Bureau for Food and Agricultural Policy

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ADDING VALUE IN THE SOUTH AFRICAN MAIZE VALUE CHAIN

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The Maize Trust

The Bureau for Food and Agricultural Policy (BFAP)

The Bureau for Food and Agricultural Policy (www.bfap.co.za) links analysts with multi-disciplinary backgrounds to a coordinated research unit that informs decision making within the Food System. BFAP advises government, agribusinesses and farmers by providing analyses of future policy and market scenarios and measuring their impact on farm and firm profitability. BFAP acknowledges and appreciates the insight of all partnering institutions and industry specialists.

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Table of Contents

List of Figures iii

List of Tables iv

1 Introduction 1

2 Objectives 3

3 Global Market Overview 3

3.1 The United States 8

3.2 Brazil 11

3.3 European Union (EU-28) 13

3.4 China 17

3.5 Mexico 21

3.6 Argentina 24

3.7 Ukraine 28

3.8 Japan 31

4 South Africa: Current Trends and Issues 34

4.1 Maize Production 35

4.2 Food and Animal Feed 36

4.3 Bio-Ethanol 41

4.4 Maize Starch 44

4.5 Glucose-Fructose Syrup 45

5 Assessment 48

5.1 South Africa's Maize Exports: Normal or excessive? 48

5.2 Maize Consumption: How does South Africa compare with other markets? 49

5.3 The case for adding value 51

6 Conclusion 55

7 References 57

8 Appendix 63

List of Figures

Figure 1: Maize consumption in South Africa, 2013/14 2
Figure 2: Maize consumption in the United States, 2013/14 2
Figure 3: Global maize production 2013/2014*, million metric ton 5
Figure 4: Global maize consumption 2013/2014*, million metric ton 6
Figure 5: Forecasted imports of maize among leading importers, 2000 – 2024 7
Figure 6: US maize consumption, 2000/01 – 2013/14 8
Figure 7: US feed consumption and meat production, 1996/97 – 2013/14 10
Figure 8: Brazil's meat production and maize feed consumption, 1987 – 2014 12
Figure 9: EU grain maize balance sheet, 2005/06 – 2014/15f 14
Figure 10: EU-28 meat production; 2000 – 2015f 15
Figure 11: EU grain maize consumption, 2005/06 – 2014/15f 16
Figure 12: China's crop production, 1991/92 – 2013/14 19
Figure 13: China's maize balance sheet, 1987/88 – 2014/15 19
Figure 14: China's meat production and maize feed consumption, 1988 – 2015 20
Figure 15: China's maize consumption, 2009/10 – 2014/15 21
Figure 16: Mexico maize production and use, 1987/88 – 2013/14 23
Figure 17: Mexico meat production, 1987 – 2014 24
Figure 18: Argentina's meat production and maize feed consumption, 1987/88 – 2014/15 27
Figure 19: Argentina's maize production and consumption, 1989/90 – 2013/14 28
Figure 20: Ukraine maize balance sheet, 1987/88 – 2014/15 30
Figure 21: Ukraine meat production and maize feed consumption, 2000 – 2015 31
Figure 22: Japan's Maize imports per destined use, 2011 – 2014 32
Figure 23: Japan's Starch Production and products produced from starch, 2014 33
Figure 24: Japan's maize imports, 2010 – 2014 34
Figure 25: South African maize production, 2000 – 2024 36
Figure 26: South African maize consumption, 2000 – 2014 37
Figure 27: Changes in class mobility observed between 2004 and 2013 38
Figure 28: Household expenditure on maize decreases as income increases 38
Figure 29: South African meat and egg consumption, 2005 – 2023 39
Figure 30: South African maize consumption, 2000 – 2024 41
Figure 31: South African starch and glucose production and markets, 2009/10 – 2013/14 44
Figure 32: South African maize exports, 2000-2023 49
Figure 33: South African maize consumption potentials, 2013/14 – 2023/24 51
Figure 34: Potential Value Created per Ton of Maize, April – September 2014 54
Figure 35: Maize expenditure per ton for selected countries, (2010–12 avg.) 56

List of Tables

Table 1: What can be produced with one ton of maize? 4
Table 2: Country Snapshot – United States, 2013/14 9
Table 3: Country Snapshot – Brazil, 2013/14 11
Table 4: Country Snapshot – EU-28, 2013/14 14
Table 5: Country Snapshot – China, 2013/14 18
Table 6: Country Snapshot – Mexico, 2013/14 22
Table 7: Country Snapshot – Argentina, 2013/14 25
Table 8: Country Snapshot – Ukraine, 2013/14 28
Table 9: Country Snapshot – Japan, 2013/14 32
Table 10: Country Snapshot – South Africa, 2013/14 35
Table 11: Plant profit calculations per crop, 2014 average prices 43
Table 12: South Africa's starch and glucose imports, 2014 45
Table 13: Maize Balance Sheet in selected countries, 2013/2014 48
Table 14: Domestic maize consumption in selected countries, 2013/14 50
Table 15: South African maize consumption potentials; 2013/14 – 2023/24 63
Table 16:Value added per ton of maize, April – September 2014 64

1 Introduction

Maize is the most important grain crop in South Africa, being both the major feed grain for the animal feed industry and the staple food for the majority of the South African population. The Grain and Oilseed Supply and Demand Estimates Committee estimated that the 2014/2015 commercial maize crop will reach 14.2 million tons and consist of 7.7 million tons white maize and 6.5 million tons yellow maize (NAMC, 2015a). The fact that South Africa produces a surplus of maize forces industry role players to utilise maize in one of two ways. The first option involves exports. South Africa exported 2.5 million tons of raw maize (or 19 percent of maize production) during the 2013/14 season, with leading export destinations including Japan, China, Mexico, Namibia, Zimbabwe and Mozambique. The second option is to transform maize into secondary or value-added products,[1] such as maize meal, animal feed, and starch.

Figure 1 and Figure 2 provide, respectively, a comparison of how maize stocks are consumed in South Africa and in the United States, the world's leading maize consumer. South Africa utilises maize predominantly in the manufacturing of animal feed (39.8 per cent) and food (37.4 per cent) products. Exports account for 17.9 per cent of consumption, with the remaining 4.8 per cent being used in the production of starch and glucose. Maize consumption in the United States, on the other hand, is more diversified and maize is mainly used in the production of biofuels (38.2 per cent) and animal feed products (37.5 per cent), with exports accounting for 14.3 per cent of domestic production. The remainder of the stock is used to produce the following products: starch, glucose and dextrose (3.9 per cent); high-fructose corn syrup (3.6 per cent); food

1 A broad definition of adding economic value to a product is transform a product in terms of is current place, time, and form characteristics to characteristics more preferred in the marketplace. As a specific example, a more narrow definition would be to economically add value to an agricultural product (such as maize) by processing it into a product desired by customers (such as maize meal) (Coltrain *et al.*, 2000).

and cereal products (2 per cent); and alcohol for beverages and manufacturing (1 per cent).

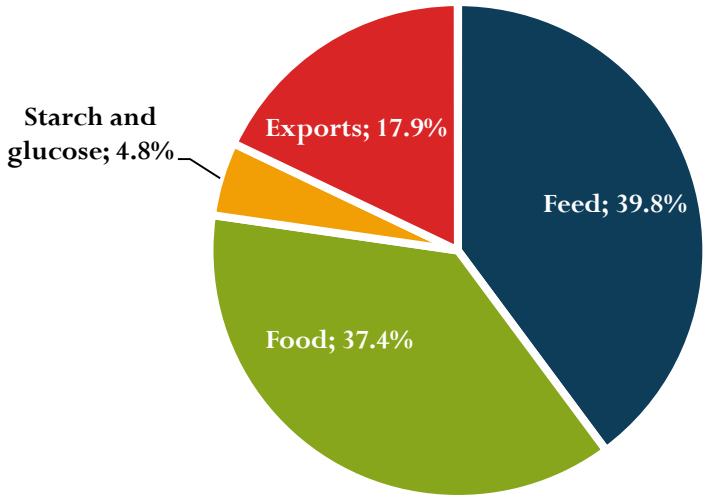

Figure 1: Maize consumption in South Africa, 2013/14
Source: SAGIS, 2015

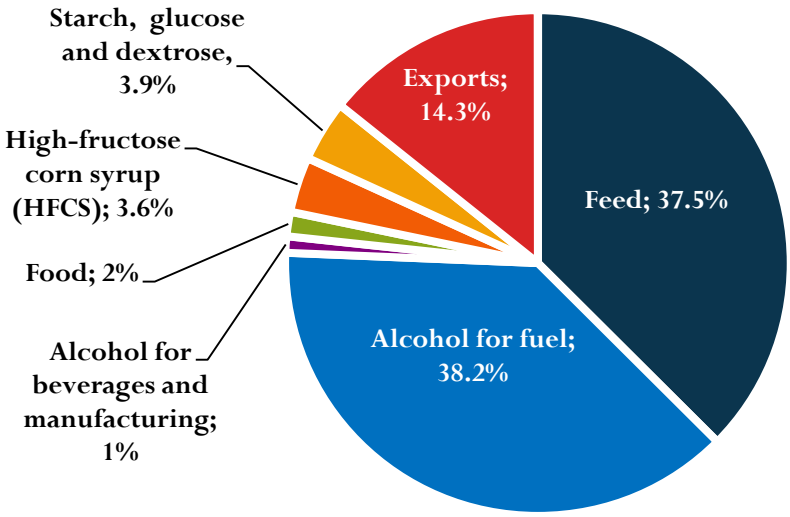

Figure 2: Maize consumption in the United States, 2013/14
Source: ERS, 2015a

Although the United States has a more developed economy, relative to the South African economy, the diversified nature of US maize consumption raises the question of whether South African maize consumption can also be diversified to a greater extent. Hence, considering the fact that South Africa exports a significant share of the domestic crop, is

there space in the domestic value chain to grow and diversify value addition in order to create employment opportunities, substitute imports or even export value-added products? This study aims to identify opportunities for value addition to domestically produced maize through a detailed analysis of the world's leading maize producing and consuming economies.

2 Objectives

The first objective of this report is to compare the utilisation of maize in South Africa with other leading maize markets in terms of trade and food, animal feed and industrial consumption. This objective will be met by firstly benchmarking the share of South Africa's crop that is exported against those of other leading maize exporters to determine if this share is normal or excessive; and secondly, by illustrating how the South African maize value chain consumes maize as between food, animal feed and industrial manufacturing, and how this consumption compares with other markets.

The second objective is to consider the potential to add value to the current exported surplus by expanding food, animal feed, ethanol, maize starch and glucose-fructose syrup production. Identifying these possibilities relies on research conducted by BFAP and other institutions, as well as on discussions held with key experts in these industries. This analysis is not meant to be exhaustive, but rather to show on an aggregated level the areas of industry in which South Africa can add value to locally produced maize, as well as to identify the factors that hinder these industries from expanding.

3 Global Market Overview

Maize is one of the oldest human-domesticated plants. Its origins are believed to date back to at least 7000 years ago when it was grown in the form of a wild grass called *teosinte* in Central Mexico. Several hybrids of maize exist, each with its own specific properties and kernel characteristics; the most common ones include dent (or field maize), flint (or Indian maize, grown mostly in Central and South America), and sweet

(or green maize). Depending on its colour and taste, maize grown around the world is generally categorised into two broad groups: yellow and white. Yellow maize constitutes the bulk of total world maize production and international trade. It is grown in most northern hemisphere countries where it is traditionally used for animal feed. White maize is produced in only a handful of areas, namely the United States, Mexico and in southern Africa. White maize is generally considered a food crop.

During processing, maize is either wet or dry milled, depending on the desired end products. Wet millers process maize into glucose-fructose syrups,[2] glucose and dextrose, starch, oil, beverage alcohol, industrial alcohol, and ethanol. Dry millers process maize into flakes for cereal, maize flour, maize grits, maize meal, and brewer's grits for beer production. Both the dry-milling and wet-milling methods of producing ethanol generate a variety of economically valuable co-products, the most prominent of which is distiller's dried grains with solubles (DDGs), which can be used as a feed ingredient for livestock (World Bank, 2006).

Table 1: What can be produced with one ton of maize?

29 Kg of Maize Oil		**571 Kg of Starch**
and		**or**
241 Kg of 21 % Protein Gluten Feed	**AND**	**589 Kg of Sweetener**
and		**or**
46 Kg of 60 % Gluten Meal		**402 Litres of Ethanol/Alcohol**

Source: World Bank (2006)

At around 984 million tonnes, world maize production represents nearly half of world cereal output. Over the past decade, global maize production has increased by 57 per cent, at a 3.3 per cent annual compound growth rate. Most of the increase in world maize production between 2004 and 2014 can be attributed to significant growth in

2 Also known as high fructose corn syrup or isoglucose.

maize production in the two leading maize producers, namely the United States and China. Chinese maize production grew by nearly 89 per cent during the past decade, accounting for almost 30 per cent of the global increase. Production in the United States also grew by 97 million tons, or 38 per cent, over the same period and accounted for 28 per cent of the growth in global maize production (FAS, 2015a). South Africa produced 11.8 million tons during the 2013/14 season, or 1.1 per cent of global maize production. According to the International Grains Council, global production is projected to reach 1025 million tonnes in 2019/20, up from 980 million tonnes in the 2013/14 season (IGC, 2014). However, due to constraints on availability of arable land in some countries, area expansion is likely to be much slower, with production growth instead being mainly linked to productivity gains.

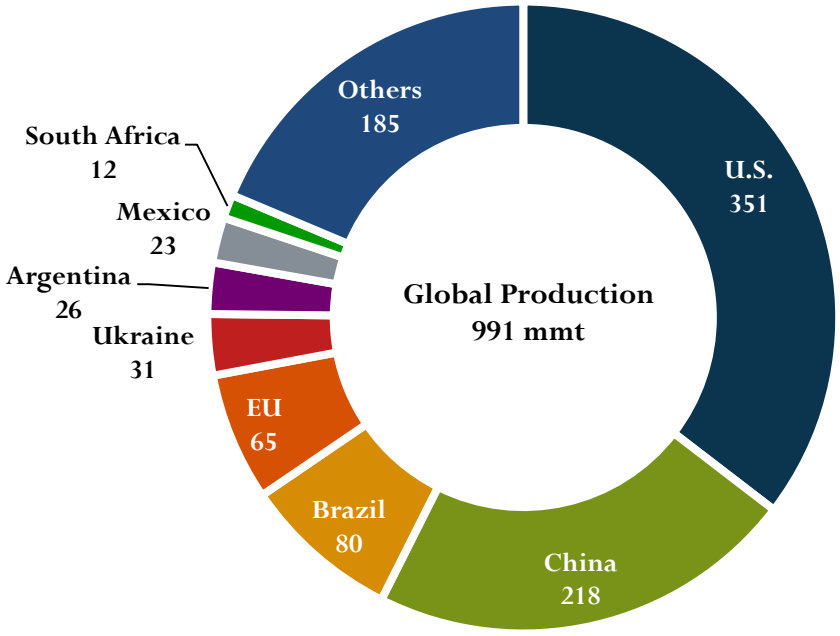

Figure 3: Global maize production 2013/2014*, Million metric ton
Source: FAS, 2015b; NAMC, 2015a

Maize is an economical energy ingredient for livestock and poultry feeds, with high levels of carbohydrates and fat contributing to rapid animal weight gain. It is by far the most widely used feed grain crop, with consumption reaching more than 540 million tonnes in 2013/14. In comparison, wheat consumption for feed reached only 130 million tonnes during the same period. Feed demand accounted for 60 per cent of overall maize use in

2013/14 and is expected to be the main driver of growth in demand for maize in the medium term. With an underlying, long-term upswing in global meat demand projected to remain in place in the near future, feed grain consumption is expected to increase to new levels. Projected gains in meat consumption will be tied to income growth, rising populations, urbanisation and shifting dietary preferences. Feed use is therefore expected to increase rapidly in developing countries, especially where livestock production is switching to larger, commercialised operations, which typically utilise more compound feed ingredients (IGC, 2014).

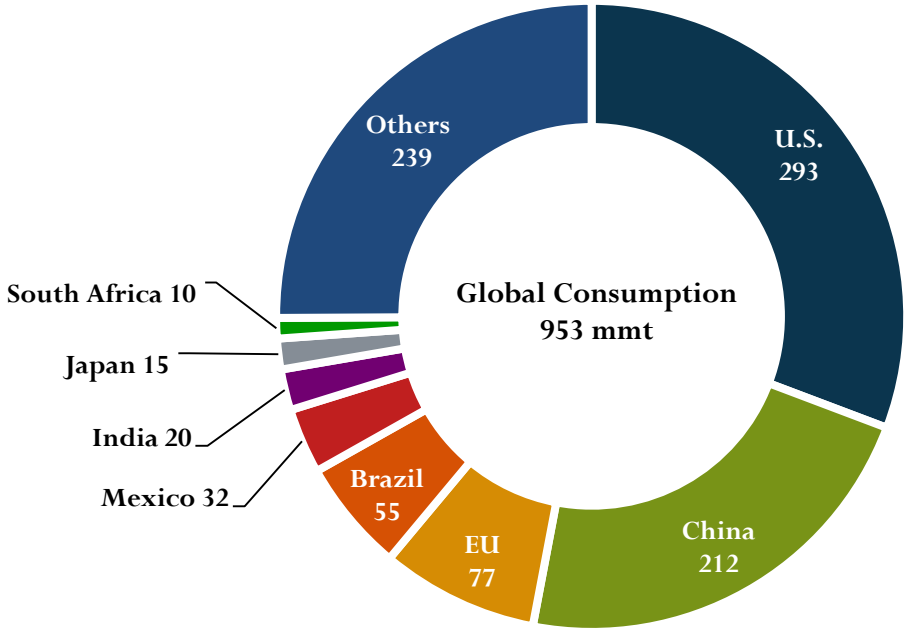

Figure 4: Global maize consumption 2013/2014*, Million metric ton
Source: FAS, 2015b; NAMC, 2015a

Industrial consumption is expected to grow by 1.1 per cent annually until 2019/20. Consumption constraints, such as the so-called "blending wall" in the US ethanol market, will limit further industry expansion and, unless the adoption of higher ethanol fuel blends exceeds current expectations or exports increase particularly strongly, production of maize-based biofuels is expected to rise only slightly from current levels. Apart from the United States, maize utilisation for ethanol production is projected to increase in Canada, the EU and South America. Given projections for mild economic growth, global starch consumption is forecasted to increase, led mainly by gains in China (IGC, 2014).

Maize is an important food staple in parts of Africa, Asia and Latin America, where it is commonly consumed as porridges, breads or tortillas. Direct human consumption of maize typically accounts for just 11 per cent of overall use. Due to changing tastes and preferences, such as for the incorporation of more wheat-based foods and meat in diets (usually linked to an increasing income per capita), food consumption between 2015/16 and 2019/20 is projected to increase at a slower pace than in recent years (IGC, 2014).

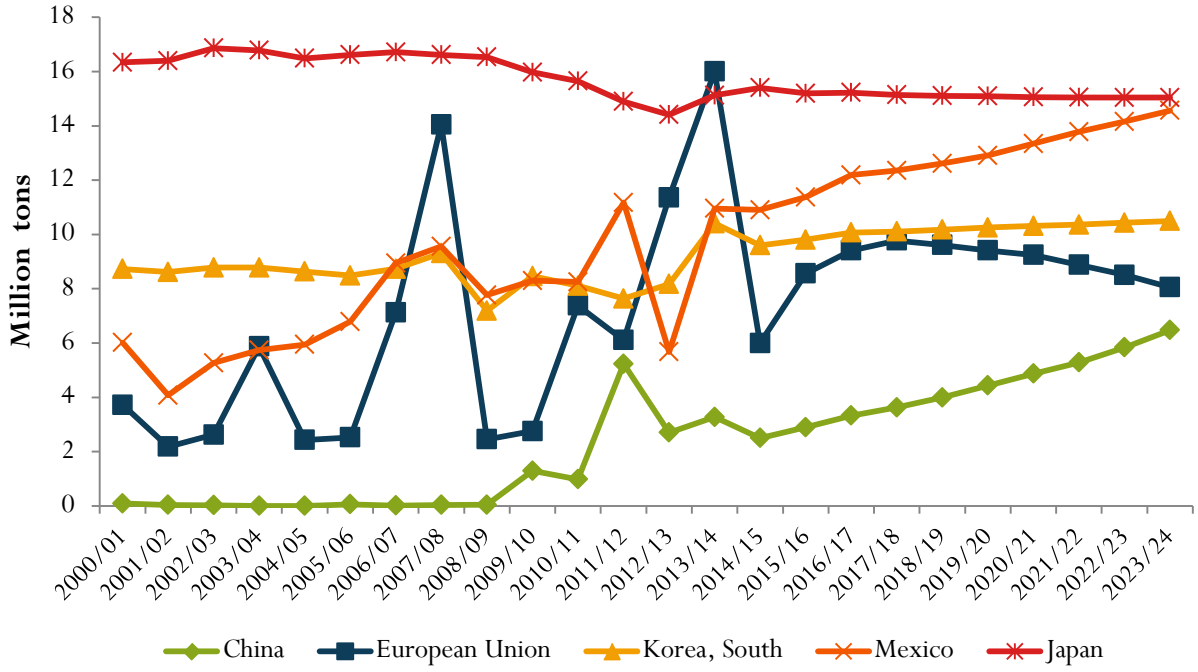

Figure 5: Forecasted imports of maize among leading importers, 2000 – 2024
Source: ERS, 2015b

While international trade accounts for only 13 per cent of world maize production, maize represents almost 40 per cent of all cereal trade. Global trade in maize has increased significantly over the past two decades, from 71 million tonnes in 1995 to around 127 million tonnes in 2014, with the fastest expansion taking place in more recent years. Maize exports are driven by a handful of countries that have the domestic weather conditions to produce surpluses. The United States is the world's largest maize exporter and accounts for over 40 per cent of global exports. Japan, Mexico and Europe were the leading import markets during the 2013/14 season, each importing 15.5, 14.4

and 11.5 million tons, respectively. Figure 5 illustrates USDA forecasts on the expected growth in maize imports over the coming decade and how Chinese and Mexican imports are expected grow in the coming decade (ERS, 2015b).

3.1 The United States

The United States is not only the world's largest producer and exporter of maize but, equally significant, the largest consumer of maize. Maize is grown in most US states, with production being concentrated in the Heartland region (including Illinois, Iowa, Indiana, eastern portions of South Dakota and Nebraska, western Kentucky and Ohio, and the northern two-thirds of Missouri). Iowa and Illinois, the top maize-producing states, typically account for just above one-third of the US crop. The 35.9 million hectares harvested in the US yielded 351 million tons of maize during the 2013/14 season, representing more than 35 per cent of global maize production (FAS, 2015a; FAS, 2015b).

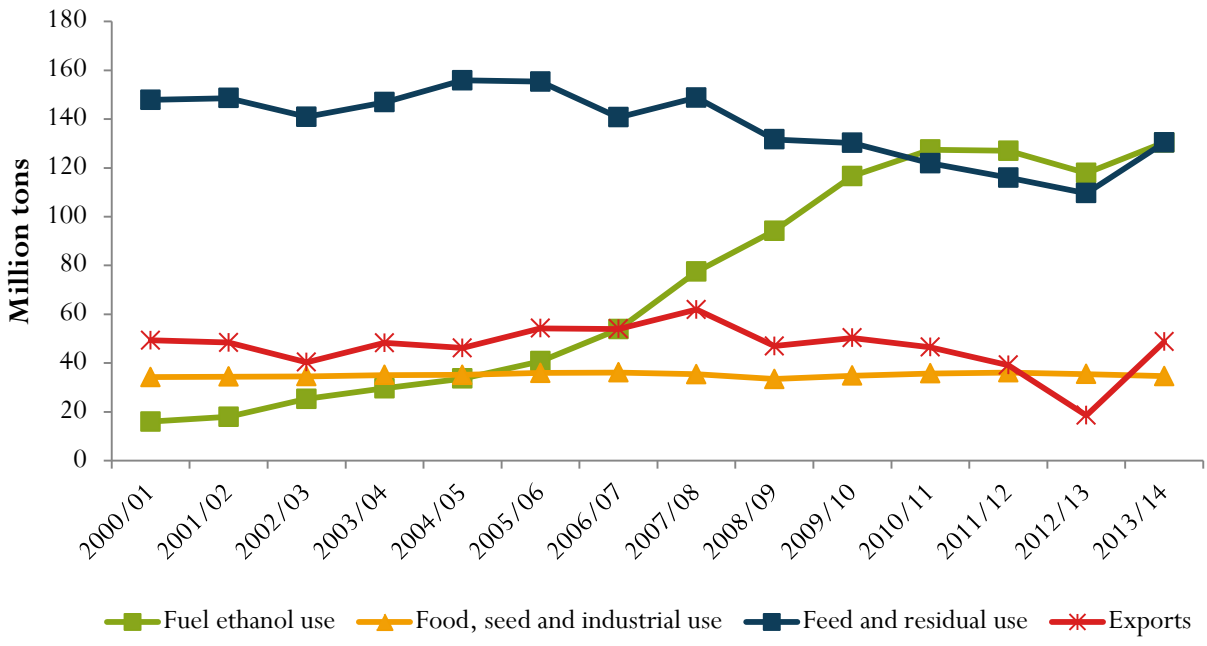

Figure 6: US maize consumption, 2000/01 – 2013/14
Source: USDA ERS, 2015a

Domestic maize consumption in the US was estimated at 293 million tons during 2013/14, 44 per cent of which was used as feed for the livestock industry. Feed usage is expected to grow due to relatively low projected maize prices, increasing meat production and a slowdown in the growth of production of distillers grains (a co-product ethanol production) as maize-based ethanol expansion moderates. Around 4 per cent of maize consumption in the US is used in the manufacturing of glucose-fructose syrup, which is a popular substitute for sucrose used in soft drinks and other processed foods. Future glucose-fructose syrup production in the US is expected to be supported by growing exports to Mexico. Also, roughly 5 per cent of maize is processed into starch, dextrose and glucose for food and industrial use (such as in paper, textiles, adhesives, plastics, baked goods, condiments, candies, soups and mixes) and around 2 per cent is consumed as food (ERS, 2015a; ERS, 2015b).

Table 2: Country Snapshot – United States, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*%*
Production	351.3	Food	5.1	1.7
Domestic Consumption	293.1	Industrial**	159.5	54.5
Imports	0.9	Feed	127.9	43.7
Exports	48.7			
Dependence on Trade				
Exports as a share of Production		13.9 %		
Imports as a share of Domestic Consumption		0.3 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

The US became the world's leading ethanol producer in 2005 after increases in global energy prices and federal bioenergy policies stimulated maize-based ethanol production. In just over a decade, the share of domestic maize consumption that was fermented into fuel alcohol or ethanol grew from 12 to 38 per cent, with almost all ethanol production in the United States being based on maize as the feedstock (ERS, 2015a). However, declining overall gasoline consumption in the United States (which is mostly a 10-per cent ethanol blend), infrastructural and other constraints on growth in the E15 (15-per

cent ethanol blend) market, and the small size of the E85 (85-per cent ethanol blend) market will limit growth in maize-based ethanol production over the next decade (ERS, 2015b).

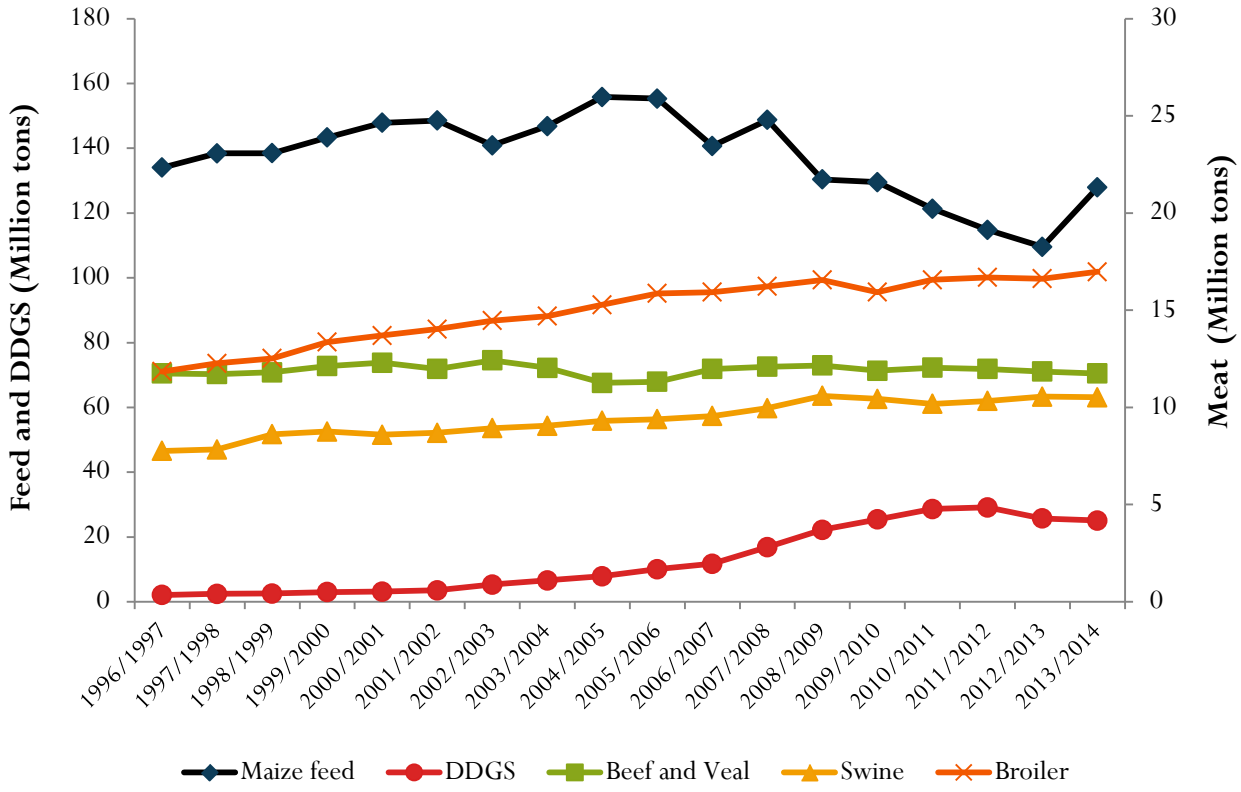

Figure 7: US feed consumption and meat production, 1996/97 – 2013/14
Source: FAS, 2015a; ERS, 2015c

The US is the world's largest maize exporter, supplying 39 per cent of world maize exports during 2013/14. Exports rebounded to 50.7 million tons during 2013/14 after drought conditions in 2012/13 had reduced exports to only 18.2 million tons. Major export markets included Japan (25 per cent), Mexico (21 per cent) and South Korea (9 per cent). US exports are expected to grow over the next decade in response to strong global demand for feed grains to support growth in meat production (USDA ERS, 2015b).

3.2 Brazil

The last three decades have seen the rise of Brazil as a major agricultural producer and exporter, owing to reforms implemented in the 1980s and early 1990s that enabled improved economic and financial stability. Brazil's climate allows the country to produce both a summer (September to December) and a winter or "safrinha" (January to March) maize crop. Most of the summer crop maize is used domestically, while the "safrinha" maize crop is typically exported. During the 2013/14 season, Brazil is expected to produce 81.3 million tons of maize, most of which is destined for the feed and export markets (IGC, 2015a). Although "safrinha" literally means "smaller crop", the 2013/2014 "safrinha" crop is forecasted to be 58 per cent of the total crop (FAS, 2014a).

Table 3: Country Snapshot – Brazil, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	81.3	Food	4.0	8.0 %
Domestic Consumption	53.2	Industrial**	1.7	3.4 %
Imports	0.6	Feed	44.5	88.6 %
Exports	24.9			
Dependence on Trade				
Exports as a share of Production		30.7 %		
Imports as a share of Domestic Consumption		1.1 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

The vast majority of Brazil's maize is consumed by the animal feed industry, with relatively minor shares going into food and industrial consumption. The Brazilian Feed Industry Association, Sinirações, estimated that maize constitutes 60.5 per cent of total feed usage (excluding grass and silage). Maize feed use during 2014 had the following consumption breakdown among major livestock categories: broilers at 49 per cent, layers at 9 per cent, swine at 25 per cent, dairy at 8 per cent, beef at 2 per cent, and other categories at 7 per cent (Sindiracoes, 2015). Since maize is a key input in Brazilian broiler production, the consistent growth of the broiler industry since the late 1980s has

created a significant demand for feed and therefore maize. Between 2001 and 2014, Brazil's broiler production increased from 6.5 million tons to 12.6 million tons (or 94 per cent), whereas maize feed usage increased by 61 per cent (FAS, 2015a). Feed use is projected to grow even further as a result of the expansion of the poultry and swine sectors (FAS, 2014b). Although there are indications that maize-based ethanol production can grow in the world's second largest bio-fuel producer, only 0.04 per cent of Brazil's domestic ethanol production was produced from maize in 2013/14 (FAS, 2014a).

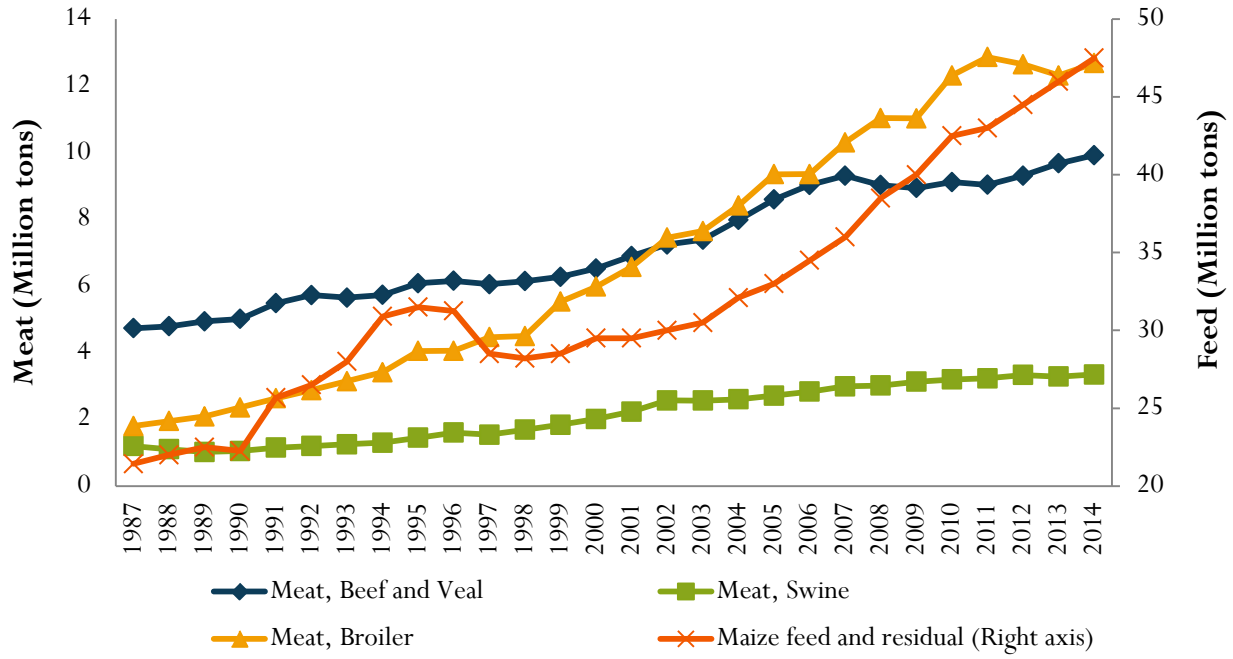

Figure 8: Brazil's meat production and maize feed consumption, 1987 – 2014
Source: FAS, 2015a

Brazil is also the second-largest exporter of maize in the world, exporting 24.9 million tons of maize in the 2013/2014 marketing year. Main export destinations during 2014 included Iran (23 per cent), Vietnam (15 per cent) and South Korea (9 per cent) (ITC, 2015). Maize exports in 2013 were constrained by export infrastructure when large maize and soybean crops competed for logistics resources. Although infrastructure is still expected to be a constraining factor, the lower expected levels of maize exports, new

port covers that enable ships to load in the rain and a system of ship preference, have assisted exports and reduced bottlenecks in 2014. Despite signing a Sanitary and Phytosanitary (SPS) agreement with China in November 2013, which went into effect in March 2014, very little maize has been exported to China. Low international prices, high transportation costs and competition with soybeans for logistics are the main drivers behind the lack of substantial exports to China (FAS, 2014a).

3.3 European Union (EU-28)

The European Union (EU) is a significant producer and consumer of grains, with total grain production and consumption reaching 300 million tons and 274 million tons, respectively, in 2013 and 2014 (IGC, 2015a). Of the total grain production, maize production was estimated at 65.2 million tons during the 2013/14 season, with France, Romania, Hungary and Italy being the largest producers. The European Union's maize production is forecasted to increase to 79 million tons by 2024 through a combination of yield improvements and area increases. In the cereals sector, maize is the only crop expected to grow in area and yield, mainly due to increasing demand in the ethanol, animal feed and isoglucose (or glucose-fructose syrup) industries (EC, 2014).

The usage of maize in the production of animal feed accounts for 73 per cent of the EU's maize consumption. Aggregate meat production reached 44.7 million tons during 2014, with future growth being driven mainly by sustained growth in the production of poultry meat. Despite a recovery projected for the short term caused by the removal of milk quotas in the dairy sector, beef production is expected to return to its current declining trend in subsequent years. Production of pig meat will remain relatively stable, while only poultry is expected to continue its pattern of steady growth. Given these trends, the EU's feed consumption of maize is not expected to grow significantly, only projected to grow 2.1 per cent between 2014 and 2024 (EC, 2014; EC, 2015).

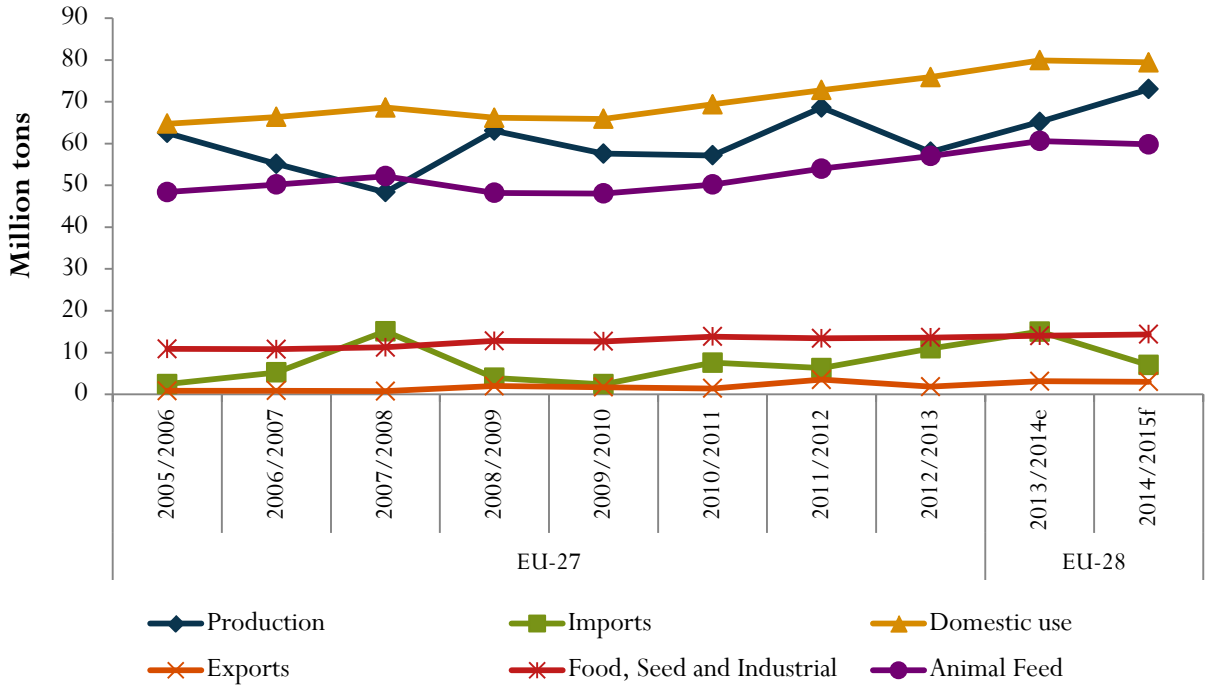

Figure 9: EU grain maize balance sheet, 2005/06 – 2014/15f
* e = estimate, f = forecast; Source: EC, 2015

Table 4: Country Snapshot – EU-28, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	64.0	Food	4.2	5.7 %
Domestic Consumption	76.1	Industrial**	13.8	18.6 %
Imports	15.8	Feed	56.0	75.7 %
Exports	2.3			
Dependence on Trade				
Exports as a share of Production		3.6 %		
Imports as a share of Domestic Consumption		20.8 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

EU biofuel production reached 13.2 million tons in 2014, consisting of 9.6 million tons biodiesel and 3.6 million tons bio-ethanol. The main feed stocks used for the production of biodiesel are vegetable oils, such as rapeseed, whereas bio-ethanol is mainly produced from cereals and sugar beet. The proportion of sugar beet used to produce ethanol is expected to decrease, following the EU's abolition of the sugar quota in 2017, due to prices for sugar beet for industrial uses increasing. Therefore, most of the future demand

for bio-ethanol in the EU will be met with consuming other cereals, especially maize. Maize used for the production of bio-ethanol is estimated to increase from 4.1 million tons to 7.1 million tons between 2014 and 2024 (EC, 2014).

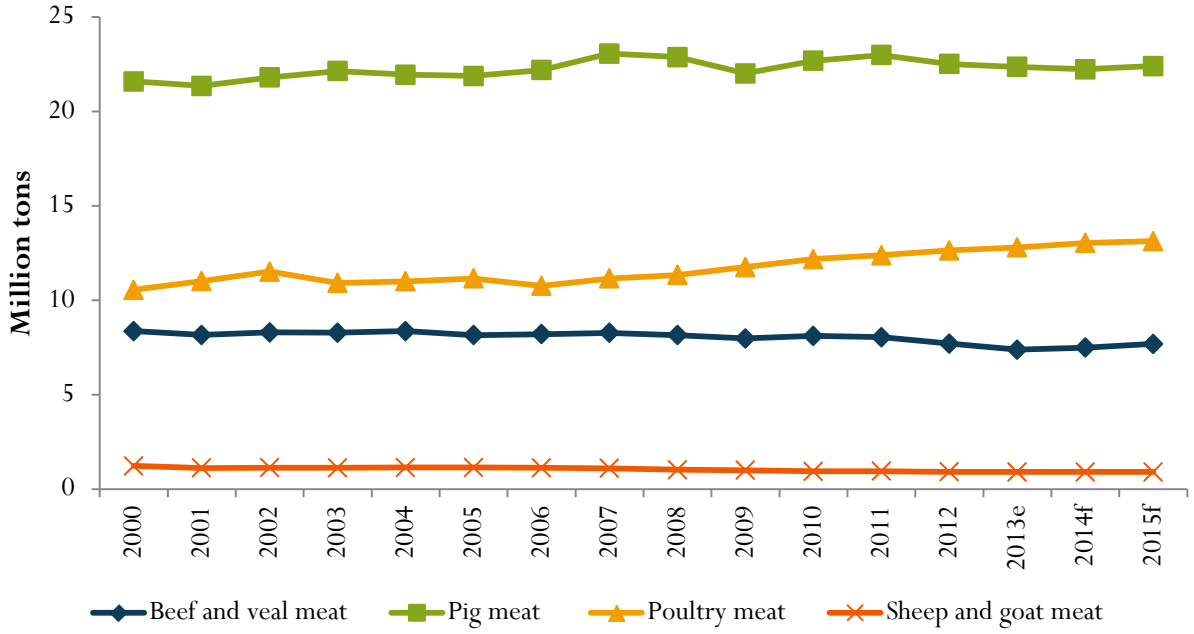

Figure 10: EU-28 meat production; 2000 – 2015f
*e = estimate, f = forecast; Source: EC, 2015

Human and industrial (excluding biofuels) consumption of maize reached 4.9 million tons and 5.3 million tons, respectively, during 2014. The starch industry is crucial in supplying various food and industrial consumers with inputs. The EU used close to 7.7 million tons of maize to produce 4.8 million tons of maize starch during 2013. During 2013, domestic starch consumption had the following distribution: 32 per cent for the confectionary and drinks markets, 29 per cent for processed foods, 29 per cent for corrugating and paper, and 5 per cent for the pharmaceutical and chemical markets (Starch Europe, 2015a).

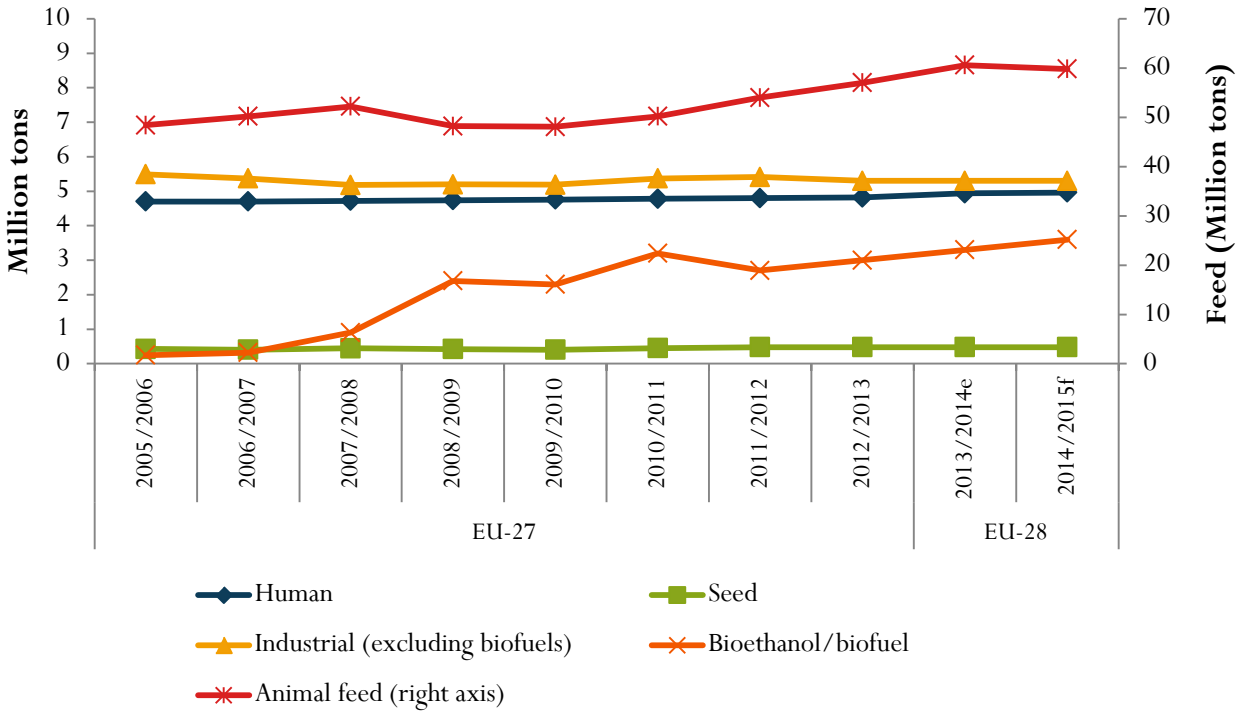

Figure 11: EU grain maize consumption, 2005/06 – 2014/15f
*e = estimate, f = forecast; Source: EC, 2015

A new development in maize consumption is the expected growth in the production of glucose-fructose syrups, also known as isoglucose in the EU. Current quotas in the EU limit the production of glucose-fructose syrups to only 700 thousand tons, which equates to 3.6 per cent of the EU's sweetener consumption during 2014 (EC, 2014). The EU will abolish the glucose-fructose syrup and sugar quota systems over 2016/2017, leading to increased competitiveness in the domestic sweetener market. Zimmer (2013) estimated that about 30 per cent of the EU sugar market can be replaced by glucose-fructose syrup and that the EU sugar industry will have to reduce its current processing and profit margin by around 40 per cent in order to sell sugar at the same price as glucose-fructose syrup. Although it is unclear how the sugar industry will react to this increased competition, current estimates indicate that glucose-fructose syrups production will reach 2.3 million tons or almost 12 per cent of total sweetener use by 2024 (EC, 2014).

The EU was expected to export 3.1 million tons and import 15 million tons of maize during 2013/14. EU maize imports mainly originated from Ukraine (64 per cent), Brazil (9 per cent) and Russia (8 per cent), with the major importers being Spain (29 per cent), the Netherlands (19 per cent) as ports of entry, together with Italy (13 per cent) and Portugal (9 per cent) (EC, 2015). Although maize production over recent years has increased faster than that of any other cereals, it still falls short of the overall demand and the EU is expected to remain a net importer of maize in the future (EC, 2014).

3.4 China

China is the second-largest maize producer in the world after the United States, having produced 218 million tons during 2013/14. In 2003/04, maize surpassed rice to become the largest single crop produced in China. Maize production is expected to grow from 139 million tons in 2005/06 to a forecasted 215 million tons in 2014/15 (FAS, 2015a). Due to maize being a key feed crop, the Chinese government encourages maize production through financial incentives which enhance the profitability of maize. As a result, maize is continuing to erode less profitable soybean acreage in northeast China and cotton acreage in parts of the Northern Plain (FAS, 2014c).

On February 1, 2015, China issued a major policy document on agriculture calling for a coordinated response to rising production costs and internationally uncompetitive prices. The plan calls for subsidy and land reform, in addition to exploring greater utilisation of innovative agricultural technologies such as biotechnology. While the document is short on specifics, the 2015 No 1 Document emphasises the need to make Chinese agriculture more competitive, efficient, and sustainable (FAS, 2015c).

China's maize consumption is expected to reach 214 million tons during 2015/16, with approximately 68 per cent of China's maize being consumed as animal feed, 23 per cent used in industrial processing, and less than 3 per cent consumed directly as food. China's

growth in maize use is mainly driven by an increasing demand for feed created by rising livestock output and a transition to modern livestock production systems that consume maize instead of traditional energy sources such as brans, straw and residues from agricultural processing. During 2015, broiler and beef production are expected to remain stable at 13 million and 6.4 million tons, respectively, while pork production is expected to grow by 2 per cent and reach 57 million tons (FAS, 2015a). The modest expansion of China's pork production and the high maize prices resulting from government procurement programmes are expected to limit maize feed growth to only 3 per cent in 2015 (USDA FAS, 2014d; FAS, 2015a).

Table 5: Country Snapshot – China, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	218.5	Food	7.3	3.7 %
Domestic Consumption	206.4	Industrial**	49.0	25.0 %
Imports	3.3	Feed	139.8	71.3 %
Exports	0.2			
Dependence on Trade				
Exports as a share of Production		0.1 %		
Imports as a share of Domestic Consumption		1.6 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

China is expected to consume 52 million tons of maize for the production of starches (77 per cent) and ethanol (23 per cent) during 2014/15. In 1985, less than 2 million tons of maize was used for industrial processing; however, the amount grew throughout the 1990s, reaching 10.5 million ton in 2001. With strong government support and robust demand, industrial use of maize then doubled to 20 million tons in 2004, and doubled again to 40 million tons in 2006. The growth in industrial use of maize slowed in 2007 and reversed in 2008 as the slowing economy reduced demand. Industrial processors cut back production in 2008 when the Chinese government set a minimum maize purchase price, since maize represents approximately 90 per cent of the variable cost of starch production and 80 per cent of maize-alcohol variable costs (Yue, 2009; Gale *et al.*,

2009). Sources estimated that ethanol and starch manufacturers only ran at 40 to 45 per cent capacity in 2012/13 and 2013/14, mainly due to a slowdown in the overall economy and lower consumption of hard liquor (FAS, 2014c).

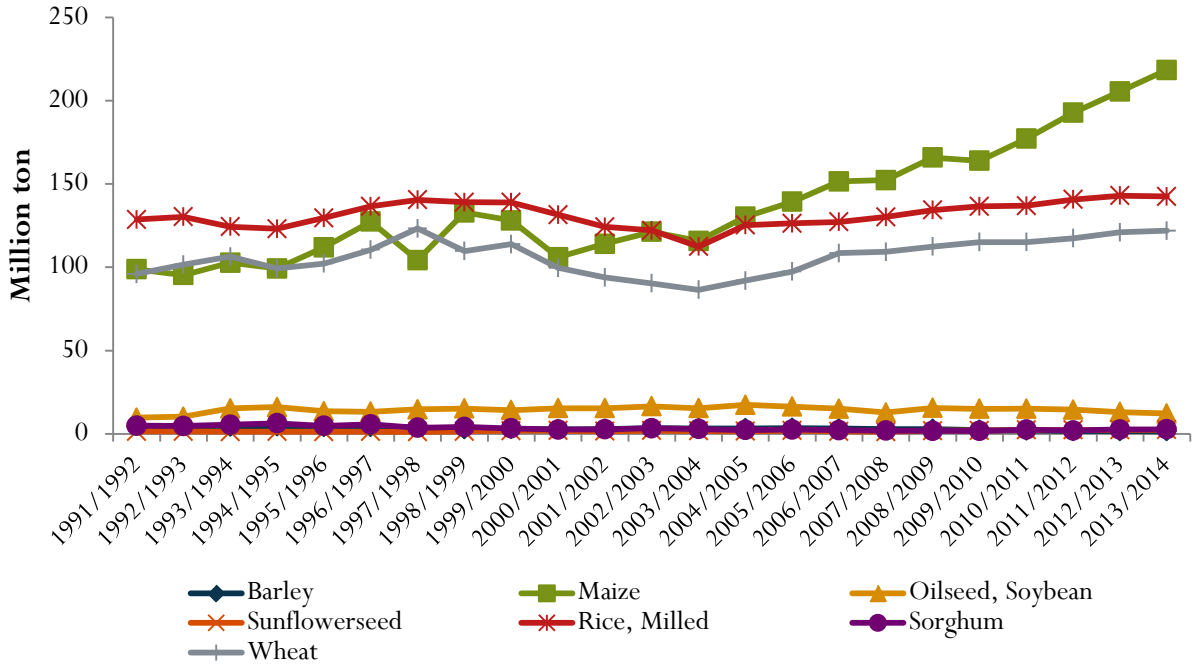

Figure 12: China's crop production, 1991/92 – 2013/14
Source: FAS, 2015a

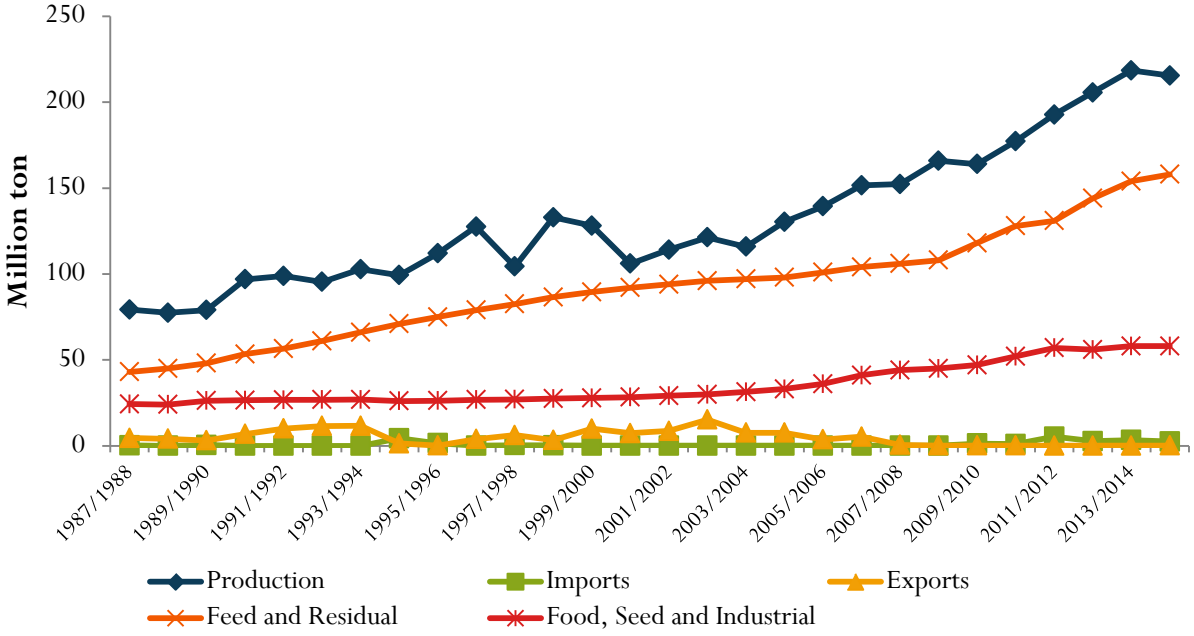

Figure 13: China's maize balance sheet, 1987/88 – 2014/15
Source: FAS, 2015a

Fuel ethanol production was estimated to be 2.8 billion litres during 2014, up 6 per cent from the previous year in response to increased fuel consumption in provinces with blend mandates. The mandated blend in designated provinces is 10 per cent, while in practice the blend rate for ethanol in gasoline is between 8 and12 per cent. Biofuel production accounts for less than one per cent of China's liquid fuel production and is below targets set in the 12th Five Year Plan. Maize accounted for 76 per cent of fuel ethanol production in 2014, and another 14 per cent came from wheat. The government, concerned about maintaining self-sufficiency in grains, has promoted the use of cassava, sweet sorghum, and other non-food grain feed stocks in the biofuel sector. However, these crops still compete with food crops for land, and only one cassava and one sweet sorghum ethanol plant are approved for production by the government. There have been no new policies or incentives announced for the sector in recent years, although China's Ministry of Finance announced that by 2015 it will remove the Value Added Tax rebate of 17 per cent and impose a five per cent consumption tax for grain-based ethanol production (FAS, 2014e).

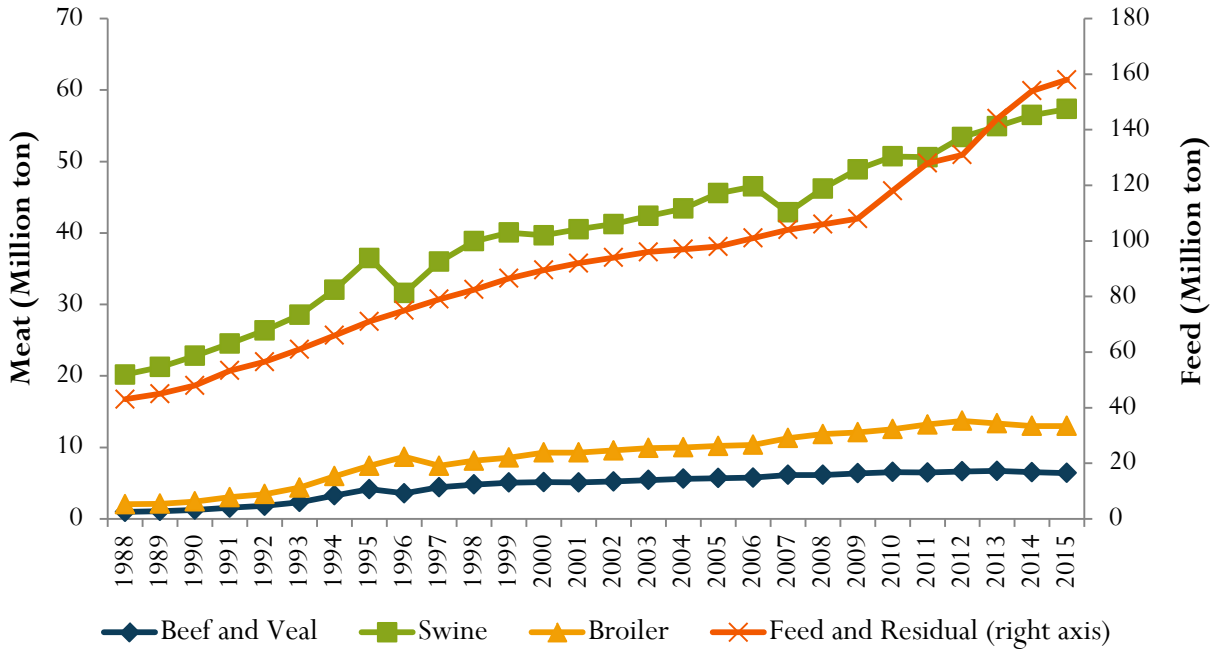

Figure 14: China's meat production and maize feed consumption, 1988 – 2015
Source: FAS, 2015a

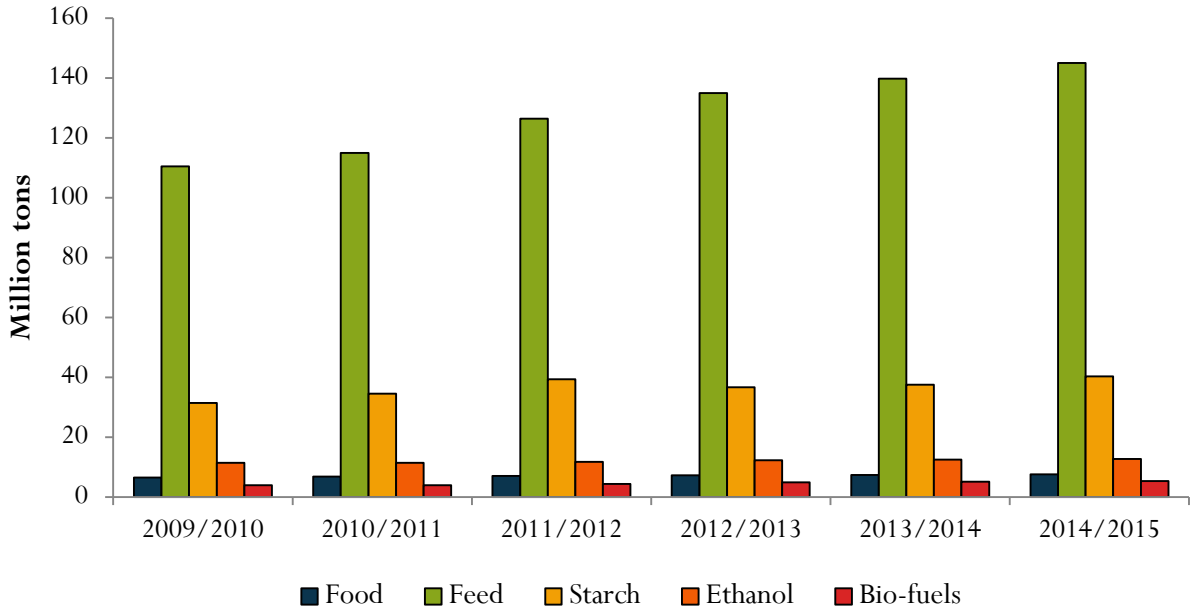

Figure 15: China's maize consumption, 2009/10 – 2014/15
Source: IGC, 2015b; IGC, 2015c

In terms of trade, China only became a consistent net importer of maize in 2011/12 when increasing feed and industrial demand required the country to import 5.2 million tons of maize. China imported 2.6 million tons of maize during 2014, mostly from the US (39.5 per cent), Ukraine (37.1 per cent) and Thailand (11.1 per cent) (ITC, 2015). Large domestic maize stocks, government incentives to purchase domestic maize, and uncertainty in the treatment of imported genetically modified maize will, however, limit imports in the near future (FAS, 2014c). China's maize imports are projected to increase gradually and reach 7.2 million tons by 2024/25 (ERS, 2015b).

3.5 Mexico

Mexico is the world's third-largest importer, the eighth-largest producer and the fifth-largest consumer of maize (FAS, 2015a). The Mexican maize market is different from most, as maize, to a larger degree, is considered to be a food grain rather than a feed grain. Because of this difference, Mexico has developed two distinct maize markets: one for white maize, which is mainly for human consumption, and one for yellow maize,

which is mainly for feed, although a share of yellow maize is also used for starch. During 2013, Mexico produced roughly 22.7 million tons of maize, consisting 89 per cent of white maize and 8.9 per cent of yellow maize (SIAP, 2015). In January 2014, producers, entrepreneurs and associations throughout the maize value chain presented the "2020 Strategy of Promoting Yellow Maize Production in Mexico" to the Economy Secretariat (SE). The strategy aims to convert one million hectares of white maize to yellow maize by 2020 to substitute the imports of yellow maize from the US with domestically produced yellow maize. However, Mexican growers are reluctant to switch to yellow maize due to the lower profitability, higher cost of seed and stronger competition from US and Brazilian growers (FAS, 2014f).

Table 6: Country Snapshot – Mexico, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	22.9	Food	14	44.2 %
Domestic Consumption	31.6	Industrial**	2.5	7.9 %
Imports	10.9	Feed	15.2	47.9 %
Exports	0.5			
Dependence on Trade				
Exports as a share of Production		2.2 %		
Imports as a share of Domestic Consumption		34.5 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

Maize continues to be the most important staple crop in Mexico, with consumption of maize and tortillas accounting for an average 7 per cent of a family budget. Between 2009 and 2014, real tortilla prices in supermarkets and in tortilla shops increased by 57 per cent and 32 per cent, respectively (SNIIM, 2015). Subsequently, there has been a substitution effect in low-income groups switched from tortillas to other foods, such as bread and crackers. However, for those groups where income is strengthening, such as the middle class, tortilla consumption dropped as they moved to more expensive sources of caloric intakes, such as pastas (Sherwell, 2013). The demand for maize flour for

human consumption has remained stable over the last few years and was expected to remain stagnant in 2014 (FAS, 2014f).

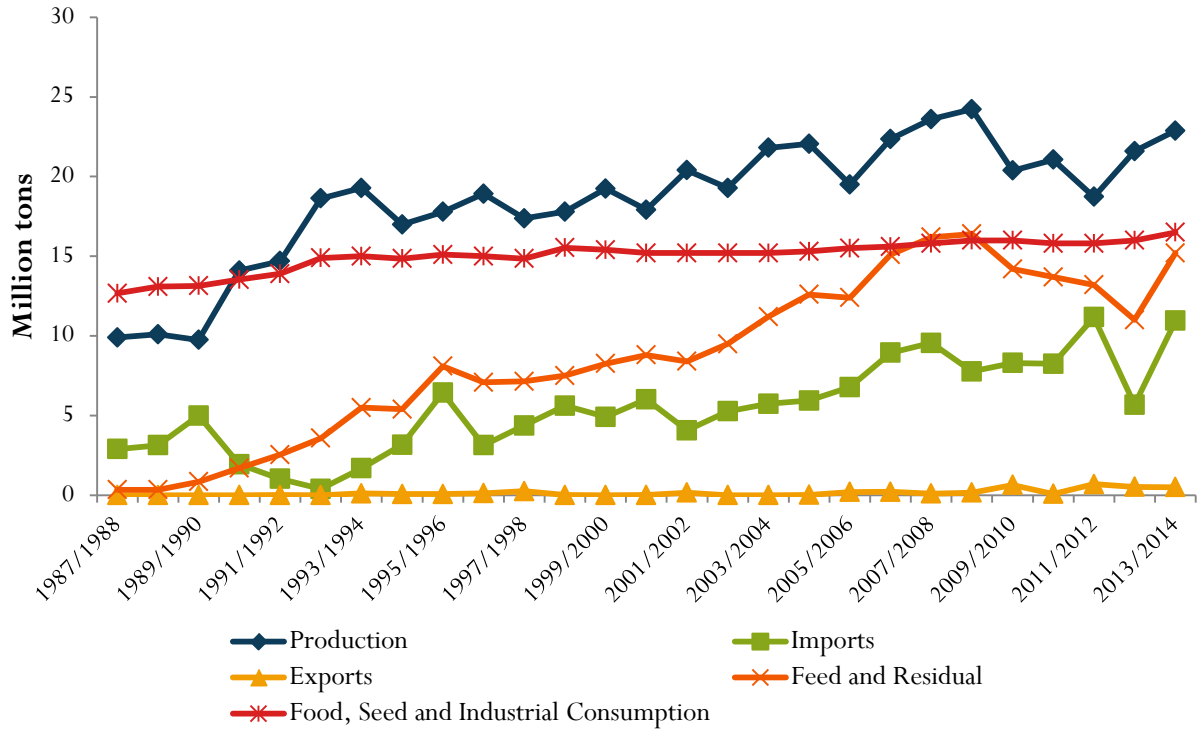

Figure 16: Mexico maize production and use, 1987/88 – 2013/14
Source: FAS, 2015a

Animal feed consumption has grown from 8.4 million tons in 2001/02 to over 15 million tons during 2013/14. The poultry sector continues to be the major consumer of feed grains in Mexico, with broiler production reaching 3 million tons in 2014. The sector's ongoing consolidation, along with improved biosecurity measures, has enabled the industry to overcome the challenges of the 2012 and 2013 Highly Pathogenic Avian Influenza (HPAI) outbreaks that occurred across the country (FAS, 2014g). Maize-starch production uses nearly 2.5 million tons of yellow maize annually and 90 to 95 per cent of Mexico's maize-starch is produced from maize imported from the United States. The USDA forecasts that total maize consumption will grow by 2.1 per cent in the 2014/15 marketing year due to the expansion in the Mexican livestock and poultry sectors, as well as in other food industries such as starch, cereal and snacks (USDA FAS, 2014f).

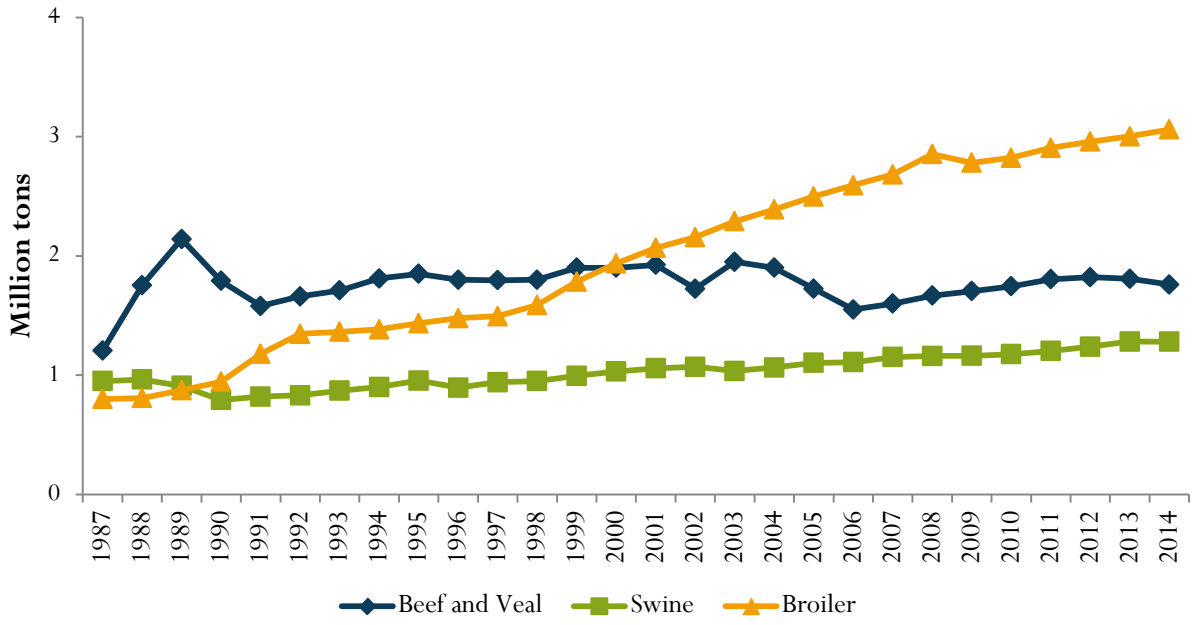

Figure 17: Mexico meat production, 1987 – 2014
Source: FAS, 2015a

In the 2013/14 marketing year, Mexico's imports amounted to 10.9 million tons (USDA FAS PSD, 2015). Traditionally, Mexico imports almost all of its maize from the US due to the US having an economical and logistical advantage over other exporting countries. These imports are directed primarily at balancing feed for the livestock industry and the starch, chips, snacks and breakfast cereal sectors. Over the past 5 years, imports consisted, on average, of 90 per cent yellow maize and 9.1 per cent white maize. Mexico's imports mainly originated from the US (93 per cent), South Africa (4 per cent) and Argentina (2 per cent) during 2013 (ITC, 2015).

3.6 Argentina

Argentina is similar to Brazil in terms of large shares of the country's maize crop being directed at the export and animal feed markets. The International Grains Council estimated that Argentina produced 32.1 million tons of maize during 2013/14, of which 18.6 million tons was exported and 9.2 million tons was used in the production of animal feeds (IGC, 2015a). Although good weather is expected to benefit production, the Argentinian Post of the United States Department of Agriculture has estimated that

production will fall to 22.5 million tons during the 2014/15 season (FAS, 2015d). The main reasons for this expected drop in production is that Argentinian maize farmers are faced with lower international maize prices, high production and freight costs, high inflation, a stronger local currency and continued government policies that limit exports. The conjunction of all these factors makes the production of maize risky and unprofitable, especially on farms that are far away from ports, on leased land or with poorer soils (FAS, 2014h).

Table 7: Country Snapshot – Argentina, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	32.1	Food	0.3	2.7 %
Domestic Consumption	12.1	Industrial**	1.8	15.9 %
Imports	0.0	Feed	9.2	81.4 %
Exports	18.6			
Dependence on Trade				
Exports as a share of Production		58.1 %		
Imports as a share of Domestic Consumption		0.0 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

Argentina's domestic maize consumption reached 12.1 million tons during 2013/14, with consumption for 2014/15 estimated at close 15 million tons (IGC, 2015a). The main drivers of consumption growth are the new grain bio-ethanol industry and the poultry and pork industries which are expected to continue their growing trend (FAS, 2014k; FAS, 2015d). Bio-ethanol production and consumption during 2015 are projected at a record level of 720 million litres. Argentina implemented a biofuels policy in early 2010, under which ethanol and biodiesel use is obligatory. The biodiesel mix is currently at 10 per cent and ethanol, in practice, ranges between 5 to10 per cent. In the case of ethanol produced from grains, the policy allows the use of maize in areas that suffer significant discounts from commercialisation and high freight costs, such as those far away from ports. The policy also supports the addition of value in remote rural areas. Bioethanol producers purchase maize locally at prices well below international prices due

to the 20 per cent export tax on maize and government administration of export volumes. Currently, Argentina's six grain-ethanol plants are capable of using either maize or sorghum, but are all using almost exclusively maize. Between 2014 and 2015, maize used for the production of bio-ethanol is expected to increase from 870 thousand tons to close to 1 million tons by 2015 (FAS, 2014j).

Domestic beef demand for 2015 is forecast at 2.6 million tons, practically unchanged from 2014, as production and exports are also expected to remain at somewhat similar levels. Argentina's consumption of poultry and pork is, however, expected to grow. Poultry consumption in 2014/15 is estimated at 2.1 million tons, 2 per cent higher than in 2013/14. Consumption has doubled over the past ten years, primarily due to very competitive prices in relation to beef prices. Consumption of pork has also grown rapidly over the past few years, with production increasing from 416 thousand tons in 2013/14 to an expected 450 thousand tons in 2014/15 (or by 8 per cent). Increased domestic production, improved quality, better distribution and certain marketing practices have positioned pork as one of the preferred meats. Most supermarkets and butcheries in Argentina sell a variety of pork cuts at prices that are, on average, 10 to 15 per cent less expensive than beef (FAS, 2014k). Due to these changes, Argentina's maize feed consumption is expected to grow by 5.2 per cent during 2014/15 (FAS, 2015a).

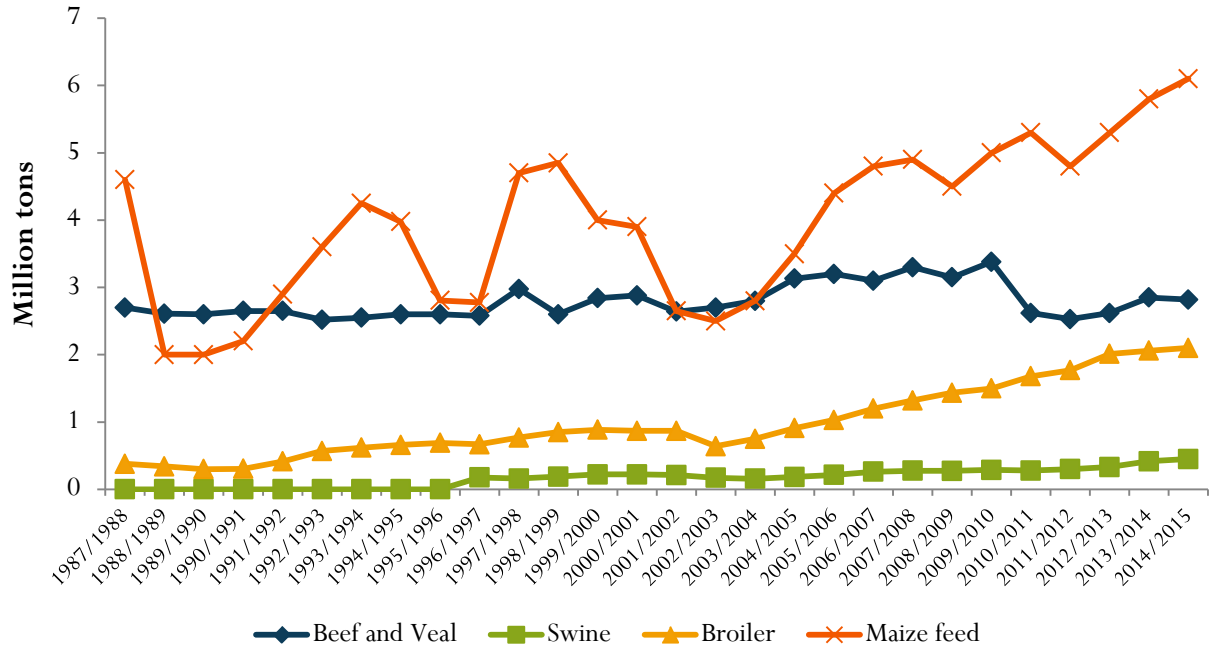

Figure 18: Argentina's meat production and maize feed consumption, 1987/88 – 2014/15

Source: FAS, 2015a

The largest share of Argentina's maize crop is directed at the export market, with any changes in production having a direct impact on export volumes and a limited effect on domestic consumption (see Figure 19). These relationships are for the most part caused by the Argentinian government's policies that aim to ensure stability in the domestic market by limiting exports through export quotas. During the 2013/14 marketing year, Argentina exported 18.6 million tons of maize, or 58 per cent of domestic production (IGC, 2015a). Decreased maize production is expected to cause exports to decline to 13.5 million tons during the 2014/15 marketing year. Available trade data shows that, for the first six months of 2014, Argentina mainly exported maize to Algeria (22 per cent), Egypt (12 per cent) and Malaysia (9 per cent) (ITC, 2015). Argentina exported 66 thousand tons of maize to China during 2013, but no exports were recorded in 2014. With China's recent approval of imports of Syngenta's genetically modified MIR162, exports to China are expected to resume in 2015 (FAS, 2015d).

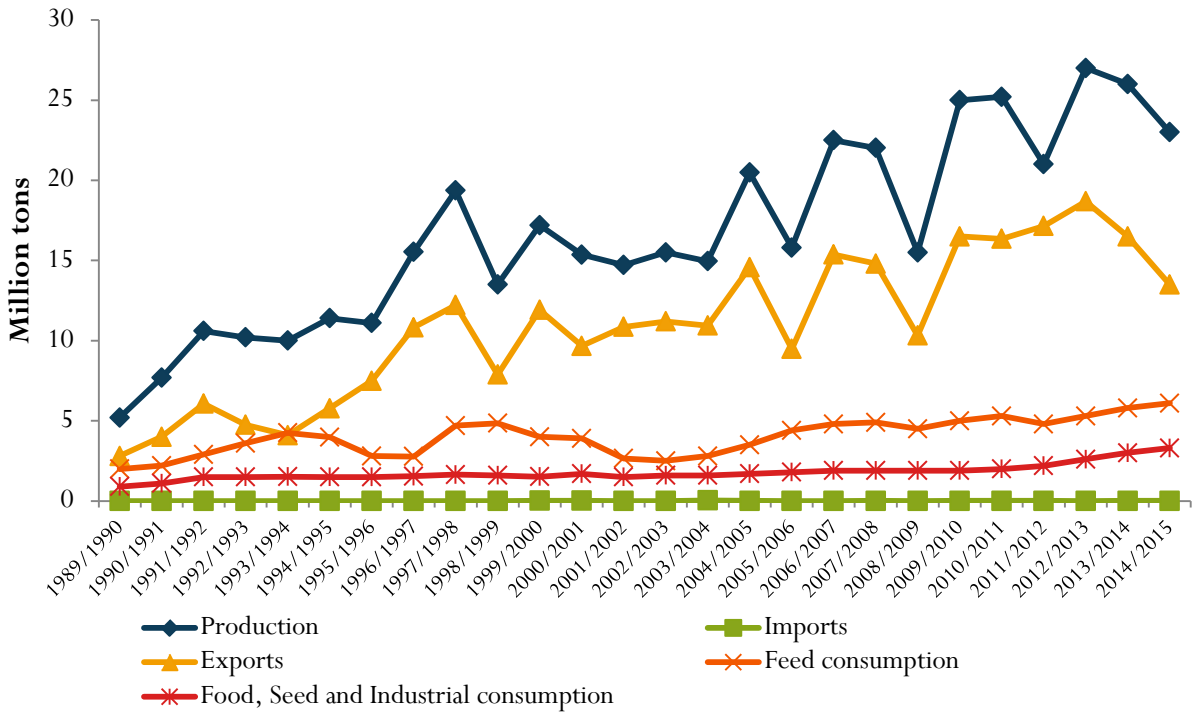

Figure 19: Argentina's maize production and consumption, 1989/90 – 2013/14
Source: FAS, 2015a

3.7 Ukraine

Ukraine and Argentina are similar in terms of both countries using significant shares of their annual maize crop for the export and animal feed markets. Ukraine's maize harvest for the 2014/15 marketing year reached 28.5 million tons, with the crop being both 2.4 million tons less and of a lower quality than the previous season due to adverse weather conditions throughout the summer (IGC, 2015a). The present political and economic crisis in the country has led to a significant devaluation in the local currency, undermining imports and boosting exports. However, the positive gains made by exporters from the devaluation may be limited from a broader perspective, as the weaker currency increased the cost of essential agricultural inputs, most of which are imported. Production during the 2015/16 marketing year is expected to be negatively affected by the currency devaluation due to producers moving to lower quality and less expensive inputs (FAS, 2015e).

Table 8: Country Snapshot – Ukraine, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	30.9	Food	0.5	5.9 %
Domestic Consumption	9.8	Industrial**	0.3	3.5 %
Imports	0.0	Feed	7.7	90.6 %
Exports	19.9			
Dependence on Trade				
Exports as a share of Production		64.4 %		
Imports as a share of Domestic Consumption		0.0 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

Ukraine's maize feed consumption grew significantly when broiler production increased from 102 thousand tons to 970 thousand tons between 2002 and 2014. However, the above-mentioned currency devaluations have had a profound impact on the Ukrainian meat and animal feed markets. Increasing prices for red meat and the strong dependency on imported pork resulted in consumers moving to more affordable poultry meat. Although poultry production is expected to increase to over 1 million tons in 2015, poultry producers reported lower revenues due to the devaluation and declining real prices. Pork production in 2015 is expected to decrease by 4 per cent, influenced by the on-going political and economic crisis and the subsequent decline in consumer demand. Similarly, pork imports are expected to decline by over 80 per cent due to the currency devaluation and consumer re-orientation to more affordable poultry meat. Beef production is expected to decline slightly due to a lower supply of dairy cattle caused by Russia's import ban on Ukrainian dairy products. Beef imports are also expected to decrease considerably in 2015 (FAS, 2014l). In light of the above, the growth in maize feed consumption seen in the past 13 years is expected to slow down and only grow by 200 thousand tons in 2015 (FAS, 2015a).

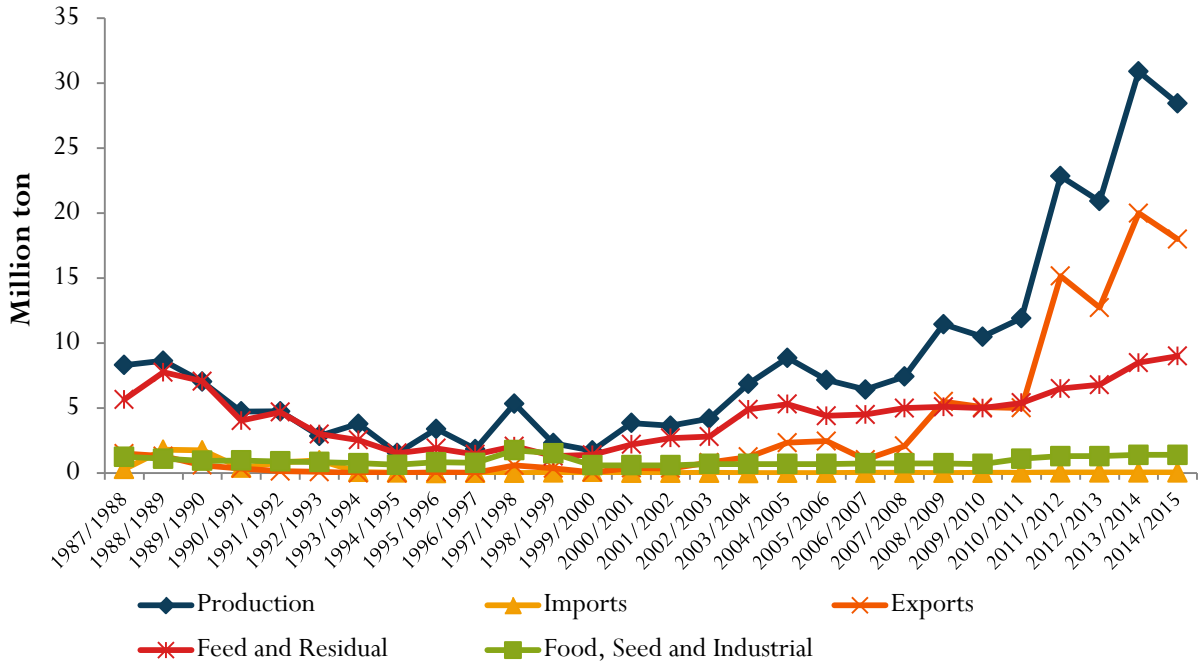

Figure 20: Ukraine maize balance sheet, 1987/88 – 2014/15
Source: FAS, 2015a

In an attempt to increase the influx of currency into the country and relax market limitations, Ukrainian authorities have taken major steps aimed at market deregulation. The closure of the government's agricultural inspection service and the removal of a number of deemed unnecessary quality and grain warehouse certification requirements for grains, allowed logistics costs to decrease and have expedited deliveries. These deregulations not only had a significantly positive impact on trade by creating better trade margins and farm gate prices, but also significantly decreased corruption incentives along export chain (FAS, 2015e). Exports during 2014/15 are estimated at 18 million tons, 10 per cent lower than the previous season, but still the second-largest volume ever recorded (IGC, 2015a). Ukraine's main export markets during 2013/14 were Spain (15 per cent), Egypt (12.7 per cent) and South Korea (8.8 per cent) (FAS, 2014l).

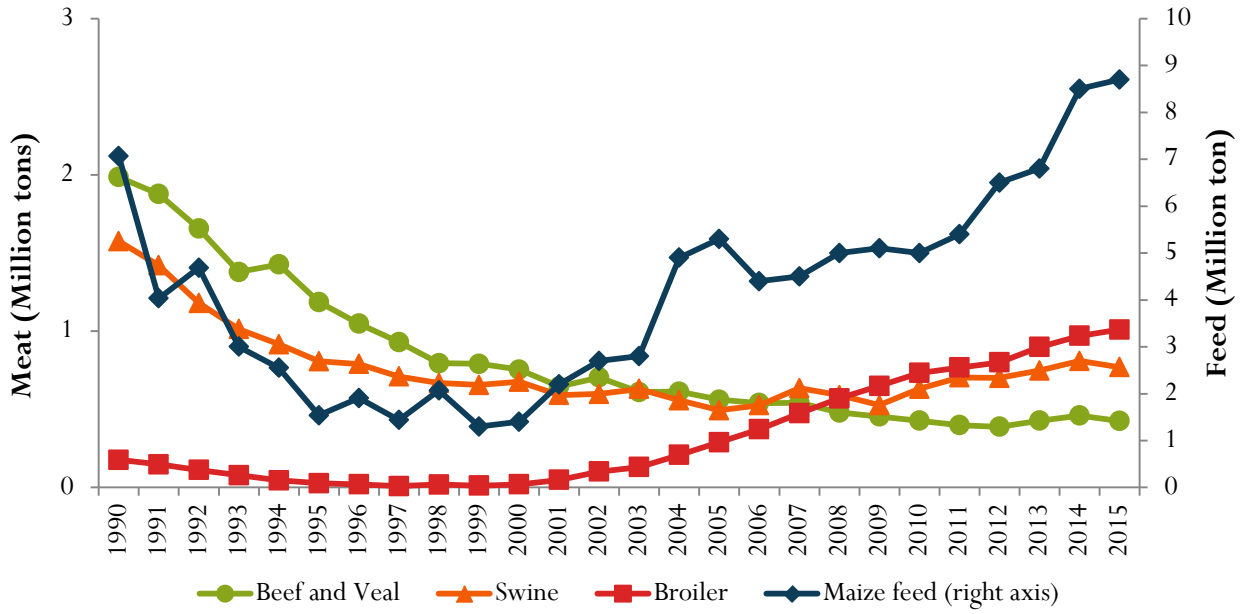

Figure 21: Ukraine meat production and maize feed consumption, 2000 – 2015
Source: FAS, 2015a

3.8 Japan

Japan relies on imports to supply virtually all of the 15.1 million tons maize consumed in the country (IGC, 2015a). Japan's trade description and coding system describes the intended use of all maize that is imported. From Figure 22, it is evident that most of Japan's maize imports are used for the production of feed, followed by starch and other uses such as the production of food, ethyl alcohol and distilled alcoholic beverages. The broiler industry consumed 43.8 per cent of the country's maize feed consumption, while the cattle and swine industries consumed 29.1 per cent and 24.8 per cent, respectively. Due to Japan's traditional maize supplier, the US, not being able to supply Japan with sufficient volumes of maize during 2012 and 2013, Japanese importers had to source maize from other markets at higher than usual prices. These higher maize prices resulted in decreased feed imports during those years as feed millers substituted maize with wheat, rice, sorghum and a feedstock known as Distiller's Dried Grains with Solubles (DDGS), a protein-rich livestock feed that is primarily used in the Japanese layer industry. Japan benefited from the ethanol boom in the US due to an increasing

availability of DDGS, resulting in Japan's imports of DDGS from the US increasing significantly since 2005/06, to reach almost 600 thousand tons in 2013/14. Japanese meat consumption has, however, stagnated since 2010 and with increasing meat imports and a declining livestock population, Japan's feed consumption is expected to decline in the future (FAS, 2015a; FAS, 2015f).

Table 9: Country Snapshot – Japan, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	0.0	Food	1.1	7.4 %
Domestic Consumption	15.1	Industrial**	3.4	23.0 %
Imports	15.1	Feed	10.3	69.6 %
Exports	0.0			
Dependence on Trade				
Exports as a share of Production		0.0 %		
Imports as a share of Domestic Consumption		100.0 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

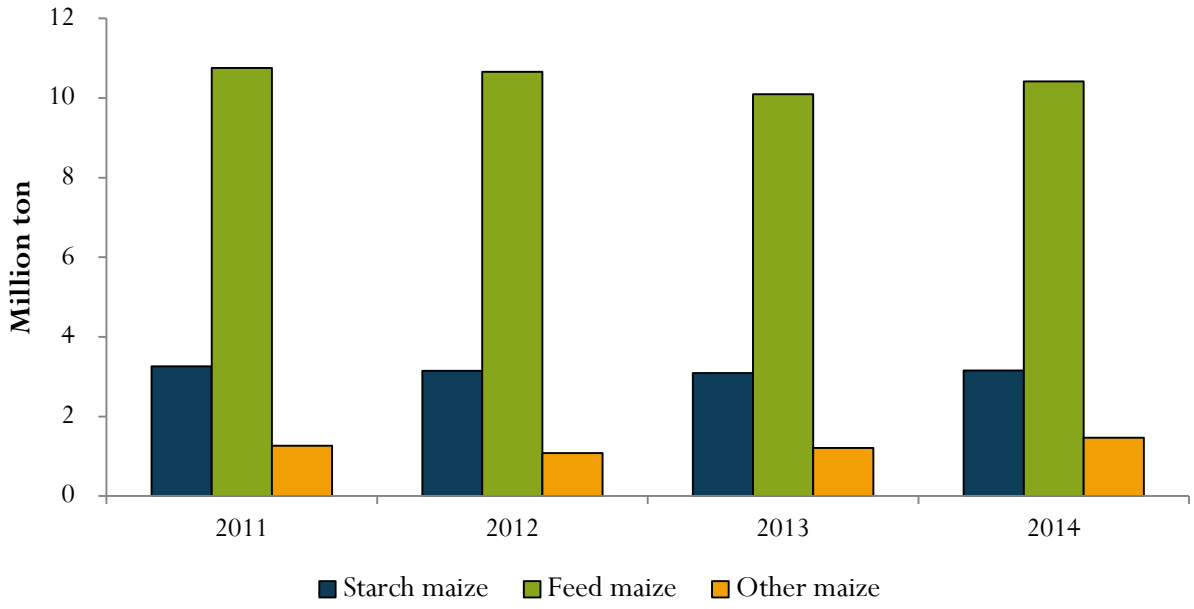

Figure 22: Japan's Maize imports per destined use, 2011 – 2014
Source: ALIC, 2015a

Japan's industrial use of maize mainly consists of the manufacturing of starch and starch-based products. Maize starch constitutes 84 per cent of Japan's starch supply, with the

remainder being supplied by potato, sweet potato, wheat and imported starches. The largest share of Japan's starch is consumed during the production of saccharised products such as glucose-fructose syrup, maltose and glucose (ALIC, 2015a). Despite growth during the 1990s and early 2000s, glucose-fructose syrup production in Japan has stabilised at around 800 thousand tons since 2007. Production reached 811 thousand tons during 2014, a 1 thousand ton reduction from the previous year (ALIC, 2015b).

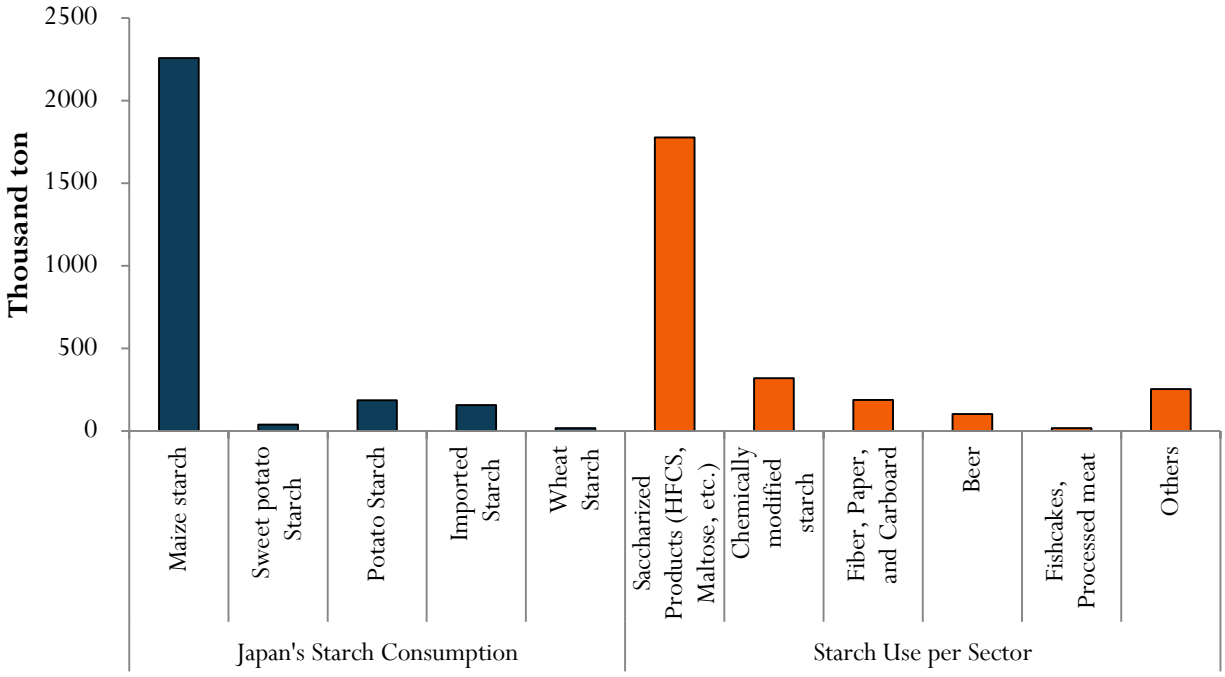

Figure 23: Japan's Starch Production and products produced from starch, 2014

Source: ALIC, 2015a

As mentioned above, the drought in the US in 2012 and 2013 forced Japanese importers to source maize from other markets, such as Brazil, Ukraine and South Africa. The US, however, reclaimed most of the Japanese market during 2014, and is expected to fully recover its traditional market share in 2015 (FAS, 2015f). Although Japanese demand for grain is strong, end-users are geographically dispersed, and the cost of transporting grains by road remains prohibitively expensive. As a result, grain delivery in Japan tends to be characterised by small volumes landing in old ports around the country, either on partially laden vessels (such as Panamax or Handymax) or on small coastal freighters.

Most Japanese ports have neither sufficiently deep channels nor berths to accommodate fully laden vessels, because they were built during the post-war economic boom, and the Government of Japan (GOJ) has not invested in port facilities since the early 1990s. Japanese ports are, therefore, not able to accommodate the scale of modern cargo fleets, and Japanese consumers have not benefited from the increasing efficiencies of today's ocean freight market. To address this issue, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has begun the implementation of the International Strategic Bulk Port Project, which is designed to improve strategically important port facilities in order to reduce ocean transportation costs. As of March 2015, work has begun at only one of the five grain ports targeted for expansion (FAS, 2015g).

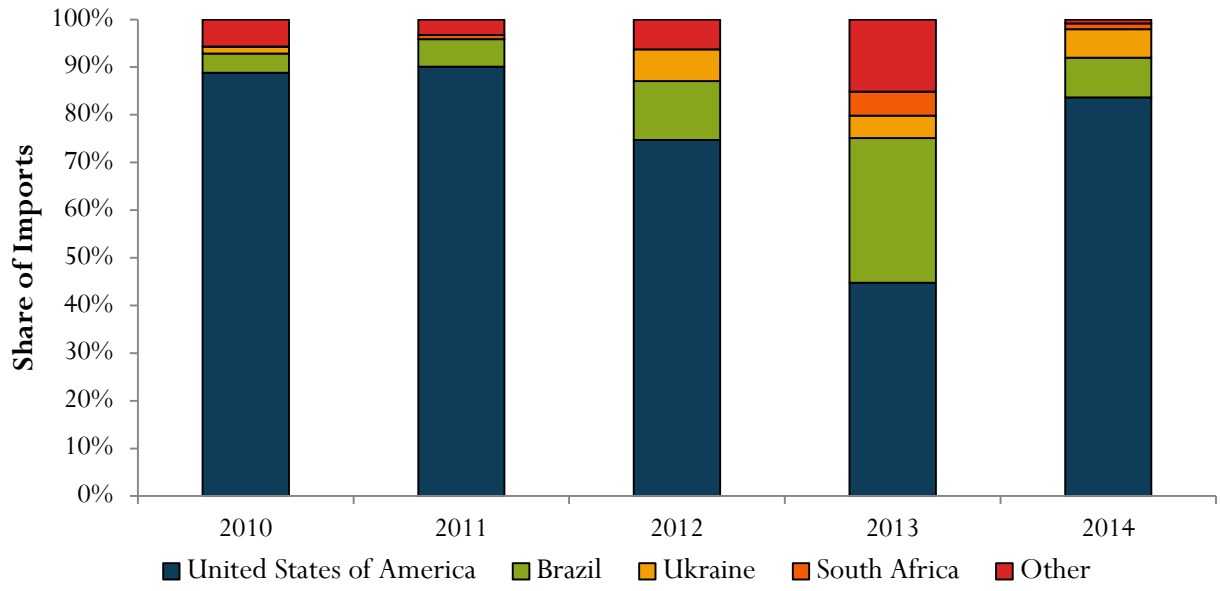

Figure 24: Japan's maize imports, 2010 – 2014
Source: ITC, 2015

4 South Africa: Current Trends and Issues

The previous section provided a detailed perspective on international trends in maize production, consumption and trade. This section will focus on South Africa's current and projected maize production and consumption trends and elaborate on the issues that

constrain the expansion the existing food, animal feed and starch industries or in creating new bio-ethanol and glucose-fructose syrup industries.

Table 10: Country Snapshot – South Africa, 2013/14

Balance Sheet*		Domestic Consumption Split		
	Million ton		*Million ton*	*Share*
Production	11.8	Food	4.66	45.6 %
Domestic Consumption	10.2	Industrial**	0.6	5.9 %
Imports	0.1	Feed	4.96	48.5 %
Exports	2.23			
Dependence on Trade				
Exports as a share of Production		18.9 %		
Imports as a share of Domestic Consumption		0.8 %		

*Balance sheet does not include beginning- or ending stocks; **Industrial use includes maize used for the production of beer, fuel and starch; Source: IGC, 2015a

4.1 Maize Production

South Africa is currently the main maize producer on the African continent, with most production being concentrated in the North West province, the Free State and the Mpumalanga Highveld. As indicated in Table 10, South Africa's maize production reached 11.8 million tons during 2013/14 and consisted of 5.6 million tons white maize and 6.2 million tons yellow maize. The subsequent 2014/15 season yielded a crop of 14.2 million tons, the largest crop in 33 years. The Bureau for Food and Agricultural Policy (BFAP) projects that domestic human consumption of white maize will remain relatively constant over the long term and any significant growth in white maize production will have to be absorbed by the export market, or alternatively, substitute yellow maize in the feed market at a discounted price. Projected growth in white maize yields (to 5,66 ton/ha) and a relatively stable demand for white maize leads to the total area allocated to white maize being projected to decline by 27 per cent between 2014 and 2023. South Africa is still expected to remain a net exporter of white maize under normal weather conditions until 2023. Regarding yellow maize, the increased demand for animal feed will be met by improved average yields in yellow maize in the short and medium term, assuming a constant area. In the longer term, yield increases (to 6

ton/ha) alone might not be enough to provide for the growing demand for feed and an increase in yellow maize plantings will be needed to ensure a net export position for yellow maize. Therefore, in the long run the area planted to yellow maize is expected to expand, reaching a level of 1.2 million hectares by 2023 (BFAP, 2014a; BFAP, 2015).

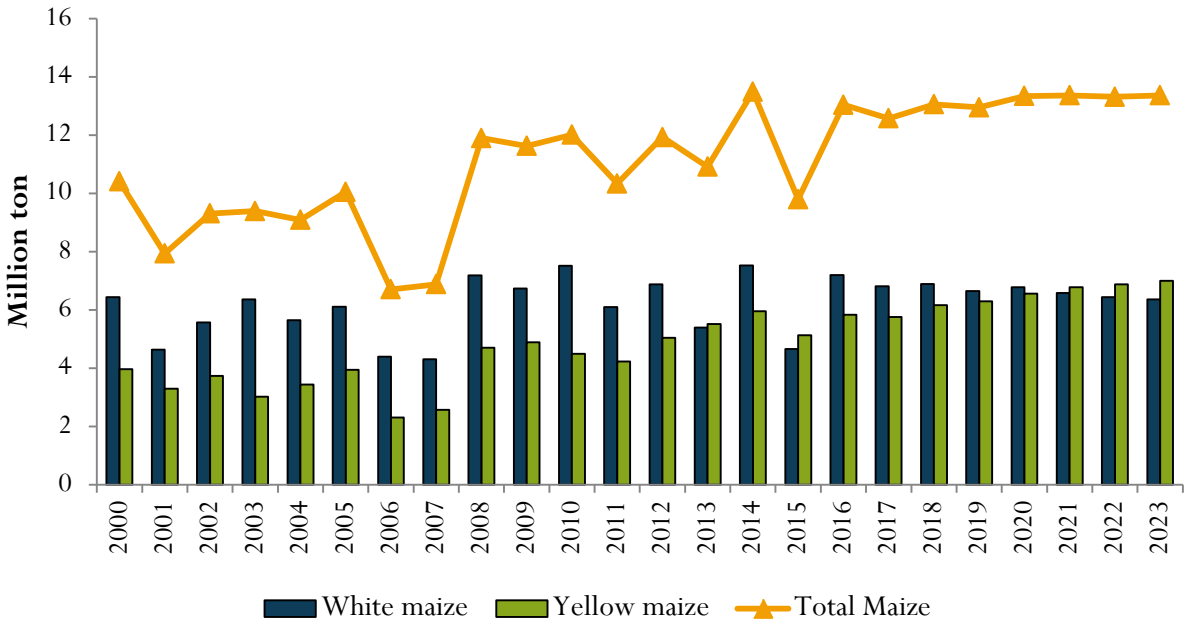

Figure 25: South African maize production, 2000 – 2024
Source: BFAP, 2015

4.2 Food and Animal Feed

Maize is the most important grain crop in South Africa, being both the major feed grain and the staple food of the majority of the South African population. Figure 26 illustrates how South Africa's food and animal feed consumption changed between 2000 and 2014. Maize used for human consumption has trended sideways since the turn of the century, trending between the 4 million tons and 4.5 million tons per annum levels. Animal feed consumption, on the other hand, has grown from 3.3 million tons to 4.8 million tons per annum, or by 45 per cent between 2000 and 2014 (BFAP, 2015).

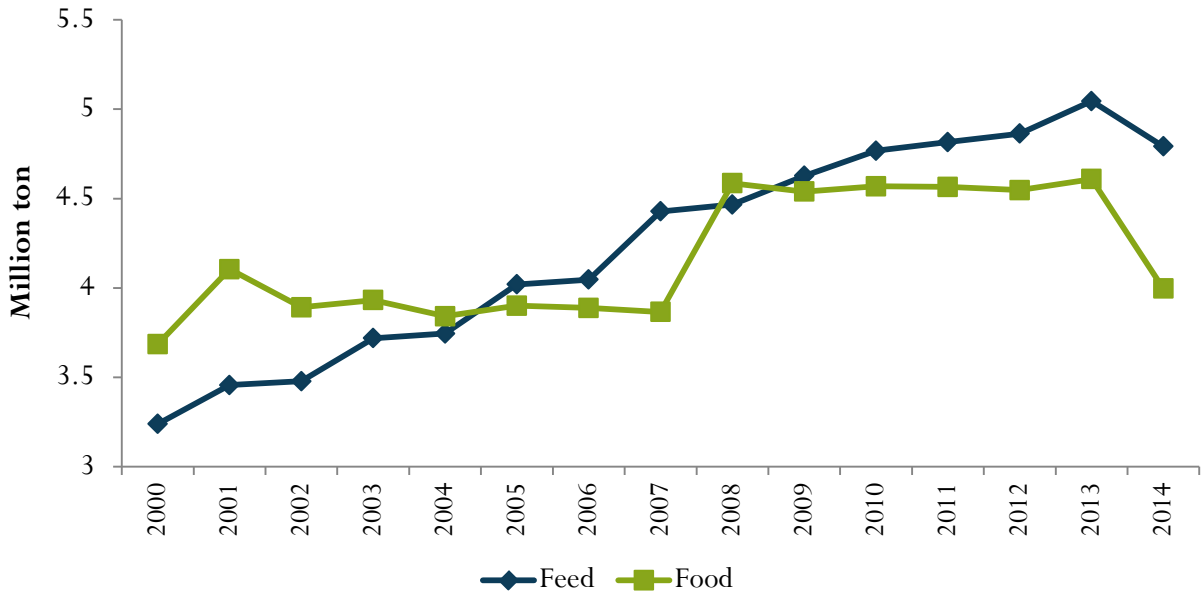

Figure 26: South African maize consumption, 2000 – 2014
Source: BFAP, 2015

Before considering the future of food and animal feed consumption of maize in South Africa, it is important to first understand how growing consumer incomes will affect consumer dietary preferences in the future. Figure 26 indicates that since 2004, the South African adult population experienced a migration from the lowest income groups (Living Standards Measures 1 to 4) towards the middle- and upper-income groups (SAARF, 2014). This growth in income affects South African maize consumption in two ways. The first is that since maize (or more specifically white maize meal) is an important staple food consumed by lower-income groups in South Africa, this migration will have a negative impact on maize consumption. Using StatsSA Income and Expenditure data, Figure 28 illustrates how household expenditure on different staples moves away from maize meal in favour of a variety of other starches like bread, rice, potatoes and pasta. As indicated by the red arrows, maize meal moves from being the biggest contribution to staple expenditure, to contributing only 7 per cent of the household staple expenditure as income increases (StatsSA, 2012).

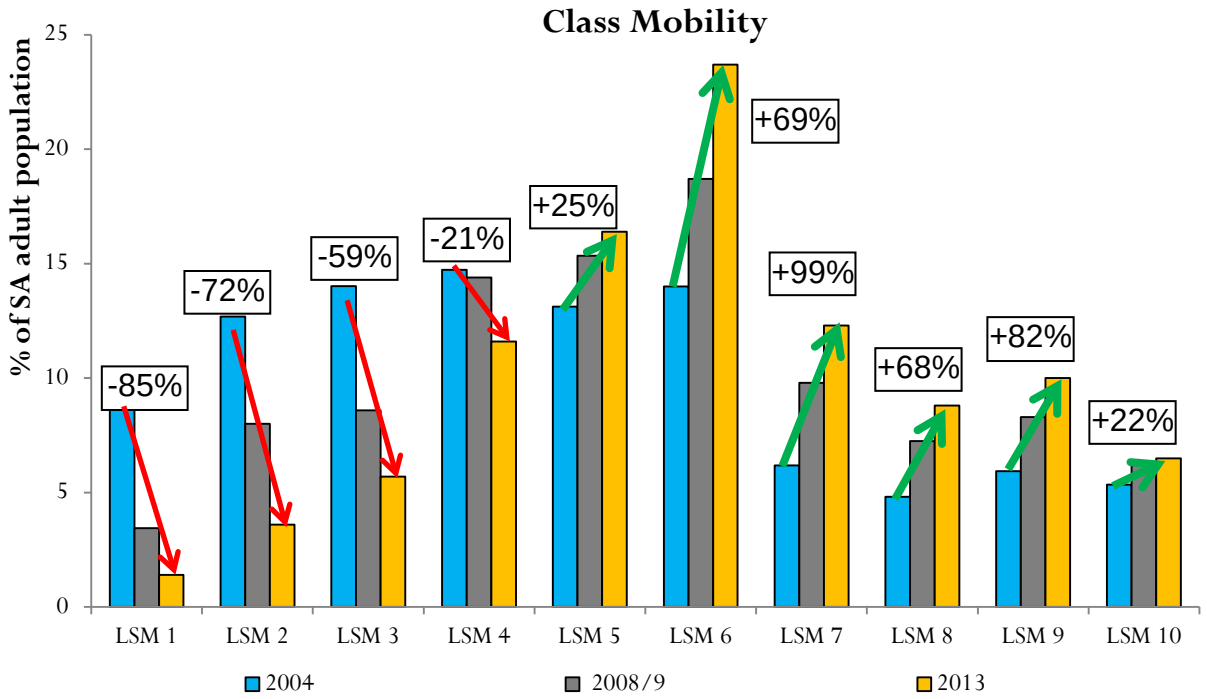

Figure 27: Changes in class mobility observed between 2004 and 2013
Source: SAARF, 2014

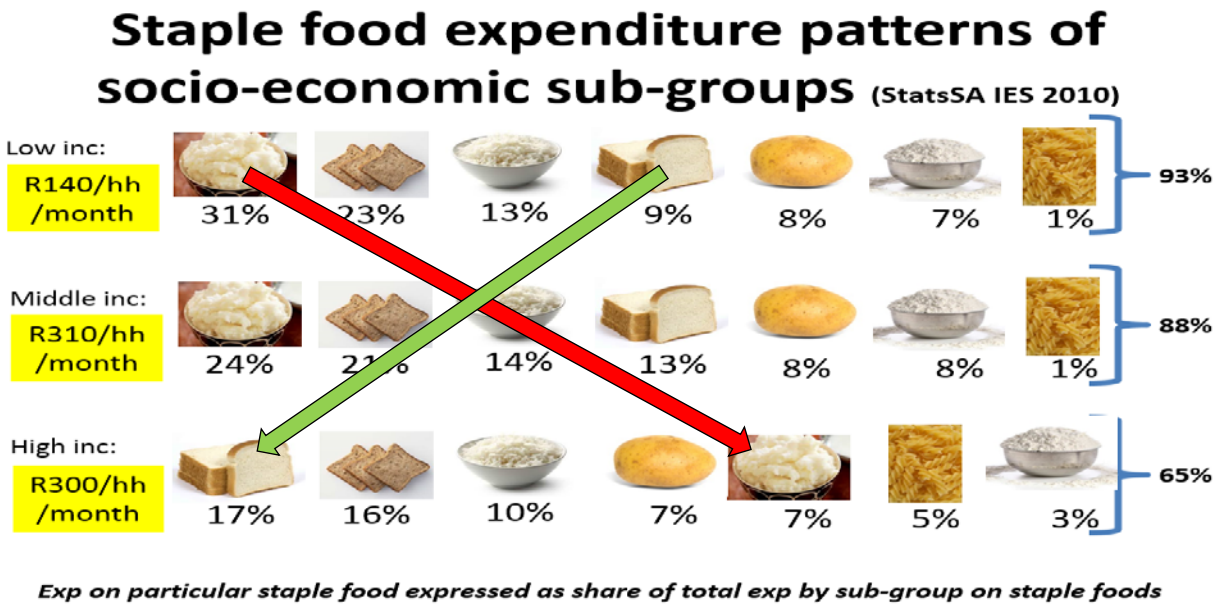

Figure 28: Household expenditure on maize decreases as income increases
Source: BFAP, 2014; based on StatsSA, 2008 and StatsSA, 2012

The second manner in which maize consumption is affected by this growth in consumer income is that this same income growth has driven large increases in the consumption and production of animal-based proteins. The growth in the demand for meats, dairy

products and eggs in South Africa resulted in the volume of maize used to produce animal feeds growing by 19 per cent between 2005 and 2014. Chicken meat consumption increased by 45 per cent between 2005 and 2014 and remains the most affordable source of protein in South Africa. BFAP projections indicate that chicken consumption will expand by a further 29 per cent over the next decade and will account for 70 per cent of additional meat consumed by 2023. Pork consumption is set to grow the fastest of all meat types, yet an expansion of 37 per cent through the next ten years will account for only 10 per cent of additional meat consumed by 2023, reflecting its small share in total meat consumption. The demand for beef is projected to increase by 23 per cent through the next decade, accounting for 18 per cent of additional meat consumed by 2023. Egg consumption will also expand by approximately 22 per cent, whereas fresh milk, cheese and butter consumption will increase by 19 per cent, 45 per cent and 12 per cent, respectively (BFAP, 2014a).

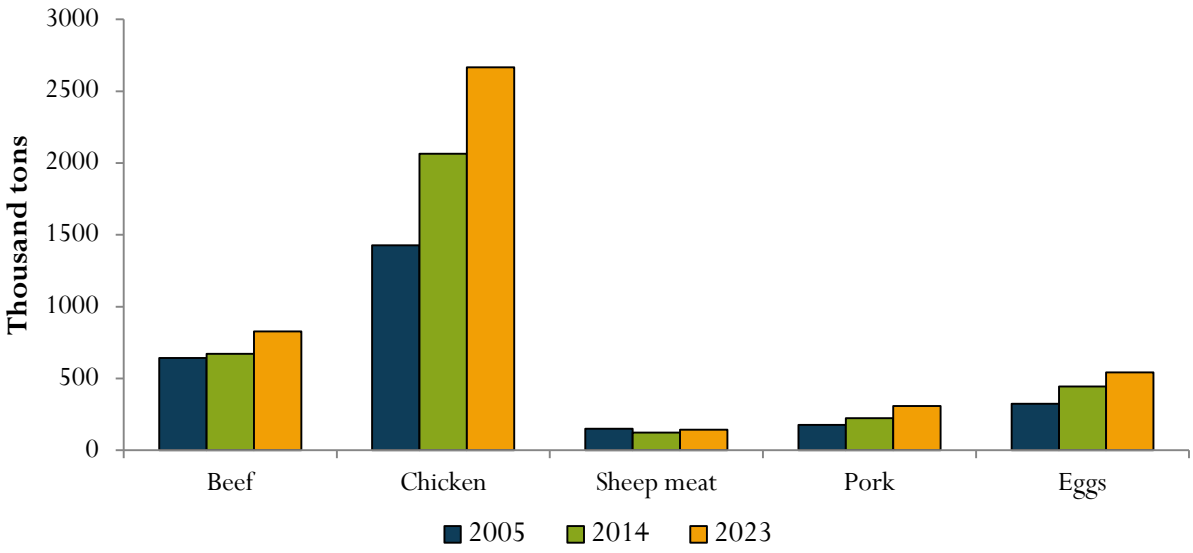

Figure 29: South African meat and egg consumption, 2005 – 2023
Source: BFAP, 2014a

In light of the above consumption and other social and economic trends, BFAP estimates that food consumption of maize will continue to trend sideways over the next decade, to reach 4.77 million tons by 2023. This view is to a large degree shared by the milling industry, with a representative stating that although government feeding programmes

and new maize-based food products might stimulate consumption, the industry's long-term view is that growth in this sector will remain constrained by a lack of growth in the demand for maize-based food products.

Regarding the demand for maize used in the production of animal feeds, BFAP's expectations are that feed demand for maize will increase by a further 46 per cent between 2014 and 2023, to reach just over 7 million tons (BFAP, 2014a). A representative of the animal feed industry has stated that although additional demand for animal products will naturally drive maize feed demand in the future, the maize industry can stimulate growth even further by supporting the growth of industries that are dependent on animal feed and to assist these industries to develop their export potentials. For example, the South African poultry industry is faced with the issue of foreign poultry meat entering the domestic market at supposedly "dumped" prices. South Africa imported approximately 370 000 tons of poultry meat during 2014, the equivalent of 408 thousand tons of maize that could have been produced and consumed domestically[3] (ITC, 2015). However, most of these imports consisted of dark poultry meat cuts from the EU that entered the country duty free under the Trade, Development and Cooperation Agreement (TDCA), and will perhaps even be imported duty free from the US in the future under the African Growth and Opportunity Act (AGOA). As a signatory of the TDCA, it will not be possible for South African broiler producers to be shielded from these imports. However, given South African consumers' preference for dark poultry cuts, South African poultry producers need to sell white poultry cuts at discounted prices in the domestic market. By supporting initiatives to find and open export markets for white poultry meat, the maize industry can assist the poultry industry to export value-added meat products.

3 Assuming a feed conversion ratio of 1.7 and that maize constitutes 65 per cent of broiler feed (Astral Foods, 2014).

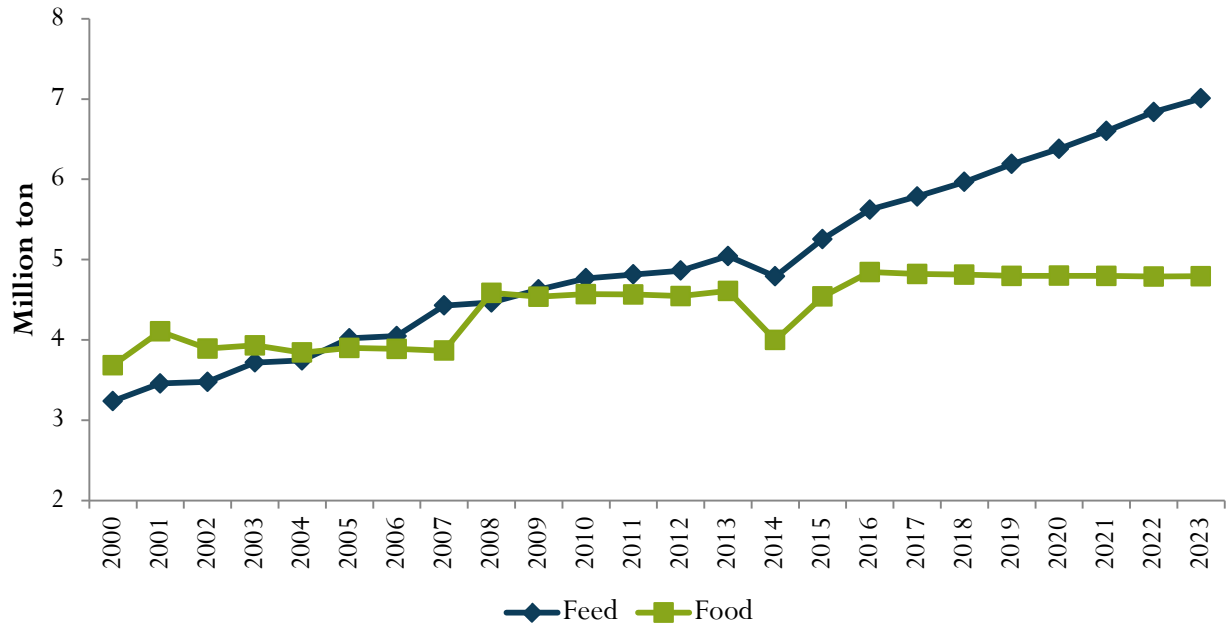

Figure 30: South African maize consumption, 2000 – 2024
Source: BFAP, 2015

4.3 Bio-Ethanol

Since the industrial revolution, the world's primary energy supply has been based on fossil fuels, i.e. oil, coal, petroleum and natural gas, because of their relatively low prices and seemingly infinite stock. An oil crisis in the 1970s, however, sent shockwaves across the globe, causing countries to start investigating alternative fuels to lower their dependency on oil from the Organization of the Petroleum Exporting Countries (OPEC). Countries around the world have introduced policies to stimulate the production or use of non-fossil fuels, both to diversify their energy sources and to gain environmental benefits. Such policies often emphasise ambitious and extensive biofuel mandates, supported by programmes that include government financing for biofuel project development, write-off of loans and favourable credit for biofuel production, tax credits for fuel blenders, and tax rebates for fuel suppliers. These policy instruments have resulted in high levels of support for producers of first-generation biofuels, and expanded the markets for agricultural feedstocks used in the production of biofuels (Josling *et al.,* 2010).

In many of the now dominant biofuel producing nations, government support has played, and in most instances is still playing, an important role in developing the industry. The tabling of the Biofuels Industrial Strategy (BIS) for the South African biofuel industry has brought with it hope and expectation that the incentives proposed will be sufficient to kick-start the domestic industry (South Africa, 2007). The exclusion of maize from the Strategy did surprise stakeholders, as its inclusion in the feedstock mix could create an alternative market which would help boost the industry and support the government's rural development goals. However, a cautious approach to implementing policies that could exacerbate food insecurity or reduce household purchasing power is understandable.

According to the Draft Position Paper published by government in January 2014, sorghum was selected as the crop to produce bio-ethanol from during the initial phases of implementing the Strategy and will be sourced from under-utilised land in the former homelands (South Africa, 2014). Two ethanol plants are currently planned that will use sorghum as feedstock for the production of bio-ethanol; one in Bothaville and one in Cradock. At a blending rate of 2 per cent, more than 600 thousand tons of sorghum will be required (BFAP, 2014b). It is currently envisaged within the BIS that bio-ethanol production from maize will be considered only once certainty on the ability of the currently under-utilised land to produce has been established and measures are in place to guard against extreme (industry linked) food inflation (South Africa, 2007).

Although it is not within the ambit of this study to argue for the inclusion of maize as a feedstock, a number of arguments question the exclusion:

- Firstly, should maize be included as a crop in the future, the impact on food prices can be minimised by establishing quota limits through the issuing of licenses within the industry. On average, South Africa is food self-sufficient and is therefore not expected to trade at import parity. This situation could, however, change with an

impact on supply due to externalities such as drought, and local prices could be driven towards import parity levels. Such a policy should therefore go hand in hand with the support of local production. South Africa has the potential to produce more maize under the correct set of policy incentives (BFAP, 2008).

- Over the past few years, South Africa has moved from being a net exporter of sorghum to being a net importer. The area under sorghum production has declined as profit margins of maize have been outperforming those of sorghum due to the rapid rise in maize yields and genetic modification applications that are available in maize and not in sorghum (BFAP, 2014a). If both maize yields and profit margins are higher than those of sorghum, why can new farmers in the former homeland areas not supply the biofuels industry with a crop that provides them with the most income?
- Lastly, under a 2 per cent blending regime and with the establishment of crop production outside existing maize areas, the relative impacts on maize prices and food security would be minimal. It is, therefore, worth asking why refiners are not allowed to use the economically most competitive crop for bioethanol production, which is currently maize (see Table 11).

Table 11: Plant profit calculations per crop, 2014 average prices

Calculation (c/litre)	Maize	Sorghum	Sugar
Cost of crop	533.9	623.22	518.17
Ethanol non-crop variable costs	184.06	184.66	173.14
Ethanol non-crop capital costs (WACC = 14.75 %)	104.21	104.55	105.38
– Income from Dried Distillers Grains	-176.85	-127.95	-
Total costs	645.31	784.48	796.69
Ethanol price at plant	807.82	807.82	807.82
Profit Margin	**162.51**	**23.34**	**11.14**

*WACC= Weighted Average Cost of Capital; Source: BFAP, 2015

During the initial phases of the Biofuels Industrial Strategy it will therefore not be possible to add value to exported surpluses through the production of bio-ethanol, and any opportunities to add value will therefore depend on whether maize will be included as a production crop in the future.

4.4 Maize Starch

South African starch producers convert more than 600 000 tons of maize per annum into starch and starch-based products, representing 6 per cent of aggregate maize consumption during 2013/14. South African starch is produced using non-GMO maize sourced from contract growers and consists of 10–15 per cent white maize, with the rest being food grade yellow maize. Starch is made using the wet milling process to separate maize into relatively pure chemical compound classes of starch, protein, oil, and fibre. Products vary from unmodified maize starch to highly refined glucose products, which are key ingredients for manufacturers of foodstuffs, beverages and a variety of industrial products. Figure 31 illustrates how South Africa's maize starch production increased by 9 per cent, from 593 thousand tons to 644 thousand tons, between 2009/10 and 2013/14. Over the same period, the domestic markets for starch and glucose grew by 4 per cent, whereas exports grew by 41 per cent (Starch Industry, 2015).

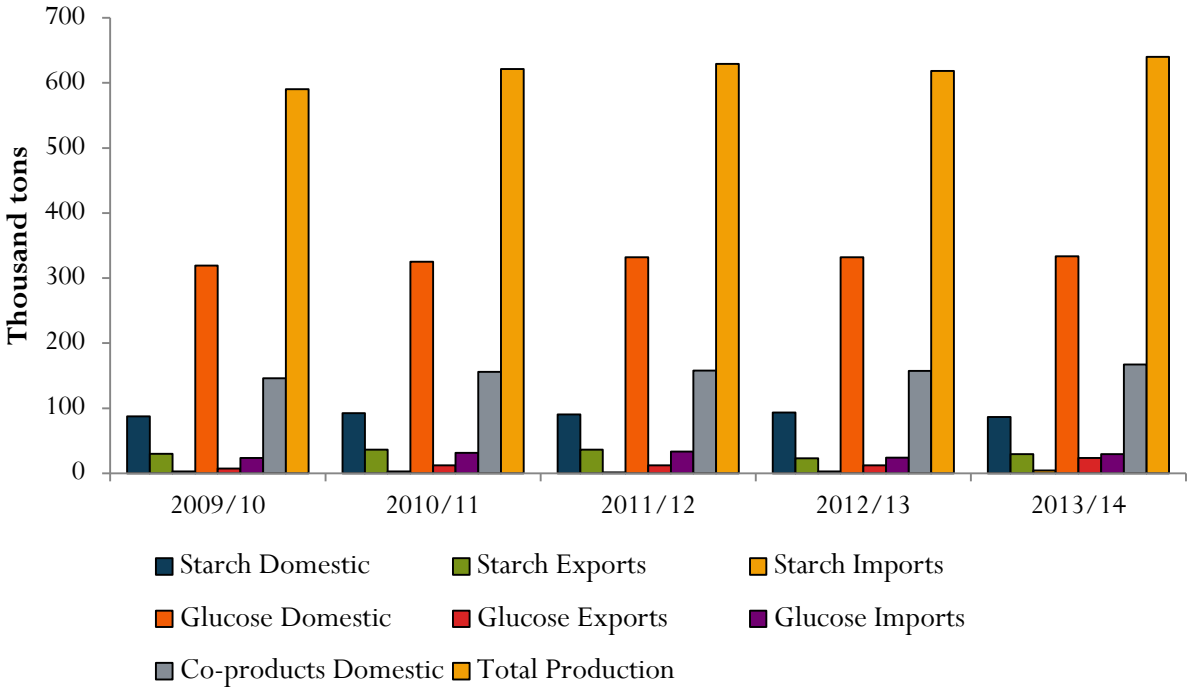

Figure 31: South African starch and glucose production and markets, 2009/10 – 2013/14

Source: Starch Industry, 2015; ITC, 2015

According to industry representatives, South Africa currently has about 20 per cent of its installed up-stream wet-milling capacity available, and domestic industries are well positioned to realise opportunities for growth in the domestic market. In the domestic market the industry is constrained by a) a limited growth in demand for starch and glucose products, which mirrors income and population growth; and b) the unfair advantage of foreign starch (maize, wheat and potato) imports that benefit from foreign governmental support and enter the South African market duty free. The industry does, however, feel that the greatest opportunity for growth lies in the export market for non-GMO based starch and glucose products. To realise these opportunities, the industry needs assistance to gain access to foreign starch markets.

Table 12: South Africa's starch and glucose imports, 2014

	Importer	Imported quantity, Tons	Tariff applied by SA (%)	Tariff applied by importer to SA product (%)
Maize Starch (HS 110812)	India	2461	0	30
	Thailand	1351	0	30.00 % or 64.14 $/ton, whichever is the greater
	Turkey	474	0	OQTR*: 27.00 %, IQTR*: 0 %, Quota= 1000 ton
Glucose (HS 170230-40)	China	14159	0	30
	United States of America	11300	0	0
	India	2401	0	30

OQTR = Out of Quota Tariff Rate; IQTR = Out of Quota Tariff Rate; Source: ITC, 2015

4.5 Glucose-Fructose Syrup

Glucose-fructose syrup is a liquid sweetener used in the manufacturing of foods and beverages. It is composed of different sugars, mainly glucose and fructose, with varying compositions, with a fructose content ranging from 5 to 50 per cent. Glucose-fructose syrups and fructose-glucose syrups are typically made from wheat or maize starch by first making glucose syrup and then, through a process called hydrolisation, liberating free glucose molecules. With the use of enzymes, some of these glucose molecules are then

changed into fructose in a process called isomerisation. In Europe, because of this isomerisation process, glucose-fructose syrups and fructose-glucose syrups with a fructose content of more than 10 per cent are referred to as isoglucose. In the United States, this type of product is produced from maize starch, most commonly either with a 42 per cent or a 55 per cent fructose content, and is called high fructose corn syrup (HFCS) (Starch Europe, 2015b). Glucose-fructose syrups have been widely adopted by food manufacturers because they offer advantages over granulated sucrose, including supply, stability and ease of handling. Although glucose-fructose syrup has replaced sucrose in many prepared foods and beverages in the US and Japan, sucrose remains the primary sweetener used around the world (Beverage Institute, 2015).

In the US, consumer concerns about glucose-fructose syrups began in 2004, following widespread media attention of a commentary published in the American Journal of Clinical Nutrition (AJCN) on glucose-fructose syrups and obesity that speculated that differences in the sweetness, fructose content or satiety value of glucose-fructose syrups, versus sucrose, could be linked to rising obesity rates in the US (Bray, Nielsen & Popkin, 2004). In 2008, the American Medical Association (AMA) reviewed the relevant research related to glucose-fructose syrups to address consumer concern regarding this sweetener (Moeller *et al.*, 2009). In its statement, the AMA noted that, "Because the composition of Glucose-Fructose syrups and sucrose are so similar, particularly on absorption by the body, it appears unlikely that Glucose-Fructose syrups contribute more to obesity or other conditions than sucrose." However, the AMA also encouraged independent research on the health effects of glucose-fructose syrups and other sweeteners and recommended that consumers limit all added caloric sweeteners, in keeping with recommendations from the Dietary Guidelines for Americans. Glucose-fructose syrups and sucrose are, therefore, so similar that substituting one for the other will have no distinguishable impact on obesity or health (Beverage Institute, 2015).

Although South Africa produces ample volumes of maize and glucose-fructose syrups that can serve as a substitute for sucrose in several prepared foods and beverage markets, glucose-fructose syrups are currently not produced or consumed in the country. Assuming that the consumption of glucose-fructose syrups in South Africa will mirror the consumption of the world's largest glucose-fructose syrup consumer, the US, the beverage industry would likely be the most significant consumer in the country. An expert from the beverage industry has noted that the industry has developed a sophisticated model to measure the economic viability of switching to glucose-fructose syrups. The increasing price of sugar and the limited ability of the industry to pass input cost increases on to the consumer, the increased level of protection against imports due the increase in the dollar-based reference price from US$358/ton to US$566/ ton, and low maize prices may make glucose-fructose syrups an economically viable alternative to sucrose in the future.

The adoption of glucose-fructose syrups does, however, present several challenges. Firstly, although medical research has proven that the consumption of glucose-fructose syrups does not increase the risk for obesity and other adverse health outcomes any more than other caloric sweeteners do, the doubts of the public regarding the safety of glucose-fructose syrups remain. Changing this negative perception will require significant investment in marketing and domestic clinical trials, and in avoiding risk being attached to the established image of beverage brands that include glucose-fructose syrups. Secondly, any domestically produced glucose-fructose syrups will most likely need to be produced from non-GM maize. Non-GM maize is traded at a premium, when compared with more readily available GM maize, since 86 per cent of all maize produced in South Africa is GM (James, 2013). Due to the limited amount of non-GM maize planted, sourcing only non-GM maize will therefore create additional administrative and logistical challenges and present a risk in securing adequate supplies for glucose-fructose syrups producers and industrial consumers. Lastly, the adoption of glucose-fructose syrups will substitute domestically produced sugar that is currently being used in the prepared food

and beverage industries, and therefore will be to the detriment of the already stressed and labour-intensive domestic sugar industry.

5 Assessment

5.1 South Africa's Maize Exports: Normal or excessive?

During the 2013/14 marketing year, South Africa exported the equivalent of 19 per cent of the country's 11.8 million ton crop. Compared with other leading maize exporters, exporting 19 per cent of the domestic crop is not excessive. Brazil, Ukraine and Argentina export significantly greater shares of their annual maize production, and even the world's most advanced consumer of maize and maize-based products, the US, exports 14 per cent of its crop (see Table 13). However, under normal weather conditions South Africa is expected to remain a net exporter of maize(see Figure 32), and questions regarding whether exported surpluses could not be better utilised in the domestic market to create employment opportunities, to substitute imports, or to produce and export value-added products will remain (BFAP, 2015).

Table 13: Maize Balance Sheet in selected countries, 2013/2014

Country	Production	Domestic consumption (*)	Imports	Exports	Exports/ production	Imports/ domestic consumption
Argentina	32.1	12.1	0.0	18.6	58.1 %	0.0 %
Brazil	81.3	53.2	0.6	24.9	30.7 %	1.1 %
EU-28	64.0	76.1	15.8	2.3	3.6 %	20.8 %
South Africa**	**11.8**	**10.2**	**0.0**	**2.2**	**18.9 %**	**0.0 %**
Ukraine	30.9	9.8	0.0	19.9	64.4 %	0.0 %
USA	351.3	293.1	0.9	48.7	13.9 %	0.3 %
China	218.5	206.4	3.3	0.2	0.1 %	1.6 %
Japan	0.0	15.1	15.1	0.0	0.0 %	100.0 %
Mexico**	22.9	31.6	10.9	0.5	2.2 %	34.5 %
World	**991.5**	**947.9**	**120.7**	**120.7**	**12.2 %**	**12.7 %**

Domestic consumption figures include: Food, Industrial, Feed, Seed and Wastage. Calculation = Production – Exports + Imports + Begin stock – Ending stock; ****South Africa data: SAGIS, 2015 and Starch Industry, 2015; ** Mexico data: Industrial Use = USDA FSI-Starch consumption. Source: FAS, 2015a; Source of other data: IGC, 2015a

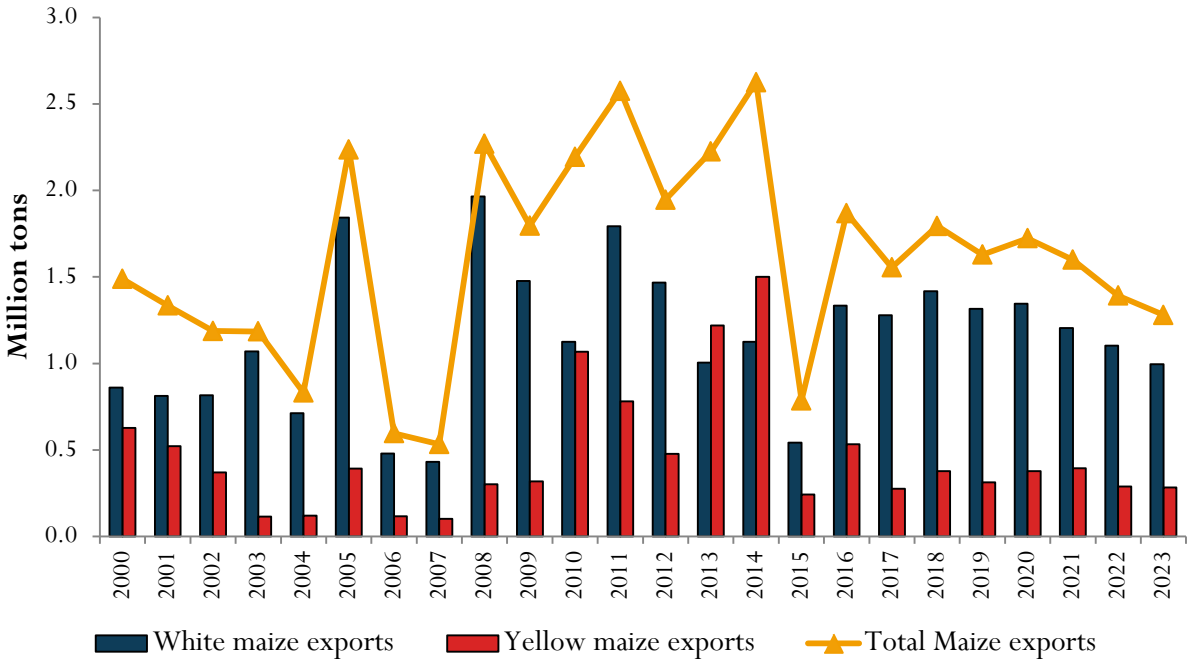

Figure 32: South African maize exports, 2000-2023
Source: BFAP, 2015

5.2 Maize Consumption: How does South Africa compare with other markets?

The main trend internationally is to employ ever greater shares of maize production in the manufacturing of animal feed. Feed demand accounted for 60 per cent of overall maize consumption in 2013/14. Projections made by the International Grains Council (IGC) indicate that feed demand will be the main driver behind maize consumption growth in the medium term, expanding a further 60 million tons (or 11 per cent) between 2013/14 and 2019/20 (IGC, 2014). Projected gains are linked to income growth, rising populations, urbanisation and shifting dietary preferences (IGC, 2014). This same trend is observed in South Africa, with most future maize consumption gains occurring within the animal feed sector.

Table 14: Domestic maize consumption in selected countries, 2013/14

Country	Use			Share (%)			Area/s of expected growth (^{M}=modest growth)
	Food	Industrial*	Feed	Food	Industrial*	Feed	
Argentina	0.3	1.8	9.2	2.7 %	15.9 %	81.4 %	Feed and Ethanol
Brazil	4.0	1.7	44.5	8.0 %	3.4 %	88.6 %	Feed, Ethanol ^{M}
EU-28	4.2	13.8	56.0	5.7 %	18.6 %	75.7 %	Glucose-fructose syrups and Ethanol
South Africa**	**4.6**	**0.6**	**4.9**	**45.6 %**	**5.9 %**	**48.5 %**	**Feed and Food ^{M}**
Ukraine	0.5	0.3	7.7	5.9 %	3.5 %	90.6 %	Feed ^{M}
USA	5.1	159.5	127.9	1.7 %	54.5 %	43.7 %	Feed, Glucose-fructose syrups ^{M} and Ethanol ^{M}
China	7.3	49.0	139.8	3.7 %	25.0 %	71.3 %	Feed and Starch ^{M}
Japan	1.1	3.4	10.3	7.4 %	23.0 %	69.6 %	-
Mexico***	14	2.5	15.2	44.2 %	7.9 %	47.9 %	Feed, Food ^{M} and Starch ^{M}
World	103.8	256.8	550.3	11.4 %	28.2 %	60.4 %	Feed, Food ^{M} and Industrial ^{M}

* Industrial use includes maize used for the production of beer, fuel and starch; **South Africa data: SAGIS, 2015 and Starch Industry, 2015; *** Mexico data: Industrial Use = USDA FSI-Starch consumption, Source: FAS, 2015a; Source of other data: IGC, 2015a

Industrial consumption of maize consists mainly of ethanol, starch and fructose-glucose syrup production. Global consumption is projected to expand by 19 million tons (or by 7.3 per cent), of which the expansion of ethanol accounts for only 4 million tons. South Africa's industrial consumption may seem low at 6 per cent of domestic consumption compared with the global average of 28 per cent; however, one should take into account that a) South Africa does not produce maize-based ethanol or glucose fructose syrup, and b) that ethanol production in the US is so significant that it lifts the global average. Excluding the US, the global average industrial consumption of maize is only 16 per cent.

Direct human consumption of maize typically accounts for just 11 per cent of global maize consumption and is projected to only increase by 9 million tons (or by 9 per cent)

between 2013/14 and 2019/20 (IGC, 2014). Among the countries studied, food consumption of maize only played a significant role in South Africa and Mexico. As discussed above, the role of food consumption in South Africa is, however, expected to diminish in the future as larger shares of maize production will be consumed by the animal feed sector as consumption patterns evolve to favour animal- and wheat-based products.

5.3 The case for adding value

The second objective of this study was to provide a high-level overview of South Africa's potential to add value to the current exported surplus by expanding food, animal feed, ethanol, maize starch and glucose-fructose syrup production. Figure 33 presents a summary of plausible future scenarios, based on a set of assumptions (also see Table 15 in the Appendix):

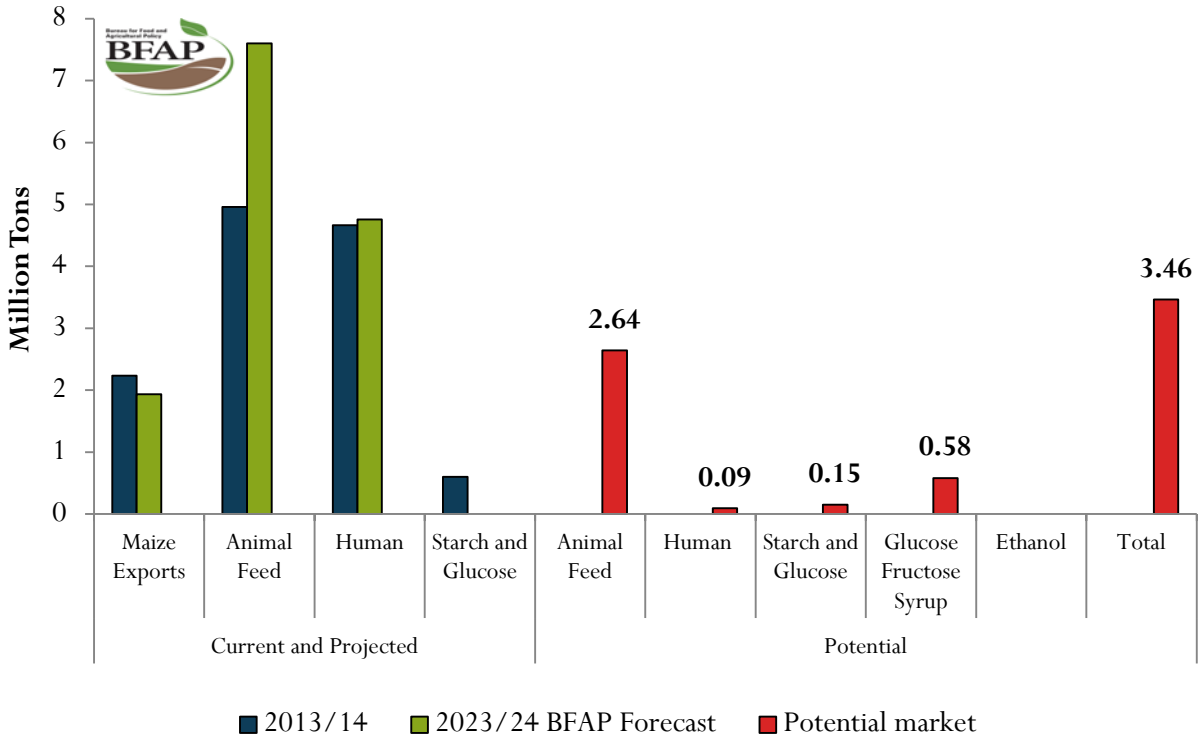

Figure 33: South African maize consumption potentials, 2013/14 – 2023/24
Source: BFAP, 2015

- **Exports:** BFAP projects that maize exports will decline from 2.23 million tons to 1.96 million tons between 2013/14 and 2023/24. The main driver of this reduction is that growth in domestic demand for maize (especially yellow maize) will outpace production growth (SAGIS, 2015; BFAP, 2015).

- **Feed consumption:** Rising demand for animal-based products is projected to drive a feed demand growth of 2.64 million tons between 2013/14 and 2023/24 (BFAP, 2015). Assuming that the 370 thousand tons of dark poultry meat imports can be substituted by 370 thousand tons of white poultry meat exports, a further 410 thousand tons[4] of maize can potentially be consumed by the South African poultry industry (BFAP, 2015; ITC, 2015; Astral Foods, 2014).

- **Human consumption:** Due to the limited growth in the demand for maize-based food products, BFAP estimates that food consumption will continue to trend sideways over the next decade, only expanding 90 thousand tons by 2023/24 (SAGIS, 2015; BFAP, 2015).

- **Starch and glucose:** Assuming the country utilises the available 20 per cent wet-milling capacity, a further 150 thousand tons of maize can be used in the production of starch and glucose products (Starch Industry, 2015).

- **Glucose-Fructose syrup (HFCS):** Industry sources have indicated that between 350–400 thousand tons of sugar is consumed by the South African beverage industry. BFAP estimates that 581 thousand tons of maize can be consumed during the production of glucose-fructose syrup under the following assumptions:

  - 1 ton of glucose-fructose syrup replaces 1 ton of sugar, based on the perfect rate of substitution observed in the US between 1977 and 1988 (ERS, 2015d);

4 Assuming a feed conversion ratio of 1.7 and that maize constitutes 65 per cent of broiler feed (Astral Foods, 2014).

- 1.66 tons of maize is required to produce 1 ton of glucose-fructose syrup (Gray, 1991);
- Glucose-fructose syrup can replace 350 thousand tons of sugar in the beverage industry.

- **Ethanol:** As discussed in Section 4.3, maize is currently excluded as a production crop within the South African Biofuels Industrial Strategy (BIS) due to food security concerns. Until such time that maize is included as a production crop in the BIS, it is not possible to legitimately produce maize-based ethanol in South Africa and the potential market space is therefore naught.

- **Total Potential:** In light of the above, the total additional market space for maize in 2023/24 is projected at 3.46 million tons (excluding the potential 410 thousand tons that could be consumed under a poultry export scenario).

Perhaps the greatest motivation to further research and to coordinate the manner in which the South African maize value chain can process currently exported surpluses is presented in Figure 34. By calculating the difference between the average values of exported and processed maize products from the average maize prices typically used to produce these products, Figure 34 indicates the value that is unlocked per ton of maize per product (see Table 16 for detailed information). Exporting a ton of maize adds the least value among the products considered, only adding an additional R853/ton. The production of "Super" maize meal adds on average R2662/ton of white maize, whereas starch and glucose production add on average R3529/ton of non-GM maize. One ton of yellow maize, on the other hand, enables the creation of 1.54 tons of broiler feed, allowing the domestic feed industry to add an additional R5531/ton through further processing and adding additional inputs. Hypothetically, should the 2.2 million tons of maize that South Africa exported during 2013/14 have been converted to poultry feed, R10.3 billion of additional value would have been created within the domestic maize

value chain. The value created, should this additional feed have been used in the production of meat products, would have been even greater. Based on this assessment, it is thus clear that, given current market trends, the expansion of the domestic animal feed sector is the most economical way to add value to currently exported maize.

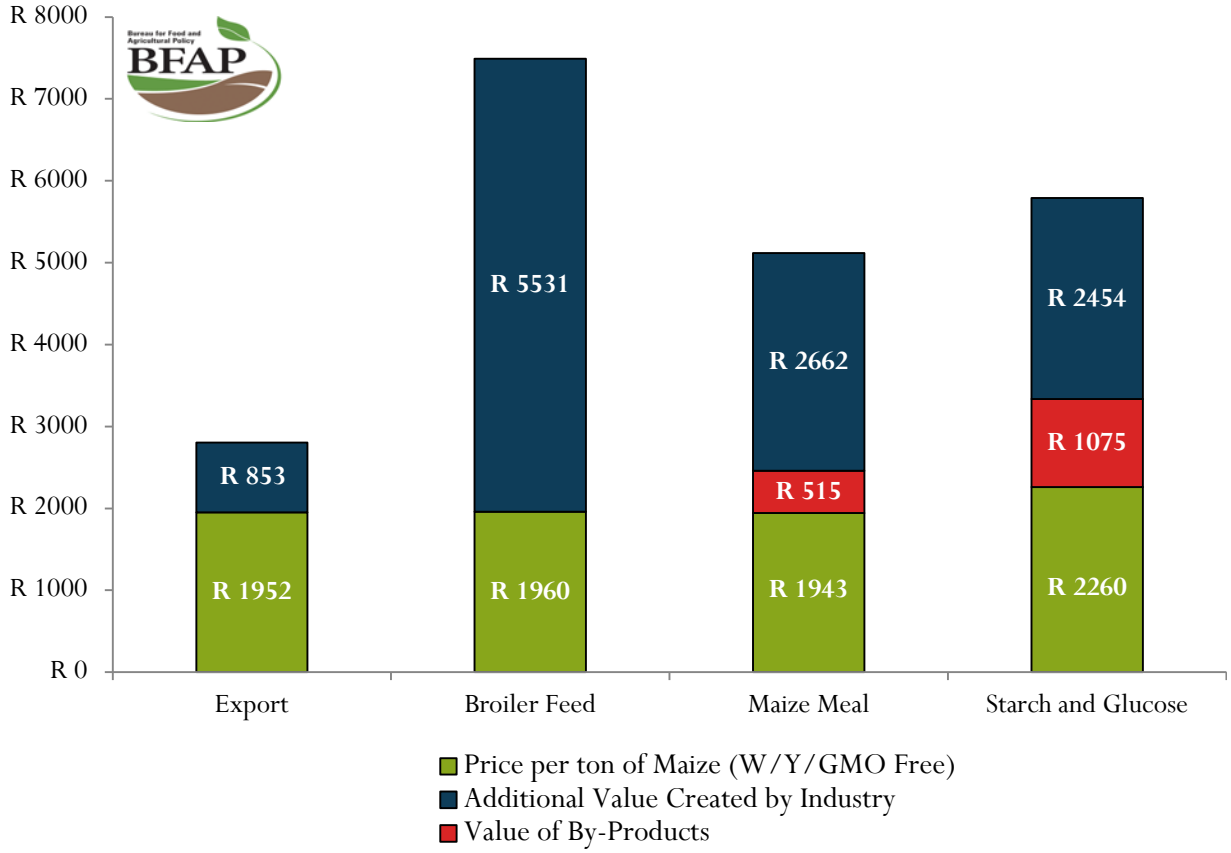

Figure 34: Potential Value Created per Ton of Maize, April – September 2014

*W/Y/GMO Free = White Maize/Yellow Maize/ GMO Free Maize; Source: Author's own calculations

6 Conclusion

This report has shown that although South Africa's maize exports are not excessive when compared with other exporters, exports are economically the least efficient way to employ maize surpluses. Although there are challenges to establish or expand the production of value-added maize products, there is significant scope and opportunity to develop the South African maize value chain and as a result create significant wealth among the participants of the chain and potentially thousands of jobs. Overcoming the individual industry challenges will be necessary to expand value-added production, but before each of these value-added industries can reach their full potential, the maize value chain first needs to achieve cost minimisation in production. In other words, the South African maize value chain needs to produce maize and value-added maize products at the lowest cost possible.

Assuming that individual farms and firms are indeed producing maize at the lowest cost possible, what other cost-drivers does the chain face that impede price competitiveness? The South African maize and other agricultural industries are heavily reliant on the transportation of inputs (such as fuel, fertiliser, pesticides, seed and machinery) and outputs (such as raw or value-added maize products) between areas of production and ports. Figure 35 illustrates that between 2010 and 2012, the average cost of producing a ton of maize on typical South African farms was 24 per cent higher than the average production cost in selected American and European markets, while the cost of fertiliser in South Africa was nearly double that reported in these same markets. A combination of factors influenced this high cost of domestic fertiliser, but the exchange rate, deep sea freight rates and inland transportation costs were the key contributors. Due to South African agriculture's dependence on foreign imports for a range of inputs, deterioration in the exchange rate is debilitating for the competitiveness of the sector, yet not within the control of the maize or other agricultural industries. What can, however, be

influenced to the benefit of the agricultural sector, the economy and society as a whole, are port and rail infrastructure facilities and services.

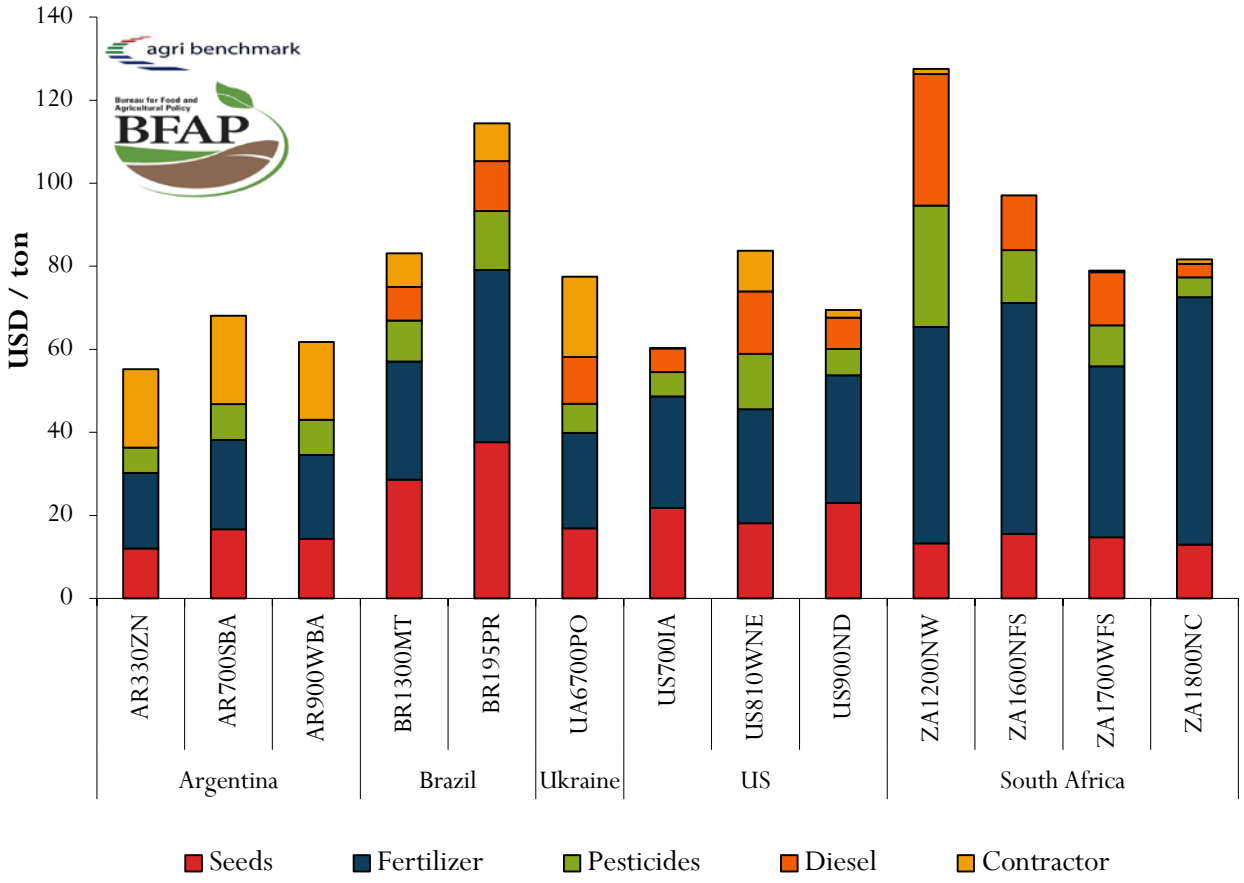

Figure 35: Maize expenditure per ton for selected countries, (2010–12 avg.)
Source: BFAP, 2014

An essential first step in minimising costs throughout the value chain would, therefore, be the establishment of cost-efficient port and rail infrastructure and services. The establishment of these services is, however, not a step that individual members of the maize value chain can take, but is rather one that needs to be taken by a joint partnership between agribusiness and government institutions such as the Department of Agriculture, Forestry and Fisheries (DAFF), the Industrial Development Corporation (IDC) and the Department of Trade and Industry (the dti).

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8 Appendix

Table 15: South African maize consumption potentials; 2013/14 – 2023/24

	Current consumption 2013/14	BFAP consumption projections for 2023/24	Potential market	Substitute poultry imports	Source/Assumptions
Maize Exports	2 232 596	2 002 651	-	-	SAGIS, 2015; BFAP, 2015
Animal Feed	4 960 722	7 601 634	2 640 912	408 850	**Potential market** consists of projected market expansion over the next 10 years. **Replacing Poultry Imports:** SA imported approx. 370 000 tons of poultry during 2014, assuming a feed conversion ratio of 1.7 and that maize constitutes 65 per cent of broiler feed; SAGIS, 2015; BFAP, 2015; ITC, 2015; Astral Foods, 2014.
Human consumption	4 663 310	4 756 211	0	-	SAGIS, 2015; BFAP, 2015
Starch and glucose	600 000	-	150 000		**Market Potential:** Assume the country utilises 20 per cent currently available processing capacity; Starch Industry, 2014
Ethanol	0	0	0		Under the policy environment, maize cannot be used in the production of bio-ethanol.
Glucose-Fructose syrup	0	-	581 000	-	**Market Potential:** 350-400 thousand tons sugar used by SA beverage sector. Assuming 1 ton of HFCS replaces 1 ton of raw sugar, based on the perfect rate of substitution observed in the US between 1977 and 1988 (USDA ERS, 2015), and assuming 1.66 ton of maize is required to produce 1 ton of HFCS (Gray, 1991)

Table 16: Value added per ton of maize, April – September 2014

	Description	Value unlocked per ton of maize, Rand (A multiplied by B)	Price (Rand/ton) (A)	How many tons can be produced with 1 ton of maize (B)	Assumptions	Sources
Maize Exports	Average SAFEX price (yellow/white-April to September)	1952	1952	1	Average SAFEX price of White- and Yellow maize	GrainSA, 2015
	Export Equivalent (April to September)	2805	2805	1	Average export price	(ITC, 2015)
	Additional value created	853				
Animal Feed	Yellow maize SAFEX (September)	1960	1960	1	SAFEX Yellow maize price	GrainSA, 2015
	Broiler feed equivalent (April to September)	7491	4869	1.54	Price of broiler feed as reported by SAPA. Assume that maize constitutes 65 per cent of broiler feed, therefore 1 ton of maize enables the production of 1.54 (1/0.65) tons of broiler feed.	SC, 2015 Astral Foods, 2014
	Additional value created	5531				
Maize meal	White maize SAFEX (August to September)	1943	1943	1	SAFEX Yellow maize price	GrainSA, 2015
	Value of by-product	515	1372	0.38	Assume that chop is sold for 70 per cent of the SAFEX yellow maize price and a 62.5 per cent extraction rate (as was assumed by the NAMC in 2004)	NAMC, 2004.
	Maize meal retail equivalent ("Super"-April to September)	4090	6488	0.63	Retail price of "Super" maize meal per ton, and assuming a 62.5 per cent extraction rate.	NAMC, 2015b
	Additional value created	2662				
Starch and glucose	Yellow maize SAFEX+R300 GMO Free premium	2260	2260	1	Starch and glucose are produced from non-GMO yellow maize. Assume a R300 non-GMO premium per ton.	GrainSA, 2015
	Local equivalent (Apr-Sep average)	3979	5451	0.73	The starch industry uses around 600 thousand tons of maize per annum. For the 6 month period April to September 2014 (assuming 300 thousand tons of maize was used) South Africa produced: a) 219 386 tons of local starch and glucose to the value of R1.196 billion, b) 30 952 tons of exports starch and glucose to the value of R221 million, c) 86 253 thousand tons of co-products to the value of R323 million. Therefore per ton of maize used, 0.73 tons of local starch and glucose, 0.1 tons of export starch and glucose and 0.29 tons of co-products were produced.	Starch Industry, 2015; Authors Assumptions
	Export equivalent (Apr-Sep average)	735	7140	0.10		
	Co-products equivalent (Apr-Sep average)	1075	3744	0.29		
	Additional value created	3529				