

Water for Food, Virtual Water for Food Security



Hans Schreier, Faculty of Land & Food Systems, UBC

Water for Food: Are We Heading for a Crisis?



Projections:

At least 50% increase in food production is needed over the next 40 years.

Why?

2 Billion new people

0.8 Billion have not enough

1 Billion is changing diets

3 Billion move into cities

10-20% of food biomass for ethanol & biodiesel

Water Use by Agriculture:

Agriculture uses about 70% of all fresh water

40% of all food comes from 19% irrigated land





- Globally
- Agriculture Uses 70% of all Water

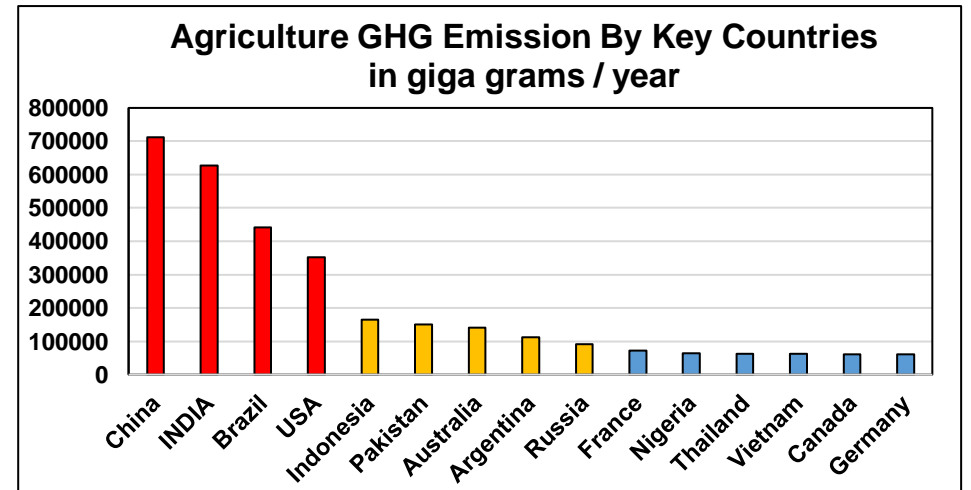


- Only 20% of the Ag-Land is Irrigated
- But Produces 40% of all Food

Agriculture uses 43% of the Terrestrial Land Surface
87% is used for Food Production
13% is for Non-Food (Biofuel, Textiles, Wool & Leather)

Environmental Impacts:

13% of Global GHG is Generated from Food Production
26% of Global GHG is Generated from Production & Consumption
32% of Terrestrial Acidification is from Agriculture
78% of Eutrophication is from Agriculture
45-50% of Water is used for Irrigated Agriculture



According to Poore & Nemecek 2016. Reducing Food's Environmental Impacts Through Producers & Consumers. Science 360, 987-992

Global Food Production 2018

Global Production in Million Tonnes				% Increase
Food Items	2010	2014	2018	2010-2018
Sugar	1911	2156	2182	14%
Maize	851	1004	1147	35%
Rice	701	742	782	12%
Wheat	640	729	735	15%
Cow Milk	603	655	682	13%
Potatoes	333	370	368	10%
Soybeans	265	306	348	31%
Vegetables	260	286	298	14%
Cassava	241	291	278	15%
Oil Palm Fruit	223	286	272	22%
Tomatoes	153	175	182	19%
Barley	123	145	142	15%
Pork	109	117	121	11%
Bananas	109	112	116	6%
Sweet Potatoes	102	93	92	-10%
Watermelons	101	99	100	-1%
Chicken	87	100	114	31%
Beef	67	64	67	0%



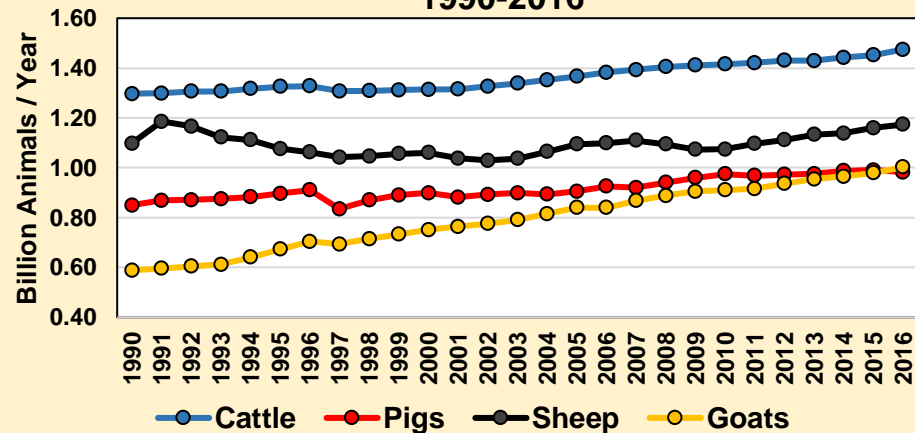
% of Global Food Produced that is Exported

	Rice	Potatoes	Maize	Wheat	Soybeans	Rapeseed
1990	2.4	2.6	14.9	16.7	23.9	18.9
2000	3.9	2.4	14.0	20.0	29.4	24.5
2010	4.8	3.5	12.7	22.7	36.7	27.9
2017	5.8	3.7	13.8	25.4	40.5	33.4

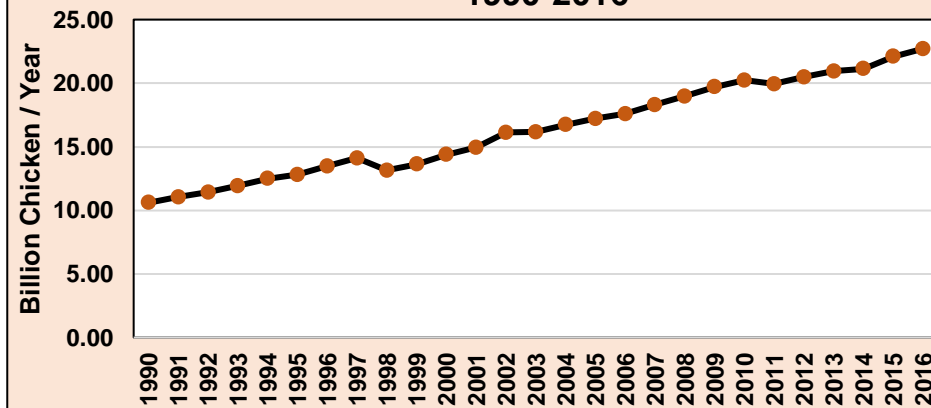
	Pork	Beef	Chicken	Sheep	Milk
1990	3.6	4.2	6.2	11.5	0.5
2000	2.8	7.0	11.7	12.1	1.1
2010	3.5	8.4	13.4	11.4	1.4
2017	5.3	9.3	12.6	12.3	1.5



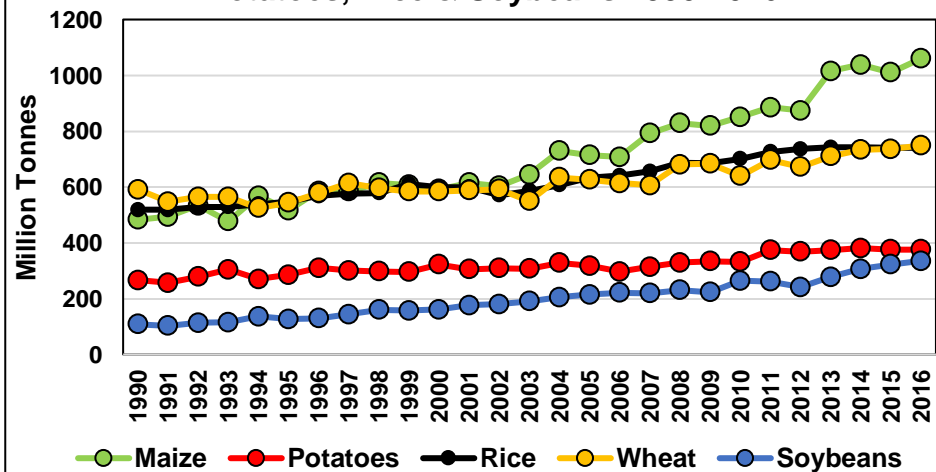
Changes in Global Number of Livestock 1990-2016

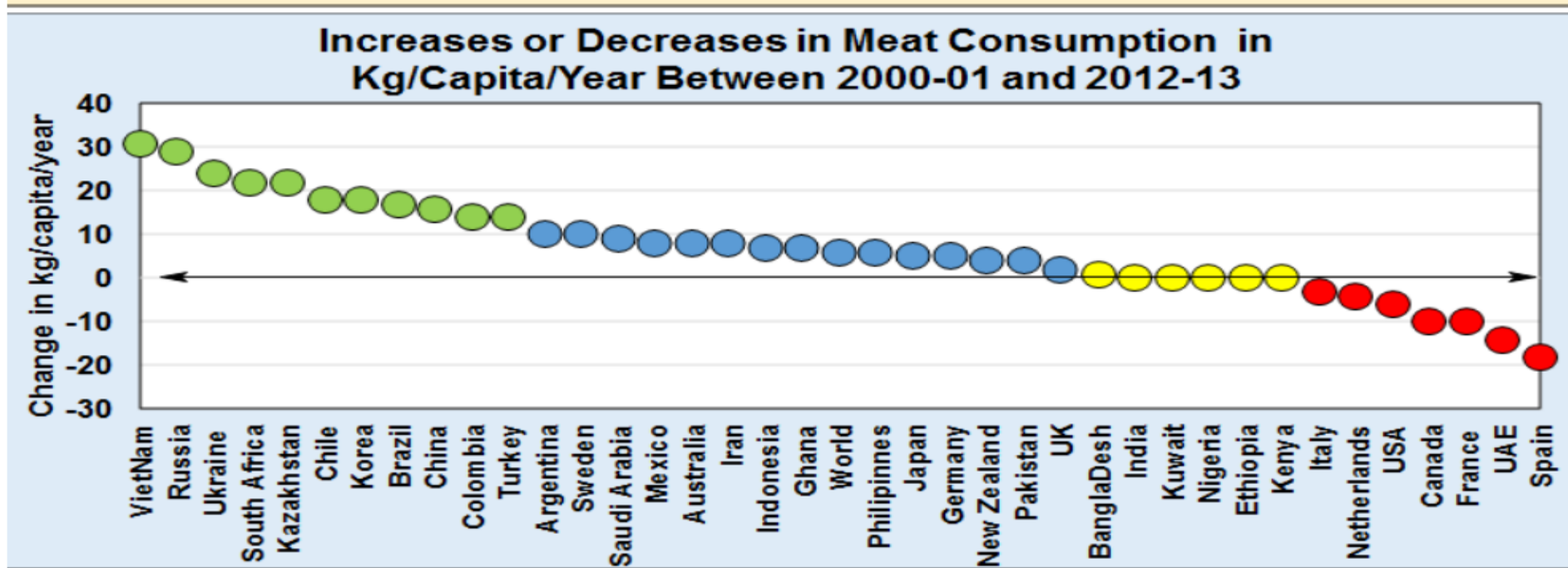
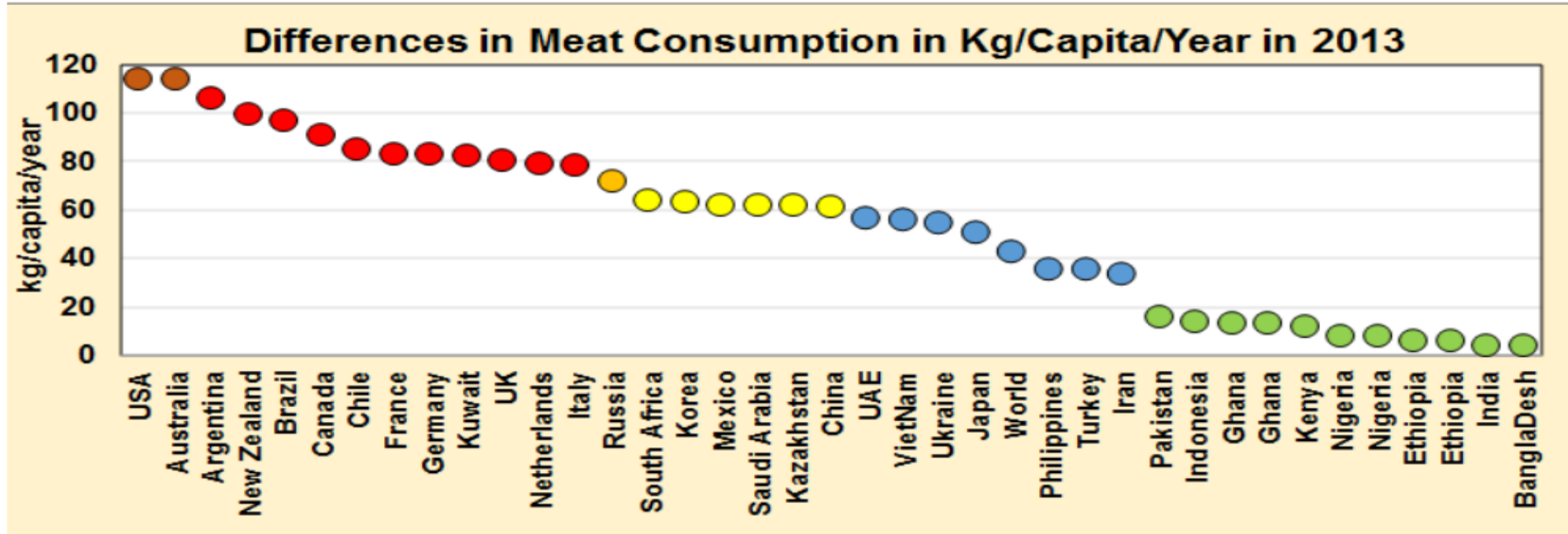


Changes in the Global Number of Chickens 1990-2016



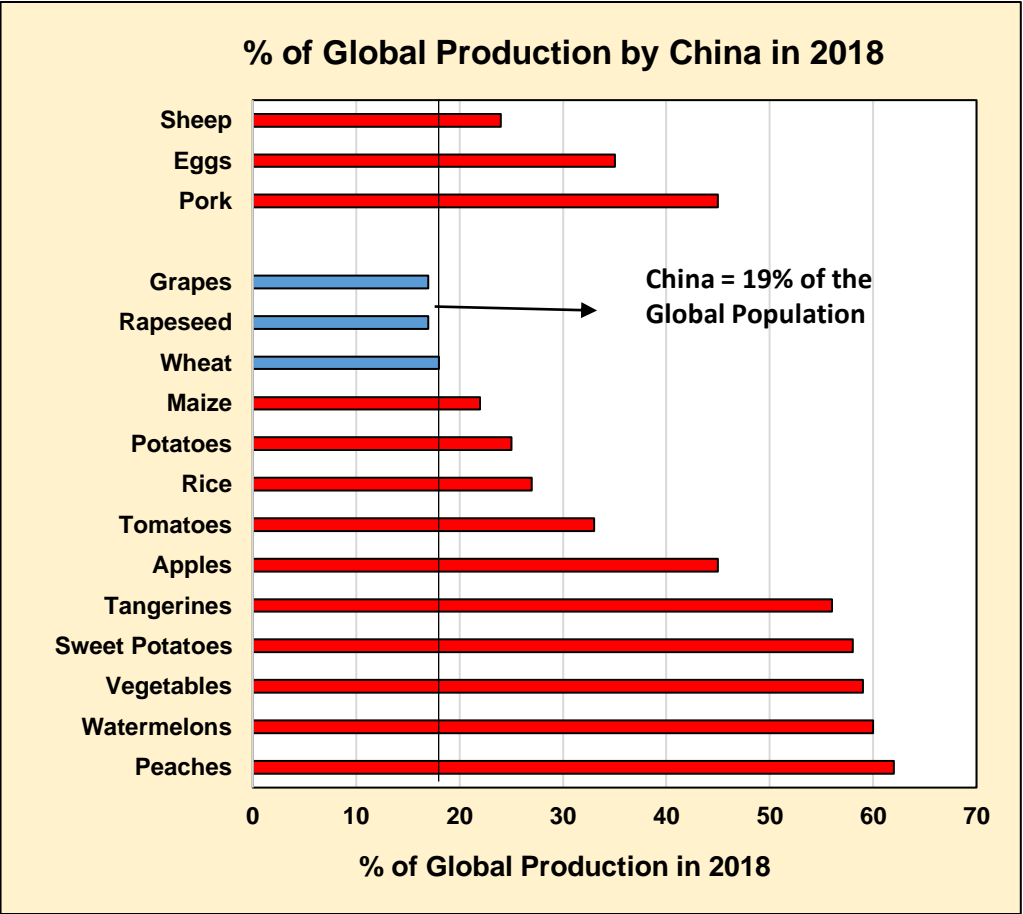
Changes in Global Production of Maize, Wheat, Potatoes, Rice & Soybeans 1990-2016



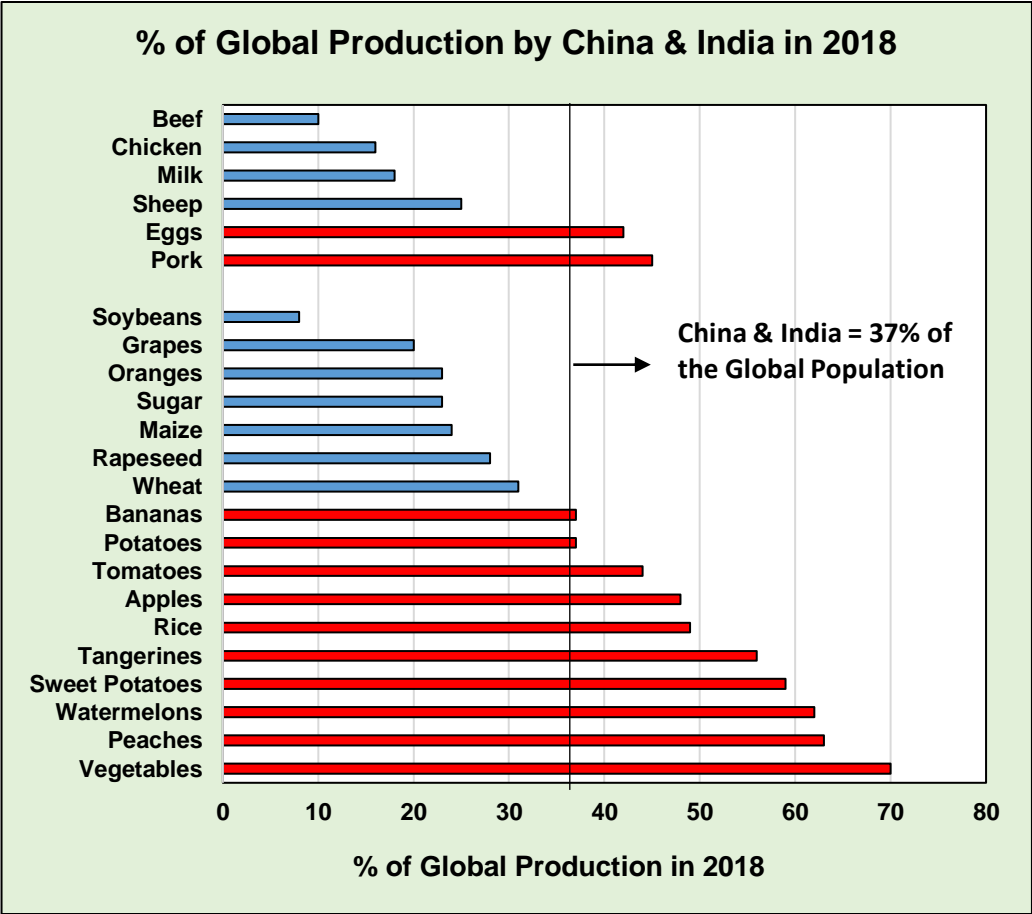


% of Global Production in 2018

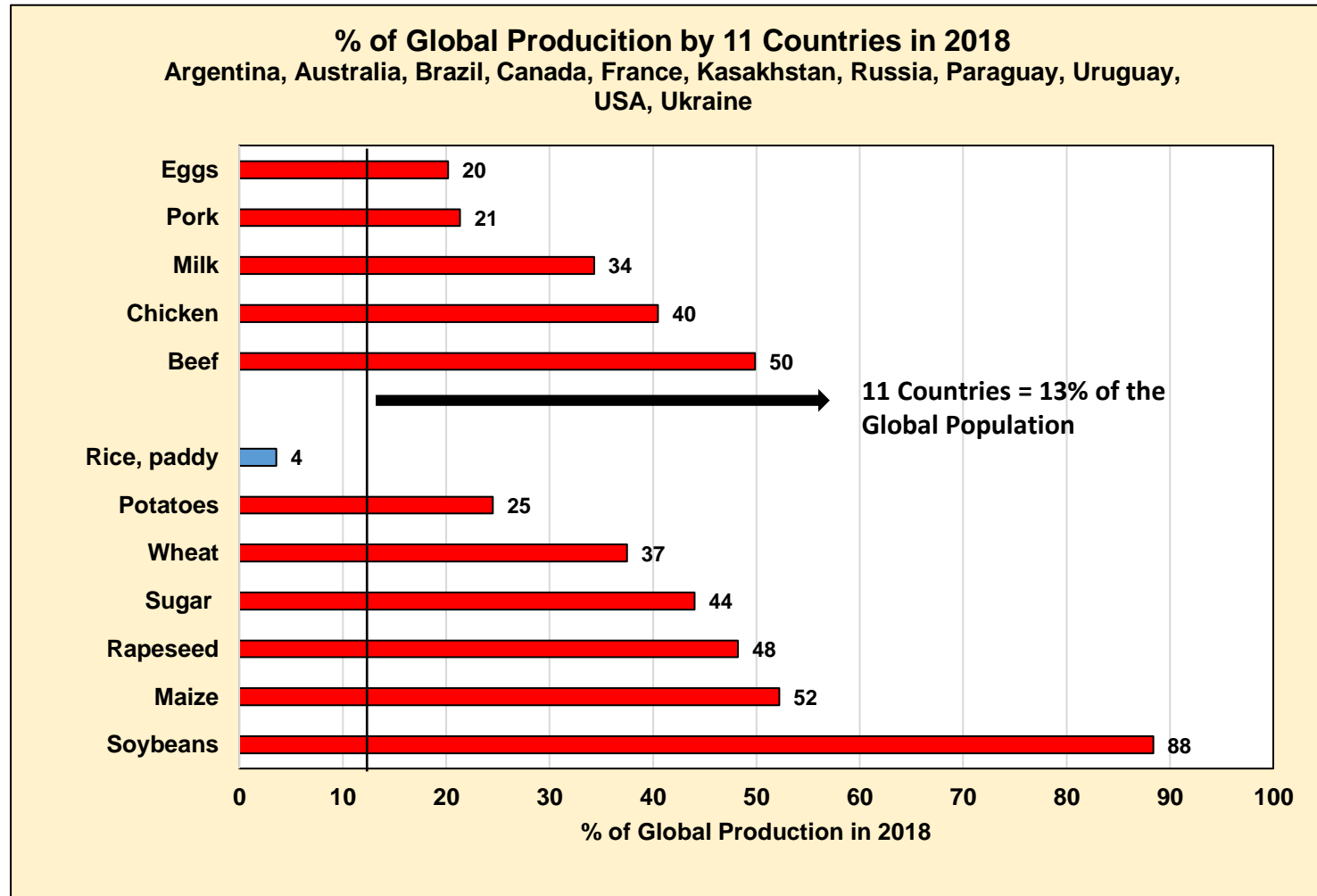
China



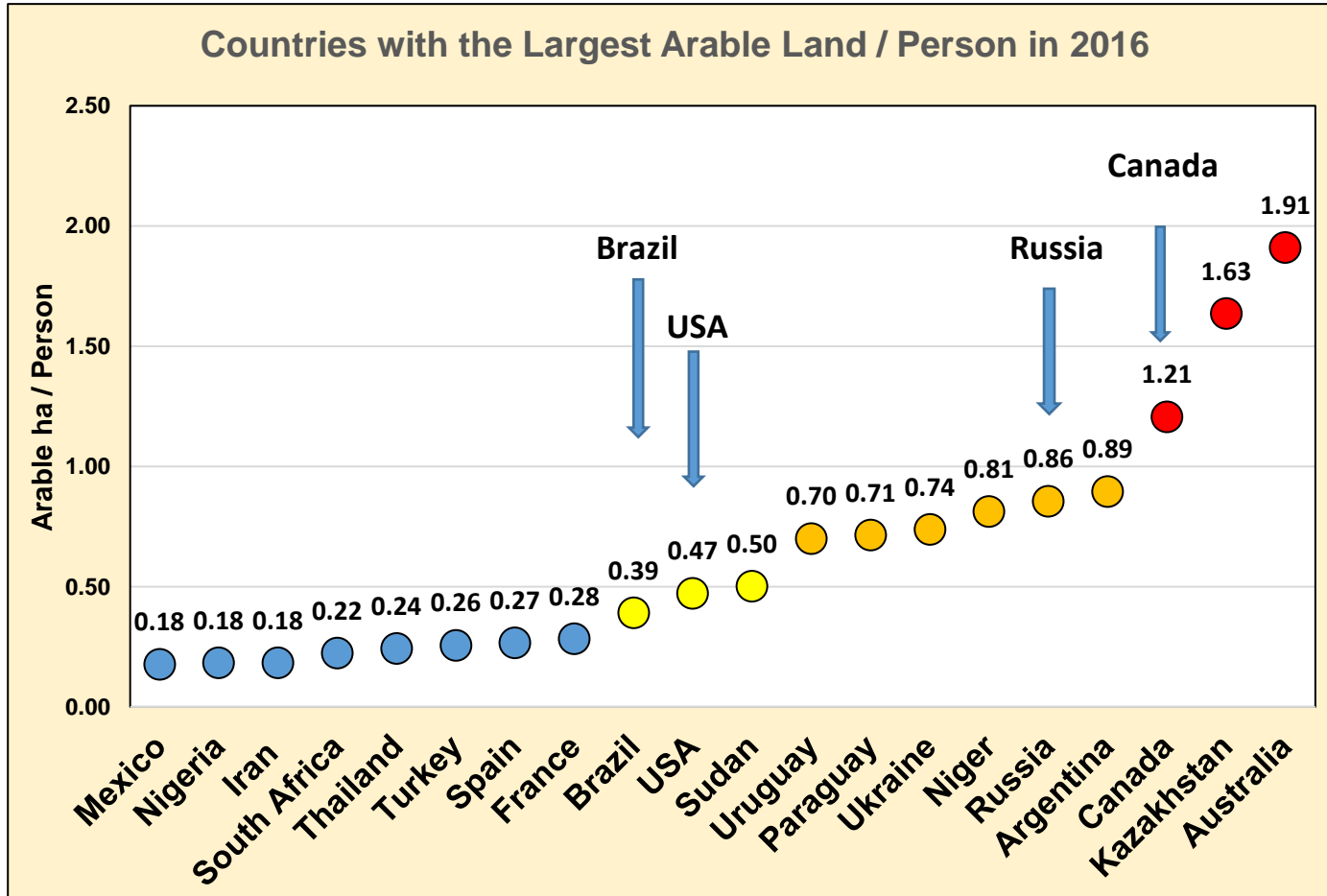
India & China



% of Global Food Production by 11 Key Countries



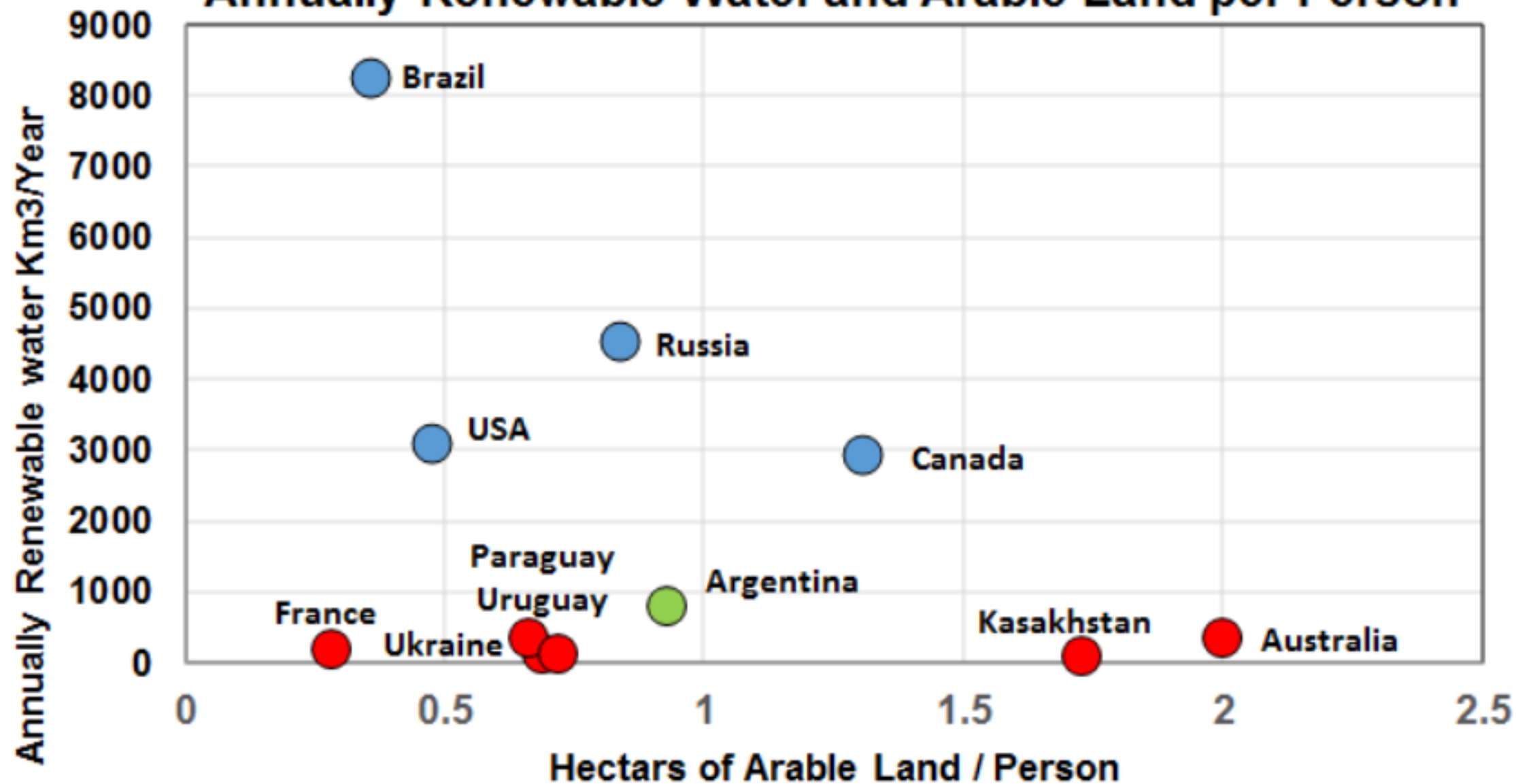
Arable Land / Person in Different Countries (ha / Person)



Countries with Low Arable Land / Person

	2016	2050		
S-Korea	0.03	0.03	ha/Person	
Egypt	0.03	0.02	ha/Person	
Japan	0.03	0.04	ha/Person	
Bangladesh	0.05	0.04	ha/Person	
Philippines	0.05	0.04	ha/Person	
Viet Nam	0.07	0.06	ha/Person	
China	0.08	0.09	ha/Person	
Indonesia	0.09	0.07	ha/Person	
India	0.12	0.09	ha/Person	

Annually Renewable Water and Arable Land per Person



The Most Important Food Exporting Countries

Global Rank by Net Quantity Exported in 2017

	Brazil	USA	Argentina	Canada	Uruguay	Paraguay	Australia	France	Ukraine	Russia
Wheat		2	7	4			3	6	5	1
Maize	2	1	3	14		10		7	4	5
Soybeans	1	2	4	5	6	3			7	
Rice		6	12			10				
Potatoes			15	2				4		
Beef	1	3	9	10	8	7	2			
Chicken	1	2	8				15			
Pork	5	1	13	3			15			
Sheep					7		1			
Milk (dry)			4		3		2	7		

Note: Beef = boneless, Potatoes = Fresh and Frozen, Rice = Total Patty Rice

The Most Important Food Importing Countries

Global Rank by Net Quantity Imported in 2017

	Japan	China	Italy	Saudi Arabia	Mexico	UAE	Russia	Iran	Egypt	Philippines	Korea
Wheat	8	7	5						2	10	
Maize	1	8	9	12	2			6	4		3
Soybeans	4	1	14		2		11	10			15
Rice					12			4		9	
Potatoes	5		1	14	15	11	3				
Beef	3	1				7			6		
Chicken	4	3		2	1		14		15	7	
Pork	1	3	5				4			11	2
Sheep	10	1	11	5		6		12			
Milk (dry)		1	11	7		3	10		14	13	

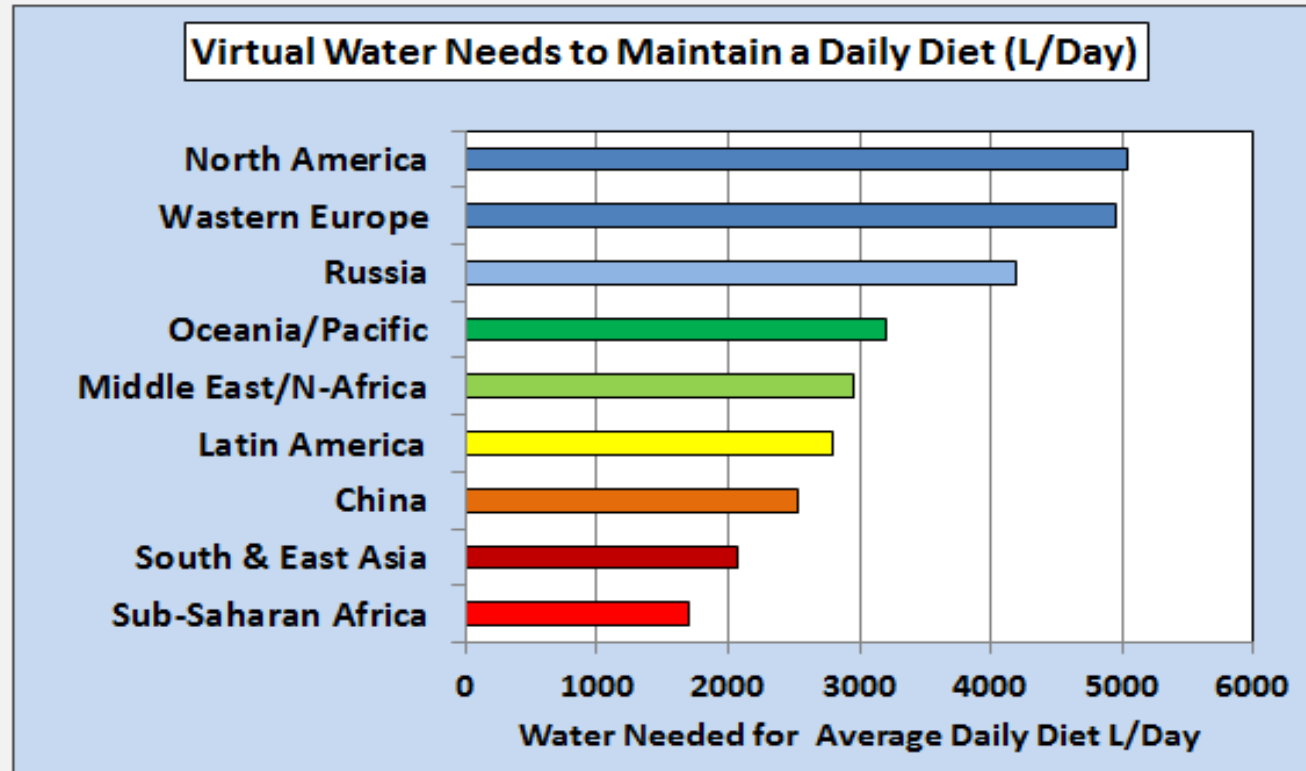
Note: Beef = Boneless, Potatoes = Fresh and Frozen, Rice = Total Paddy Rice

How much Water does it take to Maintain your Daily Diet?

What food do you like most?

And how much water is required to produce different Food Items?

How much water does it take to maintain a Canadian Daily Diet



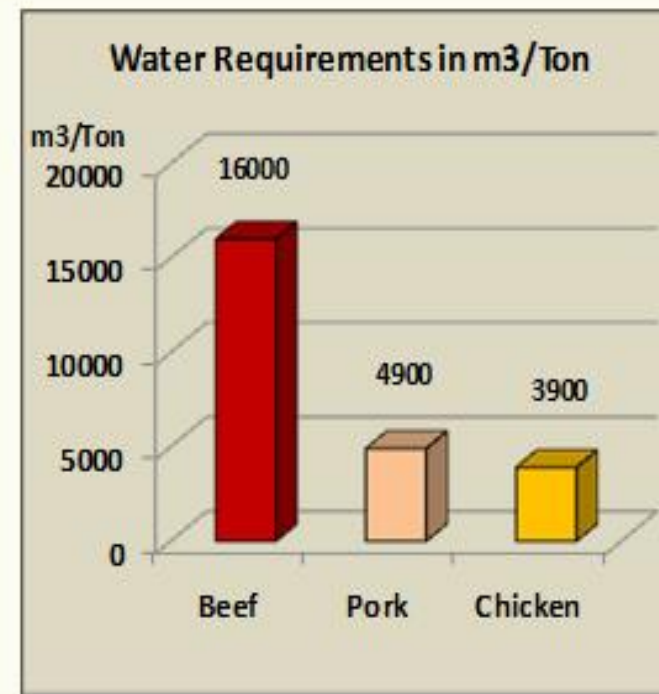
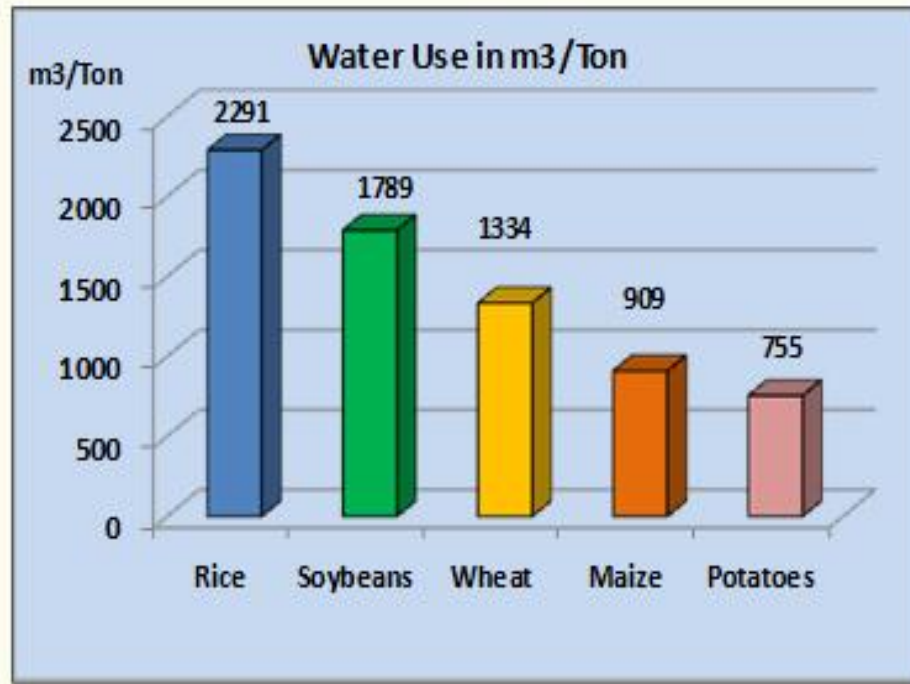
The Average Canadians Food Consumption in 2010:

Daily Diet: 5000 L of Water/Day

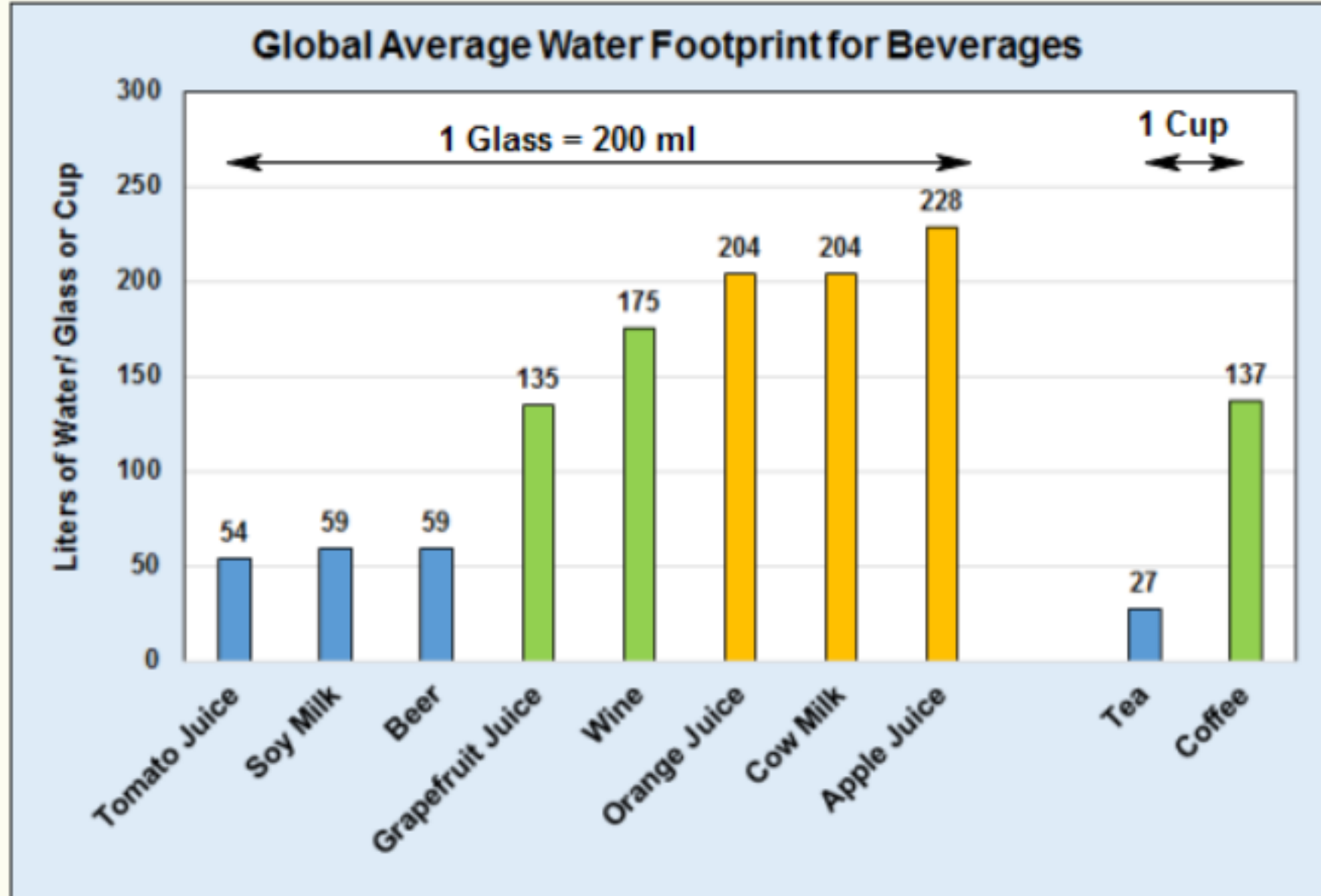
Meat Consumption: 95kg/Capita/Year

Kcal Consumption: 3500 kcal/Day

Water Requirements to Produce Different Food Commodities



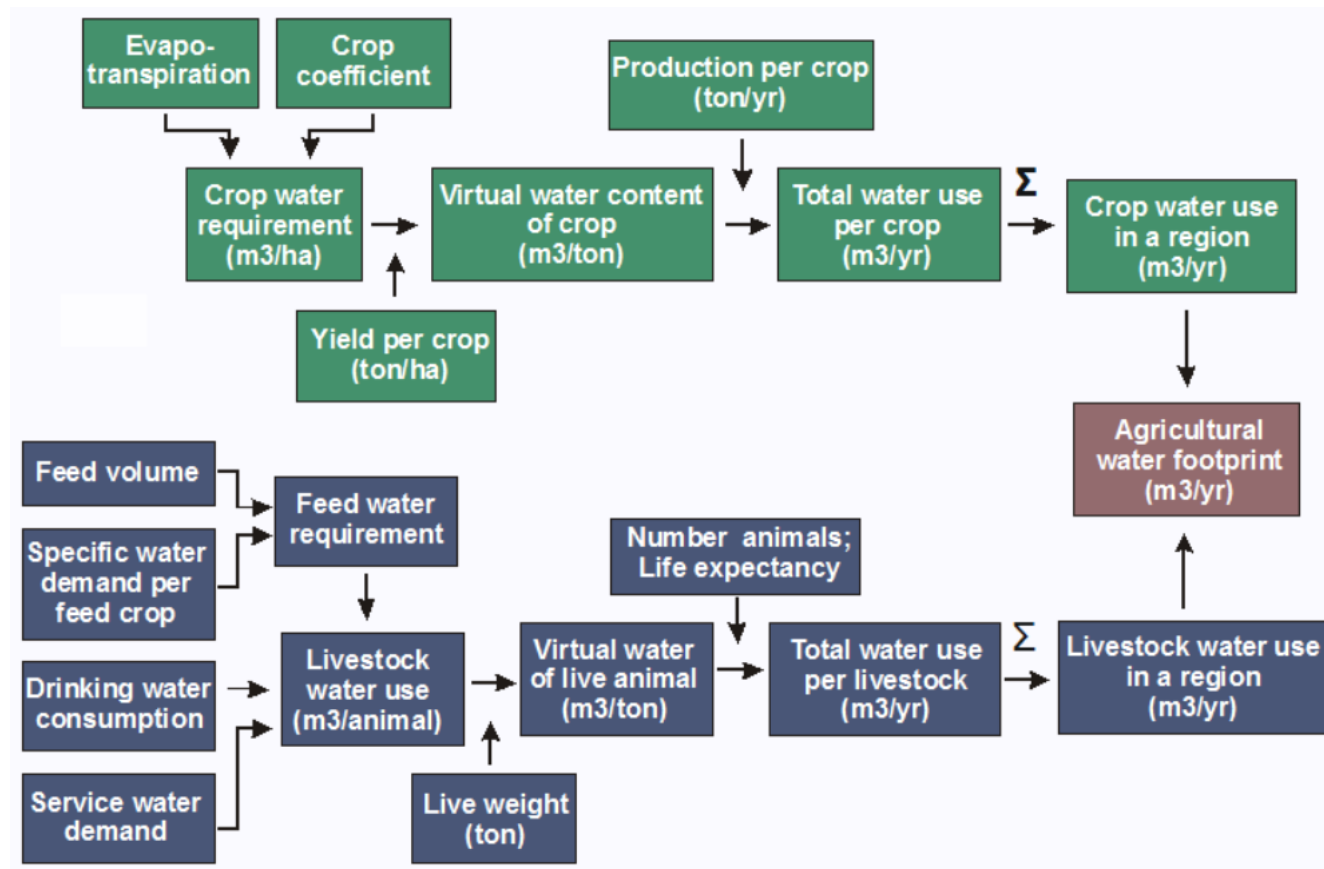
Water Requirements for Different Beverages



The Water needed to produce a Food Commodity that is exported

That water cannot be used for other purposes

Countries that are water short will rely on water intensive food imports to save water for demestic and industrial purposes



Green Water

Precipitation

Evaporation

Evapotranspiration

Storage

Interception

Evapotranspiration

Soil Water

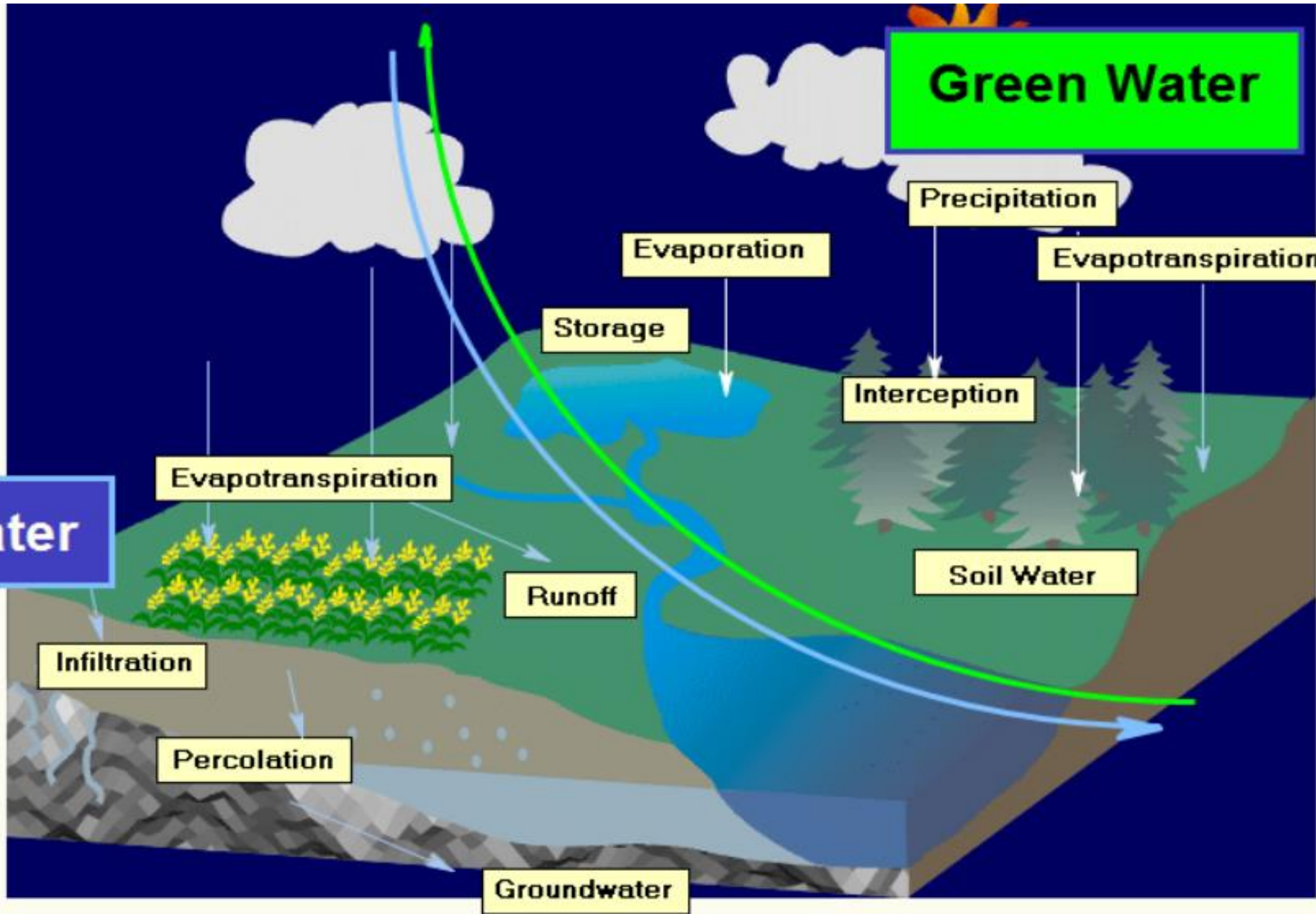
Blue Water

Runoff

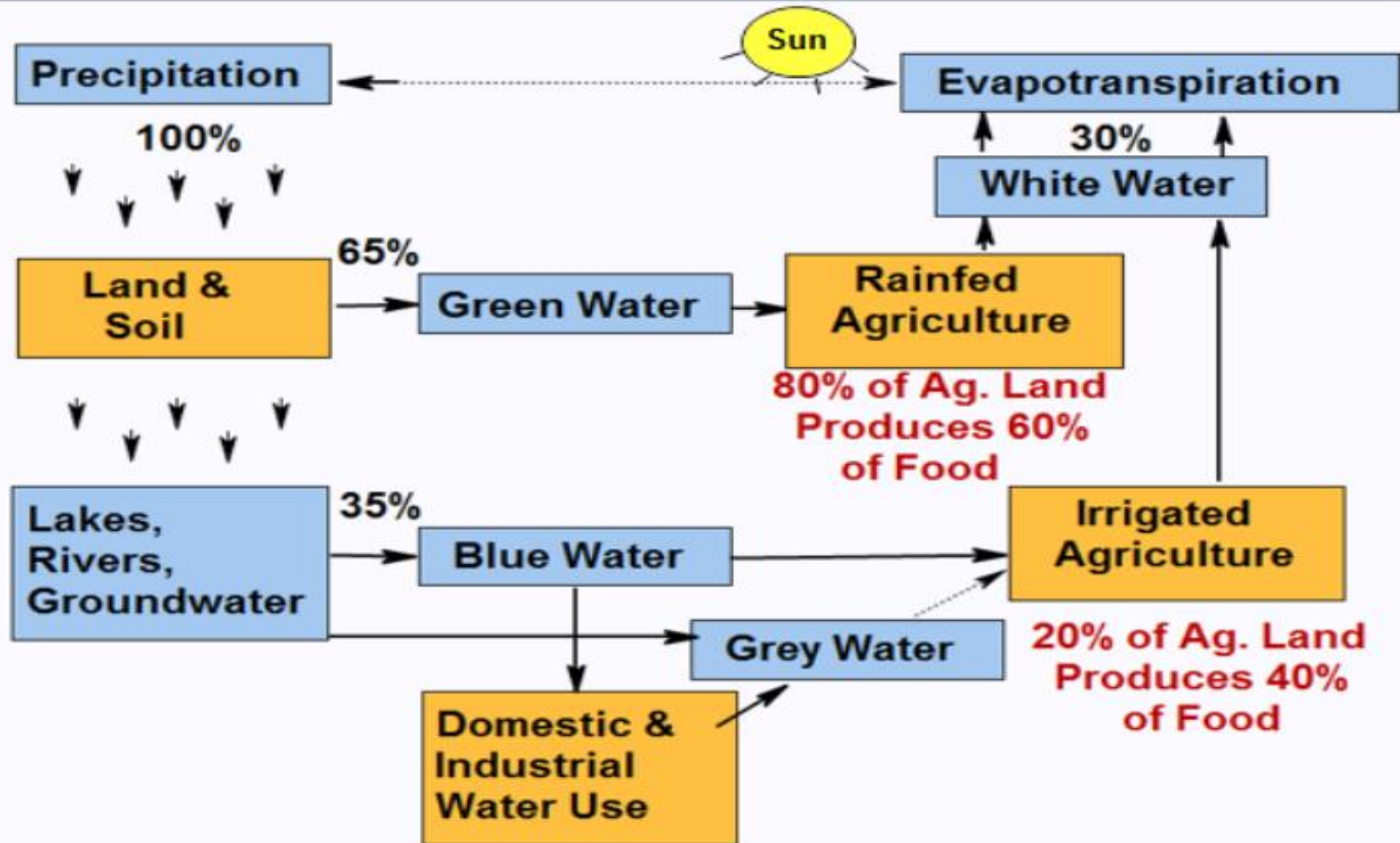
Infiltration

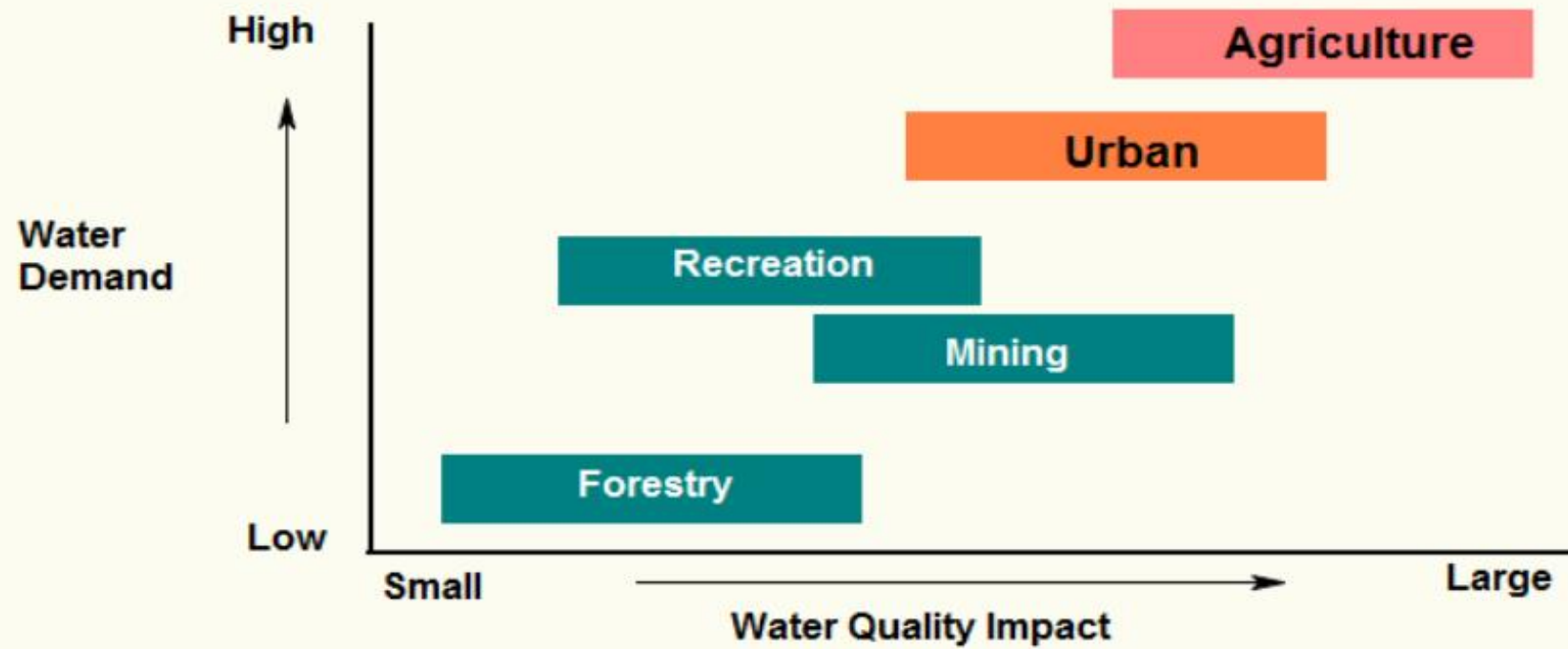
Percolation

Groundwater



Green Water, Blue Water, White Water, Grey Water





Summary: Total Virtual Water Imported in 2016 by Key Countries in km ³ /Year			
	Meat	Crops	Total
China	15.96	239.4	255.38
Japan	11.44	35.05	46.49
Mexico	3.98	39.40	43.38
Saudi Ara	4.26	38.08	42.34
S-Korea	6.21	19.45	25.66
Indonesia	1.55	22.84	24.39
Italy	2.06	22.10	24.16
Iran	1.53	20.33	21.86
Vietnam	3.19	18.41	21.6
Spain	0.38	20.84	21.22
Egypt	3.07	16.70	19.77
Russia	7.91	7.43	15.34
Malaysia	2.50	10.43	12.93
China Tai	1.99	10.74	12.73
Philippin	2.89	8.16	11.05
Netherla	0.03	10.73	10.76
UAE	3.35	6.98	10.33
Germany	0.77	7.86	8.63
UK	2.93	3.82	6.75
France	3.04	2.48	5.52
Singapor	1.23	0.97	2.2
Meat: Beef, Pork, Sheep, Chicken Crops: Wheat, Maize, Rice, Soybeans, Potatoes			

Total Virtual Water Saved by the Major Food Importing Countries



**Virtual Water Exported by Key Exporting Countries
in Km3/Year in 2016**

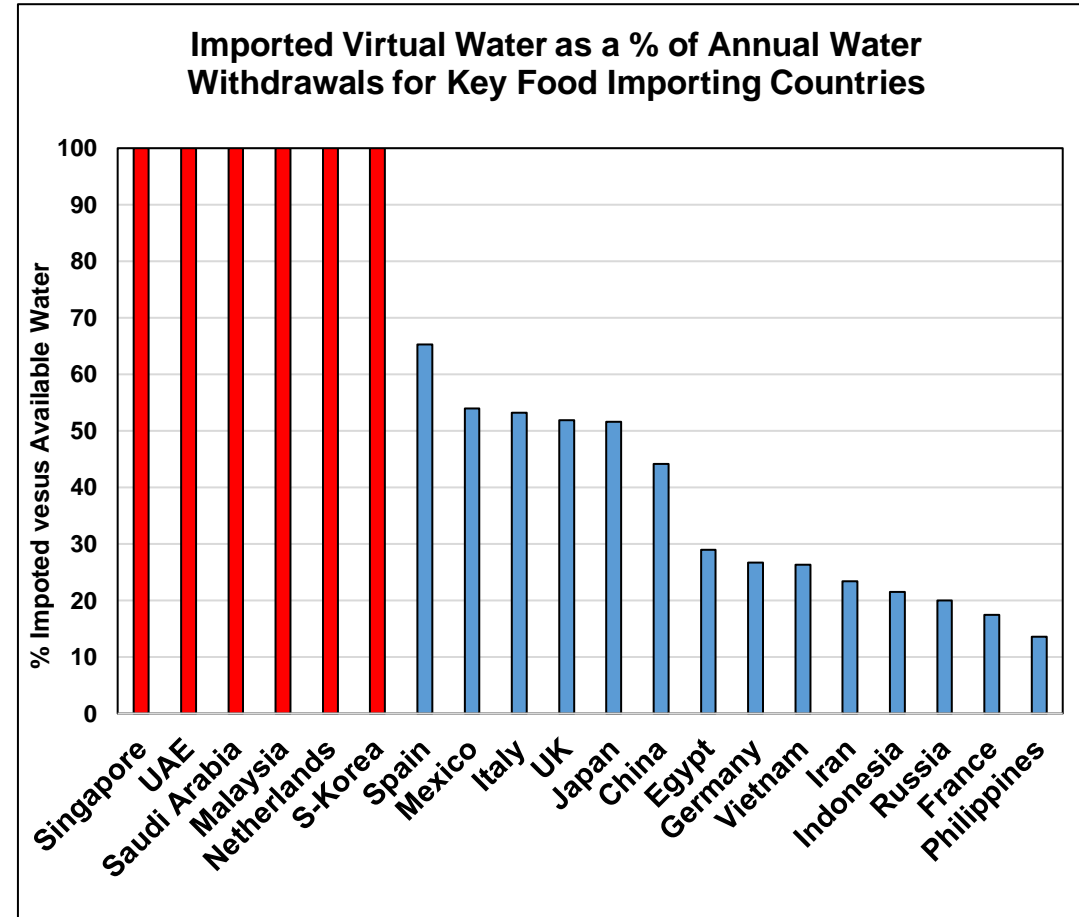
Countries	CROP	MEAT	TOTAL
USA	155.8	20.8	176.6
Brazil	82.5	36.5	118.9
Russia	69.3	0.5	69.8
Australia	25.8	20.0	45.8
Canada	35.8	8.4	43.7
Argentina	28.0	3.1	32.1
Ukraine	28.8	0.4	29.2
France	19.2	2.4	21.6
Paraguay	13.1	4.3	17.4
Uruguay	3.7	4.1	7.8

Water Exports & Imports versus Water Withdrawals

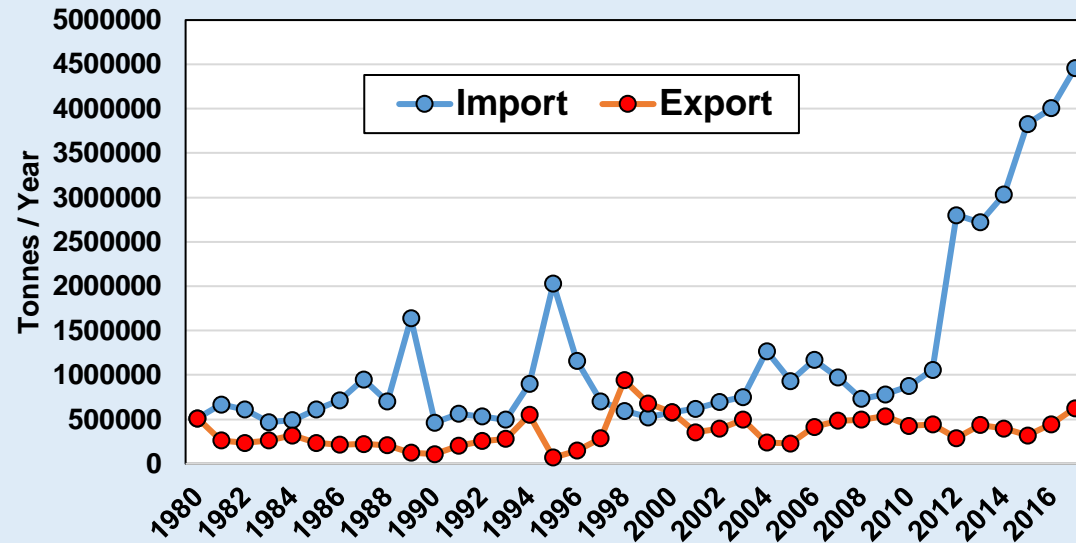
Exporting Countries

	Annual H2O	Virtual H2O	% of Annual
	Withdrawals	Exported	Withdrawals
USA	482.2	176.6	37
Brazil	58.1	118.9	>100
Russia	76.7	68.8	90
Australia	59.8	45.8	77
Canada	45.1	43.7	97
Argentina	32.6	32	98
Ukraine	19.2	29.2	>100
France	31.6	21.6	68
Paraguay	0.5	17.4	>100
Uruguay	3.7	7.8	>100

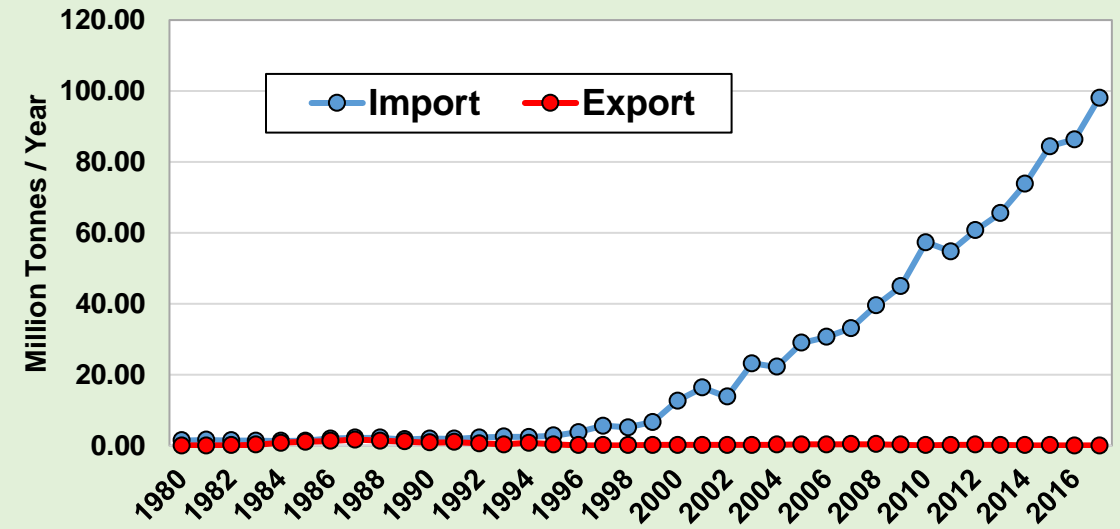
Importing Countries



Rice Imports & Exports by China 1980-2017



Soybean Imports & Exports by China 1980-2017



Case Study

China's Food Challenge

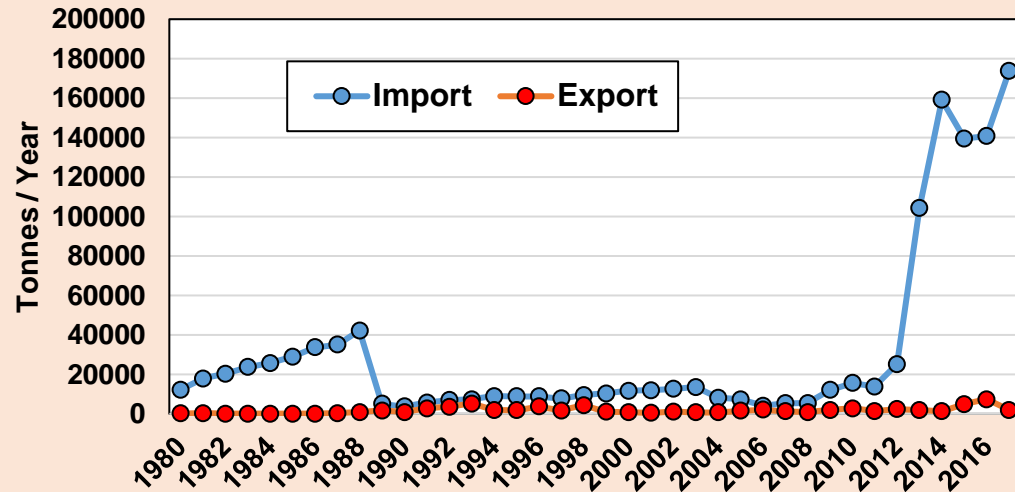
% of Global imports in 2017

64% of Soybeans

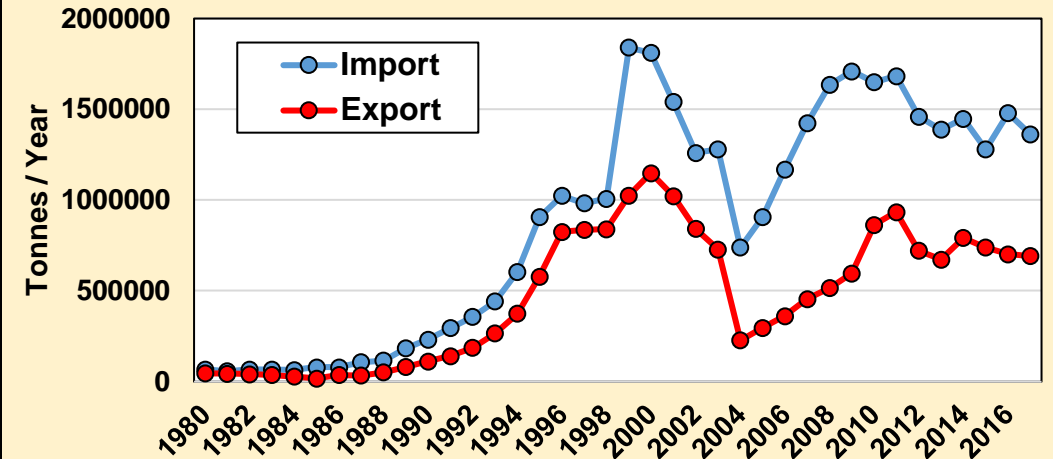
10% of Rice



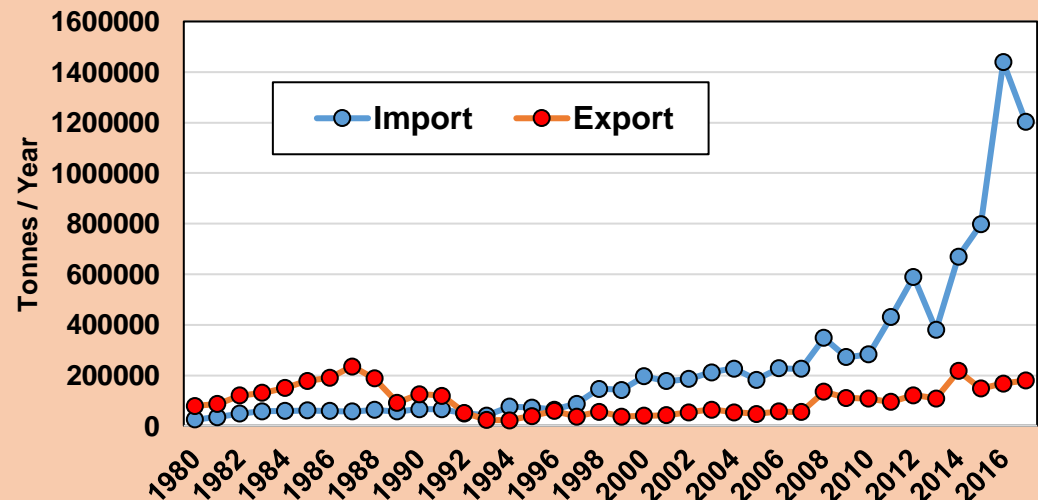
Beef Imports & Exports in China 1980-2017



Chicken Imports & Export in China 1980-2017



Pig Meat Import & Export in China 1980-2017



In 2018 China had :

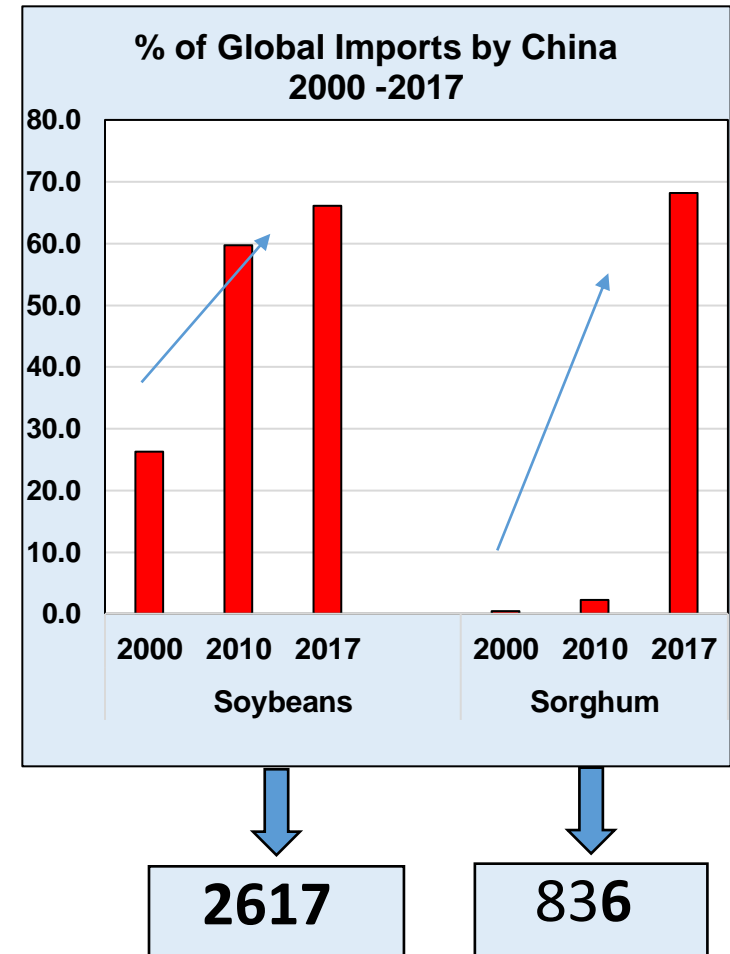
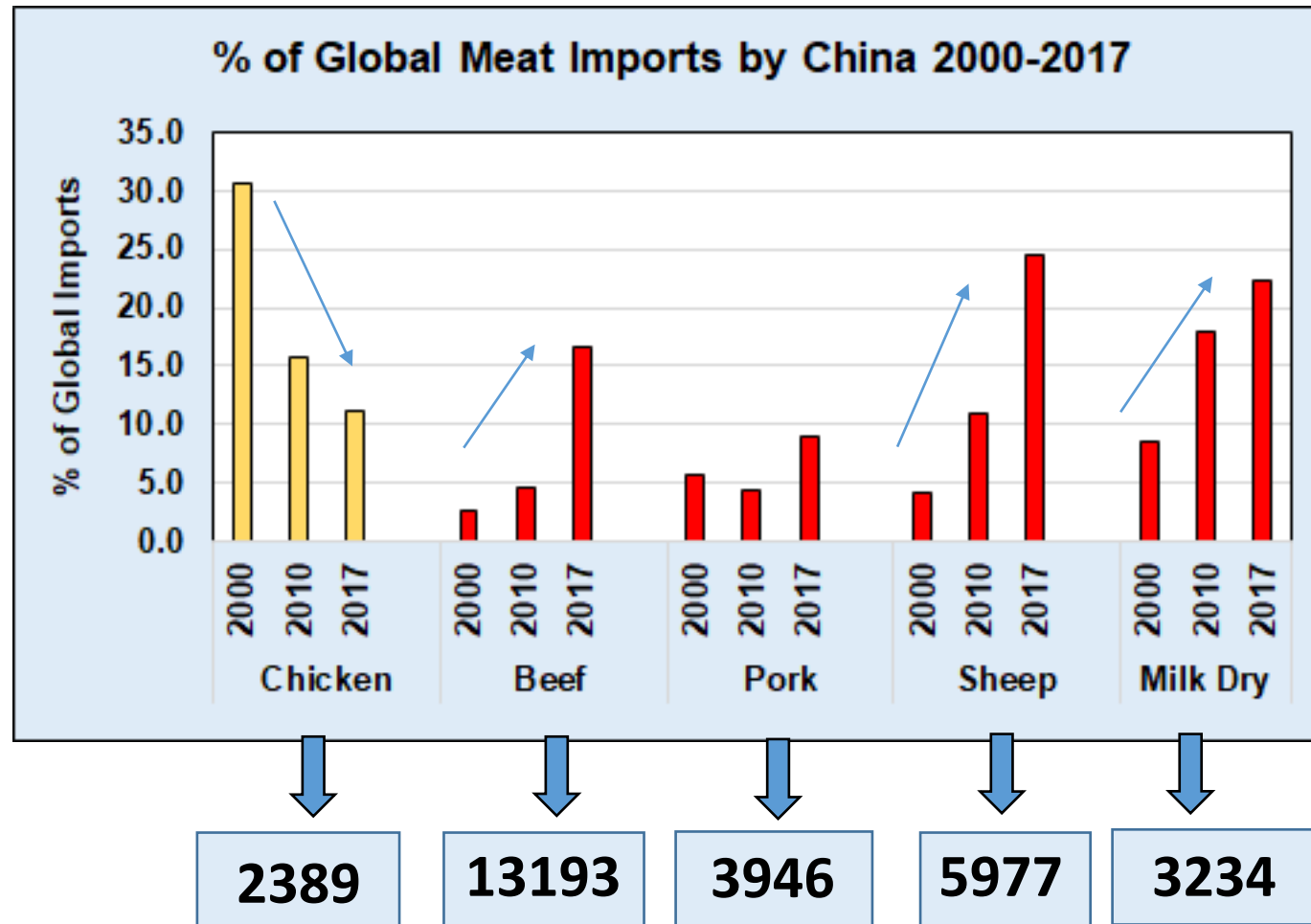
19 % of Human Population (1.4 Billion)

46 % of all Pigs (447 Million)

23 % of all Chickens (54 Billion)

14 % of all Sheep (1.2 Billion)

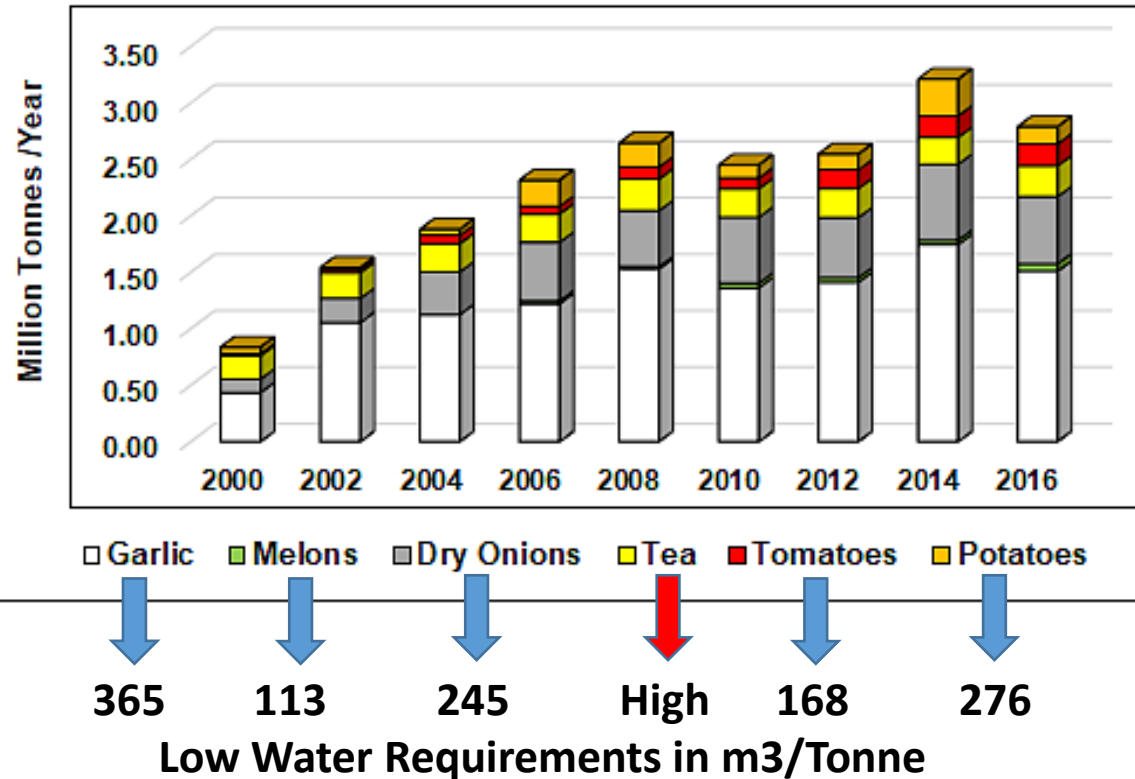
4 % of all Cattle (63 Million)



Virtual Water Requirement in m3/Tonne

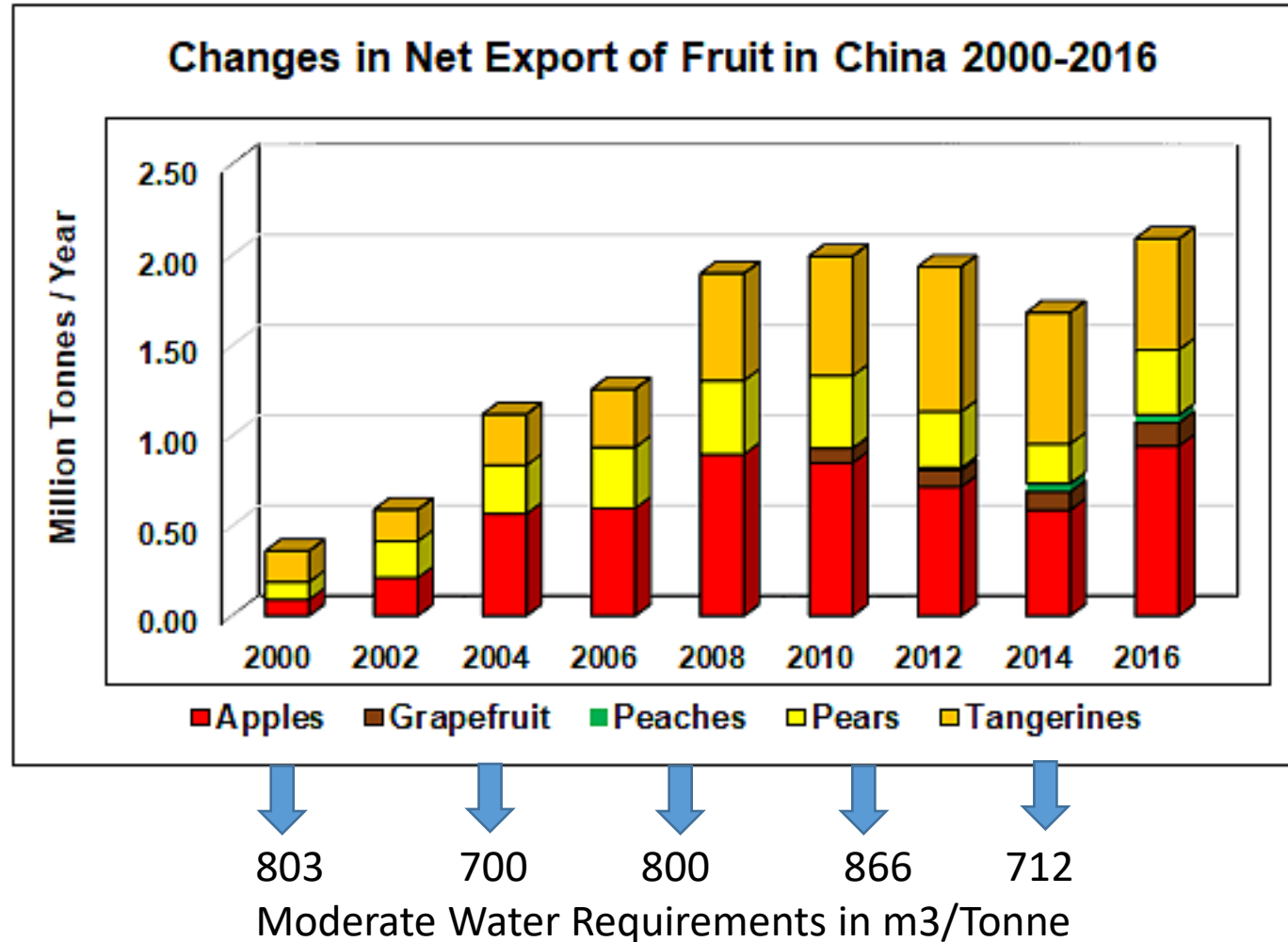
China Exports Crops with Low Water Requirements

Changes in Net Food Export by China 2000-2016

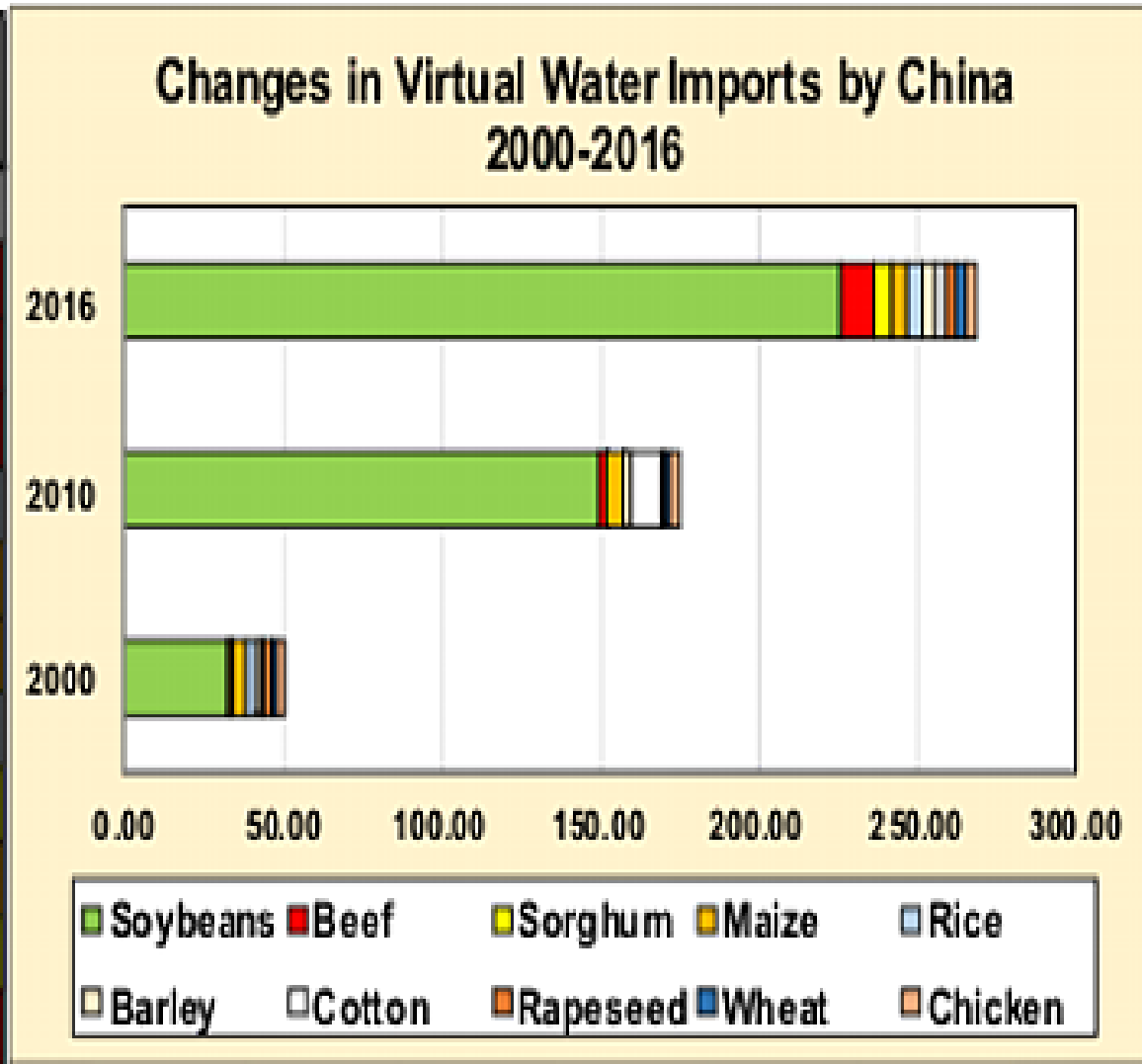


Water Requirement for Food Produced in China							
Meat		Crops High		Crops Moderate		Crops Low	
	m3 / tonne		m3 / tonne		m3 / tonne		m3 / tonne
Beef	12560	Tea	11110	Rapeseed	907	Garlic	369
Sheep	5202	Cotton	3210	Pears	866	Grapes	326
Milk, dry	4648	Soybeans	2617	Sorghum	863	Potatoes	276
Chicken	3652	Rice	1321	Barley	848	Onions, dry	245
Eggs	3550	Peas, green	2188	Apples	803	Tomatoes	168
Pork	2211	Beans, green	1867	Maize	801	Sugar Cane	117
Milk	1000	Millets	1863	Tangerines	712	Melons	113
				Wheat	690		

China's Slope Cultivation & Production Initiatives



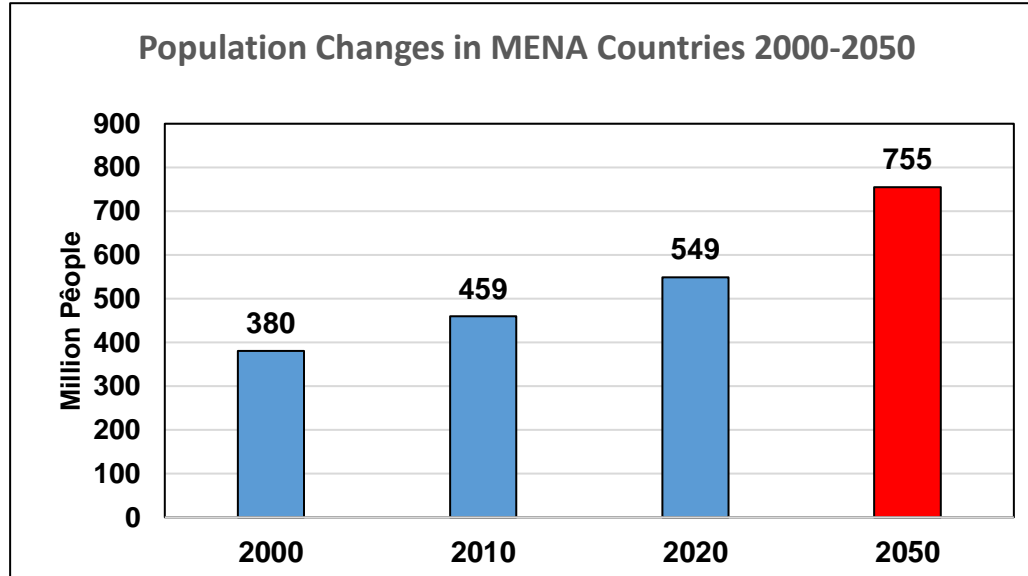
Changes in Virtual Water Imports Km ³ /Year			
Food Item	2000	2010	2016
Soybeans	32.79	149.70	225.7
Beef	1.04	2.23	10.69
Sorghum	0.02	0.09	5.79
Maize	4.40	5.19	4.92
Rice	3.28	0.34	4.55
Barley	1.79	2.05	4.28
Cotton	0.44	9.84	3.30
Rapeseed	2.69	1.13	3.23
Wheat	1.41	1.63	3.25
Chicken	2.42	2.87	2.84
Total	50.28	175.08	268.55



Estimated Water Use		Comparison
	Km3	
Domestic	69	4 Times
Industrial	133	2 Times
Agriculture	377	75% of Agric. Use
Total Use	579	
Virtual Water		
Imported	285	49% of Total Use



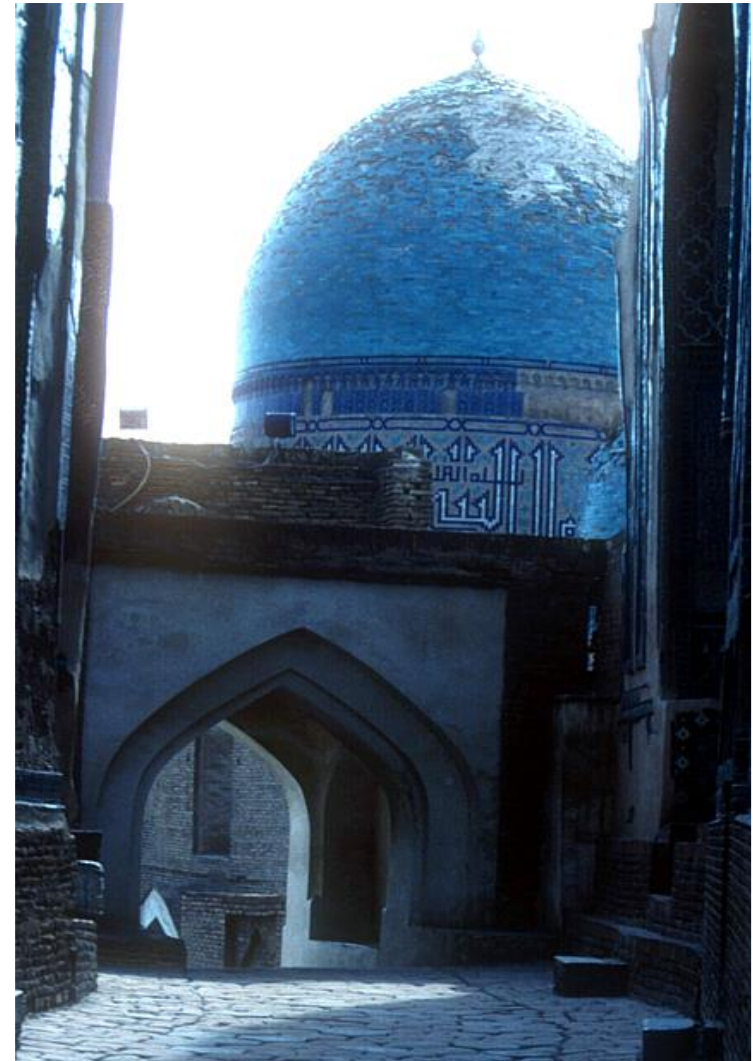
Middle East & North Africa (MENA Countries)



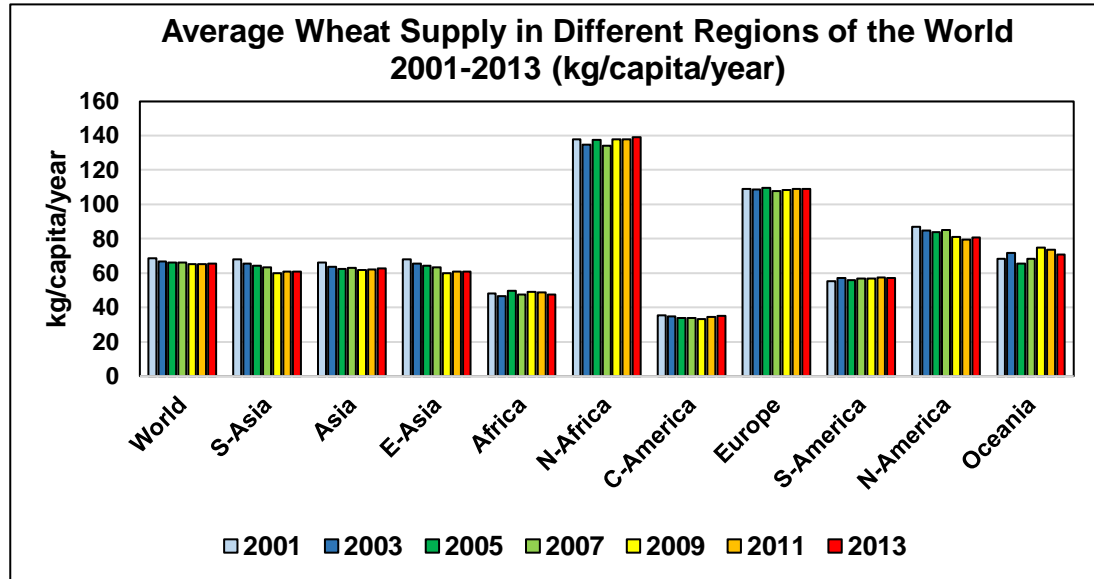
MENA Countries

Algeria, Azerbaijan, Bahrain, Egypt, Iran,
Iraq, Jordan, Kuwait, Lebanon, Libya,
Morocco, Palestine, Oman, Qatar, Syria,
Saudi Arabia, Tunisia, Turkey, UAE, Yemen

Increases between 2020-2050 = 200 Million



Wheat

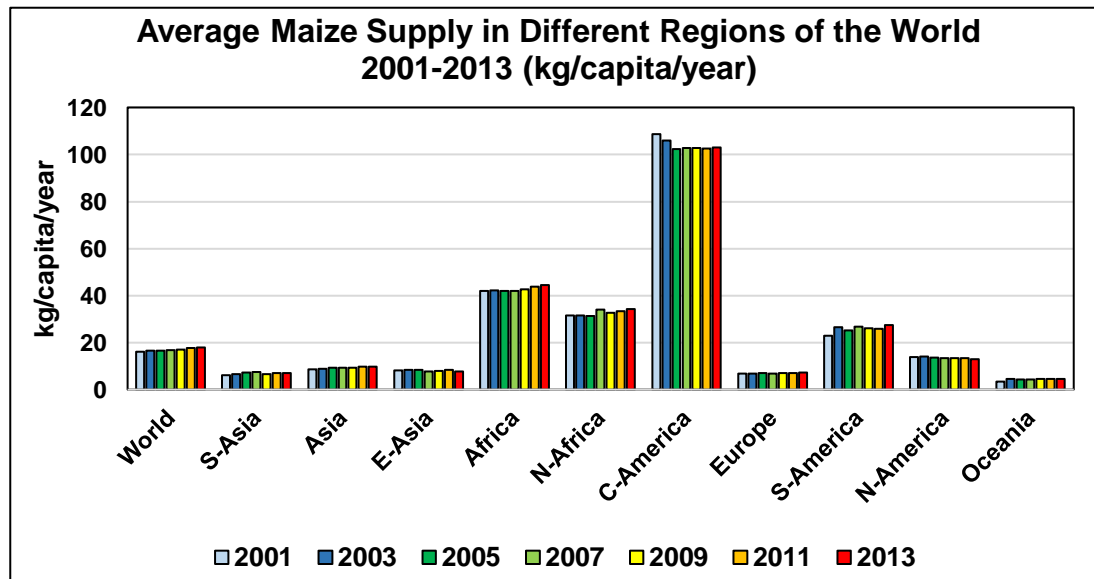


MEAN = 7 % of Global Population

In 2017 MENA is Relying on:
21 % on Globally Traded Maize
22 % on Globally Traded Wheat

Between 2010-2017
Imports of Maize = 2x higher than Production
Imports of Wheat = 62% of Production

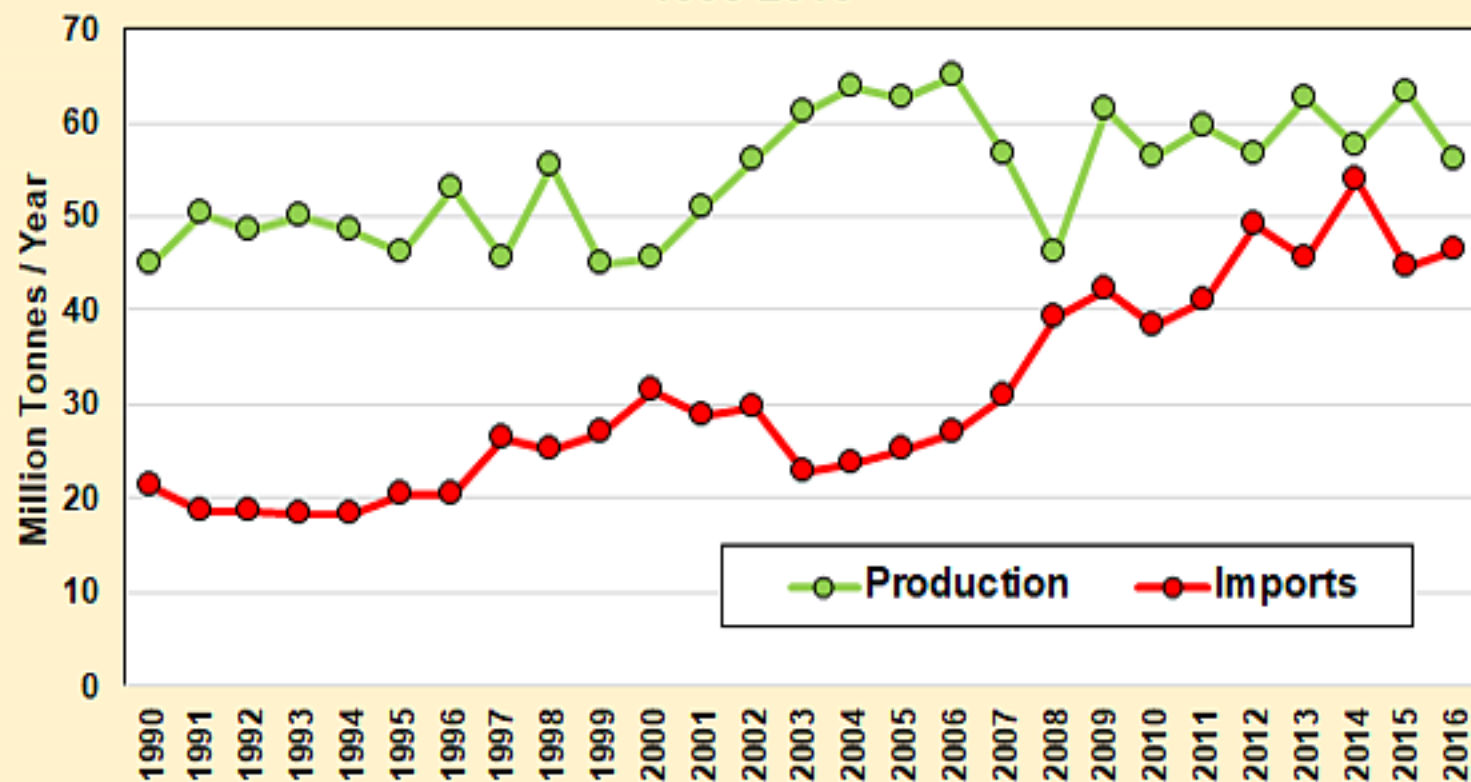
Maize



Production & Imports in 2017 in Million Tonnes

	Maize Imports	Maize Production	Wheat Imports	Wheat Production
2010	24.2	14.1	38.4	59.8
2017	33.4	16.5	42.2	67.4

Wheat Production and Import Trends in 20 MENA Countries
1990-2016



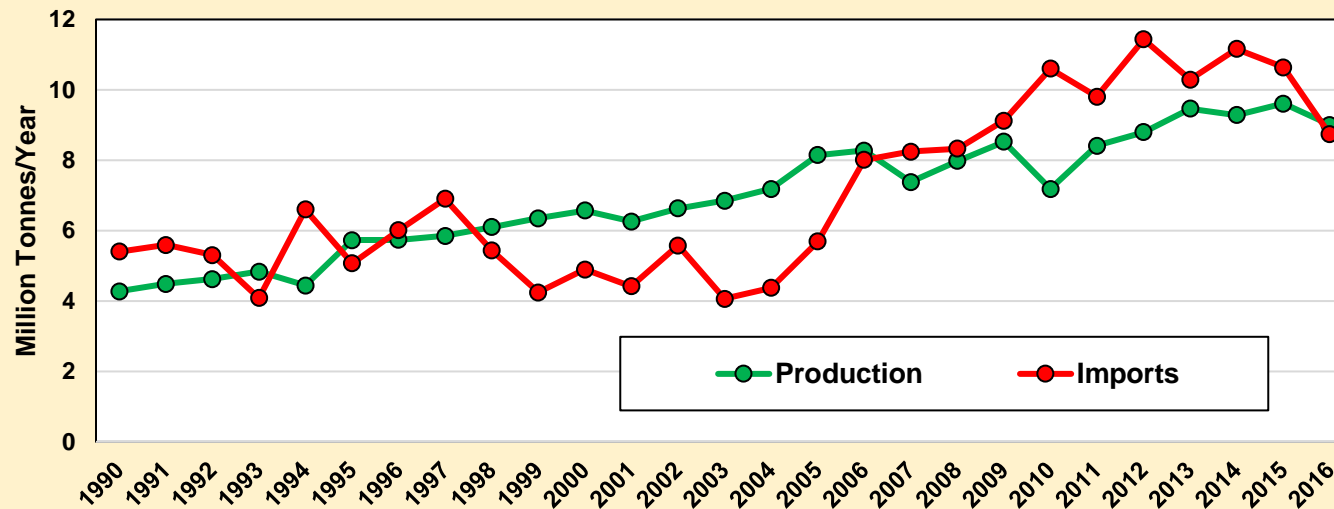
Projection Scenarios to 2050			
		Scenario A	Scenario B
	2016	2050	2050
Wheat	Million Tonnes		
Production	55.9	55.9	67.1
Imported	46.3	99.4	88.2
Total Wheat	102.2	155.3	155.3
Virtual Water		Km3	
Production	143.6	143.6	172.4
Imported	178.3	382.8	339.7
Annual H2O			
Withdrawals	359.1	359.1	359.1



The Case of Egypt



Changes in Wheat Production & Imports in Egypt 1990-2016



Annually Available Water in Egypt in 2016: 68.3 Km³

Virtual Water Imported in Wheat in 2016 : 8.1 Km³ = 12% of Available Water

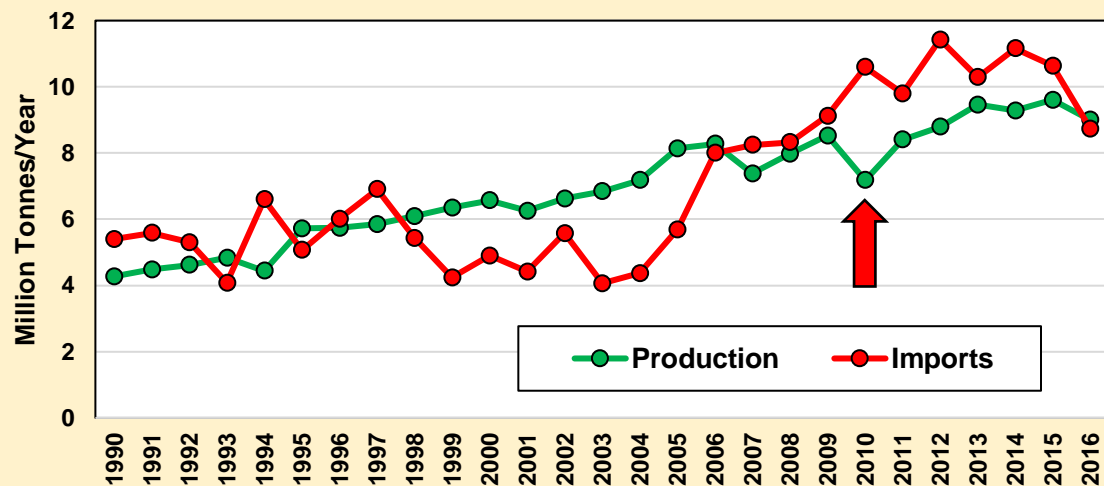
Virtual Water Imported in Wheat in 2050 : 13.1 Km³ = 19% of Available Water (BAU)

Virtual Water Imported in Maize in 2016 : 6.1 Km³ = 9% of Available Water

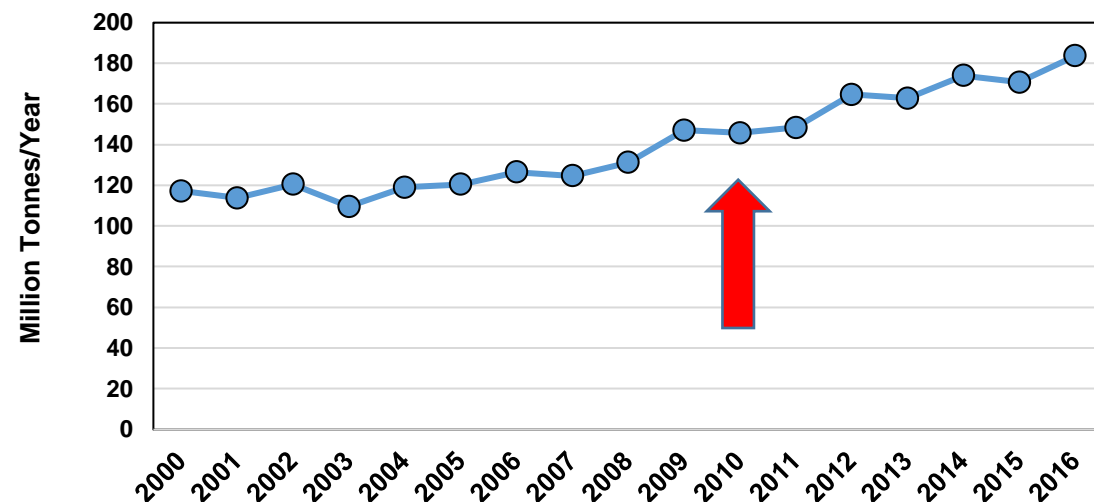
Virtual Water Imported in Maize in 2050 : 13.0 Km³ = 19% of Available Water (BAU)

VW in Wheat and Maize Imports = 21% of available water but 38% of in 2050 (BAU)

Changes in Wheat Production & Imports in Egypt 1990-2016

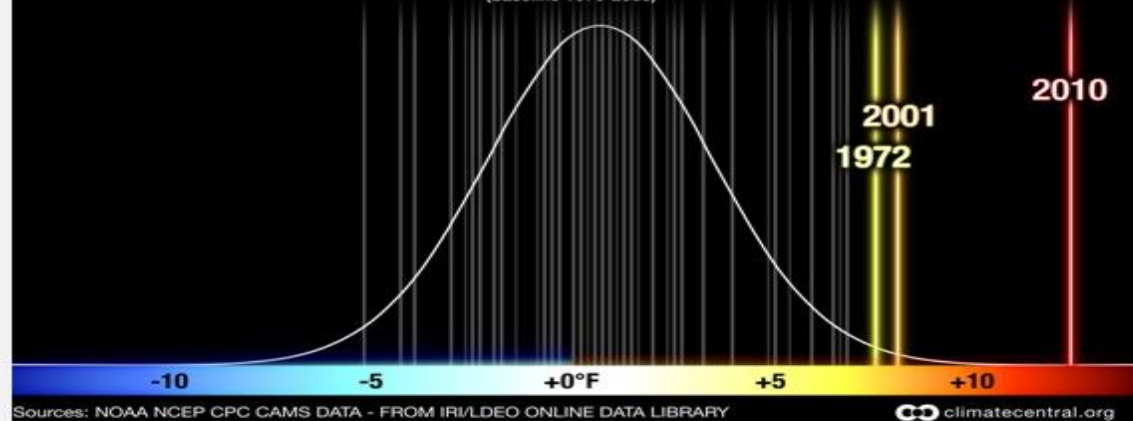


Global Wheat Exports 2000-2016



July Temperature Anomalies in Moscow since 1950

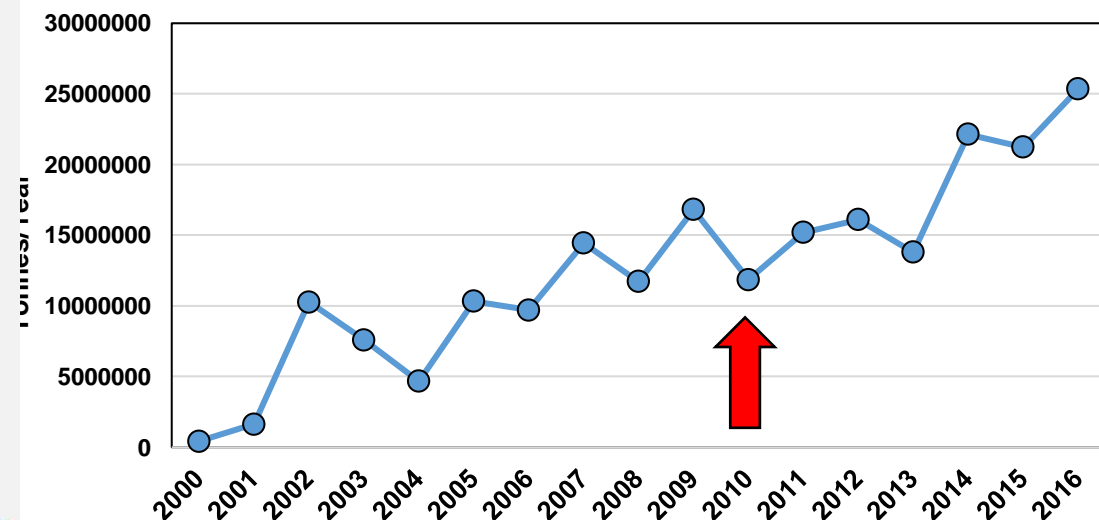
(baseline 1970-2000)



Anomaly of July 2010 Temperature in Moscow since 1950

Source: NOAA, Climate Central and Tebaldi & Ziemlinski, 2010 (with permission)

Wheat Exports by Russia 2000-2016



Egypt

Annual Water Withdrawals	68.3 Km ³
Virtual Water Imported	28.2 Km ³
Domestic Water Used	5.5 Km ³

Virtual Water = 40% of Annually Used Water

5 Times more Water than Domestic Use

Population in 2016 **96 Millions**
Projected Population 2050 **154 Millions**

Arable Land / Person in 2016 **0.03 ha**
Arable Land / Person in 2050 **0.03 ha**



Case Study Saudi Arabia

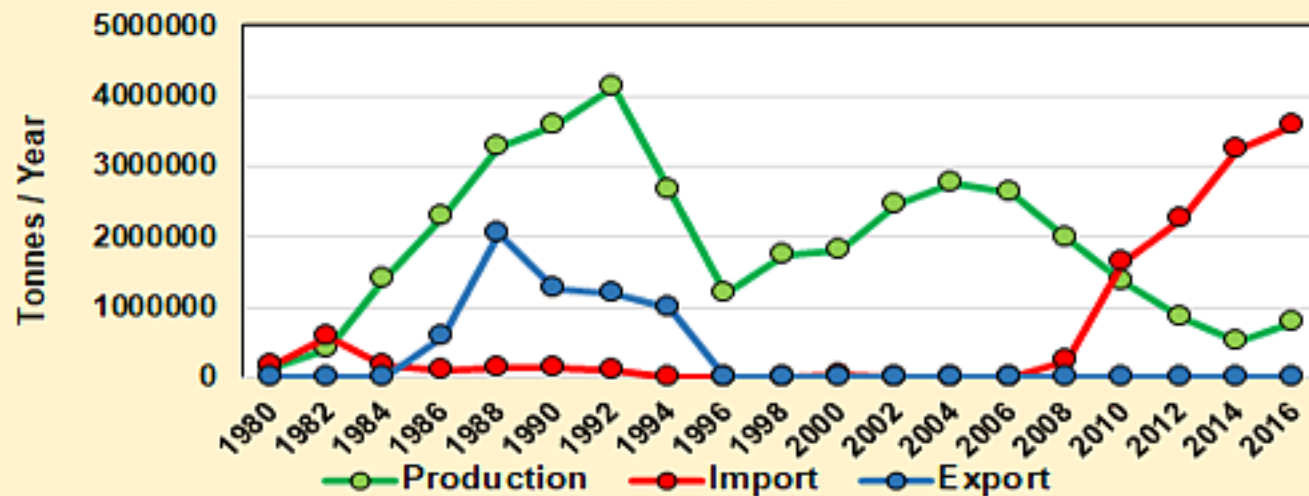
Population in 2016 = 32.3 Millions

Population in 2050 = 45.1 Millions

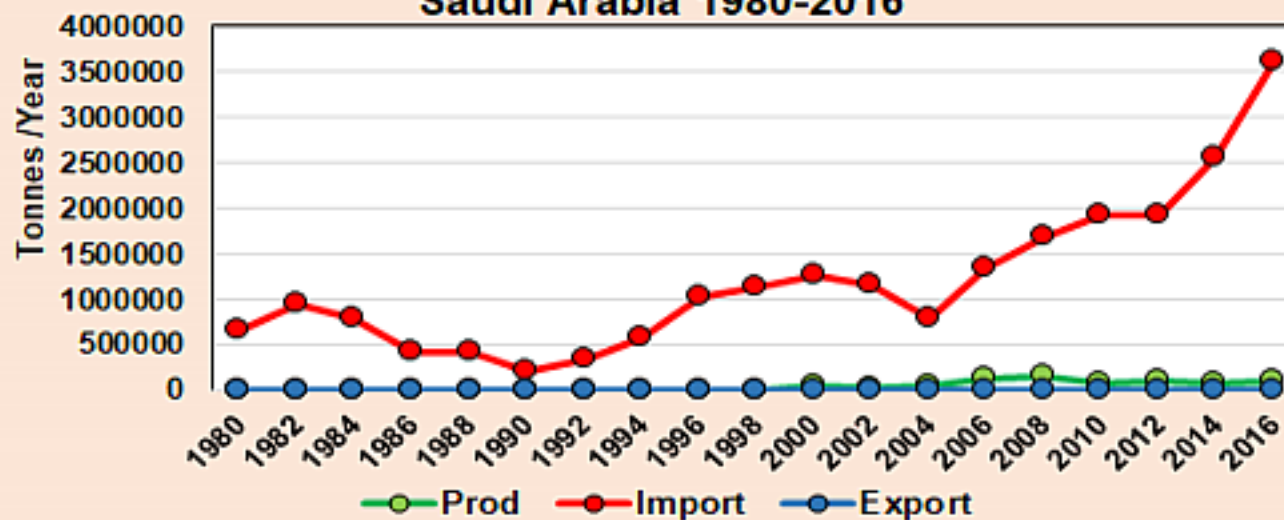
Arable Land / Person in 2016 = 1.10 ha / Person

Arable Land / Person in 2050 = 0.07 ha / Person

Wheat Production, Imports & Exports in Saudi Arabia 1980-2016



Maize Production, Imports & Exports in Saudi Arabia 1980-2016



Saudi Arabia

Annual Water Withdrawals	23.7 Km ³
Virtual Water Imported	31.8 Km ³
Domestic Water Used	2.1 Km ³

Virtual Water = 25% More than Annually Used Water

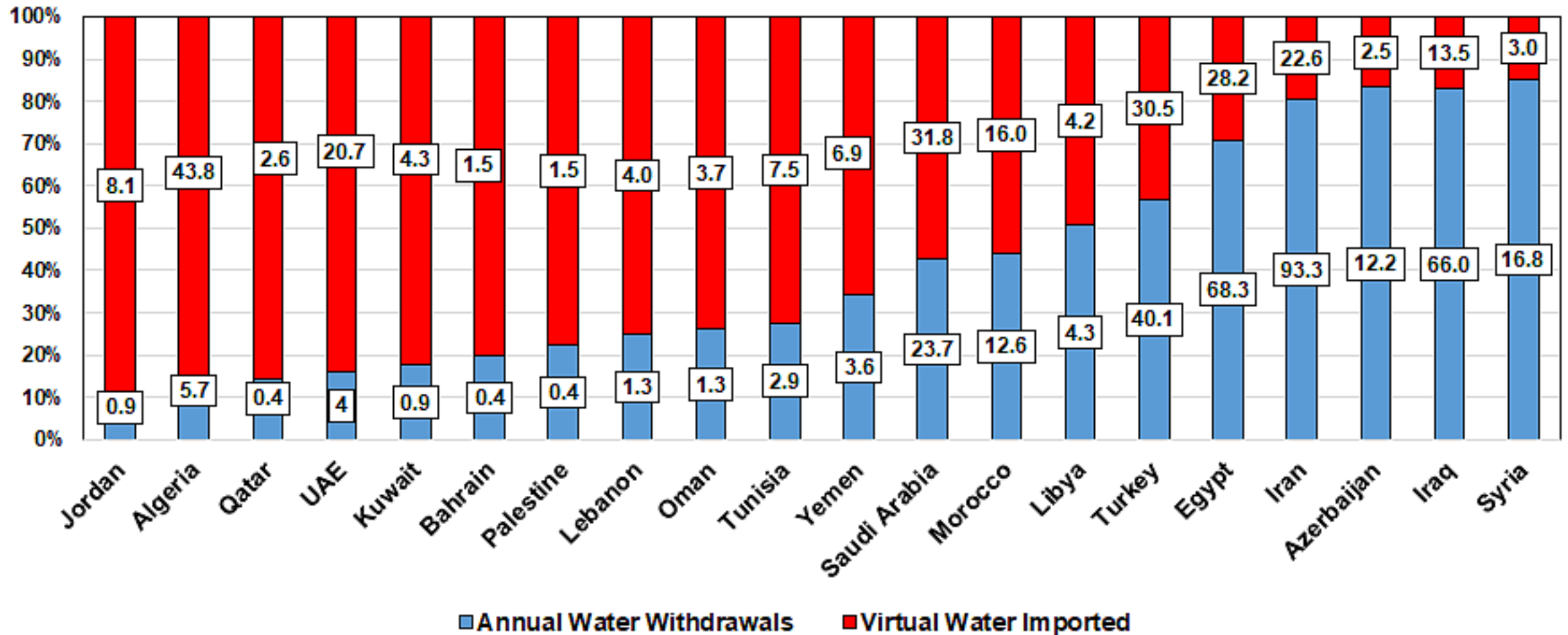
16 Times more Water than Domestic Use

Estimated Desalinated Water Available = 1.1 Km³/Year

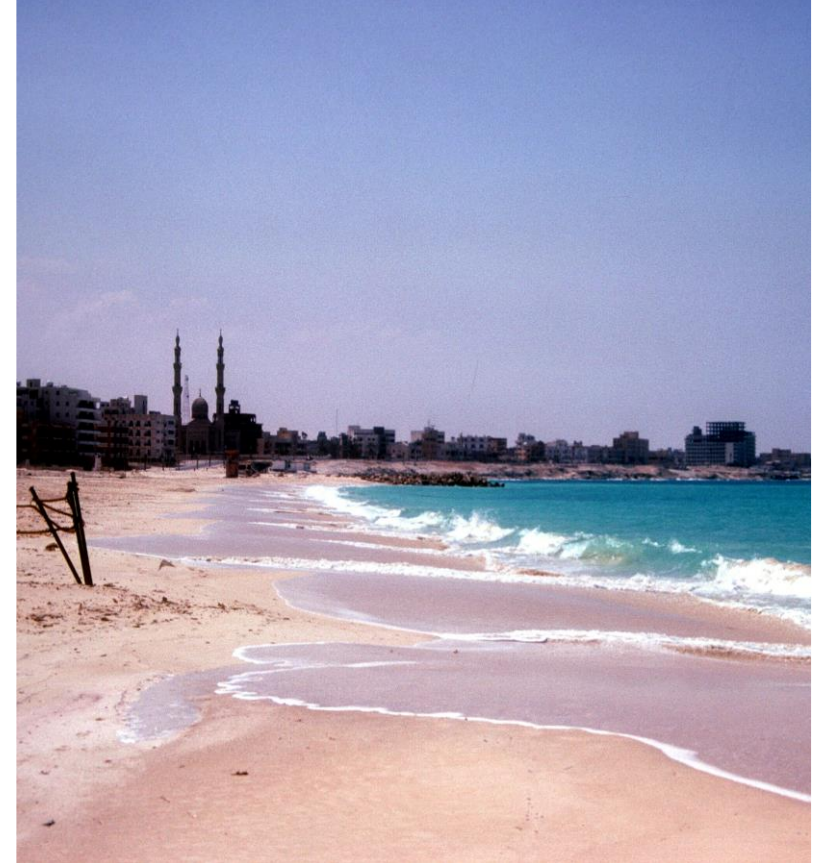
**By 2050 the Reliance on Food Imports will increase by 39%
In a Business as Usual Scenarios**

MENA Regional Summary

% of Imported Virtual Water (RED) versus Annual Water Withdrawals (Blue) in the MENA Countries
(Numbers = km³ of Water / Year in 2016)



Regional Projection to 2050		
		Scenario BAU
	2016	2050
Wheat	Million	Tonnes
Production	55.9	55.9
Imported	46.3	99.4
Total Wheat	102.2	155.3
Virtual Water	Km3	Km3
Production	143.6	143.6
Imported	178.3	382.8
Annual H2O		
Withdrawals	359.1	359.1
Imported VW as a %		
of Available Water	49%	106%



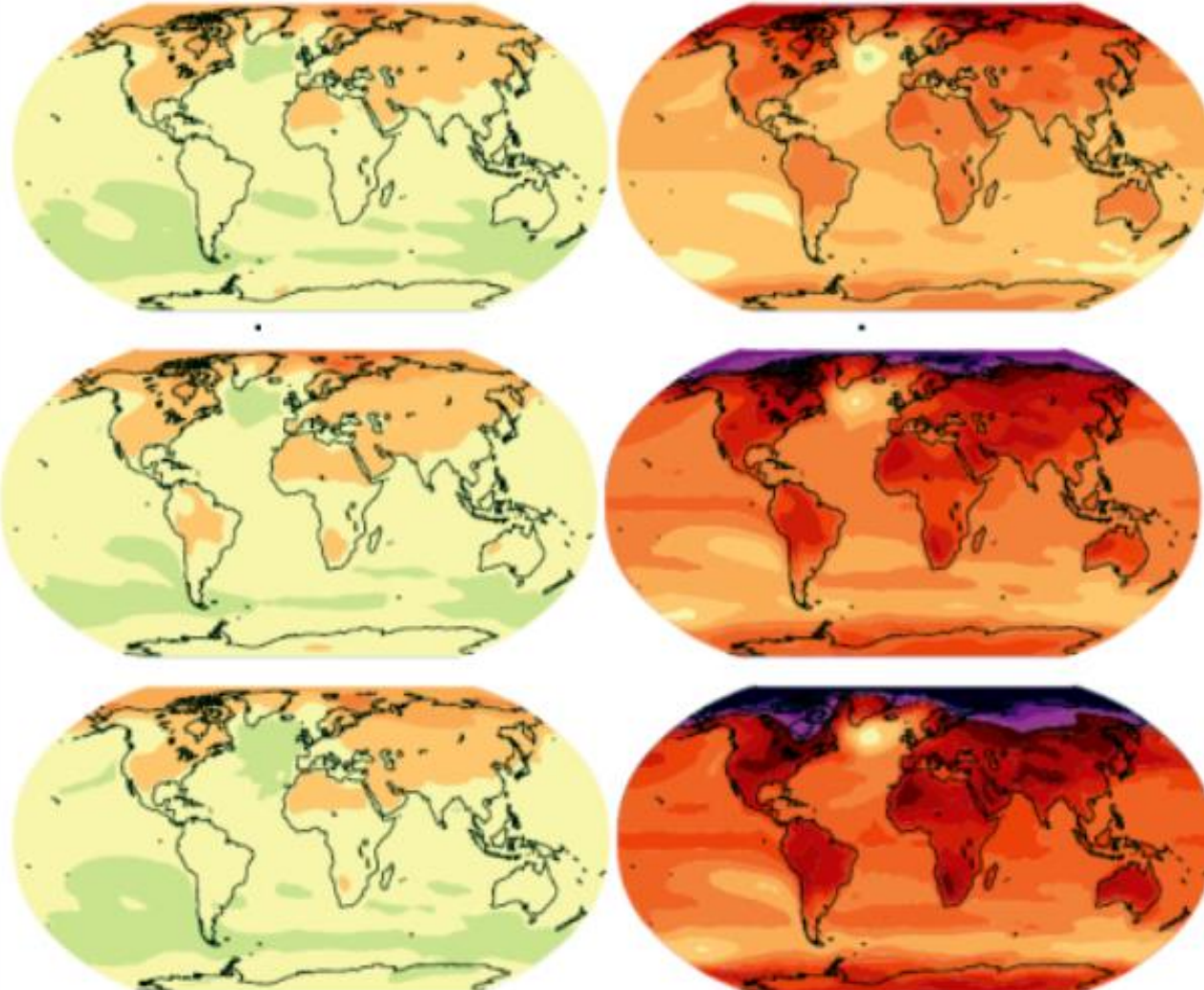
**Low Emission
Scenario
B1 = 1.8 °C**

**Moderate
Emission
Scenario
A1B = 2.8°C**

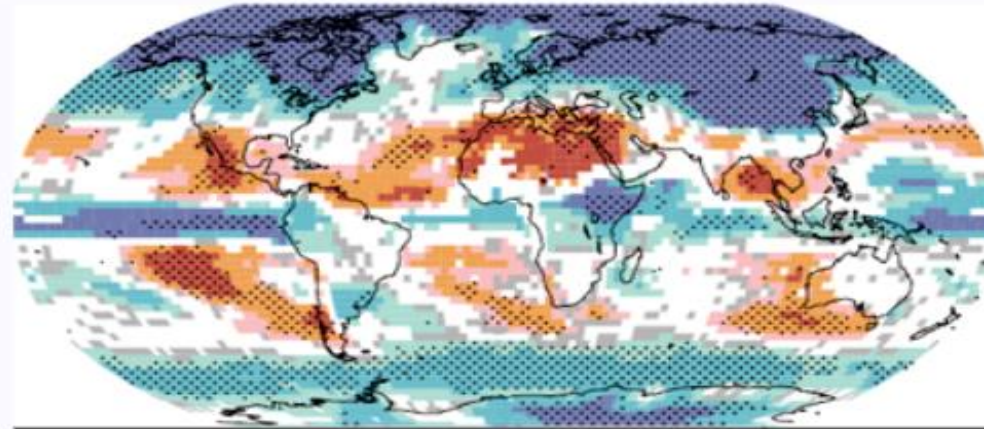
**High Emission
Scenario
A2 = 3.4°C**

2020 - 2029

2090 - 2099

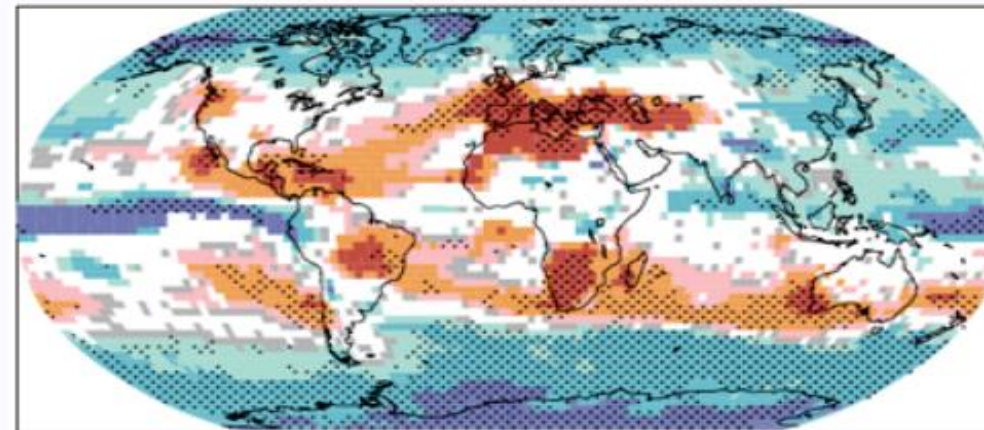


Precipitation Projections to 2099



**A1B High
Emission
Scenario**

Dec-Feb



Jun-Aug

**Note:
Arab Middle East**

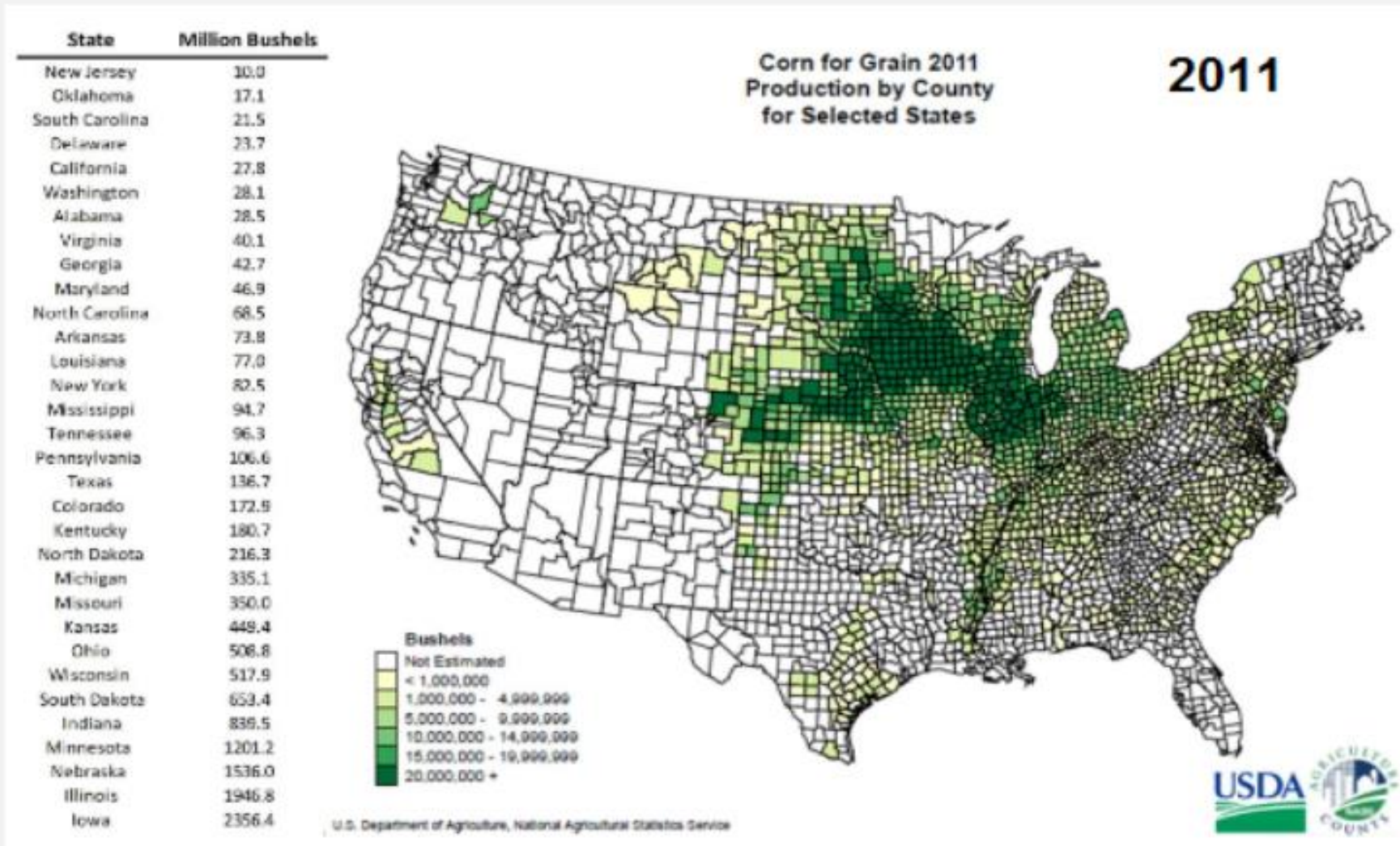
**A 20% Reduction
in Precipitation**



Green Water Management:
Holding back the runoff from rainfall to infiltrate into the
soil is sufficient to grow a crop of barley in Egypt

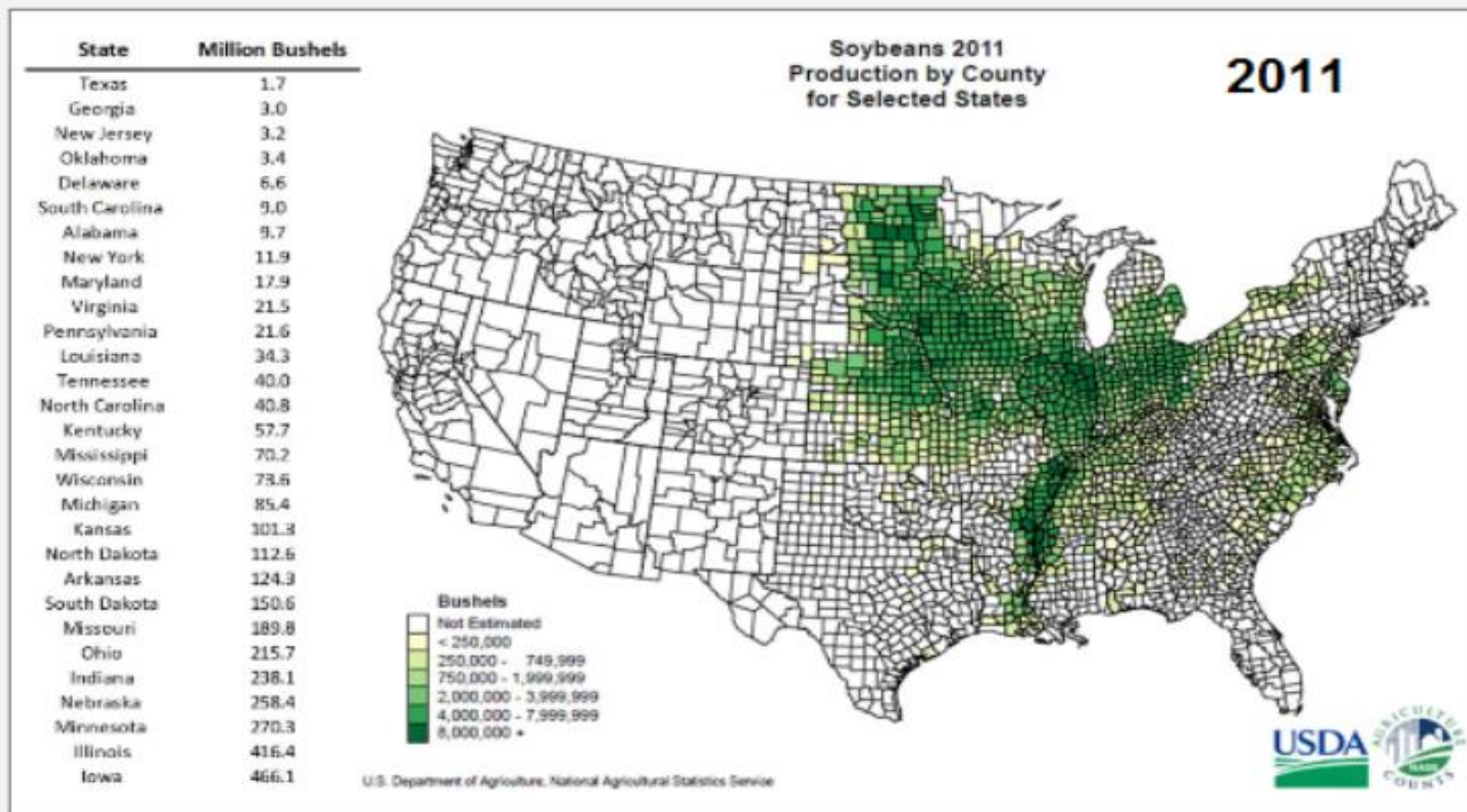


Regional Concentration of Crop Production Destined for Export. The Increase in Extreme Climatic Events Increases the Global Food Security Risk



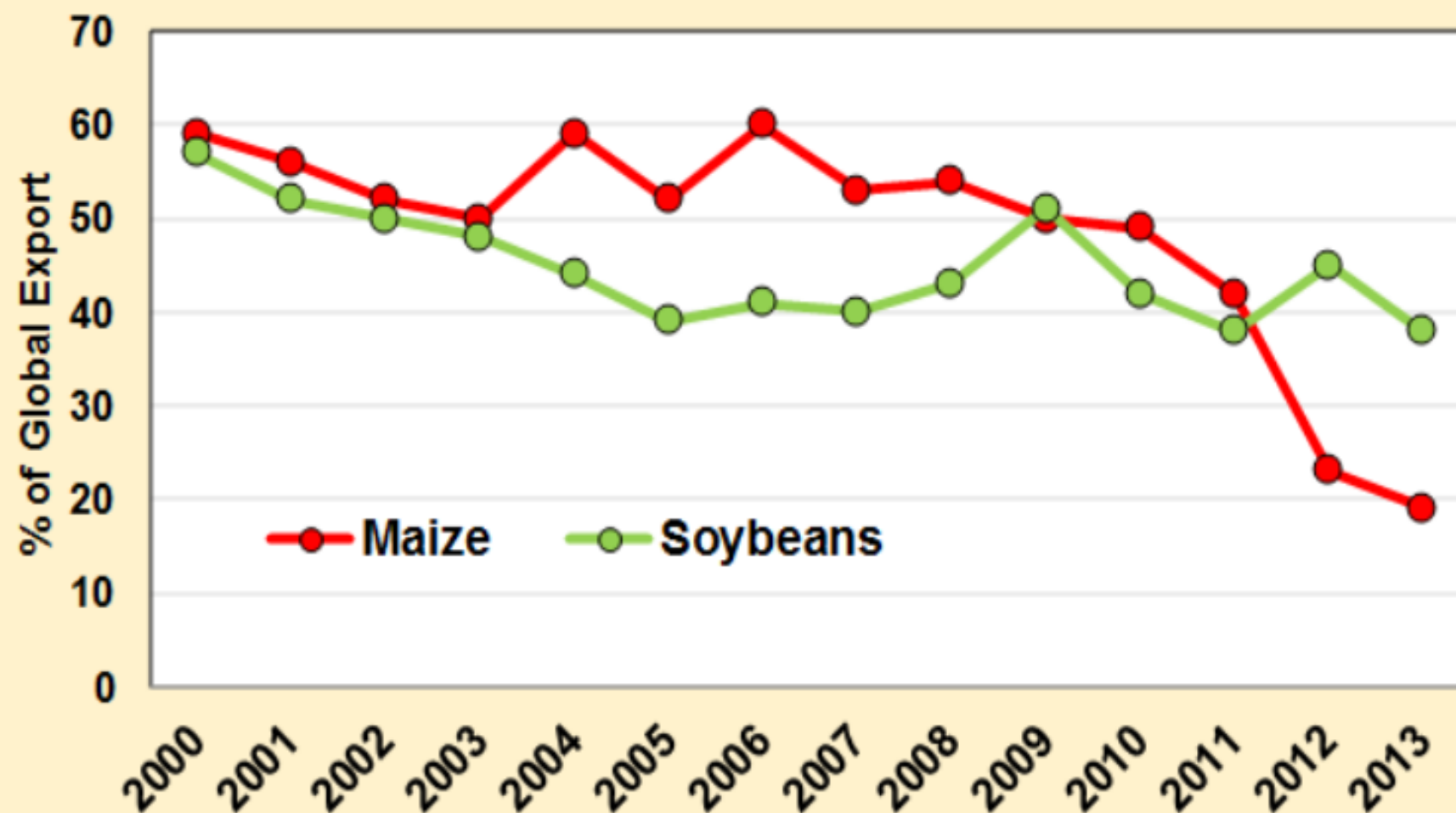
48% of all Maize exported globally comes from the Green Area

Regional Concentration of Crop Production Destined for Export. The Increase in Extreme Climatic Events Increases the Global Food Security Risk



45% of all Soybeans Exported Globally come from the Green Area

Change in the % of Global Export in Maize & Soybeans from the USA 2000-2013



Other USA Export

% Of Global Export in 2013

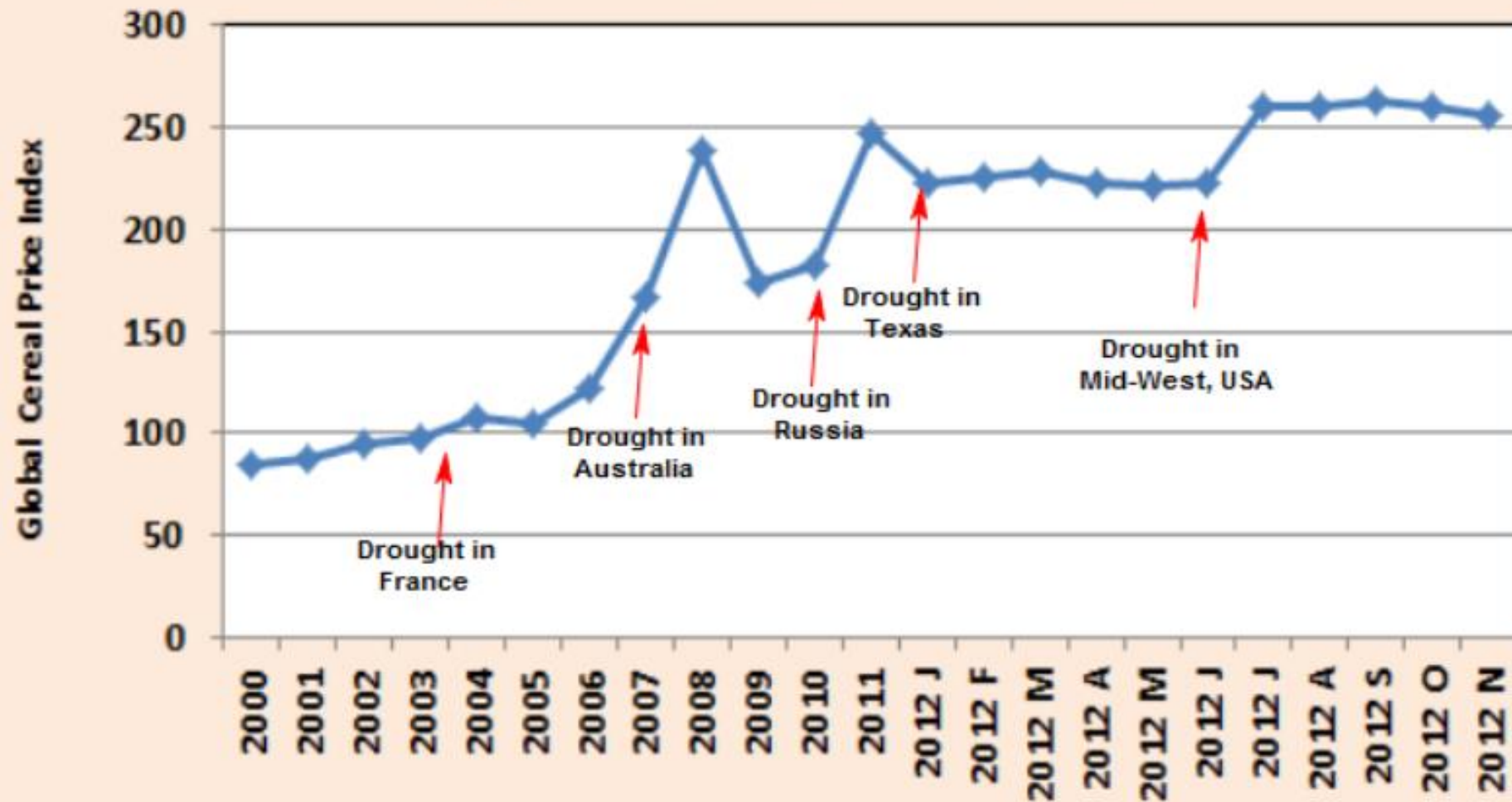
Chicken 28%

Pork 22%

Beef 13%

Wheat 20%

Changes in Global Cereal Price Index



Food Security Challenges In Mountains

Mountain Communities	Now	Future
Food Supplies	Mostly Insufficient	Improved
	Low Yields Harsh Climate Short Growing Season Inefficient Irrigation Limited Crop Diversity	Higher Yields (Legumes, Fertilizers) Longer Growing Season Efficient Irrigation (Drip) Greater Crop Diversity
Food Imports	Challenging	More Challenging
	Difficult Access Poor Infrastructure Food Storage Issues High Transport Cost	Increased Urban Demand More Competition Higher Costs More Risks (drought, floods)