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FOOD SECURITY IN TUNISIA WITHIN WATER SCARCITY THE RELATIVE IMPORTANCE OF THE MEAT SECTOR

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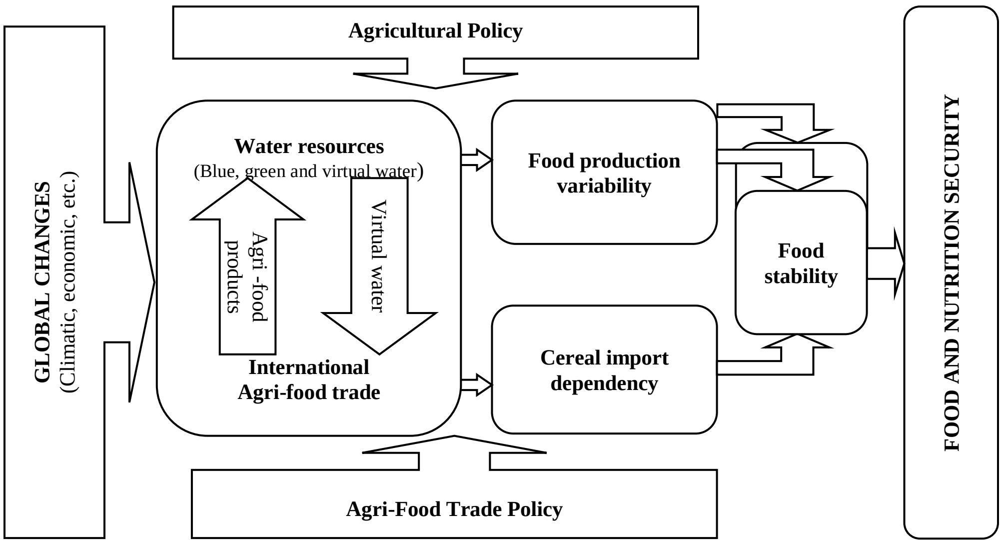
Abstract

This paper analyzes the evolution of food and nutrition security in Tunisia, judges its sustainability within water scarcity conditions and free trade areas, with a specific focus on the meat sector. For such purpose, the FAO indicators and Food Balance Sheets, as well as the Global Food Security Index are all analyzed. Virtual water, owed to meat and cereals for animal feed production and trade, was estimated to expect food security sustainability. Results indicated that Tunisian food and nutrition security (FNS) has been improved over the years, but its stability remains vulnerable because of the political and economic risks and the dependence of Tunisia on imported cereals for animal feed due to water scarcity. Tunisian agricultural policy, especially in both sectors of cereals and meat, should be readjusted to guarantee food and nutrition sustainability.
Keywords: *Food security, meat, nutrition, virtual water*

1. Introduction

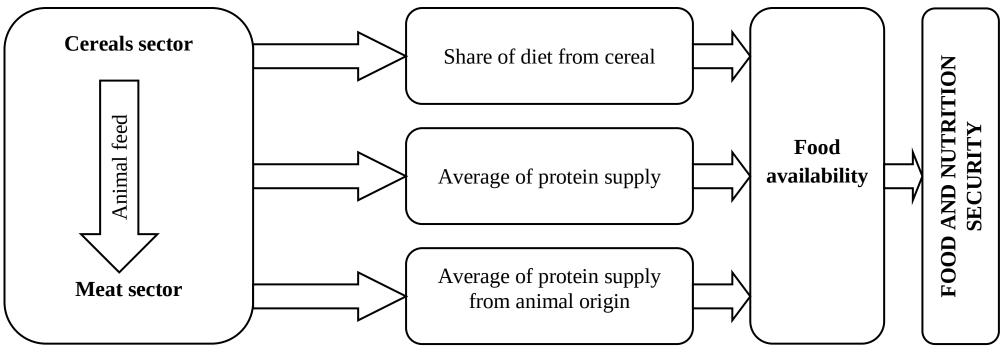
The Food and nutrition security question has become imperative, especially with trade internationalization. Besides national production, it includes the possibilities of importing products (FAO, 2002; Fernandez, 2007). However, international agricultural trade engenders indirect water transfers between exporting and importing countries: it's the water consumed for the production of agricultural and agri-food marketed products (Le Vernoy, 2006; Lysiane & Corinne, 2005). According to the comparative advantage economic theory, virtual water concept was used to justify the agricultural international trade contribution in reducing the pressure on the national natural resources, especially water resources (Allan, 1993; WTO, 2010). In this context, food security should be rethought within a liberal vision while considering the available water resources (green, blue and virtual water). Limited domestic water resources and climatic changes have an impact on food production variability and in consequence on food stability. To equilibrate this situation, international food trade is necessary but it indirectly induces water flows, with an impact on domestic water availability. Enhancing food security in a context of global change requires reconciliation between agricultural and water policies in a context of trade liberalization. Nevertheless, covering agricultural and agri-food production deficit by import flows remains economically and politically unacceptable because of cereals import dependency, the value of food imports and political stability raisons (Hamdane, 2012). All these factors impact food stability as presented in figure 1.



Source: Author's elaboration, 2015

Figure 1. Factors Affecting Food Stability

By focusing on the contribution of the different agro-food products to FNS, it seems that some of them have a great importance such as cereals and meat. In fact, nutritive aspects such as the share of diet energy from cereal and the average of protein supply especially from animal origin both reveal food availability (figure 2).



Source: Author's elaboration, 2015

Figure 2. Factors affecting food availability

On the other hand, these products (meat and cereals) are among the most consumers of water: one ton of beef needs 11thousand m^3 of water and one ton of wheat needs 2 thousand m^3 of water. So, over the years, their production has a high impact on water security. (Mekonnen & Hoekstra, 2010)

Tunisia, one of the water stressed countries, represents a relevant investigation field for food and water security researches, but studies on these concerns are relatively limited. Some

Tunisian strategic products, such as cereals and beef, were the subject of a first investigation on these concerns, proving that the optimization of the three set "blue water - green water - virtual water" are crucial in ensuring sustainable food security, especially with the rarity of water resources. Conversely, the water resources management has to consider the pluvial farming and the international agricultural and agri-food products trade, for the reason that foreign trade varies in consonance with the national agricultural production, widely dependent on Climate change (Fernandez, 2007; Hamdane, 2013a; Rastoin & Benabderrazik, 2014). These studies use virtual water as an indicator analyzing water management in shortage situation, without emphasizing the impact of these agricultural and water policies on the food and nutrition security.

Thus, enhancing FNS in Tunisia still represents a major challenge: significant improvements are being recorded; nevertheless such improvements came with an increasing share of food imports in food availability (FAOSTAT, 2015) due to production fluctuation given natural constraints. The Tunisian diet grew rich, yet remained a hyper-caloric and hypo-protein diet: animal products contribute up to 10% of calorie intakes and 25% of total proteins share, against respectively 29% and 58% in the European Union (FAOSTAT, 2015).

Especially in the meat sector and for political raisons, Tunisian decision-makers try to reduce the imports by improving national meat production to market at bearable prices, to guarantee food independence (Hamdane, 2013b), while these products and particularly beef are among the biggest water consumers and have the highest contribution to virtual water flows because of the high consumption of imported cereals for animal feed (Mekonnen & Hoekstra, 2010, 2011a&b).

Thus, the purpose of this paper is to analyze the evolution of food and nutrition security in Tunisia, to evaluate its sustainability within water scarcity, with a focus on the contribution of domestic meat production and to propose some reforms of agri-food production and trade policies.

The remainder of the paper is organized as follows: the next section describes the theoretical framework useful for this study. This is followed by a section on data sources and methodology. Section 4 presents the data analysis and the discussion. The last section presents the concluding remarks.

2. Theoretical Framework

2.1. Food and Nutrition Security: concepts, theoretical frameworks and indicators

Multiple conceptual frameworks have been developed to define food and nutrition security. The FAO, by defining food security as "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life", based food security on the availability, the accessibility, the utilization and the stability of food (Pangaribowo, Gerber & Torero, 2013; Santeramo, 2015).

A concrete relation exists between food security and nutrition security concepts. The conditions of availability of food and access to it are not sufficient for nutrition security. To ensure a healthy life for all household members and to guarantee nutrition security, these conditions must be enhanced by secure access to food, sanitary and healthy environment, adequate health services, and knowledgeable nutrition care. Thus, FAO has defined food and nutrition security as a condition “Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life.” (Pangaribowo & al, 2013).

A number of economic models of FNS were developed, based on UNICEF Conceptual Framework of Under-nutrition. Pangaribowo & al (2013) presented a review of the principal models such as:

- The static FNS production function of Strauss and Thomas (2007),
- Dynamic models of FNS developed by Gross and Webb (2006), Pinstrup-Andersen and Watson II (2011),admitting the dynamic nature of FNS,
- Scientific works of Karlan and Appel (2011), Stirling (1998, 2007), Scaramozzino (2006) who included the risk indicators in the FNS analysis.

These models are essential for the choice of appropriate indicators of food and nutrition security. Indeed, a variety of indicators of food and nutrition security have been proposed. The most used in the literature of various disciplines are the FAO Indicator of Undernourishment (FAOIU), the Diet Diversity Score (DDS). Anthropometric indicators (AI) and Medical and biomarker indicators (MBI) are the most fundamental indicators of nutritional outcomes.

Moreover, various composite indicators have been elaborated such as the Global Food Security Index (GFSI), the Global Hunger Index (GHI), and the Poverty and Hunger Index (PHI). (Aberman, Meerman & Benson, 2015; De Haen, Klasen & Qaim, 2011; Pangaribowo &al, 2013; Santeramo, 2015).

Each indicator reflects a specific aspect of FNS and thus is only relevant for certain situations. Pangaribowo & al (2013) and Santeramo (2015) presented a review of the classification of these indicators into:

- Global, national, household, and/or individual indicators,
- Indicators to measure FNS outcomes, Indicators to measure FNS drivers and risks and Indicators to measure FNS interventions,
- Static and dynamic indicators, and
- Specific indicators that may privilege particular type of information.

2.2. Food and water security challenges

Water has several roles in food and nutrition security: it influences health, nutrition, agri-food production and food access. Food security in the context of the global changes (climatic, energetic, and demographic) depends on water security as ascertained during the second world Water Forum. (Yves, 2012)

"Water security is defined as availability of, and access to, water in sufficient quantity and quality to meet livelihood needs of all households throughout the years, without prejudicing the needs of other users". This concept is used to describe the relationship between water availability, its accessibility and its use. Surely, a number of countries experience substantial water stress as a result of deficient and variable rainfall; this may contribute to an increased food and water insecurity. (Ludi, 2009)

Water scarcity and productivity have a huge impact on food security. In fact, one liter of water is needed to produce one kcal for the average diet; so for a daily dietary energy intake of 2700 kcal, about 2700 L/capita are required. Consequently, food production requires about 6800 km^3 of water/year. Out of this, 1800 km^3/year are supplied by irrigation water (blue water resources), the remainder of water needs are supplied by green water (Rainwater). (Hanjra & Qureshi, 2010)

Due to population growth, the world needs to increase food production with as limited resources as possible. Thus, the focus has been on how to guarantee sustainable food security in the framework of increasing water, land, and energy stress conditions. Focus on water resources conservation and efficient usage of such resources, seems to be required, not only in production, but also in processing and trade. When comparing future water requirements with projected water availability, experts fear that food security will be threatened, they recommend that food demand have to decrease which is possible via minimizing animal products consumption and restricting population growth increase. They also suggest the use of non-conventional water such as saline and wastewater for irrigation and the relocation of existing water. (Hanjra & Qureshi, 2010; Ludi, 2009; Von Grebmer &al, 2012)

2.3. Agri-food trade and virtual water

The concept of "virtual water" was introduced by Tony Allan in the 1990s and refers to the water required for the production of agricultural commodities. Thus, international food trade can be considered as virtual water trade: flows of virtual water exist between the export and the import countries (Le Vernoy, 2006; Lysiane & Corinne, 2005; Meissner, 2002; Schubert, 2011; WWC, 2004). According to the UNESCO (2015), the world virtual water flows represent about 40% of the total water consumption. Approximately 80% of these flows of virtual water result from agro-food traded products, and especially cereal (Dinesh &Singh, 2004; Scardigno, 2006). In general, no country is able to produce all of its food locally, so countries have to trade in foodstuffs. Therefore, virtual water can be crucial for any country's food security (Dinesh & Singh, 2004; Meissner, 2002).

Economies facing water scarcity problems may answer to their water demand for food through imports from water rich countries, thus virtual water trade can be used to achieve water security (Dinesh & Singh, 2004).Combining virtual water calculations of food with rainfall projections, governments can plan their food products imports or exports. States, with limited water resources, can plant crops with less water requirement and turn to the international market for the other crops. But this solution for water scarcity is considered highly complex due to natural, political and economical reasons. (Meissner, 2002)

The increased pressure of water scarcity, and virtual water trade helping global water balance in a sustainable and profitable way, may require from policy-makers to re-think water scarcity as a challenge beyond regional limits (Allan, 1993; Gawel & Bernsen, 2013; Lysiane & Corinne, 2005; WWC, 2004). Despite the fact that virtual water calculations can be an essential planning tool for agriculture production, they are dependent on other factors, especially political, economic and natural ones. (Meissner, 2002)

Similar to product's virtual water, the water footprint concept was developed by the same researchers who have promoted empirical use of the virtual water. The water footprint calculates the respective real as well as virtual water consumption of businesses, people, or entire nations. (Gawel & Bernsen, 2013; Schubert, 2011; Water Footprint Network, 2015; WWC, 2004)

2.4. Virtual water traffic and food security linkages

International food trade is imperative to enhance global food security. Indeed, it guarantees domestic food availability, leading to a lower food prices for domestic consumers, hence, a better physical and economic access to food. On the other hand, through food trade, a virtual trade of water occurs from producing (and exporting) countries to importing (and consuming) countries. (FAO, 2015; Hanjra & Qureshi, 2010)

The virtual water trade, as a concept, was developed especially within the Ricardian theory of comparative advantage and the H-O model of factor endowments. This economic dimension of virtual water concept was also developed by its founder as a "descendant of comparative advantage" (Antonelli & Sartori, 2014; WTO, 2010). According to the comparative advantage theory, a country should specialize only in the production of goods in which it does have a comparative advantage with a possible cost lower than in its trading partners, it can obtain a net gain by exporting products with a relative comparative advantage in production, while importing products in which it has a relative comparative disadvantage (Antonelli & Sartori, 2014; WTO, 2010). Considering water as an input, "a water-scarce country should have a comparative disadvantage in producing water-intensive goods and thus be a net importer of these goods...." (Antonelli & Sartori, 2014)

The Heckscher-Ohlin (H-O) model explains international trade flows on the basis of relative factors' abundance; it relates the comparative advantage of a country to the relative abundance of primary resources, such as water resources. So a country will import goods whose production is intensive in the factors that are relatively scarce within the country. Consequently, a water-scarce economy will be an importer of water demanding goods. (Antonelli & Sartori, 2014; WTO, 2010)

Besides the Ricardian theory and the H-O model, Krugman's trade theory (1990) proves the advantages of specialization, even in the absence of differences in endowments and production technology between countries. In this case, trade takes advantage of increasing returns, rather than taking advantage of inherent differences between trading partners. (Antonelli & Sartori, 2014; WTO, 2010)

But in reality, many countries produce and export water-intensive goods and have a positive virtual water trade balance under severe water scarcity conditions. Therefore, the virtual water concept has been strongly criticized. Indeed, many factors, other than relative water abundance or shortage, are influencing decisions on goods trade. There are many examples such as other resources availability (labor, land, knowledge and capital) national policies, domestic export subsidies and import duty on food products, and other distorting measures associated with water resources trade barriers. (Antonelli & Sartori, 2014)

3. Methodology

This section presents the data sources and the methodology used to explore the evolution of food and nutrition security in Tunisia and to judge its sustainability within water scarcity, with a review of the specific case of meat products which are among the most consumers of water.

3.1. How to explore the evolution of FNS in Tunisia?

To explore the evolution of FNS in Tunisia, the FAO Indicators, as simple indicators, and the Global Food Security Index (GFSI) as a composite indicator, seem to be the most appropriate to this investigation.

Seen the multidimensionality of food security, the FAO indicators capture various aspects of food insecurity. These indicators are classified along four dimensions: food availability, economic and physical access to food, food utilization and stability over time. Each food security dimension is described by specific indicators as described on table n°1.

- Food availability is important for food security. Supplying enough food to a population is a necessary condition, but not sufficient for an adequate access to food.
- Food access is dependent on economic and physical access. Economic access is determined by disposable income, food prices and the social support. Physical access is determined by the availability and the quality of infrastructure.
- To measure stability (or exposure to risks), two types of indicator have been proposed. The first group of indicators includes the area equipped for irrigation and the share of food imports in total merchandise exports. The second group of indicators captures risks affecting food security, such as volatility of food and input prices, production and supply variability. Other indicators cover more measures such as political instability.

- Food utilization includes two distinct dimensions. The first is captured by anthropometric indicators. The second dimension is represented by some indicators that reflect food quality and preparations, health and hygiene conditions.

To study the evolution of these four FNS dimensions in Tunisia, the FAO database (2015) put forward all indicators, calculated in three year averages, from 1990-92 to 2011-13.

Table 1. FAO Food Security Indicators

Food Security Dimensions	Availability	Access	Stability	Utilization
Food Security Indicators	Average dietary energy supply adequacy	Percent of paved roads over total roads	Cereal import dependency ratio	Access to improved water sources
	Average value of food production	Road density	Percent of arable land equipped for irrigation	Access to improved sanitation facilities
	Share of dietary energy supply derived from cereals, roots and tubers	Rail lines density	Value of food imports over total merchandise exports	Percentage of children under 5 years of age affected by wasting
	Average protein supply	Gross domestic product per capita (in purchasing power equivalent)	Political stability and absence of violence/terrorism	Percentage of children under 5 years of age who are stunted
	Average supply of protein of animal origin	Domestic food price index	Domestic food price volatility	Percentage of children under 5 years of age who are underweight
		Prevalence of undernourishment	Per capita food production variability	Percentage of adults who are underweight
		Share of food expenditure of the poor	Per capita food supply variability	Prevalence of anemia among pregnant women
		Depth of the food deficit		Prevalence of anemia among children under 5 years of age
		Prevalence of food inadequacy		Prevalence of vitamin A deficiency in the population
				Prevalence of iodine deficiency

Source: FAO, 2013

The Global Food Security Index (GFSI) is developed by the Economist Intelligence Unit (EIU) and cover 109 countries. It's a dynamic, quantitative and qualitative benchmarking model, with a range of analytical tools intended to facilitate cross-country and cross-regional comparisons. Available in both Excel and web based versions, it also provides detailed information about each country's score, year-on-year. This index proposes three dimensions of food security: Affordability (similar to the accessibility of FNS according to the FAO definition), availability, and utilization (Quality & Safety). Each dimension of the GFSI is measured by FNS indicators as detailed in table 2. The source data of the GFSI are based on existing research on food security, including FAO's Annual State of Food Insecurity in the World report, the GHI and other documents. (Pangaribowo &al., 2013; The Economist Intelligence Unit, 2015)

Table 2. GFSI Indicators

Affordability	Availability	Quality and safety
Food consumption as a proportion of total household expenditure	Average food supply in kcal/capita/day	Diet diversification
Proportion of population living under the global poverty line	Dependency on chronic food aid	National dietary guidelines
GDP per capita (at PPP)	Public expenditures on agriculture research and development	National nutrition plan or strategy
Agricultural import tariffs	Existence of adequate storage facilities	Nutrition monitoring and surveillance
Presence of food safety net programs	Road infrastructure	Dietary availability of vitamin A, animal iron, and vegetal iron
Access to financing for farmers	Port infrastructure	Protein quality
	Volatility of agricultural production	Agency to ensure the safety and health of food
	Political stability risk	Percent of population with access to potable water
		Presence of formal grocery sector

Source: Pangaribowo & al. (2013)

3.2. How to focus on the contribution of domestic meat production to Tunisian FNS?

To investigate the contribution of domestic meat production to Tunisian FNS, the Food Balance Sheets of the FAO are very useful. These sheets offer continuous, homogeneous, detailed and exhaustive information. They were used to diagnose meat and cereals for animal feed trade between Tunisia and the other countries since 1971, as well as production and consumption of these products, to evaluate the impact of agricultural and commercial policies, especially in the meat sector, on food and nutritional security.

3.3. How to assess Tunisian FNS sustainability?

To evaluate FNS sustainability within water scarcity conditions, the investigation of the degree of use and the affectation of domestic water resources is necessary. To this end, the virtual water concept was of much use. The databases of the Water footprint Network was used to estimate the virtual water, owed to meat and cereals for animals feed production and trade. In fact, water footprint statistics (WaterStat) are formulated according to the methodology of the Global Water Footprint Standard, so they are comparable and can be used for the different application of Water Footprint Assessment. WaterStat includes five datasets for which product water footprint statistics are very useful in this case. They provide statistics on green, blue and grey water footprints of crops, derived crop products and farm animal products. These data are available at national and sub-national levels. They refer to Mekonnen &Hoekstra (2010, 2011a&b, 2012), proposing the volume of virtual water by Kilogram of product and by country, and they were used to assess the virtual water flows embedded in meat and cereals for animal feed production and trade.

4. Data Analysis And Discussion

4.1. FNS improvements in Tunisia

4.1.1. An average position of FNS in Tunisia

With a GFSI 2015 score of 60/100 and a rank of 51/109, Tunisia is classified as a country in a good FNS environment. Compared to the best (the United Nation) and the worst (Burundi) scored countries, Tunisia have an average position. As presented in table 3, FNS in Tunisia improves over the years. But, this improvement is especially owed to food availability progress.

Table 3. Evolution of Tunisian GFSI

	Score / 100				Rank / 109			
	2012	2013	2014	2015	2012	2013	2014	2015
Overall score	54.7	56.4	58.1	60.1	53	54	52	51
Affordability	53.1	52.5	56.1	56.1	57	60	54	58
Availability	53.0	57.5	58.4	62.6	57	50	47	44
Quality and safety	63.2	62.9	62.0	62.9	44	47	49	47

Source: The Economist Intelligence Unit, 2015

Between 2012 and 2015, availability of food increased by 9.6 points. This development reflects especially a progress on the average food supply. However, this progress of Tunisian daily food ration is not strengthened by a nutritional quality and safety of food improvement. Indeed, quality and safety score of food relatively decrease between 2012 and 2015 reflecting a limited diet diversification and an insufficient protein quality, and leading to national nutrition strategy critics. Concerning the affordability score, it increases yearly by one point since 2012, reflecting the relative development of consumer’s ability to purchase food and their vulnerability to price shocks.

4.1.2. Fluctuant food availability in Tunisia with a remarkable dependence on cereals imports

Trends of food availability in Tunisia can be studied by tracking progress on FAO food availability indicators: Average value of food production, share of dietary energy supply derived from cereals and average protein supply especially of animal origin.

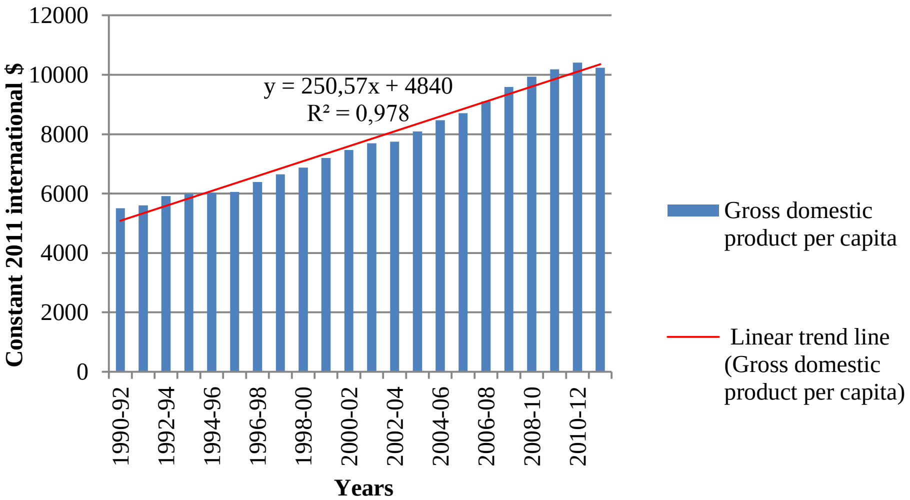
Food production is characterized by its fluctuation, with an average of 309 (constant 2004-2006 I$ per caput) between 1990 and 2013 (FAO, 2015). In the same period, the average dietary energy supply adequacy in Tunisia is around 140% of the average dietary energy requirement.

The dependence on cereal products is remarkable in Tunisia: the share of dietary energy supply derived from cereals, roots and tubers in Tunisia is around 53% in 2009-2011 compared to 56% in 1990-92, aligned with the World rate which is 52% and higher then developed countries rate equivalent to 32 in 2009-2011(FAO, 2014). In fact, multiple by-products of cereal are subsidized in Tunisia.

While average protein supply in Tunisia is equivalent to 97 gr/capita/day in 2009-2011, which is higher than the World average (79 gr/capita/day in 2009-2011), it is not animal origin protein. Average protein supply from animal origin is 26 gr/capita/day in Tunisia representing 27% of total protein supply, compared to 31 gr/capita/day for the World (40%). Despite the continued increase in Tunisian protein supply, the rates recorded in developed countries far exceed the Tunisian average. (FAO, 2015)

4.1.3. Relative decline of food access in Tunisia

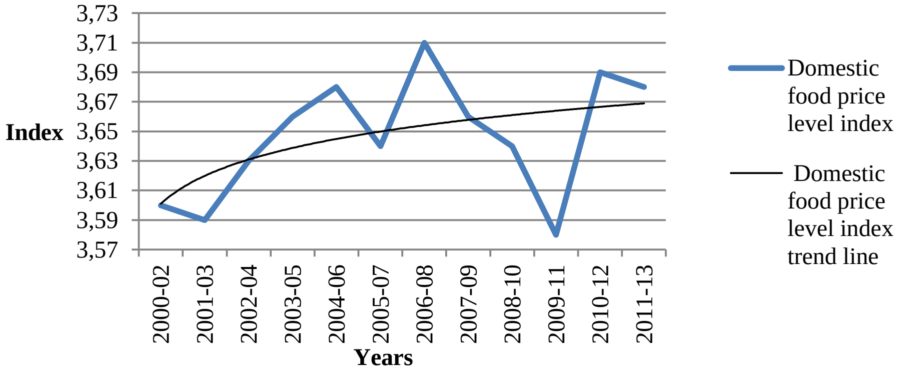
Knowing that food access is radical for food security and that accessibility includes both physical and economic access to food, we mainly focus on economic access. From 1990 to 2013, the gross domestic product (GDP) per capita (in purchasing power equivalent) in Tunisia doubled to reach about 11,000 (constant 2011 international $), with 13,000 forecasts in ten years according to its linear trend line (figure 3). It's far below the word average equivalent to 14,000 (constant 2011 international $) and the developed countries average (36,600 constant 2011 international $) in 2013.



Source: FAOSTAT, 2015

Figure 3. Gross domestic product per capita in Tunisia (1990-2013)

On the other hand, a slight increase in domestic food price index has been observed since 2000 reaching 3.7 in 2013 (FAOSTAT, 2015). This index registers an irregular and intermittent expansion over the years (figure 4). It contributes to the decline in food access, especially for poor households whose food expenditure share of the total expenditure border the 41% in 2014. This category of households is more exposed to any food prices changes. (FAOSTAT, 2015)



Source: FAOSTAT, 2015

Figure 4. Domestic food price index in Tunisia (2000-2013)

4.1.4. Food utilization and iron deficiency in Tunisia

Looking at FAO food security indicators, food utilization in Tunisia recorded significant improvements. Especially concerning the prevalence of anemia among pregnant women, this rate has dropped from around 39% in 1990-92 to 29% in 2011-13. With a slope of -0.5 of the linear trend line of the prevalence of anemia among pregnant women (figure 5); this rate will continually decrease to 23% in ten years. But, for children under 5 years old, this rate has an irregular and intermittent evolution: it reached its minimum in 2000-02 with 24%, then start to raise to 29.5% in 2011-13 as described in figure n°3 (FAOSTAT, 2015).

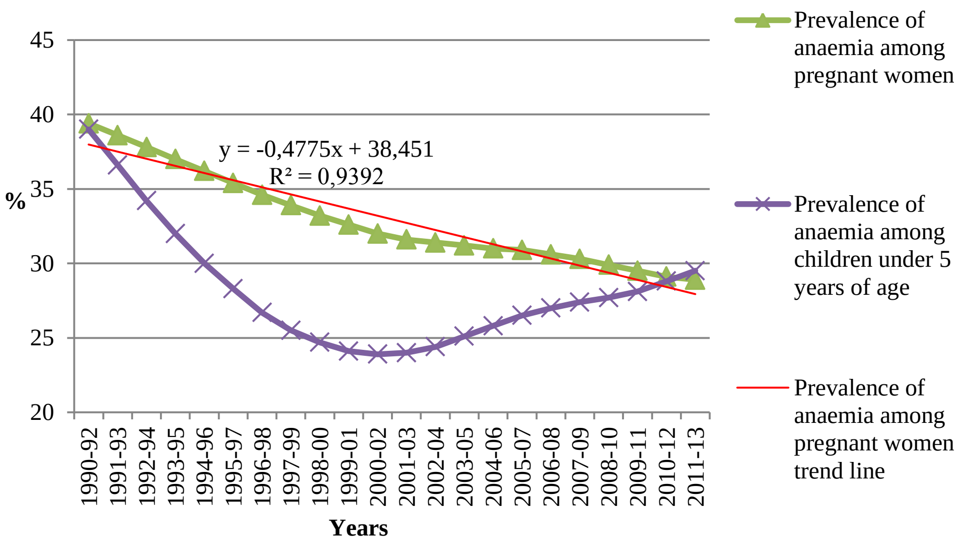
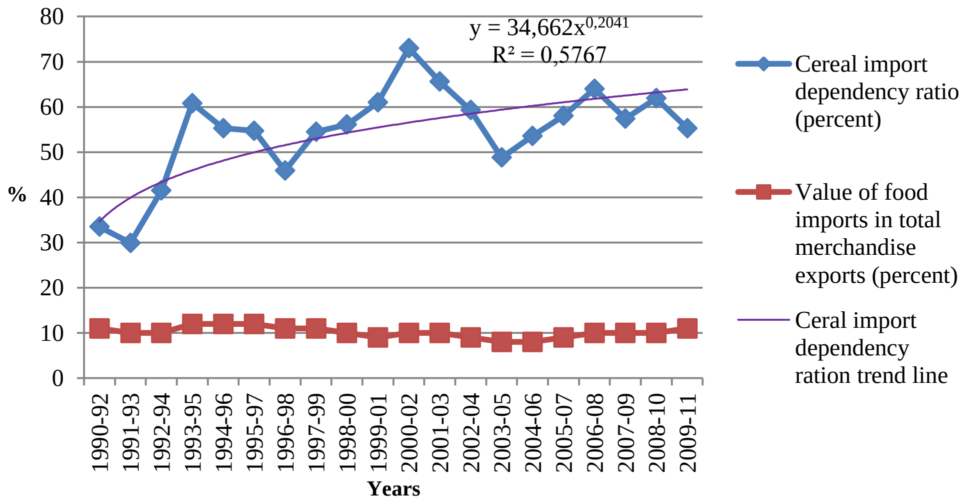


Figure 5. Prevalence of anaemia in Tunisia (1990-2013)
Source: FAOSTAT, 2015

Knowing that the bioavailability of iron varies according to the food origin, the food origin of iron intakes has a major importance especially for Tunisian suffering from the anemia problem. In fact, there are two forms of the iron contained in food heme iron and non-heme iron. The heme iron is present only in the animal products excepting for eggs and dairies products with a bioavailability of 25%. But this heme iron is small in the Tunisian diet. The iron brought by vegetable products exceeds 80%, arriving even at 95% for the lowest level expenses. The iron, retained from milk and eggs, represents 5% (INC, 2013). Dietary iron intakes increased according to the spending. There are deficiencies in dietary iron intakes for lower spending level households. Tunisian diet is always dominated by vegetable intakes, providing non heme iron with low bioavailability. Thus in Tunisia, the anemia problem is alarming.

4.1.5. Climate, political and economic instability in Tunisia

The arable land equipped for irrigation has increased from 13% in 1990 to reach 16% in 2011. With this low rate, Tunisian farming remains basically pluvial, extensive and high dependent on climatic changes, leading to instability of domestic agricultural production (FAO, 2015). As a result, Tunisia has been extremely dependent on cereal imports. In fact, cereal import dependency ratio increases over the years with an intermittent rhythm with a projection of 70% in 2019/21 Financially, about 10% of foreign exchange reserves are intended to pay for food imports (figure 6).



Source: FAOSTAT, 2015

Figure 6. Import dependency in Tunisia (1990-2011)

Both domestic production and trade are dependent on political and economic conditions. In Tunisia, the political stability index is substantially zero and became negative since the Tunisian revolution (2011). This political instability has a great effect on domestic food price volatility, manifested by a peak in 2011, as shown in figure 7.

Climate changes, political and economic risks affect enormously domestic agricultural production and food trade, affecting food supply per capita, highly variable over the years. (FAOSTAT, 2015)

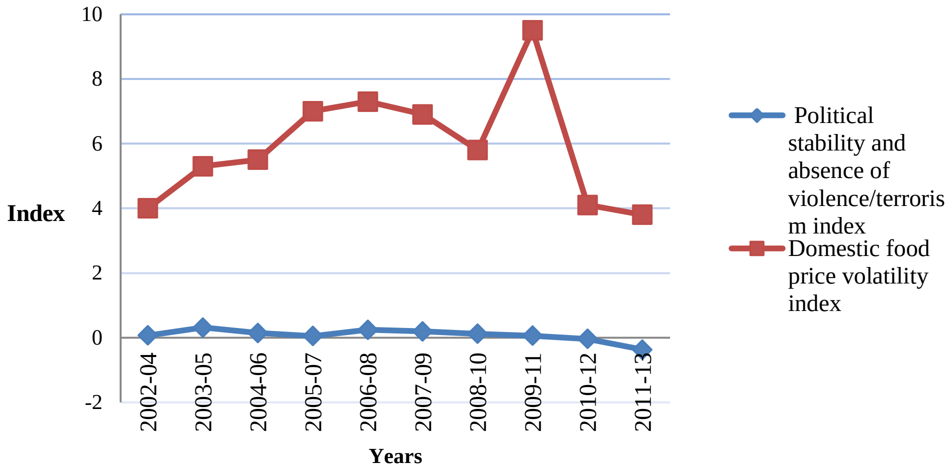


Figure 7. Political and economic risks in Tunisia (2002-2013)
Source: FAOSTAT, 2015

4.1.6. Challenges of FNS in Tunisia

Based on the above-exposed food security indicators, Tunisian FNS has been improved over the years, but food supply still dependent on cereal imports. In fact, Tunisian farming remains basically pluvial, extensive and highly dependent on climatic changes; water shortage is a major challenge facing domestic agriculture, and consequently, the dependence of Tunisia on cereal imports. What is more, and as a cost to these imports, 10% of foreign exchange reserves are spent. Tunisia is facing important challenges with diminishing agriculture potential, water scarcity, climate change and rising import bills.

Besides, though the gross domestic product (GDP) per capita increased, it remains far below the world average; and the observed slight amplification of food price inflation, has been thwarting to food accessibility.

Climate changes, political instability and economic risks affect enormously domestic agricultural production, food trade and food price volatility, which can be seen on food supply per capita variability. Therefore, there is no doubt that a high correlation exist between food security and environmental (water scarcity, climate changes) and both political and economic stability in Tunisia.

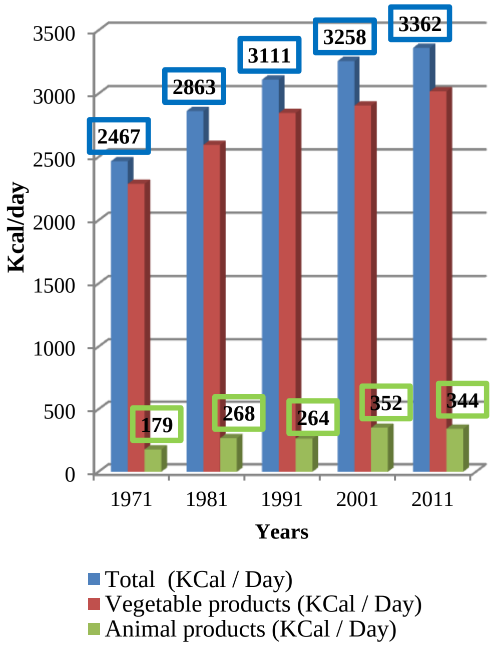
In what concerns the nutritional aspect, the essential of the Tunisian protein supply, unlike developed countries, is not from animal origin, which increases the anemia risks. Therefore, the focus on the contribution of domestic meat production to Tunisian FNS is needed.

4.2. The contribution of domestic meat production to Tunisian FNS

4.2.1. Tunisian diet with a real deficiency on animal proteins

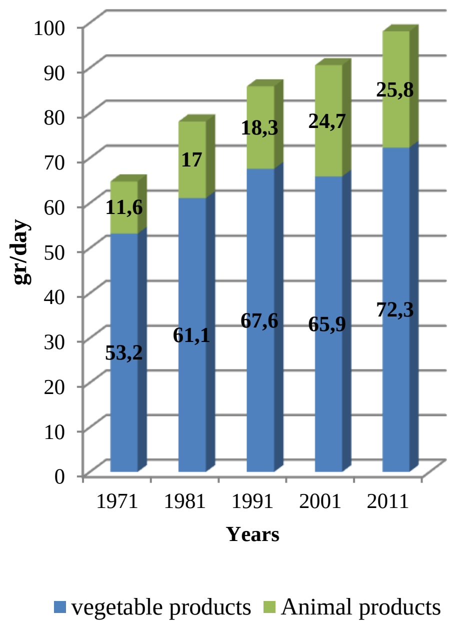
The Tunisian diet grows rich, but stays hyper-caloric and hypo-protein: animal products contribute to 10% of calorie intakes in 2011 (7% in 1971) as exposed in figure 8, against 29% in the European Union and 27% in the USA. (FAOSTAT, 2015)

It should be noted that quantities and structure of food intakes differ between living environment and spending levels. Animal Products continue to represent the biggest slice of the food expenses (more than 40%) especially in municipal environment. Inversely, vegetable products dominate food expenses in non municipal environment (INC, 2013). Tunisian diet derives its protein essentially form vegetable products (figure 9). Animal products contribute to 26% of total proteins daily intakes in Tunisia, which is lower than 58% in the European Union and much lower that the USA average of 65%.(FAOSTAT, 2015)



Source: FAOSTAT, 2015

Figure 8. Daily food intakes per capita in Tunisia (1971-2011)



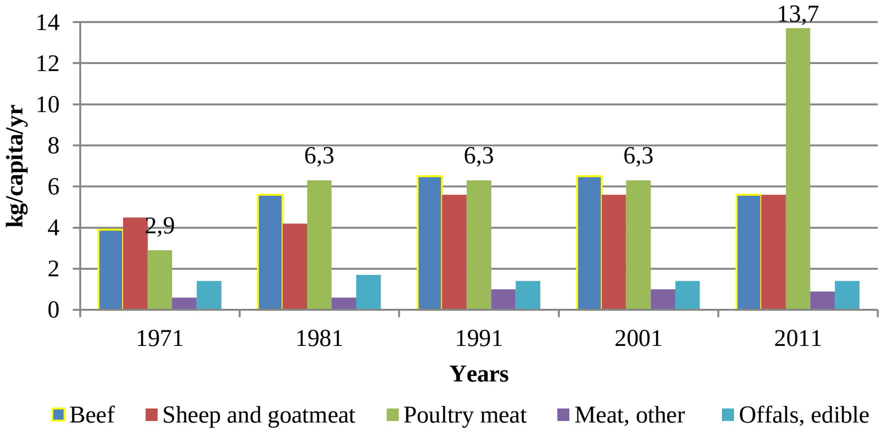
Source: FAOSTAT, 2015

Figure 9. Total protein intakes by origin in Tunisia (1971-2011)

The ratio animal protein on vegetable protein increases proportionally to the household food expenditure. Over the years, the lower level of expenses came along with a reduction in this proportion. These low rates sign a real deficiency on animal proteins; it means a lack of essential amino-acids, leading in the long term to protein malnutrition (INC, 2013). In addition to that, the anemia problem is alarming in Tunisia because of low heme iron availability due to low meat and fish consumption, among other factors. In fact, though meat consumption increased over the years, it remains insufficient.

4.2.2. FNS in Tunisia and meat consumption

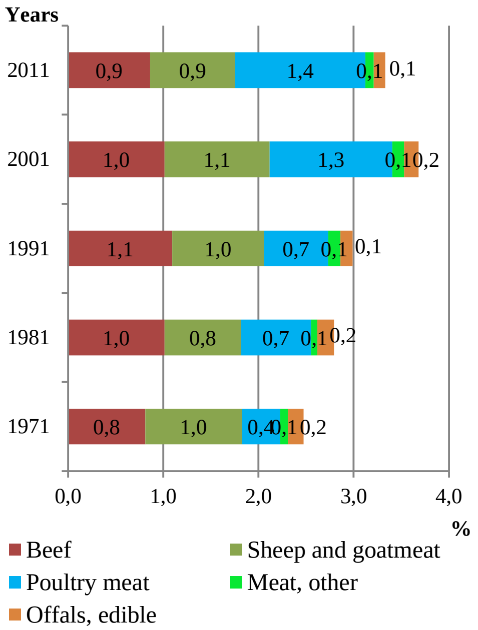
Tunisian consumption of meat is in progress since 1971 especially poultry consumption (figure 10). Poultry consumption increase from 3 kg/capita/yr in 1971 to 14 in 2011. This remarkable enhance is due to their affordable prices, lower than beef, sheep and goat meat prices. Poultry represent the main meat eaten in both municipal and non municipal environment. But, beef consumption is lower in non municipal environment. Sheep and goat meat consumption is similar in municipal and non municipal environment. (INC, 2013)



Source: FAOSTAT, 2015

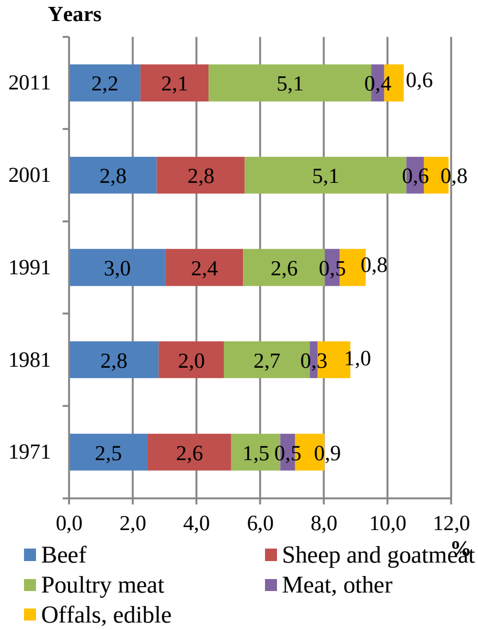
Figure 10. Meat consumption in Tunisia (1971-2011)

Since 1971, the ratio of meat consumption on daily caloric intakes per capita increased based only on the progress of poultry meat consumption; this rate for poultry meat has increased fivefold in four decades. Consequently, its contribution on daily protein intakes increased from 1.5% in 1971 to 5.1%in 2011 (Figures 11&12).



Source: author's calculation based on FAOSTAT, 2015

Figure11. Ratio of meat consumption on daily caloric intakes per capita



Source: author's calculation based on FAOSTAT, 2015

Figure 12. Ratio of meat consumption on daily protein intakes per capita

4.2.3. Meat sector challenges in Tunisia

In order to guarantee independence and food security, the high-priority objectives of Tunisian decision-makers are to improve domestic production, to reduce meat imports and to market meat at bearable prices (Hamdane, 2013b), although these products and particularly beef are among the biggest water consumers and the highest contributors to virtual water flows. In fact, Tunisia reached the self-sufficiency for poultry meat and even generates a surplus. The same is for sheep and goat meat, though occasional imports arise from time to time. The cover rate in beef demand is fluctuating and oscillates between 76% and 100% since 1971, so beef imports are needed. (Author’s calculation based on FAOSTAT, 2015)

Tunisian diet is largely starch-based in terms of calories, it derives its protein especially form vegetable products. Animal products contribute by 1/4 of total proteins daily intakes in Tunisia. This low rate of animal protein signs a lack of essential amino-acids, leading in the long term to protein malnutrition. Additionally, low meat consumption exacerbates the anemia problem in Tunisia. In order to enhance food security, a healthier diet should be adopted, based on a greater consumption of animal products, especially meat. In this context, the Tunisian agricultural policy tends to improve domestic meat production, to reduce meat imports with the aim of economic independence and to market meat at bearable prices. But animal husbandry, and particularly beef industry, is strongly dependent on imports of cereals for animal feed that it’s extremely water-consuming, which has an impact on FNS stability and sustainability.

4.3. Meat sector and FNS stability and sustainability in Tunisia

As presented in table 4, the average of water consumption for meat production in Tunisia far exceeds the world average, especially for beef. This exposes the problem of water resources management in animal husbandry in Tunisia. According to this average, meat production in Tunisia in 2011 consumes the equivalent of 5.4 billions of m^3 of water. Beef production uses about 40% of total consumed water. However, 12% are used for poultry meat production and 9% for sheep and goat meat production.

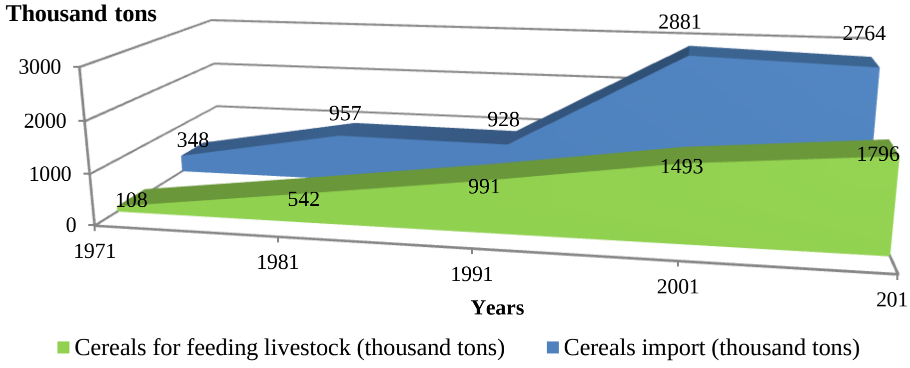
Table 4. Water Footprint of Animal Products in M^3/Ton (1996-2005)

	World Average	Tunisia Average
Beef	10942	37329
Sheep and goat meats	6915	7955
Poultry meat	3845	4479
Meat, other	51779	210449
Offals, edible	11155	34913

Source: Mekonnen & Hoekstra, 2010

Given its limited water resources, Tunisia should import the maximum of agri-food products with high water-consumption. Moreover, it should produce and export those with low water-consumption and high added value. Thus, it is not recommended to produce meat in Tunisia for water security reasons, contrary to the national strategies promoting domestic meat production for independence reasons.

Nevertheless, the strong density in virtual water of meat is due to feed animal consumption. The problem in the meat sector in Tunisia is not limited to the occasional meat imports, but also concerns the Tunisian dependence on cereals imports. Indeed, a huge part of cereals imports is intended for animal feed as clear in figure 13.



Source: FAOSTAT, 2015

Figure 13. Cereals import and animal feed use in Tunisia (1971 -2011)

The equivalent virtual water of cereal for animal feed in 2011 is around 2.5 billion m^3, almost all of which are imported. However, it's important to note that virtual water related to agri-food imports is about 4.5 billion m^3 (Hamdane, 2013a). Thus, producing meat to satisfy domestic demand and even to export, while importing cereal for animal feed at fair prices, is a relevant alternative for Tunisia. Fernandez (2007) and Hamdane (2013a&b) share this view. But, reducing deficit of cereal production by massive import flow remains economically and politically unacceptable, especially within this politic and economic, national and international, instability. The stability and the sustainability of FNS remain threatened by the dependence of Tunisia on cereals imports and by water scarcity. Tunisian agricultural policy, particularly in the cereals and meat sectors, is to be reviewed according to diverse constraints: politic and economic risks, water availability, rationalization of household diet, etc.

Subsequently, to decrease dependence on cereals imports in the aim of enhancing FNS, Tunisian farming policy should be reformed. These reforms should promote breeding system, the least consuming of water by changing the structure of animal feed and by supporting poultry, sheep and goat farming, at the expense of cattle breeding. Also, Tunisian agri-food trade policy should be centered on reducing cereal imports, while importing beef which represent meat with high consumption of water. Furthermore, Tunisian food policy should strengthen meat consumption to decease anemia risks, taking into account food availability in Tunisia.

5. Conclusion

This study uses FAO and GFSI indicators to explore FNS evolution in Tunisia; as well as the Food Balance Sheets of the FAO to investigate the contribution of domestic meat production on Tunisian FNS. To evaluate FNS sustainability within water scarcity conditions, the databases of the Water footprint Network was used to estimate the virtual water, owed to meat and cereal for animals feed production and trade.

The results indicate that Tunisian FNS has been improved over the years, but food supply still influenced by water scarcity, climate changes, political and economic instability. Tunisian diet is largely starch-based in terms of calories, with a low rate of animal and especially meat protein. Low meat consumption exacerbates the anemia problem in Tunisia. Therefore, a healthier diet should be adopted. As a result, the high-priority objectives of

Tunisian decision-makers were to improve domestic production and to market meat at bearable prices. Knowing that the strong density in virtual water of meat is due to feed animal consumption, producing meat, while importing cereal for animal feed, can be justified for the Tunisia situation. But, massive cereals import remains economically and politically unacceptable, especially in light of the politic and economical, national and international, instability.

The sustainability of FNS remains threatened by the dependence of Tunisia on cereal imports and by water scarcity. Tunisian agricultural and agri-food trade policies, in particular those concerning cereal and meat sectors, should be reviewed to decrease cereal imports dependency and to promote water saving breeding system.

References

Aberman, N.L, Meerman, J., & Benson, T. (2015). Mapping the linkages between agriculture, food security & nutrition in Malawi. A publication of the Malawi Strategy Support Program of the International Food Policy Research Institute

Allan, J.A. (1993). "Fortunately there are substitutes for water otherwise our hydro-political futures would be impossible". ODA, In Priorities for water resources allocation and management. Pages. 13-26. London, United Kingdom

Antonelli, M. & Sartori M. (2014). Unfolding the Potential of the Virtual Water Concept. What is still under debate?. MPRA Paper No. 60501. Retrieved from: https://mpra.ub.uni-muenchen.de/60501/

De Haen, H., Klasen, S., Qaim, M. (2011). What do we really know? Metrics for food insecurity and under nutrition Hartwig. Food Policy . Volume 36, Issue 6, Pages 760–769

Dinesh, K.M. & Singh, O.P. (2004). Virtual water in global food and water policy making: is there a need for rethinking?.Water resources management 19, 759-789, DOI:10.1007/s11269-005-3278-8

FAO (Food and Agriculture Organization of the United Nations). (2002). Eau et agriculture : produire plus avec moins d'eau, Organisation des Nations Unies pour l'alimentation et l'agriculture, Rome, 2002. Retrieved from: ftp://ftp.fao.org/docrep/fao/005/y3918F/Y3918F00.pdf

FAO. (2015). The State of Food Insecurity in the World, Meeting the 2015, international hunger targets: taking stock of uneven progress. Retrieved from: http://www.fao.org/3/a-i4646e.pdf

FAOSTAT. (2015). FAOSTAT |© OAA STATISTICS DIVISION 2015 | 11 August 2015. Retrieved from: http://faostat3.fao.org

Fernandez, S. (2007). Gestion de la demande en eau en Méditerranée, progrès et politiques, Zaragoza, 19-21/03/2007, Etude régionale, L'eau virtuelle en Méditerranée : un indicateur pour contribuer à l'analyse des questions de gestion et de répartition de l'eau en situation de pénurie ?, UMR G-EAU-ENGREF–Centre de Montpellier, Département « Eau »

Gawel, E. Bernsen, K. (2013). What is wrong with virtual water trading? On the limitations of the virtual water concept. DOI: 10.1068/c11168

Hamdane, A. (2012). L'eau et la sécurité alimentaire. Cas de la Tunisie, Conference Sharing Knowledge Across the Mediterranean. 17-19 May 2012- Tunis

Hamdane, A. (2013a). La triade « eau bleue, eau verte, eau virtuelle » et la sécurité alimentaire en Tunisie. Dossier Eau et sécurité alimentaire et dynamiques régionales pour un défi planétaire. Demeter. 19, 65-73

Hamdane, A. (2013b). Le défi vital de la Méditerranée. Séminaire Eau et sécurité alimentaire, séminaire Eau et Sécurité Alimentaire en Méditerranée. 21- 22 février 2013, Agropolis International, Montpellier, France

Hanjra, M.A. & Qureshi, M.E. (2010). Global water crisis and future food security in an era of climate change, Food Policy 35. Pages 365–377

INC (Institut National de Consommation). (2013). Les changements des modes de consommations en Tunisie. Retrieved from: http://inc.nat.tn/sites/default/files/document-files/rapport_final mai_2013_0.pdf

Le Vernoy, A. (2006). Eau et commerce agricole, les échanges d'eau virtuelle dans la région méditerranéenne. Policy Brief du Groupe d'Economie Mondiale (Sciences-Po). Retrieved from: http://gem.sciences po.fr/content/publications/pdf/levernoy_eauvirtuelle_FR310506.pdf

Ludi, E., (2009). Climate change, water and food security, Background Note, Overseas Development Institute

Lysiane, R. & Corinne, G. (2005). Le commerce de l'eau virtuelle : du concept à la politique. G2O / vol. 80/4

Meissner, R. (2002). Regional Food Security, Using the concept of virtual water. African Security Review Vol 11 No 3, 942044-32-5

Mekonnen, M.M & Hoekstra, A.Y. (2010). The green, blue and grey water footprint of farm animals and animal products, Value of Water Research Report Series No. 48, UNESCO-IHE, Delft, the Netherlands.

Mekonnen, M.M & Hoekstra, A.Y. (2011a). National water footprint accounts: The green, blue and grey water footprint of production and consumption Volume 1: Main Report. Value of water Research Report Series No. 50, UNESCO-IHE Institute for Water Education. Retrieved from: http://waterfootprint.org/media/downloads/Report50-NationalWaterFootprints-Vol1.pdf

Mekonnen, M.M & Hoekstra, A.Y. (2011b). The green, blue and grey water footprint of crops and derived crop products, Hydrology and Earth System Sciences, 15(5): 1577-1600. DOI: 10.5194/hess-15-1577-2011

Mekonnen, M.M & Hoekstra, A.Y. (2012). A global assessment of the water footprint of farm animal products, Ecosystems, 15(3): 401–415. DOI: 10.1007/s10021-011-9517-8

Pangaribowo, E. H., Gerber, N., & Torero, M. (2013). Food and nutrition security indicators: a review. Working Paper 108. ZEF Working Paper Series, ISSN 1864-6638

Rastoin, J.L. & Benabderrazik, E.H. (2014). Céréales et oléoprotéagineux au Maghreb Pour un co-développement de filières territorialisées, IPEMED. Paris (France). 134 p. Retrieved from: http://www.ipemed.coop/fr/-r17/collection-construire-la-mediterranee-c49/cereales-et-oleoproteagineux-au-maghreb-pour-un-co-developpement-de-filieres-territorialisees-a2288.html

Santeramo, F.G. (2015). On the composite indicators for food security: decisions matter! Food Reviews International. 31:63-73.

Scardigno, A. (2006). Virtual water flows and food security. CIHEAM Briefing note, N°16

Schubert, H. (2011). The Virtual Water and the Water Footprint Concepts, Acatech Materialien – Nr. 14 ISSN: 2191-84

The Economist Intelligence Unit. (2015). Global food security index 2015. An annual measure of the state of global food security. The Economist

Von Grebmer, K., Ringler, C., Rosegrant, M. Olofinbiyi W. T., Wiesmann, D., Fritschel, H. Badiane, O., Torero, M., Yohannes, Y., Thompson, J., Von Oppeln, C., Rahall. J. (2012). The Challenge of Hunger: Ensuring Sustainable Food Security under Land, Water, and Energy Stress. Retrieved from: http://www.ifpri.org/publication/2012-global-hunger-index

Water Footprint Network. (2015). Retrieved from: http://waterfootprint.org/

WTO. (2010). Rapport sur le commerce mondial: Théorie du commerce international et ressources naturelles. Retrieved from: https://www.wto.org/french/res_f/booksp_f/anrep_f/world_trade_report10_f.pdf

WWC (World Water Council). (2004). E-Conference Synthesis: Virtual Water Trade - Conscious Choices, ISBN: 92-95017-10-2

Yves, R. (2012). L'eau et la sécurité alimentaire face au changement global : quels défis, quelles solutions ? Contribution au débat international Préface de la FAO