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PARI

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About this study

In 12 African countries and India Green Innovation Centers (GICs) have been established under the ‘‘One World, No Hunger’’ Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector of these countries. The Program of Accompanying Research for Agricultural Innovation (PARI) has been providing independent research to the SEWOH since 2015. PARI is led by the Center for Development Research (ZEF) at the University of Bonn in close collaboration with the Forum for Agricultural Research in Africa (FARA) and its network of national and regional partners in Africa, the African Growth and Development Policy Modeling Consortium (AGRODEP) facilitated by the International Food Policy Research Institute (IFPRI, Africa Office) and other partners in Germany and India. This country dossier offers a situation analysis of the current state of the agri-food sector, related policies and existing agricultural innovations. It thereby provides basic background knowledge necessary to make fruitful investments in line with the country‘s policies and its potentials, and to find promising partners for development cooperation.

Table of Contents

List of Tables

List of Figures

Acronyms/Abbreviations

ACIAR	Australian Center for International Agricultural Research
ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
AFD	Agence française de développement / French development agency
APIA	Agence de Promotion des Investissements Agricoles / Agency for the Promotion of Agricultural Investments
ARIMNet	Agricultural Research in the Mediterranean Network
AVFA	Agence de la vulgarisation et de la formation agricoles / Agency for Agricultural Training and Extension Services
CAADP	Comprehensive Africa Agriculture Development Program
CANA	Adapting Conservation Agriculture for Rapid Adoption by Smallholder Farmers in North Africa
CGIAR	Consultative Group International Agricultural Research
CIHEAM	Centre International de Hautes Etudes Agronomiques Méditerranéennes / International Center for Advanced Mediterranean Agronomic Studies
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement / French Agricultural Research Centre for International Development
DCT	Double Concentrated Tomato
DGAB	Direction Générale de l'Agriculture Biologique / General Directorate for Bio-Agriculture
DGF	Direction National des Forêts / General Directorate of Forests
ENPI-CBC-MED	European Neighbourhood Partnership Instrument – Cross-Border Cooperation in the Mediterranean basin
EBRD	European Bank for Reconstruction and Development
EU	European Union
FAO	Food and Agriculture Organization
GIC	Green Innovation Center
GDP	Gross Domestic Product
GHI	Global Hunger Index
GIL	Groupement interprofessionnel des legumes / Inter-professional group for vegetables
GIP	Groupe interprofessionnel / Inter-professional group
GIPAC	Groupement Interprofessionnel des Produits Avicoles et Cunicoles / Interprofessional Group of Poultry and Rabbit Products
GIFruits	Groupement interprofessionnel de fruits / Inter-professional group for fruits
GIPP	Groupement interprofessionnel des produits de la pêche / Inter-professional group for fishing products
GIVLait	Groupement interprofessionnel lait et viande rouge / Inter-professional group for milk and read meat
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit / German Agency for International Cooperation
GNI	Gross National Income
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
INGC	Institut National des Grandes Cultures / National Institute of Field Crops
INRA	Institut national de la recherche agronomique / French National Institute for Agricultural Research
INRAT	Institut National de Recherche Agronomique de Tunis / National Agricultural Research Institute of Tunisia

IP	Innovation platform
IRESA	Institution de la Recherche et de l'Enseignement Supérieur Agricoles/ Institution of Agricultural Research and Higher Education
IRSTEA	Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement / Research Institute for Agricultural and Environmental Engineering
NARS	National Agricultural Research System
PARI	Program of Accompanying Research for Agricultural Innovation
PPP	Purchasing Power Parity
R&D	Research and Development
RCA	Revealed Comparative Advantage
SEWOH	"One World, No Hunger" Initiative
SMSA	Société Mutuelle de Services Agricoles / Mutual for Agricultural Services
TFP	Total Factor Productivity
UNICEF	United Nations International Children's Emergency Fund
UNIDO/SECO	United Nations Industrial Development Organization/ Swiss Secretariat of Economic Affairs
WHO	World Health Organization
ZEF	Zentrum für Entwicklungsforschung / Center for Development Research

1 General background information on the agricultural and food sectors

Tunisia occupies an area of 16.3 million ha and has an estimated population of about 11 million people. Farmland covers about 10 million ha of which 4.2 are cultivated under irrigation. These areas are used for (i) grain farming: 1.7 million ha and (ii) tree growing: 2.2 million ha (1.7 million ha of olive trees) (iii) forage crops and vegetable. Agriculture is an important sector in the Tunisian economy – it contributes about 11.5% of Gross Domestic Product (GDP) and employs about 22% of the Tunisian workforce (i.e. providing one fifth of the jobs and permanent income to 470,000 farmers and 60,000 fishermen) (Dhehibi and Rached, 2010; Augustin *et al.,* 2012). The agricultural growth rate is estimated at 6% compared to the population growth rate of about 1% (ibid). Agriculture contributes about 14% of the national investments. The sector is the largest user of the natural resources: 80% of water resources, and 90% of fertile land (Havnevik *et al.,* 2007; Augustin *et al.,* 2012). In addition, the sector ranks second in terms of production and value-addition after industry (manufacturing). It contributes about 14% to the balance of payments through exports which consist mainly of olive oil, fruits (dates, orange) and seafood. Cereals, vegetable oil, and sugar are the major imports.

Over the last three decades and before the Tunisian revolution in 2011, agricultural policy was characterized by a State control (Havnevik *et al.,* 2007). This is reflected by the following:

- Protection of the consumer purchasing power by giving priority to the domestic market;
- Mobilization of natural resources for the sector;
- Rural development and support to small-scale agriculture (family farming);
- Promoting the export of products that have a comparative advantage.

Two successive shocks have led authorities to begin discussions on a new strategy; firstly, the 2008 food crises which led several vulnerable countries, including Tunisia, to review their concept of food security. Secondly, the revolution of 14 January 2011 proved how fragile the development models were being applied. These led to the redefinition of the notion of food security on one hand and the refocusing of concerns on employment and regional development on the other. Refocusing should lead to a better consideration of smallholders in deprived regions.

In twelve African countries, including Tunisia, Green Innovation Centers (GICs) have been established in selected regions under the ‘‘One World, No Hunger’’ Initiative (SEWOH) of the German government and other investors. The aim of the GICs is to promote agricultural innovation, improve food and nutrition security and build sustainable value chains in the agri-food sector. The selected value chains in Tunisia are red meat/milk (which constitutes 37% of agricultural economic output), fruit/tree crops (which constitutes 40% of agricultural economic output) value chains in Beja and Kairouan regions of Tunisia. Both value chains are high quality processed products in the local market. There exists growth potential for the fruit/tree crops/vegetables value chain in the export market. These value chains would require consistent quality assurance systems, sustainable production systems, and energy efficient technologies.

1.1 Pan-African policies and strategies

Since the launch of the Comprehensive Africa Agriculture Development Program (CAADP) in 2003, Tunisia has not met the CAADP 10% expenditure target[1]. The average share of agricultural expenditure in total public expenditure was 8.5% during the 1995-2003 period; this declined to 6.8% during the 2003-2008 period and further to 5.3% during the 2008-2013 period (ibid).

Building on its multiples identities (Mediterranean, Arab-Muslim, Maghrebin and African), Tunisia has diversified its collaborative relationships in various fields, particularly in agriculture. The **Mediterranean and Euro-Mediterranean** area has offered Tunisia several opportunities, including to be a member of CIHEAM (Centre International de Hautes Etudes Agronomiques Méditerranéennes)

[1] www.resakss.org

and its several initiatives and networks, to carry out joint research programs and technical projects, engage in collaborative networks for development and to be included in the various research networks, such as the 7th Framework Program for Research and Technological Development and the Agricultural Research in the Mediterranean Network (ARIMNet). It has also given Tunisian agriculture a valuable advance through the European Neighborhood Partnership Instrument – Cross-Border Cooperation in the Mediterranean basin (ENPI-CBC-MED) Good neighborliness initiative and has strengthened collaboration with France (which is a traditional partner), particularly through the French National Institute for Agricultural Research (INRA), the French development agency (AFD), the French Agricultural Research Centre for International Development (CIRAD) and with Italy. There are also good development-oriented collaborations with the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ), the German development aid agency, and the *Deutscher Akademischer Austauschdienst*, the German Academic Exchange Service. Bilateral programs of research with France, Turkey, and Spain for example are launched frequently.

Being a member of the **Maghreb region or the Arab-Muslim world** has allowed Tunisia to have direct bilateral or multilateral cooperation and assistance through regional organizations such as the Arab Organization for Agricultural Development and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD). Direct cooperation with **Sub-Saharan Africa** remains weak. Having joined the PARI program, Tunisia could strengthen this collaboration. Finally, the various cooperation projects contribute to the virtual library and the production of innovation.

1.2 National (and regional) policies and strategies

Tunisian Government agricultural sector policy is guided by Five Year Development Plans. Over the last 20 years, Tunisia has pursued an agricultural development strategy oriented towards economic growth and social stability. The main aim of this strategy is to ensure intensive sustainable productivity and improve access to foreign markets and thus, improve farmers' livelihoods. A summary of the development plans for the last two decades are as follows:

- The 8th Plan (1992-1996): Enhancing agricultural productivity through investments in applied agricultural research and extension, delivery of farmer support services, reforms in land tenure, agricultural credit and fiscal systems were carried out to encourage private entrepreneurship;
- The 9th Plan period (1997-2001): Domestic reforms in price subsidy in the face of a new Association Agreement with the European Union, World Trade Organization liberalization and the creation of the Arab Free Trade Area;
- The 10th Plan (2002-2006): Continuation of the 9th Plan and emphasis on private investment and smallholder agriculture's roles in social and regional development.

1.3 Data on food and nutrition security in Tunisia and GIC region

The following section includes information about important socio-economic and agricultural indicators and data on diet quantity, diet quality and nutrition status.

1.3.1 Socio-economic and agricultural data

Table 1: Selected national economic and health-related data

Indicator	Value	Year
Population, total	10,996,600	2014
Population growth (annual %)	1.0	2014
Rural population (% of total population)	33	2014
GDP per capita, PPP (constant 2011 international $)	10,768	2013
GNI per capita, PPP (constant 2011 international $)	9,719	2011
Poverty headcount ratio at $2 a day (PPP) (% of population)	4.5	2010
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	0.7	2010
Poverty headcount ratio at national poverty lines (% of population)	16	2010
Agricultural land (% of land area)	65	2012
Agricultural irrigated land (% of total agricultural land)	3.8	2011
Agriculture value added per worker (constant 2005 US$)	4,424	2013
Agriculture, value added (% of GDP)	8.6	2013
Access to electricity, rural (% of rural population)	100	2013
Employment in agriculture (% of total employment)	16	2011
Literacy rate, adult total (% of people ages 15 and above)	80	2011
Ratio of female to male secondary enrollment (%)	105	2011
Mortality rate, under-5 (per 1,000 live births)	15	2013
Maternal mortality ratio (modeled estimate, per 100,000 live births)	46	2013

Source: World Bank, data.worldbank.org/country
Note: GDP refers to Gross Domestic Product; GNI refers to Gross National Income; PPP refers to Purchasing Power Parity

1.3.2 Data on diet quantity, diet quality and nutrition status

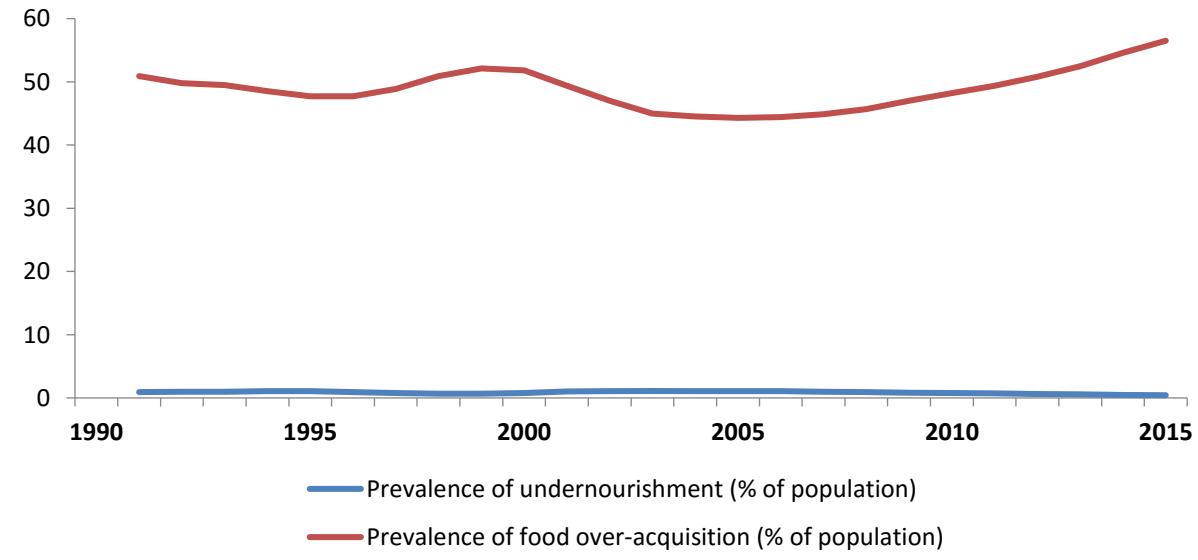
Data on diet quantity, diet quality and nutrition status are relevant for assessing food and nutrition security. Dietary energy supply per capita – a measure of diet quantity – is more than adequate in Tunisia: It exceeds the average dietary energy requirement of the population by almost 50% (Table 2). The prevalence of food over-acquisition is high: the United Nations Food and Agriculture Organization (FAO) estimates that close to 57% of the population tends to regularly acquire food in excess of their dietary energy needs. The prevalence of undernourishment has been very low for the past 25 years and is virtually zero at present (Figure 1). The prevalence of food-over acquisition has fluctuated around 50% since the early 1990s, showing an increasing trend in recent years.

Table 2: Food and nutrition security indicators

Indicator	Value	Year
Diet quantity		
Dietary energy supply (kcal/caput/day)	3491	2014-16
Average dietary energy supply adequacy (% of average requirement)	148	2014-16
Prevalence of undernourishment (% of population)	0	2014-16
Prevalence of food over-acquisition (% of population)	57	2014-16
Diet quality		
Dietary energy supply from cereals, roots and tubers (% of total dietary energy supply)	53	2009-11
Dietary energy supply from carbohydrate (% of total dietary energy supply)	65	2009-11
Dietary energy supply from protein (% of total dietary energy supply)	12	2009-11
Dietary energy supply from fat (% of total dietary energy supply)	23	2009-11
Average protein supply (g/caput/day)	97	2009-11
Average fat supply (g/caput/day)	87	2009-11
Nutrition status		
Child wasting (% of children under five)	3	2011-12
Child stunting (% of children under five)	10	2011-12
Child overweight (% of children under five)	14	2011-12
Adult overweight and obesity (% of adults 18+ years)	63	2014
Adult obesity (% of adults 18+ years)	27	2014
Vitamin A deficiency (% of children 6-59 months)	6	2013
Anemia in children (% of children 6-59 months)	29	2011
Anemia in women (% of women 15-49 years)	28	2011

Source: FAO (2016), and authors' calculations based on FAO (2016); Ministère du Développement et de la Coopération Internationale, Institut National de la Statistique, and United Nations International Children's Emergency Fund (UNICEF) (2013); Stevens et al. (2015), quoted in International Food Policy Research Institute (IFPRI) (2015); von Grebmer et al. (2016); World Health Organization (WHO) (2015a); WHO (2015b)
Note: Data on child feeding practices are not available for Tunisia. See Annex A for definitions of the indicators.

Figure 1: Prevalence of undernourishment and food over-acquisition (1990-92 to 2014-16)

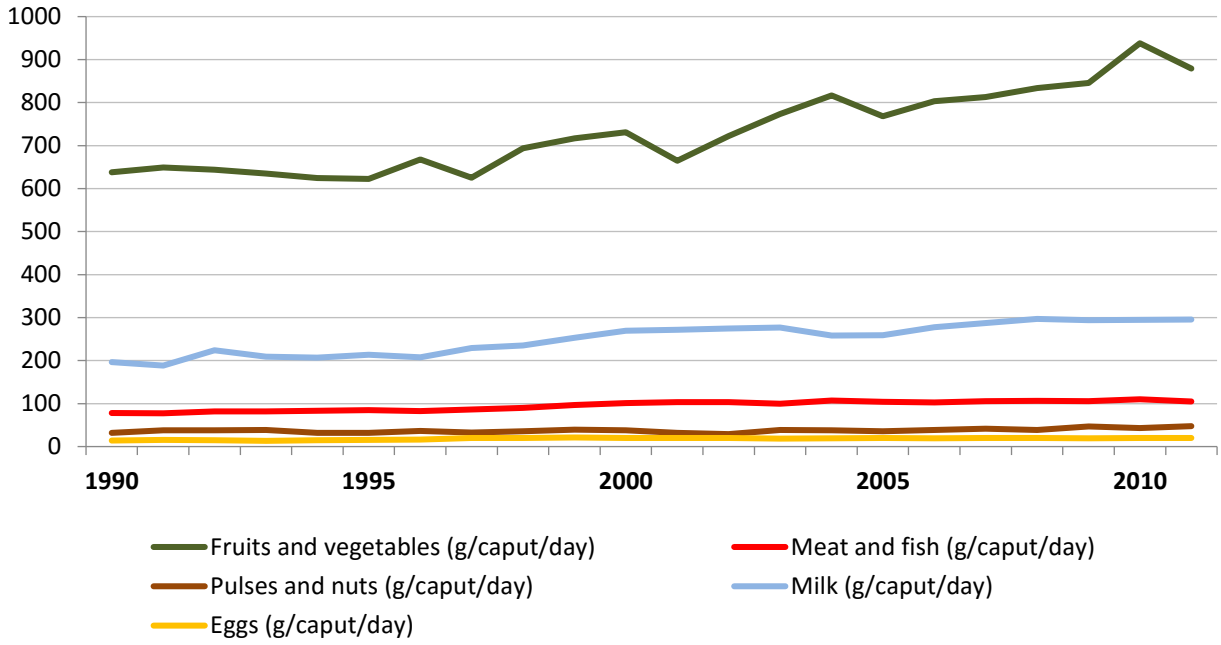


Source: Authors' presentation based on data from FAO (2016)

The main sources of dietary energy in Tunisia are cereals, vegetable oils, sugar, and dairy. Starchy staples such as wheat, other cereals and potatoes contribute only a bit more than half of overall dietary energy supply (Table 2). The shares of dietary energy supply from carbohydrates, protein, and fat are well within the recommended ranges of 55-75%, 10-15%, and 15-30%, respectively (WHO, 2003). This means that the diet is balanced in terms of the shares of the three macronutrients, yet, it has to be noted that dietary energy supply is excessive and that the absolute amounts of protein, carbohydrates, and fat available for human consumption are high. Average protein supply exceeds protein requirements considerably, yet, intakes at this level are unlikely to pose a risk (Table 2; see Annex A for further explanation).

The consumption of sufficient quantities of non-staple foods such as fruits and vegetables and animal-source foods is essential for a diet that provides adequate amounts of micronutrients. The supply of meat and fish in Tunisia has increased slowly since the early 1990s, slightly exceeding 100 g/caput/day in recent years (Figure 2). Milk supply has grown more rapidly and is relatively high by African standards, amounting to almost 300 g/caput/day, whereas the supply of eggs is moderately high. Pulses and nuts also play a role in the diet, although their supply is lower than that of most other food groups. Fruit and vegetable supply has risen to about 880 g/caput/day, more than twice the recommended intake of 400 g of fruits and vegetables per day (WHO, 2003). Tomatoes make up more than one third of overall vegetable supply.[2]

Figure 2: Supply of non-staple foods (1990-2011)



Source: Authors' presentation based on data from FAOSTAT, accessed 07 October, 2016
Note: Based on their nutrient profiles, pulses and nuts include groundnuts and soybeans, although these foods are classified by FAO as oilcrops. Coconuts are not included among pulses and nuts because they have low protein content.

Stunting and wasting are indicators of chronic and acute child undernutrition, respectively. In Tunisia, the prevalence rates of stunting and wasting were already below the thresholds for mild public health significance in the late 1980s, and stunting has declined further while wasting has remained at a low level (UNICEF/WHO/World Bank, 2016). Only 3% of children are wasted and one tenth are stunted (Table 2). However, overweight among children has almost quadrupled since the late 1980s and now

[2] Source: Food balance sheet for Tunisia, 2011, from FAOSTAT, accessed 13 November, 2016

affects 14% of all children under five (UNICEF/WHO/World Bank, 2016). This means that child overweight represents a severe public health concern in Tunisia.

Overweight and obesity are risk factors of chronic diseases such as diabetes (Must and McKeown 2012). The prevalence of overweight and obesity is very high in Tunisia: WHO estimates that almost two thirds of adults are overweight or obese and that more than one fourth is obese (Table 2; see Annex A for definitions of overweight and obesity).

Vitamin A deficiency is a risk factor for blindness and for mortality from measles and diarrhea in children aged 6-59 months (Imdad et al. 2010; Imdad et al. 2011). In Tunisia, the estimated prevalence of vitamin A deficiency among children is low, amounting to only 6% (Table 2). Close to 30% of women of reproductive age and about the same proportion of children aged 6-59 months suffer from anemia (Table 2). The prevalence of anemia among children in Tunisia is low compared to other countries on the continent, amounting to less than half the regional prevalence in Africa. Globally, about half of the global burden of anemia can be attributed to iron deficiency (WHO, 2015b).

Regionally disaggregated data for Tunisia are available for indicators of child nutrition status. The prevalence of stunting is lowest in the Centre Est and Sud Est regions, and highest in the Nord Ouest and Kairouan regions, which were selected as GIC regions (Table 3). Overweight in children varies from 10% in the Kairouan region to almost 20% in the Kasserine and Sud Ouest regions. Wasting and stunting are safely below the thresholds of mild public health significance in all regions, while overweight has severe public health significance in all regions except for the Kairouan region, where it is only a moderate concern.

Table 3: Child nutrition status by region, 2014

Prevalence among children under five:					
Stunting		**Wasting**		**Overweight**	
Region	**(%)**	**Region**	**(%)**	**Region**	**(%)**
Centre Est	6	Nord Ouest	2	Kairouan	10
Sud Est	7	Kairouan	2	Centre Est	11
District Tunis	9	Nord Est	2	Sidi Bouzid	13
Nord Est	13	Sidi Bouzid	2	District Tunis	14
Sidi Bouzid	14	Sud Ouest	2	Sud Est	14
Kasserine	14	Sud Est	3	Nord Est	16
Sud Ouest	14	Kasserine	3	Nord Ouest	17
Nord Ouest	15	Centre Est	3	Kasserine	19
Kairouan	15	District Tunis	4	Sud Ouest	19

Source: Ministère du Développement et de la Coopération Internationale, Institut National de la Statistique, and UNICEF (2013)
Notes: GIC regions are marked in red. See Annex A for definitions of the indicators.

In summary, over-nutrition is the most pressing nutrition problem in Tunisia, followed by micronutrient deficiencies; in some regions, stunting should also be addressed. The potential of the agricultural sector to counteract widespread overweight and obesity appears limited, since healthy fruits and vegetables with low energy density are already supplied in abundance.[3] The very high supply of dietary energy, vegetable oils and sugar for domestic consumption should certainly not be increased, and foods with low energy, sugar and fat content need to be promoted. In order to combat micronutrient deficiencies, value chain development may focus on lean meat (poultry, for example) and fish, low-fat

[3] Other sectors are in charge with commonly recommended measures to curb overweight and obesity, such as raising awareness, promoting health and nutrition education, and encouraging physical activity.

dairy, and on the fortification of staple foods and the production of fortified baby foods. Biofortified varieties of wheat, Tunisia's most important staple crop, have been developed for Asia, but have not yet been tested in Africa.[4]

In addition, eliminating aflatoxins in foods would improve food safety in Tunisia. Aflatoxins are highly toxic substances that are produced by certain types of fungi and can cause acute poisoning, liver cancer, and stunted growth in children (Bhat and Vasanthi, 2003; Gong et al., 2004). Aflatoxins were detected in low to moderate concentrations in about one third of samples of commonly consumed foods in Tunisia, with sorghum, spices and nuts being the most contaminated foods (Ghali et al., 2010).

Note: Tunisia is the only one of the 12 countries that did not join the Scaling Up Nutrition movement.

1.4 Data on most relevant crops and value chains

The most relevant crops in Tunisia include grains (wheat, barley), tree crops such as, olives, dates, orange and almonds, vegetables (e.g., tomatoes, peppers, carrots, melons, potatoes). There is also a significant livestock sector. Production and consumption data are provided below.

1.4.1 Production

Table 4: Top 10 crops produced by area, volume and value

Area harvested (ha)		Production volume (tons)		Production value*	
Top 10	**Share of Total (%)**	**Top 10**	**Share of Total (%)**	**Top 10**	**Share of Total (%)**
Olives	46.1	Wheat	16.6	Olives	14.2
Wheat	18.9	Tomatoes	14.2	Milk, whole fresh cow	10.8
Barley	14.3	Olives	10.1	Wheat	10.5
Almonds, with shell	5.1	Barley	7.4	Meat, chicken	6.7
Broad beans, horse beans, dry	1.5	Watermelons	5.7	Meat indigenous, chicken	6.7
Dates	1.3	Chillies and peppers, green	4.7	Dates	6.3
Pulses, nes	0.8	Potatoes	4.6	Tomatoes	4.8
Pistachios	0.7	Onions, shallots, green	3.1	Almonds, with shell	4.4
Tomatoes	0.7	Carrots and turnips	2.7	Eggs, hen, in shell	3.8
Potatoes	0.6	Dates	2.4	Chillies and peppers, green	3.4

Data: average 2012-2014, FAOSTAT, accessed 19 January, 2017
* Gross Production Value (constant 2004-2006 million US$), data: average 2011-2013, FAOSTAT, accessed 19 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

[4] See the website of HarvestPlus, www.harvestplus.org/what-we-do/crops.

Table 5: Top 10 fruits produced by area and volume

Area harvested (ha)		Production volume (tons)	
Top 10	**Share of Total fruits (%)**	**Top 10**	**Share of total fruits (%)**
Olives	84.3	Tomatoes	25.9
Dates	2.3	Olives	18.4
Pulses, nes	1.5	Watermelons	10.4
Tomatoes	1.3	Chillies and peppers, green	8.5
Grapes	1.1	Dates	4.4
Apples	1.0	Oranges	3.0
Chillies and peppers, green	1.0	Peaches and nectarines	3.0
Figs	0.9	Fruit, citrus nes	2.9
Peaches and nectarines	0.7	Grapes	2.9
Fruit, fresh nes	0.7	Apples	2.7

Data: average 2012-2014, FAOSTAT, accessed 19 January, 2017

Note: GIC value chains marked in red; nes refers to Not elsewhere specified. Tomatoes and peppers, though scientifically classified as fruits, are considered and discussed as vegetables in section 2.1.3 of this report, based on the Tunisian Inter-professional group for vegetables (GIL) classification.

Table 6: Top 10 vegetables produced by area and volume

Area harvested (ha)		Production volume (tons)	
Top 10	**Share of total veg. (%)**	**Top 10**	**Share of total veg. (%)**
Carrots and turnips	19.8	Onions, shallots, green	23.4
Onions, shallots, green	17.6	Carrots and turnips	20.4
Vegetables, leguminous nes	13.9	Onions, dry	15.6
Vegetables, fresh nes	12.3	Vegetables, leguminous nes	9.8
Onions, dry	11.7	Vegetables, fresh nes	9.3
Lettuce and chicory	5.5	Lettuce and chicory	6.5
Artichokes	5.3	Cauliflowers and broccoli	3.9
Garlic	4.6	Sugar beet	3.6
Cabbages and other brassicas	4.3	Cabbages and other brassicas	2.7
Cauliflowers and broccoli	2.7	Garlic	2.2

Data: average 2012-2014, FAOSTAT, accessed 19 January, 2017

Note: GIC value chains marked in red; nes refers to Not elsewhere specified; veg. refers to vegetables

Table 7: Top 5 meats produced

Top 5	Share of meat production (%)
Meat, chicken	21.22
Meat, indigenous, chicken	21.01
Meat, cattle	9.49
Meat, turkey	9.40
Meat indigenous, cattle	8.88

Data: average 2011-2013, FAOSTAT, accessed 9 March 2017

1.4.2 Trade

Wheat and maize account for more than half of the import volume and for 30% of the import value. Fruits and vegetables play an important role in export trade, particularly dates and olives. Meat and dairy products are not part of the Top 10. Detailed data for these GIC value chains can be found in the separate tables below.

Table 8: Tunisia's imports

Import volume (tons)		Import value (US$)	
Top 10	**Share of Total (%)**	**Top 10**	**Share of Total (%)**
Wheat	33.9	Wheat	20.2
Maize	18.6	Soybeans	10.0
Barley	10.3	Maize	9.6
Soybeans	9.7	Sugar refined	6.5
Sugar refined	5.4	Oil, soybean	5.8
Sugar Raw Centrifugal	3.2	Barley	5.3
Oil, soybean	2.8	Oil, maize	4.7
Cake, soybeans	1.9	Cigarettes	3.3
Oil, maize	1.9	Sugar Raw Centrifugal	3.1
Oil, palm	1.5	Oil, palm	2.8
Rank 15: Bananas	0.5	Rank 23: Milk, skimmed dried	0.6
Rank 37: Milk, skimmed dried	0.1	Rank 29: Cheese, whole cow milk	0.4
		Rank 30: Meat, cattle, boneless (beef and veal)	0.4

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 9: Tunisia's exports

Export volume (tons)		Export value (US$)	
Top 10	**Share of Total (%)**	**Top 10**	**Share of Total (%)**
Oil, olive, virgin	15.1	Oil, olive, virgin	25.5
Dates	11.0	Dates	14.6
Macaroni	9.9	Oil, maize	9.7
Oil, maize	8.1	Macaroni	4.3
Beverages, non-alcoholic	5.2	Pastry	3.3
Oil, soybean	3.8	Oil, soybean	2.8
Tomatoes, paste	3.0	Margarine, short	2.8
Flour, wheat	2.8	Crude materials	2.5
Margarine, short	2.6	Tomatoes, paste	2.4
Pastry	2.4	Food prep nes	2.4
Rank 11: Oranges	2.4	Rank 12: Cheese, processed	2.1
Rank 14: Watermelons	2.1	Rank 19: Yoghurt, concentrated or not	0.9
		Rank 20: Oil, olive residues	0.9

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 10: GIC value chain: meat imports

Import volume (tons)		Import value (US$)	
Top 10	**Share of Total Meat Imports**	**Top 10**	**Share of Total Meat Imports**
Meat, chicken	33.8	Meat, cattle, boneless (beef & veal)	30.0
Meat, cattle, boneless (beef & veal)	21.8	Meat, cattle	26.6
Meat, cattle	17.9	Meat, sheep	20.7
Meat, sheep	12.2	Meat, chicken	12.5
Offals, edible, cattle	8.4	Meat, turkey	3.8
Meat, turkey	3.2	Offals, edible, cattle	3.7
Meat, beef and veal sausages	1.0	Meat, chicken, canned	0.5
Meat, chicken, canned	0.5	Meat, duck	0.5
Meat, rabbit	0.3	Meat, beef and veal sausages	0.4
Meat, pig	0.3	Meat, rabbit	0.3

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017

Table 11: GIC value chain: meat exports

Export volume (tons)		Export value (US$)	
Top 10	**Share of Total Meat Exports**	**Top 10**	**Share of Total Meat Exports**
Meat, chicken	70.6	Meat, chicken	70.1
Meat, turkey	14.6	Meat, turkey	15.1
Meal, meat	12.1	Meat, nes	5.0
Meat, chicken canned	1.2	Meat, chicken, canned	3.8
Meat, nes	0.7	Meal, meat	3.3
Offals, edible, cattle	0.4	Offals, edible, cattle	1.8
Meat, beef and veal sausages	0.2	Meat, beef and veal sausages	0.5
Meat, dried nes	0.1	Meat, dried nes	0.3
Meat, pig	0.0	Meat, pig	0.1
Meat, game	0.0	Meat, cattle, boneless (beef and veal)	0.0

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 12: GIC value chain: dairy products imports

Import volume (tons)		Import value (US$)	
Top 10	**Share of Total Dairy Imports**	**Top 10**	**Share of Total Dairy Imports**
Milk, skimmed dried	20.6	Milk, skimmed dried	28.5
Whey, condensed	12.6	Cheese, whole cow milk	21.0
Cheese, whole cow milk	12.5	Milk, products of natural constituents nes	9.8
Milk, products of natural constituents nes	11.9	Milk, whole dried	8.5
Milk, whole condensed	10.0	Milk, whole condensed	7.6
Milk, whole fresh cow	9.9	Eggs, hen, in shell	5.7
Milk, skimmed cow	5.5	Eggs, dried	3.7
Milk, whole dried	4.9	Butter, cow milk	3.1
Eggs, hen, in shell	3.3	Milk, whole fresh cow	3.0
Milk, whole evaporated	2.0	Eggs, other bird, in shell	2.9

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017
Note: GIC value chains marked in red; nes refers to Not elsewhere specified

Table 13: GIC value chain: dairy products exports

Export volume (tons)		Export value (US$)	
Top 10	**Share of Total Dairy Exports**	**Top 10**	**Share of Total Dairy Exports**
Margarine, short	47.1	Margarine, short	43.0
Yoghurt, concentrated or not	20.1	Cheese, processed	32.9
Cheese, processed	19.3	Yoghurt, concentrated or not	14.2
Milk, skimmed cow	4.6	Milk, skimmed cow	2.3
Cream fresh	2.3	Ice cream and edible ice	1.2
Milk, whole fresh cow	2.1	Milk, whole dried	1.1
Milk, whole condensed	1.1	Cream fresh	0.9
Ice cream and edible ice	0.9	Milk, whole fresh cow	0.9
Buttermilk, curdled, acidified milk	0.7	Cheese, whole cow milk	0.8
Milk, whole dried	0.4	Milk, whole condensed	0.7

Data: average 2011-2013, FAOSTAT, accessed 19 January, 2017

1.5 National (and regional) innovation system:

1.5.1 Research system and organizations

1.5.1.1 International

The Institution for Agricultural Research and Higher Education (IRESA: *Institution de la Recherche et de l'Enseignement Supérieur Agricoles*) works closely with international organizations such as the European Union (EU), INRA, CIRAD, FAO, the International Atomic Energy Agency, the International Center for Agricultural Research in the Dry Area (ICARDA), the International Plant Genetic Resources Institute, CIHEAM, ACSAD, etc. The cooperation works are related to specific research programs like natural resources, crop breeding, and animal production biotechnology.

IRESA partners with several European projects within the 7th framework such as ARIMNet[5] project, Foresterra[6] project. The international organizations actively conducting agricultural research in Tunisia include:

- The FAO;
- The United Nations Development Program;
- The World Bank;
- International Fund for Agricultural Development (IFAD);
- The Consultative Group International Agricultural Research (CGIAR): International Center for Tropical Agriculture; ICARDA.

1.5.1.2 National

Agricultural research in Tunisia started since the beginning of the 19th century. After the independence (1956), it was promoted by the government with the assistance of the World Bank and other bilateral and multi-lateral donors (including the EU). Actually, the National Agricultural Research System (NARS) is composed by six national public agricultural research institutes, four regional research centers and eleven agricultural higher-education schools belonging to IRESA.

a. Institution of Agricultural Research and Higher Education (IRESA)

IRESA is a public administrative institution which was established in 1990 with the civil personality and financial autonomy under the supervision of the Ministry of Agriculture, Water Resources and Fishery. It has the national mandate to oversee a network of research and higher education institutes, to coordinate and facilitate linkages between them and with extension agencies and producer organizations, and ensure the relevance of the research conducting according to national agricultural development priorities. These research activities are conducted by the research and partially the higher education (30 % of the activities are dedicated to research) and cover natural resources management, plant and animal science, emerging diseases, sustainability of agricultural production, food security and food safety, horticulture, aquaculture and fisheries and rural socio-economy. The main activities include:

- Promoting agricultural research in Tunisia through the coordination of research (6 Research Institutes, 4 regional centers and 2 regional research clusters and more than 20 experimental stations) and higher education (11 institutions) in this field;
- Disseminating agricultural knowledge ;
- Setting up, funding and monitoring national research programs;
- Promoting cooperation between Tunisian and foreign researchers;
- Coordinating and evaluating of the national programs.

[5] www.arimnet.net
[6] www.foresterra.eu

b. National Agricultural Research Institute of Tunisia

The National Agricultural Research Institute of Tunisia (INRAT) is the oldest agricultural research institute of the NARS, it was founded in 1913 under the name "Service Botanique de Tunisie" and becomes "Service Botanique et Agronomique" in 1933 (Lasram, 1988). It is the first Tunisian institute specialized in agricultural research, mainly crop breeding. Since 1961, research activities at INRAT cover all fields of agricultural science research, including animal and crop production, biophysical and socio-economic research. INRAT's main objectives are (Salem, 2010):

- Selection of crop varieties and improvement of animal breeds;
- Improvement of techniques for animal and crop production;
- Evaluation and upgrading of genetic resources in Tunisia;
- Performing agro and socio-economic research in relation with the rural environment;
- Contribution to technology transfer, innovation and capacity building through teaching and supervising graduate and post students as well as training of students and technicians working in national and international organizations.

c. Tertiary Educational Institutions

At the national level, there are more than 198 higher education institutions in Tunisia, organized into 13 public universities and 25 Higher Institutes of Technological studies covering all specialties and the whole territory. There is also a virtual university. In 2003, as part of the reform of the national research, consideration was given to the establishment of the following:

- Research laboratories and unit, and
- Specialized support units; one unit for the valorization of research outcomes and another for documentation and publishing.

As a result, university research was organized into 241 research laboratories and 174 research units. According to this reform, the researchers belonging to the NARS are organized, now, in 29 research laboratories, 10 research units (multidisciplinary and multi-institutionally teams) and 10 specialized support units. In spite of the reform which led to the creation of four research centers on the regional experimental stations of INRAT, the researchers of these centers are registered in the laboratory of INRAT.

1.5.2 Innovation platforms

At the level of the NARS and in the framework of the project "Strengthening agriculture supporting services" co-financed by the World Bank, the first national strategy for agricultural research (1999-2008) has been developed and implemented in conjunction with development partners and the few organized professionals. Several research themes related to the quality of agricultural and fisheries products have been proposed by Inter-Professional Groups (GIP). Five ad hoc committees, within IRESA involving researchers, teachers-researchers, administration stuff, the concerned GIP and of the Agency for the Promotion of Agricultural Investments (APIA), have been formed. These committees in the areas of animal breeding, fishing, horticulture, poultry and fruit trees are in charge of selecting the projects proposed by research. The projects cover the themes proposed by the Inter-professional group for milk and read meat (GIVLait), the Inter-professional group for fishing products (GIPP), the Inter-professional group for vegetables (GIL), the Interprofessional Group of Poultry and Rabbit Products (GIPAC) and the Inter-professional group for fruits (GIFruits).

The research topics covered by the different research projects focus on the following Chains:

- Red Meat.
- Milk
- Fishing Industry
- Poultry Industry
- Vegetables
- Fruit trees

Five research and development (R&D) framework conventions established between IRESA, the GIVLait, the Office of Livestock and Pasture, GIPP, the GIL and GIPAC have crowned this call for tender.

A new innovation platform (IP) has been built in collaboration with partners such as GIZ, ICARDA, etc. and has been set up to bring together all actors involved in extensive crop farming. This platform consists of 10 units covering most grain areas throughout the country, with the aim of combining the efforts of different stakeholders to better popularize, monitor and inform farmers about all the new products in extensive crops. As such, mobile technology is used to transmit technical text messages to farmers to help them work their land. Furthermore, an android application developed for smart-phones called "Erray" (irrigation) will advise farmers on the water deficit in their areas as well as weather forecasts (Webmanagercenter.com, 2015).

A list of Innovation Platforms in Tunisia can be found in Annex B.

1.5.3 Extension system and organizations

Prior to 2011 uprising, extension services were provided by the:

- Ministry of Agriculture, Hydraulic Resources and Fisheries (Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche) – More precisely by the Agency for Agricultural Training and Extension Services (AVFA); and technical centers (particularly citrus, cereals, dates etc.)
- l'Observatoire National de l'Agriculture.

Agricultural extension services in Tunisia are provided by both governmental and non-governmental actors. AVFA is the public administrative body overseeing agricultural extension, training and oversight of extension staff (Augustin *et al.,* 2012). Agricultural extension services are also provided through projects funded through the national budget or those funded through the international donors such as World Bank, l'Agence Française de Développement (AFD), and United Nations agencies.

Extension services are also provided by the extension offices with specific budget provisions and also through agricultural professional associations and unions such as the Tunisian Union of Agriculture and Fisheries (ibid).

1.5.4 Private research and development activities

There is limited information available on the private research activities in Tunisia. At the national level, Tunisia has seen, since the early 2000s, a strong development of the higher education (Law n° 2000-73). The number of private higher education reached about 63 in 2016, with half of then focused on engineering. Agriculture has not been privatized; indeed, there is neither private higher education nor research institutes in agriculture. However, very limited R&D actions are observed at the level of some agricultural intensive production units, especially in vegetables (pepper, tomatoes, strawberry) and fruit tree production.

1.6 Key challenges, emerging needs and potentials in the agricultural sector

Overall, the current situation regarding innovation in agriculture shows the low value placed on research outcomes. The main issues are prioritized as follows:

- Decision and research activities are centralized
  - Concentration of human and material resources at the central level
  - Failure of regulations to meet research needs
- Scarcity of useful results
  - Dominance of academic research
  - Inadequacy of monitoring and transfer procedures

- Low profitability of R&D connecting structures
  - Insufficient coordination between stakeholders
  - Lack of procedures to streamline results
- Limited contribution of the profession to research mechanisms
  - Lack of adequate professional structures
  - Dominance of small and medium-sized holdings

However, this assessment is totally subjective in the absence of tangible indicators to measure the level of adoption of research outcomes particularly in agriculture.

1.7 Potential areas for investment in Tunisia

Based on the general approach (see Husmann et al., 2015) and in pursuit of efficiency and effectiveness, investments by Germany into the agricultural and food sector are suggested in those African countries, which:

- Show actual progress in sustainable agricultural productivity driven by related innovations, as indicated by comprehensive productivity measurement and innovation actions on the ground;
- Have a track record of political commitment to foster sustainable agricultural growth, as indicated by performance under CAADP, and
- Prioritize actions for hunger and malnutrition reduction and show progress, but where agricultural and rural development and nutrition interventions are likely to make a significant difference, as indicated by public policy and civil society actions.

Results of assessment for Tunisia:

Expected agricultural growth performance:

- Tunisia has increased its agricultural growth by more than the annual 6% agricultural growth target defined by CAADP only for four years, between 2005 and 2014[7].

Government commitment:

- Tunisia has no a track record of political commitment to foster sustainable agricultural growth by being inactive in the CAADP process and do not complete even a single step in the CAADP process[8];
- In addition, Tunisia has not shown willingness to invest in the agricultural sector. In no single year has the government invested more than 10% of total government expenditures (CAADP target)[9] in the agriculture between 2005 and 2014.

Food and nutrition security progress and need:

- In addition, Tunisia has a Global Hunger Index (GHI) score value that is less than 5, reflecting only a low level of hunger (von Grebmer *et al.,* 2014)[10]. This makes the investment into the agricultural and food sector in Tunisia less urgent in terms of reducing children mortality rate and the proportion of the undernourished people and underweighted children.

The economic, political, and social/nutrition framework in Tunisia does not seem to suggest accelerated investments into the agricultural and food sector of the country.

[7] www.resakss.org
[8] www.resakss.org
[9] www.resakss.org
[10] GHI score Values less than 5.0 reflect low hunger, values from 5.0 to 9.9 reflect "moderate" hunger, values from 10.0 to 19.9 indicate a "serious" level of hunger, values from 20.0 to 29.9 are "alarming," and values of 30.0 or greater are "extremely alarming"(von Grebmer *et al.,* 2014).

Table 14: Tunisia performance indicators

Indicator	Indicator score	Overall score
1. Number of Years with more than 6% agricultural growth (2005 to 2014)	4	40
2. Percentage point change in TFP index between 2001 and 2008	na	na
3. Number of years with more than 10% government expenditure (2005 to 2014)	0	0
4. Average share of agricultural GDP spent on R&D (2005 to 2011) in %	2	2
5. Steps in CAADP completed	0	0
6. Percentage point improvement in undernourishment between 2001 and 2011	0	na
7. Global hunger index (2014)	<5	0
Total score (weighted)		13

Data source: Husmann et al (2015)
Note: TFP refers to Total Factor Productivity

Based on this approach, investments into the agricultural and food sector of Tunisia cannot be expected to have a significant effect on the food and nutrition security situation in the country.

2 Most relevant value chains in Tunisia

2.1 GIC value chains

The value chains chosen for the Green innovation center (GIC) in Tunisia include meat/dairy, fruit/fruit trees and potato.

2.1.1 Meat and dairy

2.1.1.1 Dairy

The importance that the dairy sector plays in Tunisian agricultural sector cannot be overstated. Available statistics show that it contributed to about 11% to the value of agricultural production and about 25% of the total value of the livestock output in 2009 (Mattas et al., 2012). Total milk production has been steadily rising from the past decades, increasing from 515,000 tons in 1993 to almost 1.2 million tons in 2013. Average annual production for the same period amounts to over 900,000 tons (FAOSTAT, 2016). The dairy sector is also a source of income to farmers, and thus contributes to their stability and growth, which is important for them to cope with financial constraints. The sector provides significant employment due to its labor intensive nature.

The consumption of milk and dairy products has evolved in response to changes in eating habits, improved purchasing power and the development of production. It increased from 83 liters per capita in 1994 to 110 liters in 2011. Opportunities exist in the milk collection for the producers because they provide them with regular incomes and lower market risk and ensure stability in fresh milk supply to the dairy industries. There are two types of organizations for milk collection identified in Tunisia; formal and informal. The traditional distribution channels and milk marketing are unknown and unidentified. Indeed, 29% of production does not go through the organized networks (CIHEAM, 2012; Montaigne et al*.,* 2015 and GIVLait, 2015). Other opportunities exist in the milk processing and milk marketing.

2.1.1.2 Meat

The meat value chain covers essential poultry and red meat. The poultry sector in Tunisia has grown from a traditional family farming to a well-established poultry industry. The Tunisian state has played a major role in making this change by putting in place several financial and organizational incentives in the late 70's and early 80's. These incentives concerned livestock rearing facilities, providing equipment as well as concentrated feed. The organization of industrial poultry industry started with state farms, but then moved to some dynamic pioneers before the creation of the inter-professional Association of Poultry Products (GIPAC) in 1985.

The production of broilers was mostly provided by small farmers. However, production is now tilting toward large integrated groups and ranchers. As for the production of broiler turkeys, it is mostly provided by the companies integrated by large farms (20 000 to 30 000 subjects per rotation). There are also a number of small and medium sized farmers (3000 10 000 subjects). The total number of turkey farmers is about 300, compared to more than 2,500 chicken farmers.

In 2010, poultry meat reached 160,000 tons, which is roughly 56% of total meat production in Tunisia, well ahead of red meat with a total of around 125,000 tons. Consumption per capita per year in 2010 in Tunisia is estimated at 15.1 kg for poultry meat, including 9.5 kg of chicken meat and 4.6 kg of turkey, with the remainder for other meats (reformed breeders, laying poultry and backyard flocks).

The red meat sector constitutes a diverse branch of activities and represents 40% of total meat production in 2014. Production comes mainly from beef, sheep, goats, and to some extent from camels, rabbits and donkeys. The majority of cattle is in the north, while sheep and goats are distributed between the center and the south. Per capita red meat consumption is around 11 kg (FAO, 2011 and GIVLait, 2013).

2.1.2 Fruits and fruit trees

Tree crop activities are important in the agricultural sector in Tunisia. They contribute about 30% of value addition in the agricultural sector. Olive, date and citrus are particularly the most important tree crops in the country. They provide employment and help boost the economy of the country through the export earnings (Mattas et al., 2012; Montaigne et al., 2015).

2.1.2.1 Citrus

Citrus plantations cover an area of about 22,000 ha. The main crop variety is the Maltaise of Tunisia which represents about 32% of the total orange groves. The total area dedicated to oranges has increased over the last twenty years due to expansion of irrigated areas and also as a result of increased crop densities. Only 10% of citrus produced is destined for export market, with the bulk (90%) consumed locally (CIHEAM, 2012).

2.1.2.2 Date

The production of dates is done on a total area of 40,500 ha, and employs 60,000 farmers. Total number of palm trees amounts to 5.4 million, of which 3.55 million concerns the Deglet Nour variety (65%) and 1.85 million the common variety. Output reached 190,600 tons in 2011-2012. The country exported 84,000 tons with a value of 293 million dinar in the same year. Dates are the second most exported agricultural product after olive oil. They contribute to 16% of the total value of agricultural exports and 6.6% of total agricultural output. Over half of Tunisian dates are exported mainly to European markets and because of the high quality of the dates, Tunisia ranks number one in terms of export value even though it is the 11th producer of dates in the world (Centre Technique des Dattes, N.d. and Snoei, 2015).

2.1.2.3 Melon

Melons and watermelons are produced on 17,900 ha of land and output for 2014 was 510,000 tons. The main regions for growing watermelon include SidiBouzid, Kairouan, Beja, Zaghouan, Sfax for on farm, and Gabes, Tozeur and Kebili for greenhouse production. Growing season spans from May to December and the varieties grown are Sugar back, Redstar, Aswan, Augusta, Amiga, etc. They are destined for local markets. Cantaloupe production occurs from June to December in the regions of Béjà, Bizerte, Kairouan, SidiBouzid, Manouba on farm, and Tozeur, Kébili, and Gabes in greenhouses. The varieties grown are Calipso, Pancha, Panchito, Type Galia, Ananas for local and international markets mainly in Europe (Italy, France) and other North African countries (GIL, 2015).

2.1.2.4 Olive

Tunisia is the most important olive-growing country in the southern Mediterranean region and the second largest producer of olive oil in the world. The country has indeed dedicated 46% of its cultivated lands to growing olives, which represents at least 1.68 million ha and over 65 million trees. The olive sector is one of the most vital sectors of the economy, accounting for 14% of total value of final agricultural production (see Table 4). Tunisian olives are processed into olive oil and the commodity represents the first product for exports in volume (13.9%) and value (23%) (see Table 9). 60 to 70% of the oil is exported toward Europe, particularly Italy and Spain. The olive sector provides direct and indirect employment to over 1 million people (Tunisian olive oil, 2010).

2.1.2.5 Grape

Grape growing has received growing interest due to the high potentials of the fruit for direct consumption and for wine production. The harvest of table grapes (direct consumption) for 2013-2014 amounted to 137,000 tons against 132,000 tons last season. The production of grapes for conversion (wine) is estimated at 37,500 tons. During the 2013-2014 agricultural season, the land area for table grapes reached 11,000 ha split between the governorates of Ben Arous, Nabeul, Bizerte, Manouba and Sidi Bouzid. The areas devoted to grapes for processing totaled about 9,750 ha. The harvest period for table grapes extends from July to December and the "miski of Italy" is the main variety grown representing 80% of total output (Webmanagercenter.com, 2014).

2.1.3 Potato

The production of potato is done in four cropping seasons: the rear season, the extra *primeurs* season, the *primeurs* season and the normal season. Average production is about 370,000 tons, grown on an average area of about 25,000 ha. Exports of potato were on average about 11,000 tons for the past five years, mainly from the primeurs and rear season. Regions of cultivation include Cap Bon, Jendouba, Gafsa, SidiBouzid, Kasserine, Kairouan and the coastal area. Growing season goes from November to June. Potato has become an important food base for Tunisian households since local consumption per capita per year is currently exceeding 30kg (GIL, 2016; ONAGRI, 2014).

2.2 Other relevant value chains

2.2.1 Wheat

Wheat is a highly consumed grain in Tunisia. With an average per capita consumption of 265 kg/year, the country is placed among the largest consumers of wheat in the world. The area for planted wheat for the season 2015-2016 is estimated at 610,000 ha – 595,000 Ha of durum wheat and 95,000 ha of wheat. Post estimates of wheat production for the same season stand at 1.3 million metric tons. Total consumption per year is around 2.8 million metric tons, which means that the country relies on imports to satisfy total demand. Tunisia's major wheat imports come from Ukraine, Italy, France and Romania, while the remainder is from Spain, the United Kingdom, Russia and the United States (US Department of Agriculture Foreign Agricultural Services, 2016).

2.2.2 Barley

Barley is used mainly as a feed for sheep especially during shortages of good pasture, when rangelands are dry or stressed. The supplemental feed constitutes 85% of the total grain volume, while only 15% is used for food. The planting area for barley is estimated at 533,000 ha and production at 400,000 metric tons for the 2016-2017 season. Consumption is about 1.05 million metric tons and major import countries are Russia and Romania (Ibid).

2.2.3 Nuts

Nuts represent only a small part in total agricultural production. Nut trees have been traditionally grown in Tunisia due to favorable climatic conditions and almonds and pistachios are the main nut products. Almond production in 2013 amounted to 52,000 tons while that of pistachio was 1,200 tons (FAOSTAT, 2016). The main almond-producing area is the region of Sfax with more than half of the plantations, and the crop is also cultivated in the semi-arid areas in the country. Almonds are often grown together with olive trees and as an alternative for reconverting non-performing old olive tree plantations. Pistachio is mainly produced in the semi-arid zones of the center and the south. Nuts present high potentials due to increasing local demand and the prospects of exports to international markets (Laajimi and Thabet, 1999).

2.2.4 Vegetables

In Tunisia, vegetables crops occupy an area of about 167 000 ha divided on 90,000 farms. The average total production has been around 3.2 million tons per year during the last five years. The sector represents 16% of the total value of agricultural production and 28% of that of crop production. It is characterized by a diversity of products, the main ones being: Tomato 39%, onion 12%, pepper 10%, artichoke 1% and others (GIL, 2015).[11]

2.2.4.1 Tomato

Tomato is the second most important commodity produced in terms of quantity by the country and it is grown annually on an area of around 20,000 ha. Average Production exceeded 900,000 tons in the past decade, with a peak of almost 1.3 million tons in 2010. The processing of tomato into Double Concentrated Tomato (DCT) is a main agri-industrial activity that is increasing to meet a rising demand currently estimated at 100,000 tons. The DCT product is intended primarily for local consumption and secondly for export mainly towards the Libyan market. Tunisia's consumption of DCT is the equivalent of 54 Kg/capita/year of fresh tomatoes (Observatoire National de l'Agriculture, 2015).

2.2.4.2 Onion

Onions are cultivated on an average area of 16,300 ha and production reached 390,000 tons in 2014. The zones of cultivation are Jendoub, SidiBouzid and Kairouan and the produce is destined mainly for local consumption. Total exports in 2014 were only 1,966 tons. Production period of green onion spans from April to June for cropping and from October to January for bulb harvest (SOFRECO, 2007).

2.2.4.3 Pepper

Peppers are cultivated in warm regions, and are well consumed locally due to their extensive use in the Tunisian cuisine. Pepper cultivation area covers roughly 20,000 ha, with an average production of around 346,000 tons during the last five years. Beside consumption of fresh peppers, a part of harvests is processing into a paste called harrissa or seasoning powder. The main production areas are located in the North East, Bon Cap, the center, Kairouan and SidiBouzid. Exports of this product are on the rise

[11] Tomatoes and peppers are scientifically classified as fruits; however, they are considered as vegetables in the present report based on the Tunisian GIL classification.

over the last decade. They have increased from 53 tons in 2005 to 471 tons in 2014. The main importers are Libya, France and the Gulf countries (GIL, 2015).

2.3 Promising agricultural products and value chains

In addition to assessing the returns on investments into institutional innovations in Tunisia, analyses are also undertaken in order to choose the most promising value chains in the country. This analysis is important because it provides an objective indicator for priority value chains that would have the highest returns on investments into technological and institutional innovations. The trio objectives of PARI (to promote and support the scaling of proven innovations in the agri-food sector; to support and enhance investments in the GICs through research; and to contribute to the development of the agri-food sector in Africa and India through the identification, assessment and up-scaling of innovations) guide the selection of indicators. The indicators should thus focus on improving the food and nutrition security, reducing poverty and improving the market participation of the small holder farmers. Taking into account the availability of data and the purpose of the study, four indicators that focus on poverty and market potential are used to select the five most promising agricultural products from the long list of agricultural products that the country produces and sells. These indicators are:

1. Trade potential (Revealed Comparative Advantage (RCA) index): computed to identify value chains over which the country has revealed, albeit may not necessarily potential, comparative advantage in the export market. The revealed comparative advantage is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in the production and export of a certain class of goods or services as evidenced by trade flows. It is based on the Ricardian comparative advantage concept. We use Balassa's measure of RCA to determine the competitiveness of selected agricultural products in overseas export markets. In the present case, the RCA index compares the share of a given agricultural product in the country's export basket with that of the same product in total world exports.
2. Yield gap: used to assess the expected return of the envisaged investment on the given country value chains. The yield gap of a crop grown in a certain location and cropping system is defined as the difference between the yield under optimum management and the average yield achieved by farmers. A standard protocol for assessing yield potential and yield gaps is applied for some crops based on best available data, robust crop simulation models. It is a powerful method to reveal and understand the biophysical opportunities to meet the projected increase in demand for agricultural products.
3. Average yield growth: used to examine the potential of the product for poverty reduction. The most widely used indicator of crop productivity is production per unit of land (also referred to as crop yield). Average yield growth may reduce poverty in the following ways: (1) higher yield implies higher surplus product that could be sold in the market and thereby increase farmers income, (2) higher surplus product mean large quantity of food supplied to urban and rural market at a relatively lower price which in turn reduces urban and rural food poverty, (3) higher agricultural productivity will stimulate growth in the non-agricultural sector through its strong backward and forward linkage. For example, it boosts growth in the industry sector by freeing agricultural labor and reducing urban wage pressure (Lewis, 1962), and (4) agriculture's fundamental role in stimulating and sustaining economic transition, as countries (and poor people's livelihoods) shift away from being primarily agricultural towards a broader base of manufacturing and services (DFID, 2004).
4. Total production of the crop as a share of total supply (production + imports) is also used to assess the relevance of investing on that crop .Because it signals whether the agro-ecological system is suitable for the production of that crop in meeting the global demand for that particular crop. The ratio of production to total supply also illuminates the degree of integration of the producers that particular crop, small holder farmers in most African countries cases, into markets. The extent to

which small holder farmers are able to participate in both input and output markets, and the functionality of those markets, are key determinants of their willingness and ability to increase marketable surpluses (Arias, 2013). Across the developing world, smallholders farm in diverse agro-climatic systems which together with their assets and skills, shape their economic lives. Markets and the extent to which they are functioning well, also play a determining role.

Note: The share of production of that particular crop over the total crop production is another key indicator considered in this study while assessing the relevance of investing on a particular crop in a country. This indicator is used as an eliminating criteria. If the share of a given crop out of total crop production is less than 0.5 %, we consider it as less relevant and exclude from the list of most promising value chains.

The summary of the five most promising value chains based on the RCA index, average yield growth and relevance of crop is reported in Table 15 below. The production share, RCA index, actual yield growth and relative yield gap for the GIC value chain(s) is also reported at the bottom of the table, when they are not included in the list of the first five most promising chains.

Table 15: Selection of promising agricultural products /value chains

	Rank by RCA		**Rank by yield progress****		**Rank by relevance of crop**	
Rank	Name of agricultural product	RCA index (2012)*	Name of the crop	Average annual yield growth(2005 to 2012)	Name of agricultural product	Production share of supply(2012)*
1	Dates	144	Carrots and turnips	36	Lemons, Limes and products	102
2	Oil, maize	77	Vegetables, leguminous	30	Oats	100
3	Oil, olive, virgin	31	Watermelons, melons	13	Honey	100
4	Chillies and peppers, dry	14	Broad beans, horse beans	9	Rape and Mustard seed	100
5	Cheese, processed	13	Pears	8	Cottonseed	100
	Fruit, dried nes	1.08	Chillis, green pepper, onion	6	meat	100
	meat	1	Orange	5	vegetable	99
	vegetables	0.92	apples		Fruit	99

Source: * Own computation based on FAOSTAT 2015 data
Note: ** a minimum of 0.5 % production (volume) share threshold is used as a screening (crop relevance) criteria.

Results of assessment (Table 15):

- The trade potential (revealed comparative advantage (RCA) index) is very high for dates, maize and olive oil, dry chilies and peppers and processed cheese. This indicates that Tunisia has comparative advantage (in the export) of these commodities. The computed global Balassa indices have also shown that Tunisia has a modest revealed comparative advantage on the global market

on the export of one of the GIC selected value chains, fruits, while it has a comparative disadvantage in the other GIC selected value chain, vegetables;

- The yield performance indicating progress suggests that over the CAADP period (2005 to 2012) the GIC selected fruit and vegetable value chains (carrots, leguminous vegetables, water melons, melons, pears) and broad beans are the most promising value chains. The yield level of chilies, oranges and apples also shows a modest average growth;
- In terms of relevance (production share of supply), lemons, limes and products, oats, honey, rape and mustard seed and cottonseed are the leading. The total production of the first products exceeds the total supply. The total supply of the last four products and all the GIC selected value chains are also domestically produced.

2.4 Summary on selection of agricultural products and value chains

This chapter (chapter 2) has presented different relevant and important value chains in Tunisia based on different criteria – resulting on different value chains. In summary, the three top value chains – GIC selected value chains, other relevant value chains, and those identified by analysis of promising agricultural products and value chains – are presented in Table 16. The summary table shows that all he GIC-selected value chains are identified as promising by the analysis of promising agricultural products and value chains. However, none of the value chains discussed by the review of the literature is represented in the analysis of promising agricultural products and value chains.

Table 16: Summary of all value chains

GIC value chains	Other value chains	Promising agricultural products and value chains (top 3)		
		RCA	Yield progress	Relevance of crop
Meat/ dairy	Wheat	Dates	Carrots and turnips	Lemons, limes & products
Fruit/ Fruit trees	Barley	Oil, maize	Vegetables, leguminous	Oats, honey, Meat
Potatoes	Nuts	Oil, olive, virgin	Watermelons, melons	Rape & Mustard seed, cottonseed

Source: Authors' compilation

3 Innovations in value chains in the past 20 years

3.1 Main limiting factors

Limitations in the citrus value-chain include specific market requirements and value adding activities associated with boosting the citrus chain industry in Tunisia, which are primarily juiciness, sweetness and perishability. While the information flow and the relationships between different levels of the chain are for the most part strong, a lack of export contacts is a consistent barrier for European buyers in sourcing fresh oranges from Tunisia.

The red meat sector has been impacted by increasing prices due to high production costs, shortages of forage, the absence of classification criteria (cutting, categorization), the lack of information, good transportation and optimized slaughter houses. The sector also suffers from an inefficient and opaque organization of the chain involving public actors and professionals from the chain (Refik-Concina, 2014).

3.2 The most important / beneficial innovations in the relevant value chains

In this section, we describe some of the key innovations that have been initiated in selected value chains in Tunisia in the last 20 years. The described innovations are considered significant or beneficial because of widespread adoption, proven positive impact on increasing productivity, increasing incomes, adapting to the environmental challenges (such as drought), creating employment etc.

3.2.1 GIC value chains

For the dairy and meat sector, several innovations have taken place and they include:

- Reducing concentrate supply through summer mating of sicilo-sarde ewes. This results in winter lambing when green pasture is abundant, hence increasing productivity and nutritional quality of milk through the diversity of available fodder (omega 3 enriched milk).
- Genetic characterization and management of 2 lines of barbarine sheep to gain prolificacy and growth.
- Alternative feed development for ruminants raised in dry areas: spineless cactus, agro-industrial by products such as olive cake.
- Thermal stress mapping to evaluate impact on the performance of dairy cows. This technique helps crossbreeding for heat tolerance enhancement, and appropriate environmental control, feeding strategies and practices (INRAT, 2016).

For fruit and fruit trees, we can note:

- Genetic characterization of Tunisian citrus rootstock, research on citrus resistance to fungal species and viruses
- Promotion of indigenous grape varieties and yield improvement through crossbreeding, the use of bio-stimulants to mitigate acrotony in grapevine, low yield and quality of peach trees (Ibid).

In the vegetables value chains, research led to the development of:

- Hybrid pepper varieties resistant to viruses, odium, leveillulataurica, powdery mildew and root mildew.
- Improved variety of tomato with high brix and high concentration of lycopene and antioxidants, which are of high interest for research in human health, mainly in cardiovascular diseases and cancers (Ibid).

3.2.2 Other value chains and cross-cutting innovations

Regional radio in Tunisia: linking indigenous innovation and formal research and development (Reij and Waters-Bayer, 2001).
When the Arid Region Institute (Institut des Régions Arides) in Médenine, Tunisia, set out to seek the dynamics of indigenous knowledge in marginal rural areas of central and southern Tunisia, it discovered a large number of farmers -both men and women-who were developing their own innovations without the support of formal research and development services. In order to spread information about these innovations and to forge links among farmer innovators, and between these and other researchers and extension agents, the multi-disciplinary research team at the institute organized field visits. However, a much further-reaching mechanism to disseminate and stimulate farmers' ideas and experiments proved to be a weekly radio program on agricultural innovation.

Oases Ecosystems and Livelihoods Project (World Bank, 2014)
The Tunisia Oases Ecosystems and Livelihood Project objective is to improve sustainable natural resources management and promote livelihoods diversification in selected oases. In order to achieve its objectives, the project focusses on three main fields of intervention: (i) help create an enabling

environment to better manage oases at national level, (ii) support the implementation of the strategy on a small scale (six selected oases which are representative of the variety of Tunisian traditional oases), and (iii) provide support to the implementation of the activities and their monitoring and evaluation. Therefore, in line with this approach, are the following components: (i) strengthening capacities for sustainable management of oasis ecosystems, (ii) supporting the implementation of the Oasis Participatory Development Plan (iii) project coordination and management.

The European Bank for Reconstruction and Development (EBRD) Local Enterprise Facility
The European Bank for Reconstruction and Development (EBRD) is developing the agricultural sector in Tunisia by providing a €4 million loan to SanlucarFlor'alia, the first large-scale raspberry plantation ever established in the country. The product will mainly be exported to Europe and the Middle East. The EBRD-funded project, located in northern Tunisia in the Governorate of Bizerte, will introduce new varieties and will involve the innovative use of modern agricultural methods, allowing the farm to minimize the consumption of water, fertilizers and pesticides. Furthermore, the project will provide new and stable jobs for farm workers and agricultural engineers.

Technological innovations for enhanced adaptation to climate change in North Africa
There is little doubt that Tunisian agriculture will be affected by the effects of climate change (increased temperatures, heavy rainfall events etc. (Nefzaoui *et al.,* 2012). Therefore, research for innovations to increase adaptation is ongoing on different aspects of agriculture and includes:

- Soil and water conservation and use;
- Conservation agriculture;
- Biodiversity and crop variety development;
- Integrated crop-livestock-rangeland production systems:
  - Participatory collective rangeland management;
  - Matching small ruminant breeds to environments;
  - Efficient animal feeding using cost-effective alternative feeds.

Institutional innovations: Empowering local communities
Promoting community-based organizations and empowerment will support adaptation to climate change (Garforth, 2008) through:

- Helping to build strong institutions that can facilitate both collective and individual adaptation and response to climate change and other external pressures, both in the short and long term;
- Platforms for managing conflict over natural resources;
- Creating and intensifying learning opportunities, to broaden the set of information and knowledge available to farmers and support local innovation. Livestock Field Schools are an example of how this can be done;
- Supporting local innovation processes;
- Helping livestock keepers identify opportunities to enrich the set of options they have when making livelihood choices, e.g., re-thinking how advisory services are provided, particularly to small-scale, relatively poor livestock keepers.

3.3 Important value-chain related and cross-cutting innovations

Citrus Value chain

Some elements for improvement of the current approach are suggested:

- Better extension work, and a better supply of vegetal material, so that farmers and investors in the citrus sector can choose varieties that better respond to importer preferences. These varieties need to be reinforced and extended to other markets;

- Providing incentives to producers and marketers to improve logistics facilities to extend the shelf-life of Tunisian oranges on international markets and reduce waste, since transportation is increasingly a key element affecting the citrus supply chain and in preserving the quality of products;
- Encourage promotional campaigns of citrus products outside traditional markets so as to facilitate the establishment of contacts between traders and improve the image of Tunisian oranges;
- Facilitate the credit acquisition by the citrus industry so as to enhance investment capabilities in quality improvements.

The role of the citrus industry in Tunisia is significant within the agricultural sector in view of its direct and indirect linkages with the other economic sectors and its export earnings. However, rapidly changing market drivers and competition among fruits make it necessary to improve the competitiveness of the citrus production to better compete in local and international markets. A key instrument in improving competitiveness is to achieve a better management of the value chain. Exporters who wish to increase their competitive advantage face challenges ranging from increasing trend in inputs costs, to issues of distribution, transport, quality and adequate marketing and promotion practices. The needed policies should aim at recognizing the citrus sector as an essential component of Tunisian agriculture. The main objectives to be addressed are:

- Improving the competitiveness of citrus products through a better response to international consumers;
- Identifying and expanding marketing and business opportunities for producers and exporters;
- Improving the supply and the quality of citrus produce through the value chain.

Milk Value chain

The Tunisian dairy sector has seen tremendous and consistent growth since the 1980s. The country reached self-sufficiency in drinking milk in 1999 and has been generating surpluses since 2000. The industry has also been able to extend his dairy product offers. A study of the Tunisian dairy sector by the LACTIMED project[12], promoting Mediterranean dairy products, shows that these achievements were possible because of efforts made to develop every link in the dairy value chain. These efforts include the improvement of the genetic potential of herds, an optimum network coverage of collection centers throughout the country, the multiplication of processing units and the involvement of processors in milk production and collection links to ensure product quality, the development of an organized marketing channel as well as the identification of the regulatory mechanisms in the value chain.

Despite these successes, several constraints persist. They are related to climatic conditions (high weather variability), low yields and milk quality due to poor rearing techniques, lack of extension services and farmer training, low quality and shortages of fodder. Furthermore, the informal nature of a part of the value chain makes it harder to better organize the entire chain. The perishable nature of the product also presents challenges for conservation, commercialization and consumption. Therefore, the following priorities can be identified in order to strengthen to milk value chain:

- Mastering livestock feeding to reduce costs and improve animal productivity;
- Enhance national genetic potential to reduce dependence on imported breeds, thus reducing costs and developing genetic improvement techniques;
- Improving milk quality through the installation of on-farm chilling facilities and more farmer training;
- Increasing the processing capacity in order to respond to growing demand;

[12] www.lactimed.eu/

- Promoting the consumption of milk products through tax break incentives and lower margins for distributors;
- Organizing the informal sector of the industry (LACTIMED, 2013).

Other promising innovations are also worth noting. The INRAT has several research projects that cover a wide spectrum of agricultural products from crops to livestock. The following are a few examples in soil management and crop improvements:

- The use of indigenous soil bacteria such as the rhizobia to inoculate grain and forage legume in bio-fertilization research. This valorization of local symbiotic diversity to produce a bio-fertilizer is undertaken as a substitute for chemical fertilizers while promoting environmental preservation.
- Weed management solution by proposing water-extracts from barley and thistle to neutralize ryegrass, one of the most problematic weeds in economic crops. This study was done in the light of weed resistance to herbicide, which is a major concern for farmers and agricultural researchers.
- Improving plant yield through a technical package for seed production of common vetch. The package consists of sowing the vetch with an accompanying crop like the triticale for tutor purposes. The use of this package results in better protection against frost damage, better spring vigor and higher harvested yields (INRAT, 2016).

4 Suggestions for Collaboration

Partnership to foster agricultural innovation will be most useful in the case of Tunisia; such partnership should give attention to pertinent issues such as:

- Development and use of technology packages that enable production with minimal water requirement;
- Development of moisture conservation techniques;
- Technologies development to enhance productivity and competitiveness in price of commodities;
- Facilitating capacity development for the smallholder's farmers;
- Mechanization of the smallholders' system to enhance competitiveness and reduce drudgery;
- Development of an export promotion system to ensure income delivery;
- Enhancing entrepreneurial capacity of agricultural stakeholders.

An entry point for German-Tunisian collaboration will be the existing national agricultural research and development organization. Collaboration with the NARS institutions belonging to the Institution for Agricultural Research and Higher Education (IRESA) could leverage a good opportunity to access various research and development partners in agricultural research.

The current PARI program is already working with INRAT, the National Agricultural Research Institute. As a leader of a consortium of five institutions (INRAT and four regional research centers), the large scale of research activity of this consortium (except forestry, water mobilization and fishery) and the partnership network established with professional organization, INRAT is an appropriate collaboration partner for R&D and innovation.

The adequacy between strategic axes of the agricultural development in Tunisia and needs for research are summarized in the Table 17.

Table 17: Strategic axes and corresponding needs

Strategic Items and value chains	Needed implementation research		Innovation
	Vertical Items	Cross cutting items	
Food security 1- Cereals 2- Food leguminous 3- Forages 4- Milk 5- Meat 6- Fruits 7- Vegetables			
Exportation products 1- Olive oil 2- Dates 3- Oranges 4- Other products			
And preservation of natural resources 1- Water 2- Soil 1- Biodiversity	- Irrigation monitoring - Conservation agriculture - Biodiversity characterization and preservation		

Authors' compilation

Beside the classic vertical items representing the most important value chains, we can add the main challenges that they are facing as cross cutting items. Moreover, produce innovation needs a strong partnership with representative professional organizations in one hand and reliable indicators to measure degree of adoption.

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Annex A: Background Information on Nutrition

This annex provides background information on diet quantity and quality, child feeding practices and nutrition status (including micronutrient deficiencies) and definitions of the food and nutrition security indicators presented in Chapter 1.4.2.

Background on food and nutrition security

Diet quantity: Dietary energy supply per capita is an indicator of diet quantity that can be gauged against a population's average dietary energy requirement. The data are based on FAO's food balance sheets that estimate the quantity of each food item available for human consumption at the national level. It has to be emphasized that supply does not equal intake: Supply includes food that households feed to domestic animals or pets and food that they waste. Also, a sufficient average supply of dietary energy (or a nutrient such as protein) may leave those parts of the population deprived that have greater-than-average requirements or lower-than-average intakes. Indicators of undernourishment and food over-acquisition seek to consider the distribution of dietary energy consumption in the population and the minimum/maximum requirements of the average individual in a country (Cafiero, 2014).

Diet quality: Assessing diet quality requires a look at the composition of the diet. In the absence of national food consumption surveys for most countries, data from FAO's food balance sheets are used. The percentage of dietary energy supply from starchy staples (cereals, roots and tubers) is a rough indicator of diet quality: generally, the higher this percentage, the lower the micronutrient density of the diet; starchy staples are rich in carbohydrate and good sources of dietary energy, but they are usually not very micronutrient-rich. Non-staple foods are important for micronutrient and protein supply: Foods of animal origin are good sources of high-quality protein and vitamin A as well as highly bioavailable iron and zinc (meat, fish) and calcium (milk, small fish eaten whole with bones). Pulses and nuts are also good sources of protein and micronutrients. Fruits and vegetables provide a range of micronutrients while generally contributing little dietary energy (USDA, 2016).

The shares of dietary energy supply from carbohydrate, protein, and fat roughly indicate whether the diet is balanced in terms of its macronutrient composition. The recommended shares of dietary energy are 55-75% for carbohydrate, 10-15% for protein, and 15-30% for fat (WHO, 2003). It should be noted that these shares do not reveal whether dietary energy supply per capita and average protein supply are insufficient, sufficient, or excessive in absolute terms. A diet that meets the average dietary energy requirement for Africa as a whole (2200 kcal/day according to FAO, 2016) and provides 55-82.5 g protein per day and 36-73 g fat per day contains the recommended shares of 10-15% of dietary energy from protein and 15-30% of dietary energy from fat. For an adult weighing 60 kg, a protein intake of 50 g/day is considered sufficient, and 60 g/day for an adult weighing 75 kg. No safe upper limit of protein intake has been established, but it is unlikely that intakes of twice the recommended level pose any risk (WHO/FAO/UNU, 2007).

Child feeding practices: Feeding practices are determined by local food availability and household access to food, but also by maternal knowledge and care. Breastfed and non-breastfed children aged 6-23 months should eat foods rich in iron (meat, fish, or eggs) and fruits and vegetables rich in vitamin A daily, and consume at least 4 out of 7 food groups every day (PAHO/WHO, 2003; WHO, 2005; WHO, 2010).

Nutrition status: Household food security, the health environment, and mothers' caring capacity influence children's dietary intakes and the risk of infection, and thereby their nutrition and health status (UNICEF, 2013). Wasting, or acute undernutrition, is the result of recent rapid weight loss or the failure to gain weight that is caused by inadequate diets or infection. Stunting is the failure to grow adequately and results from chronic or recurrent undernutrition or infection (UNICEF/WHO/World Bank, 2016). Stunting in early childhood can have irreversible consequences, such as impaired motor and cognitive development, shorter adult height, lower attained schooling, and reduced adult income, whereas wasting carries a higher mortality risk (Victora et al. 2008; Black et al. 2013; Olofin et al. 2013). Overweight in children and overweight and obesity in adults occur when dietary energy intakes exceed

dietary energy requirements. Overweight and obesity increase the risk of noncommunicable diseases (UNICEF/WHO/World Bank, 2016).

Micronutrient deficiencies arise from insufficient intakes or absorption of essential vitamins and minerals. Major causes are poor diets, diseases, and increased requirements during life stages such as early childhood, pregnancy, and lactation. Micronutrient deficiencies are not limited to poor populations with inadequate dietary energy intakes, but may coexist with overweight and obesity in individuals and communities. Measuring micronutrient deficiencies poses challenges: There is often a need to resort to proxy indicators and large data gaps persist. Anemia, for example, is used as a proxy indicator for iron deficiency, although only about half of the global burden of anemia can be attributed to iron deficiency. Iron deficiency anemia impairs cognitive and motor development, causes fatigue and low productivity, and may result in low birth weight and increased maternal and perinatal mortality if pregnant women are affected (WHO 2015b). Whenever survey data on anemia prevalence are not available, modeled estimates from WHO (2015b) are used. Vitamin A deficiency increases the risk of vision problems, infectious diseases, and death among children (Imdad et al., 2010). Without exception, the data on vitamin A deficiency that are presented in this dossier are modeled estimates (Stevens et al., 2015, quoted in IFPRI, 2015).[13]

Table A1: Cutoffs to identify nutrition problems of public health significance in children

Category of public health significance	Stunting	Wasting	Overweight	Iron deficiency anemia
Severe	≥40	≥15	≥10	≥40
Moderate	30-39	10-14	5-9	20-39
Mild	20-29	5-9	3-4	5-19

Source: Adapted from World Bank (2006) and based on data from WHO (1995) and WHO (2000)

Notes: The cutoffs for public health significance were applied to prevalence rates of stunting, wasting, overweight and iron deficiency anemia (estimated from anemia prevalence) that were rounded to the first decimal. In the tables in Chapter 1.4.2, the data have been rounded to integers, which may lead to seeming contradictions: In a region where 29.8% of children under five were stunted (30% if rounded), stunting would be considered a mild public health problem, and in a region where 30.3% of children under five were stunted (also 30% if rounded), stunting would be considered a moderate public health problem.

Indicator definitions

Dietary energy supply: National average energy supply, expressed in kcal/caput/day (FAO, 2016).

Average dietary energy supply adequacy: Dietary energy supply expressed as a percentage of the average dietary energy requirement. Each country's average supply of calories for food consumption is divided by the average dietary energy requirement estimated for its population to provide an index of adequacy of the food supply in terms of calories (FAO, 2016).

Prevalence of undernourishment: Probability that a randomly selected individual from the population consumes an amount of calories that is insufficient to cover her/his energy requirement for an active and healthy life (FAO, 2016). This indicator seeks to estimate of the percentage of individuals in the population who are chronically undernourished because they fail to meet their minimum dietary energy requirements on a consistent basis.

Prevalence of food over-acquisition: Percentage of individuals in a population who tend, on a regular basis, to acquire food in excess of their maximum dietary energy requirements (FAO, 2016).

Dietary energy supply from cereals, roots and tubers: Percentage of dietary energy supply provided by cereals, roots and tubers (FAO, 2016). A higher share of dietary energy supply from cereals, roots and tubers is generally associated with a lower micronutrient density of the diet.

[13] Iodine deficiency disorders are an important public health problem in many countries. They are not discussed here because salt iodization, the main prevention and control strategy, is not related to agricultural value chains.

Dietary energy supply from carbohydrate: Percentage of dietary energy supply provided by carbohydrates, calculated by subtracting dietary energy supply from protein and dietary energy supply from fat from 100%.

Dietary energy supply from protein: Percentage of dietary energy supply provided by protein, calculated as average protein supply times 4 kcal/g divided by total dietary energy supply.

Dietary energy supply from fat: Percentage of dietary energy supply provided by fat, calculated as average fat supply times 9 kcal/g divided by total dietary energy supply.

Average protein/fat supply: National average protein/fat supply, expressed in g/caput/day (FAO, 2016).

Minimum dietary diversity: consumption of 4+ food groups: Percentage of children aged 6-23 months fed four or more food groups in the 24 hours preceding the survey. The food groups are 1) infant formula, milk other than breast milk, cheese or yogurt or other milk products; 2) foods made from grains, roots, and tubers, including porridge and fortified baby food from grains; 3) vitamin A-rich fruits and vegetables (and red palm oil); 4) other fruits and vegetables; 5) eggs; 6) meat, poultry, fish, and shellfish (and organ meats); 7) legumes and nuts (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in vitamin A: Percentage of children aged 6-23 months who consumed foods rich in vitamin A in the 24 hours preceding the survey. Foods rich in vitamin A include meat (and organ meat), fish, poultry, eggs, pumpkin, red or yellow yams or squash, carrots, red sweet potatoes, dark green leafy vegetables (for example, cassava leaves, pumpkin leaves, kale or spinach), mango, papaya, and other locally grown fruits and vegetables that are rich in vitamin A (ICF International, 2015, The DHS Program STATcompiler).

Consumption of foods rich in iron: Percentage of children aged 6-23 months who consumed foods rich in iron in the 24 hours preceding the survey. Foods rich in iron include meat (and organ meat), fish, poultry, and eggs (ICF International, 2015, The DHS Program STATcompiler).

Child wasting: Percentage of children under five who are wasted, that is, have weight-for-height below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too thin for their height (UNICEF/WHO/World Bank, 2016).

Child stunting: Percentage of children under five who are stunted, that is, have height-for-age below minus 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too short for their age (UNICEF/WHO/World Bank, 2016).

Child overweight: Percentage of children under five who are overweight, that is, have weight-for-height above 2 standard deviations of the median of the WHO Child Growth Standards. This means that they are too heavy for their height (UNICEF/WHO/World Bank, 2016).

Adult overweight and obesity/overweight and obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women of reproductive aged 15-49 years whose body mass index (BMI) is equal to or greater than 25 kg/m2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler). BMI is calculated by dividing body weight in kg by squared height in m.

Adult obesity/obesity among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is equal to or greater than 30 kg/m^2 (WHO, 2015a; ICF International, 2015, The DHS Program STATcompiler).

Adult underweight/underweight among women of reproductive age: Percentage of adults aged 18 years or older/percentage of women aged 15-49 years whose body mass index (BMI) is below 18.5 kg/m^2 (ICF International, 2015, The DHS Program STATcompiler).

Vitamin A deficiency: Percentage of children aged 6-59 months with a serum retinol concentration below 0.7 µmol/l.

Anemia in children: Percentage of children aged 6-59 months with anemia, namely, a blood hemoglobin concentration below 11.0 g/dl.

Anemia in women: Percentage of women aged 15-49 years with anemia, namely, a blood hemoglobin concentration below 12.0 g/dl for non-pregnant women and below 11.0 g/dl for pregnant women.

Annex B: Inventory of innovation platforms of the last 10 years

#	IP name/ name of the PI	Rental/ region of intervention	Value Chain concerned/commodity of interest	Beneficieries/beneficiaries	Funders/funders	Starting year/ year of start-up	Status
1	AllouchSidiBouzid	SidiBouzid, Central Tinisia.	Meat Quality of the local breed barbarine	Community of Zoghmar	ICARDA/CGIAR	2013	Over 2016
2	Lactimed	Beja and Bizerte	Value chain for the milk and its derivatives of sheep and dairy cattle	Dairy Breeders of Beja and Bizerte	European Union/APIA	2007	Over 2015
3	Harissa	Tunis, Capbon and Kairouan	Pepper puree	-8 manufactures of transformation -2000 producers of hot peppers -100 women engaged in artisanal transformation of the pepper	nido/SECO	2014	In Progress
4	Figs from Djebba	Beja, Djebba village	Figs from the region of Djebba	Producers of figs from the region of Djebba, 1 SMSA representing 200 Farmers	Unido/SECO	2015	Startup
5	Fig of barbarism	Kasserine	Organic local Cactus fruits	-2 groupings of farmers representing 870 farmers - 1 refrigerated warehouse in Kasserine - 5 Tunisian businesses of transformation of the cactus/	Unido/SECO	2012	Mid-period
6	CANA	Fernana	Conservation agriculture among small farmers: Design of direct planter for holdings of small size	5000 farmers of the region targeted. A workshop to manufacture small machines for the design of the direct smoir Tunisian	ACIAR/ICARDA	2011	Completed (2 015)

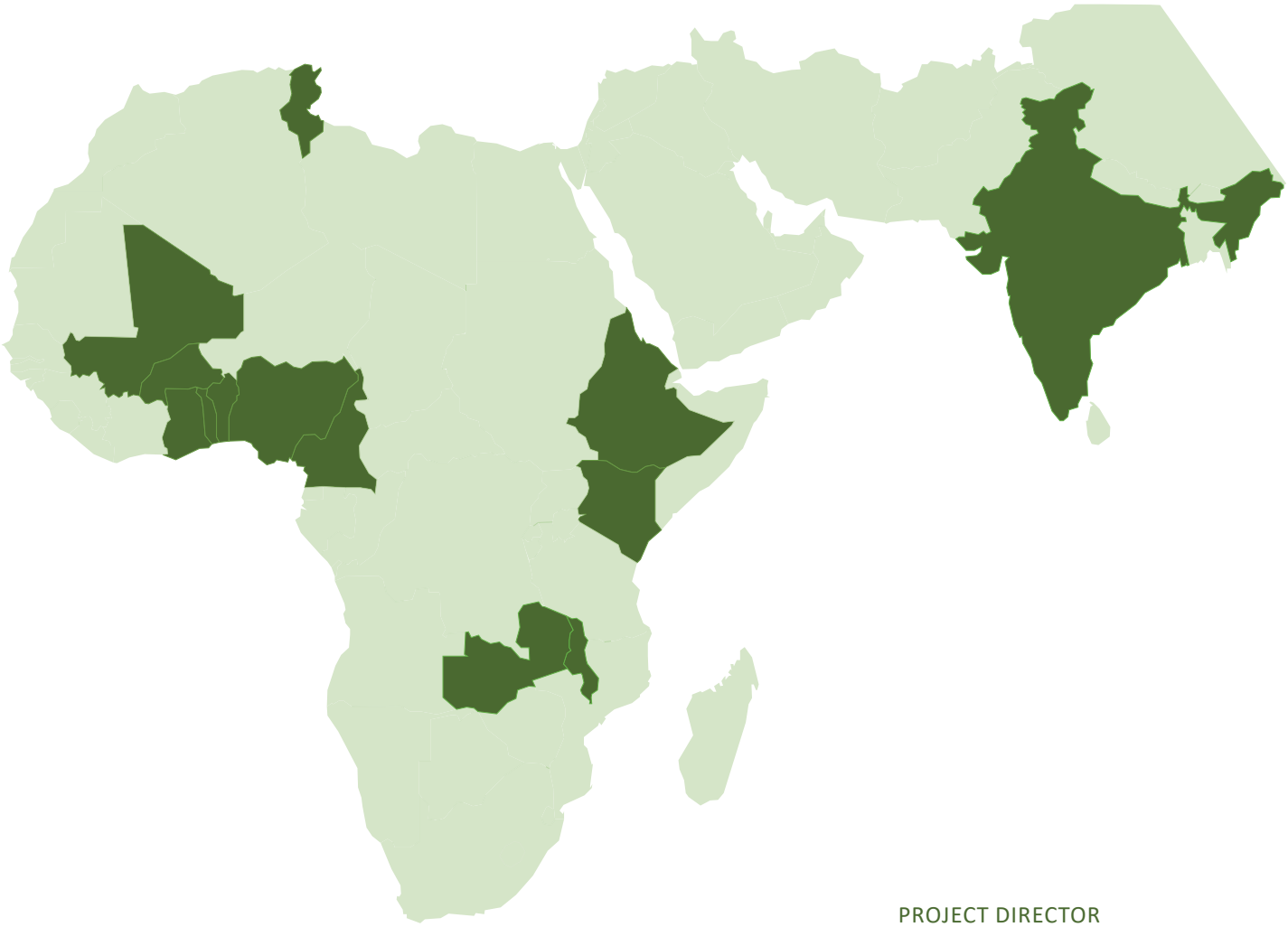
7	Enhancing Food Security in Arab Countries	Fernana (north-west) and Kairouan (Central Tunisia sous irrigation)	Technical package adapted to maximize the performance of wheat in dry and in irrigated	1000 farmers in the two regions Targets	Koetienne bank	2011	In Progress
8	EU-IFAD:	Northern Tunisia	Intensification of the production of cereals with the integration of pulses to seeds	5000 farmers in the target regions	IFAD	2013	In Progress
9	The analysis of the value chain The Aleppo pine "zgougou	The Governorates of Kasserine, Kef and Siliana	Seeds of the Aleppo pine	5000 Operators of the drill bit and 300 artisanal Transformers			
10	Essential oil of myrtle	The Governorates of Jendouba, Bizerte	Extraction of essential oil in prtir of the fruit of the myrtle	2500 Operators of the drill 300 transformers, + 5 companies			
11	Fixed oil of Lentisque	Benzart and Beja	Extraction of the fixed oil of fruit of lentisque	300 operators/habitants of the Foret+50 Transformers			
12	Rosemary essential oil	Kef, Siliana, Kasserine and Kairouan and Zaghouan	Extraction of fixed oil of rosemary	1500 Operators/forest inhabitants+ 50 processors		2014	
13	Pinion pin	Benzart, Beja, Jandouba and Nabeul	Fruit of the pinion pin	3000 collectors among the inhabitants of the forest+ 11 micro firms		2012	Finished
15	Olive oil Zarrazzi	Medenine	Olive oil coming from the local olive variety Zarrazi/ olive oil from the local variety of Olivier Zarrazi	310 000 farmers	ICARDA/CGIAR	2013	Finished 2016

Source: Hamouda et. al. (2016)

Note: ACIAR = Australian Center for International Agricultural Research; CANA = Adapting Conservation Agriculture for Rapid Adoption by Smallholder Farmers in North Africa; DGAB = General Directorate for Bio-Agriculture; DGF = General Directorate of Forests; EU-IFAD = European Union-International Fund for Agricultural Development; GIZ = Deutsche Gesellschaft für Internationale Zusammenarbeit; ICARDA/CGIAR = International Center for Agricultural Research in the Dry Areas/ Consultative Group International Agricultural Research; INGC = National Institute of Field Crops; SMSA = Mutual for Agricultural Services; UNIDO/SECO = United Nations Industrial Development Organization/ Swiss Secretariat of Economic Affairs.

ABOUT PARI

The Program of Accompanying Research for Agricultural Innovation (PARI) brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth and food and nutrition security in Africa and India as part of the “One World, No Hunger” Initiative supported by the German government.



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