increase climate change resilience, pests and diseases linked to climate change, adaptive management of water and soil resources, and adaptation of agricultural systems (FACCE-JPI 2014).

Russia is also concerned with climate-smart technological developments, and has budgeted US$790 million for this sector in its 2013-2020 agricultural plan. However, this is only one-fifth of the amount originally requested by the Ministry of Agriculture, with the likely conclusion that Russia will be unable to fully address climate change mitigation and adaptation in the agricultural sector (USDA 2012).

MIDDLE EAST AND NORTH AFRICA

All of the countries in the Middle East and North Africa (MENA) region face moderate to high degrees of food insecurity, with threats from water scarcity and climate change set to grow over time.

1. Current trends in supply and demand

The FAO (2001) has classified the types of agriculture practiced in this region into eight types (see Table 1). Cereal production, predominantly wheat, takes place mainly in the countries along the Mediterranean. In the Gulf Cooperation Council (GCC) countries, low precipitation, high temperatures, and fragile soils prohibit the growth of rain-fed cereals. Horticultural crops, as well as olives, are grown as both rain-fed and irrigated crops (Dixon et al. 2001).

Table 2: Major farming systems of the Middle East and North Africa

Farming Systems	Land Area (% of region)	Agric. Popn. (% of region)	Principal Livelihoods
Irrigated	2	17	Fruits, vegetables, cash crops
Highland Mixed	7	30	Cereals, legumes, sheep, off-farm work
Rainfed Mixed	2	18	Tree crops, cereals, legumes, off-farm work
Dryland Mixed	4	14	Cereals, sheep, off-farm work
Pastoral	23	9	Sheep, goats, barley, off-farm work
Sparse (Arid)	62	5	Camels, sheep, off-farm work
Coastal Artisanal Fishing	1	1	Fishing, off-farm work
Urban Based	<1	6	Horticulture, poultry, off-farm work

As of the turn of the millennium there was anticipated to be considerable scope for expanding the area of land under cultivation, which in 2001[12] accounted for 76 per cent of total potentially cultivable land (Dixon et al. 2001, 92).

Livestock production primarily comprises range-fed small ruminants such as goats and sheep. By global standards, protein food demand in MENA is at moderate levels. However, demand for all types of livestock products is projected to grow at rates comparable to, if not in excess of, those in Asia: demand for beef, mutton, and milk will roughly double to 2030 (from a 2000 baseline), while that for poultry will rise by nearly 250 per cent (FAO 2011).

Although the MENA region accounts for only a small share of global fish production, at just over 2 per cent and with Egypt, Iran, and Turkey together accounting for the majority of production (FAO 2014c), demand growth has been high; average annual per capita seafood production stood at 9.9 kg in 2010. Aquaculture has experienced high output growth rates in recent years: while accounting for only 21 per cent of total seafood production in 2001, by 2011 that figure had grown to 44 per cent (ibid).

12 This is the most recent year for which figures are available

In the GCC member countries, 80-90 per cent of food demand is met via imports (Bailey and Willoughby 2013). Meanwhile various sources of geopolitical instability, including the threat of trade sanctions and the insecurity of vital supply routes such as the Strait of Hormuz, add still further to the vulnerability of these countries' food supply.

2. Historical performance

By far the greatest bottleneck to production in MENA is water scarcity (discussed below), given that the region is characterised by arid and semi-arid climates. High temperatures and a relative lack of arable land are further constraints on productivity. At the same time, historically top-down planning systems have discouraged innovation and diversification in agriculture. Agricultural extension services have also been under-resourced and often fail to reach smallholder farmers (Dixon et al. 2001).

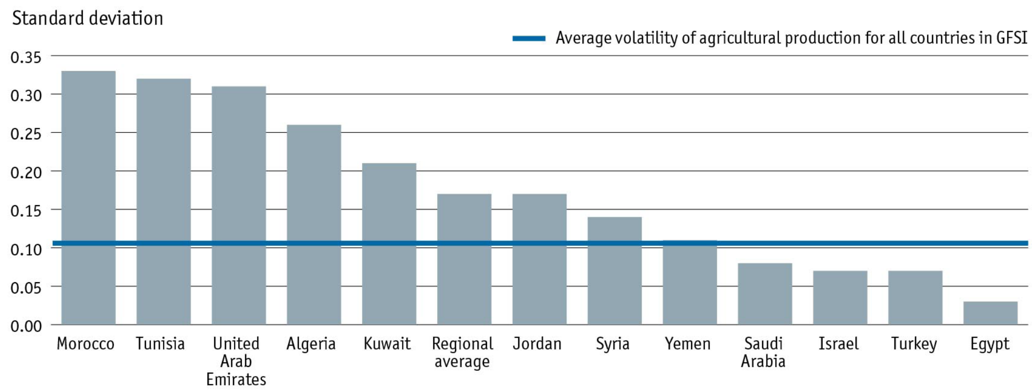
While prevalent, smallholder agriculture often does not provide a sustainable livelihood for many families. Bottlenecks here include centralised planning and policies which have long favoured urbanisation and the allocation of resources to urban populations; lack of information on potential foreign markets; lack of access to credit; trade liberalisation which favours large agribusiness; and poor agricultural extension services. As a result, many smallholder farmers have had to diversify their sources of income through non-farming activities (Dixon et al. 2001, 94-6).

3. Risks

Physical risks

As mentioned, water scarcity is the limiting factor in food production in MENA. Agriculture accounts for 83 per cent of total water withdrawals, in contrast to the 70 per cent global average (FAO 2009c). About one-third of agricultural land is irrigated – a source of considerable risk in an area with only 1.4 per cent of the developing world's annual renewable water sources but only 50 per cent irrigation efficiency[13] (Dixon et al. 2001, 92). 58 per cent of available water resources are used for irrigation, and many countries' withdrawal rates are greater than the rate of recharge for natural aquifers (ibid.), particularly in the GCC countries. Unpredictable rainfall means that agricultural production fluctuates from year to year (see figure 15).

Figure 16: Volatility of agricultural production in the Middle East and North Africa



Source: Economist Intelligence Unit 2014

Climate change has exacerbated existing environmental challenges to food production. . One study by the International Food Policy Research Institute (Nelson et al. 2009) estimates that climate change could reduce wheat yields by 20 per cent, rice yields by 30 per cent, and maize yields by 47 per cent. Extreme weather events,

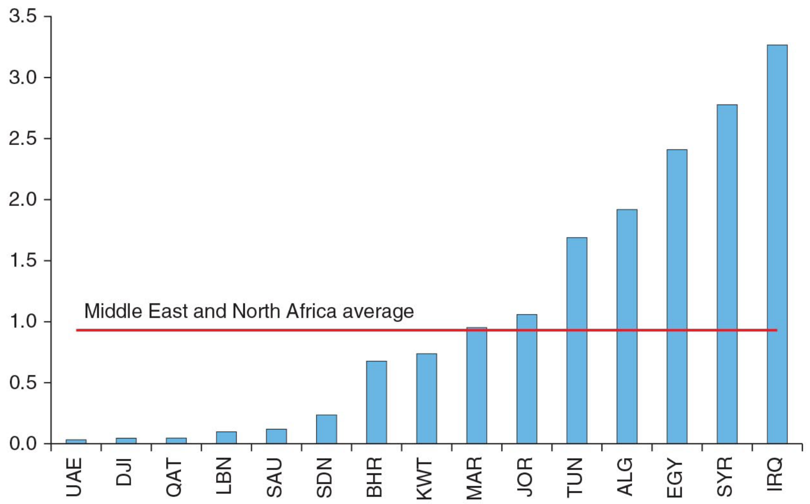
13 This refers to the proportion of water that reaches from its source to the root zone of plants rather than being lost in transit (Brouwer et al. 1989).

including floods and droughts, are predicted to become more common, and storms in major waterways in the Gulf region could result in supply disruptions at key ports.

Regulatory risks

Food price subsidies, while less costly than energy subsidies, still accounted for 0.7 per cent of GDP in the region (Sdralevich et al. 2011), albeit with significant country-by-country variation (see Figure 16). However, removing or decreasing subsidies may be a political non-starter. In many MENA countries, as elsewhere in the developing world, rising food prices are regarded as a key risk leading to social unrest, political instability, and in some cases even violence. Indeed, a spike in the price of wheat has been pinpointed as the spark that ignited the Arab Spring.

Figure 17: Food subsidies in MENA countries, per cent GDP, 2011



Source: Sdralevich et al. 2011

Meanwhile, f**ood production subsidies** are also a drain on states' fiscal resources. In Saudi Arabia, wheat production subsidies are estimated to have cost the government at least $5bn per annum from 1984-2000, or 18 per cent of oil revenues – all to produce wheat at quadruple the prevailing global market price (Elhadj 2008). Data is scarce, but subsidy levels are also high for horticulture, dairy, and livestock production.

Centralised planning has also had implications for environmental risks. For instance, provisioning of water resources tends to favour urban areas, while national livestock policies encourage overstocking and thus overgrazing of relatively fragile grassland ecosystems (Dixon et al. 2001, 96).

Overseas farmland investments, in which finance-rich, resource-poor nations such as various Gulf states lease or buy large tracts of land from resource-rich, finance-poor nations – typically in sub-Saharan Africa, Latin America, South and Southeast Asia, and the former Soviet Union – and grow food for re-export to the investing country. These investments have been decried as 'land grabs' for what is frequently taking advantage of unclear land tenure rights and a failure to compensate locals adequately, and so are associated with operational as well as reputational risks. In principle, however, there does exist great potential for local benefit sharing in the form of knowledge and technology transfers, as well as more equitable wealth distribution (Cotula et al. 2009).

Infrastructure risks

Infrastructure for efficient water delivery and storage for agricultural uses is severely lacking in the region. As noted above, inefficient irrigation systems result in 50 per cent water losses, exacerbating the over-exploitation of groundwater resources. At the same time, the region relies on large-scale dams for much of its storage, though most of these dams were built in a period before the impacts of climate change became significant.

Likewise, **post-harvest transport, storage, and marketing infrastructure** has significant scope for development. Refrigeration is of course especially crucial, and in turn requires high energy inputs. While this is currently unproblematic in an oil-rich region, meeting these needs in a sustainable manner will require a wider transition to non-fossil fuel energy systems.

Strategic stockpiling of essential foodstuffs is also costly, albeit generally less so than domestic production. In Saudi Arabia, for instance, storage of a year's worth of wheat is estimated to cost $70 million (as against the $5bn in domestic production costs noted above) (Elhadj 2008).

4. Key Opportunity to Watch: National Food Security Strategies

A handful of governments in the region have comprehensive food security policies. In the UAE, governments have pushed hard for sustainability planning to ensure local food and water security. Abu Dhabi's Vision 2030, a comprehensive long-term plan for urban sustainability, included a campaign to achieve 40 per cent fruit and vegetable self-sufficiency while cutting water use by 40 per cent to 2013 (Malek 2011). For its part, Qatar has set an ambitious target of achieving 70 per cent food self-sufficiency by 2023 (Bailey and Willoughby 2013). In Morocco, Plan Maroc Vert, the national agricultural strategy, has the threefold objective of increasing the value of agricultural production in an environmentally sustainable manner while improving rural livelihoods. Investment in Moroccan agriculture has doubled in the past five years as a result (Denis et al. 2015). One key to the success of such programmes is the development of the agri-tech sector (see part III).

In parallel and throughout the MENA region, various water efficiency and reuse technologies are being developed, although none has yet been proven. Examples include the following:

- Hydroponic farming relies on nutrient-rich water rather than soil. Most hydroponic operations are still small-scale, however, and data on both existing investments and future capital requirements is scarce.
- Drip irrigation (also known as micro-irrigation) is generally thought to be more efficient than traditional spray irrigation. Contrary to this common belief, however, it has been found that runoff from spray irrigation, rather than being 'wasted', in fact seeps back into groundwater reserves and thus increases recharge rates (Ward and Pulido-Velaszquez 2008).
- Similarly, desalination plants – of which 70 per cent of the global total can be found in MENA – generate significant negative environmental externalities such as high energy use and increased ocean salinity (Cooley and Heberger 2013).
- The potential for wastewater recycling is limited by religious restrictions[14] (Nasr and Kaldjian 1997).

14 There is a widespread belief that Islam prohibits the reuse of wastewater, although many dispute the basis for this (see Farooq and Ansari 1983; Abu Madi and Al-Sa'ed 2014).

SUB-SAHARAN AFRICA

Agriculture accounts for at least a quarter of this region's GDP and provides two-thirds of the population with full-time employment. Yet the region remains highly dependent on food imports, and the proportion of people living with chronic hunger in the region hasn't changed over the last 20 years.
1. Current trends in supply and demand

Food crops

Increasing imports of cereals indicate the inability of domestic agriculture production to meet the demands a growing African urban community is creating. For instance, West Africa now accounts for one-fifth of world rice imports (African Progress Panel, 2014).

The daily per capita consumption of cereals has only increased modestly since the early 1980s. Wheat consumption is predicted to increase in the region while it drops in other countries across the world. Coarse grains account for 69 per cent of food consumption of some cereals in SSA; this is the mainstay of diets (Alexandratos and Bruinsma, 2012). There has been a decrease in the consumption of pulses, mostly due to changes in consumer preferences and the failure to promote these crops. In the DRC, Congo, and Rwanda staple crops are roots and tubers, with consumption at over 50 per cent. This high dependence is expected to continue to account for over 30 per cent of total consumption into the 2050s (Alexandratos and Bruinsma, 2012).

Livestock

Per capita consumption of meat and dairy has remained low, at 50 to 100g per person per day (Rakotoarisoa et al., 2011). As in other regions, the consumption of meat is expected to increase.

In 2011 total meat production in the region comprised of beef and buffalo meat (39.2 per cent), pork (7.7 per cent) and poultry (5.4 per cent) (FAOSTAT, 2014). The increase in meat production over the period of 2000-2011, at 3.4 per cent, was comparable with North Africa (3.6 per cent).

Fisheries and aquaculture

West Africa and East Africa had the highest SSA regional growth rate 3.4 per cent and 2.7 per cent respectively of fish production in the region, over the period of 2000 to 2011 (FAOSTAT, 2014). The growth of capture fish production in Southern Africa and Central Africa has dropped during the same period at a rate of 1 per cent and 0.9 per cent respectively. The growth in aquaculture in the region is mostly concentrated in East Africa (27.2 per cent) and West Africa (21.0 per cent).

2. Historical performance

Historically, agricultural yields in the region have been constrained by limited access to inputs (fertilizers, land, and water), slow transfer and adoption of technology, insecurity, conflicts, and natural disasters (Rakotoarisoa et al., 2011). Large areas across the region consist of agro-ecological conditions are suitable for the growing of roots, tubers and plantains, which are the mainstay in a number of countries. Alexandratos and Bruinsma (2012) amongst others mention this as one of the reasons for the persistence of poverty as reliance on these starchy foods has hampered progress on the diversification of other foods.

In the early 1980s the region had an almost balanced agricultural trade, with exports and imports at US$ 14bn. By 2007, agricultural imports exceeded exports by US$ 22bn (FAOSTAT, 2011). These imports have been for basic foodstuffs such as dairy products, edible oils and fats, meat and meat products, sugar, and cereals.

Lack of development in the sector has led to most production constrained to smallholder farming. Meanwhile the share of those working in the agricultural industry has declined by 10 percentage points largely due to rural to urban migrations. This threatens the necessary human capital and agricultural research essential for growth in the industry. Agriculture in the region has been neglected for several decades by policymakers, although governments are shifting their attention towards agricultural development in hopes of harnessing what has been labeled Africa's blue and green revolutions[15] .

3. Risks

Physical risks

Climate change and climate variability will compound the challenges for agricultural development (Thornton et al, 2011), Much of SSA will undergo a loss in growing season length, while part of East Africa may see moderate increases in the growing season. However, there is much uncertainty

15 See African Progress Panel report of 2014.1983; Abu Madi and Al-Sa'ed 2014).

surrounding these estimations (Thornton et al, 2011). The impacts of agriculture production in a warming world in the region threaten current crop and livestock varieties, with current agricultural practices being inadequate for resilience. Southern Africa experiences one of the highest climate variability in the world.

Increased stress on freshwater resources in the region is expected, as food production has a great impact on freshwater ecosystems, coupled with poor infrastructure for water management in a number of countries.

Unsustainable production practices and desertification in agro-pastoral regions are leading to decreasing soil quality and loss of biodiversity. Approximately 2600 plant species, 2000 fish species, and 811 bird species are threatened (FAOSTAT, 2014).

Regulatory risks

The region faces a governance challenge over control of increasing areas of agricultural land. It is estimated that there will be an additional 51 million hectares of arable land by 2050 (Alexandratos and Bruinsma, 2012). The challenge over land will be influenced by past and future land-purchase and leasing agreements involving both foreign sovereign wealth funds and private companies (Foresight, 2011; see also section II.4 of this report).

Illegal and unregulated fishing cost West Africa US$1.3bn a year. It is estimated that losses related to illegal logging on the continent are up to US$17bn every year.

Infrastructure risks

Poor infrastructure development hampers progress in the agriculture sector (Thornton et al, 2011). No other region has less developed road networks and energy systems. Infrastructure such as roads, ports, irrigation, storage facilities and information and communication technology continues to hinder development.

A combination of low per capita food consumption and high population growth rates leads to constraints on food security. Major uncertainties still exist as to the degree to which food consumption in the region will continue to rise as population grows (Foresight 2011a).

Urbanisation presents risks as well as opportunities; leading both to the depopulation of rural areas threatening rural food production while creating infrastructure challenges in new cities. Unprecedented growth in sub-Saharan Africa is largely expected in urban areas (Thornton et al., 2011). By 2030, one half of Africans will live in cities creating markets for agricultural products and opportunities to link urban and rural markets (African Progress Panel, 2014).

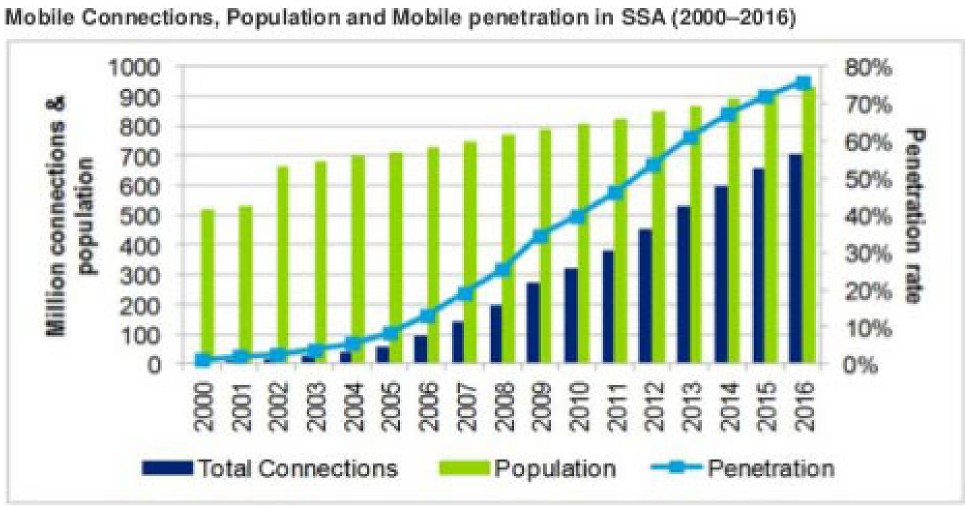
Armed conflicts have led to large numbers of displaced people. In 2011, the region had approximately 3 million refugees. Conflict in the Horn of Africa coupled with severe drought has led to a major food crisis in the area.

Weak financial systems continue to weaken African markets. Financial exclusion includes the lack of access to insurance for African farmers.

4. Key Opportunity to Watch: Mobile Technologies for Better Production

The region has witnessed an acceleration of mobile phone use (see figure 17) and has been dubbed the 'mobile continent'[16] . There are nearly 950 million mobile phone subscribers across the continent. As a result, a range of mobile technology is being developed to assist with agricultural production, increased access to information on best practices and new techniques, and market-related information. The use of mobile banking is also spreading, creating opportunities for the use of innovative insurance products. The role of mobile phones is impacting nearly all of life in Africa, providing opportunities for increased efficiency of smallholder markets, allowing for the easy transfer of money, and access to valuable information for best practices in farming.

Figure 18: The use of mobile phones on the African continent, 2012



Source: World Bank (WDI)

Some examples of innovative uses of mobile technology in farming include the

16 http://www.ssireview.org/articles/entry/the_mobile_continent

the following:

- ‘M-Farm’ in Kenya connects farmers in a virtual space and assists them in collectively buying inputs from manufacturers, and selling produce to the market.
- Through ‘farmerline’, Ghanaian farmers are using voice and SMS messages to collect data, share new farming techniques, and link up to other actors in the agricultural value chain (African Progress Panel, 2014).
- African farmers are able to receive subsidized vouchers for seeds and fertilizer with ‘e-wallet’ in Nigeria.
- Livestock insurance schemes that are weather-indexed, where policy holders are paid in response to negative climatic events (abnormal rainfall), have been piloted in Kenya using public-private partnerships.

ASIA

China and India have been called ‘new food superpowers’ (Foresight 2011a, 14) given the size of both their exports and their rapidly growing domestic markets.

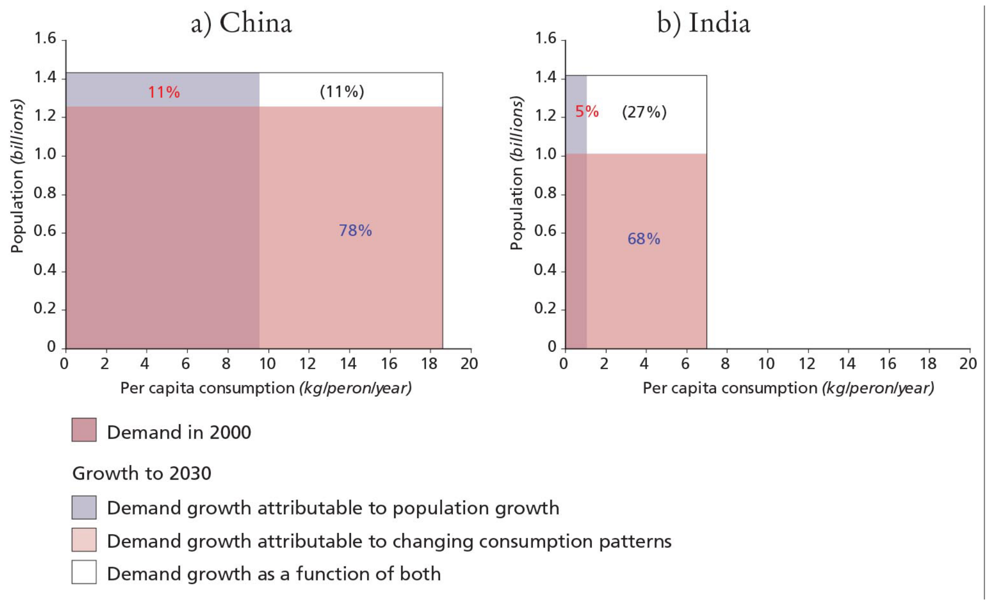
1. Current trends in supply and demand

Per capita food consumption in East Asia rose 41 per cent and by 13 per cent in South Asia between 1969-2005 (Foresight 2011a, 51). Cereal demand is expected to grow by 34 per cent in East Asia and 73 per cent in South Asia to 2050 (from a 2000 baseline), with much of this additional demand coming from animal feed (Msangi and Rosegrant 2011, 70).

While Asia is the most significant source of global food demand growth, it is also a major producer of food crops, livestock, and fish. The economic importance of exports varies greatly by country. Overall, China is a net food importer while India is a net exporter.

One of the greatest challenges facing agriculture in Asia will be satisfying a rapidly growing demand for meat (Foresight 2011a, 52). The greatest demand growth will be in pork and poultry – both of which are relatively resource-efficient to produce – although (largely for cultural and religious reasons) there is significant geographic variation in consumption patterns, both in terms of overall consumption and by type.

Figure 19: Demand growth for poultry meat in China and India, 2000-2030



Source: Robinson and Pozzi 2011

In China, meat consumption grew from 9kg to 50kg per person per year over a 30-year period (Alexandratos 2011), and while this demand growth is expected to diminish slightly as China makes the transition from middle- to high-income economy, it will still account for much of the demand increase for livestock products in Asia. By contrast, annual per capita meat consumption in South Asia is relatively low even by developing-country standards, standing at about 5kg per person per year in 2000, and is projected to triple by 2050 (ibid.). On the other hand, demand for poultry is projected to grow at a rate of 725 per cent to 2030 (Robinson and Pozzi 2011), and demand for dairy products in India will grow by about 125 per cent to 2030; for eggs, by 300 per cent (ibid.).

Asia, led by China, already dominates fish and seafood production. Fish consumption in this region, particularly parts of East and South Asia, is expected to increase at a similar rate to other protein-based foods, and the majority of demand will be met through aquaculture (Foresight 2011a, 53).

2. Historical performance

Here as elsewhere in the world, deep-rooted cultural and religious customs remain a pervasive influence on consumption patterns. For instance, while regular meat consumption is considered a hallmark of affluence in China, 40 per cent of the population in India are vegetarian for religious reasons.

At the same time, there are exceptions to 'Bennett's law' that protein (along with fat and sugar) consumption rises along with per capita GDP: nomadic groups in Central Asia and elsewhere with a pastoral lifestyle have traditionally relied primarily on meat and dairy products for the bulk of their dietary needs (Foresight 2011a, 52-3).

Demand growth for food crops since 1960 has been met without expanding the area of land under cultivation (ibid., 55), and there is little scope for further expansion given that 60 per cent of the world's population lives in Asia (Fischer 2011, 104). Fertilizer inputs have historically been high, particularly in China, as they are heavily subsidised.

As elsewhere in the world, livestock production poses one of the greatest sustainability challenges in Asia. Overexploitation of fish stocks is also problematic throughout the region, notably in the South China Sea, where it is recommended that fishing drop by 50 per cent to restore fish stocks to sustainable levels (GIWA 2006).

Although there is little consensus on the merits of smallholder agriculture for more sustainable production increases, encouraging evidence from China and India strongly suggests that investment in R&D in less-developed regions with smaller average farm size is beneficial for economic growth and poverty reduction (Foresight 2011a, 120).

3. Risks

Physical risks

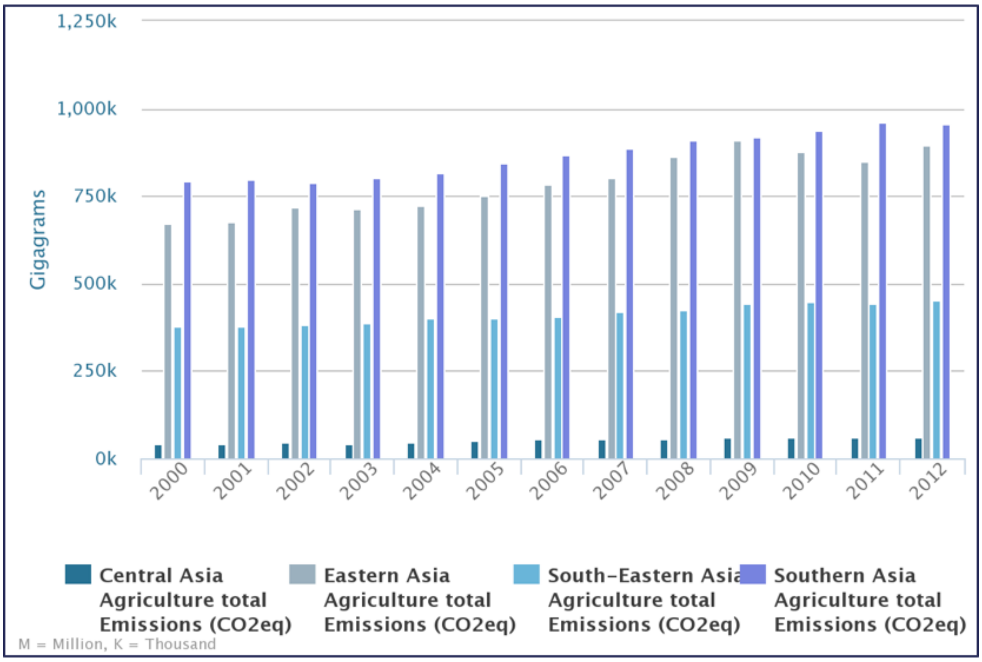
Here as elsewhere, **competing land and resource uses** pose a threat to agricultural production. This is especially true of water resources. For instance, intensive water use in India's coal mining industry has resulted in the diversion of water from agricultural uses.

Deforestation is also a significant ecological risk. Tropical forests are threatened by demand for palm oil products: in Indonesia, it is estimated that 9 million hectares have already been converted to palm oil plantations. The Indonesian government plans to convert a further 18 million hectares by 2020 (Rainforest Action Network 2012), with all the risks that natural habitat loss and monocultural cropping entails. In arid and semi-arid regions, such as northern China, deforestation has contributed to desertification. Joint forest management programmes in India and Nepal have been successful at preventing deforestation (Foresight 2011a, 84).

The impacts of climate change on agricultural production, and in turn of agriculture on climate change, vary greatly by geography and food type.

One of the most significant sources of greenhouse gas emissions will come from increased livestock production, as already noted. Climate change is expected to intensify the hydrological cycle in, for example, India, with lower precipitation during the dry season and higher levels through the rest of the year (Gornall et al. 2010). China, Vietnam, India, Bangladesh, and Myanmar are all projected to be at significantly higher risk of tropical storms (ibid.).

Figure 20: Total emissions from agricultural production by Asian region, CO2 equivalent, 2000-2012



Source: FAOSTAT

Box 4: Palm Oil [17]

Palm oil is the most produced and traded vegetable oil, surpassing soybean oil in volume, its closest competitor, since 2006. This dominance has been due to its high yield per hectare (5-10 times more productive than other oils), low cost of production and its substitutability for most other oils. It is now considered to be the marginal vegetable oil on the global market. Average oil palm yields at present range from 3-3.6 tonnes/ha; however, yields of 5-6 tonnes/ha are already achievable if not more idealistic volumes of 8-9 tonnes/ha in the future.

17 SThis information box on palm oil has been prepared by Dr Alexandra Morel, post-doctoral researcher at the Environmental Change Institute (ECI) at the School of Geography, University of Oxford.

This yield gap is primarily due to low quality planting material among smallholders and has been identified as a clear target for meeting projected vegetable oil demand growth. Palm oil is also a preferred input for processed foods, because of its favorable chemical properties, linking its demand growth to increasing incomes and changing diets driven by rapid urbanization.

While crude palm oil (CPO) is relatively cheap to produce, its recent drop in prices has been affecting its profitability. At the same time, the sector's heavy reliance on manual labor, averaging 5 workers per hectare, has made the industry vulnerable to rising labour costs. The main importers of palm oil are India, China, Europe and North America, in order of importance by volume. India is the most price sensitive market, with a preference for CPO from Indonesia. China imports mostly refined palm oil (RPO) from Malaysia. Europe and North America are importing palm oil primarily as an input for processed foods. These markets are the most sensitive markets to environmental and social problems exacerbated by oil palm expansion.

Environmental and social concerns around palm oil production are manifold, including: significant carbon emissions from clearing tropical rainforest and draining and planting on peatlands; regional health effects for ASEAN countries from large-scale forest fires on industrial plantations; biodiversity loss due to replacement of tiger, orang utan and rhino habitats and conflicts with local communities by perceived illegal "land grabs" by large oil palm corporations.

There have been many efforts to address this reputational risk of the palm oil sector through a series of sustainability certification schemes and socially responsible reporting mechanisms. The Roundtable on Sustainable Palm Oil (RSPO) is one of the most visible schemes; however, it has suffered from external criticism. In the RSPO's current iteration, it lacks any greenhouse gas (GHG) reporting requirements and suffers from poor oversight mechanisms for ensuring members are meeting their commitments. Also producers of certified sustainable palm oil (CSPO) complain they are not receiving an adequate premium, partially caused by an overproduction of CSPO with little more than 54% of available CSPO being bought.

Further confusion has been created for investors by the Indonesian government deciding to develop their own, mandatory, certification scheme called the ISPO. They blamed the slow progress of the RSPO for this development. On the other extreme, because RSPO members could not agree on any GHG principles to include in the scheme, companies, such as Wilmar, have partnered with environmental NGOs to develop independent transparency initiatives showing their commitment to zero deforestation.

Regulatory and other risks

Subsidies to both production and consumption remain in place throughout the region, although in some cases governments are exploring alternative policies. For instance, wheat prices are currently subsidised in India but may be replaced by conditional cash transfer programmes, which may prove a more effective measure against food poverty (Foresight 2011a, 122). In China, some subsidies to production have proven wasteful and environmentally damaging: for example, fertilizer price support has encouraged over-application, which has led to widespread freshwater pollution.

Weak property rights are an obstacle to increased agricultural production in many countries. By contrast, land tenure reform in China has been cited as a key driver in that country's greater agricultural productivity (Bruce and Li 2009 cited Foresight 2011a, 84).

National food security policies vary by country; while many countries embrace more open global trade, others, most notably China, actively pursue self-sufficiency. In both China and India the historical memory of famine remains a strong influence on food security policies. A more immediate trade risk may be the imposition of export quotas, tariffs, or outright bans in the case of crop failures, as occurred for example when both Vietnam and India imposed rice export restrictions in 2008 (Childs and Kiawu 2008).

Although much work has been done by NGOs and the public sector to mitigate the causes of overfishing, as noted above, much work remains to ensure that fisheries in Asia be managed in a more sustainable manner. In traditional fisheries, in many cases the establishment of clear community-based property rights and common management practices has reduced overfishing (Foresight 2011a, 84).

At the same time, in many parts of this region, **malnutrition and hunger** remain persistent problems (Foresight 2011a, 9, 117). South Asia ranks alongside sub-Saharan Africa as the part of the world where chronic hunger is most acute (Foresight 2011a, 25). By contrast, China achieved one of the UN's Millennium Development Goals (MDGs) of halving hunger by 2015 in the early 2000s (Foresight 2011a, 117).

Infrastructure risks

Average farm size is problematic in some countries. In China, for instance, the average holding size is 1.6 acres, versus 400 acres in the United States. Consolidation would allow for the realization of economies of scale, but because land is owned by the government and leased to farmers, consolidation faces high legal barriers.

Post-harvest losses are significant in Asia, with the region-wide rate estimated at 13-15 per cent (Grolleaud 2002). These losses are attributable to deficits in preparation, storage, and transport infrastructure, all of which are functions of urbanisation levels as well as the diversity of the local diet.

Rapid **urbanisation** will place further strain on the food system. The world is projected to add 26 new 'megacities' by 2025, of which five will be in Asia (UN-HABITAT 2008). Ensuring that adequate infrastructure is in place to feed these cities poses a challenge to the private and public sectors alike. In parallel to this challenge, the relative attractiveness of urban job prospects and lifestyles to young people has already led to depopulation of rural areas and a loss of labour and talent in the agricultural sector. In China, for instance, urban incomes are three times those in rural areas.

4. Key Opportunity to Watch: R&D Spending Growth

In 2002, total expenditure on agricultural research and development (R&D) for the Asia region was an estimated $9.6bn, of which China, Japan, and India accounted for 70 per cent (Beintema and Stads 2008). China in particular has raised its productivity in part through the central government's strong commitment to agricultural research. While precise figures for total investments are difficult to come by, annual expenditure may be as high as several billion dollars if supplementary funds from private institutions are included (Chen and Zhang 2011).

Biotechnology has been central to the Chinese government's R&D efforts since the 1990s, with spending of $1.22bn in the 2006-2010 period alone. As far back as 2003 China had an estimated 4000 biotechnology researchers, the largest number in any country (Chen and Zhang 2011, 9). Likewise, India's Department of Biotechnology (DBT), established in 1986, administers the development and commercialization of innovations at a number of laboratories and research centres.

AUSTRALIA AND NEW ZEALAND

Australia and New Zealand both aim to capture a greater share of Asia's food imports. But both countries face ecological constraints – especially freshwater availability – to expanding production.

1. Current trends in supply and demand

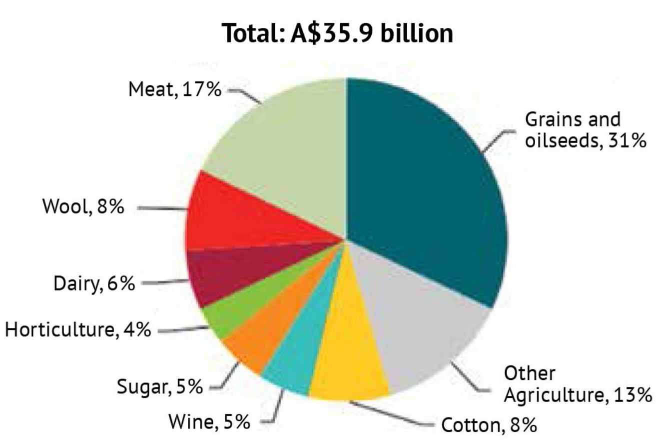
Agricultural production directly accounts for 3 per cent of Australia's GDP, with economic activities that support farming accounting for another 9 per cent (National Farmers' Federation 2013). 60 per cent of production is exported (ibid.). Agricultural goods account for around two-thirds of New Zealand's total exports.

Australia is a globally significant grain producer, and due to relatively low internal consumption levels it exports a relatively high proportion of what it grows. While the cultivation of cereals, particularly wheat, and other crops, remains economically significant in New Zealand, imports have begun displacing domestic production (Farmers' Federation of New Zealand 2015a).

Australia and New Zealand are both important livestock producers, particularly of beef and sheep. In the decade from 2000-2010, the value of lamb exports from Australia and New Zealand to the EU doubled (UN COMTRADE 2010 cited Foresight 2011a). New Zealand is the world's eighth-largest dairy producer, with industry revenues at NZ$14bn in 2012-13 (Farmers' Federation of New Zealand 2015b).

Australian seafood production was valued at A$1bn in 2012-13 (ABARES 2014). This represented a substantial decline from a peak of A$2.5bn in 2000-01 (in real terms), largely due to declines in wild-catch fish stocks which were in line with global trends (State of the Environment 2011; ABARES 2014). Future opportunities exist to develop aquaculture, particularly given the country's sheltered coastlines, but there are significant risks associated with sea- as well as land-based aquaculture (State of the Environment 2011, 425). For its part, in 2006 New Zealand's industry undertook a campaign to turn aquaculture into a billion-dollar industry by 2025, for which it subsequently gained government support and, in 2012, issued an Aquaculture Strategy and Five-Year Action Plan (New Zealand Government 2012).

Figure 21: Value of Australian farm exports by commodity, 2011-12

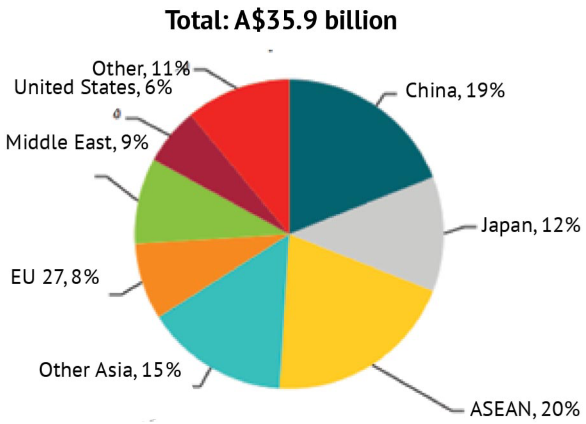


Source: National Farmers' Federation 2013

Australia is a globally important exporter of a number of commodities, including beef, of which it is the top exporter in the world, and wheat, of which it is the fourth largest (National Farmers' Federation 2013). The value of Australian exports is projected to increase 140 per cent through 2050, as compared to 77 per cent growth in the total value of food production.

Northeast Asia accounts for one-third of Australian food exports (ABC News 2014). Although the current government in Australia has touted a plan to turn that country into the 'food bowl of Asia', such a scenario seems highly unlikely given that Australia currently produces only 1 per cent of the world's total food supply, much of it in drylands where water constraints will impede increased crop output (ibid.).

Figure 22: Markets for Australian agricultural exports



Source: National Farmers' Federation 2013

2. Historical performance

Agricultural productivity doubled in Australia between 1965-2000 (ibid.) due to structural reform of the industry, massive increases in water and fertilizer inputs, and technological innovation. However, sharp rises in global food commodity prices during the 2000s did not translate into strong growth in agricultural productivity in Australia: production and export volumes remained flat, although the value of production grew at an average of 4.3 per cent per annum from 2000-2011 (National Farmers' Federation 2013, 25).

The profitability of farming in Australia has declined due to a number of factors, including the prevalence of capital-constrained family farms, an ageing workforce coupled with low agricultural career uptake by younger workers, and the dominance of a small number of retailers (ibid.).

Meanwhile, the high value of the Australian dollar has constrained export growth since the 1990s. However, a slowdown in the commodities super-cycle of the 2000s and early 2010s may bring the value of the dollar down if it persists.

3. Risks

Physical risks

Climate change will affect food production in a number of ways. In Australia, average warming of 1°C is expected by 2030. This will alter precipitation patterns throughout the continent in unpredictable ways while also potentially making certain types of cultivation viable in southern areas (State of the Environment 2011). Likewise, in New Zealand heavy precipitation days have increased in the west while becoming less frequent in the east (IPCC 2012, 143).

Drought has been and will continue to be exacerbated by climate change in many regions, particularly the south (IPCC 2012, 147). Persistent drought cut the land area dedicated to irrigated agriculture in Australia by 29 per cent between 2000-01 and 2007-08 (Primary Industries Standing Committee 2011, 13), and bad harvests in 2006 and 2007 contributed to the global food price spike of 2008. Heat waves, such as that which occurred in southeast Australia in 2009, are often also associated with drought conditions (IPCC 2012, 134). Extreme weather events possibly linked to climate change have also damaged transport infrastructure in agriculture (National Farmers' Federation 2013, 27). Flooding in Queensland in 2010-11, while not definitively proven to have been caused by climate change, nonetheless affected 50 per cent of crops in the region and pushed up food prices (BBC 2011).

Water scarcity is also a major risk. In Australia as in other arid regions, a lack of water availability is a growing bottleneck to production. The country's river systems have been greatly stressed by over-exploitation as well as persistent drought. In the best-known and most extreme example, the Murray-Darling River no longer reaches the sea – and 75 per cent of the country's irrigated agriculture is located in this river basin (Primary Industries Standing Committee 2011, 9). A National Water Initiative has been in place for over a decade, but implementation has been slow (State of the Environment 2011). Meanwhile, non-renewable fossil aquifers are being depleted in an attempt to make up the shortfall (Foresight 2011a, 58). And as noted above, climate change has affected water availability in a number of ways, often adversely.

The **degradation of aquatic habitats** will continue to have negative impacts on seafood availability. Reefs such as Australia's Great Barrier Reef are important sources of fish (as well as possessing enormous ecological and socio-cultural value) but faces severe sustainability challenges. Ocean warming and acidification, both due to climate change, have resulted in observed rates of decline in massive coral growth of about 10 per cent (State of the Environment 2011, 415), and runoff from fertilizer over-application further contributes to degradation.

Regulatory risks

Subsidies for food production are relatively low: about 1 per cent in New Zealand and 3 per cent in Australia, against an OECD average of 19 per cent. These two countries have the lowest and second-lowest agricultural subsidy rates in the OECD, respectively (OECD 2013). Risks typically associated with high subsidies, notably diminishing the productivity of agriculture, are therefore lower in this region.

On the other hand, small average farm size is a risk in that most farms are family-owned and face significant **capital constraints**. It is estimated that A$600bn will be required to increase productivity through 2050, with an additional A$400bn required to facilitate the takeover of the next generation (Port Jackson Partners 2012). Meanwhile, foreign investments are subject to review by the Foreign Investment Review Board, a process has been critiqued as lacking transparency (National Farmers' Federation 2013).

Competing land uses from mineral and hydrocarbon extraction, as well as from environmental offset projects, are placing restrictions on the area of land available for food production. 'Co-use', in which land is simultaneously used for agricultural and non-agricultural purposes, has fallen out of favour (National Farmers' Federation 2013, 62).

Water pricing for irrigated agriculture has been in place at the state level in Australia since the 1990s. Pricing regimes differ greatly between and within states, and have yet to be integrated into long-term water management policy planning (OECD 2010).

Infrastructure risks

Chronic **under-investment** in infrastructure, especially transport infrastructure, is a significant risk to the competitiveness of Australian agriculture. In 2008, the government appointed an expert body, Infrastructure Australia, to develop an action plan for the modernisation of the country's infrastructure, although it is not clear whether the agricultural sector will be given priority within this plan (National Farmers' Federation 2013, 27).

4. Key Opportunity to Watch: R&D Spending for High-Quality Production

Rural R&D spending in Australia in 2008-09 was approximately A$1.5bn, of which roughly one-quarter comes from private sources (as compared to an OECD average of about half). Agricultural R&D spending has stagnated since the 1970s. A prominent government report has recommended the creation of policy and taxation regimes that would be more hospitable to private and philanthropic R&D investments (National Farmers' Federation 2013).

For its part, New Zealand has been cited as a model among developed countries for scientific research on food quality and safety, market research and communication back to food producers on consumer preferences, and developing branding campaigns based on health and sustainability criteria (White and Pearce 2012 cited in National Farmers' Foundation 2013, 25).

Part III

The Bottom Line for Investors

Strategic Asset Allocation Opportunities: Farmland and Agriculture in Investment Portfolios

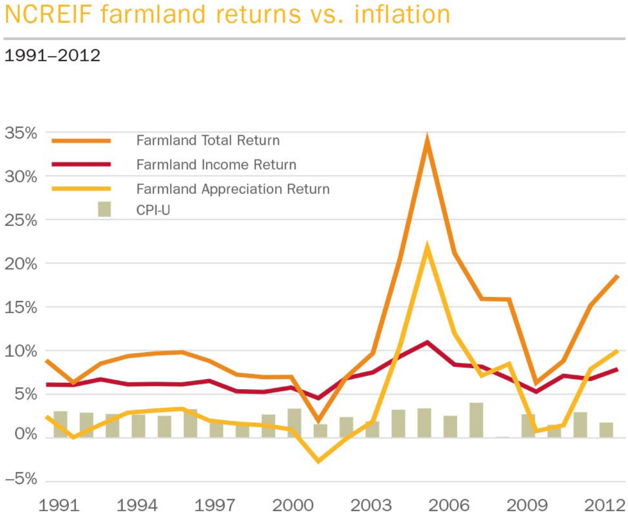
Despite the aforementioned challenges and risks inherent in agriculture and food systems around the world, research has shown distinct benefits from investing in agriculture and food production for investors. The most obvious investment opportunity for institutional investors, in particular pension funds and insurance companies, is to invest in real agricultural assets, specifically farmland, whether in the form of direct investments or lease agreements where institutional investors lease the land from its owner.

> *"Global agricultural land is emerging as an exceptionally compelling investment opportunity..."*
>
> *TIAA-CREEF, 2012*

To underpin the argument that there is a benefit to institutional investors from investing into agricultural assets, it is important to start with a discussion of institutional investment portfolios. Institutional investment portfolios generally consist of fixed-income securities (e.g., corporate and governmental bonds), equities (both public and private equity; globally diversified), real estate (e.g., commercial or residential property, real estate investment trusts [REITs]), hedge funds (e.g., funds-of-funds), and other alternative asset classes (e.g., commodities). It has been argued that farmland investments – which we consider to be part of the agricultural investment universe – are similar to real estate assets with respect to their inflation-hedging properties, liquidity, and volatility levels[18]. Farmland returns in the United States were consistently (and often significantly) above the inflation rate, which indicates the great inflation-hedging potential of farmland (see Figure 23).

18 See, for example, Painter and Eves (2008).

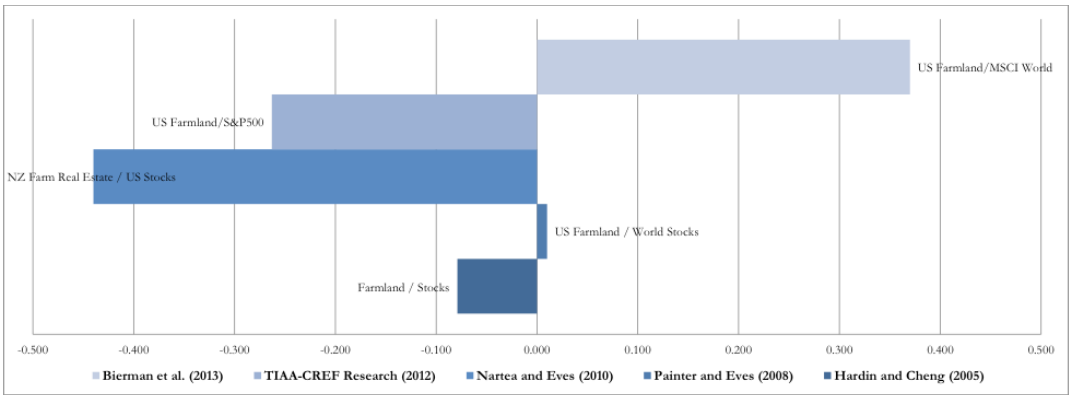
Figure 23: NCREIF Farmland Returns vs. Inflation Rates



Source: TIAA-CREF Asset Management Research 2012

Yet farmland offers a substantial diversification benefit to institutional investment portfolios because of its low and sometimes even negative correlations with other asset classes such as equities and fixed-income securities (see the chart below)[19].

Figure 24: Compiled correlation statistics from various sources.



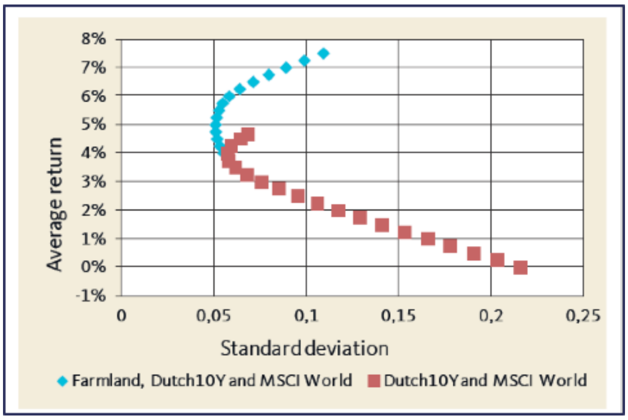
Source: Author

In a standard mean-variance context, there have been investigations of whether this diversification benefit of farmland also translates into a measurable change of the efficient frontier for institutional investment portfolios (see Bierman et al. 2013). The investigations reveal that the efficient frontier of portfolios moves up, as a result of adding farmland as an asset class.

19 For example, low and even negative correlations between farmland investments in New Zealand, Australia, the US, and Canada have been documented by Hardin and Cheng (2005), Painter and Eves (2008) and Bierman et al. (2013).

The graph below clearly illustrates that there is a diversification benefit from adding farmland to investment portfolios. Other research (Nartea and Eves 2010; Hardin and Cheng 2005; Painter and Eves 2008) shows that even minor investments to farmland can lift up the efficient frontier of these institutional investment portfolios.

Figure 25: Efficient Frontier With and Without Farmland.



Source: Bierman et al. 2013

Given that farmland investments have historically offered attractive risk/return characteristics along with inflation hedging properties, institutional investors are increasingly allocating a greater percentage of their portfolios into farmland and agricultural real assets to capture the diversification potential.

Investment opportunities

Institutional investors can invest in agriculture and food through various means. TIAA-CREF (2012) identifies three major types of agricultural assets that would be most suitable for institutions to invest in:

1. Row crops
2. Permanent crops

Whereas row crops can be harvested every year (such as corn, soybeans, etc.), permanent crops have a much longer lifetime. Also, permanent crop investments have a significantly higher payback period for the investments as there is a considerable gap between the high upfront investment and the generation of financial returns. Value-added investments are investments whereby institutional investors do not directly invest in food or agriculture, but rather in the supply chain of food production, by for example acquiring a food distribution network.
The fact that permanent crops have a huge upfront cost and a relatively long

payback period makes them an interesting asset class. In order to reap the financial returns from those kinds of investments, it is important for institutional investors to design investment structures that allow them to invest directly in farmland and crops, and then closely monitor the development of that farmland. Hence, we suggest that institutional investors look for the means to set up private equity or mezzanine private equity capital structures which would allow them to invest more efficiently into farmland and agriculture.

Asset-liability management

Next to all the advantages of investments in farmland, and especially into permanent crops as outlined above, there is another important feature of agricultural land that institutional investors should take into account in their strategic asset allocation: The time horizon of these investments. Usually investments into farmland and agriculture (especially permanent crops) will have payback periods of up to 15 years or even longer. As most pension funds and other larger institutional investors have an investment horizon of more than 15 or 20 years, investments into farmland offers institutional investors a tool to optimize their asset-liability management process during which they match the future payouts of the fund (i.e., liabilities) with the returns of the assets in order to sustain a long-term payment of liabilities, such as pension payments.

Farmland Capital Structures

Farmland is predominantly family-owned and -run across the world, as referenced in the regional profiles in Part II of this report. However, this has already begun to run into problems of intergenerational transfer. Increasing urbanisation and associated education and employment possibilities mean that younger generations are less likely to farm; added to this is the fact that farming is a less desirable lifestyle in the modernising world (Melberg and Berg 2006).

It is not only these factors which are threatening family farming, but also the issue of inheritance. When there is more than one child, the question of who inherits the farmland, or even whether this inheritance might be divided, has to be tackled. When more than one sibling inherits farmland, it cannot provide a livelihood for all of them – and no sibling can make enough profit from farming to buy the entirety of the land from the other siblings.

The implications arising from the farms' capital structures are as follows:

1. Family-run farms are decreasing in number, with a concomitant decrease in output for local and global supply;
2. There will likely be an increase in farmland available for purchase, which could be an investment potential for direct investments.

Agri-tech

Recent technological revolutions in informatics, genetics, robotics, and remote sensing have created a wealth of new investment opportunities throughout the agricultural supply chain. These wide-ranging technologies have been collectively termed 'agri-tech'. These technologies have the potential to help address future problems of land, water, and energy scarcity in a growing world and usher forth a second 'Green Revolution'. This section briefly covers some of the most promising investment opportunities related to this field.

Precision Farming

The concept of precision farming is based on observing, measuring, predicting, and responding to crops in a targeted manner across both space and time. Not only does this allow for a more efficient use of resources (reducing environmental impact), but it also makes it possible to benchmark yields and refine management practices over time. Remote sensing (including UAVs), robotics, automation, and management protocols are being developed to calibrate farming practice and deal with issues such as; pests, disease, nutrient deficiency, weeding, soil moisture and irrigation management, fertiliser and pesticide application, and seeding rates.

Biological enhancement

The use of biological agents to increase yield is another growing field of agri-tech. In addition to genetic modification, researchers are investigating the use of endophytes (in particular bacteria and fungi) which live symbiotically inside of plants and can increase resistance to pests and yields. Another avenue being pursued is biological pest control via predatory insects, targeted diseases, and the use of sentinel plants to forewarn of impending infestations.

Sustainability

Regulatory and consumer demands are increasing the development of sustainable farming practices. Among these include natural and low-carbon fertilisers, alternative farming techniques such as indoor and vertical farming, recycled waste-water technologies, and bio-pesticides (naturally occurring pesticides) that decompose rapidly upon application and prevent the fouling of water supplies. Although many of these practices are currently the domain of microfarms targeting the wealthy, as environmental awareness increases and technologies mature we will some of these methods spread to mainstream agriculture.

Future challenges

In spite of its potential as an asset class,
agri-tech has a number of issues that will complicate successful investment. For example, the majority of agri-tech markets are currently in an early development-phase, and therefore an inevitable shake-out will occur as these markets mature. Similarly, currently promising technologies may be leap-frogged by competitors, adding risk to mid and long-term investment time-scales. In addition, as farms are biological systems they are inherently complex. Consequently, for many technologies it may not be feasible to develop scalable solutions that are suitable to all growers. Regulation may also prove to be a significant roadblock for a number of agri-tech technologies. In particular, any aspect of agri-tech with a biological component such as biological enhancement, and remote sensing technology, which in the case of UAVs may be thwarted by aviation authorities. Farmers themselves are notorious for eschewing new technology for traditional methods. Hence a key component of any agri-tech campaign will be framing these new technologies in a way that is attractive to them.

Finally, while it is widely recognised that an integrated understanding of the components of farming as related to agri-tech (genetics, soil science, ecology, etc.) is necessary for its true potential to be realised, our understanding of how these phenomena fit together to achieve maximum yield is still in its infancy. Therefore, it may be some time yet before agri-tech is able to achieve its full promise.

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Long-term price guarantees for producers

Beyond upfront financing of capital investments, one further obstacle to farm profitability is the limited range of options available to farmers wishing to hedge price risk. Contracts available on most futures exchanges are relatively short in duration - 18-24 months at most - and many farmers lack the necessary training and experience to participate effectively in these markets. Consequently, trading in many markets is thin, while in others there is so little liquidity that futures markets have failed (e.g. diammonium phosphate [DAP] fertilizer), or simply do not exist (e.g. almonds).

There exists a vast academic as well as policy literature on the performance of futures markets, the effects of 'financialization' (or 'speculation', as it is often dubbed) on volatility as well as asset bubbles, and the need to improve producer access to futures exchanges - all topics deserving of attention and policy action[20]. We also suggest, however, that there is a further need to diversify the range of options available to farmers wishing to lock in price levels over multi-year periods. Without longer-term price guarantees, farmers can bear significant risk of annual price volatility whether or not they engage in forward trading.

20 For a review, see FAO et al. 2011; Foresight 2011a.

Lacking this assurance of production profitability, and without access to other forms of capital, farmers are often unwilling or unable to make precisely the kinds of capital-intensive investments that would boost long-term farm productivity.

One existing model which is being tested in various countries in sub-Saharan Africa is that of offtake agreements. Under these contractual arrangements, a buyer - typically a food processor or marketing organisation, whether a large multinational, a smaller company, a government entity (including national stockpiling programmes), or even an international organisation such as the World Food Programme - agrees to provide upfront financing for a given agricultural project in return for a fixed percentage of the project's output at a predetermined quality, usually over a multi-year period[21]. The buyer may also offer support in the form of production inputs, such as seeds and fertilizers, or technical advice. Offtake agreements offer a long-term guaranteed producer income while allowing suppliers to invest in a project with less recourse to leverage (Byoun et al. 2013; Byoun and Xu 2014)[22].

21 Offtake agreements are also common in the extractive industries, and in project finance more generally.

22 This can in essence be considered a type of contract farming (Eaton and Sheppard 2001; Will 2013).

Offtake agreements tend to work best when the crop in question has high input costs, or is high-value, perishable, or unfamiliar to farmers. This is in part because lower-value, more easily marketable crops such as cereals are prone to side selling (Evans-Pritchard 2012).

A number of new institutional innovations will need to take place in order to support new price hedging mechanisms. For instance:

- **New contractual forms** in which the respective obligations of buyer and seller are specified should be devised. In particular, contracts should be clear in providing for specific investments in 'embedded services' - including inputs to production, extension services, packaging, and marketing services (Will and Rockenbauch 2012) - from the buyer.
- The tradeoff entailed in choosing longer-term pricing agreements has been described as 'stability at the expense of flexibility' (Rogers and Robertson 1987). While the main aim of any longer-term pricing arrangement would be to provide stability, mechanisms to ensure a degree of price flexibility should also be provided for within the new contractual forms.
- The structure of many agricultural markets - many small sellers on the one hand and few large buyers on the other - entail significant transaction costs, particularly asymmetries of bargaining power. **New farmer organisations** that offer a single convening point for a large number of small farmers could be established in order to minimise transaction costs such as coordination and information sharing. Cooperatives and other such organisations can also facilitate access to third-party credit (Evans-Pritchard 2012).

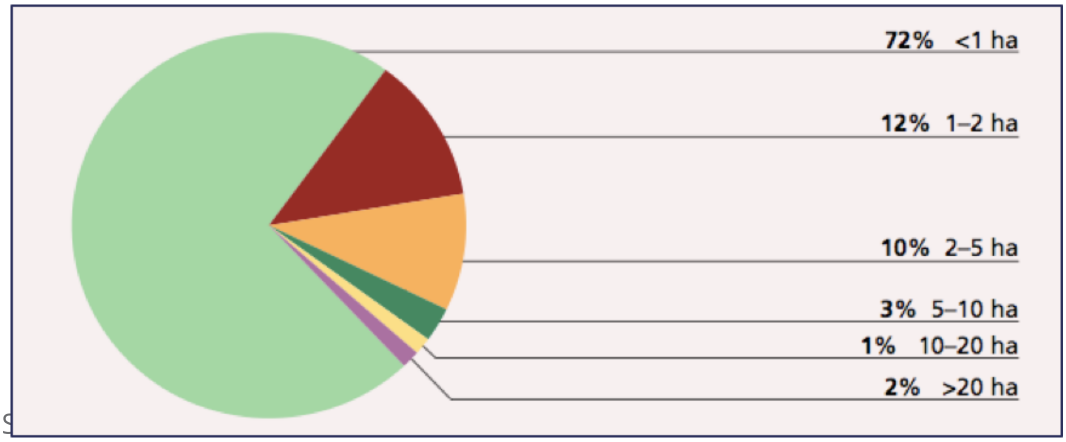
One potential stumbling block in introducing offtake agreements in agriculture is their generally negative reputation. Many of the more familiar precedents have occurred in the extractive industries between sovereign states such as China and various sub-Saharan African nations. One rather ambitious idea to overcome this reputational risk would be to introduce a transparency initiative similar to the Extractive Industries Transparency Initiative (EITI), under which mining and oil companies agree to disclose all payments made to the governments of investee countries.

As it happens, the widespread adoption of offtake agreements and transparency measures could also set off a virtuous cycle: by encouraging investment by farmers, the resulting productivity gains would help to stabilise longer-term food supply, which would in turn mitigate the very price volatility that can discourage investment in the first place (G20 2011, 15).

Human Capital: the key to sustainable growth in production

According to some estimates, smallholder farmers produce up to 80 per cent of the world's food supply in value terms (FAO 2014). Frequently the methods used by smallholders can be more efficient and environmentally sound than those employed in industrial operations. Yet it is often the case that urban areas offer greater economic opportunity, and so the growing migration of rural populations – particularly the young – into cities has diminished smallholder agriculture's human capital base, placing still more stress on food supply. The retention of skilled labour and continuous development of human capital in food production, whether in large agribusiness or small-scale farming, are therefore two challenges the agriculture sector faces.

Figure 26: Share of the world's farms by land class size



Labour supply shortages

The agriculture industry in some regions is threatened by labour shortages. For example, employment in the Australian agricultural sector has decreased by 27.2 per cent in the last decade, the largest decline of any sector in Australia over this period (Blueprint for Australian Agriculture 2013). The initial reduction in labour numbers in Australia was attributed to prolonged drought, but there is an increasing realisation that labour shortages are endemic and related to the lack of knowledge and understanding of the sector, the image of the sector, and poor uptake of agricultural careers.

Other labour shortages in developing countries can be attributed to the growing rural-to-urban migration trend or the impact of HIV/AIDS on farmworkers in SSA.

Rural-urban migration is primarily driven by the availability of better-paying jobs in urban areas. In some cases this has been viewed as paving the way for technological developments and mechanization of the sector. However, evidence from China reveals that while the quantity of farmers in rural areas is declining, the quality of the farm labour force might diminish as well. This is due to the skills that those leaving for urban areas take with them, as migrants tend to have higher educational qualifications and could more readily implement new production technology (Luo and Escalante 2015).

Ongoing developments with immigration legislation in the U.S. may lead to fewer migrant farm labourers entering the country. It is estimated that over the last 15 years, half of crop farm workers in the U.S. were undocumented (Carroll, Georges, and Saltz, 2011). Recent evidence shows that the vegetable sector (which is among the most labour-intensive in the agricultural industry) in countries with strict immigration enforcement has experienced significant reductions in labour supply. Evolving sub-federal laws may in the future have diverse effects on the agriculture sector, some of which pose substantial impacts on labour supply from neighbouring countries such as Mexico (Escalante et al. 2014).

To address future labour shortages, the agriculture industry needs to employ strategies to ensure a flexible and skilled workforce is in place in the short and long term, as well as strategies on how to find alternative labour. Governments can employ a range of favorable policies to increase labour market participation in agriculture. These can be from ensuring migration policies in the U.S do not have an adverse impact on seasonal migrant labor to subsidizing college fees for those studying agriculture based courses in higher education in Australia.

Skills constraints

The future of food production is contingent on developing the skills and expertise of the world's farmers. A number of countries have already identified significant challenges to the availability and skills for farm labourers (Blueprint for Australian Agriculture 2013) and to talent as a driver of the growth of agribusiness (Puri 2012). Additionally, lifelong learning and vocational training in the agricultural sector is one of six European Union priorities for rural development (EU 2013).

Farm management has historically entailed farmers making decisions restricted to production. Moreover, these decisions have generally been made by one person (i.e. the owner-operator of the farm), albeit sometimes with advice from consultants and other partners. Farmers are also making decisions on the environment, finance and investment, marketing, and other domains that traditionally were not their purview. These changes in farming and agribusinesses are driven by rapid advancements in technology, communications, and globalization (Shelman and Connolly 2012). In order to overcome such hard and soft skills constraints, there are opportunities for identifying, educating, training, and advising these decision-makers.

New skills are needed to shift to more sustainable production practices across the globe. In the least developed countries, the majority of the working population are found in the agricultural sector. 80 per cent of the working population in Tanzania, and over 70 per cent in Nepal, earn their living from farming, forestry, and fishing (ILO 2014). With agriculture affected by the negative impacts of climate change, many in this sector need training to apply climate adaptation measures and greener practices such as water conservation, and prevention of soil loss or salination. Training for mitigation and adaptation practices, for example transitioning to sustainable organic farming or sustainable biofuel production, is needed[24].

24 See the FAO's handbook on 'climate-smart agriculture' (FAO 2013), defined as 'an approach to developing technical, policy, and investment conditions to achieve sustainable agricultural development for food security under climate change' (FAO 2010)..

These skills for 'green jobs' are amongst other skills needs for human capital across the world.

Changing Farm Structures

Across the world, family farms passed on from one generation to the next are the typical farm structure. This family farm partnership model is a successful means of transferring ownership, responsibility, knowledge, and skills between generations. The majority of European farms take on this structure, and the EU's common agricultural policy (CAP) continues to encourage this for future agricultural sustainability (European Union, 2014). Family farm partnerships tend to ensure higher labour input securing employment for the majority of those in rural areas. Other regions across the globe have benefitted from maintaining a similar structure, as Asia's green revolution was largely attributed to the productivity of small-scale farms.

There is a growing number of medium-scale farms (defined as between 5 and 100 hectares) in much of Africa, encroaching on the availability of land for expansion of rural family farms (usually less than 5 hectares in size). The pace of land acquisitions by medium-scale African investors who control more land than large-scale foreign investors in Ghana and Zambia has been increasing since 1992. In Zambia 4.6 million hectares of farmland is owned by medium-scale farmers, compared to 1.21 million hectares for domestic and foreign large-scale holdings (Jayne et.al. 2014). The majority of medium-scale farm owners are urban-based investors with little knowledge and skills on farming, and who cultivate only a portion of their land. Ghanaian and Zambian farm owners with between 20 to 100 hectares cultivated just 11 per cent of their land, as opposed to farm owners less than 2 hectares who cultivated 91 per cent of their land in 2012 (Jayne et.al. 2014).

This shift in farm structure impacts the number of farm jobs as well as the indirect employment effects through growth multipliers attributed to family farm partnerships. Access to land for the expansion of small-scale farming has the potential of enabling rural Africans to maintain a decent livelihood. While larger scale industrial farming brings with it key infrastructure development, and the creation of some jobs for those in rural areas. Maintaining family farm structures in Africa for the short term has the potential of ensuring farming skills are transferred from one generation to the next. This in conjunction with the development opportunities brought about by big industrial farms will help in securing rural employment for a growing population and assisting in poverty reduction.

CONCLUDING SUMMARY

Region by region, the following trends should be watched by investors:

- In North America, ongoing international trade liberalization will do much to improve the competitiveness of the region's agricultural products in a global market.
- In LAC, there have been a number of recent developments in the insurance industry with the overall aim of helping Caribbean countries adapt to climate change.
- In Europe, the focus of policymakers is now on agricultural innovation to adapt to and mitigate climate change, under the rubric of climate-smart agriculture.
- In MENA, the national food security policies of several countries have done much to promote investment in biotechnology. In parallel, various water efficiency and reuse technologies are being developed, although none has yet been proven.
- In sub-Saharan Africa, mobile phones are impacting agriculture along with many other aspects of life, providing opportunities for increased efficiency of smallholder markets, allowing for the easy transfer of money, and access to valuable information for best practices in farming.
- In Asia, China in particular has raised its productivity in part through the central government's strong commitment to agricultural research.
- In ANZ, New Zealand has been cited as a model among developed countries for scientific research on food quality and safety, market research and communication back to food producers on consumer preferences, and developing branding campaigns based on health and sustainability criteria.

At the global level, we have outlined two broad classes of investment opportunities as well as two sets of 'policy' measures through which investors can play an active role in enhancing agricultural productivity – and thereby returns:

- The most obvious opportunity set lies in direct investment in food production. Despite the challenges and risks posed to agriculture and food systems around the world, research has shown distinct benefits from investing in agriculture and food production for investors.
- A broader and more diverse set of investment opportunities lies in the agri-tech sector.
- While a number of price hedging mechanisms are currently available to farmers (notably through commodity futures exchanges), there is a further need to diversify the range of options available to farmers wishing to lock in price levels over multi-year periods.
- The widest-ranging and perhaps most challenging area will be investment in human capital. While not obviously an area where investors can or should have involvement, the training and retention of skilled labour is in the direct financial interest of producers, just as ensuring the livelihoods of producers is key to providing enough to feed the world.

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