Virtual Water and Food Trade - Yarmouk Tributary to the Jordan River

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1. Abstract

In water scarce countries, and with increase of pressure on water resources and climate change challenges especially in terms of drought, understanding the virtual water trade concept and strategy is important for formulating informed policies for improving water use efficiency at different levels. It is crucial understand the virtual water food trade on the basin level in order to be able to develop a management plan that takes into consideration the agricultural potential, water resources and other environmental factors, market potential as well as the socio-economic aspects. The main objective of this study is to detail the extent that food production and food trade relates to water resources use in the transboundary Yarmouk basin between Syria and Jordan. The specific objectives are to quantify and qualify food trades and virtual water patterns in both countries and downscale it to the Yarmouk basin level, explore potential export market, and recommend scenarios for a management plan for food trade.

The methodology consists of identification of local food production and quantification of the related virtual water volumes from land cover land use maps and the agricultural water use. Second, a quantification and qualification of food imports and exports for Syria and Jordan as well as food production is required to get the virtual water flows. Data is then downscaled from country level to the Yarmouk basin level taking into consideration the agricultural area and population within the basin. Then, based on the export market potential of the country, the water resources and the socio-economic factors, different scenarios for virtual water trade are proposed taking into consideration land productivity, water scarcity and water resources threshold and its implications on food security, and the market mechanism and the scarcity of water resources.

The study showed that the net virtual trade in the Syrian part of the Yarmouk basin is about 19 Million m^3/year while in the Jordanian part it is about 573 Million m^3/year obviously setting Jordan as a net importer of virtual water (mainly through cereals and meat). This is helping Jordan reduce the pressure on the water resources in this water-scarce country and this can further be improved by improving food trade policies. With the declining water resources in Syria as well, it is important that it starts adopting some externalization of the water footprint by reducing the production of high water consuming crops and producing more cash crops that have low footprint such as cumin, pistachio and olive oil.

Including virtual water trade analysis in drafting national water policy plans is very important. Virtual water trade should be encouraged to promote water savings for arid countries and at global level through enhancing food security by appropriate agreements and increasing reciprocity in agricultural products trade. Knowing the national virtual water trade balance is essential for developing a rational national policy with respect to virtual water trade. It is clear that further research should be carried out to study the natural, social, and economic implications of using virtual water trade as a strategic instrument in water policy.

2. Introduction

One of the major indicators of water deficit in a country is the level of its food imports. The reason food imports are such a strong indicator of water deficit is that the water used in agriculture to grow the food is the major consumptive use of water. Water used in the agricultural sector may exceed by ten times the water used by the industrial and municipal sectors combined.

With increase of pressure on water resources and climate change challenges especially in terms of drought, virtual water imports is a way to address such challenges in the Yarmouk tributary basin. Understanding the virtual water trade concept and strategy is important for formulating informed policies for improving water use efficiency at different levels (El Sadek 2010). For water-scarce countries, achieving water security by importing water-intensive products could be a more attractive option compared to producing all water-demanding products domestically (Hoekstra and Hung 2005).

Therefore, it is crucial understand the virtual water food trade on the basin level in order to be able to develop a management plan that takes into consideration the agricultural potential, water resources and other environmental factors, market potential as well as the socio-economic aspects. Virtual water food trade management plans are informed decisions taken by informed policymakers and such strategic plan can for example help substituting water demanding irrigated crops by imported rainfed ones, thus alleviating the pressure on water resources. It is important that such the objectives and interests of such strategy should meet national water resources plan whenever they exist.

The main objective of this study is to detail the extent that food production and food trade relates to water resources use in the transboundary Yarmouk basin between Syria and Jordan. The specific objectives are to quantify and qualify food trades and virtual water patterns in both countries and downscale it to the Yarmouk basin level, explore potential export market, and recommend scenarios for a management plan for food trade.

3. Literature Review

3.1. Virtual Water Trade

Allan who defined it as the volume of water required to produce a commodity or service introduced the term ‘virtual water’ in the early 1990s (Allan 1993, Hoekstra 2008). When there is a transfer of products or services from one place to another, there is little direct physical transfer of water (apart from the water content of the product, which is quite insignificant in terms of volume). There is however a significant transfer of virtual water. From a country’s perspective, Haddadin (2003) has defined this water also as ‘exogenous water’.

As water is quite a bulky item to transport, trading water in its actual form is costly, which is where the concept of virtual water appears especially in food trade. Virtual water trade is not new; it is as old as food trade. However, it is not referred to as virtual water trade unless there is a conscious

decision and related policy to import low value but high water consuming food such as cereals. International trade in food commodities has been shown to save water; thus food trade is an important element of both food and water security in water-scarce regions (Hoekstra, 2003; Chapagain et al. 2006; Hanjra and Qureshi 2010; Fader et al. 2011; Konar et al. 2012). In addition, food trade could contribute to global water savings if food is exported by countries with a higher water productivity than the countries of import (Konar et al., 2012). The concept and quantitative estimates of virtual water can help to realistically assess water scarcity for each country, projecting future water demand for food supply and thus increasing public awareness on water and identifying water wasting processes in production (Oki and Kanae 2004).

Hence, to promote water savings and enhance food security, virtual water trade should be encouraged. Such decisions cannot be taken in isolation but rather through fair trade agreements that takes into considerations the strategies and policies of other countries. Any policy related to virtual water trade necessitates and understanding of the impact and interactions of virtual water trade on the local socio-economic and environmental conditions (WWF 2014). For example, on way to contribute to water saving via virtual water is a shift in dietary habits. There is ample evidence in the scientific literature about dietary recommendations that address both health and environmental sustainability, among which the EAT Lancet[1] has emerged with specific dietary recommendations of each of the food groups. The EAT-Lancet diet suggests substantial dietary shifts where the global consumption of fruits, vegetables, nuts, and legumes will have to almost double, and consumption of foods such as red meat and sugar will have to be reduced by more than 50% (Willet et al. 2019). Another example is also the Mediterranean diet which also land itself as a healthy yet environmentally sustainable diet (Naja et al. 2018). As such, it is important to highlight the virtual water content through water footprints to increase water awareness among population and this may lead water savings.

3.2. Water Footprint

The water footprint of a nation is an indicator of water use in relation to the consumption volume and pattern of the people. As an aggregated indicator it shows the total water requirement of a nation, a rough measure of the impact of human consumption on the natural water environment (Allan 2001, Hoekstra 2008, Hoekstra et al. 2011).

The water footprint has three components: green, blue and grey. Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by any vegetation (i.e. trees, grass). It is particularly relevant for agricultural, horticultural and forestry products. Blue water footprint is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated

[1] The EAT-Lancet report is the first full scientific review of what constitutes a healthy diet from a sustainable food system, and which actions can support and speed up food system transformation: https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf

agriculture, industry and domestic water use can each have a blue water footprint. Grey water footprint is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources (Mekonnen and Hoekstra 2011).

Together, these components provide a comprehensive picture of water use by delineating the source of water consumed, either as rainfall/soil moisture or surface/groundwater, and the volume of fresh water required for assimilation of pollutants.

More information about the precise components and characteristics of the total water footprint will be needed, however, before one can make a more balanced assessment of the effects on the natural water systems. For instance, one has to look at what is blue versus green water use, because use of blue water often affects the environment more than green water use. Also it is relevant to consider the internal versus the external water footprint. Externalizing the water footprint for instance means externalizing the environmental impacts. One has to realize that some parts of the total water footprint concern use of water for which no alternative use is possible, while other parts relate to water that could have been used for other purposes with higher added value. There is a difference for instance between beef produced in extensively grazed grasslands of Botswana (use of green water without alternative use) and beef produced in an industrial livestock farm in the Netherlands (partially fed with imported irrigated feed crops) (Hoekstra and Chapagain, 2006).

3.3. Situation of Virtual Water and Food Trades in Syria and Jordan

About 1.6 million people live in the Yarmouk basin and together with climate change challenges and drought risks, there is the inevitable pressure on water resources that required long-term planning, and effective cooperation if tensions are to be reduced. This pressure on water resources is also due to intensification of agriculture irrigated from groundwater or surface water (particularly within Syria on the Hauran Plain, within Jordan in the Jordan River Valley, in addition to sub-optimal infrastructure and very poor water governance (YHPB, 2018). In a rational world, the shortcomings might be addressed through technological innovation, demand-management (rather than supply-management) shifts in agricultural policy (beyond the irrigation efficiency of ‘crops per drop’ to allocative efficiency of ‘dollars per drop’, and consideration of food (or ‘virtual water’) imports), or the re-negotiation of transboundary water treaties. However, such policies would oblige decisions that could be politically suicidal.

The scramble to satisfy water demand through ever-greater exploitation means that the Jordan River basin in 2018 is not just “closed”, in the hydrological sense (Swatuk 2008), but effectively sealed shut (YHPB, 2018). Any image of the basin in 2070 under ‘business as usual’ comprises evermore redundant and overlapping infrastructure continuing to push at the tensions and sustainable limits of the resource. A preferable reality would result from serious engagement with the alternatives: wastewater re-use, demand-management, shifts in agricultural policy, and re-

negotiation of transboundary water treaties leading to more equitable and sustainable transboundary water arrangements.

The country is a large net virtual water importer (among the top 30 in the world in 1995-1999 period). The total WF of Jordan's consumption in the period 1996–2005 is estimated at 8.3 billion m^3/year, of which 6.7 billion m^3/year is virtual water import. With virtual water import being more than six times larger than virtual water export, Jordan is a large net virtual water importer. Jordan obtained a national water savings of 7.1 billion m^3/year through trade in the period 1996–2005. This is the volume of water that would have been required had Jordan produced all imported commodities itself (Hoekstra 2003, Schyns et al. 2015). This is vital information to understand the economy of Jordan, but economists easily remain blind for this because there is no real but virtual water trade and because water scarcity is not factored into the price of commodities and thus invisible to economists (Hakimian 2014, Hoekstra 2017). Haddadin (2003) demonstrated that it is cheaper for Jordan to import food than to grow it under irrigated conditions; but such a straightforward conclusion could be misleading because the other economic and social benefits from agriculture are not accounted for in the comparison of the cost of indigenous and exogenous waters.

On the other hand, Syria was known to have good water resources and almost self-sufficiency in crops, it was classified among the top 30 net virtual exporters of water between 1995 and 1999 (Hoekstra 2003). However, with the increase on pressures on its water resources, the increase in population and food demands, the climate change in addition to the recent war and crisis that started in 2011 and the international pressures on its trades, it is shifting to become a net virtual importer. Unfortunately, there has been no virtual water studies for Syria as there was for Jordan. Therefore, it is important to quantify and understand of its virtual water trade related to food in order to inform strategies of the cropping plans and develop the right policies.

4. Methodology

In order to better analyze the food trade and virtual water in the Yarmouk tributary basin it is important to first identify local food production and quantify the related virtual water *volumes*. This includes the use of land cover land use maps and other existing data to determine the agricultural areas and the agricultural water use based on the local conditions. Second, a quantification and qualification of food imports and exports for Syria and Jordan as well as food production is required to get the virtual water *flows*. As this data is available at country level, it will be downscaled to the Yarmouk basin level taking into consideration the agricultural area and population within the basin. Finally, based on the export market potential of the country, the water resources and the socio-economic factors, different scenarios for virtual water trade are proposed taking into consideration land productivity, water scarcity and water resources threshold and its implications on food security, and the market mechanism and the scarcity of water resources.

4.1. Land use and cover, and population

Land Use Cover (LUC) maps was established (Figure 1) below was built from ESRI base maps of GEOEYE 2011 (50 cm resolution) at a scale of 1: 20,000, with thirteen different classes and was presented in the Hydro-political baseline study of the Yarmouk Basin that was done in 2018 (YHPB, 2018). The different classes of the LUC were realized through intensive visual interpretation of the satellite images over a period of five months, and spot-checked with field observation in Jordan with approximately 97% accuracy.

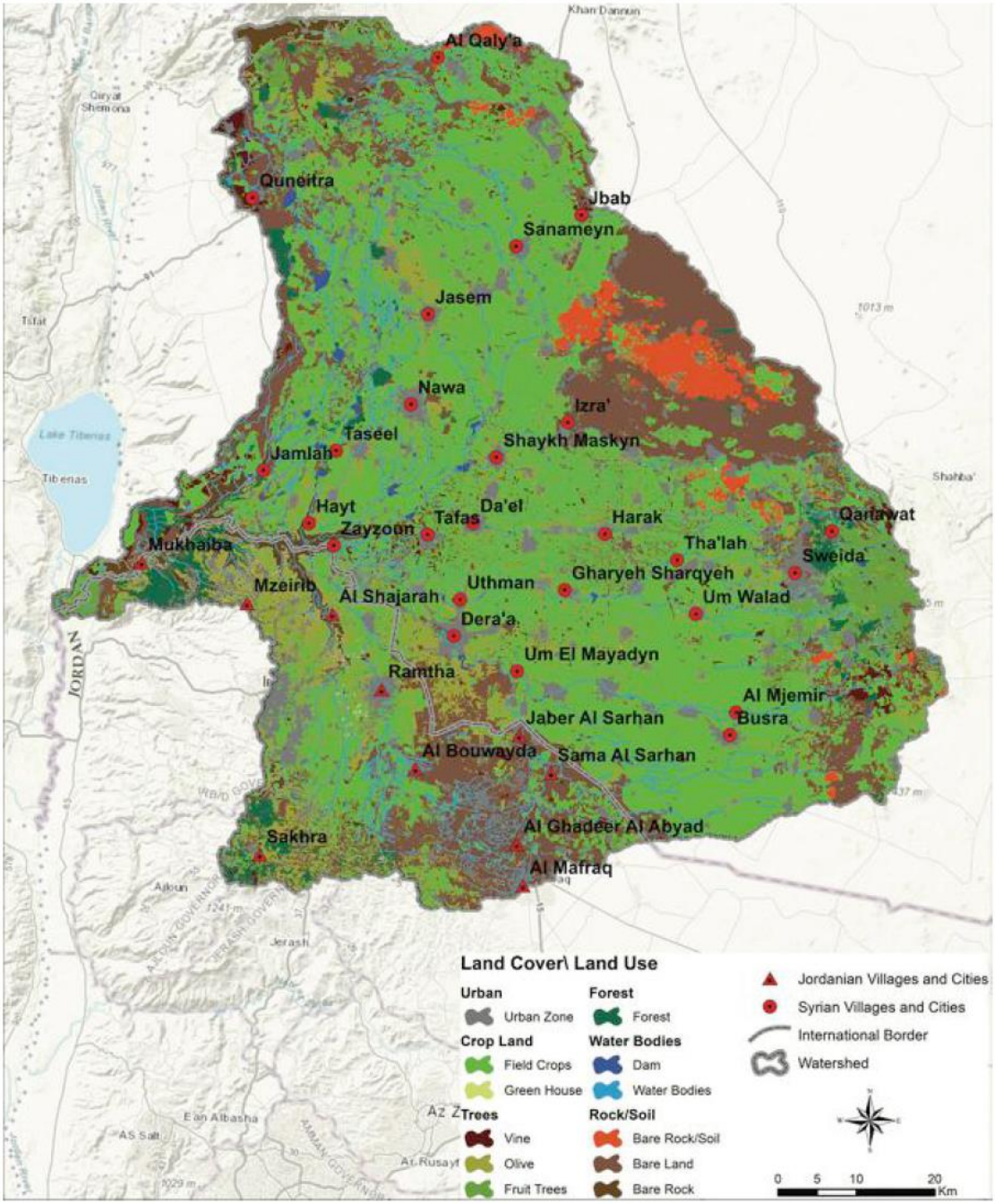

Figure 1: Land Use Cover Map (1:20,000) - GEOEYE 2011 for the Yarmouk Basin

As presented in the Hydro-political baseline report of the Yarmouk Basin (YHPB 2018), the area of the basin is 7,360 km^2 based on SRTM - DEM of 30m resolution estimated Yarmouk tributary basin.

The LUC map of the basin shows that the Jordanian part of the basin constitutes about 19% of the watershed area, while the Syrian part is roughly 81%. In the Jordanian part, crops (including field crops and vegetables) occupy about 33% of the total area, while olives are 17% and trees only constitute 1% of the area (Figure 2). On the other hand, in the Syrian part, crops represent a bit more than half of the area (55%), olives 10%, fruit trees 2% and grapes about 1% of the area (Figure 3). There are about 35,000 hectares irrigated in the basin.

Area of JOR in Watershed (ha)	Total Area of Watershed (ha)	Percentage
140,846	736,027	19

Type	Area (Ha)
Bare land-rock	37,749
Crop	46,865
Forest	6,861
Fruit trees	1,936
Green House	479
Urban Zone	19,484
Vine	1,098
Olive	23,410
Water Bodies	198
Dams	19
Surface Flow	2,744
Undefined	3

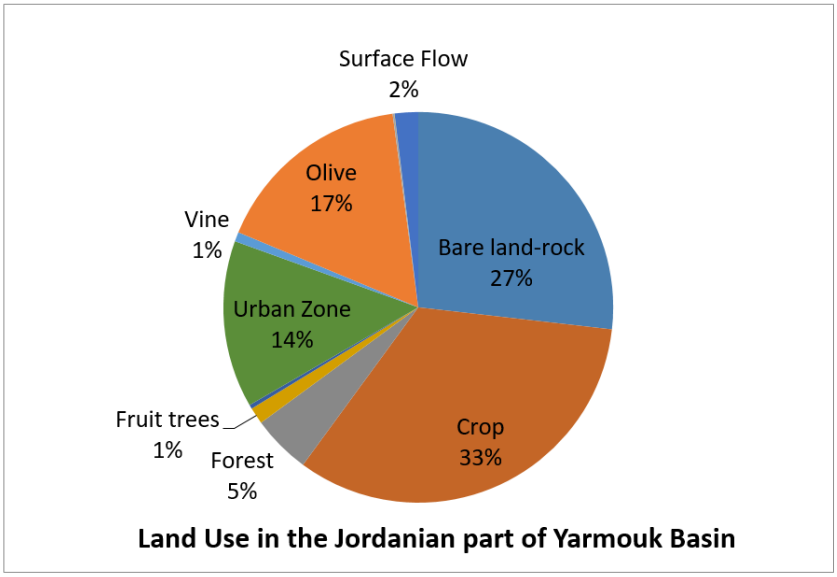

Figure 2: Estimated Land Use in the Jordanian Part of Yarmouk Basin in 2019-2020

Area of SYR inWatershed (ha)	Total Area of Watershed (ha)	Percentage
595,181	736,027	81

Type	Area (Ha)
Bare land	127,527
Crop	324,502
Forest	10,012
Fruit Trees	9,063
Green House	95
Olive	57,461
Urban Zone	48,350
Vine	7,955
Water Bodies	372
Dams	2,143
Surface Flow	7,482
Undefined	219

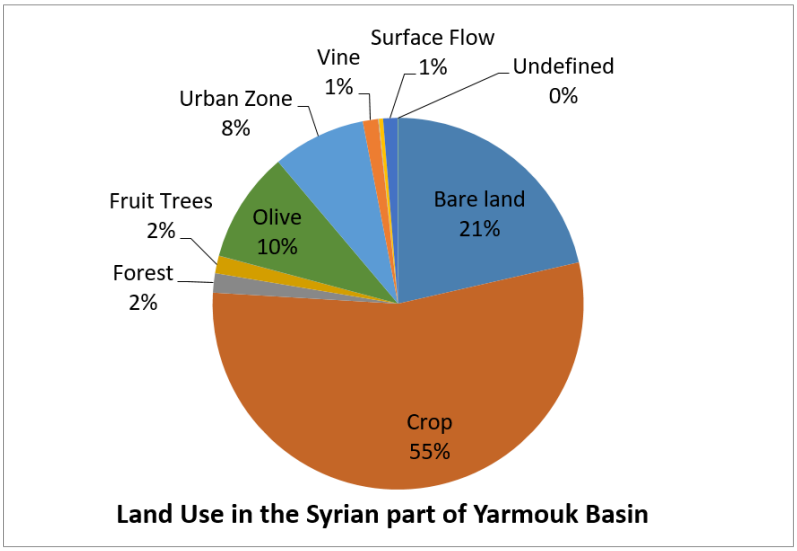

Figure 3: Land Use in the Syrian Part of Yarmouk Basin in 2019-2020

From these land-use results, the agricultural area was calculated in order obtain the share of the Yarmouk basin of the total cultivated areas in Jordan and Syria. These areas and percentages are shown in Table 1 below.

Table 1: Area of cultivated lands in the Yarmouk basin (source FAO Aquastat 2008 and Land Use Map of 2019-2020)

Country	Total Area of the country (Km^2)	Total Cultivated Area in the country (ha)	Total Cultivated Area in the Yarmouk Basin (ha)	% of cultivated area in basin out of total
Syria	185,180	4,730,000	399,076	8.4%
Jordan	89,342	270,000	73,788	27.3%

On the other hand, the very roughly estimated percentage of population living within the Yarmouk Basin is to downscale import data from country to basin level as this reflects the consumption directly presented in Table 2 below and will be used related to import of food.

Table 2: Percentage of populations living within the Yarmouk Basin in year 2014 (source: YHPB, 2018)

Country	Total Population	Population in Yarmouk Basin	% of population in basin out of total
Syria	16,900,000	519,273	3.1%
Jordan	9,970,000	1,080,000	10.8%

4.2. Food trade and virtual water flows

The food imports and exports of Syria and Jordan are available at the national level through the FAO Stat database and the International Trade Center (ITC) database. For this study, several food

groups were selected to be included in this study namely: Edible vegetables and certain roots and tubers, edible fruits and nuts, cereals, and oil seeds and oleaginous fruits. In addition, meat and animal products (including eggs, cheese, milk, honey, etc.) were included in the study as they constitute a major part of the food trade and virtual water flows.

This study considered 5 years of data from 2014 to 2018 (Annex A include all data). Food production data was acquired for the FAO Stat database for the same period.

On the other hand, the water footprint of the different crops was acquired from Water Footprint Network Assessment tool, which splits the water footprint (WF) into blue water, green water and gray water. This Water Footprint Assessment is a four-phase process that quantifies and maps green, blue and grey water footprints. The data collected come from global databases, such as WaterStat, or collected locally. The calculations for the green, blue and grey water footprint follow the methodology described in the Water Footprint Assessment Manual (Hoekstra et al., 2011). After collecting these data, the WF of each crop was calculated in cubic meters per ton by dividing the yearly water volumes by the production. This provides the WF of the local products which should be considered when calculating the exporting water flows. However, for imported crops, global WF averages were used (Zimmer and Renault, 2003; Hoekstra and Chapagain, 2006; Hoekstra 2008; Naja, et al., 2018). In some cases, and when data was available in the literature, a comparison and validation was done to verify the WFs (Shtull-Trauring et al., 2016; Lee et al., 2019; Mourad et al., 2019).

All the data on food trade and virtual water are available at the national level. In order to downscale it to the basin two approaches were considered. For export, downscaling was done based on the land use areas in the basin compared to the country. While for imports, the downscaling was done based on population share in the basin which is a better indicator on how much of the imports (food) reached the basin and eventually was consumed by the population.

As presented in the previous report, the total population in the basin is about 1.6 million with about 519,273 people living in the Syrian part of the basin (401,427 in Dera'a, 66,566 in As Suwayda, and 51,280 in Al Quneitra. In addition, the population within the Jordanian part was estimated to be roughly one million in 2015 (MOLA 2014, 2015 Census).

4.3. Food trade maps and potential scenarios

In order to develop a management plan for the food trade in a country, it is important not only to consider the water footprints and virtual water trade, but also analyze the food trade maps and explore the potential export markets. Food trade map provides indicators on export performance, international demand, alternative markets and competitive markets. The analysis of present export markets helps examining the profile and dynamics of export markets for any product, assessing the value, size and concentration of exports and highlight countries where market shares have increased. This analysis together with the water footprint assessment helps defining different scenarios for virtual water trade of a country or basin and hence are the basis to develop a strategic plan. Such strategic plan can for example help substituting water demanding irrigated crops by

imported rainfed ones, thus alleviating the pressure on water resources. It is important that such the objectives and interests of such strategy should meet national water resources plan whenever they exist.

5. Results and Discussion

This section presents the results of this study in terms of trade data of the major food group selected, as well as their related water footprint. In addition, food trade maps for different food categories are detailed along with the export potential indicators and the product diversification indicator, which identifies new products with favorable chances of export success in regional and global markets. A discussion of these results and potential scenario for changes in virtual trade is presented to guide policymakers with decisions related to food trade in the basin.

5.1. Market Data

The International Trade Center (ITC) in Geneva compiles data on import and export for over 220 countries. The average import, export and re-export data of Jordan for five years period (2015-2019) is presented in Table 3 below. Jordan is known to be a transit country especially to Saudi Arabia, Iraq and Syria, this is why re-export is a main component in its food trade and should be removed from the total import and exports when looking at virtual water trade. Only domestic exports (produced in Jordan and then exported) should be considered. The table below show the trade data for selected food categories including crops and animal products, there are considered the main food groups for the analysis of virtual water trade. It is important to mention that some industrial products or other non-food products may have very high water footprint however they do not fall under the scope of this study and this is ok to omit, as Jordan is not a big industrial producer.

From Table 3, we may note that the main imports of Jordan are cereals (wheat, maize, rice and barley) with over 2.8 Million tons per year followed by meat (120,361 tons/year), dried leguminous vegetables (61,191 tons/year) and fruits trees such as apples (55,272 ton/year) and citrus fruits (47,356 tons/year each). On the other hand, Jordan is a main exporter of local tomatoes with over 312,118 tons/year followed by poultry products (eggs) with 166,891 tons exported per year. Exports of other vegetables (cabbages, lettuce, cucumber and other vegetables) also constitute a major export with about 173,913 tons/year. Apricot export is also important for Jordan with over 68,368 tons exported per year.

It is important to note that the data in acquired from UN Comtrade where imports are recorded CIF (cost insurance and freight) while exports are FOB (free on board). This may create a difference of up to 10%. Despite all efforts made by national and international agencies, data quality may vary among countries. For a given country, imports are usually recorded with more accuracy than exports because imports generally generate tariff revenues while exports don't. At a detailed level, a same good may be recorded in different categories by the exporter and the importer.

Table 3: Trade Data for crops and food items in Jordan, averages from 2015-2019. Source: UN Comtrade

	Code	Product label	Import (Tons)	Export (Tons)
			Avg (2015-2019)	Avg (2015-2019)
02 Meat and edible meat offal	'0201	Meat of bovine animals, fresh or chilled	15,390	23
	'0202	Meat of bovine animals, frozen	18,639	2,144
	'0204	Meat of sheep or goats, fresh, chilled or frozen	23,221	53
	'0206	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, ...	1,249	223
	'0207	Meat and edible offal of fowls of the species Gallus domesticus, ducks, geese, turkeys and ...	61,773	7,656
	'0208	Meat and edible offal of rabbits, hares, pigeons and other animals, fresh, chilled or frozen ...	60	244
	'0210	Meat and edible offal, salted, in brine, dried or smoked; edible flours and meals of meat or ...	29	-
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ..	'0401	Milk and cream, not concentrated nor containing added sugar or other sweetening matter	17,878	24
	'0402	Milk and cream, concentrated or containing added sugar or other sweetening matter	28,453	60
	'0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk and ...	7,311	788
	'0405	Butter, incl. dehydrated butter and ghee, and other fats and oils derived from milk; dairy ...	3,877	20
	'0406	Cheese and curd	24,703	6,290
	'0407	Birds' eggs, in shell, fresh, preserved or cooked	14,632	166,891
	'0408	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in ...	529	5
	'0410	Turtles' eggs, birds' nests and other edible products of animal origin, n.e.s.	3	7
07 Edible vegetables and certain roots and tubers	'0701	Potatoes, fresh or chilled	27,329	2,553
	'0702	Tomatoes, fresh or chilled	8	312,118
	'0703	Onions, shallots, garlic, leeks and other alliaceous vegetables, fresh or chilled	15,435	332
	'0704	Cabbages, cauliflowers, kohlrabi, kale and similar edible brassicas, fresh or chilled	19	22,329
	'0705	Lettuce "Lactuca sativa" and chicory "Cichorium spp.", fresh or chilled	14	39,130
	'0706	Carrots, turnips, salad beetroot, salsify, celeriac, radishes and similar edible roots, fresh	9,393	56
	'0707	Cucumbers and gherkins, fresh or chilled	12	43,942
	'0708	Leguminous vegetables, shelled or unshelled, fresh or chilled	277	1,873

	'0709	Other vegetables, fresh or chilled (excluding potatoes, tomatoes, alliaceous vegetables, edible ...	307	68,512
	'0710	Vegetables, uncooked or cooked by steaming or boiling in water, frozen	8,177	81
	'0711	Vegetables provisionally preserved, e.g. by sulphur dioxide gas, in brine, in sulphur water	30	9
	'0712	Dried vegetables, whole, cut, sliced, broken or in powder, but not further prepared	624	2
	'0713	Dried leguminous vegetables, shelled, whether or not skinned or split	61,191	807
	'0714	Roots and tubers of manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and similar	486	42
08 Edible fruit and nuts; peel of citrus fruit or melons	'0802	Other nuts, fresh or dried, whether or not shelled or peeled (excluding coconuts, Brazil nuts ...	11,138	62
	'0803	Bananas, incl. plantains, fresh or dried	33,603	5
	'0804	Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried	18,269	5,002
	'0805	Citrus fruit, fresh or dried	47,356	4,375
	'0806	Grapes, fresh or dried	3,205	618
	'0807	Melons, incl. watermelons, and papaws (papayas), fresh	17	47,846
	'0808	Apples, pears and quinces, fresh	55,272	401
	'0809	Apricots, cherries, peaches incl. nectarines, plums and sloes, fresh	2,394	68,368
	'0810	Fresh strawberries, raspberries, blackberries, back, white or red currants, gooseberries and ...	9,909	4,539
	'0811	Fruit and nuts, uncooked or cooked by steaming or boiling in water, frozen, whether or not ...	1,114	1
	'0813	Dried apricots, prunes, apples, peaches, pears, papaws "papayas", tamarinds and other edible ...	377	12
10: Cereals	'1001	Wheat and meslin	1,091,362	16
	'1003	Barley	761,420	-
	'1004	Oats	116	-
	'1005	Maize or corn	760,612	121
	'1006	Rice	191,676	6
	'1007	Grain sorghum	1,436	-
	'1008	Buckwheat, millet, canary seed and other cereals (excluding wheat and meslin, rye, barley, ...	1,968	13
12 Oil seeds and	'1201	Soya beans, whether or not broken	236	24
	'1202	Groundnuts, whether or not shelled or broken (excluding roasted or otherwise cooked)	9,942	58
	'1206	Sunflower seeds, whether or not broken	8,523	189

	'1207	Other oil seeds and oleaginous fruits, whether or not broken (excluding edible nuts, olives, ...	35,188	140
	'1213	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form ...	35,463	46
	'1214	Swedes, mangolds, fodder roots, hay, alfalfa, clover, sainfoin, forage kale, lupines, vetches ...	58,932	12
Others	'1215	Olive	40	3,400
	'1216	Olive oil	10	575
	'1217	Pistachio	3,115	170

For Syria, the trade data available is for years 2015 to 2019, as shown in Table 4. These are expected to be considerably lower than the pre-war period due to restrictions of food trade, reduced population due to displacements among others. Table 4 shows the average import and export data of Syria between 2015 and 2019 for the selected food categories and products. The top import is cereals with a total of 587,344 tons per year (approximately 2.2M tons less than Jordan as Syria produces a lot of cereals as well). Potato is also a major import with about 100,000 tons per year. In terms of exports, these recent years, apples are exported largely (76,845 tons/year) followed by olive oil with about 40,300 tons exported per year in addition to some tomatoes and legumes. Two major potential crops were added to this table: pistachio and cumin. These two crops will be discuss in the following sections for the potential export and relatively reduced water footprint.

Table 4: Trade Data for crops and food items in Syria, averages from 2015-2019. Source: UN Comtrade

	Code	**Product label**	**Import (Tons)**	**Export (Tons)**
			Avg (2015-2019)	**Avg (2015-2019)**
02 Meat and edible meat offal	'0202	Meat of bovine animals, frozen	1,750	44
	'0204	Meat of sheep or goats, fresh, chilled or frozen	18	-
	'0206	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, ...	44	1
	'0207	Meat and edible offal of fowls of the species Gallus domesticus, ducks, geese, turkeys and ...	18,156	117
	'0208	Meat and edible offal of rabbits, hares, pigeons and other animals, fresh, chilled or frozen ...	-	1
	'0210	Meat and edible offal, salted, in brine, dried or smoked; edible flours and meals of meat or ...	13	-
04 Dairy produce; birds' eggs; natural honey; edible products	'0401	Milk and cream, not concentrated nor containing added sugar or other sweetening matter	5,512	26
	'0402	Milk and cream, concentrated or containing added sugar or other sweetening matter	19,762	76
	'0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk	148	2,399
	'0405	Butter, incl. dehydrated butter and ghee, and other fats and oils derived from milk; dairy ...	2,589	67
	'0406	Cheese and curd	1,553	2,906

	'0407	Birds' eggs, in shell, fresh, preserved or cooked	20,910	-
	'0408	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in ...	32	-
	'0410	Turtles' eggs, birds' nests and other edible products of animal origin, n.e.s.	10	-
07 Edible vegetables and certain roots and tubers	'0701	Potatoes, fresh or chilled	98,395	8,829
	'0702	Tomatoes, fresh or chilled	43,295	16,879
	'0703	Onions, shallots, garlic, leeks and other alliaceous vegetables, fresh or chilled	19,462	5,594
	'0704	Cabbages, cauliflowers, kohlrabi, kale and similar edible brassicas, fresh or chilled	236	8,039
	'0705	Lettuce "Lactuca sativa" and chicory "Cichorium spp.", fresh or chilled	162	524
	'0706	Carrots, turnips, salad beetroot, salsify, celeriac, radishes and similar edible roots, fresh ...	7,366	12,382
	'0707	Cucumbers and gherkins, fresh or chilled	1,793	2,139
	'0708	Leguminous vegetables, shelled or unshelled, fresh or chilled	491	3,118
	'0709	Other vegetables, fresh or chilled (excluding potatoes, tomatoes, alliaceous vegetables, edible ...	4,017	10,731
	'0710	Vegetables, uncooked or cooked by steaming or boiling in water, frozen	135	95
	'0711	Vegetables provisionally preserved, e.g. by sulphur dioxide gas, in brine, in sulphur water	984	4,489
	'0712	Dried vegetables, whole, cut, sliced, broken or in powder, but not further prepared	232	81
	'0713	Dried leguminous vegetables, shelled, whether or not skinned or split	49,098	19,778
	'0714	Roots and tubers of manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and similar ...	30	10
08 Edible fruit and nuts; peel of citrus fruit or melons	'0803	Bananas, incl. plantains, fresh or dried	37,373	28
	'0804	Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried	7,608	6,820
	'0805	Citrus fruit, fresh or dried	11,246	14,174
	'0806	Grapes, fresh or dried	3,208	1,203
	'0807	Melons, incl. watermelons, and papaws (papayas), fresh	2,749	326
	'0808	Apples, pears and quinces, fresh	32,775	76,845
	'0809	Apricots, cherries, peaches incl. nectarines, plums and sloes, fresh	7,010	14,511
	'0810	Fresh strawberries, raspberries, blackberries, back, white or red currants, gooseberries and ...	8,497	12,909
	'0811	Fruit and nuts, uncooked or cooked by steaming or boiling in water, frozen, whether or not ...	27	83
	'0813	Dried apricots, prunes, apples, peaches, pears, papaws "papayas", tamarinds and other edible	264	299
10: Ce	'1001	Wheat and meslin	233,913	7,269

	'1003	Barley	64,679	-
	'1004	Oats	17	
	'1005	Maize or corn	194,572	2
	'1006	Rice	92,628	69
	'1007	Grain sorghum	253	-
	'1008	Buckwheat, millet, canary seed and other cereals (excluding wheat, meslin, rye, barley,)	1,282	2
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit;	'1201	Soya beans, whether or not broken	16,023	9
	'1202	Groundnuts, whether or not shelled or broken (excluding roasted or otherwise cooked)	-	57
	'1206	Sunflower seeds, whether or not broken	4,446	20
	'1207	Other oil seeds and oleaginous fruits, whether or not broken (excluding edible nuts, olives, ...	8,643	4,854
	'1212	Locust beans, seaweeds and other algae, sugar beet and sugar cane, fresh, chilled, frozen or ...	465	1,538
	'1213	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form ...	1,029	-
	'1214	Swedes, mangolds, fodder roots, hay, alfalfa, clover, sainfoin, forage kale, lupines, vetches ...	519	600
Others	'1215	Olive	-	487
	'1216	Olive Oil	2,500	40,300
	'1217	Pistachio	9,800	3,750
	'1218	Cumin	41	8,167

5.2. Water Footprint and Virtual Water in Yarmouk Basin

The water footprint assessment followed Hoekstra et al. (2011) methodology to consider green, blue and grey water footprints and the production quantities for each crop. This assessment was used to calculate the "local" water footprint, which in the virtual water trade, is required to calculate virtual water exports, this also considers the local crop water requirement in the Yarmouk basin. For virtual water imports, global water footprint averages were used from literature as it is very difficult to get the imported water footprint of each crop which has to consider the local footprint of each of the countries from which this crop is imported. Since most of the crops are imported from several sources, the risk of error using global averages is reduced and is the best estimate for virtual waster imports. The detailed water footprint for each crop in cubic meter per ton and the total footprint are presented in Annex A for both Jordan and Syria.

Table 5 below shows the summary of total water footprint and the net virtual trade of food categories in Jordan. Cereals are the main virtual water import (~2.7 Billion m^3/year) followed by meat (~0.87 Billion m^3/year). Edible fruits and nuts and vegetables are the main virtual water export of Jordan with about 91 Million m^3/year. The total virtual water import for these crop categories is 5.81 Billion m^3/year and the virtual water export is 0.11 Billion m^3/year resulting in a 5.7 Billion m^3/year of net virtual trade for Jordan. Chapagain and Hoekstra (2003) reported that Jordan had a 4.5 Billion m^3/year net virtual import for the period of 1995-1999 with a virtual

import of 5.3 Billion m^3/year and 0.8 Billion m^3/year of virtual export. This increase in sue to the increased population as well as changes in climatic conditions.

Table 6 presents the water footprint per food category in Syria, also the main virtual imports are cereals, fruits and vegetables and the total of virtual water import of Syria is 1.42 Billion m^3/year while the main virtual exports are fruits and nuts and vegetables. The total virtual water export is 0.31 Billion m^3/year and the net virtual water trade is 1.1 Billion m^3/year. Syria use to export 5.26 Billion m^3/year in the late 1990s early 2000s (Chapagain and Hoekstra 2003). This decrease in virtual water exports is related to the post 2011 war period and all the political pressure and restrictions on Syria that came with it which forced Syria to try to achieve more food self-sufficiency.

It is important to note, that for the fruits and buts crop category, Syria is a net exporter (-33.5 Million m^3/year) mainly due to apple exports which have a higher footprint than the global average (1,191 vs. 700 m^3/ton).

*Table 5: Summary selection of Water Footprint per largest Food Category in **Jordan**. Refer also to Annex A.1. Source: trade data come from UN Comtrade and water footprint was calculated by authors based on method proposed by Hoekstra 2011.*

Food category	Import (Tons)	Export (Tons)	Total Water Footprint ('1000 m^3/year)		
	Avg (2015-2019)	Avg (2015-2019)	Imports	Exports	Net
02 Meat and edible meat offal	120,361	10,342	822,500	1,648	820,852
04 Dairy produce; birds' eggs; etc.	97,385	174,085	225,315	9,706	215,609
07 Edible vegetables and tubers	123,301	491,786	268,494	34,667	233,828
08 Edible fruit and nuts	182,654	131,229	248,074	51,763	196,311
10 Cereals	2,808,589	156	3,537,915	113	3,537,802
12 Oil seeds and oleaginous fruits	148,284	469	427,785	783	427,001
Other (Olive, Olive Oil, Pistachio)	3,165	4,145	35,716	12,534	23,182
Total	**3,483,739**	**812,211**	**5,565,799**	**111,214**	**5,454,585**

*Table 6: Water Footprint per Food Category in **Syria.** Refer also to Annex A.2. Source: trade data come from UN Comtrade and water footprint was calculated by authors based on method proposed by Hoekstra 2011.*

Food category	Import (Tons)	Export (Tons)	Total Water Footprint ('1000 m^3/year)		
	Avg (2015-2019)	Avg (2015-2019)	Imports	Exports	Net
02 Meat and edible meat offal	19,981	163	67,036	31	67,005
04 Dairy produce; birds' eggs; etc.	50,515	5,473	93,942	383	93,559
07 Edible vegetables and tubers	225,694	92,686	245,196	108,602	136,594
08 Edible fruit and nuts	110,758	127,197	92,142	125,720	(33,577)
10 Cereals	587,344	7,342	740,139	9,991	730,147
12 Oil seeds and oleaginous fruits	31,124	7,076	83,446	14,683	68,763
Other (Olive, Olive Oil, Pistachio, Cumin)	12,341	52,704	147,772	54,444	93,328
Total	**1,037,756**	**292,640**	**1,469,673**	**313,853**	**1,155,820**

The tables above presented the data at the national scale, in order to download it to the Yarmouk basin scale, population percentage (for imports) and cultivated area percentages (for exports) were used. For food imports, we considered that the food imported into the Yarmouk basin is 3.1% of total food imported to Syria (3.1% being the percentage of population from Syria living in the Syrian part of the Yarmouk Basin); and the food imported into the Jordanian part of the basin is 10.8% of the total food imported into Jordan. On the other hand, to estimate the amount of exports from the basin as a percentage of the total export of the country, we downscaled based on the cultivated area: the Yarmouk basin includes 8.4% of the total cultivated area of Syria, hence 8.4% of Syria's export are considered to be coming from the basin. It also includes 25.5% of the total cultivated area in Jordan; hence, 25.5% of Jordan's export originate from the basin. Table 7 shows that the net import of virtual water of the selected crop categories in the Syrian part of the basin is 45.6 Million m^3/year while this increases to 601.1 Million m^3/year in the Jordanian part of the basin. This high difference is related to the higher water footprint of imports in Jordan and the higher population in the Jordanian part of the Yarmouk basin. Although the net virtual water exports of Syria are three times higher than Jordan (314 MCM vs. 111 MCM), however, within the basin they are almost equal (26 MCM vs. 28 MCM) and this is because Jordan has about 25.5 % of its cultivated are located within the Yarmouk Basin while only 8.4% of Syria's cultivated area falls within the basin. The net virtual trade for the Syrian part of the basin is about 19 Million m^3/year while in the Jordanian part is about 573 Million m^3/year. In other words, Syria imports about 19 MCM/year of virtual water from the basin, and Jordan about 573 MCM/year. Although Syria has a higher population, but it does have much higher food production especially in terms of cereals (about 27% of Syria's cultivated land is planted with wheat and the production was 4.5 Million ton in 2020 while in Jordan it was only 24,000 tons (IndexMundi, 2020)) which is decreasing its overall virtual water trade.

Table 7: Total Water Footprint in Yarmouk Basin

Country	**Total Water Footprint ('1000 m^3/year)**		**Total Population**	**Population in Yarmouk Basin**	**Population % in Yarmouk Basin**	**Cultivated Area % in Yarmouk Basin**	**Virtual Water in Yarmouk Basin ('1000 m^3/year)**		
	Imports	**Exports**					**Import**	**Export**	**Net**
Syria	1,469,673	313,853	16,900,000	519,273	3.1%	8.4%	45,560	26,364	19,196
Jordan	5,565,799	111,214	9,970,000	1,080,000	10.8%	25.5%	601,106	28,360	572,747
						Total	**646,666**	**54,723**	**591,943**

5.3. Food Trade Maps for Different Food Categories

The trade maps of Figures 4 and 5 were developed for the different crop categories and are presented in the figures below as three main graphs/maps. The graphs on the right provide an indication of the prospects for diversification of suppliers for products imported or exported by the country. The trade maps in the middle of the figures present the list of supplying (or importing) markets for a product imported (or exported) by a country with different colors showing the share % in imports or exports. While the graphs on the left show the growth of national supply and international demand for products exported or imported by the country.

Figure 4 shows the food trade maps for vegetables and tubers (including tomato, cucumber and potato among others) for Jordan for 2020. Egypt represent over 25% of the shares of Jordan's imports. Other countries such as Russia and Spain are showing an increase in their annual growth of export to the world. On the other hand, it is noticed that Saudi Arabia is one of the major markets for Jordanian export with 85.2% of the export share: for example, Jordan exported 100% of its tomatoes export to Saudi Arabia (about 160,000 tons of tomatoes) (ICT Trade Map, 2020).

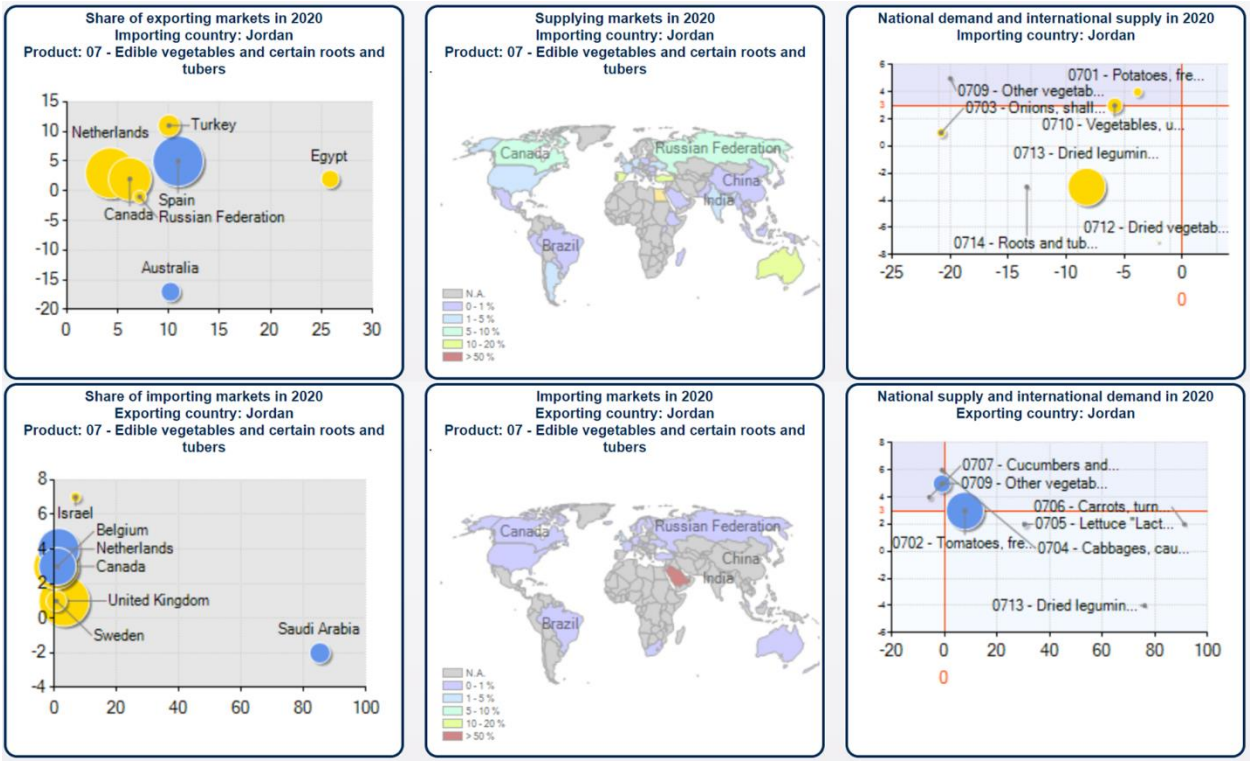

Figure 4: Food Trade Maps for Vegetables and Tubers in Jordan 2020. Source: https://www.trademap.org/Index.aspx

For Figures 4 to 7, here is the legend explanation (more details may be found here: https://www.trademap.org/Docs/TradeMap-Userguide-EN.pdf):

- Left graphs: The bubble size is proportional to the share in the world imports of partner countries for the selected product. Yellow color means the country's export growth to partner is less than the partner's import growth from the world. Blue color means the country's export growth to partner is more than the partner's import growth from the world
- Middle graphs: the colors of the map shows the different shares of import (or export) in %
- Right graphs: The bubble size is proportional to export/import value. Yellow colors means the country is a net importer for the selected product. Blue color means the country is next exporter for this product.

Another example of these maps is the trade map of fruits and nuts also for Jordan (Figure 5). This map shows that Jordan imports about 35% of its fruits and nuts from USA especially citrus and nuts such as almonds and the main export market is also Saudi Arabia where figs and apricots are

the main exported crops. United Kingdom is also a good market for fruits and nuts of Jordan (~11% of Jordan's export).

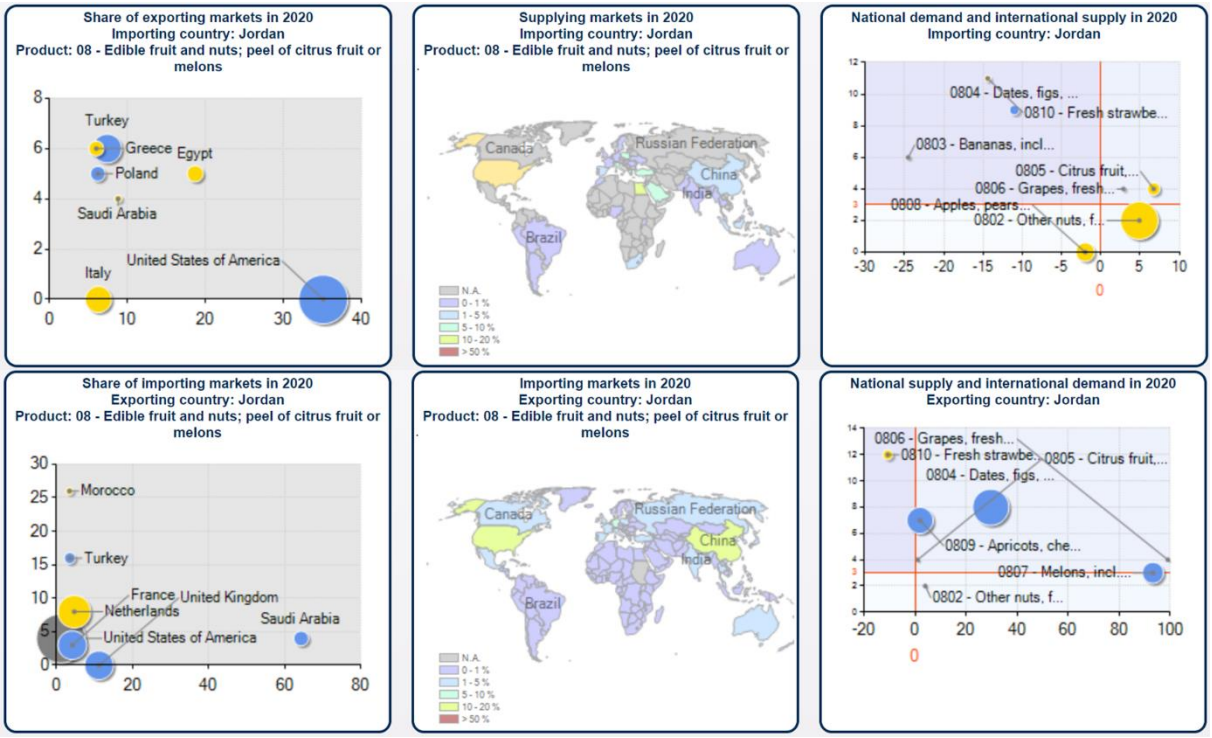

Figure 5: Food Trade Maps for Fruits and Nuts in Jordan 2020 Source: https://www.trademap.org/Index.aspx

Similarly, Figures Figure 5Figure 6 and Figure 7 shows the trade maps of vegetable and tubers and for dairy produce, eggs and honey for Syria during 2020. More maps for all food groups in Jordan and Syria are shown in Annex B.

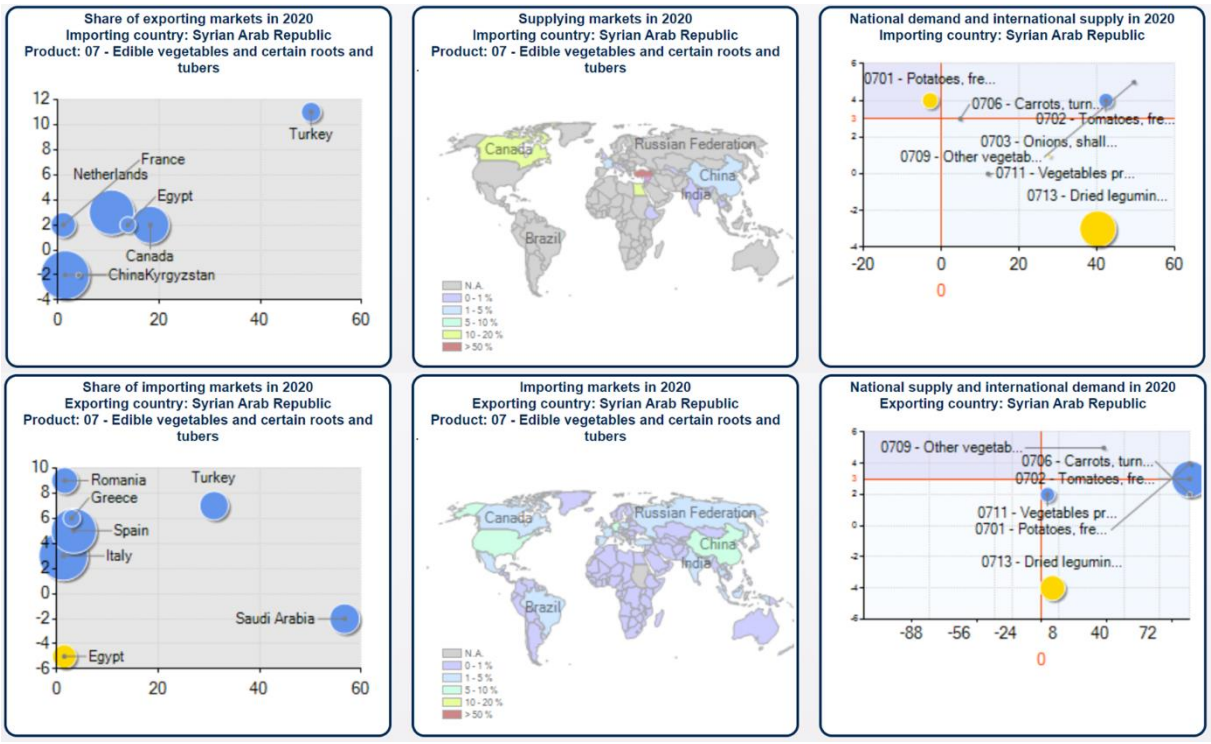

Figure 6: Food Trade Maps for Vegetables and Tubers in Syria 2020. Source: https://www.trademap.org/Index.aspx

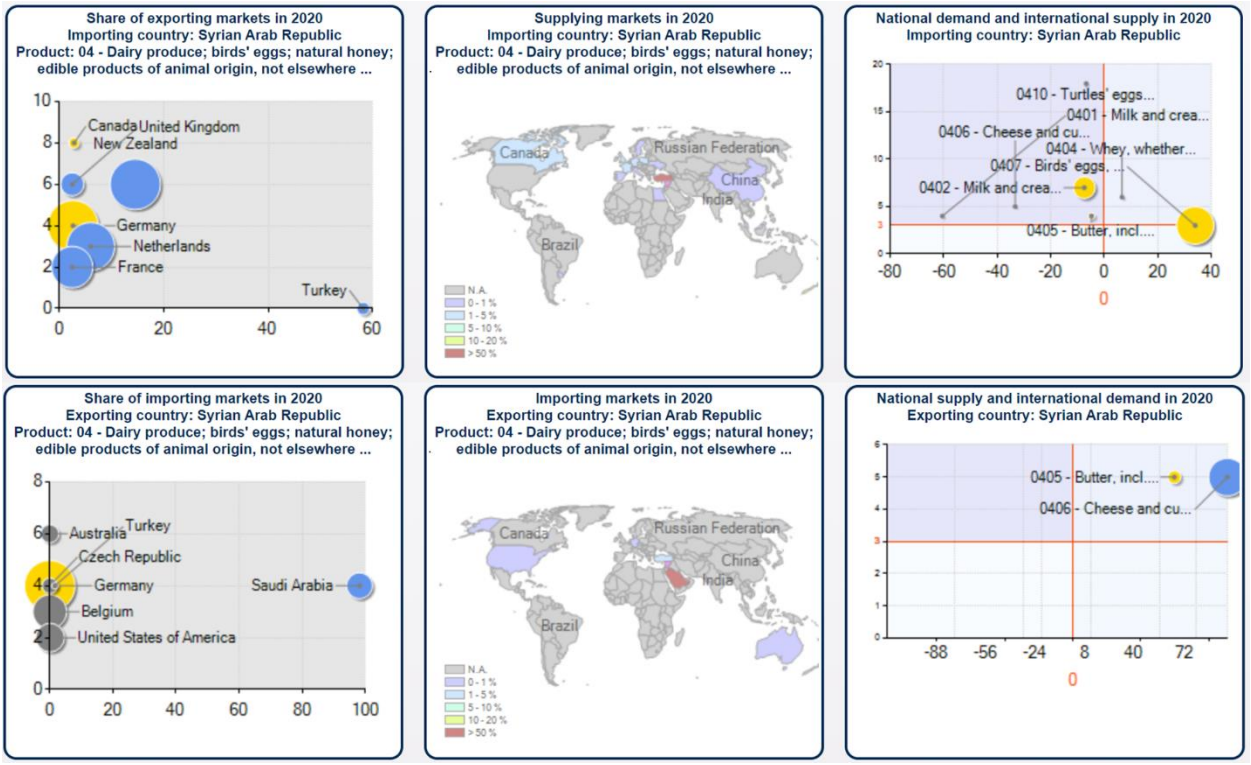

Figure 7: Food Trade Maps for Dairy produce, eggs & honey in Syria 2020. Source: https://www.trademap.org/Index.aspx

After examining and analyzing the food trade maps, export potential maps were developed. The Export Potential Map identifies products, markets and suppliers with (untapped) export potential as well as opportunities for export diversification for 226 countries and territories and 4,377 products. Based on the ITC export potential methodology (Decreux and Spies, 2016), which evaluates export performance, the target market's demand and market access conditions as well as bilateral links between the exporting country and target market to provide a unique ranking of untapped opportunities based on an economic model that draws on trade, tariff, GDP and geographic data. This methodology relies on two indicators to helps evaluate a country's potential to boost exports: (1) the Export Potential Indicator identifies markets that offer room for export growth in established export sectors; and (2) the Product Diversification Indicator identifies new products with favorable chances of export success in regional and global markets.

Figure 8 below shows the export potential indicator of Jordan for food crops and animal products. The different colors represent different food groups, the bigger the boxes, the higher the export market share. For each crop, the dark color represent the realized potential of the export market. For Jordan, it is obvious that vegetables constitute a big portion of the food export especially tomato with about 69% realized potential of export market. The Product Diversification Indicator in Figure 9 shows that tomato ranks first followed by other vegetables watermelon and dates.

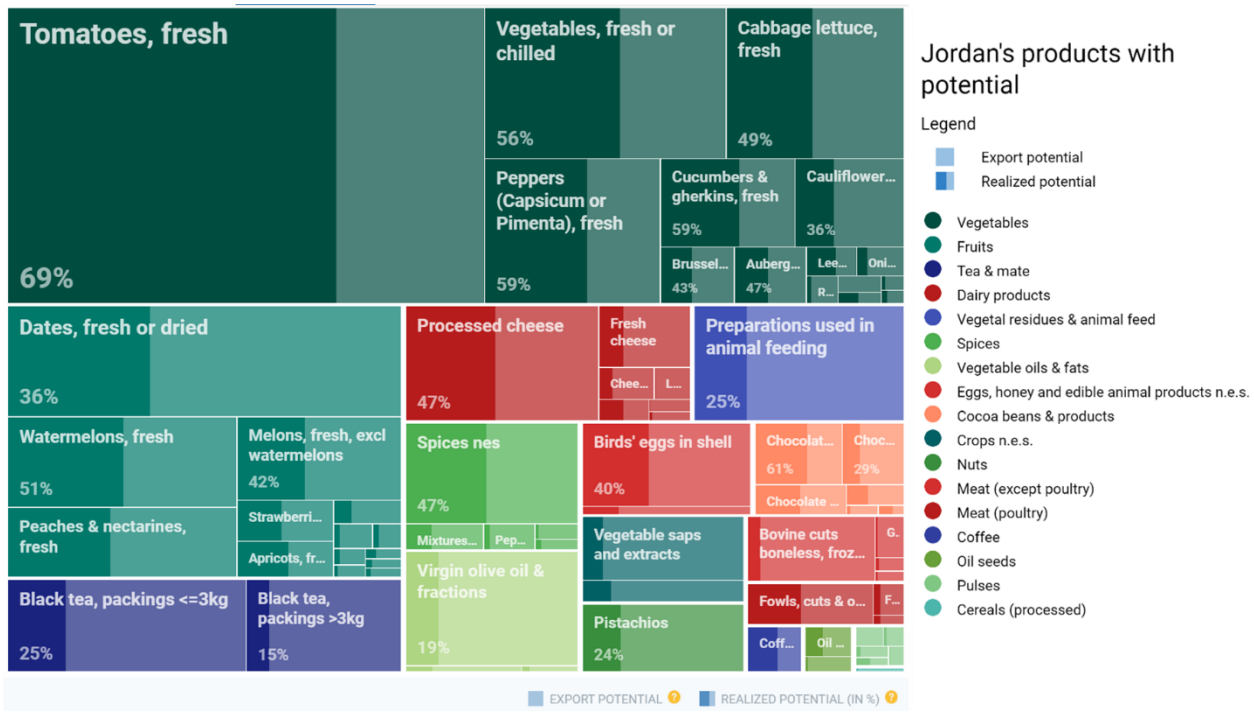

Figure 8: Jordan's Export Potential Indicator with Realized Potential for 2020. Source: https://exportpotential.intracen.org/

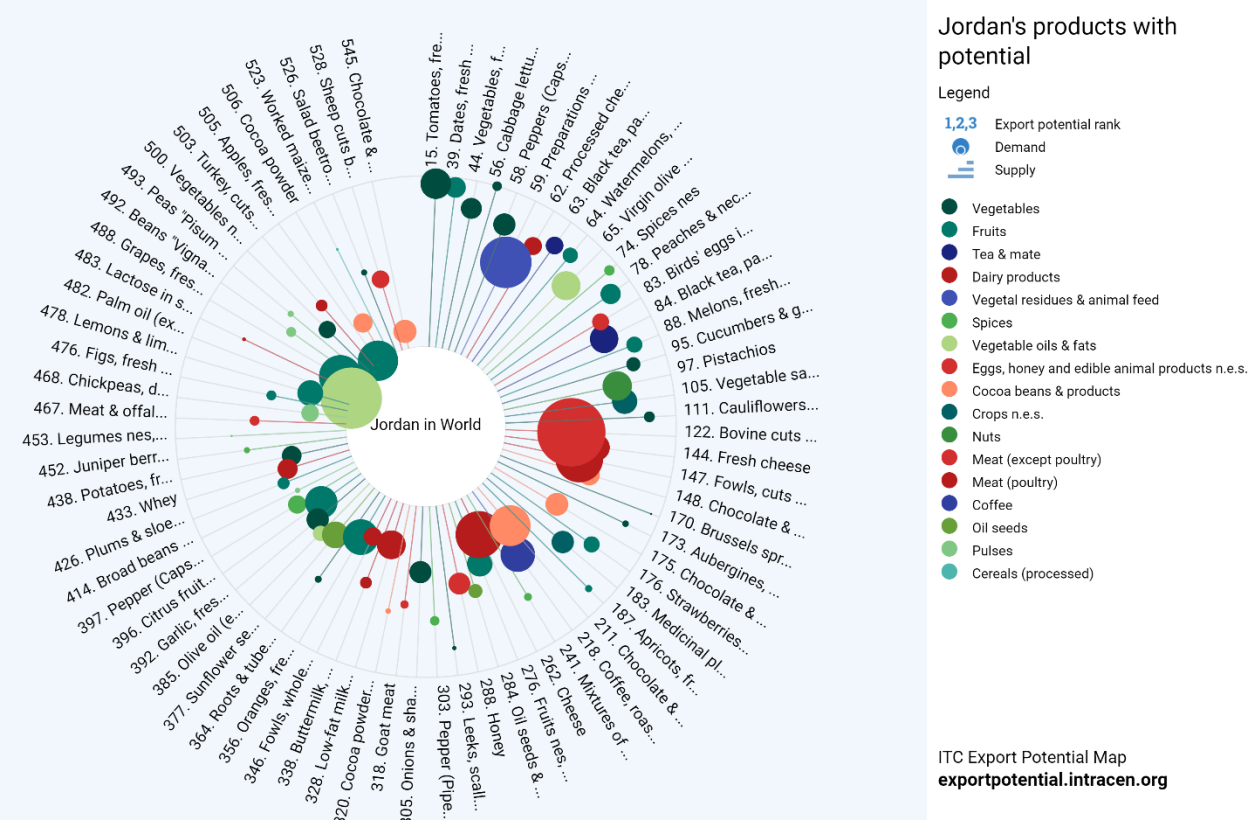

Figure 9: Ranking of export potential crops for Jordan in 2020 (Product Diversification Indicator). Source: https://exportpotential.intracen.org/

In Jordan, the local water footprint of tomato is 55 m^3/ton while the global average is 180 m^3/ton, but even if the water footprint is low, with the large amounts of tomatoes being exported, it will put additional stress on water resources there. Similarly, watermelon has a local water footprint of 78 m^3/ton compared to a global average of 235 m^3/ton, and dates with 852 m^3/ton local and 2,130 m^3/ton global water footprint. Hence, scenarios including increase export of tomatoes, watermelon and dates (within the limits of available water) would be beneficial to Jordan assuming the land availability is not a constraint. This increase in export should be accompanied with a decreased export of apples and pears which local footprint is 1,250 m^3/ton compared to a global average of 700 m^3/ton. Cereals exports should also be reduced as the local footprints for barley is 3,488 m^3/ton, and for wheat 3,256 m^3/ton while the global averages are 1,388 m^3/ton for barley and 1,344 m^3/ton for wheat. Given that cereals have lower yield compared to vegetables for which land use efficiency is much higher, this proposed scenario to reduce cereals production/export will make more land available for the increase in vegetable and fruits production.

The same indicators for Syria are presented in Figure 10 (export potential indicator) and Figure 11 (product diversification indicator) and they show high export share and potential of additional export of spices, fruits and nuts mainly with pistachios, apples, cumin and olive oil ranking as the top potential products for increased export potential. The local water footprint of cumin in Syria

is 3,330 m^3/ton compare to 8,280 m^3/ton global average which suggests that a scenario with increases export of cumin is favorable to Syria. Similarly, pistachio and olive oil which have a local footprints of 4,861 and 223 m^3/ton respectively while their global averages are 11,363 and 14,430 m^3/ton respectively. On the other hand, although apples show to be a high potential export crop, however to produce it in Syria about 1,200 m^3 of water are required per ton while the global average is 700 m^3/ton, hence it is not advisable to export more but rather try to limit the export.

These indicators are excellent tools for policymakers to gather information about their country's export potential when prioritizing products and markets for national and regional export strategies, as well as for trade policy negotiations. Together with information about water footprint and water resources, it will guide the management plan and food trade policies.

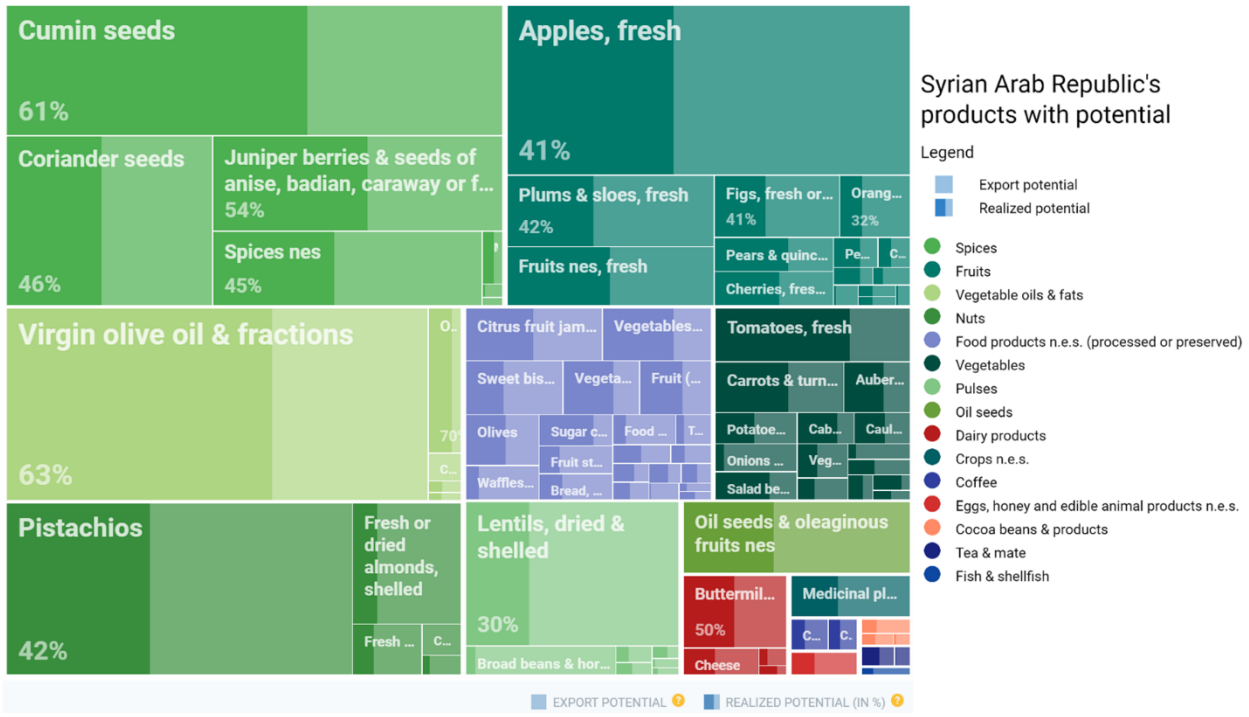

Figure 10: Syria's Export Potential Indicator with Realized Potential for 2020. Source: https://exportpotential.intracen.org/

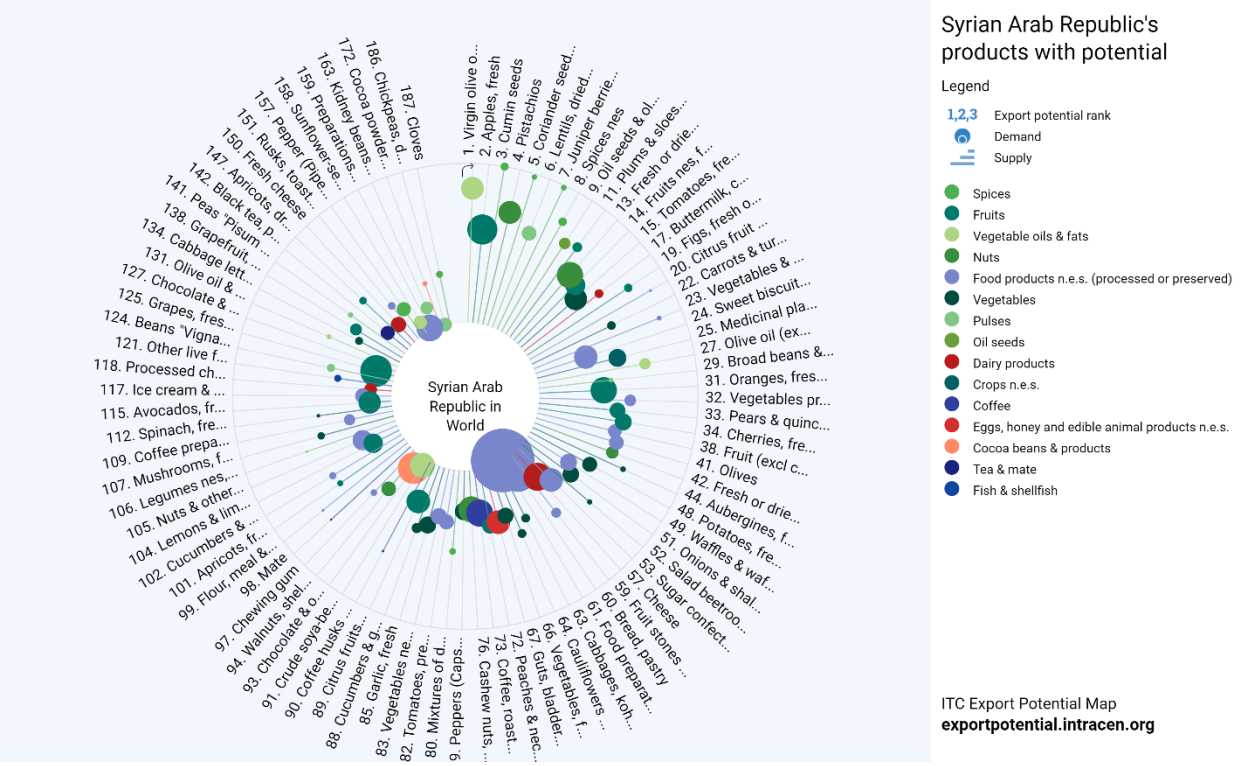

Figure 11: Ranking of export potential crops for Syria in 2020 (Product Diversification Indicator). Source: https://exportpotential.intracen.org/

6. Conclusion

This study showed presented the calculation of the virtual water trade in the Syrian and Jordanian parts of the Yarmouk Basin. The net virtual trade in the Syrian part was about 19 Million m^3/year while in the Jordanian part is about 573 Million m^3/year. This latter suggests that the move towards importing virtual water (mainly through cereals and meat) is helping Jordan reduce the pressure on the water resources in this water-scarce country and this can further be improved by improving food trade policies.

There are several reason behind high water footprints for crops. A main factor is that people have a water-intensive consumption pattern. Particularly high consumption of meat significantly contributes to a high water footprint. Another factor is climate. In regions with a high evaporative demand such as Jordan and Syria, the water requirement per unit of crop production is relatively large. Another important factor that can explain high water footprints is water-inefficient agricultural practice, which means that water productivity in terms of output per drop of water is relatively low. Reducing water footprints can be done in various ways such improving agricultural practices to improve water use efficiency and increase water productivity, or a shift to consumptions patterns that require less water, for instance by reducing meat consumption. However, it has been debated whether this is a feasible road to go, since the worldwide trend has been that meat consumption increases rather than decreases. Hence the approach of shifting virtual

water trades maybe present a solution for these challenges. This is an approach that Jordan has adopted successfully before externalizing its water footprint by importing wheat and rice products from the USA, which has higher water productivity than Jordan and which will need to continue with the suggested scenarios to increase tomato and watermelon export and reducing more cereals exports. In Syria, the increase of export of cumin, pistachio and olive oil and the decrease of apples exports will improve the net virtual water trade.

While import of virtual water will relieve the pressure on the nation's own water resources and environment, it is important though to note that the consequences of change in food trade patterns for water reasons should be examined in terms of value (money), food security, food sovereignty, and employment and of course water resources. Unemployment is a problem most of the virtual water importing countries are facing.

Including virtual water trade analysis in drafting national water policy plans is very important. Virtual water trade should be encouraged to promote water savings for arid countries and at global level through enhancing food security by appropriate agreements and increasing reciprocity in agricultural products trade. It seems wise to include virtual water accounting in any national or regional water and agricultural policy analysis. Common procedures of virtual water accounting and references should therefore be developed and disseminated. Knowing the national virtual water trade balance is essential for developing a rational national policy with respect to virtual water trade. A nation's goal with respect to food and water security should be considered within the broader framework of national objectives such as providing national security, promoting economic growth, creating employment for people and reducing poverty. It is clear that further research should be carried out to study the natural, social, and economic implications of using virtual water trade as a strategic instrument in water policy.

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Annexes

Annex A.1.: Trade Data and Total Water Footprint for crops and food in **Jordan**. Source: trade data come from UN Comtrade and water footprint was calculated by authors based on method proposed by Hoekstra 2011.

	Code	Product label	Import (Tons)	Export (Tons)	Water Footprint (m3/ton)		Total Water Footprint ('1000 m^3/year)	
			Avg (2015-2019)	Avg (2015-2019)	Imported	Local	Imports	Exports
02 Meat and edible meat offal	'0201	Meat of bovine animals, fresh or chilled	15,390	23	16,195	622	249,238	14
	'0202	Meat of bovine animals, frozen	18,639	2,144	16,195	622	301,862	1,334
	'0204	Meat of sheep or goats, fresh, chilled or frozen	23,221	53	5,757	428	133,682	23
	'0206	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, ...	1,249	223	5,757	428	7,188	95
	'0207	Meat and edible offal of fowls of the species Gallus domesticus, ducks, geese, turkeys and ...	61,773	7,656	2,110	23	130,341	176
	'0208	Meat and edible offal of rabbits, hares, pigeons and other animals, fresh, chilled or frozen ...	60	244	2,110	23	127	6
	'0210	Meat and edible offal, salted, in brine, dried or smoked; edible flours and meals of meat or ...	29	-	2,110	23	61	-
04 Dairy produce; birds' eggs; natural honey;	'0401	Milk and cream, not concentrated nor containing added sugar or other sweetening matter	17,878	24	897	35	16,036	1
	'0402	Milk and cream, concentrated or containing added sugar or other sweetening matter	28,453	60	897	35	25,522	2
	'0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk and ...	7,311	788	897	35	6,558	28

	'0405	Butter, incl. dehydrated butter and ghee, and other fats and oils derived from milk; dairy ...	3,877	20	4,914	193	19,054	4
	'0406	Cheese and curd	24,703	6,290	4,914	264	121,389	1,661
	'0407	Birds' eggs, in shell, fresh, preserved or cooked	14,632	166,891	2,424	48	35,467	8,011
	'0408	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in ...	529	5	2,424	48	1,281	0
	'0410	Turtles' eggs, birds' nests and other edible products of animal origin, n.e.s.	3	7	2,424	48	8	0
07 Edible vegetables and certain roots and tubers	'0701	Potatoes, fresh or chilled	27,329	2,553	250	112	6,832	286
	'0702	Tomatoes, fresh or chilled	8	312,118	180	55	1	17,166
	'0703	Onions, shallots, garlic, leeks and other alliaceous vegetables, fresh or chilled	15,435	332	407	343	6,282	114
	'0704	Cabbages, cauliflowers, kohlrabi, kale and similar edible brassicas, fresh or chilled	19	22,329	285	90	5	2,010
	'0705	Lettuce "Lactuca sativa" and chicory "Cichorium spp.", fresh or chilled	14	39,130	130	39	2	1,526
	'0706	Carrots, turnips, salad beetroot, salsify, celeriac, radishes and similar edible roots, fresh ...	9,393	56	195	150	1,832	8
	'0707	Cucumbers and gherkins, fresh or chilled	12	43,942	240	25	3	1,099
	'0708	Leguminous vegetables, shelled or unshelled, fresh or chilled	277	1,873	4,055	1,600	1,124	2,997
	'0709	Other vegetables, fresh or chilled (excluding potatoes, tomatoes, alliaceous vegetables, edible ...	307	68,512	362	119	111	8,153
	'0710	Vegetables, uncooked or cooked by steaming or boiling in water, frozen	8,177	81	362	120	2,960	10
	'0711	Vegetables provisionally preserved, e.g. by sulphur dioxide gas, in brine, in sulphur water ...	30	9	195	150	6	1

	'0712	Dried vegetables, whole, cut, sliced, broken or in powder, but not further prepared	624	2	180	55	112	0
	'0713	Dried leguminous vegetables, shelled, whether or not skinned or split	61,191	807	4,055	1,600	248,129	1,292
	'0714	Roots and tubers of manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and similar	486	42	2,254	112	1,095	5
08 Edible fruit and nuts; peel of citrus fruit or melons	'0802	Other nuts, fresh or dried, whether or not shelled or peeled (excluding coconuts, Brazil nuts ...	11,138	62	8,047	1,493	89,631	93
	'0803	Bananas, incl. plantains, fresh or dried	33,603	5	860	577	28,899	3
	'0804	Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried	18,269	5,002	2,130	852	38,903	4,259
	'0805	Citrus fruit, fresh or dried	47,356	4,375	695	675	32,913	2,953
	'0806	Grapes, fresh or dried	3,205	618	608	198	1,948	122
	'0807	Melons, incl. watermelons, and papaws (papayas), fresh	17	47,846	235	78	4	3,732
	'0808	Apples, pears and quinces, fresh	55,272	401	700	1,250	38,691	501
	'0809	Apricots, cherries, peaches incl. nectarines, plums and sloes, fresh	2,394	68,368	1,200	580	2,873	39,654
	'0810	Fresh strawberries, raspberries, blackberries, back, white or red currants, gooseberries and ...	9,909	4,539	484	96	4,796	436
	'0811	Fruit and nuts, uncooked or cooked by steaming or boiling in water, frozen, whether or not ...	1,114	1	8,047	1,493	8,964	1
	'0813	Dried apricots, prunes, apples, peaches, pears, papaws "papayas", tamarinds and other edible ...	377	12	1,200	797	452	10
10: Cereals	'1001	Wheat and meslin	1,091,362	16	1,334	3,256	1,455,876	52
	'1003	Barley	761,420	-	1,388	3,488	1,056,851	-
	'1004	Oats	116	-	1,788	3,256	207	-

	'1005	Maize or corn	760,612	121	909	127	691,396	15
	'1006	Rice	191,676	6	1,673	273	320,674	2
	'1007	Grain sorghum	1,436	-	2,853	127	4,098	-
	'1008	Buckwheat, millet, canary seed and other cereals (excluding wheat and meslin, rye, barley, ...	1,968	13	4,478	3,488	8,814	44
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit;	'1201	Soya beans, whether or not broken	236	24	2,750	1,789	650	43
	'1202	Groundnuts, whether or not shelled or broken (excluding roasted or otherwise cooked)	9,942	58	3,100	4,815	30,820	278
	'1206	Sunflower seeds, whether or not broken	8,523	189	3,366		28,690	-
	'1207	Other oil seeds and oleaginous fruits, whether or not broken (excluding edible nuts, olives, ...	35,188	140	2,271	2,271	79,911	317
	'1213	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form ...	35,463	46	3,048	3,048	108,090	141
	'1214	Swedes, mangolds, fodder roots, hay, alfalfa, clover, sainfoin, forage kale, lupines, vetches ...	58,932	12	3,048	323	179,624	4
Others	'1215	Olive	40	3,400	4,400	2,215	176	7,531
	'1216	Olive oil	10	575	14,430	7,264	144	4,177
	'1217	Pistachio	3,115	170	11,363	4,861	35,396	826
							5,565,799	**111,214**

Annex A.2.: Trade Data and Total Water Footprint for crops and food in **Syria.** Source: trade data come from UN Comtrade and water footprint was calculated by authors based on method proposed by Hoekstra 2011.

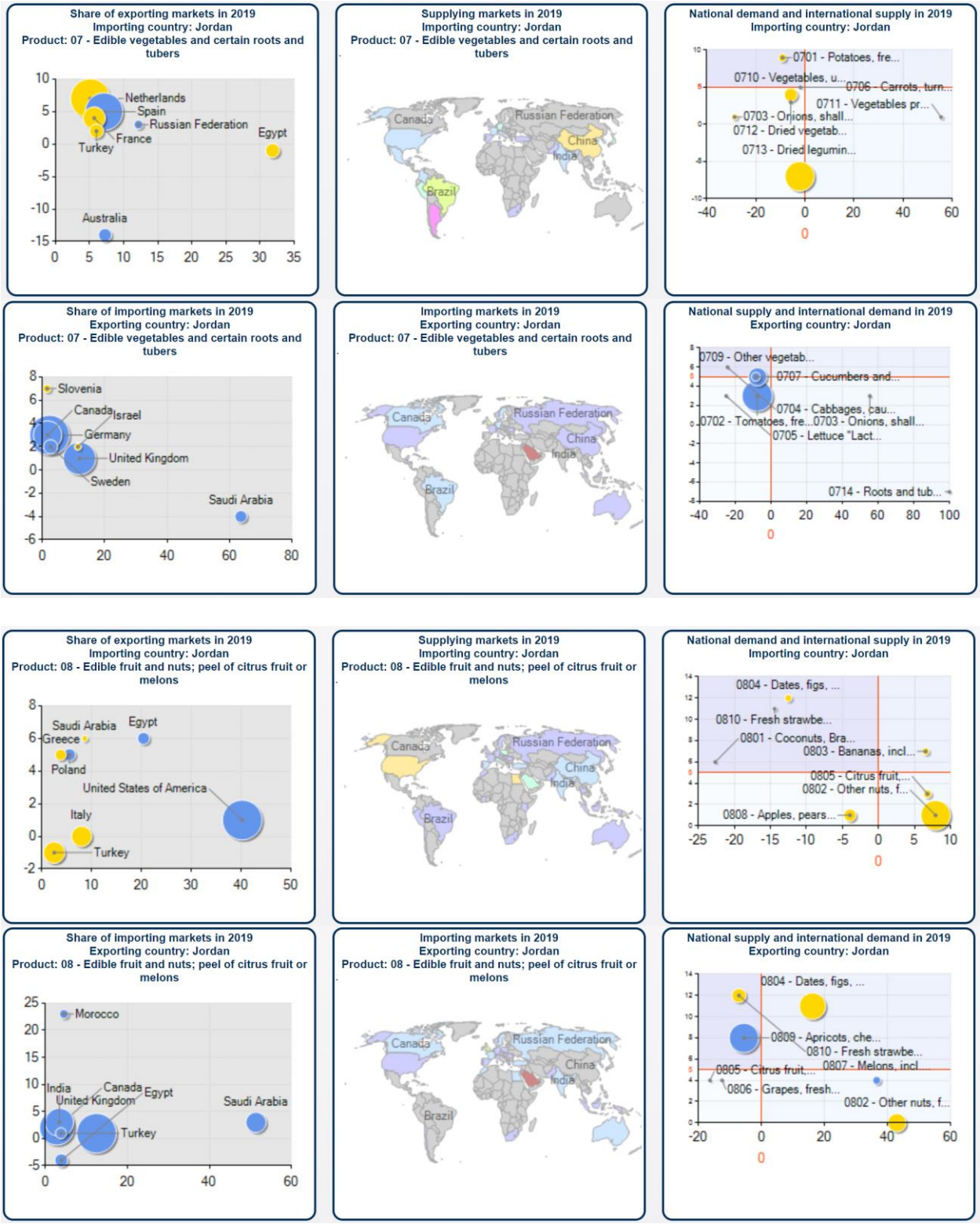
	Code	Product label	Import (Tons)	Export (Tons)	Water Footprint (m3/ton)		Total Water Footprint ('1000 m^3/year)	
			Avg (2015-2019)	Avg (2015-2019)	Imported	Local	Imports	Exports
02 Meat and edible meat offal	'0202	Meat of bovine animals, frozen	1,750	44	16,195	622	28,341	27
	'0204	Meat of sheep or goats, fresh, chilled or frozen	18	-	5,757	428	106	-
	'0206	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, ...	44	1	5,757	428	253	0
	'0207	Meat and edible offal of fowls of the species Gallus domesticus, ducks, geese, turkeys and ...	18,156	117	2,110	23	38,308	3
	'0208	Meat and edible offal of rabbits, hares, pigeons and other animals, fresh, chilled or frozen ...	-	1	2,110	23	-	0
	'0210	Meat and edible offal, salted, in brine, dried or smoked; edible flours and meals of meat or ...	13	-	2,110	23	27	-
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not	'0401	Milk and cream, not concentrated nor containing added sugar or other sweetening matter	5,512	26	897	35	4,944	1
	'0402	Milk and cream, concentrated or containing added sugar or other sweetening matter	19,762	76	897	35	17,726	3
	'0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk and ...	148	2,399	897	35	133	84
	'0405	Butter, incl. dehydrated butter and ghee, and other fats and oils derived from milk; dairy ...	2,589	67	4,914	192	12,720	13
	'0406	Cheese and curd	1,553	2,906	4,914	97	7,632	283
	'0407	Birds' eggs, in shell, fresh, preserved or cooked	20,910	-	2,424	48	50,687	-

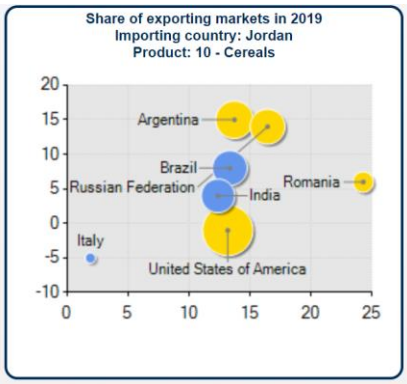
	'0408	Birds' eggs, not in shell, and egg yolks, fresh, dried, cooked by steaming or by boiling in ...	32	-	2,424	48	76	-
	'0410	Turtles' eggs, birds' nests and other edible products of animal origin, n.e.s.	10	-	2,424	48	24	-
07 Edible vegetables and certain roots and tubers	'0701	Potatoes, fresh or chilled	98,395	8,829	250	1,814	24,599	16,015
	'0702	Tomatoes, fresh or chilled	43,295	16,879	180	117	7,793	1,975
	'0703	Onions, shallots, garlic, leeks and other alliaceous vegetables, fresh or chilled	19,462	5,594	407	508	7,921	2,842
	'0704	Cabbages, cauliflowers, kohlrabi, kale and similar edible brassicas, fresh or chilled	236	8,039	285	373	67	2,999
	'0705	Lettuce "Lactuca sativa" and chicory "Cichorium spp.", fresh or chilled	162	524	130	257	21	135
	'0706	Carrots, turnips, salad beetroot, salsify, celeriac, radishes and similar edible roots, fresh ...	7,366	12,382	195	231	1,436	2,860
	'0707	Cucumbers and gherkins, fresh or chilled	1,793	2,139	240	420	430	898
	'0708	Leguminous vegetables, shelled or unshelled, fresh or chilled	491	3,118	4,055	3,300	1,990	10,288
	'0709	Other vegetables, fresh or chilled (excluding potatoes, tomatoes, alliaceous vegetables, edible ...	4,017	10,731	362	315	1,454	3,380
	'0710	Vegetables, uncooked or cooked by steaming or boiling in water, frozen	135	95	362	460	49	44
	'0711	Vegetables provisionally preserved, e.g. by sulphur dioxide gas, in brine, in sulphur water ...	984	4,489	240	420	236	1,885
	'0712	Dried vegetables, whole, cut, sliced, broken or in powder, but not further prepared	232	81	180	117	42	9
	'0713	Dried leguminous vegetables, shelled, whether or not skinned or split	49,098	19,778	4,055	3,300	199,091	65,267
	'0714	Roots and tubers of manioc, arrowroot, salep, Jerusalem artichokes, sweet potatoes and similar ...	30	10	2,254	456	66	5

08 Edible fruit and nuts; peel of citrus fruit or melons	'0803	Bananas, incl. plantains, fresh or dried	37,373	28	790	1,120	29,524	31
	'0804	Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried	7,608	6,820	2,130	852	16,202	5,807
	'0805	Citrus fruit, fresh or dried	11,246	14,174	695	242	7,816	3,430
	'0806	Grapes, fresh or dried	3,208	1,203	608	918	1,950	1,104
	'0807	Melons, incl. watermelons, and papaws (papayas), fresh	2,749	326	235	633	646	206
	'0808	Apples, pears and quinces, fresh	32,775	76,845	700	1,191	22,942	91,522
	'0809	Apricots, cherries, peaches incl. nectarines, plums and sloes, fresh	7,010	14,511	1,200	1,500	8,412	21,767
	'0810	Fresh strawberries, raspberries, blackberries, back, white or red currants, gooseberries and ...	8,497	12,909	484	96	4,113	1,239
	'0811	Fruit and nuts, uncooked or cooked by steaming or boiling in water, frozen, whether or not ...	27	83	8,047	1,980	219	164
	'0813	Dried apricots, prunes, apples, peaches, pears, papaws "papayas", tamarinds and other edible ...	264	299	1,200	1,500	317	449
10: Cereals	'1001	Wheat and meslin	233,913	7,269	1,334	1,370	312,039	9,959
	'1003	Barley	64,679	-	1,388	5,126	89,775	-
	'1004	Oats	17		1,788	1,894	30	-
	'1005	Maize or corn	194,572	2	909	1,894	176,866	4
	'1006	Rice	92,628	69	1,673	273	154,967	19
	'1007	Grain sorghum	253	-	2,853	1,894	722	-
	'1008	Buckwheat, millet, canary seed and other cereals (excluding wheat and meslin, rye, barley, ...	1,282	2	4,478	5,126	5,739	10

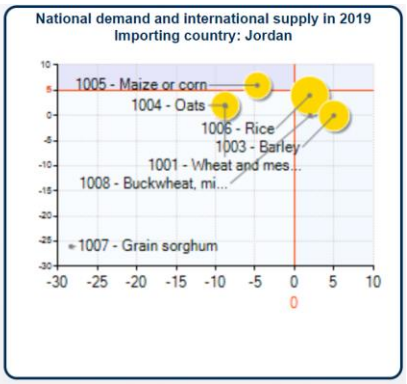
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit;	'1201	Soya beans, whether or not broken	16,023	9	2,750	1,789	44,063	15
	'1202	Groundnuts, whether or not shelled or broken (excluding roasted or otherwise cooked)	-	57	3,100	4,815	-	274
	'1206	Sunflower seeds, whether or not broken	4,446	20	3,366	7,000	14,965	137
	'1207	Other oil seeds and oleaginous fruits, whether or not broken (excluding edible nuts, olives, ...	8,643	4,854	2,271	2,271	19,627	11,022
	'1212	Locust beans, seaweeds and other algae, sugar beet and sugar cane, fresh, chilled, frozen or ...	465	1,538	155	306	72	471
	'1213	Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form ...	1,029	-	3,048	3,048	3,136	-
	'1214	Swedes, mangolds, fodder roots, hay, alfalfa, clover, sainfoin, forage kale, lupines, vetches ...	519	600	3,048	4,610	1,582	2,764
Others	'1215	Olive	-	487	4,400	68	-	33
	'1216	Olive Oil	2,500	40,300	14,430	223	36,075	8,987
	'1217	Pistachio	9,800	3,750	11,363	4,861	111,357	18,229
	'1218	Cumin	41	8,167	8,280	3,330	339	27,195
						74,102	**1,469,673**	**313,853**

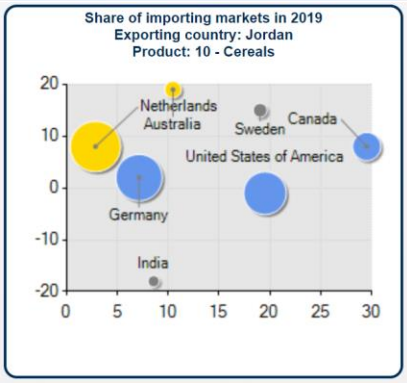
Annex B.1.: Food Trade Maps for different crops categories in Jordan. Source: https://www.trademap.org/Index.aspx

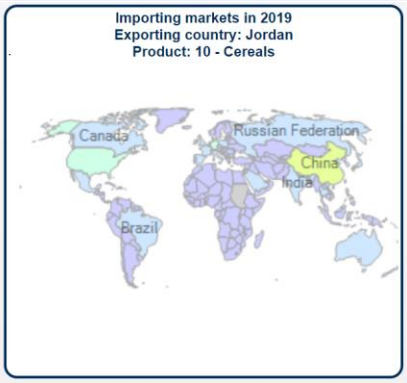


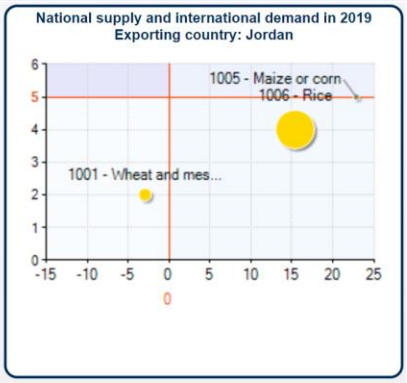

Share of exporting markets in 2019
Importing country: Jordan
Product: 10 - Cereals
Argentina
Brazil
Russian Federation
India
Romania
Italy
United States of America

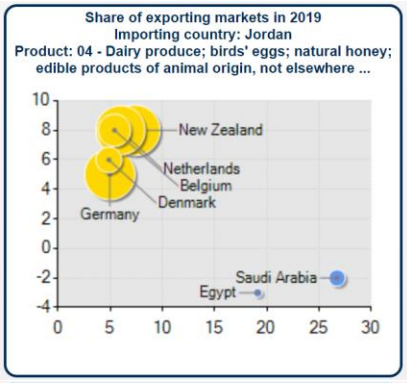

Supplying markets in 2019
Importing country: Jordan
Product: 10 - Cereals
Canada
Russian Federation
China
India
Brazil


National demand and international supply in 2019
Importing country: Jordan
1005 - Maize or corn
1004 - Oats
1006 - Rice
1003 - Barley
1001 - Wheat and mes...
1008 - Buckwheat, mi...
1007 - Grain sorghum

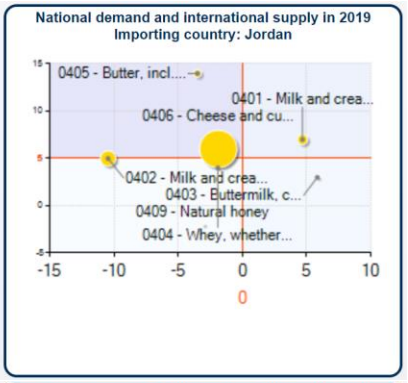

Share of importing markets in 2019
Exporting country: Jordan
Product: 10 - Cereals
Netherlands
Australia
Sweden
Canada
United States of America
Germany
India

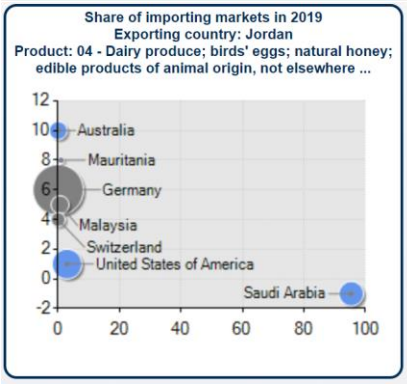

Importing markets in 2019
Exporting country: Jordan
Product: 10 - Cereals
Canada
Russian Federation
China
India
Brazil


National supply and international demand in 2019
Exporting country: Jordan
1005 - Maize or corn
1006 - Rice
1001 - Wheat and mes...

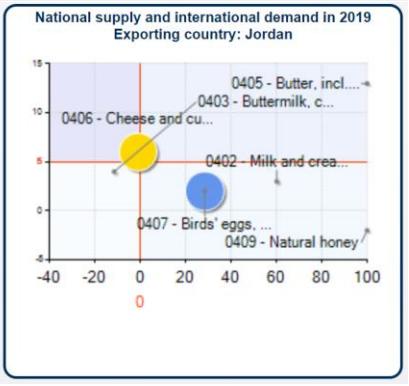

Share of exporting markets in 2019
Importing country: Jordan
Product: 04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...
New Zealand
Netherlands
Belgium
Denmark
Germany
Saudi Arabia
Egypt

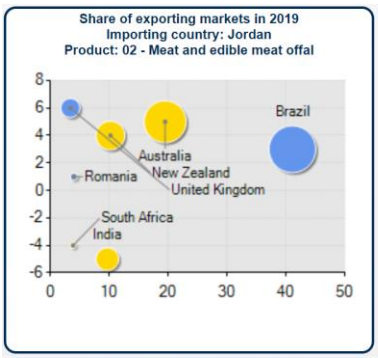

Supplying markets in 2019
Importing country: Jordan
Product: 04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...
Canada
Russian Federation
China
India
Brazil

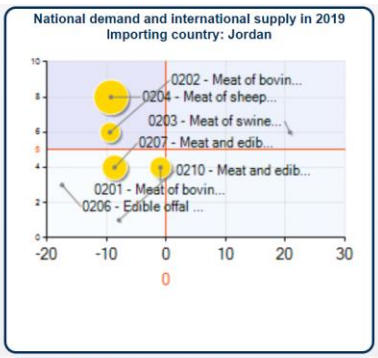

National demand and international supply in 2019
Importing country: Jordan
0405 - Butter, incl....
0401 - Milk and crea...
0406 - Cheese and cu...
0402 - Milk and crea...
0403 - Buttermilk, c...
0409 - Natural honey
0404 - Whey, whether...

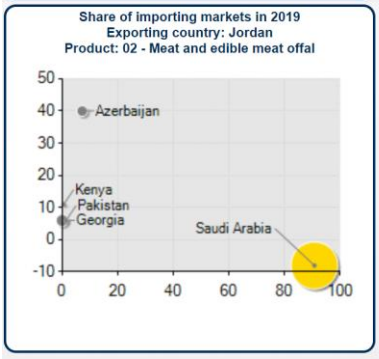

Share of importing markets in 2019
Exporting country: Jordan
Product: 04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...
Australia
Mauritania
Germany
Malaysia
Switzerland
United States of America
Saudi Arabia

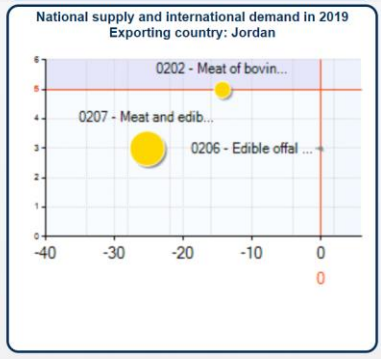

Importing markets in 2019
Exporting country: Jordan
Product: 04 - Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere ...
Canada
Russian Federation
China
India
Brazil

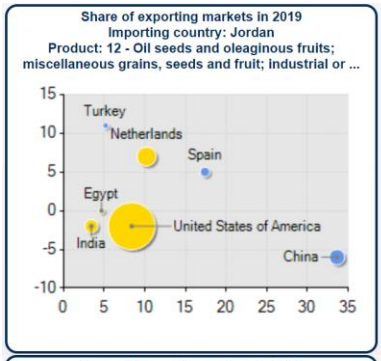

National supply and international demand in 2019
Exporting country: Jordan
0405 - Butter, incl....
0403 - Buttermilk, c...
0406 - Cheese and cu...
0402 - Milk and crea...
0407 - Birds' eggs, ...
0409 - Natural honey

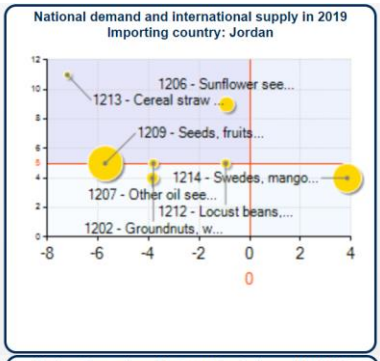


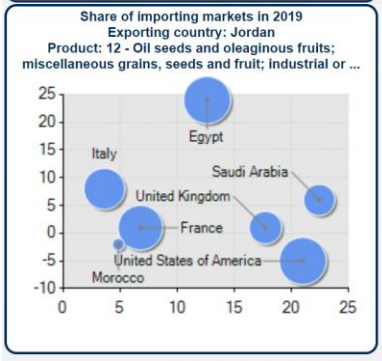


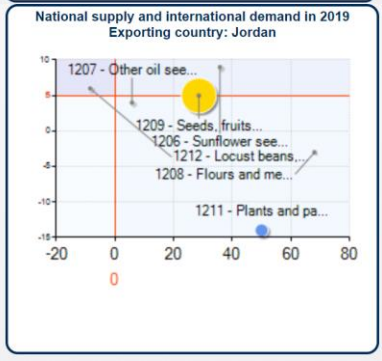








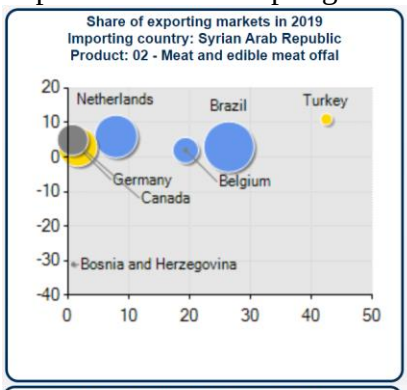


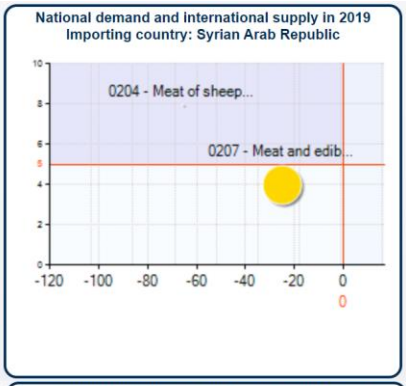


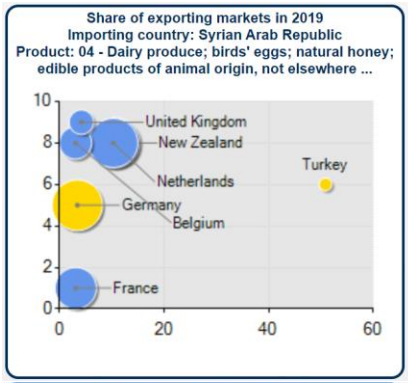
For left side graphs:

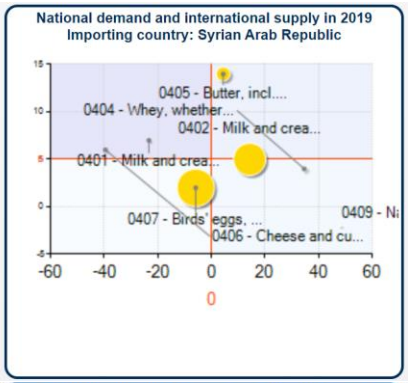
For right side graphs:

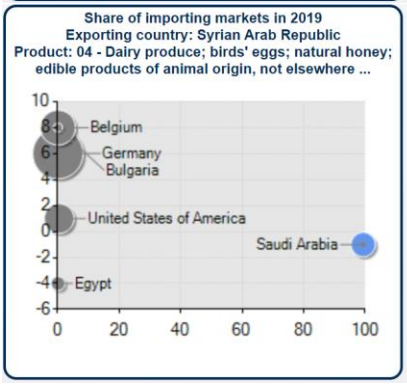
Annex B.2.: Food Trade Maps for different crops categories in Syria. Source: https://www.trademap.org/Index.aspx

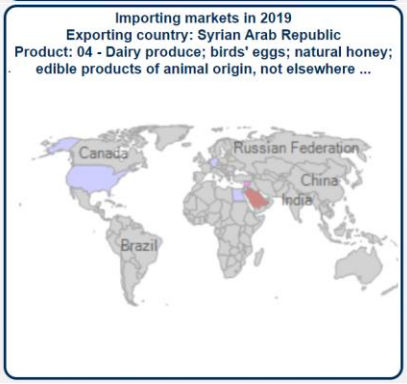


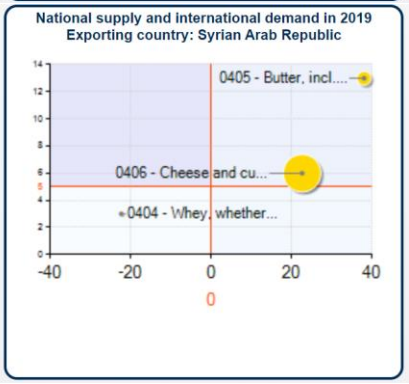






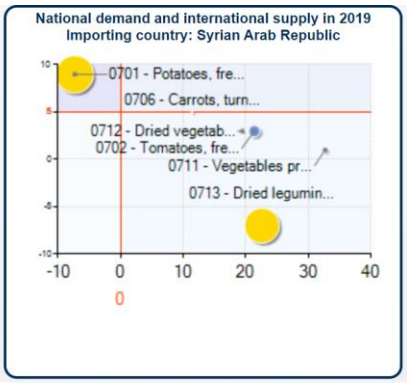


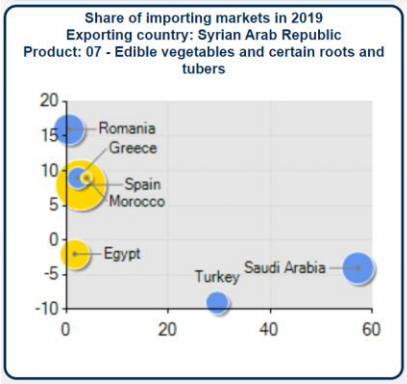




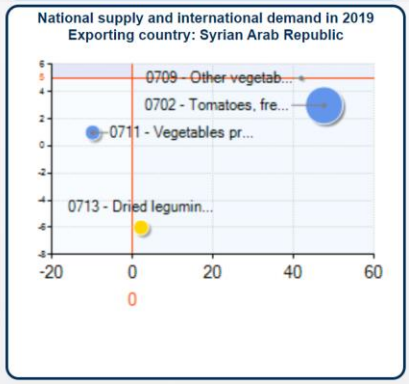

Share of exporting markets in 2019
Importing country: Syrian Arab Republic
Product: 07 - Edible vegetables and certain roots and tubers
China
Netherlands
Russian Federation
Turkey
Egypt
Canada

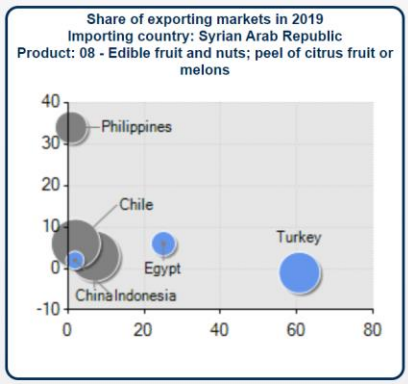

Supplying markets in 2019
Importing country: Syrian Arab Republic
Product: 07 - Edible vegetables and certain roots and tubers
Canada
Russian Federation
China
India
Brazil

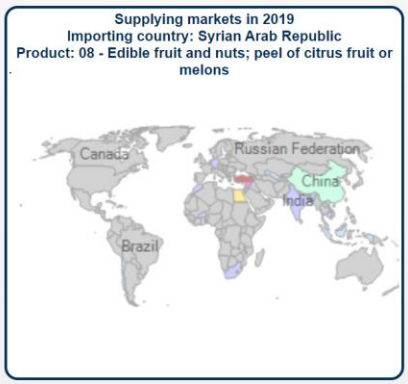

National demand and international supply in 2019
Importing country: Syrian Arab Republic
0701 - Potatoes, fre...
0706 - Carrots, turn...
0712 - Dried vegetab...
0702 - Tomatoes, fre...
0711 - Vegetables pr...
0713 - Dried legumin...

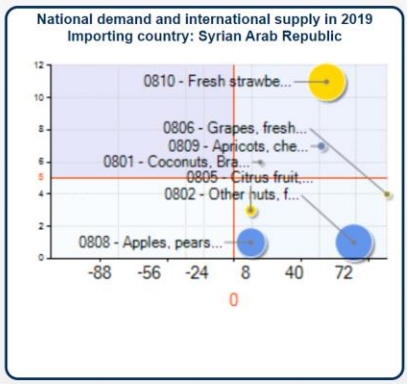

Share of importing markets in 2019
Exporting country: Syrian Arab Republic
Product: 07 - Edible vegetables and certain roots and tubers
Romania
Greece
Spain
Morocco
Egypt
Turkey
Saudi Arabia

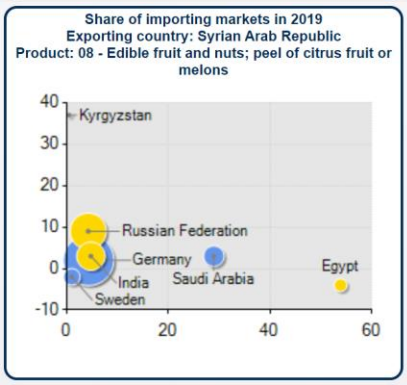

Importing markets in 2019
Exporting country: Syrian Arab Republic
Product: 07 - Edible vegetables and certain roots and tubers
Canada
Russian Federation
China
India
Brazil

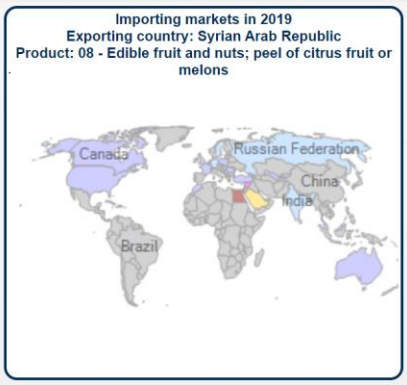

National supply and international demand in 2019
Exporting country: Syrian Arab Republic
0709 - Other vegetab...
0702 - Tomatoes, fre...
0711 - Vegetables pr...
0713 - Dried legumin...

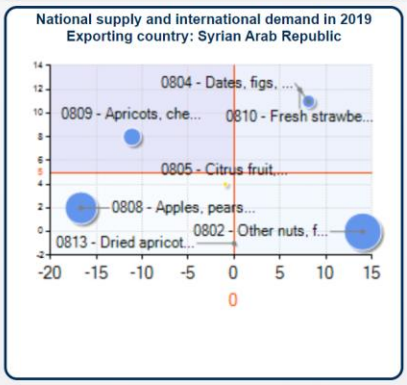

Share of exporting markets in 2019
Importing country: Syrian Arab Republic
Product: 08 - Edible fruit and nuts; peel of citrus fruit or melons
Philippines
Chile
Turkey
Egypt
China
Indonesia

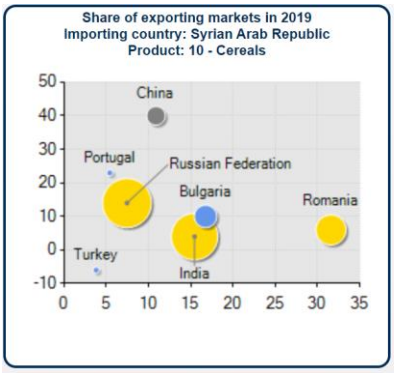

Supplying markets in 2019
Importing country: Syrian Arab Republic
Product: 08 - Edible fruit and nuts; peel of citrus fruit or melons
Canada
Russian Federation
China
India
Brazil

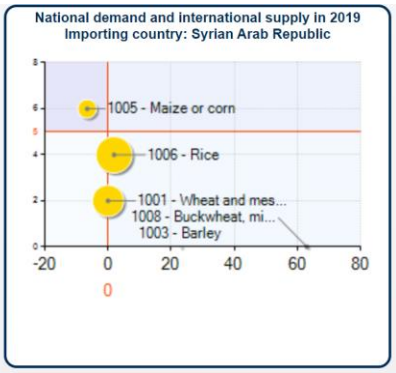

National demand and international supply in 2019
Importing country: Syrian Arab Republic
0810 - Fresh strawbe...
0806 - Grapes, fresh...
0809 - Apricots, che...
0801 - Coconuts, Bra...
0805 - Citrus fruit,...
0802 - Other nuts, f...
0808 - Apples, pears...

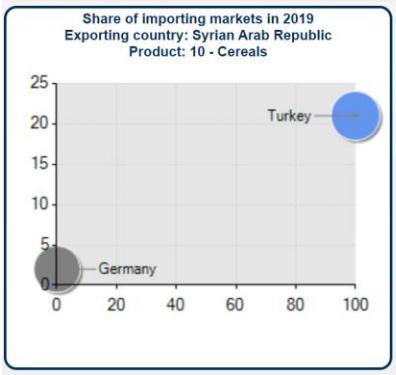

Share of importing markets in 2019
Exporting country: Syrian Arab Republic
Product: 08 - Edible fruit and nuts; peel of citrus fruit or melons
Kyrgyzstan
Russian Federation
Germany
India
Saudi Arabia
Egypt
Sweden

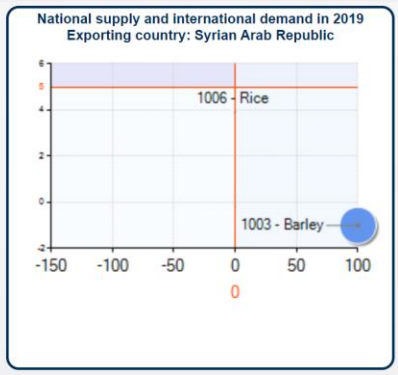

Importing markets in 2019
Exporting country: Syrian Arab Republic
Product: 08 - Edible fruit and nuts; peel of citrus fruit or melons
Canada
Russian Federation
China
India
Brazil

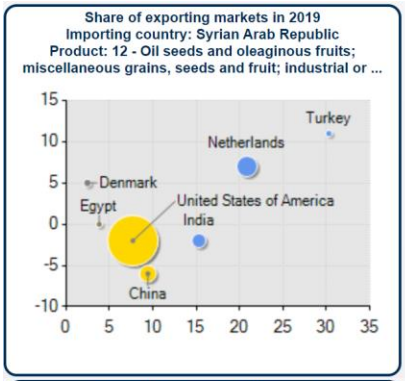

National supply and international demand in 2019
Exporting country: Syrian Arab Republic
0804 - Dates, figs, ...
0809 - Apricots, che...
0810 - Fresh strawbe...
0805 - Citrus fruit,...
0808 - Apples, pears...
0802 - Other nuts, f...
0813 - Dried apricot...

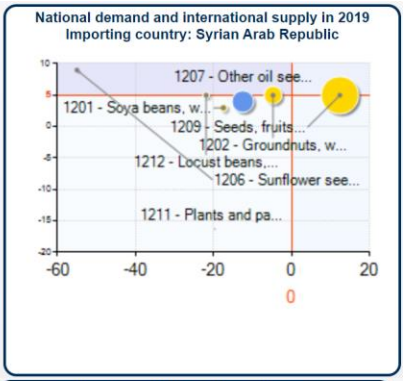


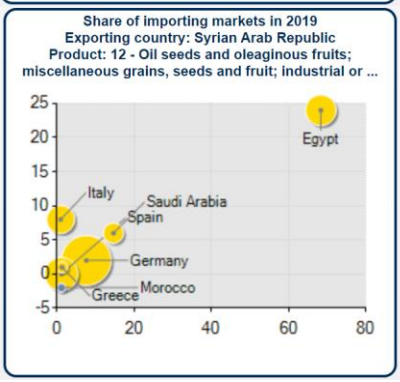


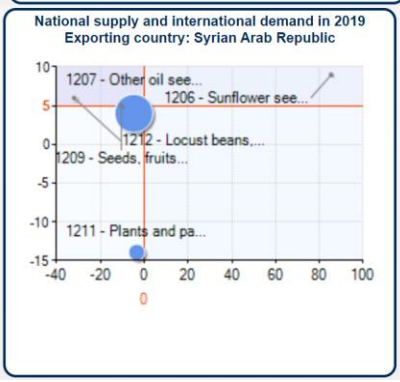












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