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Syrian Agriculture

Historical and Environmental Context

June 18, 2014

Syrian Agriculture
Historical and Environmental Context

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KSC Research Series

ABSTRACT: Syria is a semi-arid country with a Mediterranean climate but one that also includes major river systems that supply water for irrigation. Crops best suited to the climate include wheat, barley, chickpeas, and drought resistant trees such as olive, but many other crops can be grown with the assistance of irrigation. Through aggressive agricultural policies created in the 60s and 70s that heavily subsidized the cost of production, Syria became food self-sufficient and a major exporter of wheat and cotton. In recent years the agricultural sector has proven to be unsustainable as a combination of frequent and sustained drought and withdrawal of farming subsidies devastated agricultural production. Steps must be taken to decrease the pressure put on the limited water resources by either removing crops with a high water demand, such as cotton, or improving the efficiency in which irrigated water is delivered.

PB-AAC-901

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Contents

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Syrian Agriculture

Syria's agriculture is as much constrained by its climate as it is by government policy and land management practices. While Syria lies in the ancient Fertile Crescent, the foundation of agriculture and civilization in the Western World, it cannot be expected to keep up with modern industrial farming techniques and yields that have become standard elsewhere in the world. While soil fertility and available land are the limiting factors for increased productivity in many places of the world, water is the limiting factor for productivity in Syria. In order to continue sustainable and self-sufficient production, Syria and its farmers must make changes to the agricultural sector that realize the limitations and variability of Syria's water supply.

Climate and Water Resources

Syria is divided into 14 Governorates that range in size from over four million hectares in the Homs Governorate to under 200,000 in both Quneitra and Tartous Governorates (see table 8 in Supplemental Information). It is here in Syria that many rainfed grains and tree fruits were first cultivated, irrigated farmland was developed, and some of the first animal domestication took place (Zeder 2008). This is in part due to Syria's unique location which provides a range of ecological environments that tailor to different agricultural practices. The coastal regions of Syria along the Mediterranean (Tartous and Lattakia Governorates) receive the highest amount of rainfall in Syria, even supporting forests in the mountains just east of the sea. The eastern inland regions of Syria are much more arid, but the north of the country still receives enough rainfall for rainfed agriculture and grazing, while the south does not (see Table 1 and Figure 1). Although many regions of Syria do not receive enough rainfall for rainfed agriculture, the rivers that run through the country provide enough water for limited irrigated agriculture (see Figure 7 in Supplemental Information).

Table 1

Annual Rainfall By Governorate

	1989- 2012 Average (mm)	Standard Deviation
Al-Ghab*	880.49	289.38
Al-Hassakeh	312.01	89.33
Al-Rakka	180.60	47.56
Al-Sweida	328.13	99.07
Aleppo	332.65	60.76
Damascus	271.86	90.91
Dar'a	285.04	83.24
Deir-ez-Zor	127.48	48.43
Hama	673.33	168.79
Homs	587.76	178.30
Idlib	516.55	96.95
Lattakia	906.60	219.96
Quneitra	642.34	324.05
Tartous	1056.49	257.41
Country	252	

Source: Syrian Agricultural Database (http://www.napcsyr.net/sadb.htm)

Syria follows a fairly typical Mediterranean type climate, with cool to mild winters and hot dry summers. The majority of rainfall comes between late November and early March. Typical of most Mediterranean climates, Syria is prone to frequent and prolonged droughts (de Chaâtel, 2014). Droughts can last from one year to decades and can have devastating impacts on agriculture and animal husbandry. Aside from climatic droughts, Syria's irregular rainfall can cause agricultural droughts when rainfall stops in key periods of plant development. This can cause circumstances where crops suffer from water-restricted yield reductions, despite average or even above average annual rainfall (Hole 2009, Oweis & Hachum 2012).

Water Reserves

The total amount of water available for sustainable human use in a given area is referred to as the total renewable water resource. It is comprised of all the water that enters the area in a given year through surface water, ground water, and rainfall. By withdrawing more than the total renewable water resources available humans can eventually drain the lakes and aquifers in the given area. Syria, like most places on earth, has two major sources of water reserves: above ground water in rivers, reservoirs, lakes, and streams, and below ground water stored in aquifers. Rivers by far are the largest source of water reserves in Syria, with 37.52 km^3 flowing through the country each year. If it was feasible, and if Syria tapped all of this resource, it would create devastating impacts for downstream neighboring countries, as well as the ecology of the entire region. Through agreements and treaties with neighboring countries (namely Turkey and Iraq) for allowable inflows and outflows, Syria's total renewable water resources from rivers are limited to 8.34 km^3/year. Groundwater inflows and outflows behave in a similar manner and are treated like surface water resources under treaties and agreements. The total renewable water resource from groundwater is 1.33 km^3/year. Lastly, rainfall in Syria adds 7.1 km^3/year to surface and groundwater resources, making the total renewable water resources available to Syria 16.8 km3/year (FAO AquaStat).

Figure 1. Source ICARDA

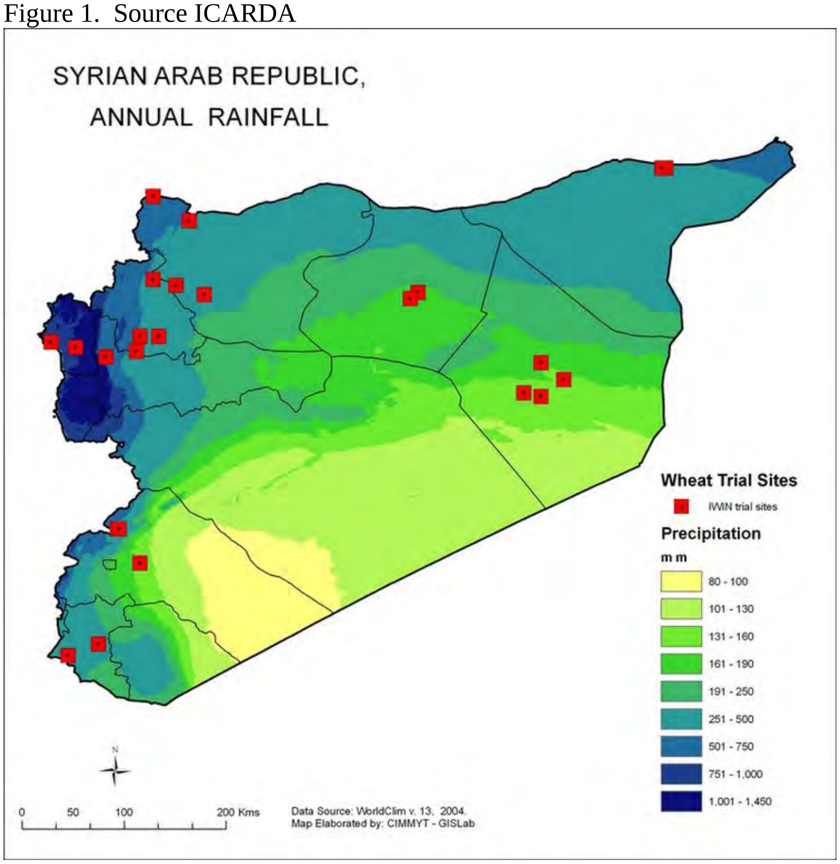


Table 2.		
Main damns in Syria (MLAE, 2007)		
Basin	Number of dams	Total Storage capacity (millions m^3)
Yarmouk Barada and Awaji	42	245
Coastal	21	602
Orontes	49	1492
Al Badia	37	69
Euphrates and Allepo	4	16146
Tigris and Khabour	12	1045
Total	165	19599

Historically the majority of renewable water resources have been withdrawn from surface water. This dates back to ancient times when natural and irrigated flooding of the lands around the Euphrates, Tigris, and Khabur rivers occurred. While these are major rivers that contribute heavily to Syria's overall water resources, the availability of water from these sources has always been variable. As the rains in Syria, and in neighboring countries that contribute to Syrian rivers, are seasonal and do not come in consistent volumes, neither is the flow in many of the rivers. While overall flow in many streams and rivers can easily meet human demands, the inconsistency in flow may inhibit irrigation when water is needed (Hole 2009). In Syria's modern history extensive dams and reservoirs have been built to capture and store this water so it is available more regularly (see Table 2). While the total reserves stored in these dams is 19.6 km^3, this does not affect the total renewable water resources available. Dams merely store water on the surface, which makes it easier for controlled temporal and spatial use by humans.

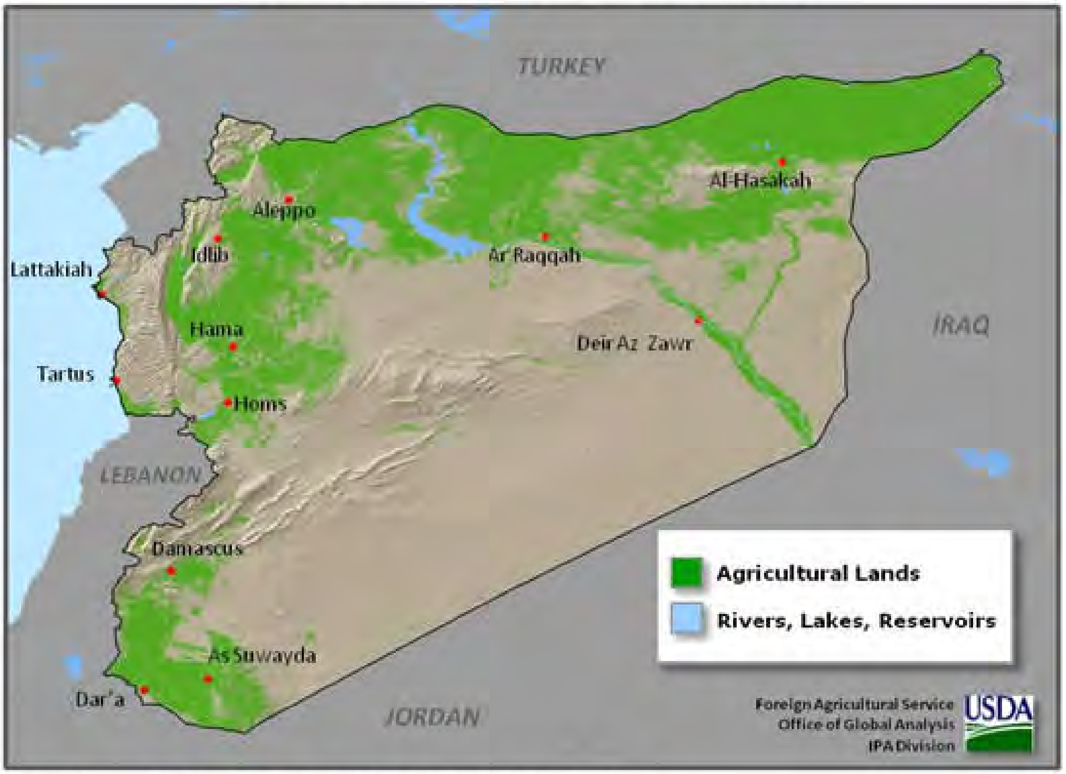
In recent decades, starting in the 1970s, bore hole drilling became prevalent and allowed for groundwater to be reached and pumped out, vastly expanding the availability of water for agricultural and human use. By the 1990s, groundwater surpassed surface water as the primary source of agricultural irrigation (see Figure 4). Agriculture is still by far the largest consumer of water in Syria, with crop and livestock consumption drawing 87% of used water (FAO AquaStat) (see Supplemental Information).

Al-Ghab

The Al-Ghab region is a 140,997 ha area of land in the Northwest region of the Hama Governorate. The area is surrounded by the coastal mountains to the West and rolling hills to the East making a basin like topography. The area historically was used as pasture range as it receives moderate rainfall but has poorly draining soils, making it a poor location for agriculture. The area, which was sometimes referred to as a swamp, began to be drained into the Orontes River in the 1970's through a government program and quickly became an agricultural hotspot (UN-Al-Ghab Project 2010). Because the Al-Ghab region receives more rain than the rest of the Hama Governorate and the government's interest in the agricultural potential of the area, it often listed as a separate agricultural area in much of Syria's agricultural reporting.

Figure 2

SYRIA: Distribution Of Agricultural Lands



Data Source: GeoCover LC 2000; NASA SRTM Elevation & Water Data

Image Source: USDA Foreign Agricultural Service

Agriculture

Syrian soils are typical of the Mediterranean area with little weathering, but lack of sufficient nutrients (namely nitrogen and phosphorus) that are required for typical modern agricultural yields (Ryan, 2004). This requires the heavy use of fertilizers. Despite this, agriculture in most of Syria is water limited, not land or nutrient limited, therefore most of Syrian agriculture takes place in areas that receive adequate rainfall or is adjacent to a reliable water source (Oweis & Hachum, 2012). Human technology has allowed for transportation of surface water, and tapped groundwater supplies, increasing the area of agriculture (see Figure 2). The agricultural area of each Governorate in 2012 can be found in Table 3, further separated into rainfed area and irrigated area.

Production/Yield

The agricultural production in Syria is divided into four main types, field grains and cereals, vegetables, tree fruits, and animal production. Table 4 identifies the top 7 crops (field and vegetable) by the categories of production (tons), area under cultivation (ha), and yield (tons/ha), as well as identifying the Governorate that has the highest corresponding production category. The crops identified and values used are the nationwide averages calculated from 1985-2012, while the Governorate listed is simply the top producer in each category. Tobacco was added to this list as it historically has been a focus of the government's attention and deemed a key crop. It is worth noting that Al-Ghab is identified

Table 3. Data source: Syrian Agricultural Database

2012 Total and Cultivated Land Area

Thousands of ha

	Total Land Area	Cultivated - Fallow	Cultivated - Irrigated	Cultivated - Rainfed	Total Cultivated	Percent Cultivated
Al-Hassakeh	2,334	419	405	755	1579	67.65%
Al-Rakka	1,960	450	216	146	812	41.43%
Al-Sweida	554	47	3	110	160	28.88%
Aleppo	1,851	69	222	884	1175	63.48%
Damascus	1,815	17	62	57	136	7.49%
Dar'a	374	88	35	108	231	61.76%
Deir-ez-Zor	3,307	40	151	24	215	6.50%
Hama	1,017	59	146	255	460	45.23%
Homs	4,092	35	54	257	346	8.46%
Idleb	609	2	62	294	358	58.78%
Lattakia	229	4	38	61	103	44.98%
Quneitra	187	6	4	22	32	17.11%
Tartous	189	0	29	93	122	64.55%
Total Governorates	**18,518**	**1236**	**1427**	**3066**	**5729**	**30.94%**

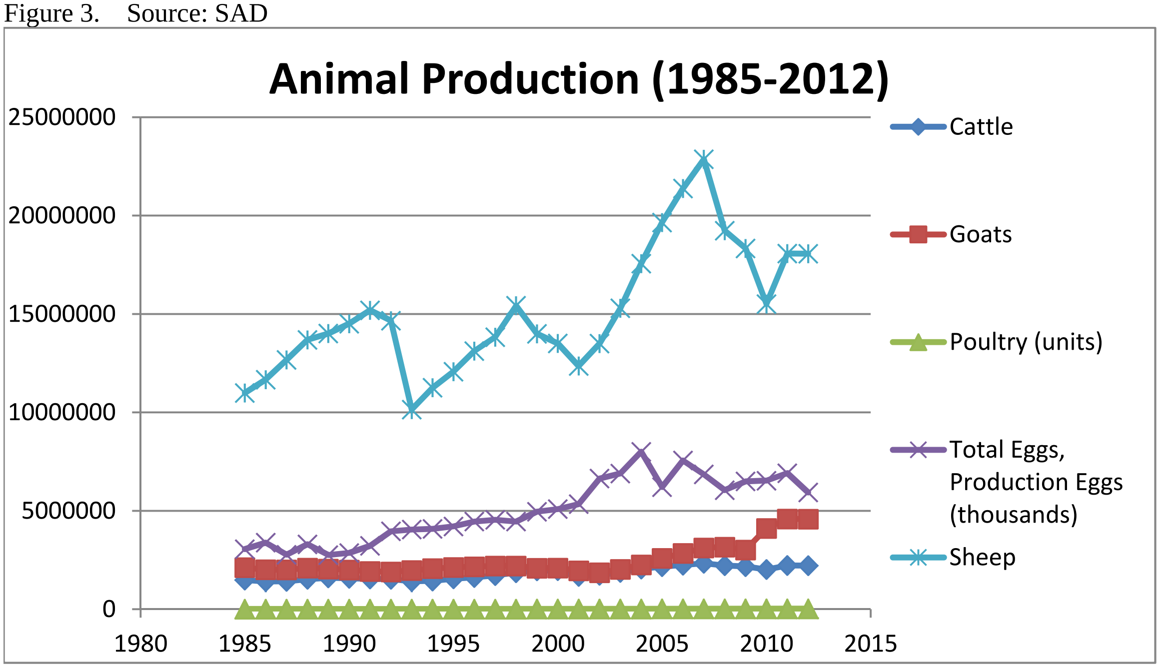
independently as the largest producer of sugar beets, while in the yield category Al-Ghab is incorporated back into the larger Hama Governorate.

Figure 3 shows the overwhelming dominance of sheep in the animal production sector. Table 4a breaks down the production of sheep by Governorate and animal production by area. Aleppo produces the most sheep but not far behind in production is Hama Governorate, which has a far higher density of sheep. It should be noted that the Al-Ghab region is not included in the Hama Governorate.

Tree fruit yields were listed as both kg/tree and ton/ha as these values give different information. Kg/tree indicates the production capabilities of each tree, which is important information for small-scale production where it would be desired to produce as much fruit as possible from a small number of trees. On a larger scale tons/ha becomes a better indicator of efficiency as it reveals production limitations such as tree spacing limitations, edge effects, pest damage, and other factors that can arise in an orchard setting and have a damaging effect on production.

Table 5 identifies total agricultural production in each Governorate in 2012. It is worth noting that the three Governorates with both the largest agricultural area, and highest production are within the river basins that contain the first and third most available water resources from dams (see Table 2). The Orontes River basin contains the second largest water reserves and flows directly through the Al-Ghab region, by far the most efficient producer of agricultural goods with an average of 6.34 tons produced per hectare, almost twice that of the next highest yielding Governorate.

Figure 3. Source: SAD



The choice of crops grown can heavily change the water resources required. Each species will have its own unique water requirements based on plant physiology and growth. Additionally plants use water as a cooling mechanism which is heavily impacted by temperature, humidity, and soil characteristics. Table 7 shows the estimated maximum water requirements needed by each crop. These numbers are estimates because they only take into account the crop's baseline water needs, average monthly temperature, average growing days, and average length of day. The values are the estimated maximum requirements for each crop because all, except the two highlighted in blue, are modeled as if the crops were grown in the summer with irrigation. Growth in the summer can, for some crops, be ideal due to the long daylight hours and warm temperatures. On the other hand, both of these factors require the plant to use additional water, and if the required water is not available, or the plant cannot draw it from the soil quickly enough, the plant can suffer from moisture stress.

Table 4. **Crops of Highest National Production, Area, and Yield (1985-2012 average)**

Field Crops and Vegetables

Production			Area			Yield		
crop	tons	Governorate	crop	ha	Governorate	crop	tons/ha	Governorate
Wheat Total	3,336,777	Al-Hassakeh	Barley Total	1,675,638	Aleppo	Sugar Beet Autumn	43.17	Hama
Barley Total	1,467,970	Aleppo	Wheat Total	1,529,890	Al-Hassakeh	Tomato Irrigated	39.04	Dar'a
Sugar Beet Total	1,052,513	Al-Ghab	Cotton	198,516	Al-Hassakeh	Water Melon Irrigated	27.42	Damascus Rural
Cotton	700,372	Al-Hassakeh	Lentil Total	124,559	Al-Hassakeh	Garlic Green	26.65	Aleppo
Tomato Total	518,598	Dar'a	Chickpea Total	75,592	Al-Sweida	Potato Irrigated Spring	23.27	Damascus Rural
Potato Total	487,741	Idleb	Maize Total	57,236	Al-Rakka	Eggplant Summer	22.10	Hama
Water Melon Total	429,424	Al-Hassakeh	Cumin Total	35,907	Aleppo	Cabbage Irrigated Winter	21.54	Hama
Tobacco*	20,602	Lattakia	Tobacco*	4,979	Lattakia	Tobacco*	3.02	Al-Ghab

Tree Fruit

Production			Area			Yield (tons/ha)		
crop	tons	Governorate	crop	ha	Governorate	crop	ton/ha	Governorate
Olives Total	889,562	Aleppo	Olives Total	623,813	Aleppo	Citruses Irrigated	86.58	Lattakia
Oranges Total	612,763	Lattakia	Almonds Total	65,044	Homs	Apples Irrigated	39.30	Lattakia
Apples Total	340,297	Damascus Rural	Pistachio Total	57,439	Aleppo	Apricot Irrigated	38.28	Homs
Grapes Total	322,657	Homs	Grapes Total	52,446	Homs	Grapes Irrigated	27.45	Lattakia
Other Citruses Total	245,144	Lattakia	Apples Total	48,579	Damascus Rural	Plums Irrigated	27.25	Deir-ez-Zor
Lemon Total	136,145	Tartous	Cherries Total	26,885	Damascus Rural	Nuts Irrigated	27.11	Al-Ghab
Almonds Total	110,192	Homs	Oranges Total	22,188	Lattakia	Peaches Irrigated	26.07	Lattakia

Yield (kg/tree)		
crop	kg/tree	Governorate
Oranges	103.17	Lattakia
Other Citruses	87.53	Homs
Lemon	85.34	Homs
Figs Irrigated	55.26	Dar'a
Apricot Irrigated	55.22	Lattakia
Apples Irrigated	47.75	Lattakia
Plums Irrigated	46.24	Lattakia

Source: Syrian Agriculture Database
Values given are national average from 1985-2012, while the Governorate listed highest individual value for that production category.

Table 4a

	Sheep by Governorate		Sheep by Area		
	2012	1985-2012 Average	Area (thousands of ha)	2012 (animals/ha)	1985-2012 Average (animals/ha)
Aleppo	2,815,292	2,443,460	1,851	1,521	1,607
Al-Ghab	228,424	97,450	141	1,620	60
Al-Hassakeh	1,632,652	1,759,004	2,334	700	2,515
Al-Rakka	2,064,390	1,815,706	1,960	1,053	1,724
Al-Sweida	349,692	251,666	554	631	399
Damascus	1,775,930	1,163,322	1,815	978	1,189
Dar'a	635,880	413,810	374	1,700	243
Deir-ez-Zor	2,597,349	2,336,177	3,307	785	2,974
Hama	2,401,614	1,705,721	876	2,742	622
Homs	2,400,000	2,343,969	4,092	587	3,996
Idleb	811,930	576,365	609	1,333	432
Lattakia	132,028	36,384	229	577	63
Quneitra	130,186	115,441	187	696	166
Tartous	87,474	33,896	189	463	73
Total	**18,062,841**	**15,092,371**	**18,518**	**975**	**15,473**

Source: SAD

Table 5

2012 Agricultural Area and Production

Field Crops, Vegetables, and Fruits

	Agriculture Area (ha)	Agriculture Production (tons)	Yield (ton/ha)
Al-Ghab	88,776	562,621	6.34
Al-Hassakeh	1,133,117	1,553,936	1.37
Al-Rakka	408,557	1,517,344	3.71
Al-Sweida	112,918	71,640	0.63
Aleppo	1,138,561	2,030,478	1.78
Damascus	118,702	118,177	1.00
Dar'a	155,286	326,800	2.10
Deir-ez-Zor	216,326	676,281	3.13
Hama	319,889	610,172	1.91
Homs	297,878	188,854	0.63
Idleb	358,407	702,285	1.96
Lattakia	100,777	56,454	0.56
Quneitra	25,404	35,790	1.41
Tartous	124,894	159,583	1.28
Total	**4,599,492**	**8,610,415**	**1.87**

Source: Syrian Agriculture Database

Water Demands

Table 7 shows that summer sugar beets, cotton, and tomatoes consume the most water per season, while barley/oats/wheat (all cereal grasses behave relatively similar), beans, and autumn sugar beets consume the least amount of water per season. As clearly shown by sugar beets, changing the season in which plants are grown can have a dramatic impact on total water consumption. While sugar beets planted in the fall do well over the winter, other crops, such as cotton, would not be able to thrive as cotton's growth is highly dependent on temperature (Kakani et al. 2005).

Table 6a

Value of Crop Production (1991 -2011)

Value (current millions SLC)

1991-2011 average		2011	
Crop		Crop	
Wheat	48,379	Wheat	81,025
Olives	29,033	Olives	65,703
Cotton lint	14,690	Oranges	19,083
Grapes	9,143	Tomatoes	17,325
Barley	8,516	Vegetables, fresh assorted	15,279
Oranges	8,340	Apples	13,234
Tomatoes	7,740	Barley	12,669
All Crops	202,148	All Crops	371,705

Source: FAO Stat

Value of Production

Wheat and Olives have continued to produce the most value by sales for a crop for the past 20 years while cotton and grapes dropped out of the list of the top 7 and were replaced by assorted vegetables and apples in 2011 (see Table 6a). Sheep meat and milk products have produced the most value by sale for an animal product for the past 20 years. While there is an overwhelmingly larger number of sheep than cattle in the country, cattle milk out-sells sheep milk (see Table 6b). Overall the value of total crop products more than tripled (361% increase) from 1991 to 2011(see Figure 4a) and the value of total animal products more than quadrupled (424% increase) in the same time period (see Figure 4b). All monetary values in this section were kept in the FAO's SLC unit, which would have been the 2011 Syrian Pound. In 2011 the conversion rate was 47.4 Syrian Pounds to the U.S. Dollar. The current conversion rate is 149 Syrian Pounds to the Dollar.

Table 6b Source FAO

Value of Animal Products in million SLC

	Average (1991-2011)	2011
Meat indigenous, sheep	42,238.00	78,783.55
Milk, whole fresh cow	17,776.86	39,141.75
Milk, whole fresh sheep	11,976.78	26,811.05
Eggs, hen, in shell	11,430.65	23,546.33
Meat indigenous, chicken	9,545.93	18,606.34
Meat indigenous, cattle	8,166.73	16,236.67
Meat indigenous, goat	2,048.21	5,574.74
All Animal Products	**106,294.15**	**215,440.10**

Table 7 **Water Requirements of Select Crops**

	Crop Average Evapotrapiration rate	Growing Days	Water need (mm/season)	Water Per day mm
Barley/oat/wheat	0.8	135	327	2.42
Cotton	0.83	188	26	4.93
Lentils	0.78	160	792	4.95
Sugar beet (summer)	0.86	195	999	5.12
Sugar beet (Autumn)	0.86	195	560	2.87
Tomato	0.87	157	825	5.25
Bean	0.71	102	455	4.46
Cabbage	0.86	130	704	5.42
Tobacco	0.81	110	573	5.21

(shaded) indicates crops were grown over winter months

Data and equation source: Brouwer and Heibloem 1986

Trade

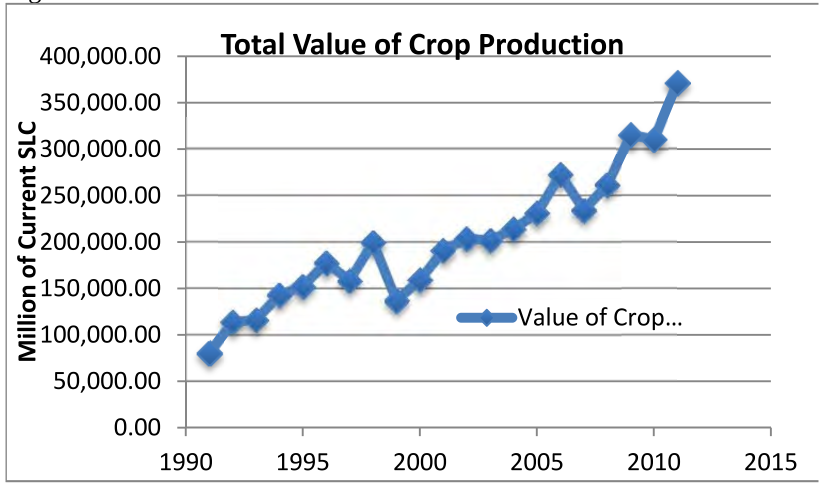
While wheat remains the crop of highest production and value in Syria, cotton is the crop of highest export value (Table 9a in supplemental information). The sale of whole live sheep overtook cotton in recent years, although much of that might be due to herders selling off their animals in response to the droughts which caused a shortage of feed. Imports (see Table 9b in supplemental information) are dominated by maize, sugar, rice and soy. Wheat also makes the list of top ten imported agricultural goods, although exports sales have consistently been greater than import. Historically, on average, Syria has imported more agricultural goods than it has exported (see Figure 8 in supplemental information), but not by much. Then in 2010/2011 exports plummeted and imports quickly rose to meet demand largely as a result of declining agriculture production and policy changes.

Issues of Concern

The availability of water for agriculture is the greatest threat to sustainable agriculture production in Syria. While this issue is not new, increased pressure due to global climate change and population increase place further stress on Syria's limited resource.

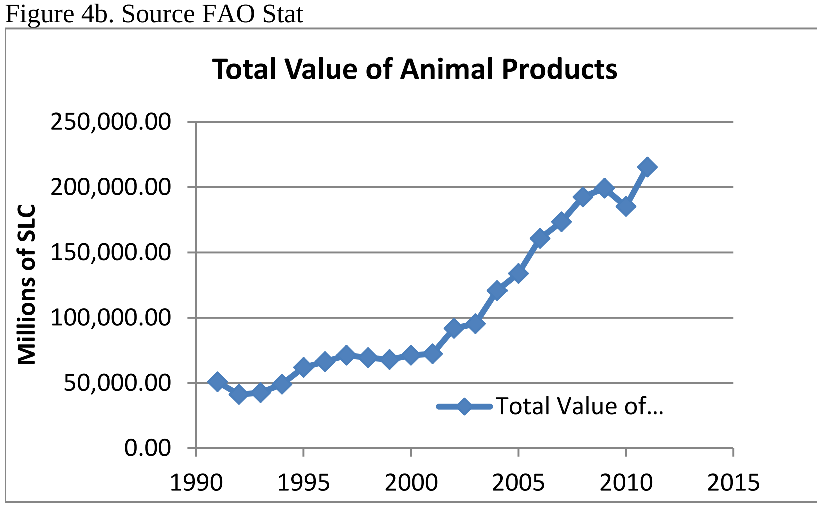
The foundation of Syria's water scarcity comes from shortsighted planning and unrealistic expectations. After Syrian independence following WWII, the government sought to gain food self-sufficiency and promote cash crops for export. Agriculture was further emphasized in the 1970's with the rise of the Ba'th party, which gained much of its support from poor rural farmers (Barnes 2009). For this reason, the government selected seven key crops to promote; wheat, barley, cotton, sugar beet, tobacco, lentils, and chickpeas. Following the soviet model for agricultural production, the government set the prices for these crops higher than the market value and subsidized fertilizer and diesel (Barnes, 2009).

Figure 4a. Source: FAO Stat



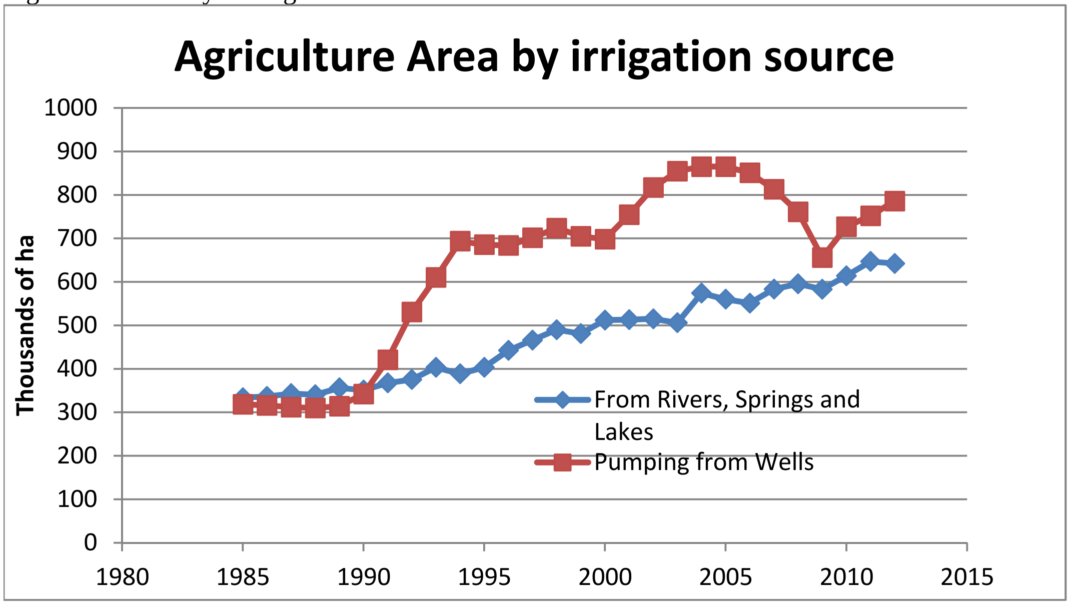
The government also outlawed the practice of tribal grazing lands as a means for facilitating national unity. This removed the tribal regulation that had been in place for centuries and encouraged an increased density of animal herding and the conversion of grazing lands to agriculture cultivation, especially in the Al-Hasakah Governorate (Barnes 2009, Hole 2009). The thin soils of the semi-arid climate of Syria's prior grazing lands cannot handle the frequent plowing required for modern agricultural practices nor the overgrazing that developed after the end of tribal rotational grazing. This has led to deleterious consequences for these marginal soils including desertification (de Chaâtel 2014).

Figure 4b. Source FAO Stat



In addition to the many dams that were built to supply water for irrigation the taping of ground water was also promoted. Interest-free loans were offered for the purchase of diesel pumps, and the diesel to run the pumps was subsidized (Barnes 2009, Hole 2009, de Chaâtel 2014). This promotion was well received and the share of well-sourced irrigated lands quickly overtook lands irrigated from surface water (see Figure 5). This led to closing the gap between rainfed agriculture and irrigated agriculture (see Figure 6). These government policies resulted in an increase in agricultural production, allowing Syria to become a net exporter of wheat and many other key crops starting in the 1990s (de Chaâtel 2014). However, the fragility of these policies became apparent in the 2006-2010 droughts. Syria received below average rainfall for this four year period, which created an increased demand for irrigated water. At the same time the Syrian government started to retract some of the pro-farmer policies it had put into place in an effort to integrate Syrian agriculture into the global economy. Specifically, the government ended the fuel and fertilizer subsidies in May of 2008 and 2009 respectively. Without the fuel subsidy the cost of both pumping water to irrigate crops as well as to transport crops to market increased dramatically. This caused the average yield of irrigated crops to fall by 43% and nearly 79% for

Figure 5. Source Syrian Agriculture Database



rainfed crops in 2008 and 2009, respectively (de Chaâtel 2014). Livestock herders were impacted as well. Grazing lands dried up and fodder could not be found, forcing many to sell of the majority of their stocks. After this double blow of drought and increased production costs, many farmers simply abandoned their farms and moved to larger cities, namely Damascus and Homs. Their lack of economic opportunity became a large source of the civil unrest that erupted in 2011 (de Chaâtel 2014).

The Syrian government was quick to blame global climate change, an increasing population, and global food market prices for the crisis. While all of these reasons likely increased the impacts of the drought, the government refused to recognize the fact that the Syrian agriculture sector had been prone for such a disaster for decades due to the unsustainable scale of agriculture promoted by the government (de Chaâtel 2014).

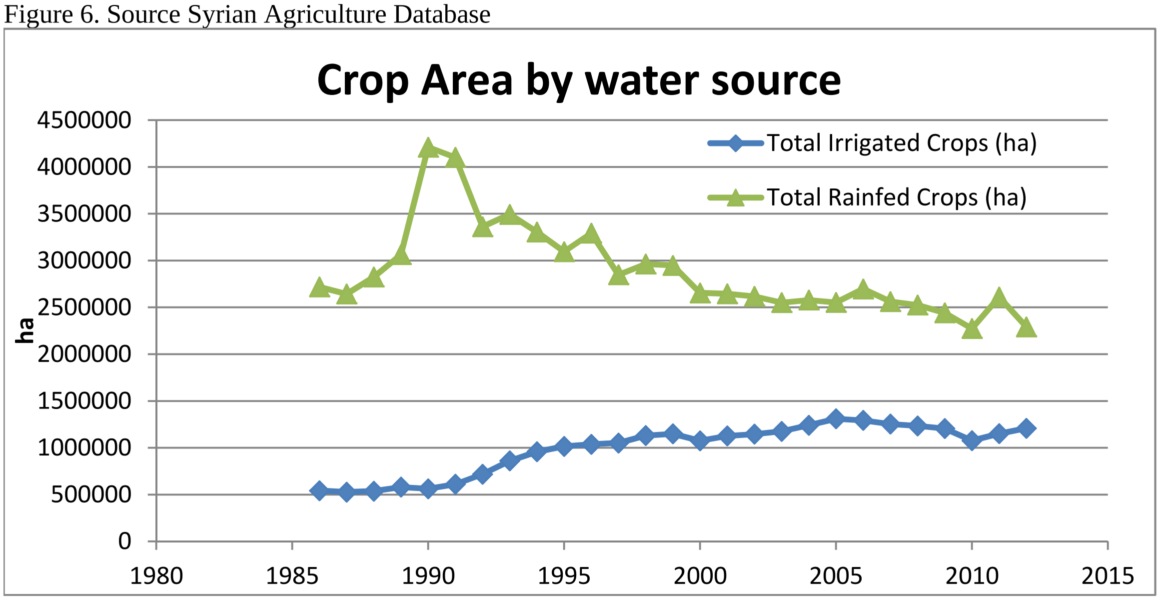
Way Forward

There are numerous suggestions on how to improve the agricultural sector Syria and most indicate the need for awareness of the natural resource limitations (Ryan 2004, Ahmad 2005, Barnes 2009, Hole 2009, ICARDA 2012, de Chaâtel 2014). Perhaps the most constructive suggestions come from the International Center for Agricultural Research in the Dry Areas (ICARDA) in its 2012 report authored by Theib Oweis and Ahmed Hachum "Supplemental Irrigation: A highly Efficient Water-Use Practice". The report highlights that much of the current irrigation equipment used in Syria is inefficient, causing unnecessary stress on Syria's water supply.

This is echoed by de Chaâtel who states that 80% of Syrian agriculture uses old outdated systems that lead to water losses between 10% and 60% (2014). While Syria does not have abundant water supply, what it does have can be used much more efficiently to decrease water use and increase production (Oweis & Hachum 2012). Decreasing agricultural water usage is critical. In 2003, the last year for which there are detailed records, Syria withdrew 16.7 km^3 of water during a non-drought year. This suggests that water resources are being overdrawn from their 16.8 km^3 renewable capacity in drought years (FAO AquaStat).

Over use of groundwater resources leads to a lowering of the water table and can have damaging effects on the ability for the aquifer to recharge (Oweis & Hachum 2012). The lowering of the water table has been confirmed indirectly by reports of springs drying up throughout Syria and water no longer being available in previously used shallow wells (Ryan

Figure 6. Source Syrian Agriculture Database



2004, Hole 2009). ICARDA suggest that above ground sprinkler systems offer a low cost solution to Syria's irrigation needs. While they are labor intensive they do not require the costly (and often impractical) land leveling of border strip irrigation, nor the costly equipment to run a drip irrigation system.

The irrigation management system, which ICARDA recommends, is a supplemental irrigation system (SI). The concept behind SI is to have irrigation systems in place, but only to water crops when they are suffering from moisture stress. In addition, when water is used, the amount would be far less than current practices allow, as the goal is not to increase yields at all costs but to maximize yields, given a reduced amount of water. In other words, "the purpose of SI is not to provide moisture stress-free conditions throughout the growing season, but rather to ensure that a minimum amount of water is available during the critical stages of crop growth that would permit optimal yield" (Oweis 1997). Farm studies carried out show that SI could increase wheat yields by 2.5kg per cubic meter of water applied; while rainfed wheat only yields 0.35kg per cubic meter of water available (Oweis 1997). These systems would only be appropriate where rainfed crops already exist, not to irrigate dry lands. In order to make SI most effective, Oweis and Hachum demonstrate that improved crop varieties and proper fertility management are necessary to see the greatest efficiency of applied water.

Aside from wheat, which was the focal point of the ICARDA studies, it was determined that barley was another appropriate crop for the SI management system. The legumes that tested well were lentils and faba bean, which responded much more favorably than did chickpeas. Although no specific species are mentioned in the ICARDA report, tree products could also benefit from SI. Due to their deeper root systems, trees should only be under moisture stress during droughts or hot spells if planted in an area with appropriate rainfall amounts (Oweis & Hachum 2012). In severe drought, watering is very cost effective if the threat of tree death due to water stress is near. If a new tree is planted to replace a dead one, it takes several years for the newly planted trees to begin to fruit. Also, it is only after several additional years that the tree produces enough fruit to make it economically viable to harvest (see Table 10 in supplemental information). It takes olive trees 6 years under good conditions to produce economically viable fruit and may take as many as 15 years.

While cotton is known to be a large drain on water resources (Chapagain 2006), simply replacing cotton with alternate crops may be more difficult than expected. The high value export crop employs roughly 20% of the workforce through farming, processing, or transportation (Maldonado 2011). Additionally, cotton is grown in the middle of summer when few other crops are grown. A cotton replacement runs the risk of overlapping with the growing season of non-summer crops already being grown. The most likely alternative summer crops with high value would be beans or a forage grass for livestock. Both of these crops have lower water requirements than cotton.

A recent report by the International Food Policy Research Center (IFPRI) sums up Syria's agricultural problems well. The report suggests that because of the frequency of drought, limited water resources, and the increased likelihood of extreme weather conditions caused by global climate change, a number of changes should be made including, improving the efficiency of the irrigation systems in the country, decreasing production of water hungry plants, such as cotton, especially in areas that rely solely on irrigation, developing more drought resistant varieties, decreasing the frequency in which animals graze on a particular piece of land, and developing more crop and animal insurance programs to help farmers better weather droughts. Many of these suggestions may lead to lower production, yields, or earnings for farmers in the short term but that might be the price of greater sustainability in the long-term. Aside from monetary assistance to help farmers update their irrigation systems, education and social welfare programs would be needed to get farmers up to speed on improved agricultural methods, or help farmers transition into another career (Breisinger et al. 2011).

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Supplemental Information:

Table 8
Source: Syrian Agriculture Database

Land Area By Governorate

Governorate	Area in thousands of ha
Al-Hassakeh	2,334
Al-Rakka	1,960
Al-Sweida	554
Aleppo	1,851
Damascus	1,815
Dar'a	374
Deir-ez-Zor	3,307
Hama	1,017
Homs	4,092
Idleb	609
Lattakia	229
Quneitra	187
Tartous	189
Total Governorates	**18,518**

The Syrian Arab Republic can be divided into five main agricultural regions, namely Southern, Central, Coastal, Northern and Eastern:

- The Southern region covers about 15.7 % of the total area of the country. It includes Damascus, Dara, Suweida, and Al-Qunaytirah. It is famous for its fruit production, especially apricots, apples and grapes, but it also produces crops such as chickpeas and tomatoes, in addition to raising cattle. Between 1998 and 1999, the region's contribution to national production was 36 percent for chickpeas, 51 percent for apples, 31 percent for grapes, and 62 percent for apricots.

- The Central region accounts for about 27.6 percent of the total area and produces mainly sugar beets, dried onion, potato and almonds. Between 1998 and 1999, the region's contribution to the national production was 57 percent for sugar beets, 53 percent for dried onions, 31 percent for potatoes, and 14 percent for irrigated wheat.
- The Coastal region on the Mediterranean Sea includes the cities of Lattakia and Tartous. Although this region is relatively small (2.3 percent of the total area), it contributes significantly to national agricultural production, with 98 percent of citrus, 42 percent of olives, 55 percent of tomatoes and 56 percent of tobacco.
- The Northern region covers 12.6 percent of the country's total area and includes the cities of Aleppo and Idleb. Its main contributions to national agricultural production are lentils with 55 percent, chickpeas 51 percent, olives 56 percent, and pistachios 69 percent. Local farmers breed about 20 percent of the total sheep population of the Syrian Arab Republic.
- The Eastern region is the largest in the country, covering 41.8 percent of the total area, concentrating the national cereals and cotton production. In order to enhance productivity through irrigation many networks have been built in this region, especially on the Euphrates and Al Khabour rivers. In addition many wells have been constructed. Farms tend to specialize in irrigated wheat which contributes 64 percent to the national production, while rainfed wheat contributes 38 percent, cotton 63 percent, and lentils 29 percent.

Source FAO Aquastat: http://www.fao.org/nr/water/aquastat/countries_regions/SYR/index.stm

FIGURE 7
Water withdrawal by sector
Total 16.69 km^3 in 2003

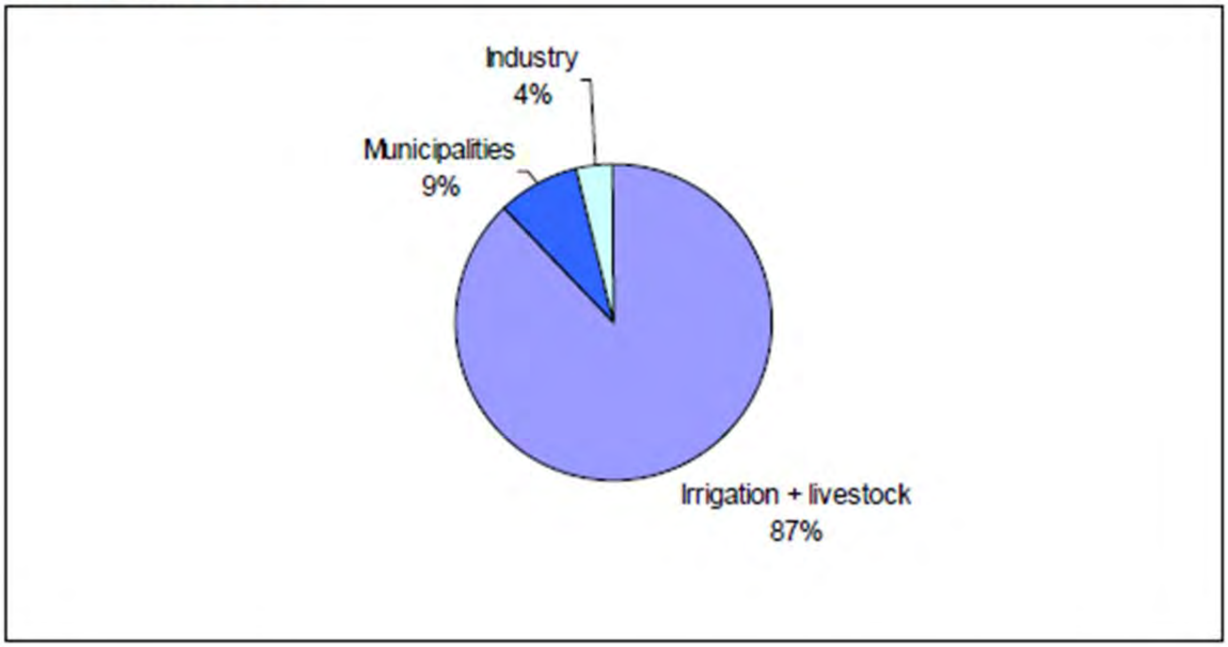

Table 9a

Exports	1961-2011 Average	2000-2011 average	Exports
	Export Value (thousands of USD)		
Cotton lint	136,646.73	175,338.50	Sheep
Sheep	66,060.94	134,229.33	Cotton lint
Tomatoes	34,235.00	104,591.83	Tomatoes
Wheat	32,395.70	88,247.08	Oil, olive, virgin
Oil, olive, virgin	31,365.89	83,802.55	Wheat
Anise, badian, fennel, coriander	25,237.20	79,920.92	Anise, badian, fennel, coriander
Lentils	19,102.41	43,856.33	Eggs, hen, in shell
Waters,ice etc	13,611.53	38,214.00	Apples
Barley	13,223.53	37,294.75	Lentils
Eggs, hen, in shell	12,573.76	35,203.17	Waters,ice etc

Source: FAOStat

Table 9b

	Import Value (thousands of USD)		
Imports	1961-2011 Average	2000-2011 average	**Imports**
Sugar refined	96,124.24	213,875.58	Maize
Maize	68,760.43	195,153.33	Sugar refined
Soybeans	58,669.39	115,902.83	Sugar Raw Centrifugal
Rice – total (Rice milled equivalent)	48,897.25	115,826.58	Rice – total (Rice milled equivalent)
Wheat	46,206.79	108,663.50	Soybeans
Cake, soybeans	44,542.08	93,337.83	Cake, soybeans
Sugar Raw Centrifugal	44,266.90	84,139.17	Cigarettes
Tea	30,665.18	75,991.75	Wheat
Cigarettes	28,049.30	75,560.42	Barley
Barley	28,046.07	65,164.17	Tea

Source: FAOStat

Figure 8. Source FAOStat

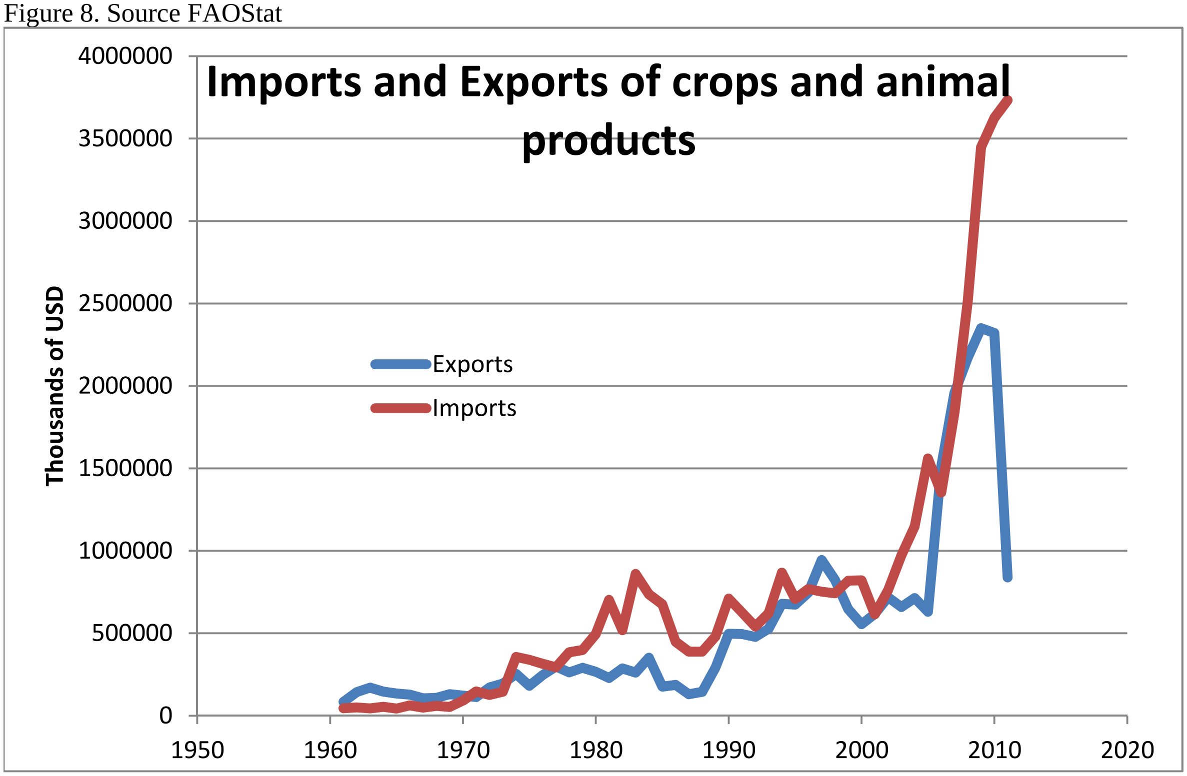

Table 10		
Crop	**Years until fruiting (profitable)**	**Source**
Olive	6-15 (good-poor conditions)	FAO Crop Water Information http://www.fao.org/nr/water/cropinfo_olive.html
Citrus	3-5 (start bearing fruit-economic yields	FAO Crop Water Information http://www.fao.org/nr/water/cropinfo_citrus.html
Apples	3-7	Stark Brothers Orchard http://www.starkbros.com/blog/how-many-years/

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