MARCH 2019 M.Sc. in Food Engineering YASEMİN GÖK

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FUTURE PROJECTION FOR SYRIAN FOOD INDUSTRY

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FOOD ENGINEERING

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FUTURE PROJECTION FOR SYRIAN FOOD INDUSTRY

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Prof. Dr. Mustafa BAYRAM

by

Yasemin GÖK

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Yasemin GÖK

ABSTRACT

FUTURE PROJECTION FOR SYRIAN FOOD INDUSTRY

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Syria is a middle-income developing country with an economy that heavily depends on the food and agricultural sectors. However, with the crisis, which started in March 2011, Syria's food and agricultural industries have been badly affected. While the most of the processing factories and agricultural facilities such as greenhouses, irrigation canals and pumps have been damaged in the conflict areas, this resulted in a huge recession in the agricultural productivity of Syria. It is estimated that this will impact the country to meet the future food requirements as well. In this study the food and energy (nutritional) requirements in Syria for the years 2020, 2030, 2040 and 2050 were calculated by assessing the demand and capacity of the country before the Syrian crisis. The food requirements (ton/year) based on the various sectors and food groups were calculated, which were used to determine the amount of food to feed Syria and investment projections on the food sector. For the enhancement of the agricultural productivity, shortcomings in the sector were identified. It is aimed to provide a guidance on which basic steps should be taken during the rehabilitation period by assessing the agricultural self-sufficiency of Syria.

Key Words: Syria; Food; Agriculture; Food Industry; Economy

ÖZET

SURİYE'DE GIDA ENDÜSTRİSİ ÜZERİNE ÖNGÖRÜLER

GÖK, Yasemin
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Suriye, ekonomisi gıda ve tarım sektörlerine dayalı, orta gelirli, gelişmekte olan bir ülkedir. Ancak Mart 2011 yılında başlamış olan kriz ile ülkenin gıda ve tarımsal endüstrileri ağır bir şekilde etkilenmiştir. Ülkedeki birçok üretim tesisi ve seralar, sulama kanalları ve sulama pompaları gibi tarımsal ekipmanlar zarar görürken, ülkenin tarımsal üretiminde de büyük ölçüde gerileme görülmüştür. Bunun gelecekte gıda ihtiyaçlarını karşılama konusunda da ülkeyi olumsuz etkileyeceği öngörülmektedir. Bu çalışmada, Suriye'nin 2020, 2030, 2040 ve 2050 yılları için gıda ve besinsel enerji ihtiyaçları ülkenin kriz öncesi gereksinimleri ve kapasitesi değerlendirilerek hesaplanmıştır. Suriye'de beslenme ihtiyaçlarını karşılamak ve yatırım öngörülerini belirlemek için farklı sektör ve gıda gruplarına bağlı olarak gıda ihtiyaçları (ton/yıl) hesaplanmıştır. Tarımsal üretimin iyileştirilmesi için ülkede tarımsal sektördeki eksiklikler belirlemiştir. Bu çalışma ile ülkenin tarımsal yeterliliği değerlendirilerek rehabilitasyon sürecinde atılacak esas adımlar için rehberlik edecek bir döküman sağlamak hedeflenmiştir.

Anahtar sözcükler: Suriye; Gıda; Tarım; Gıda Endüstrisi; Ekonomi

''Dedicated to my family''

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CHAPTER 1

INTRODUCTION

1.1 General information on the Syrian Arab Republic

1.1.1 Geography

The Syrian Arab Republic is a Middle East country situated on the eastern end of the Mediterranean Sea with an 185,180 km^2 total area and bordered in the north by Turkey, in the west by Lebanon, in the east by Iraq and in the south by Jordan and Israel (FAO, 2005). The country has maritime boundaries with Lebanon, Cyprus and Turkey (European Commission, 2011).

The Syrian Arab Republic geographically has been divided into four regions, which are the coastal, the mountainous, the interior and the desert regions (Almadani, 2014).

Also, for administrative purposes, Syria is divided into fourteen provinces, one of which is the capital Damascus and the others are Aleppo, Al-Hasakah, Al-Suwayda, Daraa, Deir Ez-Zor, Quneitra, Homs, Idleb, Hama, Lattakia, Rif Dimashq, Ar-Rakkah and Tartous (Figure 1.1) (Frenken, 2009).

In the country, pastures, steppe land and forests cover 48% of the total land, cultivable lands constitute 32%, where the remainder is rocky mountains and desert. Cultivable land is split into cultivated (92%) and uncultivated lands (8%) (Shhaideh et al., 2000). The desert areas of the country are used for grazing when there is adequate precipitate (Hassan and Krepl, 2014). Concerning forests, even though they have an essential role in the realm of economic, social and environmental aspects due to the wide-scale land clearing for human settlements and agriculture, illicit lumbering, grazing by livestock animals, burning for the production of charcoal, fires and inappropriate agricultural practices, there has been a considerable loss in the forest landscapes. Consequently, they cover only 3% of the total country land (Shhaideh et al., 2000; Sarris, 2001).

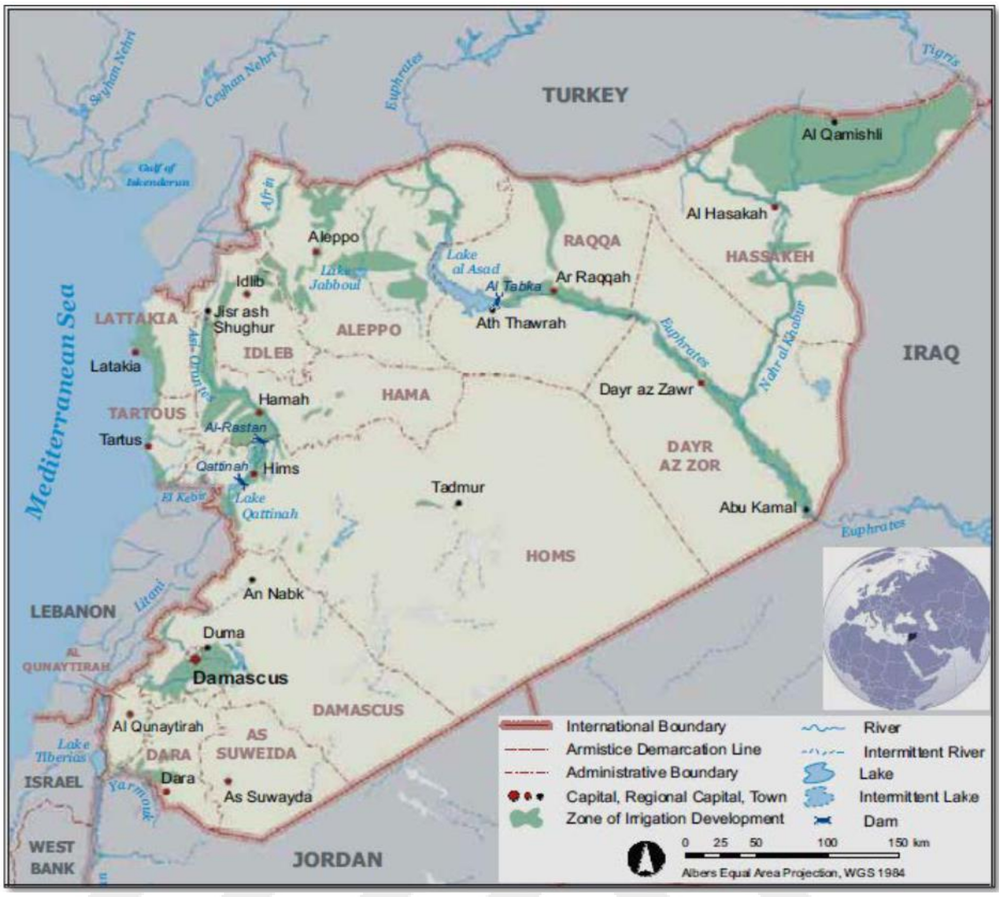


Figure 1.1 Map of Syria (Frenken, 2009)

1.1.2 Climate

In the Syrian Arab Republic, the climate type is the Mediterranean with four seasons: cool rainy winters, warm dry summers, relatively short spring and autumn (FAO, 2008). The coastland regions are characterized by a mild Mediterranean climate, while the interior parts are considerably continental with hot summers above 40 °C and cold winters below 0 °C (Masri, 2006).

Temperature variation between day and night of the Syrian Arab Republic is extremely high with a maximum difference of 32 °C in the interior and around 13 °C in the coastal region. Total annual rainfall ranges from 100 to 150 mm in the northwest, 150 to 200 mm from the south towards the central and east-central areas, 300 to 600 mm in the plains and along the foothills in the west and 800 to 1,000 mm along the coast, increases up to 1,400 mm in the mountain regions. The annual precipitation in the country is approximately 252 mm (FAO, 2008). Over 80 percent of the annual rainfall is concentrated in winter from October to April. There is almost no rainfall between June and September (The World Bank, 2001).

Since Syria is a semi-arid country, the agricultural sector heavily depends on the timing and amount of precipitation (The World Bank, 1987). However, the economic activities of Syria such as agriculture and light industry have caused unplanned urbanization, overutilization of water resources and land, deficiency of waste treatment and deforestation. All these destructions have led to climate change, which has resulted in a significant reduction in the rainfall of the country (Melhem and Higano, 2001).

1.1.3 Brief history and population

Syria was a homeland for many civilizations such as Sumerians, Egyptians, Hittites, Assyrians, Babylonians, Persians and the Seleucid Empire and the country had a significant role for trade and industry in the ancient ages due to its location. After the end of the Seleucid Empire occupation in 64 BCE, the country turned into a Roman province with a capital situated at Antioch (IBP, 2013).

In 2nd and 3rd centuries AD, Palmyra, a powerful Aramean state arose with the occupation of the Palmyrene Empire. However, with the collapse of the empire in the west, Syria became a part of the Byzantine Empire in 395 (IBP, 2013).

Syria, an important center of Christianity, ushered into an Islamic era with the conquests of the Umayyad dynasty in 634. During this time the Umayyad dynasty expanded its bases from Spain to India and Central Asia. While the Islamic empire was widening, Syria's economy was prospering and it became the center of the empire. Moreover, the official language of the country became Arabic in this era. The state had been under control of the Umayyad dynasty until it was overthrown by the Abbasid dynasty in 750 (IBP, 2013).

After Abbasids, Syria was ruled by Tulunids (887-905) and then after a period of anarchy, it was conquered by the Ikhshidids (941-969). Northern Syria was occupied by Hamdanids dynasty. Hamdanids dynasty, which was governed by Ali Saif al-Daula became a vital opponent for the threats of Byzantines. After his death, the entire country was conquered by Byzantines (969), then Seljuk Turks (1084-1086) and Ayyubid dynasty (1175-1185) (IBP, 2013).

During the 12^{th}-13^{th} centuries, the parts of the country were under the control of Crusader states; the Country of Edessa (1098-1149) and later Principality of Antioch (1098-1298). Syria was also under the threat of Assassins and the Mongols (IBP, 2013). However, after the invasion by the Mamluks (1250-1517) (Winter and Levanoni, 2004), all the Crusader states were expelled from Syria and many Mongol invasions were repelled (IBP, 2013).

In 1400, Syria was invaded by Timur Lenk, who prevailed against Mamluks. During the governance of Timur, many of the inhabitants were assaulted except for the artisans, who were expelled to Samarkand (IBP, 2013).

The exploration of a sea route from Europe to the Far East caused Syria to lose its geographical importance by the end of the 15^{th} century and in 1516, Syria was conquered by the Ottoman Empire (IBP, 2013).

The Syrian Arab Republic was a state of the Ottoman Empire for about 400 years. After the collapse of Ottoman, the country fell into the mandate of France in 1920 until gaining its independence on April 17, 1946. After then, Syria commenced forming its own geographical and demographic profile (IBP, 2013).

In the first years of the country, the population was around 3.5 million (Commins, 2004). According to the World Bank records, one year before the crisis, in 2010, the population of the country increased to 21,018,834 (The World Bank, 2018b).

While Syria is entering its seventh year with the crisis, more than 500,000 Syrians died, half of the population left their homes and migrated to neighbouring countries, mostly Turkey, Egypt, Jordan, Iraq and Lebanon, with some fled for Europe (Amnesty International, 2013; Reuters, 2018). As of October 7, 2018, the population of the country estimated as 18,430,453 based on the latest World Bank records (The World Bank, 2018b).

1.1.4 Economy

Syria used to be a middle-income developing country with an economy mainly dominated by the oil and the agricultural sector, which together accounted for half of Gross Domestic Product (GDP), where the contribution of agriculture used to be nearly

30 percent, employing 25 percent of the total labor force with another 50 percent dependent on it in the manufacturing sector (IBP, 2015; The World Bank, 2001).

In 2000, the economy of Syria attempted to pass liberal economy and innovations were performed such as opening up the market to foreign investors, licensing foreign banks to operate within the country (Raphaeli, 2007). In the recovery process of the economy, the government implemented many innovations including allowing new private-sector banks to operate, policies for the reduction of borrowing interests and government subsidies in agricultural and industrial sectors (Çakmak and Ustaoğlu, 2015). Moreover, the first stock exchange of Syria, Damascus Securities Exchange was opened in 2009 for upgrading Syria's financial system and encouraging foreign investments (Rafei, 2009).

In addition to the global financial crisis and the US sanctions, the macroeconomic performance of Syria was affected by long-term droughts, which dropped the agricultural output (Feldman, 2007). The poor climatic conditions caused the share of the agricultural sector to decline to about 17% of 2008 GDP, which was 20.4% in 2007 (IBP, 2015). Even though Syria was showing an improvement towards economic reforms and succeeding access to universal primary education, reducing the gender gap in education, decreasing the mortality and enhancing immunization coverage among children, poverty, which was falling between 1997 and 2004, had shown a rise in the second half of 2000s (Gobat and Kostial, 2016).

Even the impacts of the global crisis in 2009 had been relatively moderate and the slight impact was mostly because of the decrease in exports to trade partners in Europe and the Middle East and resulted in 1 percent reduction in GDP, about 4 percent decrease in the exports of commodities and services, and the increase of unemployment to 11% from 9% (Bloomsbury Publishing, 2010). However, the effects of the global crisis were temporary and the trade flows rose again in 2010 (Figure 1.2) (Mohsen et al., 2016).

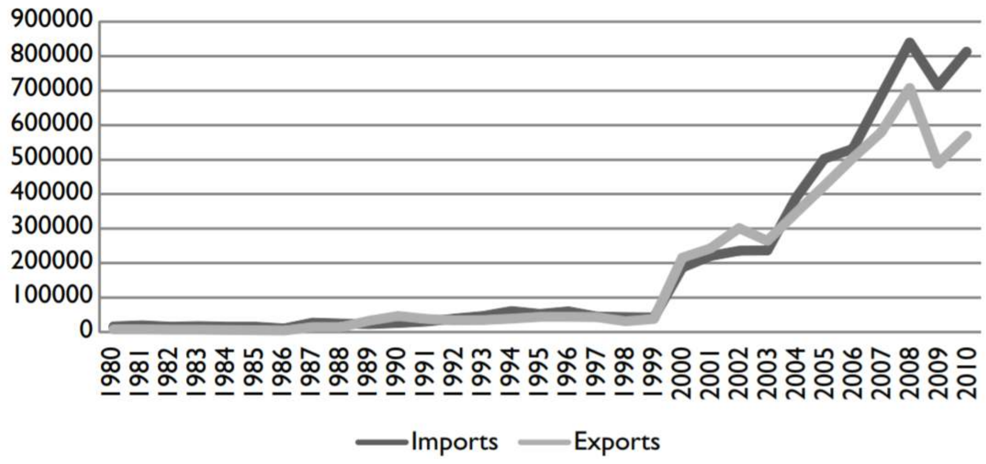


Figure 1.2 Syrian imports and exports in million Syrian Pounds, 1980–2010 (Mohsen et al., 2016)

Consequently, before the long-term effects of the economic recovery were observed, the war began in 2011 and the economic balance of the country was devastated inevitably (Çakmak and Ustaoğlu, 2015).

Before the conflict, the major trading partners of Syria were the European Union (EU) and Arab countries (Figure 1.3) (Al-Hamwi, 2005). The EU represented a significant export market for oil, in addition to some other Syrian commodities. The Arab countries were the second largest export destination for mainly food products such as cereals, vegetables and fruits (Abbas and Procházka, 2010).

Syria also used to be a transit route for agricultural exports from Jordan, Lebanon and Iraq to the black sea markets and the EU, and from Lebanon and Turkey to Jordan and the Gulf. However, the trade dynamics in the Middle East have been affected by the war and as new export routes have been emerging, trade volumes and flows have changed significantly (RFSAN, 2016).

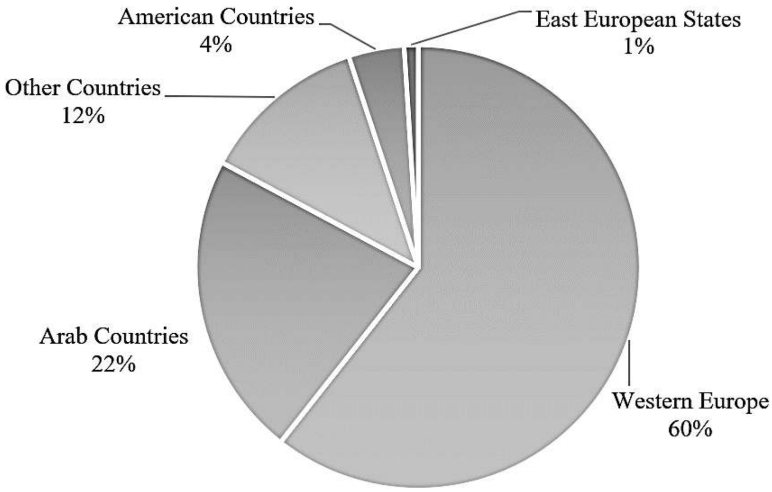


Figure 1.3 Exports in Syria, 2003 (Al-Hamwi, 2005)

The especially conflict-related disruptions and international sanctions imposed on Syria had a very significant impact on the economic recession of the country, as exports decreased by 92 percent between 2011 and 2015 (Figure 1.4). Also, the account deficit in 2016 widened sharply to 28 percent of GDP from 0.7 percent of GDP in 2010. Moreover, the number of foreign reserves fell to US$1 million in 2015 from about US$21 billion in 2010 (World Bank Group, 2017).

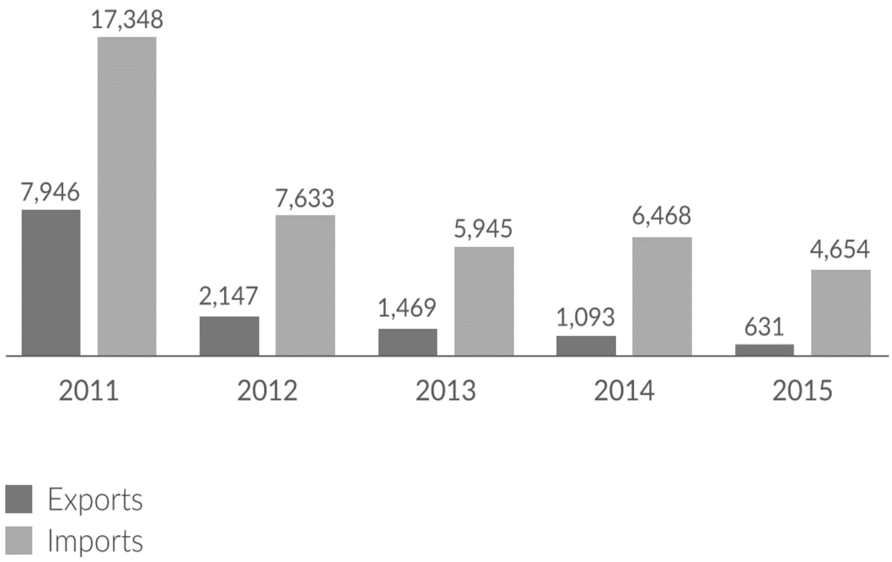


Figure 1.4 Exports and imports in Syria between 2011 and 2015, USD millions (World Bank Group, 2017)

Currently, the economy of Syria is struggling with many severe complications for growth, such as poor performance in the public sector, decline and depletion in the rates of oil, large-scale corruption, financial weaknesses of capital markets, high unemployment rates as a result of rapid population growth and increased labor force participation (IBP, 2015).

According to a report of Business Monitor International (BMI) Research, it is forecasted that the economy of Syria, annually will decline by 3.9 percent from 2016 to 2019, which will bring its economy back in the 1990s and will make the country dependent on investments from Iran and Russia (Holodny, 2016).

1.1.5 Agriculture of Syria

1.1.5.1 Agricultural zones of Syria

For agricultural planning purposes, the land in the Syrian Arab Republic is classified into five agro-ecological settlement zones based on the rainfall temporal distribution and amount per year, which are mainly specified according to land use, crops grown and crop rotations as following (Figure 1.5) (Al-Ashram, 1990).

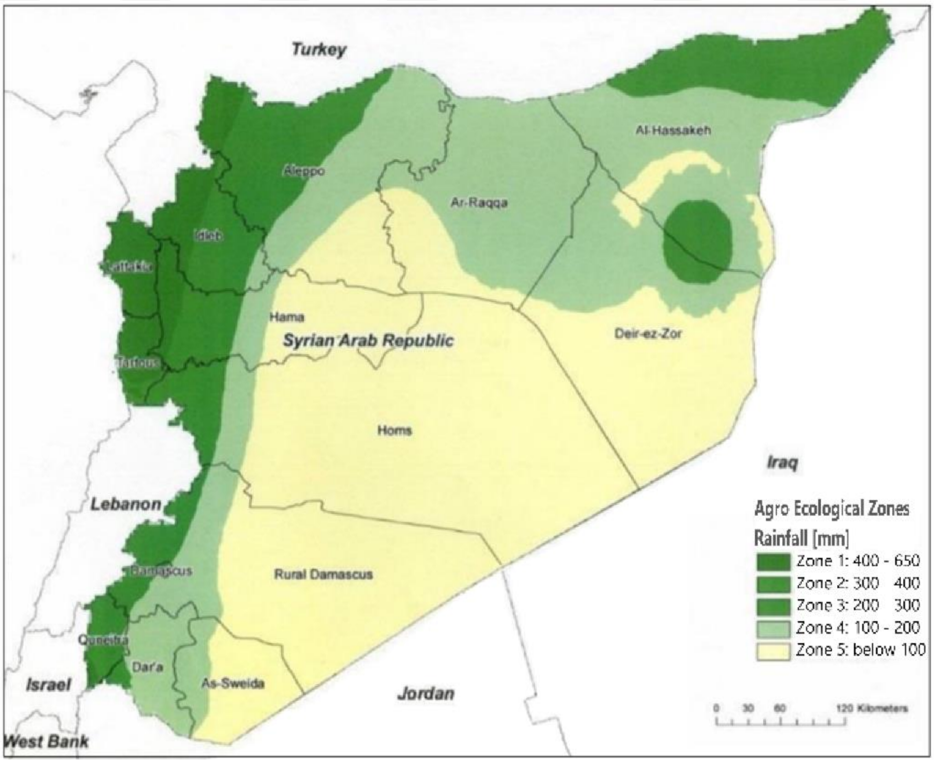


Figure 1.5 Agricultural stability zones in Syria (modified map from FAO, 2018)

Zone 1: This zone, where annual rainfall exceeds 350 mm, includes the coastal area, the Golan Heights, the northern part of Aleppo Governorate, the borderline with Turkey and the mountainous region in Suweida by covering nearly 15% of the total area of Syria (Saker et al., 2001). Summer crops such as melon and watermelon, fruitful trees and early vegetables, accompanied by barley, wheat, corn, sugar beet, cotton, etc. and almost all tobacco were planted in this zone, where high rainfall permits the agriculture of variable crops (The World Bank, 2008; FAO, 2003a; Saker et al., 2001). Zone 1 is divided into two areas:

A. The annual rainfall amount of this area is over 600 mm, where rainfed crops can be grown handily.

B. The annual rainfall amount for this area is between 350 and 600 mm (Saker et al., 2001).

Zone 2: The annual rainfall amount of this area is between 250 and 350 mm, which constitutes 13.4% of the total area of Syria, where the main crops are barley, wheat, legumes and summer crops (FAO, 2003a).

Zone 3: The annual rainfall amount of this area is between 200 and 300 mm, which constitutes 7.1% of the total area of Syria, where the main crop is barley. However, legumes can also be grown (FAO, 2003a).

Zone 4: The annual rainfall amount of this area is between 200 and 250 mm, which constitutes 9.8% of the total area of Syria, where the main crops are barley and permanent pastures (FAO, 2003a).

Zone 5: The annual rainfall amount of this area is less than 200 mm, which constitutes 55.1% of the total area of Syria, where the main vegetation is desert and rangelands (Omar, 2002). This area is not suitable for rainfed plantation, it is mostly used for natural grazing of sheep and camels (Cafiero et al., 2009).

1.1.5.2 Agriculture in Syria pre-crisis

Agriculture has been the mainstay of the Syrian economy with 6,025 million ha agricultural land, which represents 22.34% of the total area (Erian et al., 2010; SEF and Syrian Economic Task Force, 2017).

Agriculture also has a vital role in providing raw materials for the food manufacturing sector of the food industry as well as generating employment opportunities (Hassan and Krepl, 2014). While almost half of the population lives in rural areas, in 2008 the labor force in agriculture was 20-25% of the country's total population, which is more than any country in the Middle East and North Africa region except Yemen (The World Bank, 2008).

The main crops of the country are wheat, barley, lentil, chickpea and cotton (Omar, 2002). Also for the arid and semi-arid areas, where irrigation water and rainfall is insufficient, the rearing of livestock, especially sheep, goat and camel is the most important agricultural activity (Khoury, 2011).

In general, agriculture in Syria has suffered from the declines in precipitation, increasing urbanization of cultivable lands, the salinization of irrigated areas (Euphrates region) and desertification (SEF and Syrian Economic Task Force, 2017). In addition to these challenges, Syria experienced a catastrophic drought between 2006 and 2011, which was estimated as worst in the last 900 years (Stokes, 2016). Since the rain-fed agriculture areas represent around 71% of the total agriculture lands in Syria, this caused 1.5 million of Syrians to migrate to urban cities like Homs and Damascus in search of alternative work after infertile years because of the drought (Erian et al., 2010; Stokes, 2016). According to United Nations, the drought led 75% of Syria's farms to fail and 85% of livestock to die (Stokes, 2016). Especially the provinces such as Al-Hasakah, Ar-Raqqah, Aleppo or Halab, and Dier ez-Zor, which supply 75 percent of the total wheat production in Syria were badly affected (Erian et al., 2010).

The contribution of agriculture to the country's GDP was 25% before the drought and dropped to around 17% in 2008 (Figure 1.6) (Kelley et al., 2015). However, according to Trading Economics data, despite the severe drought, the Syrian Arab Republic's economy showed regular progress between the years of 2000 and 2010, while the population of the country was showing a rapid increase as well (Figure 1.7) (Trading Economics, 2017). This economic growth was maintained mainly by the transportation, communications, finance, manufacturing, real estate and construction sectors. Meanwhile, agriculture's contribution was considerably low (FAO, 2016a).

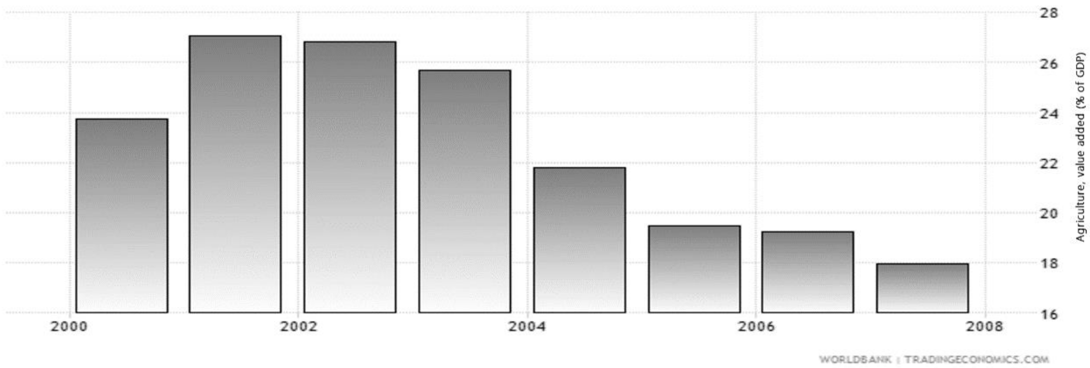


Figure 1.6 Agriculture, value added (% of GDP) (Trading Economics, 2017)

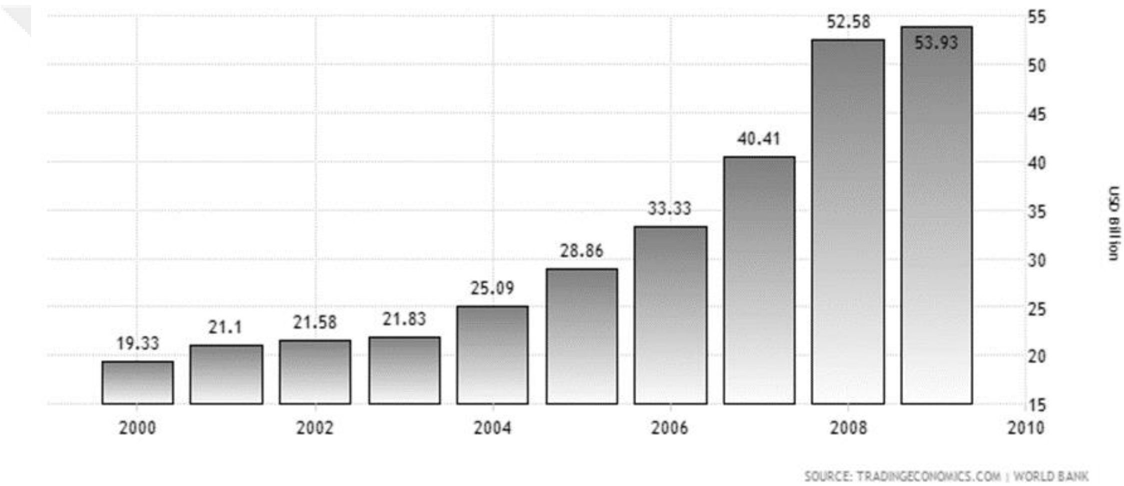


Figure 1.7 Syria GDP chart, 2000-2010 (Trading Economics, 2017)

1.1.5.3 Effects of the crisis on agriculture

The agricultural sector of Syria has experienced many severe crises because of droughts, increasing urbanization of arable lands, the salinization of irrigated lands (Euphrates region), desertification in the desert and the marginal areas, misadministration of water resources, retarded implementation of important projects, such as the adoption of neo-liberalization policies in prices of energy and fertilizers and modern irrigation systems (Nasser et al., 2013; SEF and Syrian Economic Task Force, 2017). In addition to these problems, the ongoing crisis has caused losses and enormous damage to the agricultural production (FAO, 2017a). It also affected job creation, prices of goods, and food safety and eventually the economy of the country (Nasser et al., 2013).

The FAO Report published in 2013 states that while the conflict is continuing, the agricultural production of the country also keeps dropping, where wheat and barley production has shown a 55% drop, fruit trees and olive oil production 40% and vegetables 60% drop (Jaafar et al., 2015).

The effects of the conflict include not only the decrease of crop production, disruption in the supply of agriculture inputs and reduction in livestock numbers, but also the irrevocable destruction of properties, such as farm machinery and storage, irrigation systems and processing facilities (FAO, 2016a). Assessments also demonstrate that the increased transportation costs as a consequence of increased fuel prices and insecure roads have resulted in higher prices in agricultural inputs and marketing (ACAPS and MapAction, 2013).

The conducted research by FAO shows that the ongoing crisis has caused more than $16 billion total bill damage to farming assets, crops and livestock sector. While the estimated loss in the crop production is about $6.3 billion of the total, it is calculated at around $5.5 billion for the livestock sector and $80 million for the fisheries sector. The report states that dependently on how the conflict develops, rebuilding the agricultural sector would cost between $10.7 and $17.1 billion over the first three years (FAO, 2017b).

1.2 Water resources in Syria

In Syria, water resources have a crucial role in the progress and expansion of economic activities such as agriculture, industry, and tourism in addition to their domestic consumption (Kaisi et al., 2006), where the largest amount of water is consumed in agriculture, over 85 percent, just like the other Middle East and North Africa (MENA) countries (The World Bank, 2001). However, Syria is considered as semi-arid with two-thirds of the land being desert and the water resources are very limited compared to the needs of the country (Asmael et al., 2015; Chapman, 2014). Additionally, Syria has been heavily facing climate effects on water resources. Aquastat data shows that the total renewable water resources per capita were 908 m^3/capita/year between the years 2013 and 2017 (AQUASTAT, 2018), while 500-1000 m^3/capita/year is considered as high water stress (Kummu et al., 2010). Moreover, it is estimated for this amount to decrease to 620 m^3 in 2025, which was 2,684 m^3 in 1970 (Mourad and Berndtsson, 2012a). Aw-Hassan et al. (2014) are anticipating a climate change to decrease these resources far more than expected, considering that half of the annual renewable water resources of Syria take their source from the cross-border flow, with the large amount of them flowing in from Turkey through the Euphrates (Aw-Hassan et al., 2014).

In Syria, the total estimated water use volume is about 15 km^3/year (The World Bank, 2001), where rainfalls provide the main source of the water, which corresponds to 68 percent of the total water resources (Shhaideh et al., 2000). However, while the falling rainfall amount is around 45 km^3/year because most of the water evaporates or seeps into the underlying aquifers, the contribution of precipitation to the country's surface water resources is estimated to be at around 9 km^3/year (Işıklı et al., 2007). Other water resources of the country are rivers (23%), springs (6%) and underground water (3%) (Shhaideh et al., 2000).

The rivers in Syria constitute the second largest source, which provides 37.52 km^3 flow per year. However, Syria is not able to tap all the water due to the limitations by international agreements with the neighbouring countries such as Turkey and Iraq. Therefore, the total renewable water sources from rivers are limited to 8.34 km^3/year regarding influx and outflux. The influx and outflux of groundwater of the country are also limited by the legal decisions, where the total renewable amount is around 1.33 km^3/year (Chapman, 2014).

In 1986, a law was issued for water resources assessment and management throughout the country and Syria has been divided into seven water basins according to their geological, hydrological, demographical and meteorological characteristics: Barada and Awaj (Damascus), Al-Yarmouk, Orontes (Al Assi), Euphrates and Aleppo, Desert (Steppe), Dajleh (Tigris) and Khabour and the Coastal Basin (Figure 1.8) (Mourad and Berndtsson, 2012a; Kaisi et al., 2006).

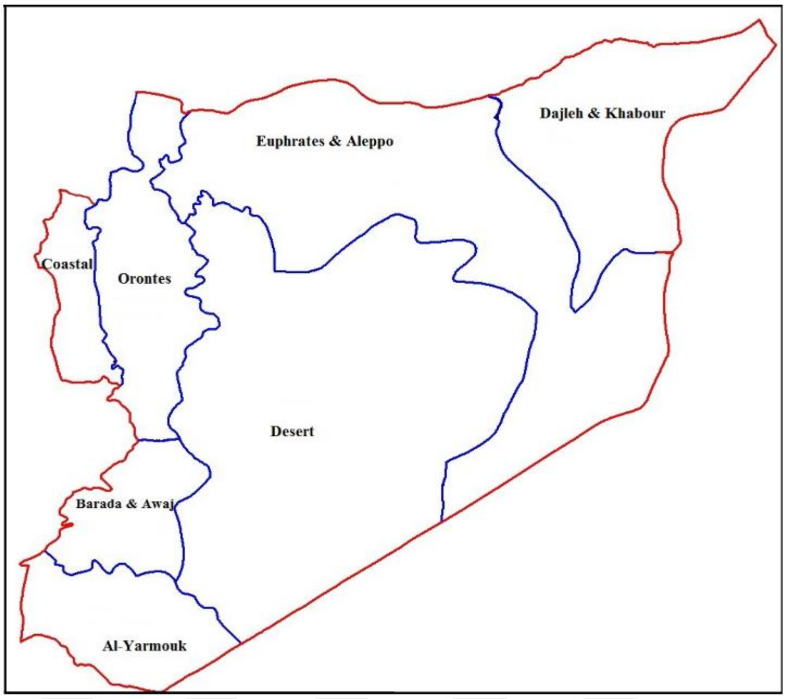


Figure 1.8 The Syrian water basins (corrected map from Mourad and Berndtsson, 2012a)

1. Barada and Awaj (Damascus) Basin: The Barada and Awaj Basins are located in the southwest area of Syria, in the capital Damascus. Barada Basin consists of the Barada River Basin, Awaj River Basin and other small valleys basin (Melhem and Higano, 2001).

2. Al-Yarmouk Basin: The Yarmouk Basin is located in the southwestern part of Syria and constitutes the border between the Syrian Arab Republic and Jordan before it flows from Daraa to join the Jordan River (FAO, 2009; Kout, 2008).

3. Orontes (Al Assi) Basin: The Orontes (Al Assi) Basin originates in Lebanon and flows through Syria into the Mediterranean Sea and it is located in the west of the middle of Syria, bordered to the east by Albadia and to the west by the coastal mountains (Kout, 2008; Kaisi et al., 2006).

4. Euphrates and Aleppo Basin: The Euphrates originates in Turkey and flows through northern Syria into Iraq (Kaisi et al., 2006). Because the Euphrates basin is consumed for ongoing and potential hydropower generation and agricultural aims, it is strategically the most critical basin (Kibaroğlu, 2014).

5. Desert (Steppe) Basin: This basin is located in the central and southwest of Syria and supplies groundwater and seasonal surface water (METAP, 2011).

6. Dajleh (Tigris) and Khabour Basin: The Tigris and Khabour Basins are located within the administrative boundaries of Mohafazat of Al Hassakeh and North-Eastern part of Turkey (Kout, 2008).

7. Coastal Basin: This basin lies between Lattakia and Tartous and forms a border between the Syrian Arab Republic and Lebanon (Faour and Fayad, 2014).

All these basins differ in size, rainfall levels, and water volume and among them, Euphrates and Tigris basins provide the largest amount of total renewable water and originates their sources from the surface water. For the other river basins, the primary source of water is groundwater (UNW-AIS, 2008). However, most of the water basins are polluted by nitrates and other chemicals used in agriculture, wastes of factories, sewage water and petroleum refineries. As a result of misusage of water, there has been a considerable reduction in water inflow and more is expected for several other reasons such as drought and population growth which might result in a water crisis (Hinnebusch et al., 2011).

Besides the existence of basins, which are the primary source of surface water, 166 dams were also constructed to increase irrigated areas and control usage of water (FAO, 2008; The World Bank, 1987). Al Tabqa dam is the largest one among all which was built on Euphrates basin in 1973, located at al-Thawrah district of the Ar-Raqqah Governorate in northern Syria and it was anticipated to extend the irrigated area of Euphrates basin by 640,000 hectares. However, the plan did not work as expected because of gypsum terrains caused collapses on the network and in the end, only 200,000 hectares had been irrigated. Moreover, 3,000 hectares of this irrigated area are facing with soil salinity and drainage problems (Shapland, 1997).

1.3 Irrigation

In 1982, with the increasing demand for water for Syria's agriculture and overall economic development, irrigation became quite necessary, as the rainfalls of the country do not fall in the growing season and the Ministry of Irrigation has been established for the entire responsibility of water resources management such as (Kaisi et al., 2006):

- Designing, operating and maintaining the sustainability of irrigation, wastewater systems and pumping stations.

- Assessment, protection and controlling pollution and use of water resources.

With the establishment of the Ministry of Irrigation, irrigated areas have increased substantially, which were around 450 thousand ha in the 1970s corresponded to 14 percent of the total cultivated area. The cultivated land area in Syria was estimated at 4.5 million ha of which about 30 percent (1.3 million ha) was irrigated in 2011 (Table 1.1) (CBSS, 2017).

Table 1.1 Distribution of irrigated areas in Syria, 2000-2011 (CBSS, 2017)

Years	Total of Cultivable Lands (km^2)	Uncultivated Lands (km^2)	Under Crop Lands (km^2)		
			Total	Non-Irrigation	Irrigation
2000	5905	553	4546	3336	1210
2001	5988	538	4549	3282	1267
2002	5911	490	4591	3258	1333
2003	5863	385	4661	3300	1361
2004	5910	385	4729	3290	1439
2005	5934	371	4873	3447	1426
2006	5950	362	4743	3341	1402
2007	6038	356	4719	3323	1396
2008	6022	357	4610	3255	1355
2009	6012	348	4339	3101	1238
2010	6045	348	4794	3453	1341
2011	6068	352	4579	3180	1399

In the past, a substantial amount of the irrigation water was withdrawn from the surface water, where the Euphrates, Tigris and Khabour rivers have been the major sources, which are dependent on the seasonal rainfalls. However, since the availability of these waters were variable, that was affecting cultivation negatively. The dams and reservoirs also did not solve the availability of total water resources, which were convenient only to control and store water. After drillholes became common to supply water for domestic and agricultural uses, groundwater supplanted traditional surface water practices and became the major source of agricultural irrigation (Chapman, 2014).

For wheat and barley basin irrigation is the predominant method used. However, the efficiency of water is quite low (40-60%) for the reason of excess irrigation with the traditional system. Even for the areas which are irrigated by furrows for the cultivation of vegetables and cotton, efficiency is still low because of the insufficiency of land leveling (Salman and Mualla, 2004).

In order to modernize and rehabilitate the use of groundwater and river water, a new policy strategy was announced by the Syrian Government Ministry of Irrigation in 2005, but implemented only from 2008 until 2011, at the beginning of the conflict in Syria. The major measures of the policy were limiting the extracted groundwater by applying penalty fees to farmers who are exceeding the allowed quantity per hectare established by law, authorization of drilling wells by issuing a license, installation of flow meters in wells and increasing the prices of groundwater pumping for adjusting to the diesel fuel prices (Aw-Hassan et al., 2014). However, the deficiency of legal controls over groundwater management caused overutilization and consequently salinity of groundwater, where almost 50% of privately operated water wells were illegal in 2011, before the war. According to FAO Reports, a survey conducted by the Ministry of Water Resources in 2011 shows that 232,000 water wells exist in Syria while 115,000 of them were unauthorized (Dost et al., 2015). Moreover, the price of irrigation water was very low and not based on volumetric measures, which resulted in inefficient use of the resources (UNW-AIS, 2008).

The biggest challenge during the rehabilitation policies was the limited number of farmers investing in modern techniques. The main obstruct which restrained small farmers from investing in modernized irrigation techniques was the low financial capacity and doubts on financial returns of the advanced methods (Farahani et al., 2006).

Given the highly increasing water scarcity and food production needs of the population, it is required to adopt modern irrigation techniques, such as drip and sprinkler irrigation, the construction of lined canals or conveyance through pipeline connections from dams to farm gates and land leveling (Kaisi et al., 2006). It is estimated that the installation of the modern irrigation techniques, which was adopted only by 13% of the farmers in 2003, could decrease average water consumption in irrigation from 12,434 m^3/ha to 8,000 m^3/ha (Fiorillo and Vercueil, 2003; Peters et al., 2008).

Adopting modern irrigation techniques will not only decline the consumption of water but also increase the profit of farmers in the country. Based upon the conducted studies regarding the efficiency of sprinkler irrigation and drip irrigation, it is concluded that for surface water, profit of the farm can increase by 38% with sprinkler irrigation and 67% with drip irrigation adoption. In case that the water is extracted from wells 50 m deep, profit of the farm can increase by 67% with sprinkler irrigation and 111 percent with drip irrigation method (Varela-Ortega and Sagardoy, 2003).

After the start of the crisis, irrigation canals or pumps were damaged or stolen in the conflict areas. This destruction has led to a significant decrease in irrigated areas, which was estimated at around 606,000 hectares in 2004. Also, the crisis has caused a high level of overutilization of groundwater and an increase of the danger of soil salinization (FAO, 2016a). Moreover, it was reported that the price of irrigation water has been soaring because irrigation is dependent on electricity provided by generators and the diesel fuel used to operate them (RFSAN et al., 2016), which are both experiencing the highest rates of the country (Nasser et al., 2013).

1.4 Agricultural products

As a benefit of the diversity in the agricultural landscape and climate of the country, the Syrian Arab Republic has been able to grow a wide variety of agricultural products. The most common agricultural products are cereals, legumes, fruits and vegetables, which increases the competitiveness of the products and allows to modify the constituents of the crop rotation to meet the requirements for both foreign markets and local consumers (Işıklı et al., 2007).

1.4.1 Cereals

Along with maize and barley, wheat is the most important cereal crop grown in Syria, as it is used to make bread, which is an important nutrient of the Syrian diet (Tull, 2017).

Around 1.5 million hectares of land was estimated to be planted with wheat in 2003, which is equal to 27% of the whole cultivated area in Syria (Pala et al., 2003). The main wheat producing districts in Syria are Al Hassakeh, Aleppo, Ar-Raqqah, Idleb, Deir Ez-Zor, Hama, Daraa, Homs, Al Ghab, Sweida, Rural Damascus, Tartous, Quneitra and Lattakia (Figure 1.9) (Cafiero et al., 2009). The Aleppo and Al Hassakeh districts are quite important, as these together provide more than half of Syria's wheat production (Hassan and Krepl, 2014).

Figure 1.9 Wheat producing regions in Syria (2005) (corrected map from Cafiero et al., 2009)

In 1990s, a special attention was paid through new strategies on Syria's agriculture policy for improving the wheat productivity of the existing lands by collaborating with international centers such as CIMMYT (Central International Center for Maize and Wheat Improvement, Centro International de Mejioramiento de Maiz y Trigo) and ICARDA (International Center for Agricultural Research in Dry Areas). In order to achieve desired developments, many studies were performed such as developing stress tolerant wheat varieties, enhancing water wells and other irrigation systems, using chemical fertilizers and pest and weed control measures, which are more suitable for the conditions of the country and for encouraging farmers, organizing extension and credit institutions in addition to subsidies and price controls. These studies helped to mechanize the production (Pala et al., 2003) and concluded with a great success story. As a former wheat importer, Syria in the 1970s became self-sufficient in wheat production in early 1990s and a wheat exporter in 2000s while the wheat area was kept almost the same. Thirty-two percent of this achievement was attributed to improved varieties, 27% to developed irrigated conditions, 18% to fertilizers and 23% to crop management and other inputs including farm mechanization and herbicides. According to ICARDA data, wheat production rose from 2.1 million to around 4.5 million tons between 1991 and 2004. Even during the severe drought which started in 2007, productivity and output were relatively high (Figure 1.10) (Tadesse et al., 2016).

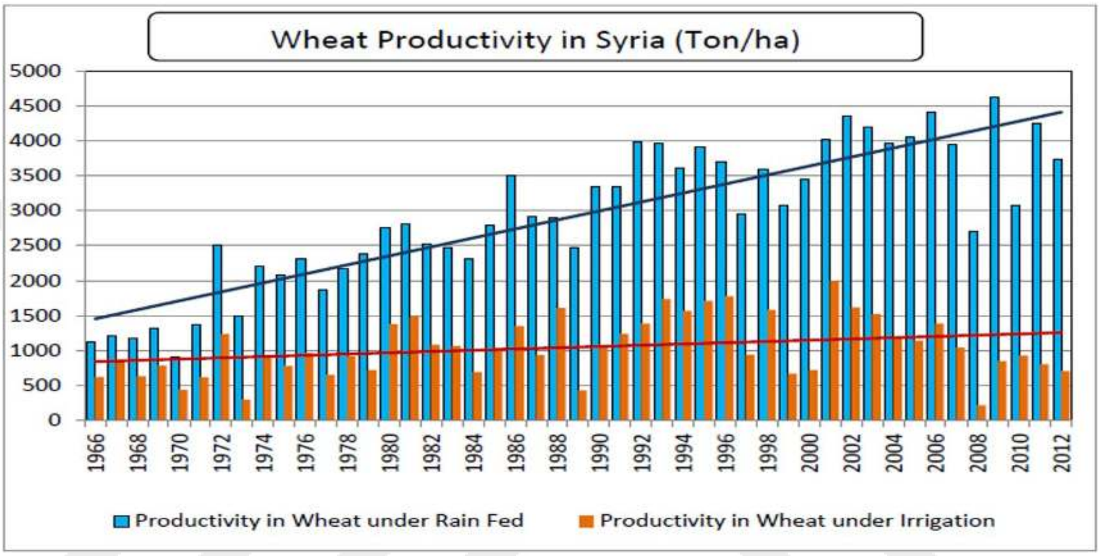


Figure 1.10 Wheat production (ton/ha), yield and the area from 1966-2012 (Tadesse et al., 2016)

In Syria, wheat is cultivated with two farming systems: irrigated and rain-fed, 45% and 55% of the wheat area, respectively (Bader et al., 2008). Most of the rain-fed wheat is grown in the comparatively high rainfall areas (300±500 mm annual rainfall) as well as in irrigated dry regions (<200 mm) (Pala et al., 2003). The irrigation in Syria is applied in two methods as flood and sprinkler, in which the most common practice is flood irrigation (Sadiddin and Atiya, 2009).

In Syria, durum wheat and soft wheat are produced during winter season, which's production percentages were 50% of soft flour and 50% of durum wheat flour. In 2008, the integrated flour production underwent a change and it began to be produced with the ratio of 75% of soft wheat flour to 25% of durum wheat flour. As a result of the change in the production percentages, the domestic consumption of soft flour rose with the production of white flour with several kinds of white bread, biscuits, cakes and suchlike. This change also has resulted in the increase of the durum wheat's surplus amount and the export quantity of durum wheat has increased. The remainder durum wheat is commonly used in a form called "bulgur" and wheat in lower quality is used by some food processing establishments to produce brown or yellow flour and bran for fodder (Karkout and Lancon, 2011).

According to FAO estimates, in 2015 the wheat production amount of Syria was 40% lower than the pre-crisis average 2.445 million tons. It is also estimated that there was 800,000 tons of wheat deficit in Syria's national wheat requirement (FAO, 2016a).

After wheat, barley is the second important cereal crop grown in Syria, which is used as a cash crop and for feeding sheep, where the sheep production is a vital enterprise.

Barley is produced in a wide range of environment where annual rainfall amount ranges from 200 mm to 350 mm. Aleppo, Idleb, Sweida, Al Hassakeh, Deraa, Ar-Raqqah, and Hama are the main cities for production of cereals. The narrowest barley planted area is in Idleb, while the largest is found in Ar-Raqqah (Mustafa et al., 2006). Indeed, barley is planted on over 1.4 million hectares area in Syria which is equivalent about 27% of total Syrian cropped land (Cafiero et al., 2009). However, the product input is very low compared to the other crops because little use is made of improved varieties (Mustafa et al., 2006).

In the country, both black and while barley are cultivated, while the black barley is used by livestock farmers and the production amount exceeds white barley (Sadiddin and Atiya, 2009).

The average barley need of Syria is 2.3 tons/year. However, since it is mainly used as animal feed, the demand for barley fluctuates in Syria every year, depending on the livestock number, production amount and the available grazing crops. Consumption increases comparatively with the lack of grass in the Syrian steppe. Therefore, in the drought years and in order to meet the fodder needs of livestock, barley is imported (Al-Shareef, 2008). While the annual barley production is ranging every year due to the high climate dependence of yield, the average output of Syria is about 1 million tons (Cafiero et al., 2009).

Like barley, maize is also produced as a fodder crop in Syria. Before the crisis, the annual production of maize ranged between 150,000 and 200,000 tons (Dost et al., 2015). FAO reports state that in 2016, the production of barley decreased about 13% compared to 2011/12 season (FAO, 2017c).

1.4.2 Legumes

Legumes, in addition to their significant place in the country's economy, also provide nutritionally rich crop residues for animal feed during the summer and early autumn months and play an essential role in maintaining the productivity of soil as a break crop in cereal-dominated farming systems (Mawlawi and Tawil, 1990; Mazid et al., 2009). In Syria, food legumes are mainly grown in Zone 1 and Zone 2 and chickpea, lentil, and fava beans are the most commonly grown types (Mawlawi and Tawil, 1990).

According to the statistics published by the Syrian Ministry of Agriculture and Agrarian Reform (MAAR), lentil is the most important rain-fed food legume crop regarding the area planted, while chickpea is the second (Mazid et al., 2009). They are grown in different soil conditions, that chickpeas are predominated in wetter areas, lentils in drier (Belaid and Morris, 1991).

Chickpea is grown in all provinces of Syria, but it is slightly more important in some regions such as Aleppo, Idleb, Hama, Suweida, Daraa, Homs, and Al Hassakeh. However, in spite of the importance of chickpea, their yield potential has been very low in Syria as a result of multiple constraints such as biotic and abiotic stresses and poor cultural practices (Mazid et al., 2009). Climatic conditions have been the most challenging problem for the production of chickpea, which is associated with irregular and low rainfalls and killing frosts in late March (Tutwiler, 1995). As it can be seen in the graphic below, there was a decrease in the yield amount of chickpea because of severe drought the country faced between the years of 2007 and 2009 (Figure 1.11) (FAOSTAT, 2018).

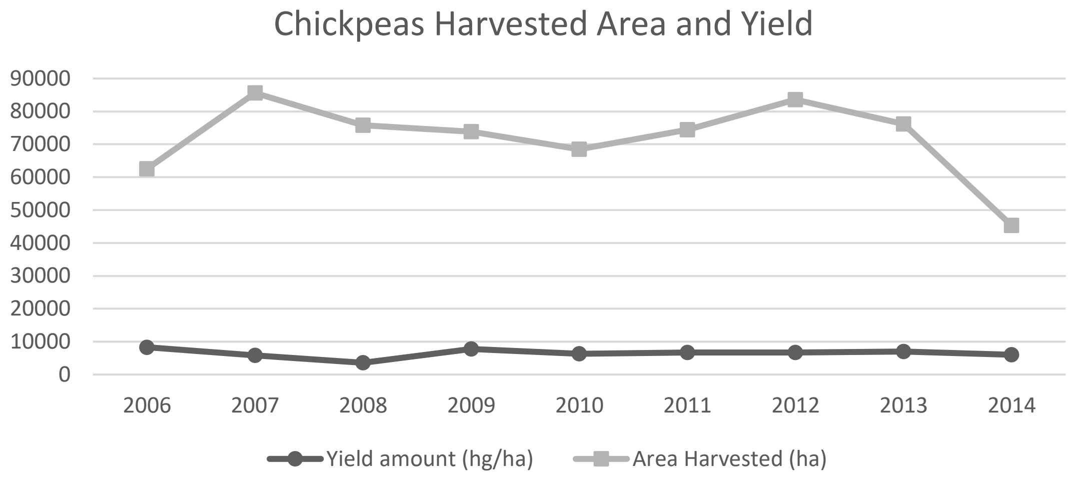


Figure 1.11 Area (ha) and yield (hg/ha) of chickpeas between of 2006 and 2014 (FAOSTAT, 2018)

Lentil, which is considered as an essential dietary protein source for low-income households is well adapted to production in the winter season in Mediterranean climates especially predominated in the Northern farmlands of Syria. The provinces of Aleppo, Idleb, Hama and Al Hassakeh account for 80% of the yearly crop of the country, where Damascus and Al Suwayda (Horan) provinces account for 20% (Yadav et al., 2007). According to the FAOSTAT Statistics, the total harvested area for lentil was 100,721 ha, yielding a total lentil production of 102,461 tons for the year 2009. However, the ongoing crisis led the harvested amount to decrease by about 30% and the estimated production was 70,907 tons in 2014 (FAOSTAT, 2018).

Fava bean, which is also known as faba bean, is a good source of cheap-quality protein and it is cultivated in areas under irrigation or with high precipitation. In Syria, its production is concentrated in mainly coastal regions and provinces such as Aleppo, Damascus, Hama, Homs, Idleb, and Quinetra. The approximate production amount in the coastal area and these provinces are respectively as following: 34, 23, 19, 11, 7, 3.5 and 2.5% (Akem and Bellar, 1999).

1.4.3 Fruits and vegetables

The importance of fruit production in Syria increased during the last two decades before the crisis as the fruit cultivated areas doubled (Mourad and Berndtsson, 2012b).

The major fruits and vegetables produced in the country are olives, tomatoes, almonds, grapes, pistachios, oranges, apples, potatoes, and citrus fruits (Hassan and Krepl, 2014).

1.4.3.1 Pistachio and almond

For all Mediterranean countries, pistachio and almond are considered as very special and important fruits. They also require a Mediterranean climate for a good quality of fruit (Baysan, 2001). They both require dry and hot summers, frost-free springs and adequate precipitation during winters and springs except for pistachio nuts which require comparatively cold winter temperatures for bud break (Almadani, 2014; Baysan, 2001). Moreover, both can be produced in poor, rocky, stony and calcareous soil (Baysan, 2001).

Among the Mediterranean countries in pistachio production, Syria leads after Turkey and produces 13% of the total global market (Almadani, 2014). Pistachio production is centered in Hamah and Idleb, both constitute half of the harvested area in Syria and produced 60% of the total pistachio between 2005 and 2011. Between the years of 2009 and 2011, the harvested area was accounted for 57,747 ha with 6,596,000 trees and the overall production was 55,000 tons (Almadani, 2014; FAOSTAT, 2018).

Almond, which is the other important fruit for Syria, has gained its importance after the 1990s. Comparison of 1990-92 and 2004-06 data show that almond production in Syria increased about 510% and 79% of almond production is covered by Homs in 2009-2012 (Cafiero et al., 2009; OCHA, 2014).

1.4.3.2 Grape

The grape cultivation is spread through Syria, while it is mostly concentrated in Rural Damascus, Homs, Hama and Aleppo. However, the production has been showing a decline since 1998 because of the replacement of grape harvesting with more profitable fruit species such as olive and apple (Baghasa, 2006b). Therefore, the total production decreased to around 337,000 tons in 2011 and 260,000 tons in 2016, which was about 540,000 tons in 1998 (FAOSTAT, 2018).

The product exceeds the demand is exported mostly to Arab countries, such as Saudi Arabia, United Arab Emirate, Kuwait, Jordan, Oman, Qatar and Bahrain. Exporters mainly purchase fruit either directly from farmers or wholesale markets, but the shortcomings in the inadequate cooling systems in warehouses or delivery vehicles and ineffective packing materials are the main problems of the sector, which cause losses of the production and rejection of the delivered products (Baghasa, 2006b).

1.4.3.3 Olive

In Syria, which is known to be the first land to produce olives, the olive trees take the first place among other fruit trees, occupying 65 percent of the total cultivated area of fruit trees with 544,000 hectares and around 80 million trees (Figure 1.12) (El Ibrahem et al., 2007). Owing to their adaptability feature in terms of the type of cultivated soil, different bioclimatic conditions, olive trees are found in many different environments and microclimates in the country (International Olive Council, 2012).

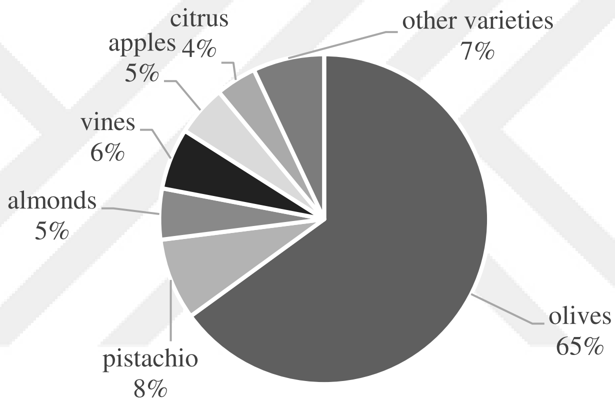


Figure 1.12 Percentage of olive cultivation (El Ibrahem et al., 2007)

Olive farming in Syria (72.20%) is centered around in the northwest (Aleppo-Idleb) and the coastal area (Tartous-Lattakia) and the remaining (26.80%) is spread out around the cities such as Al Hasakeh, Deir Ez-Zor, Homs, Hama, Damascus, Sweida, Daraa, and Tedmor. More than 95% of the cultivation depend on rainfed, remaining is irrigated (Damascus, Tedmor, and Daraa) (El Ibrahem et al., 2007). According to the statistics, in 2009, the olive sector accounted for 11% of the agricultural production of Syria and olive composed 9% of the total amount of exports (International Olive Council, 2012).

Olive farming has a critical role in agriculture of Syria, which is considered as a traditional food because of its healthy and organoleptic characteristics and it provides income for more than 200,000 families directly or indirectly in Syria (El Ibrahem et al., 2007). For these reasons and its high percentage of production, in 2001 the Syrian government had paid particular attention to enhance and expand the agricultural role of olive in Syria's economy. Regarding the olive cultivation, investment and trade policies, the Syrian government took many important actions such as: reclaiming land, dispensing olive seedlings at subsidized prices, providing free Integrated Pest Management services for the production of pesticide-free olives, supporting import of new olive mills with the exemption of taxes, fiscal fees and municipal rates. Addition to these steps, Syria joined the International Olive Oil Council for adjusting Syria's olive oil standards to comply with the standards of the Council (Al Ashkar, 2006).

As a result of the efforts made for alternate bearing phenomena and increased number of olive trees, there had been an enormous growth in the olive production (Al Ashkar, 2006; International Olive Council, 2012). The production amount reached up to 1,200,000 tons in 2006s, which had been around 400,000 tons between 1990-1997 (Figure 1.13) (FAOSTAT, 2018).

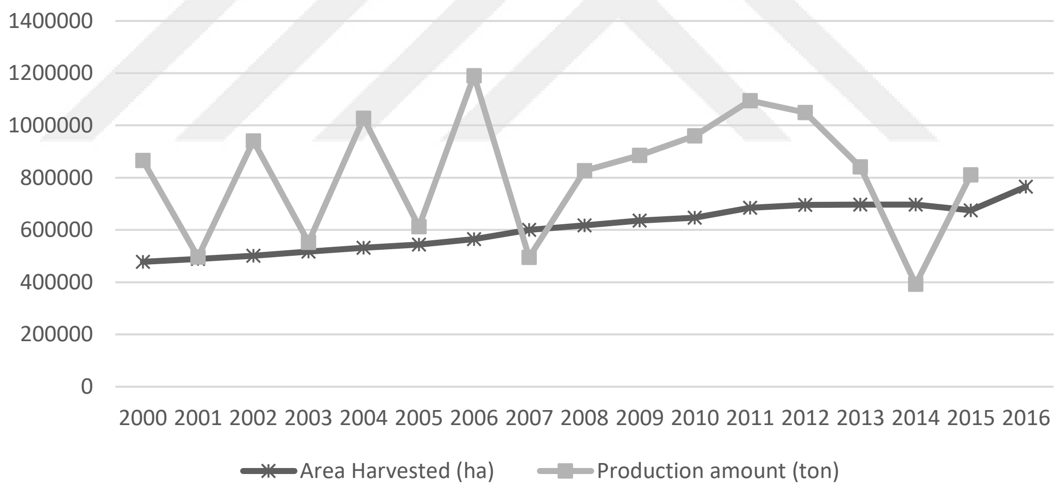


Figure 1.13 Olive production in Syria, 2000-2016 (FAOSTAT, 2018)

The olive growing industry in Syria is separated into two sub-sectors: table olive (green and black) and olive oil. After harvesting, raw olives are sorted and graded before processing. While large sorted olives are primarily used for olive oil production, which is sold to traders and wholesalers by producers after processing, table olives are directly sent to traders (SIM Team, 2018).

In 2013, the Syrian Ministry of Agriculture conducted a study and the study pointed out the existence of many difficulties in the olive oil sector as a result of the current situation in Syria, such as the increased fuel prices, lack of labor force, high transportation, fertilization, pruning and cultivation costs and rising wages (Al-Khatib, 2013). Moreover, exports of the country have been affected due to the lack of good quality control systems where the quality controls are being carried out manually and informally currently (SIM Team, 2018).

1.4.3.4 Potato

In Syria, potato cultivation is spread through a broad area from north-south mountain ranges to the intervening valleys parallel to the Mediterranean coast in the western part of the country. In this vast area, there are three main environments convenient for growing potatoes: with 30% of annual potato production in the highlands around Damascus at 700-1400 m of altitude, the internal regions at 200-250 m of altitude, including Homs, Hama, Al Ghab and Aleppo, which are representing 60% of annual potato production and coastal area near Lattakia and Tartous contributes remaining 10% of the annual production (Shalaby et al., 2007). Potato growing is involved in three seasons in Syria (Alammouri, 2008):

a. Spring season: Potato planting of this season starts from January 15 to February 15 and crops are harvested between May 15 and June 15 (International Potato Center, 1976). Spring season potato production was centered in Aleppo, Idleb, Hama and Al-Ghab, with 30%, 20%, 18% and 8% of the total production, respectively (2000-2005) (Alammouri, 2008).

b. Summer season: Potato planting of this season starts from March 15 to May 15 and crops are harvested in October (International Potato Center, 1976). Summer season potato production was centered in Aleppo, Idleb, Hama and Al-Ghab, with 26%, 24%, 18% and 12% of the total production, respectively (2000-2005) (Alammouri, 2008).

c. Fall season: Potato planting in this season starts from July 15 to August 15 and crops are harvested in December (International Potato Center, 1976). The fall season potato production was centered in Idleb, Aleppo, Al Ghab, Hama, Homs, with 30%, 23%, 19%, 18%, 10% of the total production, respectively (2000-2005). (Alammouri, 2008).

Most of the cultivation areas (98%) are irrigated, whereas, in Lattakia and Tartous, production is dependent on rain-fed (2%). Before the war, Syria consumed most of the produced potatoes locally and also made exports to some Arab countries such as Iraq, Jordan, Kuwait and the United Arab Emirates (Alammouri, 2008).

In 2010, the cultivated area of potato in three seasons was 34,500 hectares and the total production was 673,200 tons in Syria (FAOSTAT, 2018). Even though it decreased drastically in 2013 compared to the previous years, which was mainly because of the declined harvested area and reduced supply of seed potato. The production again rose to 632,218 tons in 2016 (Figure 1.14) (FAOSTAT, 2018; Dost et al., 2015).

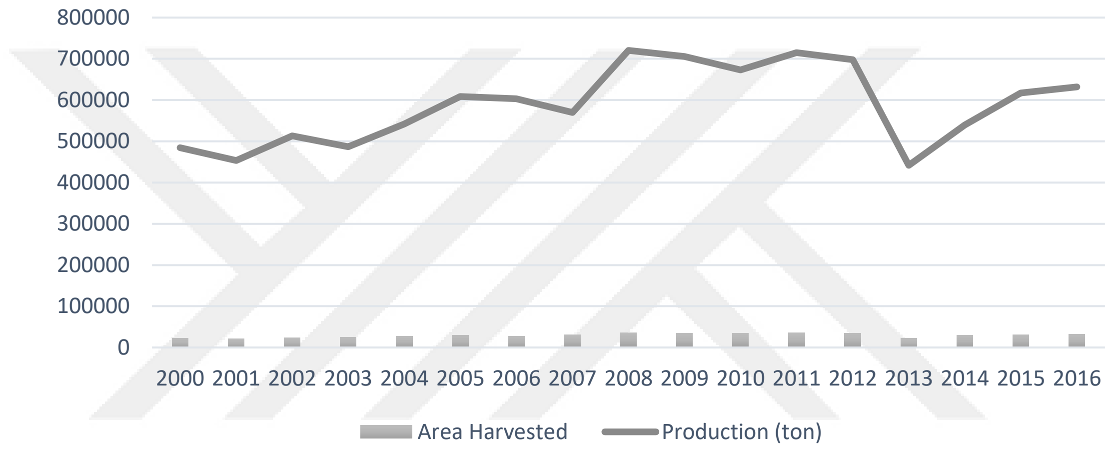


Figure 1.14 Potato production in Syria, 2000-2016 (FAOSTAT, 2018)

1.4.3.5 Tomato

Tomato as an indispensable nutrient for the cuisine of Syria and one of the most consumed vegetables (Babili et al., 2016), it is also very important to farmers because of its high productivity and relatively low cost (Al-Hamwi, 2006). Food and Agriculture Organization (FAO) statistics show that in 2011, before the ongoing crisis Syria ranked as the nineteenth tomato producer with a 0.73 percent of total world production (Babili et al., 2016).

Tomato production in Syria mostly is carried on in open fields as moderate climate conditions allow, as well as in greenhouses in the coastal areas with heating and ventilation machinery, which provide climate control. Uncovered tomato production is grown in all governorates, but the total tomato production of Syria is predominated in Daraa, Aleppo, Al Hassakeh and Al Quneitra. The protected production is concentrated in provinces such as Lattakia, Tartous, Homs and Hama, which account for 11% of the total tomato production in the country (Figure 1.15) (Babili et al., 2016).

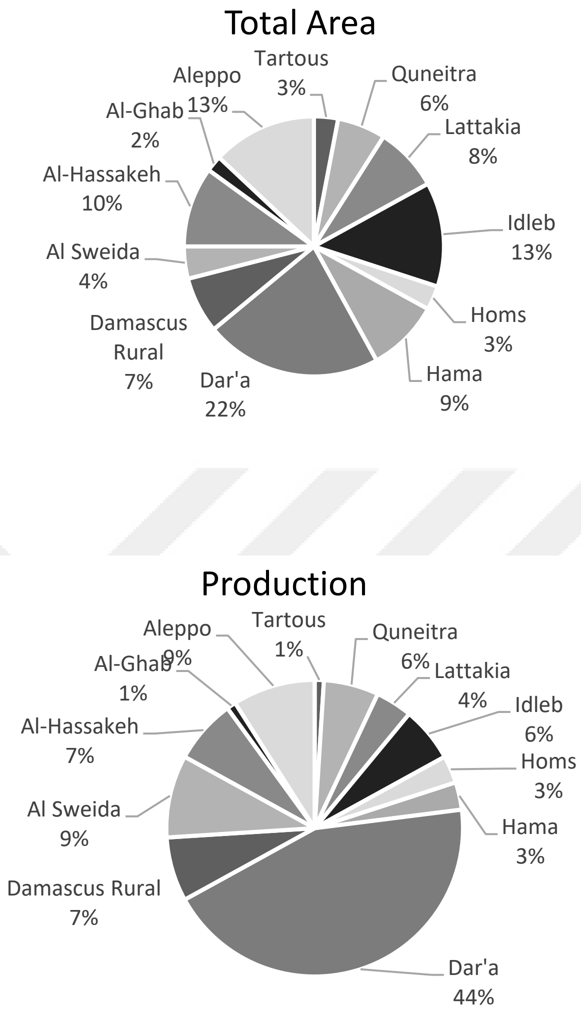


Figure 1.15 Uncovered tomato production and cultivated areas per governorate, 2013 (Babili et al., 2016)

The produced tomato is divided into three groups: for local consumption, processing and export. While most field tomatoes are domestically consumed, the most protected tomatoes are exported to the Arab countries such as Saudi Arabia, United Arab Emirate, Kuwait and Qatar and the remaining is processed or exported to neighbouring countries. Domestically consumed tomato is either consumed fresh or processed, canned and packaged in local factories which are located in Daraa, Jableh, Rural Damascus and Al Hassakeh (Al-Hamwi, 2006; Babili et al., 2016).

With the current crisis, processing factories have been damaged and this has widened up the demand which was already not meeting the need of the country regarding quantity and quality even before the war. The crisis affected not only the processing factories but also the production of the crop, while in 2012 unprotected tomato decreased by 56 percent compared to 2010 and protected tomato decreased by 40 percent (Babili et al., 2016). Moreover, 3,500 out of 5,700 greenhouses located in Al Baidaa and Al Bassateen villages in Banyas–Rural Tartous have been heavily damaged and it is not possible to operate the undamaged greenhouses due to the increased seed and fertilizer prices and water scarcity (UNDP, 2014).

1.4.3.6 Apple

Apple cultivation in Syria is centered around Rural Damascus, Sweida, Homs, Lattakia and Tartous, where irrigated areas constitute 35% of the total cultivated area. The main consumption form of apple is fresh apple, where consumption in the process of vinegar, juice and sugared apple constitutes only 5% of the total production (Hosni and Lancon, 2011).

While the exports and production of most of the other fruits have been declining, apple production has remained relatively unaffected, which was still higher in 2013 than its level in 2002 (Figure 1.16) (FAOSTAT, 2018).

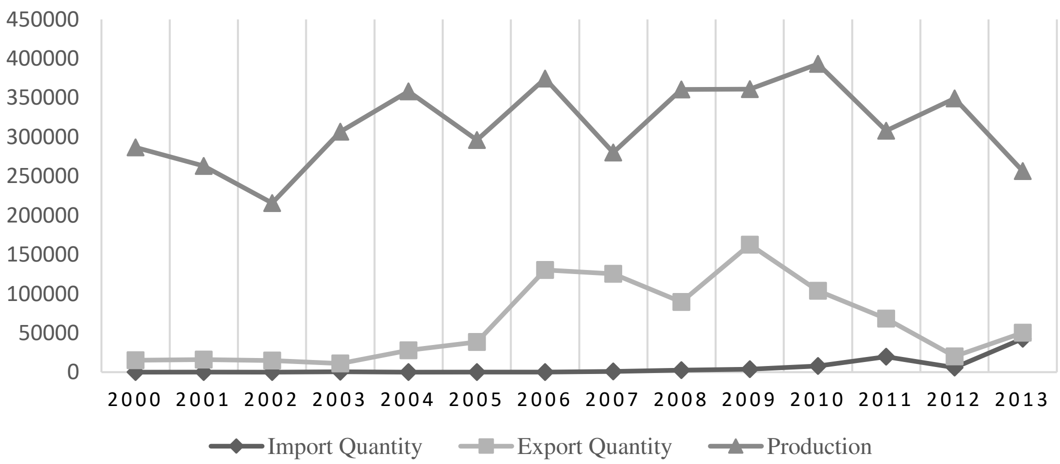


Figure 1.16 Production, export and import of apple in Syria (tons), 2000-2013 (FAOSTAT, 2018)

1.4.3.7 Citrus

The citrus sector in Syria, which was relatively unimportant until the establishment of citrus as an essential crop by the government in the 1970s. The government introduced and certified new and higher yielding citrus fruit varieties, provided public programmes and training in integrated pest management, subsidized farmers for land preparation, seedlings and inputs by providing a long-term interest-free credit between 1977 and 1993 (Westlake, 2000). After all these successfully implemented regulations, the citrus sector increased enormously and Syria became an exporting country in 2005, instead of an importing one (Mansour, 2007).

Also, the Citrus Board Directorate (CBD) stated that citrus fruits are the most promising products in Syria in the fruit production sector. According to the Citrus Board Directorate, in Syria the major advantages for the citrus fruits are (Sheheilah, 2012):

1. The integrated biological programs provide the residual pesticide-free product.

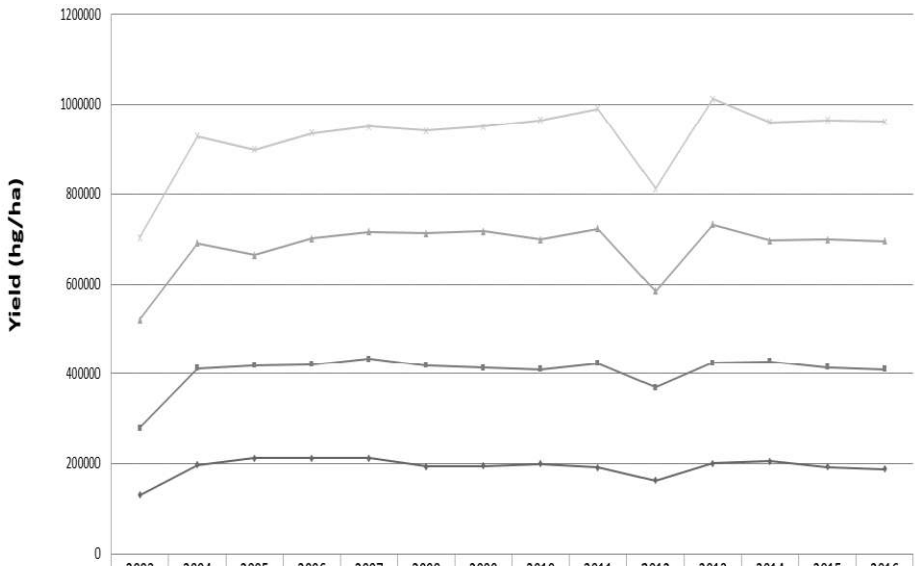
2. Multiple citrus fruit varieties and strains present in Syria, which show medium-late and early maturity, approximately a month.

3. Around 100,000 tons of citrus fruit is produced by Syria and most of these varieties are global.

4. When the fruit production prices are compared with the European countries, it is lower in Syria, at least at the farm level.

Citrus production in Syria is concentrated in Lattakia (%77) and Tartous (%23) and it is also produced in small quantities in Homs, Idleb, Daraa, Deir Ez-Zor, Hama and Al Ghab. Most of the citrus production is irrigated through either public irrigation nets or by private wells by using both flood irrigation and drip techniques (Mansour, 2007).

The impacts of the war on the citrus sector have been slightly less than the other agricultural products even though most of the farmers had difficulties accessing fertilizer and pest control supplies due to the general deficiency and high costs. This is probably because most of the citrus-producing lands are located in government-held areas (Figure 1.17) (Dost et al., 2015; Westlake, 2000).



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Grapefruit	182300	237100	234100	234000	233300	228545	231858	266667	268000	227604	280314	263667	265394	266638
Oranges	241697	278371	245978	279848	283066	293616	304311	288481	298783	215102	307494	268259	285135	285003
Lemons and Limes	148750	214423	205630	208474	221356	225082	217855	209805	232109	206327	223606	222821	221717	221942
Tangerines, mandarins, clementines, satsumas	130214	197583	212818	212727	212091	193385	195522	200000	191429	163014	200777	205444	192251	187871

Figure 1.17 Citrus yield (hg/ha) in Syria, 2003-2016 (FAOSTAT, 2018)

1.5 Livestock sector

The Syrian Arab Republic is located on a 18.6 million hectares total area and around half of the country's land is categorized as pasture (Al-Badia, which covers 8.3 million hectares), which supplies about 15% or more nutritional requirements of the national sheep flock (Baghasa, 2006a). Moreover, the sector constitutes about one-third of the agricultural exports and 35% of the total value of agricultural production (IFAD, 2012).

The composition of livestock is affected by many factors such as the amount of rainfall, availability of irrigation and forests, the development of markets for livestock products and evolvement of mechanization. For example, while Zone 2, Zone 3 and Zone 4 are predominated by cattle, Zone 5 is predominated by sheep. It is estimated that 88.79% of the total livestock population of Syria is composed of sheep, followed by goat with 5.9% and cattle with 4.66%. The population of poultry is not included in this data (Peters et al., 2008). As the main livestock species in the country, poultry, few buffalo and camel have been grown as well (Dost et al., 2015).

Sheep is the most important livestock in Syria not only because it is a dominant livestock commodity, but also it provides an essential revenue since it is exported to the Gulf countries and the Kingdom of Saudi Arabia (FAO, 2016a).

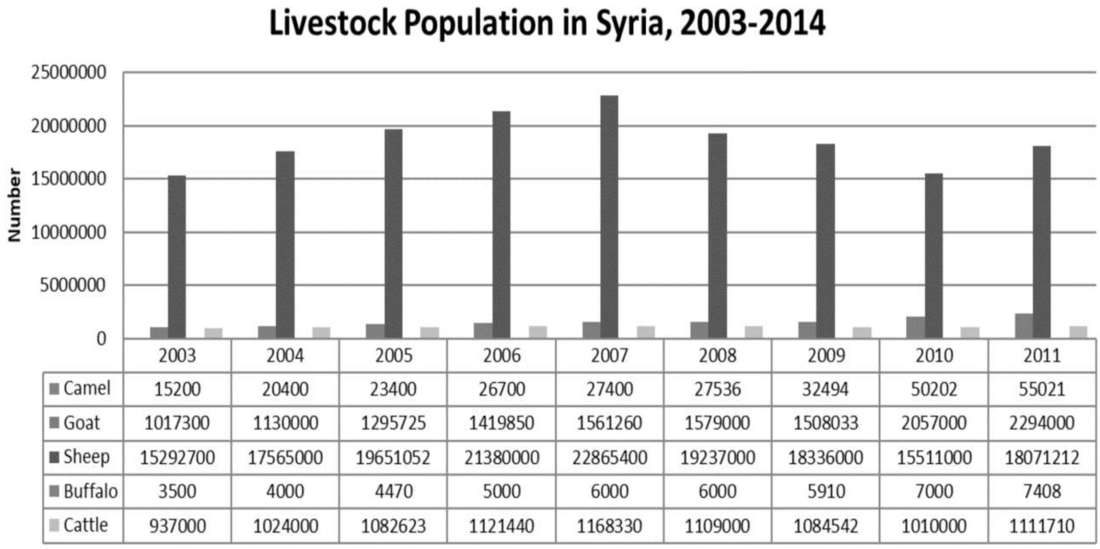
The only sheep breed in Syria is Awassi sheep, which is a local milch breed, adapted to severe desert conditions of the country. Moreover, fat tail of the animal provides a nutrient reserve during the periods of food shortage (Masri, 2006). It is also a considerable source of foreign currency and contributes 100%, 78% and 30% of the total red meat, milk and wool production, respectively (Amin and Peters, 2006).

The sheep population is concentrated in Al-Badia area with 70% and is distributed in other areas such as Deir Ez-Zor (16%), Aleppo (16%), Homs (14%), Ar-Raqqah (14%) and Hama (13%) (Peters et al., 2008). The number of sheep in Syria peaked at 22.9 million in 2007, which had declined to the levels of about 18 million by 2011 and since then it is estimated it has become 10.8 million at present by a farther 40% decrease (FAO, 2016a).

Goats are found in many parts of the country but with a very low number. There are two major breeds of goat; the mountain and Shami (Damascus) goats. Mountain goat is mostly found in the mountainous west, rain-fed and irrigated cropped areas of Syria and comprises 83% of the total goat population, while Shami goat is found in the Ghoota region of Damascus and some other irrigated areas. Shami goat is mainly bred in for milk and used as a milk improver breed (Appleby et al., 2008).

The goat population of the country was 2.3 million in 2011 and this number declined to less than 1.4 million with a 40% reduction (Dost et al., 2015). Apart from the effects of the ongoing crisis, the degradation of rangelands has been the primary constraint of grazing goat production (Masri, 2006).

There are several types of cattle breeds in Syria, the most important one is Aksi, which composes for about half of the total cattle population. It is found along the Khaboor and Euphrates rivers and in high precipitation areas and is grown primarily for meat. Friesian breed cattle comprises 29% of the total cattle population and is grown for the production of milk. Shami (Damascus) cattle accounts for 6% of the total population. They are found in the Ghoota region of Damascus and raised mostly for milk production (Appleby et al., 2008). The cattle population of the country was 1.1 million prior to 2011 and declined to around 778.000 by 30% reduction (Figure 1.18) (Dost et al., 2015).



	2003	2004	2005	2006	2007	2008	2009	2010	2011
Camel	15200	20400	23400	26700	27400	27536	32494	50202	55021
Goat	1017300	1130000	1295725	1419850	1561260	1579000	1508033	2057000	2294000
Sheep	15292700	17565000	19651052	21380000	22865400	19237000	18336000	15511000	18071212
Buffalo	3500	4000	4470	5000	6000	6000	5910	7000	7408
Cattle	937000	1024000	1082623	1121440	1168330	1109000	1084542	1010000	1111710

Figure 1.18 Livestock population in Syria, 2003-2014 (FAOSTAT, 2018)

Syria's poultry industry started to develop in 1970 and it is dominated by commercial poultry (layers and broilers) in the urban and peri-urban areas (Subuh, 2008). However, intensification resulted in water pollution and land degradation in the country (Peters et al., 2008).

It is estimated that in 2008, there were 13,000 chicken farms in Syria producing 172,000 tons of meat and the sector was employing almost 150,000 people directly (Kharseh and Nordell, 2008). The largest poultry farms are centered around Rural Damascus, Homs, Al Hassakeh, Aleppo, Idleb and Hama (Subuh, 2008).

Even the livestock is the less vulnerable sector to the climate changes of the country compared to other agricultural sectors, severe droughts that the country had experienced in 1983-1984, 1998-1999 and 2007-2009 caused degradation of the rangeland feed resources. This resulted in losses in meat and milk production, increased expenditures on water and feed because in drought years grazing pastures are sorely decreased and this caused disruptions of normal feeding cycle. When winter feedstocks of the country are depleted, drought-affected pastures cannot provide feed at the normal grazing pressure and breeders have to graze livestock on the barley crop during the early vegetative stage. While this treatment ends up with fattening lambs for sale, for the next winter it widely decreases the availability of stored feed. For this reason, in 1983-1984, it is estimated that about 25% of the national sheep flocks had to be slaughtered in Syria due to fodder shortages (Belaid and Morris, 1991; IFAD, 2012).

The sector is also constrained by various other factors such as low productivity, deficiency of animal performance control and quality control of milk products systems, lack of effective livestock support services and well-trained stockbreeding specialists, low feed conversion ratios and limited genetic improvement (IFAD, 2012).

In Syria, as a result of rising demand for livestock production all over the world, the feed and fodder market is highly considered by both the private and public sectors. The livestock is mainly fed on barley, bran, cotton seed cake and maize. The primary grain used to feed sheep is barley, the demand fluctuates every year dependently on the grass availability for sheep grazing. During the winter months and drought periods, this demand increases because of grass deficiency. For cattle and poultry, the mainly used fodders are barley, concentrated feed mixes and imported grains which are soybean, meat meal and fish (Fiorillo and Vercueil, 2003; Maldonado, 2011). Due to the poor living conditions, breeders of livestock use concentrated feed and fillers (hay and straw) to feed their flocks, as the fillers are less expensive than concentrated feed and are used for appeasing of the herd. To meet the nutritional balance of animals, breeders feed their livestock with these two types of fodder. The required daily portion of fodder is 1 kg for a single animal (ACU, 2017).

In the Syrian Arab Republic, the development of the livestock sector has a significant impact on decreasing rural poverty and increasing employability. Prior to the ongoing crisis, 11% of Syria's total labor force was employed in the livestock sector, which included many low-income earners in rural areas. While the number of rural inhabitants was more than 8 million, 2.5 million of these were of low incomes. It was estimated that improving productivity could increase incomes and Syria's rural poor would benefit. However, increased livestock populations have resulted in land degradation and excessive grazing (Cummins, 2000).

The livestock sector in Syria has been poorly affected by the ongoing crisis and the prices of egg, milk and cheese increased remarkably by around 500 percent (Leigh, 2014). Another FAO situation report, published in September 2016 states that due to the limited access to the grazing pastures and 168 percent increase in the cost of animal feed, the numbers of cattle and sheep dropped by 30 and 40 percent respectively.

Therefore, livestock rearers had to slaughter more animals than usual to reduce economic losses (FAO, 2016b). Furthermore, poultry, which is considered as the primary animal protein source of Syria has been the most affected sector with 50% reduction in the number of animals with the abandonment and destruction of farming units. The number of chicken dropped to around 13.1 million, which was approximately 26.2 million in 2011 (Dost et al., 2015).

It is forecasted for these percentages to increase as a result of the lack of routine veterinarian drugs and vaccines and further livestock owners will have to slaughter their animals (FAO, 2016b). Al Hassakeh, Deir Ez-Zor, Lattakia, Rural Damascus and Quneitra are the areas with the most loss of animals either by death as a result of lack of water, poor living conditions and killing or theft (Tull, 2017).

1.6 Fishery sector

In Syria, the fishery sector plays a minor role in the economy due to the scarcity of resources and the low natural productivity of fishing grounds because of the high salinity of the coastal water, relatively low freshwater input and low tidal range. In addition to these, administrative and legislative constraints, such as discharges of untreated wastewater into seas and high level of pollution of the sea impacts the sector negatively (FAO, 2007; European Commission, 2011). Moreover, the yearly seafood consumption of the country is estimated at 1 kg per person, which is a quite low rate compared to the neighbouring countries (Ulman et al., 2015).

In the late 1950s, with the support of an FAO aid project, the Syrian Arab Republic adopted the modern fishery and Qalaat of Madiq, the first fish farm of the country, was built in "Al Ghab" valley. With this farm, it was aimed to constitute a training center and testing of the potential of carp culture in Syria and it resulted in very high productivity. The country profited higher net incomes even more than cotton cropping, which was the most productive activity at the time (FAO, 2006).

After 1986, the catch per unit effort (CPUE) began to decrease steadily and in 1995 and 2003 dropped prominently (FAO, 2007). The decreased and quite low productivity of water compared to the water of Turkey and Lebanon is considered as evidence of overexploitation (Ulman et al., 2015).

Currently, the fishery sector in the country is divided into four: industrial (large-scale commercial), artisanal (small-scale commercial), subsistence (non-commercial, small-scale) and recreational (Ulman et al., 2015).

The main fish markets of the country are located in the north of Aleppo, Ar-Raqqah, northeast of Deir Ez-Zor, Homs, Hama, Lattakia, Tartous and Damascus. (FAO, 2007) Thus far, the most important types of fish groups are carps and tilapias for commercial aquaculture and tuna and tuna-like species, sea-breams, porgies, sardines, allies, jacks, scads, scorpionfishes and runners for the marine capture fisheries (FAO, 2007).

The impact of the fishery sector on the economy in Syria is neglectable. For example, the sector was contributing in 0.38 percent of the GDP in 2005 (FAO, 2007). However, according to an FAO report published in 2006, aquaculture is the most promising sub-sector, if the modern farming techniques are implemented correctly by using resources such as land, water and labor sustainably (FAO, 2006).

According to the FAO report published on May 2017, it is estimated that the total value of damage of the conflict to aquaculture and fisheries is nearly USD 80 million, of which USD 103,000 comprise of losses. Idleb (about USD 58 million), Hama (USD 15.4 million) and Ar-Raqqah (USD 4.8 million) have been the cities with the largest losses respectively (FAO, 2017a).

1.7 Seed industry in Syria

The Syrian government shows a particular interest in agriculture because of its strategic importance to the country. The government takes charge of the supply and production of inputs including improved seeds. For this reason, the General Organization for Seed Multiplication (GOSM) was established by The Ministry of Agriculture and Agrarian Reform (MAAR) and it became operational in 1975. The main roles of the General Organization for Seed Multiplication (GOSM) are (Omar, 2002):

1. Providing training and advisory service to farmers on seed production.
2. Marketing and distributing seed to farmers directly or through the Agricultural Cooperative Bank.
3. Instituting seed processing and storing establishments at strategic seed production sites.

4. Coordinating seed multiplication for the released crop varieties through contracts with farmers.

The strategy of providing high-quality seeds and making them available at relatively low prices resulted in a significant increase in agricultural productivity (Omar, 2002).

The objectives of GOSM are carried out in three basic steps: multiplication and production of certified seed, seed processing and seed marketing and distribution. The process starts with receiving seeds from three organizations: Directorate of Agricultural Research at Duma, ICARDA and the Arab Centre for the Study of Arid Zones and Dry Land (ACSAD). Depending on the yearly plan of each crop, multiplication of seeds is performed by cooperatives, government farms and cultivators with contracting arrangements. The crops are inspected at least three times one after planting, secondly during the growing season and lastly just before the harvesting by an experienced inspector. The fields meet the regulations accepted and the samples are tested by GOSM experts for measuring moisture content, purity and germination. This step is followed by the final step, which is the marketing and distribution of seeds through the Central Seed Marketing Directorate of GOSM (Mohammed, 1988).

In order to encourage farmers to use certified seeds, sales prices were fixed at a lower level than the actual costs. For instance, in 1983, the sales price of GOSM was 70% lower than the actual costs (Mohammed, 1986).

Before the war, the processing of GOSM took place in 11 different branches located in various multiplication areas (Aleppo, Al-Hasakeh, Deir Ez-Zor, Ar-Raqqah, Idleb, Hama, Homs, Lattakia, Tartous, Damascus, Izraa), with a total of 100,000 tons/season storing capacity (GOSM, 2007). The FAO report published in 2015 shows that the storage capacity of GOSM has been declining significantly since 2011, as eight of its seed processing units have been damaged beyond repair or are in opposition-held areas or both. However, even this causes extreme difficulties to the organization in producing clean seeds, GOSM carries out providing seeds at subsidized prices within both Government-held areas and opposition-held areas (Dost et al., 2015).

1.8 International trade in Syria

1.8.1 Exports in Syria

International trade between different countries has a quite important role in improving living standards, increasing employment opportunities, providing a more extensive variety of goods and consequently promoting economic growth. Besides all these, exports are the primary source of generating foreign exchange earnings.

Agricultural exports lead foreign currency earner in Syria and the sector has a significant contribution to industrial growth since agricultural raw materials are the source of many manufacturing activities (FAO, 2003a). For the years from 1980 to 2010, the raw material export share was about 68%, while the share of the total Syrian export for finished products and semi-finished products was 24% and 8%, respectively (Mohsen, 2015).

In 2002, the total exports of the country accounted for US$7,6 billion, as the contribution of agriculture was US$1 billion and main exported agricultural commodities before the crisis were tomatoes, sheep, cotton, anise/fennel, sugar, potatoes, oranges, apples, olive oil, cattle, poultry meat and eggs (Abbas and Procházka, 2010; Dost et al., 2015). Tomato was one of the most critical exported vegetable in Syria, which took place on the top among the Syrian agricultural exports in 2011 and 2012 (Babili et al. 2016).

The livestock sector of Syria used to have a significant contribution to agricultural exports with 15 percent revenue and live sheep was the major contributor (Cummins, 2000). The primary market of livestock exports was oil-rich Arab countries, which provided a high income for livestock farmers and directly had an impact on the domestic prices of sheep products. In 2004, Saudi Arabia was the leading importer with 74 percent of total live sheep exports, which was followed by Lebanon, Kuwait and Qatar with 8-9 percentage for each (Shomo et al., 2010).

Jordan used to be Syria's largest cross-border agricultural partner, as the exports peaked in 2010. However, the exports to Jordan went into a decline during the period of conflict and decreased by 45% between 2011-2014 (RFSAN, 2016).

At the first stage of 2011, there was a remarkable displacement of industrialists and merchants to the relatively safe coastal areas under the government control and exports to Iraq, Jordan and Iran showed an increase due to the devaluation of the Syrian Pound (SYP) (Dost et al., 2015; Nasser et al., 2013). However, it halted after the devastation of production infrastructure and equipment (Nasser et al., 2013).

It is estimated that exports decreased about 38.4 percent at the beginning of 2012 and this decline reached up to 70 percent by 2015 as a result of the international embargo, the breakdown of border-cross trading and impact of the civil war on economic activities of the country (Gobat and Kostial, 2016; Nasser et al., 2013). The decreases in export volume have resulted in an ascend in the trade balance deficit, which has been one of the reasons of depreciation in the SYP (Nasser et al., 2013).

1.8.2 Imports in Syria

Imports improve a country's capacity and productivity and enable it to acquire goods or investment equipment such as machines or new technology because not all countries can produce the required sources for certain products and services.

Before the war, the main imported goods in Syria used to be industrial and agricultural equipment, vehicles and heavy machines, where manufactured products were accounting for 87 percent of total imports in 2009 (IBP, 2015; Sleman and Farfour, 2012). The share of the agricultural products was around 11% and with sugar, maize and tea were comprising the bulk (Abbas and Procházka, 2010; Sleman and Farfour, 2012).

In 2009, most of the imports of Syria came from Asian countries (31.2%), which was followed by the EU (23.6%), non-EU Europian countries (18%) and Arab countries (16.4%) (Sleman and Farfour, 2012).

Currently, for the opposition-controlled areas of northern Syria, Turkey has the largest import share, where Iraq comes second for manufactured foodstuffs such as rice, sugar, tea, lentils, bulgur, margarine and frozen chicken. Moreover, agricultural inputs (fungicides, pesticides and fertilizers) are also provided via the port of Mersin, Turkey. Most of the cross-border trade between Turkey and Syria is carried out through Bab al-Hawa and Bab es-Salam borders, which are only one-way trades as they are under a ban for exports from Syria to Turkey for the last two years (SIM Team, 2018).

1.9. Calculation of growth gap of Syria by Hodrick-Prescott (HP) Filter method

In this study, the demand and capacity of the country before the Syrian crisis was assessed with the Hodrick-Prescott Filter method by evaluating the past agricultural GDP (%) data of the country. This data was used to predict the future potential of Syrian Agriculture.

The Hodrick-Prescott Filter method is a smoothing procedure, which "estimates potential output by minimizing the sum, over the sample period, of squared distances between actual and potential output at each point in time, subject to a restriction on the variation of potential output" (Konuki, 2008). It can be described as a time series, say y_t (or output), may be expressed as the sum of a growth component or trend y_t^*(or potential output) and a cyclical component or output gap C_t, defined by Equation 1.1:

$$y_t = y_t^* + C_t \tag{1.1}$$

The measure of the smoothness of y_t^* is the sum of the squares of its second difference. With the mean of the deviations of C_t from y_t^* is assumed to be near zero over a long period. These assumptions are expressed as (Equations 1.2 and 1.3) (Thabethe and Nyhodo, 2014):

$$\min L = \{ \sum_t^T c_t^2 + \lambda \sum_{t=2}^T (\Delta y_t^* - \Delta y_{t-1}^*)^2 \} \tag{1.2}$$

$$= \sum_{t=1}^T (y_t - y_t^*)^2 + \lambda \sum_{t=2}^T [(y_t^* - y_{t-1}^*) - (y_t^* - y_{t-1}^*)]^2 \tag{1.3}$$

The restriction parameter λ was set at 100, which is suggested for the annual time series.

The output gap is defined as the "difference between actual and potential output and often used as an indicator of the economic cycle because it allows the demand fluctuations to be disentangled from the fluctuations coming from the supply side" and its direction (negative or positive) has an impact on the inflation rates of the country (Özer et al., 2016).

The output gap calculations provide a critical understanding of the country's economic status such as inflation rates or whether the country is over-using or under-using its agricultural resources. A positive gap is an indicator of very high demand and factories and workers operate over their capacity, which will push the prices and consequently the inflation up. However, a negative gap is also not good for the economy of the country, which is a sign of weak demand and the existence of spare capacity or slack. This will reflect upon the economy with a tendency of pushing the prices down (Özer et al., 2016).

For the calculation of the output/growth gap, the actual agricultural value-added GDP (%) values between the years of 1985 and 2007 were obtained from the World Bank database (Table 1.2) (The World Bank, 2018c). The potential GDP (%) and the output gap (%) were calculated to find the future foresight for Syrian agricultural and food sectors, which is important for the raw material supply to food industry.

Table 1.2 Actual agricultural GDP, potential agricultural GDP and output gap for Syria (1985-2007) (The World Bank, 2018c)

Date	Actual GDP (%)	Potential GDP (%)	Growth Gap (%)
1985	20.8	23.7	-2.9
1986	23.6	24.6	-1.0
1987	25.2	25.5	-0.3
1988	30.2	26.4	3.8
1989	23.5	27.1	-3.6
1990	28.3	27.7	0.6
1991	30.7	28.2	2.5
1992	31.7	28.5	3.2
1993	29.0	28.6	0.5
1994	27.8	28.5	-0.6
1995	28.2	28.3	-0.1
1996	27.7	27.9	-0.2
1997	25.8	27.5	-1.7
1998	29.4	27.0	2.4
1999	24.1	26.4	-2.3
2000	24.1	25.8	-1.6
2001	25.9	25.1	0.8
2002	25.7	24.3	1.4
2003	24.7	23.6	1.1
2004	22.3	22.7	-0.5
2005	20.7	21.9	-1.1
2006	21.0	21.0	0.0
2007	19.5	20.1	-0.6

The results of the analysis show that in 1988, 1990-1993, 1998 and 2001-2003, the actual output was above the potential output, while in 1985-1987, 1989, 1994-1997, 1999-2000, 2004-2005 and 2007 the output was below the potential level. In 2006, the actual output and potential output were at the same level (Table 1.2 and Figure 1.19).

The results indicate that for the years in which the actual output was above the potential output, the output gap was positive. However, the overall results for this methodology show that in 13 periods out of the 23, the Syrian agriculture was operating below the potential (Table 1.2 and Figure 1.19).

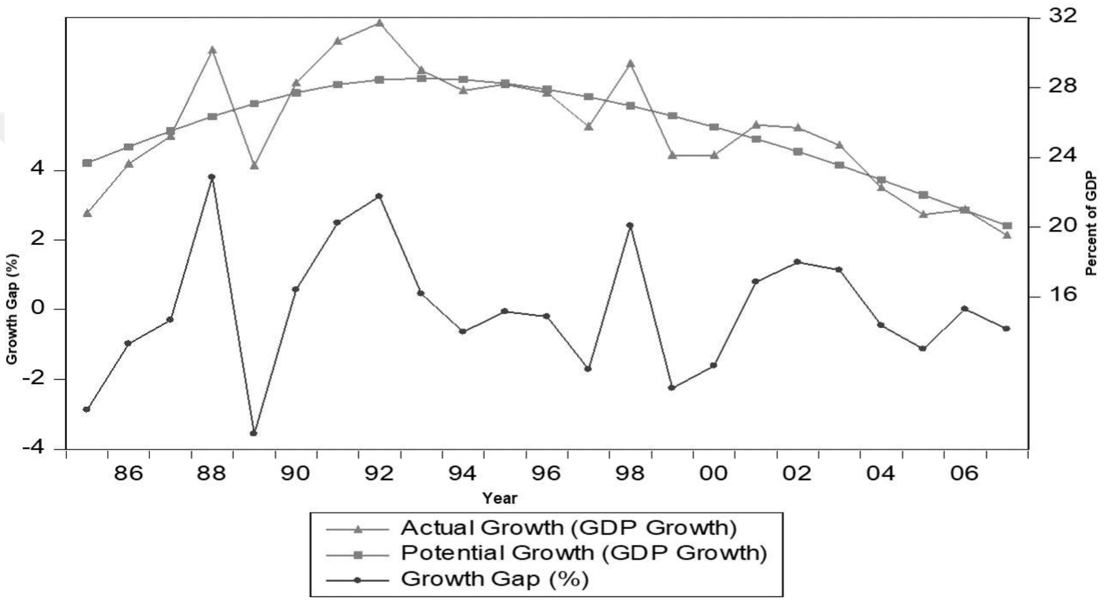


Figure 1.19 Actual and potential agricultural GDP and output gap for Syria (1985-2007)

1.10 The aim of this study

The aim of this study is to plan the food sector in Syria for the end of the war by perceiving specific shortcomings of the previous failed attempts. As the main food industries of Syria are based on agriculture and food, mainly it is concentrated upon agricultural development. In this study, firstly, the potential agricultural GDP (%) of the country was gauged by Hodrick Prescott Method and the results were evaluated. Moreover, the food requirements for the next 30 years (as near future) were estimated for Syria. It was estimated that the agricultural production growth studies will be the key aspect and it was aimed to accelerate the process by providing extensive research over the primary requirement of the country and actions to be taken for development of the agriculture and food industries. In order to evaluate the future of Syria's economy and food plant investment, this study can help governments, investors, economists and strategists. It can also help to prepare new feasibility studies related to the Syrian food sectors.

CHAPTER 2

MATERIAL AND METHODS

In the study the energy required based on food (nutritionally) and the food requirements of Syria in 2020, 2030, 2040 and 2050 were determined as foresight to predict demands in the food industry investment in Syria. By using these results, the future of Syrian agricultural and food industries was evaluated.

2.1 Calculation of food and energy requirements for Syria in the future

For the calculation of the food and energy (nutritional) requirements in Syria for the years of 2020, 2030, 2040 and 2050 (Figure 2.1), the method mentioned by Gökırmaklı (2017) was used. The method was adapted to Syria in the present study.

In this method, Syria's population estimations (Table 2.1) for 2020, 2030, 2040 and 2050 were obtained from the World Bank data (The World Bank, 2018a). The future age and gender group distributions (percentages as estimated) in the population (Table 2.2) were also used to determine their food and energy (nutritional) requirements, individually. Then, these values were used to calculate the total food and energy requirements for Syria in the future.

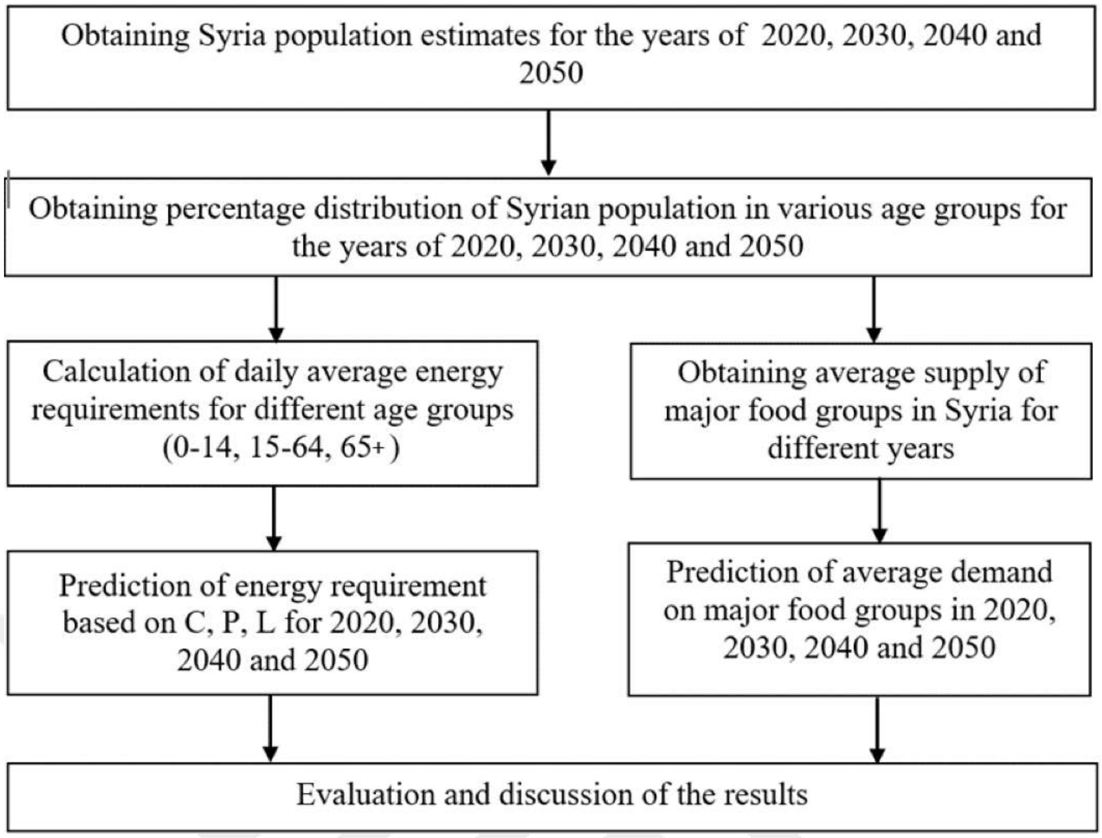


Figure 2.1 Calculation methodology of food requirements of Syria

Table 2.1 Total population estimates of Syria for 2020, 2030, 2040 and 2050 (The World Bank, 2018a)

Year	Number of the estimated population
2020	18,924,000
2030	26,608,000
2040	30,799,000
2050	34,021,000

Table 2.2 Estimated percentage distribution of Syrian population in various age groups for 2020, 2030, 2040 and 2050 (The World Bank, 2018a)

Age Groups	Years			
	2020	2030	2040	2050
0-14	34.2	28.1	25.0	21.9
15-64	60.9	65.5	66.7	66.5
65+	4.9	6.3	8.3	11.6

In order to calculate the energy requirement for each age and gender group due to their different activities and energy usages; the individual energy requirement for each group was calculated. The estimated energy requirements per day, by age and gender for moderately active individuals were taken from Britten et al. (2006) and Michaelsen et al. (2000). The calculation of energy requirements for each age and gender group are given in Table 2.3, separately. The average values were calculated as 1560.5, 2254.2 and 2000 kcal/day per capita for 0-14, 15-64 and 65+ years old, respectively. As a formulation, the following equation was used for each group:

Total energy requirement (kcal/day) = Population in the future (number) x Age/gender group percentages (%) X Average energy requirement of age/gender group (kcal/day) per capita

Table 2.3 Average energy requirement for moderately active women and men with different age groups (Britten et al., 2006; Michaelsen et al., 2000).

Age group (0-14 years old)	Energy req. (kcal/day) per capita	Age group (15-64 years old)	Energy req. (kcal/day) per capita	Age group (65+ years old)	Energy req. (kcal/day) per capita
0-12 months (boy)	745.0	15-20 (Male)	2760.0	65+ (Male)	2200.0
0-12 months (girl)	697.5	15-20 (Female)	2040.0	65+ (Female)	1800.0
2-9 (boy)	1475.0	21-60 (Male)	2550.0		
2-9 (girl)	1400.0	21-60 (Female)	1975.0		
10-12 (boy)	2000.0	61-64 (Male)	2400.0		
10-12 (girl)	1866.7	61-64 (Female)	1800.0		
13-14 (boy)	2300.0				
13-14 (girl)	2000.0				
Average energy requirements (kcal/day) per capita based on age and gender	**1560.5**		**2254.2**		**2000.0**

To determine the quantity of carbohydrate (M_C), protein (M_P) and lipid (M_L), which are used in the regular diet, the calculated overall energy requirement values were converted by using the conversion factors such as 4, 4 and 9 kcal/g for carbohydrate, protein and lipid, respectively. In a regular daily diet, human generally consumes 70% carbohydrate, 20% protein and 10% lipid (Gökırmaklı, 2017). Therefore, these percentages were also used to calculate the required quantities of carbohydrate, protein and lipid.

In addition to the previous calculations, the food requirements (quantity in tons) based on the sectors and food groups were calculated, which were used to determine the food to feed Syria and investment projection on the food sector. In order to feed the people, the major food groups as regular food requirements will be demanded for the future of Syria. Therefore, the major food groups required to feed the people were firstly determined as cereals, starchy roots, sweeteners, pulses, nuts, oilcrops, fruits, vegetables, vegetable oils, animal fats, meat, offals, fish, seafood, milk, eggs and other foods. The required average amounts of major food groups for the Syrian people in the future were calculated using the FAO data (Table 2.4). The data was based on the fundamental major food categories and the average weight supply of each food group daily per capita for Syrians for the different years, and it was presumed the fluctuations over the years are because of the decreases or increases in the supply due to the climatic conditions (FAO, 2005).

According to the data, the total average value was calculated as 1668.17 g/(dayxcapita) (Table 2.4). This was used for the percentage estimation of each food component in the regular diet of Syrians. The percentage of each food group in the diet was given in the last column of Table 2.4.

In order to calculate the required daily amount, gram/dayxper capita was multiplied with the estimated future populations and the obtained unit (gram/day) was converted into tons per day (ton/day) and tons per year (ton/year) to determine the annual daily and food requirements.

Table 2.4 Daily average supply (quantity as weight) of major food groups in Syria (g/(dayxcapita)) and their shares (FAO, 2005)

Major food groups	1965-1967	1972-1974	1979-1981	1986-1988	1993-1995	2000-2002	**Mean (g/(dayxcapita))**	**Percentage of product in diet based on the quantity (%)**
Cereals	423	469	478	503	478	465	**469.33**	**28.13**
Starchy roots	20	38	69	66	52	62	**51.17**	**3.07**
Sweeteners	49	66	97	94	103	107	**86.00**	**5.16**
Pulses, nuts, oilcrops	36	46	49	52	44	69	**49.33**	**2.96**
Fruit and vegetables	514	660	1069	799	521	477	**673.33**	**40.36**
Vegetable oils	22	25	29	32	47	56	**35.17**	**2.11**
Animal fats	11	9	14	10	7	8	**9.83**	**0.59**
Meat and offals	38	37	64	59	53	65	**52.67**	**3.16**
Fish and seafood	2	5	7	2	2	7	**4.17**	**0.25**
Milk and eggs	172	154	280	259	240	261	**227.67**	**13.65**
Other	6	6	9	10	12	14	**9.50**	**0.57**
TOTAL	1293	1515	2165	1886	1559	1591	**1668.17**	**100**

In order to determine the numbers of food plants in Syria, first, the major food products' values (as groups) in Table 2.4 were used for the calculation of the total required amount of food. For estimation of the number of plants, the calculated required amount of food was divided by the one food plant capacity. This method was applied to different food sectors.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Calculation of nutritionally energy requirements

The primary purpose of the following calculations is to estimate the total food energy requirements of Syria based on the food requirement to feed people in the future. For the calculation of total energy requirements, total population estimations (Table 3.1) and age-gender percentages in the population (Table 3.1) of Syria for 2020, 2030, 2040 and 2050 were used. The calculations were based on multiplying the percentage of each age/gender group with the total population. Then, the required average daily energy for the total population per day was calculated by using the average energy requirements (kcal/day) for the different age and gender groups (Tables 3.1 and 3.2). However, in the present calculations, the incomes (low and high) of the households, spoilage or losses in the foods were underestimated.

The total energy requirements of Syria for 2020, 2030, 2040 and 2050 were calculated as 3793313529120, 5430696791200, 6343597344360 and 7051847364250 kcal/day, respectively, which was the required minimum required energy intake based on the food requirement (Table 3.2).

As a percentage of energy intake, carbohydrates, proteins and lipids were provided. As explained previously, human obtains the daily energy from carbohydrates (70%), proteins (20%) and lipids (10%). These ratios are also considered as the share of the daily diet for carbohydrates, proteins and lipids. Therefore, the required amounts of carbohydrates, proteins and lipids based on kcal/day were calculated according to these ratios (Table 3.3).

By using Table 3.3, the amount of carbohydrate (M_C), protein (M_P) and lipid (M_L) were calculated by using the Atwater system, which considers the caloric values of 1 g of carbohydrate, protein and lipid as 4, 4 and 9 kcal, respectively (FAO, 2003b). By dividing the total energy requirements (kcal/day) into these conversion factors (kcal/g), the required amount of carbohydrate, protein and fat (g/day) were obtained (Table 3.4), then they were converted into annual quantity requirement values of carbohydrate, protein and lipid for 2020, 2030, 2040 and 2050 for Syria (Table 3.5).

Table 3.1 Distribution of age/gender groups in the populations at 2020, 2030, 2040 and 2050 and their daily energy requirement per capita

Age and gender group	Daily energy requirement for age/gender group (kcal/day)	Age/gender percentages in the population (%)			
		2020	2030	2040	2050
0-14	1560.5	34.2	28.1	25	21.9
15-64	2254.2	60.9	65.5	66.7	66.5
+65	2000.0	4.9	6.3	8.3	11.6
Total population		18924000	26608000	30799000	34021000

Table 3.2 Total energy requirement for each age/gender group in the population in the future (kcal/day)

Age and gender group	Years			
	2020	2030	2040	2050
0-14	1.01E+12	1.17E+12	1.20E+12	1.16E+12
15-64	2.60E+12	3.93E+12	4.63E+12	5.10E+12
+65	1.85E+11	3.35E+11	5.11E+11	7.89E+11
Total energy requirement for all groups (kcal/day)	3.79E+12	5.43E+12	6.34E+12	7.05E+12

Table 3.3 Estimated carbohydrate, protein and lipid requirements in the future based on daily energy requirements (kcal/day)

	Years			
	2020	2030	2040	2050
M_C for total population (70% share in diet)	2.66E+12	3.80E+12	4.44E+12	4.94E+12
M_P for total population (20% share in diet)	7.59E+11	1.09E+12	1.27E+12	1.41E+12
M_L for total population (10% share in diet)	3.79E+11	5.43E+11	6.34E+11	7.05E+11

(M_C: Mass of Carbohydrate, M_P: Mass of Protein, M_L: Mass of Lipid)

Table 3.4 Estimated carbohydrate, protein and lipid requirements in the future based on daily quantity requirements (g/day)

	Years			
	2020	2030	2040	2050
M_C (g/day) for total population (conv. fac. 4 kcal/g)	6.64E+11	9.50E+11	1.11E+12	1.23E+12
M_P (g/day) for total population (conv. fac. 4 kcal/g)	1.90E+11	2.72E+11	3.17E+11	3.53E+11
M_L (g/day) for total population (conv. fac. 9 kcal/g)	4.21E+10	6.03E+10	7.05E+10	7.84E+10

(M_C: Mass of Carbohydrate, M_P: Mass of Protein, M_L: Mass of Lipid)

Table 3.5 Estimated carbohydrate, protein and lipid requirements in the future based on annual quantity requirements (tons/year)

	Years			
	2020	2030	2040	2050
M_C (g/day) for total population (conv. fac. 4 kcal/g)	2.42E+08	3.47E+08	4.05E+08	4.50E+08
M_P (g/day) for total population (conv. fac. 4 kcal/g)	6.92E+07	9.91E+07	1.16E+08	1.29E+08
M_L (g/day) for total population (conv. fac. 9 kcal/g)	1.54E+07	2.20E+07	2.57E+07	2.86E+07

(M_C: Mass of Carbohydrate, M_P: Mass of Protein, M_L: Mass of Lipid)

With this study, it was intended to provide general information on the quantity of foods in terms of the daily and annually average intakes for the following dietary components/nutrients: carbohydrate (C), protein (P) and lipid (L). For 2020, the estimated requirement for nutritional intakes in terms of carbohydrates, protein and lipid were 242297902, 69227972 and 15383994 tons/year, respectively. However, due to the forecasted rapid increase in the annual population of Syria, these numbers were expected to rise by 450436750, 128696214 and 28599159 tons/year respectively in 2050. On the other hand, the source of carbohydrate, protein and lipid may be different for Syria, which depends on the availability of food products. They can be obtained from cereals, starchy roots, pulses, nuts, fruits, vegetables, oils, etc.

3.2 Calculation of the required amount of food

The aim of this study to calculate the food requirements based on food groups for Syria in the future in order to make a projection for the food industry and the food plant investment foresight.

In Table 2.5, the major food groups found in the diet of Syria were determined. According to the average daily food requirement (1,668.17 g/(dayxcapita)) and the percentages of these major food groups, the projections were estimated for the future populations of 2020, 2030, 2040 and 2050 separately and the obtained data was converted into ton/day and ton/year for each major food groups (Tables 3.6, 3.7, 3.8

and 3.9). The obtained data can be used during the feasibility studies to decide the food plant investments in Syria.

Table 3.6 Required amount of food for the year 2020

Type of food	Daily consumption (g/dayxcapita)	Ratio of foods in regular diet (%)	Total amount of foods	
			tons/day	tons/year
Cereals	469.33	28.13	8881.66	3241807.36
Starchy roots	51.17	3.07	968.28	353421.47
Sweeteners	86.00	5.16	1,627.46	594024.36
Pulses, nuts, oilcrops	49.33	2.96	933.58	340758.16
Fruit and vegetables	673.33	40.36	12742.16	4650888.40
Vegetable oils	35.17	2.11	665.49	242905.31
Animal fats	9.83	0.59	186.09	67921.39
Meat and offals	52.67	3.16	996.66	363782.36
Fish and seafood	4.17	0.25	78.85	28780.25
Milk and eggs	227.67	13.65	4308.36	1572552.86
Other	9.50	0.57	179.78	65618.97

Table 3.7 Required amount of food for the year 2030

Type of food	Daily consumption (g/dayxcapita)	Ratio of foods in regular diet (%)	Total amount of foods	
			tons/day	tons/year
Cereals	469.33	28.13	12488.02	4558127.79
Starchy roots	51.17	3.07	1361.44	496926.57
Sweeteners	86.00	5.16	2288.29	835225.12
Pulses, nuts, oilcrops	49.33	2.96	1312.66	479121.39
Fruit and vegetables	673.33	40.36	17916.05	6539359.47
Vegetable oils	35.17	2.11	935.71	341535.85
Animal fats	9.83	0.59	261.65	95500.55
Meat and offals	52.67	3.16	1401.35	511494.45
Fish and seafood	4.17	0.25	110.87	40466.33
Milk and eggs	227.67	13.65	6057.75	2211080.45
Other	9.50	0.57	252.78	92263.24

Table 3.8 Required amount of food for the year 2040

Type of food	Daily consumption (g/dayxcapita)	Ratio of foods in regular diet (%)	Total amount of foods	
			tons/day	tons/year
Cereals	469.33	28.13	14455.00	5276074.03
Starchy roots	51.17	3.07	1575.88	575196.99
Sweeteners	86.00	5.16	2648.71	966780.61
Pulses, nuts, oilcrops	49.33	2.96	1519.42	554587.33
Fruit and vegetables	673.33	40.36	20737.99	7569367.57
Vegetable oils	35.17	2.11	1083.10	395330.83
Animal fats	9.83	0.59	302.86	110542.74
Meat and offals	52.67	3.16	1622.08	592059.44
Fish and seafood	4.17	0.25	128.33	46840.15
Milk and eggs	227.67	13.65	7011.91	2559345.57
Other	9.50	0.57	292.59	106795.53

Table 3.9 Required amount of food for the year 2050

Type of food	Daily consumption (g/dayxcapita)	Ratio of foods in regular diet (%)	Total amount of foods	
			tons/day	tons/year
Cereals	469.33	28.13	15967.19	5828024.11
Starchy roots	51.17	3.07	1740.74	635370.53
Sweeteners	86.00	5.16	2925.81	1067919.19
Pulses, nuts, oilcrops	49.33	2.96	1678.37	612604.81
Fruit and vegetables	673.33	40.36	22907.47	8361227.77
Vegetable oils	35.17	2.11	1196.41	436687.89
Animal fats	9.83	0.59	334.54	122107.04
Meat and offals	52.67	3.16	1791.77	653997.02
Fish and seafood	4.17	0.25	141.75	51740.27
Milk and eggs	227.67	13.65	7745.45	2827088.40
Other	9.50	0.57	323.20	117967.82

In Tables 3.6, 3.7, 3.8 and 3.9, the percentage of each food groups for a regular diet was calculated. It can be said that fruits and vegetables take a crucial place in the diet of Syrians with 40.36 percent, where it is followed by cereals 28.13 percent. Although, in the Syrian diet, the share of fish consumption is extremely low, which composes only 0.25 percent of the daily food consumption.

As a developing country, it is projected for Syria to show a regular increase in the future population according to the WorldBank estimations. However, while the population will reach 34,021,000 in the 2050s, it can be concluded that Syria will face with difficulties in feeding this expanding population, which is almost twofold of the current number (Tables 3.6, 3.7, 3.8 and 3.9). Moreover, while the demand on each food group will be almost doubled by 2050 not only the impacts of war, but also climate changes are anticipated to restrict the country to fulfil the demand of Syrian people in the future. Therefore, it is projected that imports will rise continuously by 2050, if a new creative solution for the food and agriculture industries is not found.

3.3 Comparison of calculated food demands to available production in Syria

In the previous section, the required amounts of major food groups were calculated. In this section, the availability of the food and the potential of Syria are analyzed. As an important note, these calculated values were only food based, not for animal feeding, seeding or any other industrial utilization. Additionally, losses during transportation, processing or storing were not included to the calculations. These values show ordinary food requirement for nutritional purpose.

3.3.1 Cereal products

The official data states the total major cereal production (wheat, barley, millet and maize) of the country was 3898400 tons at 2010 (FAOSTAT, 2018). According to the calculations in the present study, this amount only for feeding people would be enough for meeting the cereal demand of the country almost until 2020. However, around 3077825 tons of cereal were imported in 2010, where the exported cereal of the same year is at a negligible value. The amount of export might be due to the other requirements such as animal feeding, seeding, etc. It could also be due to the maize demand as fodder in the growing poultry industry. Although, since the required amount of cereals is 3241807.36 tons for 2020, it can be deduced that the import value of the country will raise gradually if Syria does not enhance its cereal production.

Moreover, the general cereal import data of Syria depicts that the import quantity has increased notably for wheat and barley between 2007 and 2009 (Table 3.10), which were the years a disastrous drought took place in the country (FAOSTAT, 2018). Therefore, it is estimated that the foremost problem of the country is the shortcomings in the production infrastructure such as being highly dependent on rainfalls, that lead to fluctuations in the annual output. For reducing the impacts of climate on the agricultural production, irrigated lands should be enlarged, where only 65% of all cereals relied on the irrigation systems before the war (ACAPS and MapAction, 2013).

Table 3.10 Import of cereals between 2006 and 2011 (ton) (FAOSTAT, 2018)

Year	Wheat	Maize	Barley	Millet	**Total**
2006	154728	1345956	414921	0	**1915605**
2007	44569	1406477	9092	154	**1460292**
2008	261312	1009167	1193698	113	**2464290**
2009	1661053	1926527	594472	174	**4182226**
2010	1045243	1918514	112795	1273	**3077825**
2011	540494	1495036	378804	3236	**2417570**

In the realm of marketing, the storing and processing of wheat, in 2006, there were 33 operating government-controlled mills with 2 million tons of total annual milling capacity. There were also 25 private mills available in Syria with a similar production capacity (Koopman, 2013). Therefore, it is estimated that the overall milling capacity can meet the demand of Syria for the next 30 years. However, after the war, the Syrian Government should support the private sector for the rehabilitation and maintenance of the damaged plants.

3.3.2 Starchy roots

Potato is the most produced starchy root in Syria, which enjoys comparative advantages, urges the export volume of the country. The total production of potato in 2011 was around 713000 tons. According to the present calculations, this amount will be sufficient even for supplying the demanded amount for the next 30 years, which is calculated as 635370.53 tons for 2050. However, the country should focus on improving the supporting services of this crop, providing the required amount of seeds in time with fair prices and boosting the yield due to the limited possibility of horizontal growth (Alammouri, 2008).

Additionally, the quality of the potato seeds also plays a critical role in increasing productivity, since the mean yield can be increased from 30 to 50 percent with the use of good quality seed (Wang, 2008).

The two primary quality indicators of potato are biological quality and commercial quality (appearance attributes). While commercial quality has an impact on the price of seed, decreased level of infection and physiological age of seed tubers are the two aspects of biological quality, which increase the productivity (Wang, 2008). Therefore, improving food security and productivity through high-quality seeds will expand the production and export volume of Syria.

3.3.3 Pulses, nuts and oil-crops

The total production amount for pulses, nuts and oil-crops is 478900 tons according to FAO data for 2010 (FAOSTAT, 2018). According to the calculated results, the required quantity for 2030 is 479121.39 tons. Even though this amount seems numerically enough for the demand, Syria imported nuts, pulses or oil-crops in the past. This can be considered as an indicator for the requirement of a specific type of food product, such as pistachio and walnut. Details are discussed in the following topics.

i) Nuts

In Syria, the most widely produced nuts are almonds, pistachios and walnuts, with a production amount of 73100, 57500 and 12100 tons, respectively at 2010 (CBSS, 2017). According to FAOSTAT records while Syria exports almond, imports pistachio and walnut (FAOSTAT, 2018). However, Syria is one of the important pistachio producers in the world.

During the war, because of the shortage of electricity and high diesel prices, a large number of pistachio trees has been cut down for firewood (Dost, 2015). When it is taken into consideration that pistachio trees can generally begin bearing from the fourth or fifth year of its age-yet a good amount of yield is harvested after its seventh or eighth year- (Malhotra, 2008); it can be concluded that Syria will need a period of time for producing the pistachio in the same capacity as it was in the 2000s, even if they are replaced with the same number of trees.

After the war, during the planting process of pistachio trees, pollination should take notice by planting suitable pollinators in the orchards in the ratio of one male for eight females (Baysan, 2001). Additionally, as walnut and pistachio trees are wind pollinated, yield amount dependent on speed and direction of seasonal winds (Rafati et al., 2014; Krueger, 2000). Therefore, when weather conditions are restricting the pollination, artificial pollination can also be applied for increasing productivity, which is based on flowing the pollens onto trees through machines. For reducing the costs, pollen may be diluted in other substances, such as flour, powdered milk, etc., which can be easily obtained and inexpensive (Pinillos and Cuevas, 2008). Studies performed in Iran show that a traditional form of artificial pollination by generating an artificial wind had a significant impact on the productivity of pistachio trees. For artificial pollination, the applied method was the collection of the pollens of male flowers and mixing it with flour in a ratio of 1 to 3. Later, the mixture was dispersed in the air, that enabled to bring the pollens closer to female trees. Also, the generation of an artificial wind with a 3-meter fan resulted in favorable outcomes and increased the yields up to 1.5 tons in a 3000 m^2 area (Rafati et al., 2014). This study can be put into practice in Syria too for better yields.

Unlike walnut and pistachio, the almond production is dependent on pollination by bees (Goodrich and Goodhue, 2016). This information underlines the importance of adoption of the practices for protecting honey bees and training farmers on what type of pest control methods should be used during bloom. They also should be encouraged to plant bee fodders close to almond orchards before and after almond bloom.

Also, for supplying the required demand of the expanding population of Syria, various strategies should be developed for increasing the crop yield. For instance, in Syria, the primary requirement to increase the yield is growing modern irrigation systems, as the cultivation of pistachio, almond and walnut trees are dependent upon water and the yields are affected in dry years (Baysan, 2001). Studies point out that irrigation treatment may increase the yield of a pistachio tree more than twofold in weight. However, it should be noted that irrigation does not affect fruit quality (Jain et al., 2000).

On the other hand, according to the research of Goldhamer (1993), mature pistachio trees are more tolerant of water stress between the time interval that the shell expands and initiation of kernel development. Therefore, water usage can be reduced by 50% during this period and this will save about 25% of water and decrease irrigation expenses (Kirnak et al., 2001).

Moreover, in Syria, which is one of the major pistachio producers, high prices for local pistachios restrains it to compete with Iran, Turkey, Afghanistan and the United States in the international market. Besides, there are no standards in sizing; shelling, and grading for Syrian pistachios, they are all controlled by hand (Giles and Dalati, 2005).

So, Syrian producers should apply mechanization in processing, which will have an impact on the improvement of Syrian pistachio exports in the global market.

ii) Pulses

The Central Bureau of Statistics of Syria (CBSS) data illustrates that the total amount of pulses (legumes) of Syria was 174800 tons in 2010. According to the data of the cropped area and the volume of production for legumes between 2006 and 2010, while the harvested area in the country had been nearly constant, output fluctuated considerably (CBS, 2011). It can be concluded that productivity depends on the rainfall, that increases in wet years and drives a decline in dry years (Mawlawi and Tawil, 1990). This demonstrates the importance of adopting modern irrigation systems one more time, which will help the productivity to remain at a stable level.

Pulses have also been used in crop rotations for decades with the purpose of supplying nitrogen to non-legume plants and reduce the need for nitrogen fertilizers (Leikam et al., 2007). They do not only improve the physical properties of soil, but also increase the yields, reveal more considerable biodiversity, break pathogen cycles and result in reduced pesticide inputs (Watson et al., 2017). In order to enjoy the advantages of crop rotation, farmers should be fostered to implement this process and trained to acquaint with the benefits of it widely.

According to the research of Mawlawi and Tawil (1990), the main objectives should be followed for overcoming with limited legumes production are as the following:

1. Cultivating varieties with a high yield of seed and biomass potential, well-characterized disease resistance and suitably adapted to local conditions.

2. Cultivating seeds suitable for mechanical harvesting.

3. Cultivating chickpea seeds ideal for sowing in winter.

iii) Oilcrops

According to FAO data, the only oilcrops of the country are soybean, cotton and sesame and their production amounts were 91400, 49200 and 20800 tons, respectively at 2010 (FAOSAT, 2018). However, due to the limited information about oilcrops, the production conditions could not be evaluated.

3.3.4 Fruits and vegetables

Fruits and vegetables are crucial for the Syrian market and their total production amount was around 7246000 tons in 2011 (CBSS, 2017). If Syria can reach these production numbers when the war ends, this number will meet the country's needs until the mid of 2030-2040s. However, Syria should take steps for addressing the fruit and vegetable requirements of the forecasted growing population, which is calculated as 7569367.57 tons for 2040. One of the steps to be followed could be increasing the fruit and vegetable harvested lands, which were 13540 m^2 and 48378965 m^2, respectively between the years of 2010 and 2011 (CBSS, 2017). When the rainfall amount and other conditions are neglected, it is estimated that around 15% increase in the harvested area will cover the needs of the country in the 2050s.

3.3.5 Vegetable oils

FAO data illustrates that the main vegetable oils consumed and produced in Syria are olive oil and sunflower oil, where the production amount in 2011 was 208329 and 9400 tons, respectively (FAOSTAT, 2018). Before the war, Syria made little foreign trade in olive oil. It did not import any olive oil and its export numbers were very small. Besides, the country was importing sunflower oil to satisfy the needs of domestic consumption. The imported amount of sunflower was around 124963 tons in 2011, which is quite higher than the production amount (FAOSTAT, 2018). According to the calculations, the required amount for vegetable oils was calculated as 242905.31 tons for 2020. In the light of these findings, one could say that Syria will continue importing sunflower oil since there is a large gap between of the produced and imported quantity and it will not be logical to expect the country to close this gap. Therefore, the most crucial step after the war would be focusing on the constraints of the olive oil sector at least for meeting the olive oil requirements in the future.

The most important constraints of the Syrian olive oil sector are insufficient labor availability for olive harvesting, inadequate quality control for marketing standards in foreign trade, the lack of effective branding, olive cultivars have problems in chemical quality, 50% of the oil mills are press and awareness among the local consumers is low (Brillante et al., 2007).

In 2009, the number of olive oil processing plants was 1066 in Syria, with 6700 (ton/8 hr) daily capacity (Table 3.11) (International Olive Council, 2012). This number of plants will enable Syria to process 1608000 tons of olive, which is calculated with the following equation:

$$\frac{6700 \text{ tons}}{\text{day}} \times \frac{5 \text{ days}}{1 \text{ week}} \times \frac{48 \text{ weeks}}{1 \text{ year}} = \frac{1608000 \text{ tons}}{\text{year}}$$

When it is assumed that 5 kg of olive yields 1 kg of olive oil with a 1/5 ratio, this number of plants can produce about 321200 tons of olive oil in a year. Therefore, it is estimated the olive plant capacity of Syria will be sufficient for satisfying the olive oil demand of the country by 2050s.

Since olive growing in Syria is centred in the southern and western regions like Aleppo, Idleb, Lattakia, Daraa and Rural Damascus (International Olive Council, 2012), the plants should be located around these areas. This will facilitate access by suppliers and distributors.

Table 3.11 Olive oil plants in Syria, 2009 (International Olive Council, 2012)

		Number of Plants	Production Capacity (t/8 hr)
Extraction Type	Continuous-Process	756	5450
	Press Mills	310	1250
	Total	1066	6700

Even though the number of plants in the country was sufficient, there were many issues within the sector such as improper procedures for post harvesting and processing, limited mill and wholesaler sizes, lack of modern containers and absence of business linkages between processors and farmers (Fiorillo and Vercueil, 2003).

It is estimated that there is a high potential for improving the quality in case the country adapts strategies to overcome these challenges (Brillante et al., 2007). The primary approach for the sector could be upgrading milling plants with improved storage conditions and a grading system complies with international and external market standards (Wattenbach, 2006). This will enable Syria to expand into new markets and enhance the competitiveness of olive oil exports.

Also, one of the most fundamental practices affecting the oil quality is picking the optimal harvest period. For achieving the best timing, the main indicators such as the weight of fruit, chance in oil compound content, organoleptic condition and fruit drop should be observed and analyzed (International Olive Council, 2007).

Even though manual harvesting productivity is relatively low, 6-20 kg/h, almost the whole production of olives is done by hand, since the labor force cost is considerably low in Syria (Abdine et al., 2007). However, manual harvesting often damages the fruit and decreases the quality of the oil (International Labor Organization, 2014). A study carried out for assessing the effects of the olive harvesting systems on oil quality shows that the best results regarding organoleptic parameters of oil were achieved with mechanically harvested olives (Abenavoli and Proto, 2015). Even though this study demonstrates the importance of the use of mechanical techniques, farmers might not afford to invest in the new technology. In this case, they should be trained for efficient picking techniques. Therefore, the primary goal of the olive oil sector should be responding to the demand by producing high-yields of olive and raising the awareness for adopting new mechanization systems, modern techniques and economical practices.

3.3.6 Animal fats

Due to the limited information regarding this subject, the animal fats data of the country could not be evaluated. According to the calculations, the demanded amount was 67921.39 tons for 2020 as a near future.

3.3.7 Meat

The total meat production of Syria is given in Table 3.12 and the total amount in 2010 was about 421142 tons (FAOSTAT, 2018), which excludes consumption of offals. It was estimated for this amount to meet the requirements of the country until the mid-2020s. However, Syria will encounter shortcomings in satisfying the meat demand in the future as it is calculated as 511494.45 tons for 2030. Moreover, for meat, aside from the calculations, it is expected the per capita consumption is likely to increase as incomes of people grows (Bahhady et al., 1998).

Table 3.12 Meat production in Syria, 2010 (FAOSTAT, 2018)

Type of Meat	Production (ton)
Chicken	189,745
Sheep	153,197
Cattle	61,599
Goat	12,928
Bird nes	1,9
Camel	750
Buffalo	616
turkey	235
Goose and Guinea Fowl	72
Rabbit	52
Duck	48
Total	**421,142**

Shomo et al. (2010), states that despite the rapid increase in the number of sheep, the ratio of output to input remained low in the country. Addition to this, the poultry industry was suffering from high market prices due to the high cost of fodders. As poultry meat production had significantly increased in the last ten years of Syria, just prior to the war, Syria was self-sufficient for poultry meat production and had a surplus for export. However, the sector is anticipated to face competition with imported frozen chicken meat in the local market due to the high prices of domestic product and unsuitable transportation, conserving and slaughtering methods, which are causing health risks. Therefore, after the war, in order to turn into advantage its geographical location in the crossroad between Europe and Asia and highly importing Gulf markets, the livestock sector should be monitored closely and more attention should be paid for reducing the production cost of chicken meat (Al-Hamwi and Lancon, 2011).

According to Cummins (2000), “the ability of the Syrian livestock sector to meet the domestic demand for livestock products will depend on its ability to intensify production and improve the quality of its animals”.

The study of Shomo et al., 2010 points out the various ways for improving the efficiency in sheep production:

1. It has been found that flock size is an essential factor in sheep production. Studies show that technical efficiency is the highest in large flocks for the transhumance

system, though for migratory and sedentary systems small flock has shown higher efficiency.

2. Since the technical efficiency of traditional systems (migratory and transhumance) is lower than more intensive systems (semi-sedentary and sedentary), sheep producers should be encouraged to shift to semi-sedentary and sedentary systems.

3. Flock health issues such as low fertility and high abortion rates and mortality of lamb should be addressed by providing enhanced veterinary services.

4. Water resources and market infrastructure should be developed by providing feeding technologies with improved genotypes.

Moreover, overgrazing of the large population of sheep in dry regions causes land degradation (Baghasa, 2006a). Therefore, while the sector is being supported for growth, it should be balanced with measures for maintaining agricultural and environmental sustainability.

3.3.8 Fish

Syrian fishery production in 2010 was estimated as 15245 tons (from aquaculture 56%) (Encyclopedia Britannica, 2014). This amount is considerably lower than the required amount for consumption even for 2020, which is calculated as 28780.25 tons.

The major constraints of the fishery industry in Syria are stated as limited available resources, exploitation of demersal assemblages, lack of government support to small-scale fisheries and unwillingness of fishers to practice modern methods. Moreover, the fisheries are having the deficiency of being monitored and supported by governmental bodies specified for this sector even though there are two governmental bodies established for this aim (the Department of Fisheries and the General Establishment of Fisheries) (Villegas, 1983).

When the imports - exports table and the self-production amount of Syria (Table 3.13) is taken into consideration, it can be deduced that there is a need for urgent action for reviving the fishery sector.

Table 3.13 Imports and exports of fishery products in Syria, 2007-2010 (tons in live weight) (FAO, 2012)

	2007	2008	2009	2010
Imports (tons)	42,411	41,085	59,891	58,684
Exports (tons)	268	226	628	137

Based on the FAO report published for improving the quality of fishery products and market chains in Asia, the main steps that should also be followed in Syria can be enumerated as (FAO, 2013):

1. Government support should be provided for enhancing productivity and product marketing.

2. For the improvement of hygiene, product quality and nutritional value, a cold chain should be adopted and trainings provided to small and medium enterprises on hygiene and sanitation techniques.

3. Sanitary conditions and poor facilities of the fish markets and landing centers should be enhanced for improving the standards and value of fishery products.

4. Basic awareness should be raised for enhancing the water quality for reducing risks from contaminated water. Quality of water needs to be monitored regularly.

5. Government regulations should be set for product safety and implemented for management of landing sites and fish markets and they should be regularly monitored.

3.3.9 Milk and eggs

The milk production in Syria was mainly supplied by dairy cattle farms with small and micro units; these are scattered all around the country. Besides, there was a small number of states and collective farms in addition to the private pilot farms established most recently, which were providing only 10-15% of the total milk production in Syria (Fayad, 2009).

The small traditional dairy farms were accompanied by two main constraints: the collection, low productivity and quality. Due to the distance from well-equipped collection centers, around 80-90% of the produced milk is collected by traders called

Hallab, who store and transport the collected milk in primitive and unsanitary conditions. As the milk sector of Syria was being led by Hallabs, most of them adulterated the milk for covering the defects of their products, which ended up with low quality dairy products in Syria. These practices also decreased the prices and made the products processed with good quality standards impossible to compete with them (Fayad, 2009). It can be concluded that the development of the dairy industry with an efficient location and production capacity will play an important role not only in the economy of Syria but also for the health of the local people.

Plant capacity means the highest amount that can be produced per unit of time and for a factory planning the milk marketing, capacity is quite essential financially, i.e. setting the response rate, pricing. For example, excessive plant capacity might result in decreased prices for stimulating the demand, excess stocks, underutilized staff and low profit (Marin et al., 2011).

According to the given table (Table 3.14), the total milk production of Syria in 2007 was around 2588554 tons/year, which is equal to 2588554000 litres/year (Fayad, 2009). Using these numbers, the dairy plant demand of the country was calculated. For these calculations, the daily capacity of the plant is considered as 5000 litres per day, five working days/week and working 48 weeks in a year. This is equal to 1020000 litres/year annual capacity. Because it is not practical to presume a plant to run full capacity in a year-around, the operating capacity of plants is calculated at 85 percent, which is equal to 1020000 litres/year.

$$\frac{5000\ litres}{day} \times \frac{5\ days}{1\ week} \times \frac{48\ weeks}{1\ year} = 1200000\,\frac{litres}{year}$$

According to the following calculations for processing the same total milk production in 2007, 2588554 tons/year, 2537 dairy plants will be fulfilling the demand. However, due to the current situation of Syria, where the livestock sector has been severely influenced by the conflict, reduction in the supply is considered and the required number of plants were calculated for a decline by 60% in the supply (Table 3.15).

$$\frac{2588554000\ litres}{year} \times \frac{year}{1020000\ litres} = 2537\ plants$$

Table 3.14 Milking livestock (heads): by type; by variety; by milk production and average yield, 2007 (ton/year) (Fayad, 2009)

Type and Variety	Qty	Milk (ton)	Yield (ton)
Local cattle	42751	33535	785
Shami cattle	877	1986	2264
Improved cattle	547207	1447935	2646
Foreign cattle	54604	222402	4072
Total sheep	15700000	873000	55
Total goat	1064000	96967	91

Table 3.15 Estimation of required plant number in Syria

Percentage of Reduction in Supply	Produced milk (lt/year)	Required number of plants (operating with 85% capacity)
10%	2329698600	2284
20%	2070843200	2030
30%	1811987800	1776
40%	1553132400	1523
50%	1294277000	1269
60%	1035421600	1015

One of the critical points in planning the dairy industry is allocating plants near to sources for bearing on the profitability of the dairy and initial quality of the milk, minimizing the transportation cost and increasing the profit. For that reason, following factors should be considered in selecting the area: accessibility of raw material, market and labor, water supplies and its quality, transportation facilities, climatic and environmental conditions of the area including direction of prevailing wind and possible increase in dust and smoke nuisance from the neighbour, market potential and volume of power and fuel (Patel and Bhadania, 2016). In the past, the large-scale industrial processing used to be limited to the three state factories of Damascus, Aleppo and Homs. However, since the farms are located in the rural areas of Damascus, Aleppo, Hama, Homs, Lattakia, Al Hassakeh and Deir Ez-Zor (Fayad, 2009), it will be viable to construct plants in Hamma, Lattakia, Al Hassakeh and Deir Ez-Zor, too, to reduce the transportation cost.

Moreover, the egg production in 2007 was calculated as 170000 tons (in shells) (Subuh, 2008). If Syria can reach the same amount of production in 2007 for milk and egg, 2758554 tons, it will meet the demand by the end of the 2040s. The calculations also indicate that the country can cope with the milk and needs of expected population growth -which is calculated as 2827088.40 tons of milk and egg in 2050- with a relatively small effort in the sector.

3.4 Modified values for actual requirement

The required amount of food calculations was focused on the average daily supply per capita. However, these numbers do not illustrate the amount of food consumed actually because of over-consumption or waste by the human, variability in consumptions varying within regions of a country or between different socio-demographic subgroups in the population. Addition to these factors, food components are also used for feeding animals. Therefore, the actual values were calculated for food in Table 3.16 according to the following formula:

$$Actual\ Value = \frac{Theoretical\ Value}{0.70}$$

In the equation, 0.70 was used as a correction factor, except for animal feeding.

Table 3.16 Actual values for the required amount of food for 2020, 2030, 2040 and 2050 (tons/year)

Year	2020		2030		2040		2050	
Type of food	Theoretical Value	Actual Value	Theoretical Value	Actual Value	Theoretical Value	Actual Value	Theoretical Value	Actual Value
Cereals (excl. beer)	3241807.36	4631153.37	4558127.79	6511611.12	5276074.03	7537248.61	5828024.11	8325748.72
Starchy roots	353421.47	504887.81	496926.57	709895.10	575196.99	821709.99	635370.53	907672.18
Sweeteners	594024.36	848606.23	835225.12	1193178.74	966780.61	1381115.16	1067919.19	1525598.84
Pulses, nuts, oilcrops	340758.16	486797.37	479121.39	684459.12	554587.33	792267.61	612604.81	875149.72
Fruit and vegetables	4650888.40	6644126.29	6539359.47	9341942.10	7569367.57	10813382.24	8361227.77	11944611.10
Vegetable oils	242905.31	347007.59	341535.85	487908.36	395330.83	564758.33	436687.89	623839.84
Animal fats	67921.39	97030.56	95500.55	136429.35	110542.74	157918.21	122107.04	174438.63
Meat and offals	363782.36	519689.09	511494.45	730706.36	592059.44	845799.20	653997.02	934281,46
Fish and seafood	28780.25	41114.64	40466.33	57809.05	46840.15	66914.49	51740.27	73914.67
Milk and eggs	1572552.86	2246504.09	2211080.45	3158686.36	2559345.57	3656207.95	2827088.40	4038697.71
Other	65618.97	93741.39	92263.24	131804.63	106795.53	152565.05	117967.82	168525.45

3.5 Effect on interrelated industries

The food industry is additionally related to other industries such as machinery, energy, water supply, irrigation, R&D, repairing, spare parts etc. Among these industries, machinery and energy (fuel, electricity) and water supply are the most important. After the crisis, when Syria starts the re-development and re-investment periods, food machinery industry will play an important role. Therefore, local and/or import food machinery will be very strategic.

Additionally, energy (fuel, electricity) and water supplies will be other strategic issues. Especially, industrial zones for food plant investment should have energy and water supplies. Therefore, a master plan will be required for the food industry of Syria.

CHAPTER 4

CONCLUSION

In Syria, there will be an estimated 12 million more people to feed by 2050 and this forecasted increasing population is expected to result in resource scarcity and a rising demand for food. Syria will need to show a considerable effort to satisfy the requirements of the country which resulted not only from destructed agricultural infrastructure but also climate changes and financial incapabilities. However, when the high level of social and economic dependence on agriculture of Syria is considered, agricultural development will help to recover the devastated economy of the country.

The findings of this research indicate that Syria will be highly dependent on imports in the future. To close this gap there is a need for investments in agricultural and food researches for determining the best practices for improvement in productivity. Based upon the acknowledgments of this research, after the end of the conflict the most crucial steps that should be taken by the Syrian government are listed:

- For sustainability of water resources and stability and enhancement of the productivity Syria should adopt modern technologies in irrigation.

- It was observed that even though there are many governmental bodies for the control of many sectors, there is a lack of governmental monitoring in the production areas. Therefore, it is essential to increase monitoring, controlling and inspections by the governmental bodies.

- Since agriculture takes the first place in terms of water consumption in Syria and total renewable water resources per capita are considered at a high water stress level, it is vital to provide trainings to farmers over the importance of water resources for the future of Syria.

- Most of the work at the farming level is carried out manually due to the low labor costs, which is impacting the quality of the products poorly. Syrian farmers should be encouraged and supported to adoption appropriate technologies.

- For reviving the agricultural sector, the government should respond to the needs of farmers and industrialists with short-term budget supports for rehabilitation of the damaged or destroyed infrastructure, agricultural equipment and plants.

- Since the fishery sector is considered to be one of the most promising agricultural activities, serious attention should be paid for reviving that sector.

- To maintain the agricultural productivity at a constant level, it is essential to prevent the rural and urban income disparities which will prevent migration from rural to urban areas.

- The food industry will be a more critical industry for Syria similar to other arid countries and it should be supported for the food security of Syria.

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