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Tunisia

Agricultural risk assessment study in the Tunisia cereals and olive oil value chains

JULY 2024

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EXECUTIVE SUMMARY

This risk assessment study of the cereals and olive oil value chains in Tunisia seeks to forge understanding by decision-makers in Tunisia of the risks profile and suggest appropriate agricultural risk management (ARM) tools for these two major value chains, so as to reduce investment risks in both value chains.

The collaboration of PARM from January 2023 with the Ministry of Agriculture, Water Resources and Fisheries (MARHP), represented by the General Directorate for Investment Financing and Professional Organizations (DGFIOP), and the insights from the risk assessment study and dialogue with stakeholders are intended to identify priority strategies for managing agricultural risks in Tunisia. The ARM tools identified in close collaboration with the government and technical and financial partners (TFPs) will then be used to design an investment project.

This study begins with an analysis of the functioning of the cereals and olive oil value chains and highlights their key role for the Tunisian economy, in addition to profiling the country's risks.

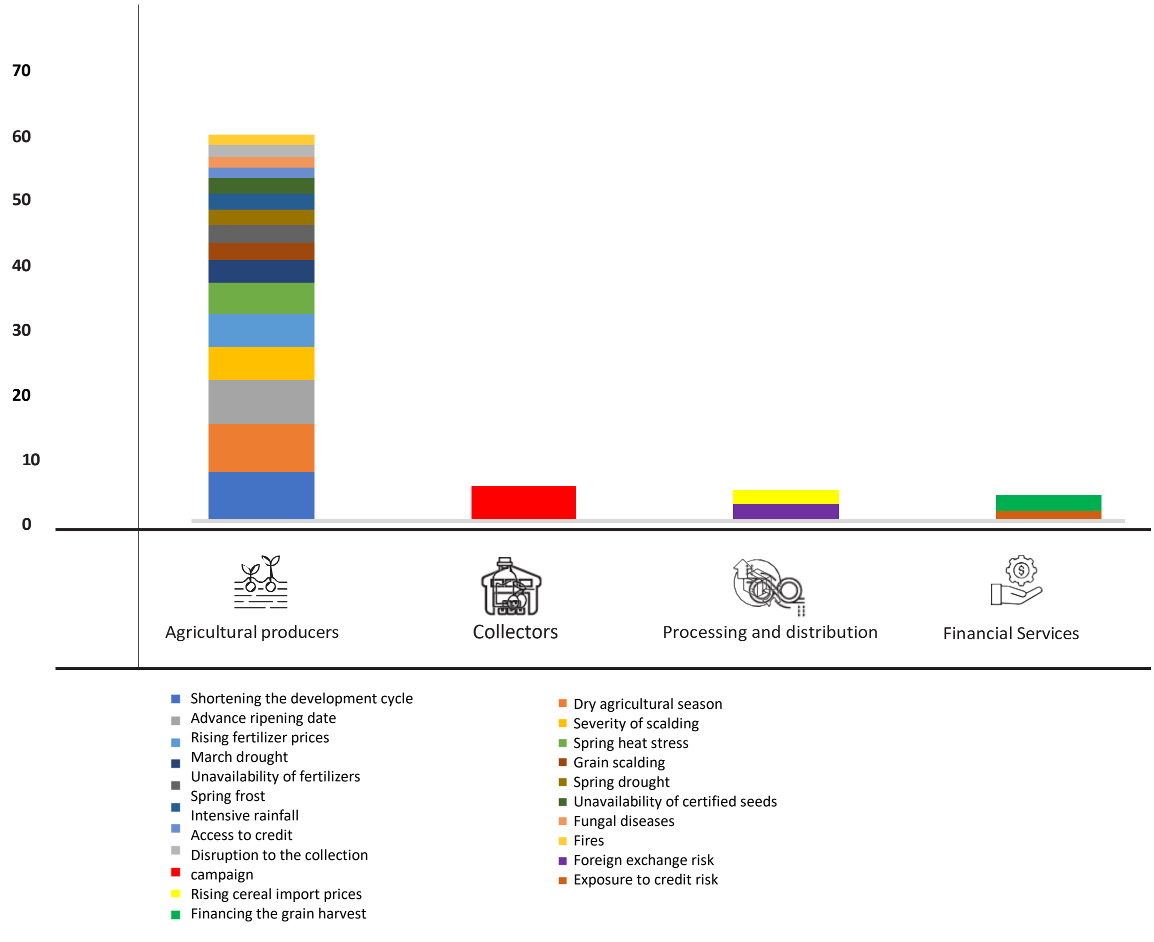
*Following a holistic assessment of risks in the Tunisian **cereals value chain**, a set of 26 systemic risks (including production, market, price and financial, logistical and institutional risks) was identified as having a significant impact on this value chain. Risks are prioritised by taking the average of the stakeholders' risk scores for each of the risks identified. This analysis reveals that the main risks weighing on the development of the cereals value chain are climatic: the shortening of the development cycle; the severe to extreme drought during the agricultural season and the early maturity date of cereals.*

For all cereals, the shortening of the development cycle is the main risk with a negative impact on Tunisian production, with a risk score of 7.50. The frequency of this risk is around 16.7%, and when it occurs, it leads to an average fall in production of around 372,000 tons, representing a loss of TND 473 million (USD 152 million). The maximum loss could reach 665,000 tons, representing a loss of around TND 823 million (USD 264 million).

Severe to extreme agricultural drought has a probability of occurrence of 16.7%. This risk, with a score of 7.50 for all cereals, results in an average loss of 344,000 tons of crops in Tunisia, at a cost of almost 393 million dinars (USD 127 million). The maximum loss caused by the severe to extreme drought which can reach 605 000 tons, at a cost of around 691 million dinars for all cereal production (232 million USD). As for the risk of advancing the maturity date, it has a probability of occurrence of 14.3% and a risk score of 6.80. This risk could lead to an average production loss of 556,000 tons, representing an average loss of 679 million dinars (USD 218 million).

In the cereal value chain, the actors most affected by climatic risks are the producers, both in terms of the number of risks to which they are exposed, and the scale of these risks. producers are also affected by the market risks associated with inputs (price and availability of fertilizers and seeds, as well as the risk of a breakdown in access to credit). Collectors are exposed to the risk of disruption to the collection season, while the risk of price rises for industrial processing, these are borne by the Caisse Générale de Compensation. For their part, financial service providers are exposed to credit risk and to the risk of financing the cereals campaign.

Fig. Cumulative risk scores by type of stakeholder and by type of risk for the cereal value chain



Note: the maximum score for each risk is 12. For ease of reading, only scores >1 are shown here.

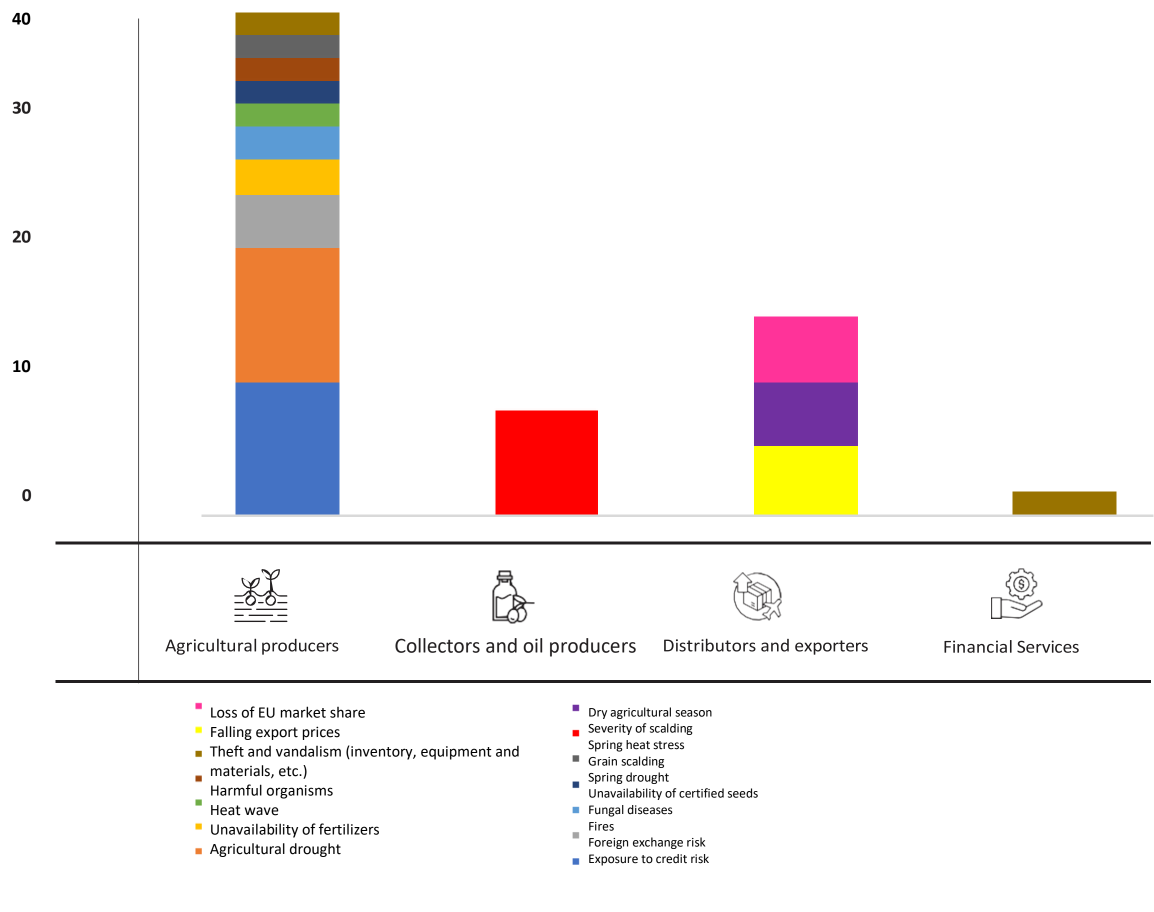
*Across the entire **olive oil value chain**, 21 risks were identified and prioritised by taking the average of the risk scores of the actors for each of the risks identified. Prioritisation shows that the main risks to the development of this value chain are (1) the failure to meet the cooling requirements of olive trees, (2) agricultural drought, and the rise in olive production prices.*

Thus, the probability of a reduction in the percentage of olive groves in Tunisia where the cooling needs of olive trees are not met is estimated at around 17.1%. This risk of not meeting cold needs could result in an average loss of 305 thousand tons of harvest in Tunisia, equivalent to a drop of almost 37.7% in national oil olive production. This average loss would result in an estimated cost of around 1 155 million dinars (USD 372 million). Of particular concern is the fact that the maximum loss resulting from this risk could reach 757 thousand tons, which would be equivalent to a maximum cost of 2 866 million dinars (924 million USD).

Sever to extreme drought, on the other hand, has a probability of occurrence of around 24.4%, and could result in an average loss of 354,000 tons, at a cost of almost 1 338 million dinars (USD 431 million). The maximum loss caused by this drought (severe to extreme) could reach 737 thousand tons, at a cost of around 2 789 million dinars (899 million USD).

In the olive sector, producers are not the only actors affected by risk. They bear the brunt of climatic risks, but market risks affect downstream actors at least as much: the risk of unavailability of inputs and falling olive prices for producers, the risk of rising olive prices for collectors and oil processors, the risk of falling export oil prices and the risk of losing market share for exporters.

Fig: Cumulative risk scores by type of stakeholder and by type of risk in the olive oil value chain



Note: the maximum score for each risk is 12. For ease of reading, only scores >1 are shown here.

Regarding the assessment of risk management capacity by stakeholders, disparities between stakeholders are highlighted by examining the different risk management options identified.

In the cereals value chain, financial services stand out as having the highest risk management capacity. However, the cereal collection link, which also acts as an input supplier to the cereal industry, has the weakest risk management capacity, highlighting the need for improvement in this area.

In the olive oil value chain, financial services, particularly insurance, have a less developed risk management capacity, particularly in relation to the risks of theft and vandalism. To counter these risks, government intervention is needed to reinforce safety and raise awareness. On the other hand, olive oil distributors and exporters have the highest risk management capacity within the olive oil value chain, benefiting from various options to maintain their operations.

In terms of vulnerability, and according to the approach defined by PARM based on the calculation of a vulnerability index based on exposure to risk (risk score) and risk management capacity, farmers and collectors emerge as the most vulnerable links in the cereals value chain. Their vulnerability can be mainly explained by their high exposure to climatic risks in the case of farmers, and to the risks associated with agricultural inputs in the case of collectors. In addition, the limited capacity of these actors to manage these risks makes the cereals value chain particularly sensitive to production hazards. Vulnerability indices exceed 5.5 for five major risks, including drought and rising fertilizer prices.

In the olive oil value chain, oil-olive producers are also considered as the most vulnerable actors. They are confronted with major risks such as the failure to meet cooling needs and agricultural drought. These risks are reflected in vulnerability indices exceeding 8, underlining the fragility of this value chain in the face of climatic risks.

The study also reveals that agricultural risk management in Tunisia requires targeted strategic action for both value chains. The experience of PARM demonstrates that strategic actions are more effective when they are implemented jointly rather than separately. For the cereal value chain, it is crucial to come up with innovative climate insurance products that respond to the production risks associated with rising temperatures, which affect agricultural productivity and profitability. In order to be relevant and effective, these insurance policies must be designed in partnership with political decision-makers, financial institutions, agricultural research centres and producers. In addition, improving the supply of seeds that are adapted and resistant to changing climatic conditions is essential to improving crop productivity and resilience. Promoting agroecology through close collaboration between research and agricultural extension will help to spread sustainable and innovative practices.

The creation of an inter-trade group is recommended for the olive sector in order to improve coordination between the various actors, develop quality standards, and promote innovation. Setting up a market and price observatory will increase transparency, stabilize producers' incomes and encourage the adoption of modern farming practices.

Specific insurance for climatic risks linked to rising temperatures and cooling requirements is also needed to protect olive producers and improve the resilience of the value chain.

Cross-cutting actions for agricultural risk management include investing in climate observation and information systems to enable effective risk management. Standardising climate data and disseminating accurate information will enable farmers to make informed decisions. In addition, it is essential to create an environment conducive to private investment by updating the regulatory framework and strengthening subsidies for sustainable agricultural practices and efficient irrigation systems. Strengthening the operations of the Agricultural Damage Compensation Fund (FIDAC) is crucial to protecting farmers against climatic hazards and ensuring their financial stability.

The study also looks at the socio-gender challenges in these two value chains, highlighting the difficult conditions faced by women. Despite their strong presence in the family workforce, they remain under-represented in permanent salaried positions, with greater insecurity in temporary jobs. Women suffer from difficult working conditions, limited access to social protection and wage discrimination, with lower pay than men. The exclusion of women from land ownership perpetuates economic inequalities and restricts their access to agricultural resources. The declining attractiveness of agriculture to young people and the ageing of the agricultural workforce underline growing urban migration, leading to a demographic imbalance and a shortage of skilled labour.

Furthermore, the emergence of female leadership in the olive oil value chain offers positive prospects, illustrating the economic opportunities for women in the agricultural sector and the potential for the revitalisation of the rural economy and the economic empowerment of women.

The study reveals the need to strengthen institutional and human capacities, with particular emphasis on the inclusion of women. This includes training agricultural actors on risks, developing the skills of extension agents, and integrating agricultural risk management considerations into agricultural education. These measures will ensure more effective management of agricultural risks and improve the resilience of Tunisia's agricultural sector against climate challenges.

ABREVIATIONS

ABIP - Agricultural Bioproducts Innovation Program

ADF - French Development Agency

APII - Agency for the Promotion of Industry and Innovation

ARM - Agricultural Risk Management

ARBL - Arab Institute of Business Leaders

ASM - Advance on merchandise

ASTREE - Insurance and reinsurance company

ATFD - Tunisian Association of Democratic Women

BAD - African Development Bank

BPEH - Office of Planning and Hydraulic Balances

CC - Climate change

CGC - General Compensation Fund

CNCNA - National Commission for Agricultural Natural Disasters

CO - Cereals Office

COI - International Olive Council

COMAR - Mediterranean Insurance and Reinsurance Company

COSEM - Central Mutual Seed Company

CTAMA - Tunisian Agricultural Mutual Insurance Fund

DGBGTH - General Directorate of Dams and Major Hydraulic Works

DGEDA - General Directorate for Agricultural Research and Development

DGPA - General Directorate of Agricultural Production

DGFIOP - General Directorate of Financing Investment and Professional Organizations

DGSV - General Directorate of Veterinary Services

DGSVCIA - General Administration of Plant Health and Agricultural Input Control

DRR - Disaster Risk Reduction

EBCNV - National survey of household budgets, consumption and living standards

EU - European Union

FAO - Food and Agriculture Organization of the United Nations

FGA - Insured Guarantee Fund

FIDAC - Agricultural Damage Compensation Fund

FGA - Insured Guarantee Fund

FIDAC - Agricultural Damage Compensation Fund

FNAB - National Federation of Organic Farming

FNG - National Guarantee Fund

FTDES - Tunisian Forum for Economic and Social Rights

GCF - Green Climate Fund

GCT - Tunisian Chemical Group

GGF - General Directorate of Forests

ha - Hectare

HCHR - Office of the High Commissioner for Human Rights

IFAD - International Fund for Agricultural Development

INGC - National Institute of Field Crops

INRAT - National Institute of Agricultural Research of Tunisia

LFU - Livestock Feed Unit

MD - Million dinars

NAB - National Agricultural Bank

NIS - National Institute of Statistics

OCT - Tunisian Office of Trade

ONH - National Olive Oil Office

ONPC- National Office for Civil Protection

OPA - Professional Agricultural Organisation

PARM - Platform for agricultural risk management

PIB - Gross domestic product

PNA - National Adaptation Plan

PPP - Public-private partnerships

RMC - Risk management capability

SH (code) - Harmonized System nomenclature

SMCSPS - Central Mutual Society for Selected Seeds and Plants

SOGAR - Mutual agricultural service companies

STAR - Tunisian Guarantee Company

TFP - Technical and financial partner

TND - Tunisian Insurance and Reinsurance Company

TD - Tunisian Dinar

TSB - Tunisian Solidarity Bank

UN Women - United Nations Entity for Gender Equality and the Empowerment of Women

URAP - Regional Union of Agriculture and Fisheries

USD - US Dollar

UTAP - Tunisian Union of Agriculture and Fisheries

VI - Vulnerability index

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1 Background

1.1 National context: Importance of the agriculture and agri-food sectors

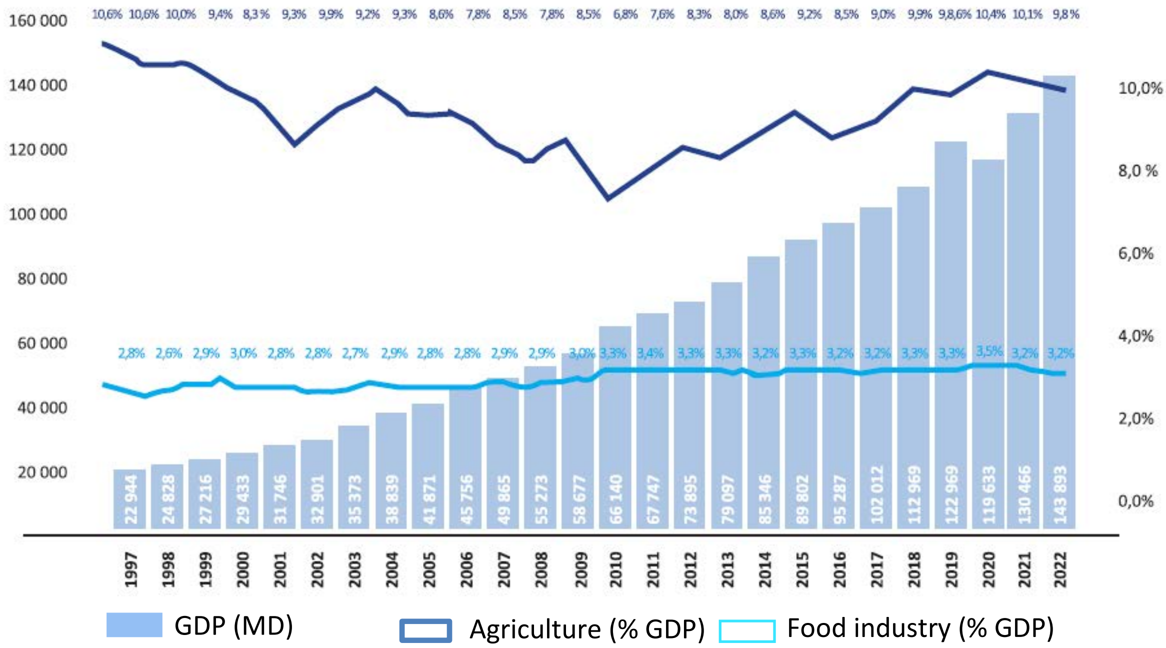
In recent years, Tunisia has been faced with a poor economic outlook. Following the impacts of the covid-19 crisis (8.7% fall in GDP), the weak economic growth of 2.4% recorded in 2022 (compared with 4.3% in 2021) is likely to amplify the country's vulnerabilities. The impact of the war in Ukraine and soaring prices on the international markets have increased pressure on public spending and are likely to worsen the country's current account and budget deficits *[1]*.

Against this backdrop, Tunisian agriculture remains vitally important and is one of the country's main sources of economic growth. Despite a severe drought in recent years, this sector has recorded average annual growth of 1.21% over the period 2015-2022, higher than that of the economy as a whole, which has grown by just 0.79% annually over the same period *[2]*. Agriculture and the agri-food industry have shown a degree of resilience, guaranteeing a minimum level of economic growth in a country affected by the post-2011 slowdown in the production system. In 2022, the contribution of these two sectors to GDP will be 18,712 million dinars, or 13% of GDP (Figure 1).

[1] *For a more comprehensive view of the Tunisian economic context, readers can consult the "Annual Report 2022" of the Central Bank of Tunisia and the World Bank's Economic Outlook.*

[2] *According to the AfDB (2022), during the Covid-19 crisis, these two sectors recorded an increase in productivity by 4.2% and 7.7% respectively between 2019 and 2020, while other sectors were more severely affected by the pandemic.*

Figure 1. Change in GDP (current prices in million dinars) and in the share of the agricultural and agri-food sectors (%)



Source: Authors, based on NIS data.

The importance of the agricultural and agri-food sectors is also evident in terms of employment and income *[3]*. Thus, the sector continues to contribute 14% of total employment, despite a downward trend since 2010. Net job creation in the agri-food industry has been positive in recent years, and its share of national employment reached 2.9% in 2020, with almost 100,000 jobs.

It is also worth recalling that the agricultural and agri-food system helped to absorb the employment shock during the Covid 19 crisis. Overall, net job creation during the 2020 crisis was therefore positive in these two sectors *[4]*.

Table 1. Position of the agricultural and agri-food sector in the Tunisian labor market

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Workforce (in thousands)	**3277**	**3155**	**3234**	**3327**	**3402**	**3395**	**3424**	**3465**	**3500**	**3540**	**3479**	**3425**	**3436**
Share of:													
Agriculture	17.6%	16.6%	16.5%	15.5%	14.8%	15.0 %	14.9%	14.6%	14.3%	13.8%	14.5%	NA	14.4%
Food industry	2.2%	2.2%	2.5%	2.5%	2.4%	2.4%	2.6%	2.7%	2.7%	2.8%	2.9%	NA	NA

Note: NA: data not available.
Source: Authors, based on NIS data.

[3] *Appendix 1 details the changes in the labor market and the position of the agricultural and agri-food sectors in Tunisia over the period 2010-2022.*

[4] *The Covid-19 pandemic had a negative impact in terms of loss of income and jobs caused by preventive measures against the virus. The unemployment rate peaked at 18% in the second quarter of 2020, compared with 14.9% at the end of 2019, before falling back to 17.4% in the final quarter of 2020. The latest figures published by the NIS show that the unemployment rate was 15.6 in the second quarter of 2023. By gender, the unemployment rate remains significantly higher for women (21.1%) than for men (13.2%).*

Moreover, if we consider the sum total of the workforce in agriculture and the agri-food industry, their share of total employment is greater than their share of GDP, a fact which suggests that average incomes in these two sectors are generally lower than in other economic (Chebbi and Overdiek, 2022).

This means that while agriculture and the agri-food industry contribute to economic resilience by addressing certain difficulties in the labor market, other sectors are more conducive to the search for well-paid employment opportunities and new avenues for growth.

1. Tunisia's agricultural and agri-food sector risk profile

1.2.1 Vulnerabilities of the agricultural sector to climate change and decline in agricultural production

Tunisia has identified a number of vulnerabilities to climate change (CC) in its agricultural sector. In the absence of adaptation and technical progress, climate simulations predict an increase in the frequency and intensity of prolonged periods of drought, which are likely to affect cereal and olive production in particular (MARHP and AFD, 2022) *[5]*. The likely impacts would be a drop in yields and a reduction in the area under tree and cereal crops, a loss of soil fertility and a reduction in the area of arable land. The highest level of vulnerability is observed in the Centre and South of Tunisia, and the level of vulnerability is particularly critical in the South (East and West).

When it comes to cereal production, all regions of the country are likely to experience a major increase in the occurrence of hazards affecting rainfed cereal crops, such as scalding, mild winters leading to the presence of diseases and pests, and early crop development cycles. The latter presents a major risk if it coincides with the onset of spring frosts, the frequency of which is set to increase in the Central East region. Finally, the southern and central-western regions will be the most exposed to periods of water stress.

Climate change is likely to have a negative impact on yields, which are expected to fall for the three main rain-fed cereals grown in Tunisia (durum wheat, common wheat and barley). Climate simulations also show a decline in the areas suitable for production cereals (durum wheat, common wheat and barley), which are likely to shrink and move towards the north of Tunisia *[6]*.

With regards to the olive sector, the joint study carried out by MARHP and AFD in 2022 revealed that Tunisian olive groves are indeed facing increased sensitivity to the effects of climate change, contrary to some previous assessments. All regions are likely to experience a sharp increase in the occurrence of climatic hazards affecting olive production, such as a high number of hot days coupled with water stress, leading to a drop in yields, or mild winters with few cool days, threatening to meet the cold requirements of the olive tree for flowering. The increased occurrence of spring frost, with its risk of destroying flowering leading to a loss of yield, is likely to be observed only in the central-eastern part of the country. In the other regions, this risk is expected to diminish or even disappear.

For yields in the oil olive sector, in the absence of adaptation measures and technological progress, climate projections show a drop of between 17% and 32% by 2050. Climatically suitable areas for olive production could shrink and move northwards in Tunisia *[7]*.

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[5] *These vulnerabilities to climate change were set out in Tunisia's updated Nationally Determined Contribution (NDC) for 2021. https://unfccc.int/sites/default/files/NDC/2022-06/Tunisia%20Update%20NDC-french.pdf*

[6] *Appendix 2 summarises the main results of the climate simulations with the RCP4.5 and 8.5 scenarios in 2050 and 2100 for the rainfed cereals sector.*

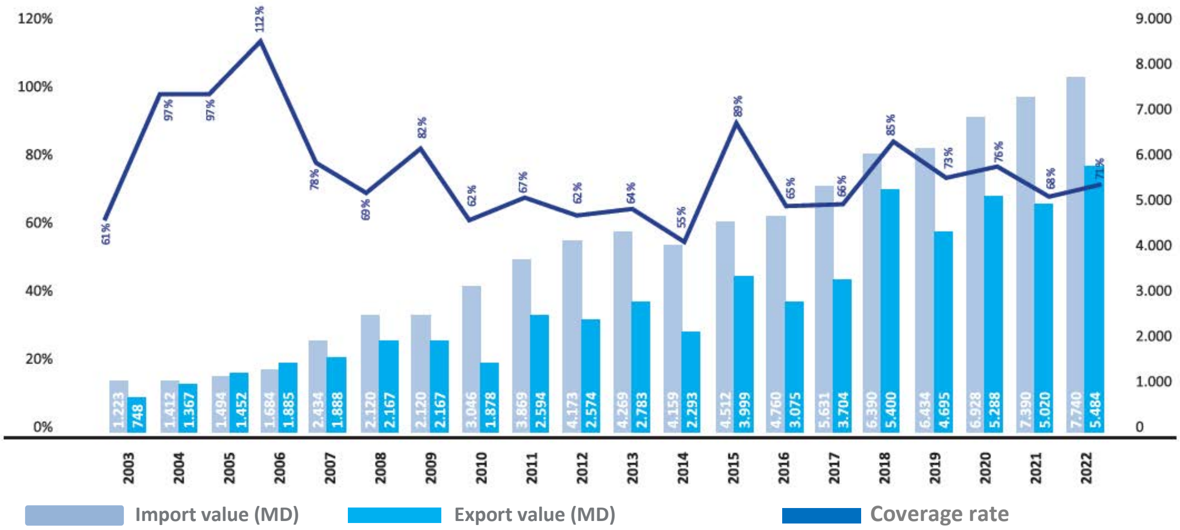
[7] *Appendix 3 summarizes the main results of the climate simulations with the RCP 4.5 and 8.5 scenarios in 2050 and 2100 for the rainfed oil olive sector.*

1.2.2 Cereals import costs that burdens State budget and widen trade deficit

In terms of foreign trade, Tunisia's agricultural and agri-food trade balance (HS chapters 01-24) has been structurally in deficit since 2006. Agricultural and agri-food exports (HS customs chapters 01-24) will account for almost 9% of the country's total exports in 2022 (Figure 2) *[8]*.

Imports, meanwhile, reached 7,740 million dinars in 2022, and the rate of coverage of imports by exports did not exceed 71% in 2022, i.e. a deficit of -2,256 million dinars (compared with a historical deficit of -2372 million Tunisia Dinars).

Figure 2. Agricultural and agri-food foreign trade and coverage rate in Tunisia (MD)



Source: Authors, based on TRADE MAP and BCT data.

Imports of agricultural and agri-food products account for more than 13% of Tunisia's total imports, i.e. more than TND 6.9 billion (around USD 2.2 billion) in 2020 (Figure 3) *[9]*. Unsatisfied needs and dependence on imports of cereals and, to a lesser extent, oil and sugar have resulted in high costs of food.

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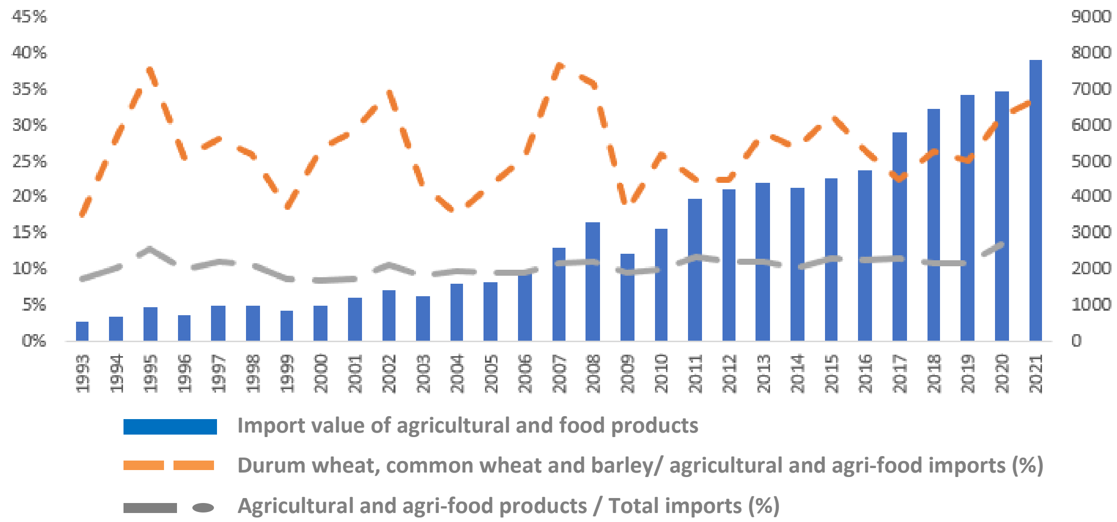
[8] *For an indication, see Appendix 4, which shows the evolution of Tunisia's trade and the agricultural and agri-food trade balance by customs chapter at international prices.*

[9] *Since 2000, agricultural and agri-food imports have grown more strongly than total imports.*

The volume of cereals imported continues to rise to meet production domestic demand, increasing the country's dependence on international cereals markets. Tunisia is therefore a major net importer of cereals, with around 70% of its cereals needs covered by imports. According to average figures for the period 2015-2021, the Cereals Office imports some 2.411 million tons of cereals annually. This quantity breaks down into 24% durum wheat (i.e. 0.590 million tons per year), 47% common wheat (i.e. 1.121 million tons per year) and 29% barley (i.e. 0.700 million tons per year).

As a result, the cereals import costs represent a significant burden on the State budget, contributing to the worsening of the foreign trade deficit. In 2021, imports of wheat (durum and common) and barley are estimated at 34% of Tunisia's agricultural and agri-food imports *[10]*.

Figure 3. Change in the value of imports of agricultural and agri-food products and share of cereals in these imports (%)



Source: Authors, based on NIS data.

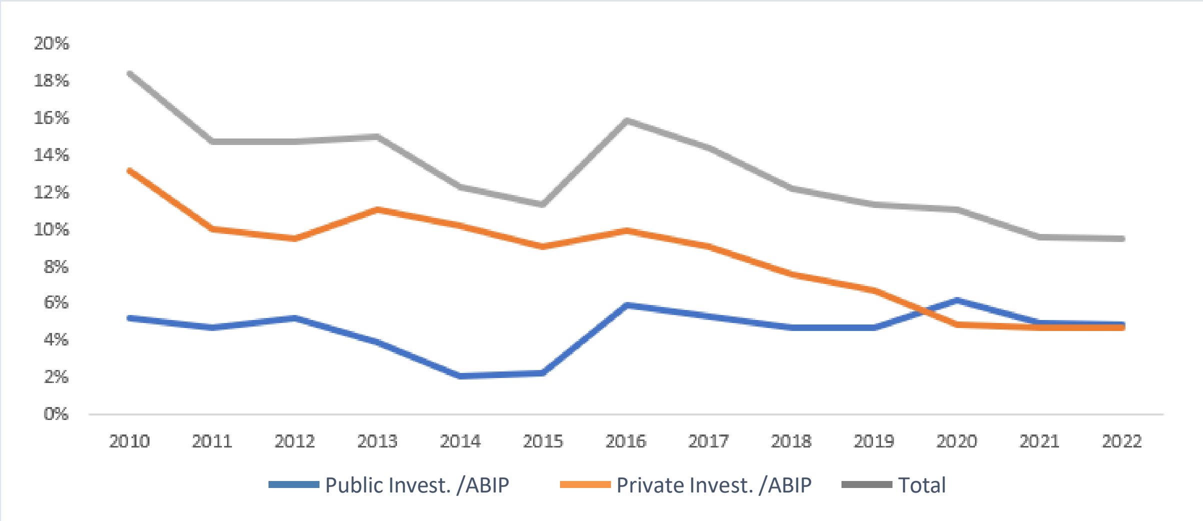
1.2.3 Decline in agricultural investment

Despite the efforts deployed towards promoting investment, the fall in the rate of investment in the agricultural sector (ratio of investment to value added) from 18% in 2010 to 10% in 2022 is likely to have negative consequences for agricultural productivity, adaptation to climate change, innovation, infrastructure, farmers' incomes, environmental sustainability, rural employment and food security (Figure 4) *[11]*.

[10]*Tunisia is the 28th largest importer of wheat (durum and common) in the world (1.2% of the volume and 1.0% of the value of world imports on average over the period 2011-2020). The country is also the 13th largest importer of barley by volume (accounting for 1.9% of the volume of imports) and the 14th largest buyer of barley by value (1.6% of the value of world imports for the same period).*

[11] *The Covid-19 pandemic has exacerbated the fragilities that are inherent in the Tunisian economy, accentuating the downward trend in investment observed since 2011. While there was a slight recovery in investment in 2021, this was undermined by the rise in prices on international markets, a direct consequence of the conflict in Ukraine.*

Figure 4. Rate of investment in the agriculture and fisheries sector in Tunisia (% Agricultural GDP)



Source: Authors, based on BCT, NIS and DGEDA data.

Indeed, the continued decline in the private sector's contribution to the rate of agricultural investment, from 13% in 2010 to just 5% in 2022, reflects the low profitability of the sector and the weakness of financial and fiscal support programs for farmers in Tunisia.

The sector is confronted with profitability challenges due to a producer price policy that is not favorable to producers (particularly low prices in the cereals and dairy sectors) and rising production costs. Farmers and investors are less inclined to invest in a sector that offers uncertain financial returns in a challenging climatic and institutional context.

Furthermore, the share of state investment in the investment rate remains stagnant at around 5%, reflecting budgetary constraints, and risks compromising the country's efforts in areas such as agricultural research, agricultural infrastructure and farmer training.

1.2.4 Rising consumer prices for food products

The loss of purchasing power has continued unabated in Tunisia since the 2010s, and inflation continues to rise, reaching 8.3% in 2022, its highest level since 1987, when the country's first structural adjustment plan was put in place *[12]*.

This is due in particular to the accelerating rise in food prices, with inflation reaching a record 11.6% in 2022 (Table 1) *[13]*. The persistence of very high levels of inflation, particularly for food products, could jeopardise access to food for many Tunisians, while poverty and unemployment remain high, bringing back painful memories of the "bread riots" of 1983-1984.

[12] *Inflation in Tunisia reached its highest level since 1962 in 1982, at 14.05%.*

[13] *Free food products rose by 17.3%, compared with 0.6% for food products at regulated prices (NIS, 2022). In Tunisia, pricing policy is governed by Law 2015-36 of 15 September 2015 on the reorganisation of competition and prices. However, even if this law enshrines price freedom as a general principle, article 3 of the said law excludes from the price freedom regime certain essential goods and services or those relating to sectors or areas where price competition is limited (either because of a monopoly situation or lasting difficulties in supplying the market or because of legislative or regulatory provisions).*

According to the National Institute of Statistics (NIS), the rise in food prices in 2022 alone is mainly due to the 38.9% increase in the price of eggs, the 26.3% increase in the price of sheepmeat, the 22.8% increase in the price of edible oils, the 19.5% increase in the price of beef, the 17.2% increase in the price of fresh vegetables, the 16.5% increase in the price of non-subsidised cereal derivatives, and the 15.6% increase in the price of dairy products and cheese.

Table 2. Change in the inflation rate for food and non-alcoholic beverages (Base 100=2015)

	2016	2017	2018	2019	2020	2021	2022
ALL	*3.6%*	*5.3%*	*7.3%*	*6.7%*	*5.6%*	*5.7%*	*8.3%*
Food products and non-alcoholic beverages	*2.7%*	*5.6%*	*7.3%*	*6,9%*	*4.7%*	*6.3%*	*10.9%*
Food products	*2.6%*	*5.7%*	*7.4%*	*6.9%*	*4.7%*	*6.7%*	*11.3%*
-Bread and cereals	*1.3%*	*2.4%*	*4.8%*	*3.9%*	*4.3%*	*3.2%*	*5.2%*
-Meat	*-2.9%*	*3.1%*	*13.1%*	*9.7%*	*5.2%*	*5.2%*	*12.0%*
-Fish	*5.6%*	*7.0%*	*9.1%*	*4.0%*	*6.3%*	*6.7%*	*9.7%*
-Milk, cheese and eggs	*-0.1%*	*2.8%*	*7.5%*	*9.7%*	*5.1%*	*6.7%*	*9.8%*
-Edible oils	*6.1%*	*16.2%*	*7.3%*	*-0.3%*	*-9.8%*	*15.7%*	*20.%*
-Fruit	*11.0%*	*3.5%*	*14.6%*	*3.6%*	*8.5%*	*3.4%*	*15.0%*
-Vegetables	*6.3%*	*11.1%*	*-1.7%*	*9.2%*	*7.1%*	*10.6%*	*12.1%*
-Sugar, jam, honey, chocolate and confectionery	*2.0%*	*3.5%*	*6.9%*	*6.7%*	*7.3%*	*5.3%*	*6.0%*
Soft drinks alcoholic beverages	*4.8%*	*4.8%*	*5.9%*	*7.1%*	*4.6%*	*1.9%*	*6.1%*
-Coffee, tea and cocoa	*1.3%*	*2.2%*	*7.9%*	*7.0%*	*6.3%*	*3.3%*	*5.6%*
-Mineral water, soft drinks and juices	*6.4%*	*5.9%*	*5.1%*	*7.1%*	*3.9%*	*1.3%*	*6.3%*

Source: Compiled by the author on the basis of data from the National Institute of Statistics.

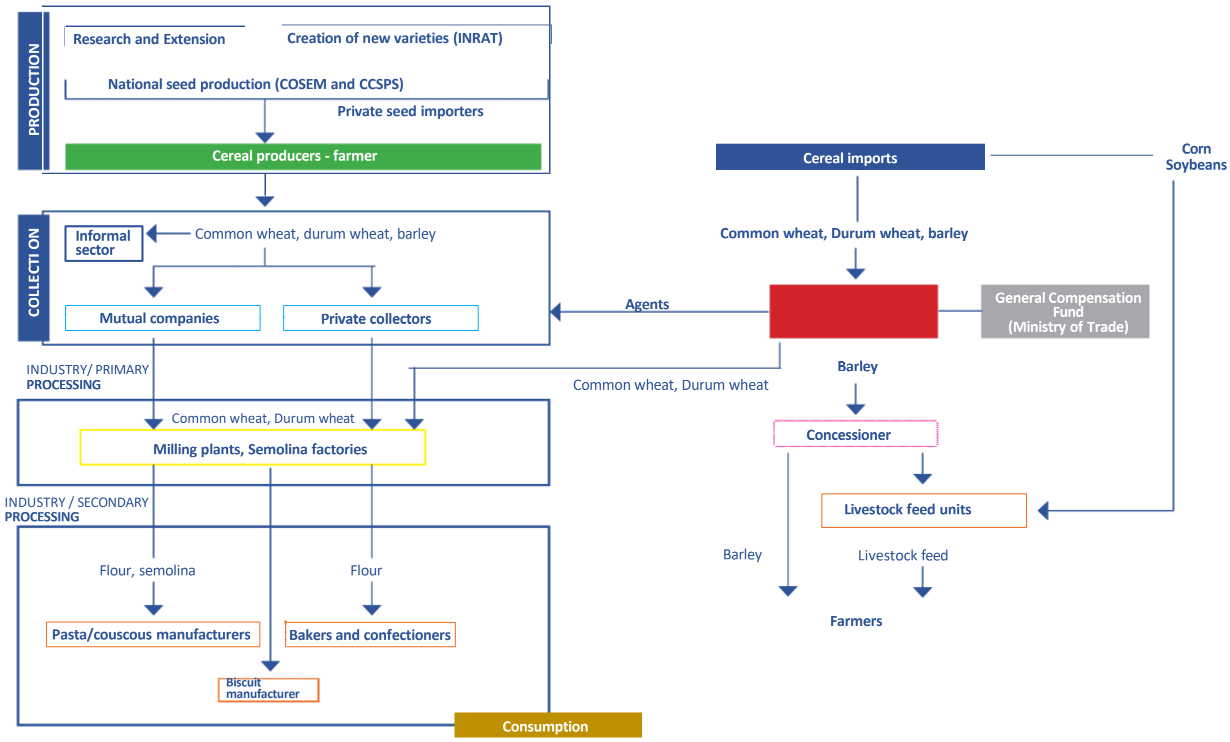
This rise in food prices is due to a number of economic and political disturbances: the fall in agricultural production and productivity at national level, the challenging agro-climatic conditions affecting Tunisia, the depreciation in the value of the dinar, the reduction in state support for the agricultural sector, the weakness of the post-covid 19 recovery and the rise in international prices linked in particular to the war in Ukraine.

It should be noted that the rise in food prices seen over the last few years has not benefited national agricultural producers, who have seen their production costs rise in the face of a policy of freezing producer prices at very low levels. For the year 2023, food prices have continued to rise due to a number of factors: a drop in agricultural production in Tunisia as a result of drought and restrictions on the use of water for farming, and persistently high prices for agricultural raw materials, energy and fertilizers.

2 Description of the cereals value chain in Tunisia

Cereals are at the heart of Tunisian agriculture and society, forming the basis of the country's diet. Along with olive production, cereals are the second pillar of Tunisian agriculture.

Figure 5. Overview of the cereals value chain in Tunisia



2.1 Production and supply of inputs (certified seeds)

On average, annual certified cereal seed production was around 25.6 thousand tons for durum wheat, 1.5 thousand tons for common wheat and 1.2 thousand tons for barley (from the 2015-2016 season to the 2021-2022 season) [*14]*.

Two mutual companies (formerly cooperatives) were responsible for the multiplication and marketing of certified cereal seed in Tunisia: the Central Mutual Society for Selected Seeds and Plants (SMCSPS) and the Central Mutual Seed Company (COSEM), which shared 55% and 45% of the market respectively. It should be noted that the multiplication programs of the two cooperatives, based on varieties obtained by INRAT, are carried out with the financial guarantee of the Cereals Office. Without this support, these two cooperatives would be unable to obtain bank financing and carry out their programs. These two cooperatives are currently facing financial problems.

[14] *In Tunisia, varietal selection is mainly carried out by the National Institute of Agricultural Research of Tunisia (INRAT).*

Since 2008, the Tunisian market has witnessed the arrival of three new private operators who market their certified seeds at free pricing, compared with an administered and subsidized price reserved for seeds marketed by the two cooperatives until the 2020/2021 season, when the state subsidy was extended to private operators for the first time *[15]*.

Certified seed is mainly distributed by cereal collectors who have a network of centers covering production areas and who have developed direct partnerships with cereal producers at regional level. Cereals are at the heart of Tunisian agriculture and society, forming the basis of the country's diet. Along with olive production, cereals are the second pillar of Tunisian agriculture.

2.2 Cereal production (durum wheat, common wheat and barley)

The average size of Tunisian farms is 10.2 hectares, but there is significant variation around this average: 54% of farms have less than five hectares and own 11% of agricultural land, while only 3% have more than fifty hectares and own 34% of the land (2005 figures).

Professional Agricultural Organisations (PAOs) play a paramount role in representing farmers' interests, developing the agricultural sector and promoting best practices. The main PAOs include:

- Tunisian Union of Agriculture and Fisheries (UTAP): Founded in 1952, UTAP is one of Tunisia's leading agricultural organisations. It represents the interests of Tunisian farmers and fishermen and aims to promote the sustainable development of the agricultural sector;
- Regional Unions of Agriculture and Fisheries (URAP): URAPs are regional organisations affiliated to UTAP. They operate at local level to represent farmers and fishermen in their respective regions and
- National Federation of Organic Farming (FNAB): This organisation represents organic farmers in Tunisia and promotes environmentally-friendly farming practices.

More than 248,000 farmers are involved in cereal production in Tunisia, representing almost half of the country's farms. This activity is also a major source of agricultural employment (especially for family labor), with an average of 141 million working days per year (i.e. 6% of the total number of working days in the agricultural sector) *[16]*.

More than 60% of farmers (157,000) are smallholders with an area of less than 10 ha, accounting for 23% of the cereal-production area. Medium-sized farms (10 to 50 ha) account for 32% of cereal producers and 40% of cereal production land. Finally, large-scale farmers (> 50 ha), located in the north of the country, account for 5% of cereal producers but 37% of cereal production area.

However, the amount of land set aside for cereals is declining and the total area sown is at its lowest level since 1996. In fact, over the last two decades, the average sown area has been reduced by almost 17%. It has fallen from 1.392 million hectares for the period 2004-2013 to an average of 1.149 million hectares for the last decade 2014-2023 (Figure 6).

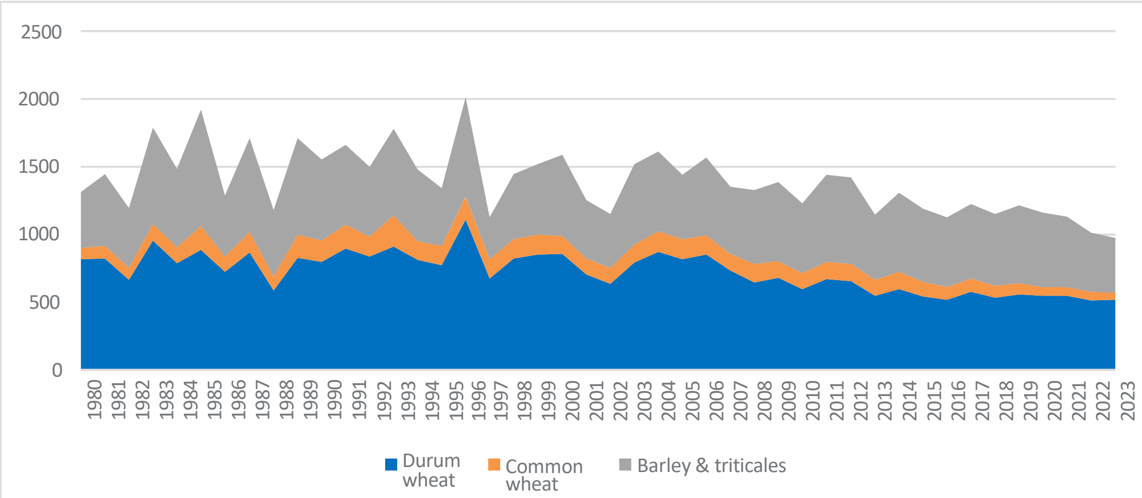
---

[15] *In addition to multiplying certain Tunisian varieties, the three private seed companies have used foreign varieties after registering them in the official catalogue. These are SOSEM (Mediterranean Seeds Company), which belongs to a group operating in the cereals collection and crushing sector; TUNIFERT, a STEC Group company also operating in the cereals collection sector and trading in chemical fertilizers and plant protection products; and Espace Vert, an agricultural services company operating in the production of seeds and seedlings, manure and fertilizers.*

[16] *These figures relate to the period 2012-2016 (Appendix 5).*

The two main reasons are the fall in the relative profitability of common wheat compared with other crops (citrus fruits, for example) due to the fixing of producer prices, which eliminates the price risk for the producer but also eliminates the potential profits from years of rising prices *[17]*, and the effects of global warming on the profitability of wheat (-20% in common wheat yields over the last 10 years).

Figure 6. Change in area sown to cereals (1000 ha) in Tunisia



Source: Authors, based on MARHP data.

As a result of heavy dependence on the vagaries of the weather, but also on other factors, such as irregular or limited availability of seeds and fertilizers, the area sown also varies from year to year *[18]*. By 2023, the sown area of cereals has been estimated at almost 1.132 million hectares:

- 545 thousand ha for durum wheat (48% of the area)
- 65 thousand ha for common wheat (6% of area)
- 512 thousand ha for barley (45% of the area)
- 10 thousand ha for triticale (only 1% of the area)

Taking all cereals together, production potential is estimated at 1.582 million tons on average for the last decade 2014-2023 (Figure 7). This production is characterized by its high inter-annual variation (a coefficient of variation of around 34% and a production peak in 2019 of 2.398 million tons) *[19]*. Despite the support policy in place, cereal production in Tunisia has not grown significantly (Figure 7).

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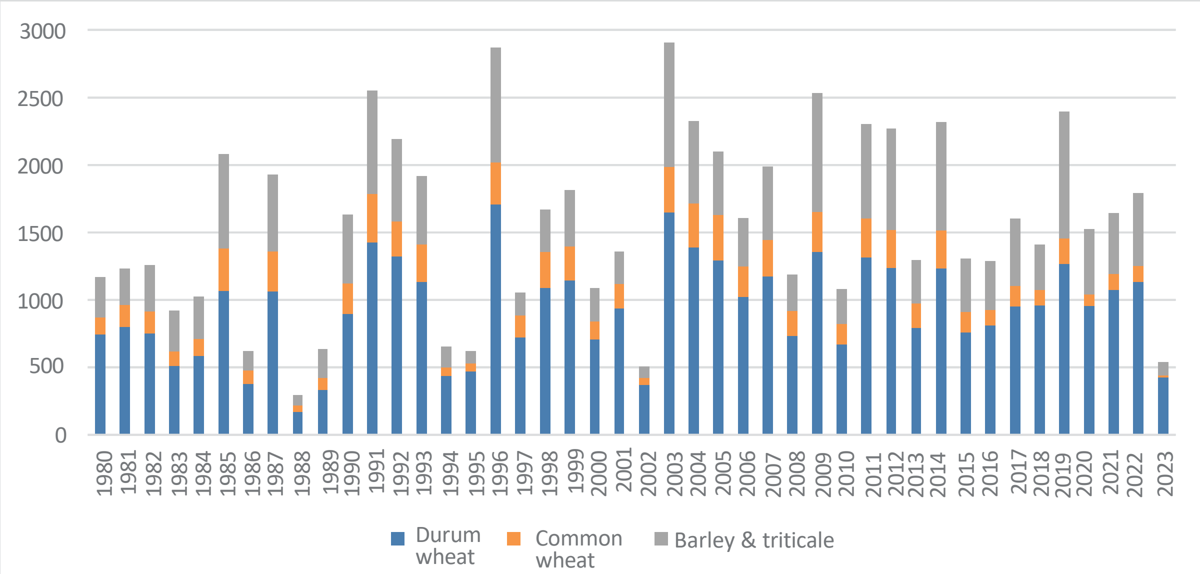
[17] *https://www.iamm.ciheam.org/uploads/attachments/691/ENPARD_20180617_Etude_soutien_au_secteur_agricole_Rapport_final.pdf*

[18] *Only 78,000 hectares are irrigated, mainly in the north and centre-west regions of the country.*

[19] *Historically, the highest level of production was reached in 2003 with 29.041 million quintals. Over the last 20 years, cereals production reached its lowest level in 2010, at 10.8 million quintals.*

Figure 7. Growth in cereals production in Tunisia (thousand tons)



Source: Authors, based on MARHP data.

In terms of yields, the sector was able to record gains for durum wheat, which rose by around 13% from 1.554 tons/ha annually during the period 2004-2013 to 1.752 tons/ha on average over the last decade 2014-2023 *[20]*. This progression has also been marked by an increase in the inter-annual variability of yields at national level, linked above all to the drought that has hit the country over the last four crop years *[21]*.

For common wheat yields, an examination of the aggregated data shows a fall of around 20%, from 1.918 tons/ha annually during the period 2004-2013 to 1.535 tons/ha on average over the last decade 2014-2023.

When it comes to barley (and triticale), average yields at national level have remained stable at around 0.920 tons/ha (average for the decade 2014-2023) but remain characterized by high inter-annual variability inherent in the rain-fed nature of this crop and its dependence on climatic conditions. The coefficient of variation in barley yields has risen from an average of 36% for the period 2004-2013 to 44% for the last decade 2014-2023.

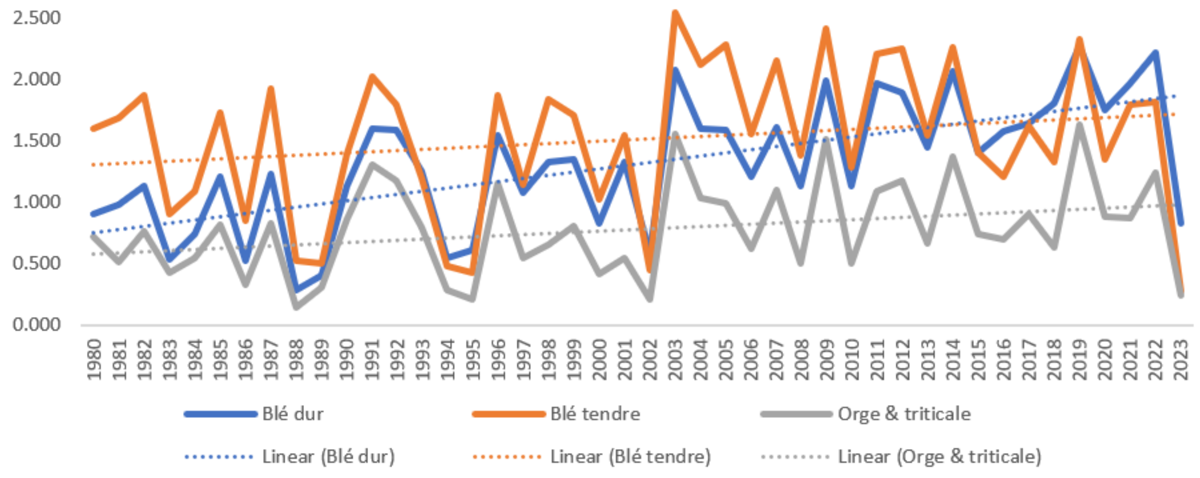
These national averages conceal major regional disparities and reveal that the increase in national durum wheat yields could not compensate for the fall in area sown, resulting in a decline in overall production levels *[22]*.

[20] *In spite of some progress, Tunisian wheat yields are far from the average world yields estimated in 2014/15 at 3.24 tons/ha, or in France (7.35 tons/ha), but close to those in Morocco, estimated at 1.84 tons/ha (International Grains Council, IGC).*

[21] *Indeed, the coefficient of variation of durum wheat yields has increased slightly, from 21% on average for the period 2004-2013 to 24% for the last decade 2014-2023.*

[22] *Appendices 6 to 13 provide an overview of changes in area sown, production and yields by region in Tunisia.*

Figure 8. Cereal yield trends in Tunisia (tons/ha)



Source: Authors, based on MARHP data.

3 Collection and storage of cereals

Unlike in many countries where collection and storage, considered an extension of production, are carried out by the farmers themselves or organized in cooperatives, the collection and storage activity involve three main operators:

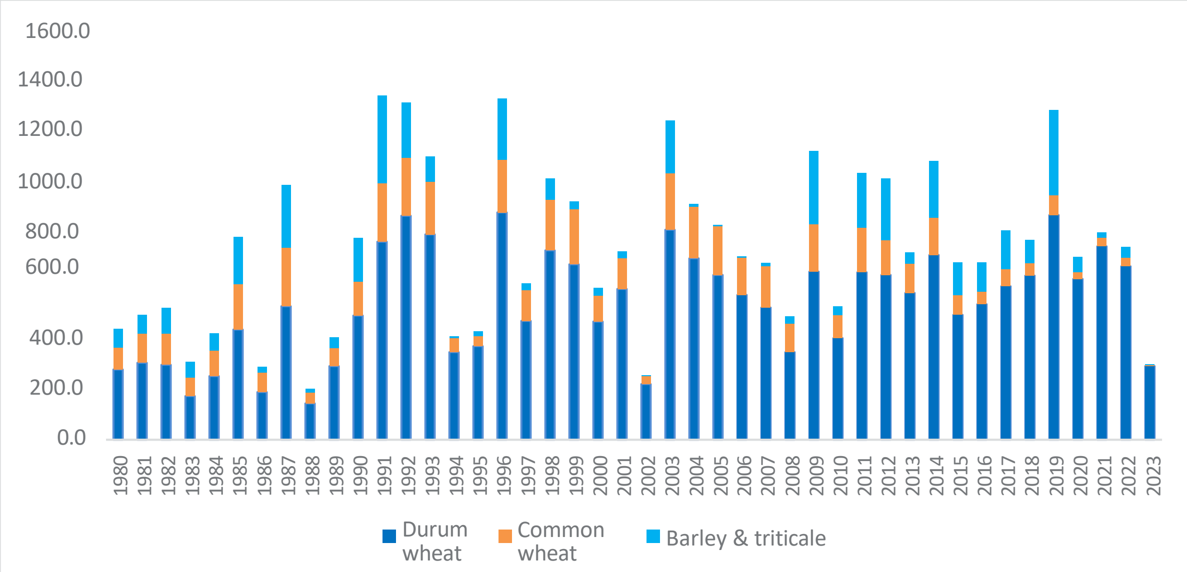
1. The Cereals Office (OC), which was responsible for all grain collection until 1990, has withdrawn almost entirely from grain collection, following a refocusing of its activities (imports, sales, storage, distribution, quality and arbitration) in favor of the private sector. Its activities are limited to hard-to-reach areas, and by 2022 its share of total quantities collected was only around 1.4%.

2. There are five Mutual agricultural service companies (SMSA), formerly known as Agricultural Cooperatives *[23]*. These SMSAs were able to contribute 40.1% of the national collection (including 6.4% of pedigree seed) in 2022. The first two SMSAs account for almost a third of national collections.

3. Private collectors who act as agents for the Cereals Office, which retains its role in both storing and selling the quantities of cereals collected. Fourteen private collectors – including three specializing in improved seeds – accounted for almost 58.5% of the total quantities collected in 2022.

[22] *One cooperative has had no collection activity since 2014.*

Figure 9. Growth in cereal crops in Tunisia (thousand tons)



Source: Authors, based on MARHP data.

Following the liberalization of the marketing of locally produced barley on the national market and the liberalization of its producer price in 1993, the Cereals Office only has a monopoly on marketing and storage on the local market for durum wheat and common wheat.

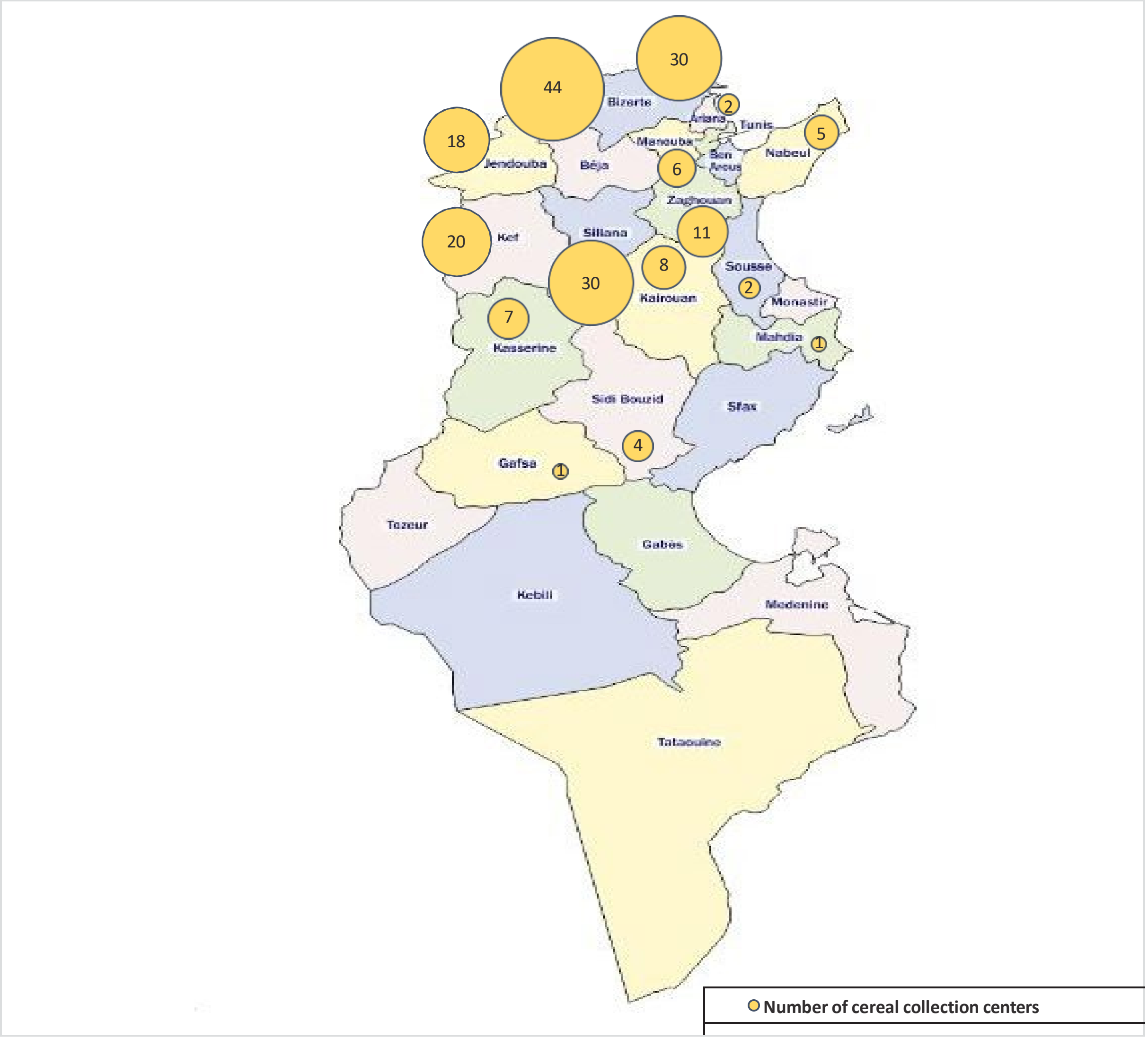
With the exception of barley, all wheat producers are required to sell their production to collecting and storage bodies, which buy the grain from farmers on behalf of the Cereals Office at a price set by government decree. This same decree sets producer prices for common wheat and durum wheat and an intervention price for the purchase of barley (and triticale) delivered voluntarily by producers to the collecting and storage organizations. This decree, which organizes the cereals season, also lays down all the procedures for payment, storage and the onward sale of cereals (i.e. their return to the market).

The local cereals gathered by the collecting and storage bodies are delivered either directly to the customers of the Cereals Office (flour mills, semolina mills, animal feed factories, barley resellers) or to the storage silos (the Cereals Office's storage silos) in accordance with the arrangements made by the Cereals Office and depending on requirements and how full the silos are.

Finally, it is worth noting that the storage capacity managed by the Cereals Office consists mainly of port silos and storage silos located in consumption areas. Overall, the Cereals Office operates a storage capacity estimated at 627 thousand tons, broken down as follows:

- 277 thousand tons owned by the Cereals Office. With 3 port silos with a capacity of 90 thousand tons divided equally between the ports of Bizerte, Radès and Gabès (i.e. 30 thousand tons for each silo) and 9 storage silos with a capacity of 187 thousand tons.
- 4 back-up silos with a capacity of 141 thousand tons for the mutual companies.
- 10 back-up silos for private operators (flour and semolina mills) with a capacity of 209,000 tons.

Figure 10. Geographical distribution of cereal collection centers in Tunisia (2023)



Source: Information by the Author based on Cereals Office and DGPA data.

2.4 Cereal primary processing units: the flour-milling plant

Milling is the most important part of the cereals industry in Tunisia. It covers two main activities: flour milling and semolina milling. The millers process the wheat and market its by-products.

In Tunisia, 21 flour and semolina mills, out of a total of 28, are operational to meet national market demand for flour and semolina, while 7 others are currently closed. Installed grain milling capacity is estimated at 3.3 million tons a year, compared with 1.8 million tons a year in the early 1990s. The sector employs around 2,500 people, with a low management ratio of 10% (APII, 2018).

This private sector industrial fabric is made up of (by type of processing): i) 2 semolina mills processing durum wheat only, ii) 7 flour mills processing common wheat only and iii) 19 mixed production units (flour mills). By 2022, these units were able to crush almost 2.4 million tons of durum and common wheat, representing an operating rate of around 72% of production capacity.

The geographical distribution shows a certain concentration in the Greater Tunis, Sousse and Sfax regions. The breakdown is as follows:

- 10 units in the Greater Tunis region (Tunis, Manouba), including 4 closed;
- 5 mills in the north (Nabeul, Béja, Jendouba and two closed mills in Kef and Jendouba);
- 6 flour mills in the Centre (in the Sousse region, 1 in Kasserine, and one closed mill in Kairouan);
- 3 units in the Sfax region;
- 3 units in the Gabès region and
- A flour mill in Gafsa.

In terms of the type of processing, a distinction is made between:

- 7 units, mills that process common wheat only.
- 2 units, semolina mills processing durum wheat only, and
- 19 mixed production units (flour mills and semolina mills).

2.5 Secondary cereal processing

2.5.1 Bakeries

In Tunisia, the activities of bakeries are regulated by strict rules governing the possession, use and marketing of subsidised flour, as well as the manufacture, display and sale of bread. In practical terms, there are two types of bread-making establishments:

1. Approved bakeries, which are authorised by the Ministry of Trade to supply bread flour (PS flour) extracted from common wheat and intended for the production of subsidised bread. There are an estimated 3,200 bakeries of this type. These are family-run, quasi-artisanal units producing bread mainly for household or similar use (local authorities, restaurants, etc.) *[24]*.
2. Non-approved establishments that produce specialty breads from products other than PS flour *[25]*.

This link in the bakery chain processes almost 903 thousand tons of flour, including 626 thousand tons of PS flour and 277 thousand tons of PS-7 flour (average for the period 2020-2022).

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24 *Under Tunisian regulations, these bakeries are entitled to a bread-making premium to cover the cost of the inputs used to make bread, and to ensure a profit margin for the bakers.*

25 *These establishments mainly use PS-7 flour to make speciality breads and pastries. A small number of industrial companies offer more elaborate products, such as industrial breads for catering, packaged sliced breads, toasted breads and semi-baked breads.*

2.5.2 Pasta and couscous factories

These six factories, which are integrated with flour-milling plants, have produced almost 302,000 tons of pasta and couscous for the local market (average for 2020-2022), using semolina subsidised by the State and extracted from durum wheat *[26]*.

Thanks to the investments they have made and the processing capacity they have installed, these units have performed well on the export market in recent years, taking advantage of the inward processing regime which allows these industrialists to import cereals directly for the production of pasta and couscous (compensating products) intended exclusively for export, while the Cereals Office retains the monopoly on imports of wheat intended for consumption on the Tunisian market. These exports are largely intended for the African market, and were boosted by the need to stockpile pasta during the value chainID-19 pandemic. Tunisia's exports of pasta products (HS code 190219) increased by 17.5% in 2020 in terms of tonnage to 86.7 thousand tons, with revenues also increasing by 27.2% (or USD 48 million in 2020).

Exports of couscous (HS code 190240) also increased by 82.1% in volume (32 thousand tons in 2020) and 107.2% in value (USD 19.6 million in 2020). The increase in export demand in 2022 was driven by the increasing demand from the Libyan market, which absorbed 13.4 thousand tons of Tunisian couscous shipments (compared with just 2 thousand tons in 2019).

2.5.3 Industrial biscuit and pastry manufacturing units

Tunisia has 13 industrial biscuit-making factories (dry biscuits, hard biscuits, filled and coated biscuits, liquid biscuits, soft egg biscuits) with a production capacity of 87,000 tons, and 11 industrial pastry-making factories (cakes, etc.) with an annual production capacity of around 10,000 tons. The value of biscuit production was around 210 million dinars, and the number of jobs created by this sector is estimated at 2,730 in 2016. (APII, 2018).

2.5.4 Production units for infant cereals

The country has two infant cereal manufacturing facilities, and this new activity is increasingly developing, competing with certain multinationals present on the national market *[27]*.

2.5.5 Livestock feed units

There are 182 Livestock Feeding Units (LFU) located mainly in the northern and Sahel governorates, with an average production of 1.9 million tons per year. These plants mainly manufacture concentrated feed to meet the nutritional needs of the livestock sector, with a production value of around 1163 million dinars in 2016 *[28]*. Poultry feed accounts for about 55% of total production, while concentrated ruminant feed accounts for 45% (INGC, 2017).

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[26] *Most of these companies have invested heavily in modernisation and expansion through industrial upgrading programs. They provide around 1,000 permanent jobs and the value of pasta and couscous production was around TND 397 million in 2016 (APII, 2018).*

[27] *According to APII (2018), certain imported cereal products used as inputs have relatively high customs duties and value added tax because these products are considered by the central government to be luxury goods.*

[28] *The number of people employed in the compound feed industry is estimated at 2,815 (APII, 2018).*

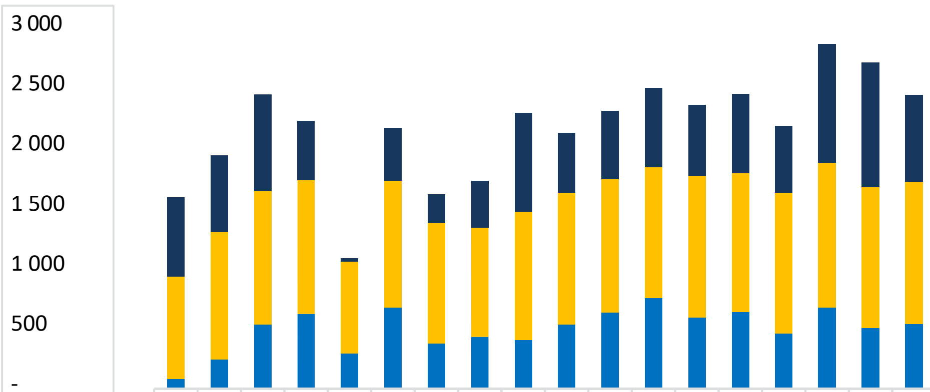
2.6 Imports by the Cereals Office for national consumption requirements

Since 2005, cereal imports have risen steadily in both value and volume to meet production demand that cannot be met by domestic production. However, imports follow the trend in production, which varies greatly from one year to the next due to erratic rainfall.

To meet the needs of its domestic market, the Cereals Office imports almost 2.457 million tons of cereals annually (average for the period 2018-2022), including 22% durum wheat (0.546 million tons/year), 47% common wheat (1.143 million tons/year) and 31% feed barley (0.768 million tons/year) *[29]*.

This import expenditure, carried out by the Cereals Office, totalled almost 6% of total State budget expenditure (excluding debt servicing) and 40% of total public expenditure allocated to the entire cereals sector with a view to ensuring the country's food security (Figure 11).

Figure 11. Cereals Office import volumes by type of grain



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Barley Import volume (thousand tons)	636	617	782	479	26	424	233	380	797	483	551	636	571	641	538	955	1 005	717
Common wheat Import volume (thousand	832	1 030	1 077	1 079	742	1 025	970	882	1 042	1 062	1 078	1 063	1 141	1 120	1 137	1 174	1 137	1 149
Durum wheat Import volume (thousand tons)	76	236	516	605	284	654	367	417	390	518	616	729	576	617	444	654	490	522

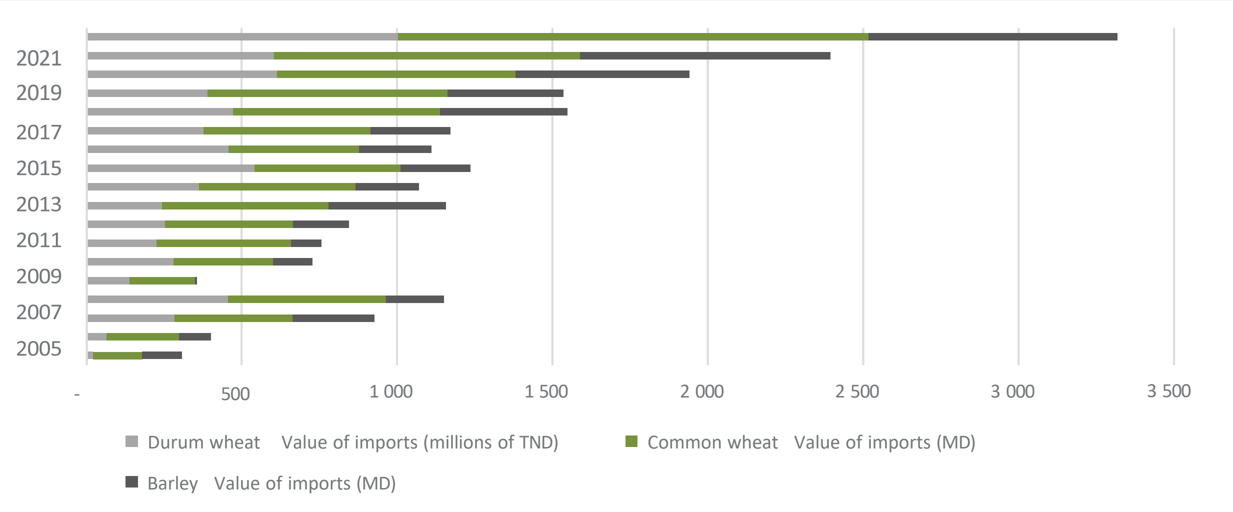
Source: Authors, based on MARHP data.

Tunisia's heavy reliance on the world market and the rise in prices as a result of the war in Ukraine have led to an explosion in the cost of cereal imports, which reached its highest level ever in 2022 (Figure 12), i.e. 3,318 million dinars (USD 1 billion): TND 1,003 million (USD 319 million) for durum wheat; TND 1,514 million (USD 483 million) for common wheat and TND 801 million for barley *[30]*).

[29] These figures only cover Cereals Office imports destined exclusively for the domestic market.

[30] Although the Cereals Office's international purchases are made through calls for tender, it should be noted that the proportion of imports originating in Ukraine and Russia has exceeded 50% since 2016, rising to almost 60% by 2021 (66% of barley imports, mainly for animal feed, come from these two countries). Compared with other countries in the Middle East and North Africa region, Tunisia is one of the countries most dependent on wheat imports from these two countries, behind Lebanon and Egypt, whose dependency rates on wheat imports from Ukraine and Russia are estimated at 88% and 78% respectively. For a comparison with other countries, see Couturier and Doublet (2022), Le blé : Limiter la dépendance aux importations. SOLAGRO – April 2022.

Figure 12. Cereals Office import values by type of grain



Source: Authors, based on MARHP data.

The latest National survey of household budgets, consumption and living standards (EBCNV) for 2021 shows that cereal products (bread, pasta, couscous, etc.) account for 11.9% of Tunisian household food expenditure (compared with 13.3% in 2015, according to the National Institute of Statistics) *[31]*. The Tunisian population is still strongly oriented towards the consumption of cereal products, with a national average estimated by the NIS at 174.3 kg/capita/year (although the quantities consumed have been falling since 1985). These products are still the mainstay of the Tunisian diet, providing an average of 49.2% of calories and 50.9% of protein. It should be noted that durum wheat and common wheat account for the bulk of this cereal demand, with 148.7 kg/capita/year, or 85% of cereals consumed in 2015 *[32]*.

To meet national demand, the Cereals Office has delivered approximately 1.335 million tons of durum wheat and 1.044 million tons of common wheat per year (average 2018-2022) to the primary processing industry for the production of subsidised cereal products to meet local market needs (Figure 13) *[33]*.

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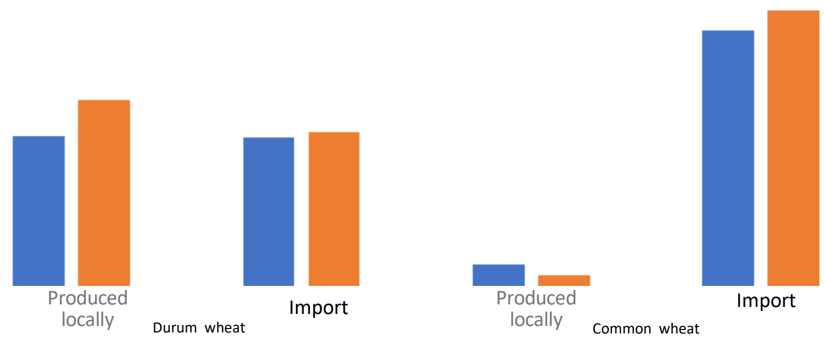
[31]*According to the NIS, the structure of average expenditure per person has seen an increase in the relative share of expenditure on food products in total expenditure, from 28.9% in 2015 to 30.1% in 2021. Food is the largest item of household expenditure in Tunisia, ahead of housing (23.9%) and clothing (11.6%). NIS figures show that for the 10% of the population with the lowest incomes, this proportion of the budget used for food rises to 35.6%.*

[32]*In addition, as a result of changing eating habits (in particular the increased consumption of flour for baking and pastry-making), durum wheat consumption has fallen sharply in favour of imported common wheat, which rose from 72.2 kg/capita to 83.6 kg/capita between 1985 and 2015.*

[33]*All these cereals are sold at reduced prices to the industrial sector, whose prices are approved by the State. This universal compensation system, paid for by the General Compensation Fund (CGC), finances industrial processing and "resale at a loss" in order to keep consumer food prices artificially low. Budgetary expenditure on subsidies for cereal products and their derivatives (flour, bread, semolina, pasta and couscous) peaked at almost 3111 million TND in 2022 (i.e. 7% of public expenditure) and has increased fivefold since 2010 due to the rise in prices on the international market and the sharp depreciation of the Tunisian dinar.*

In terms of products, the increase in subsidy expenditure on basic products is mainly due to the explosion in expenditure on cereals and vegetable oils. The CGC's commodity subsidies absorbed almost 54% of government compensation expenditure, equivalent to 6% of total government budget expenditure (excluding debt servicing) and more than 2% of GDP at current prices in 2021.

Figure 13. Subsidised purchase of durum wheat and common wheat on the Tunisian market (equivalent to 1,000 tons of grain)



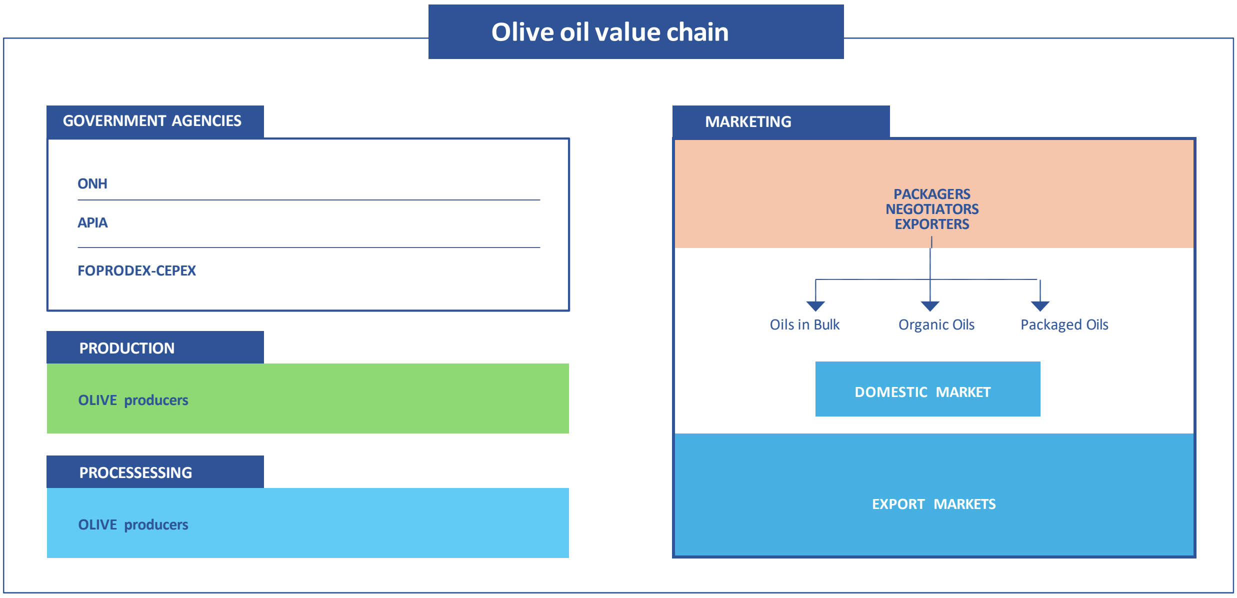
	Durum wheat – Produced locally	Durum wheat – Import	Common wheat – Produced locally	Common wheat – Import
Average 2013-2017	568	566	85	964
Average 2018-2022	704	631	46	1 039

Source: Authors, based on MARHP data.

3 Overview of the olive oil value chain in Tunisia

The olive oil value chain in Tunisia represents a crucial economic sector for the country, both in terms of agricultural production and exports.

Figure 14. Overview of the olive oil value chain in Tunisia



3.1 Olive oil production

Like cereals, olive production is one of Tunisia's main agricultural activities. With around 82 million olive trees, the country's olive groves cover 41% of the cultivated area, accounting for almost 70% of all the land planted with trees. In 2017, this corresponds to around 1.668 million hectares of olive groves out of a total of 2.3857 million hectares devoted to arboriculture (Figure 15) *[34].*

Around 309,000 people are involved in oil olive production in Tunisia, representing 60% of all workers in the agricultural sector. It is worth noting that the olive harvest continues to be heavily dominated by women, who account for almost 90% of the harvesting workforce (EU, 2021) *[35]*.

Rainfed farming accounts for 95% of cultivation. Central Tunisia and its governorates account for 65% of this surface area, while the South accounts for 18%.

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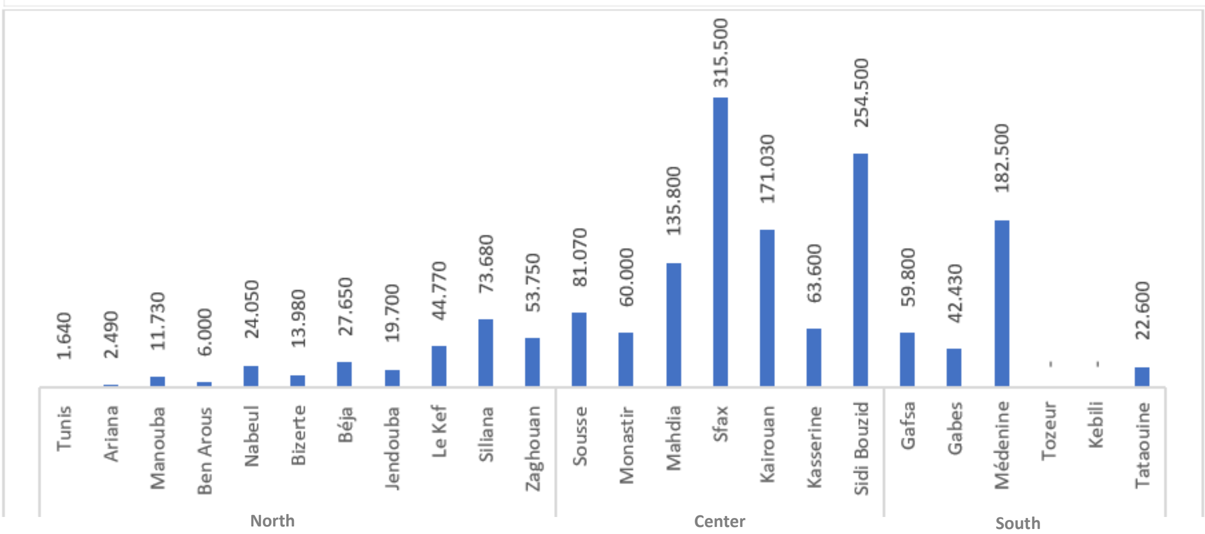
[34] *olive areas are expanding rapidly. According to available data, the area has increased from 1.371 million hectares in 2000 to 1.668 million hectares in 2017, an increase of 22%.*

[35] *For more information on gender and social inclusion issues, please see section 4 entitled "Cross-cutting issues: gender and social inclusion."*

Figure 15. Distribution of oil olive plantations in Tunisia by region and governorate (1000 ha)

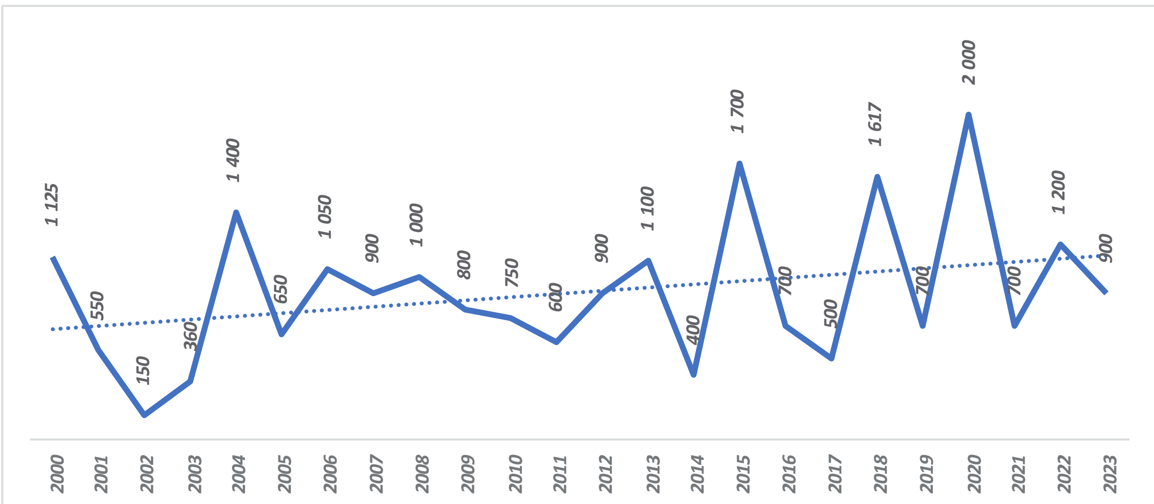


N.B. These figures are for 2017.
Source: Authors, based on MARHP data.

Oil olive production is on an upward trend, but is still characterized by strong annual variations, as the crop is mainly grown in dry conditions and is therefore dependent on rainfall (Figure 16) *[36]*.

Over the last five years (2019-2023), average olive production in Tunisia has been around 1,100 thousand tons, with a production record in 2020 of 2,000 thousand tons due to favourable weather conditions. In comparison, the annual average for the period 2014-2018 was 983,000 tons.

Figure 16. Evolution of oil olive production in Tunisia (1000 tons)



Source: Authors, based on MARHP data.

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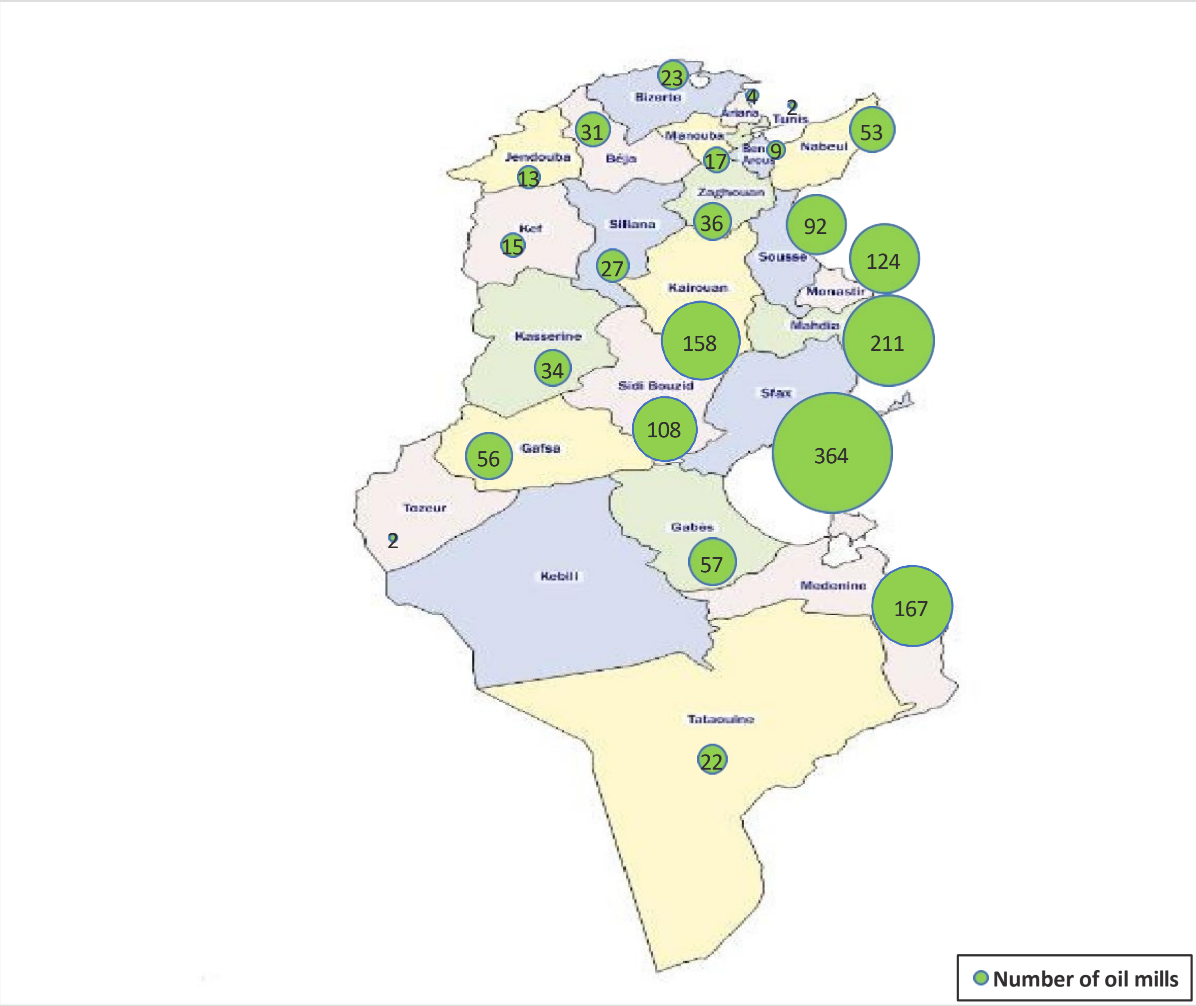
[36] *Two main cultivars are present in Tunisia. The Chemlali cultivar accounts for 80% of national production and is grown in central and southern regions with low rainfall. The Chétoui cultivar is widespread in the north and accounts for around 20% of production (Jacksonet al., 2015). Other cultivars are present in Tunisia (Ouslati, Gerboui, Zalmati, Zarazi, Barouni Chamchali and Gafsa).*

3.2 Olive processing

In Tunisia, a total of 1,625 oil mills crush olives. Figure 17 shows the geographical distribution of these facilities by governorate, based on data from the General Directorate of Agricultural Production (DGPA) for the 2023/2024 crop year.

Oil millers process olives from their own production or those delivered to them by collectors. The duration of the crushing season varies from 30 to 40 days during periods of low production to 90 to 120 days during periods of higher production *[37]*.

Figure 17. Geographical distribution of oil mills in Tunisia during the 2023/2024 season



Source: Authors, based on DGPA data (2024).

Olive oil production reflects the production of oil olives and the average extraction rate in Tunisia is around 20% (Figure 18). The theoretical capacity for crushing olives to produce oil has increased significantly.

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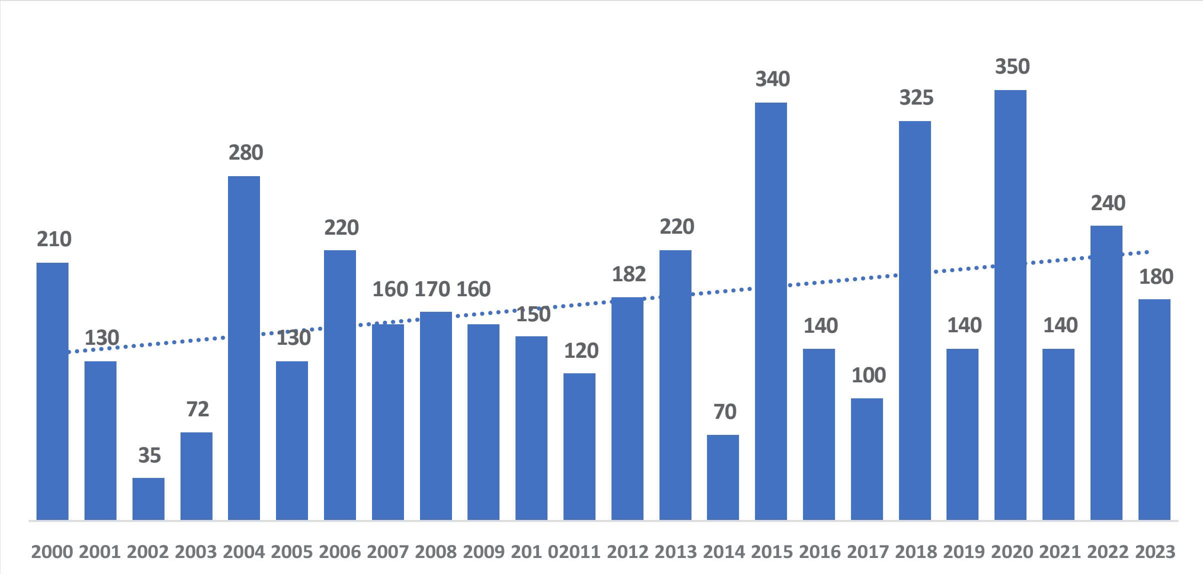
[37] *A detailed overview of the olive processing sector in Tunisia can be found in Jacksonet al. (2015).*

According to the Agency for the Promotion of Industry and Innovation (APII), it has risen from around 23,000 tons per day in 1998 to 34,000 tons per day in 2018. This increase in capacity, combined with the modernisation of equipment, has reduced the waiting time for processing olives and contributed to a significant improvement in the average quality of olive oils, a crucial aspect for export (APII, 2018).

Figure 18. Evolution of olive oil production in Tunisia (1000 tons)

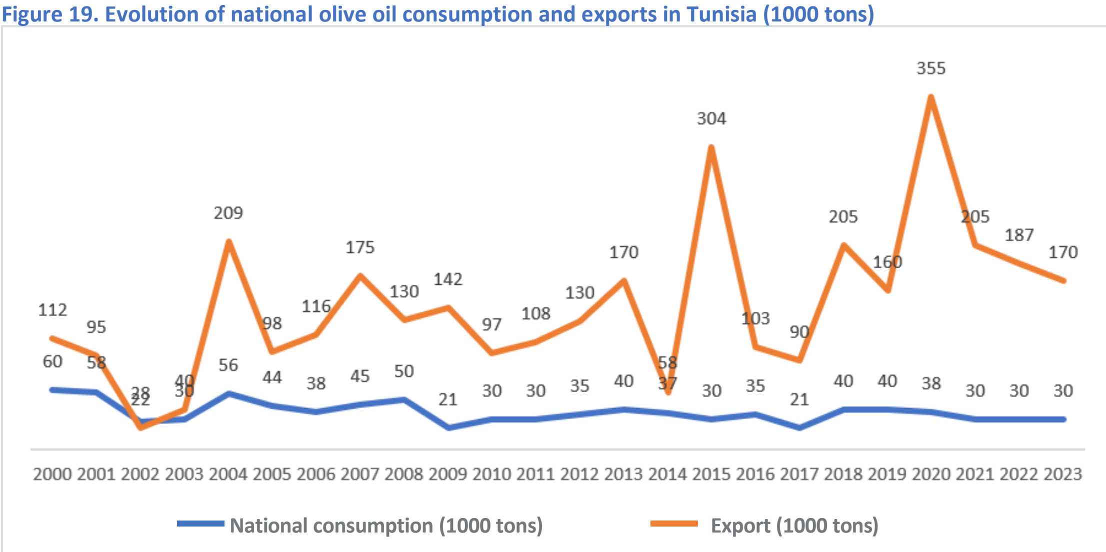


Source: Authors, based on MARHP and IOC data.

3.3 Domestic consumption and exports

Most of Tunisia's olive oil production is exported, while domestic consumption remains stable at around 30 thousand tons per year (Figure 19). The local market is dominated by self-consumption and direct purchases from oil mills or through informal channels. Per capita consumption in Tunisia has fallen to between 3.5 and 4 kg per year, mainly as a result of the higher price of olive oil compared with other vegetable oils such as sunflower and maize, and the subsidy of soya oil.

Figure 19. Evolution of national olive oil consumption and exports in Tunisia (1000 tons)

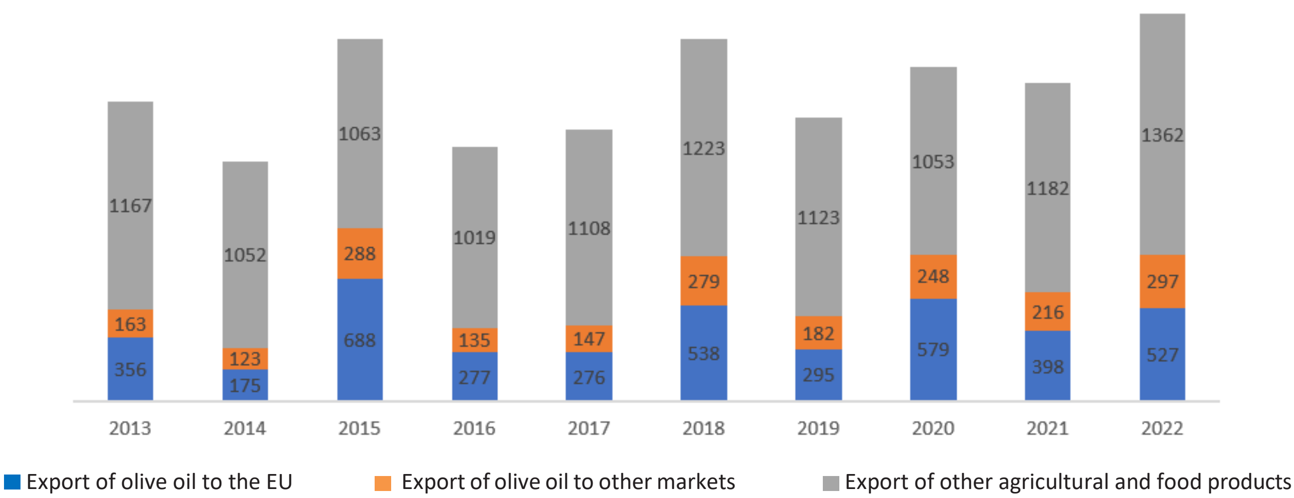


Source: Authors, based on IOC data.

Tunisia's export policy for agricultural and agri-food products is largely based on the role played by olive oil, which is by far the country's leading agricultural and agri-food export. In 2022, olive oil sales generated revenues of around USD 824 million, representing 38% of food export revenues and 3.6% of the country's total exports.

Olive oil exports to the European Union (EU) alone account for almost 24% of Tunisia's agricultural and agri-food exports (Figure 20) and remain the catalyst for the country's agricultural and agri-food export growth.

Figure 20. Weight of olive oil exports in Tunisia's agricultural and agri-food exports (Million USD)



Source: Authors, based on TRADE MAP data.

On the Tunisian olive oil export market, despite the presence of around a hundred exporters, concentration is significant: only 10% of them ship annual quantities in excess of 5,000 tons, representing 70% of exports and 69% of total export revenue. In comparison, 19% of exporters handle annual volumes between 1,000 and 5,000 tons, accounting for 25% of exports and 26% of total export revenue.

Additionally, 20% of exporters ship annual quantities of between 100 and 1,000 tons, contributing just 4% of exports and total revenue. Finally, the vast majority, 51% of exporters, ship annual quantities of less than 100 tons, contributing just 1% of exports and total revenue (IOC, 2017).

4 Cross-cutting social and gender issues

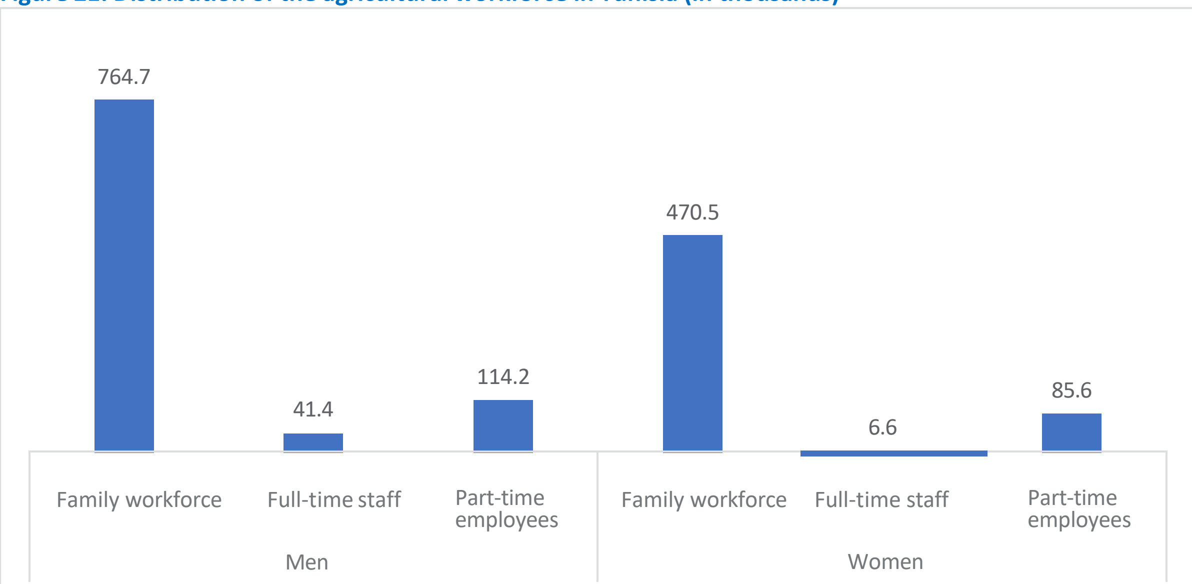
This section examines the intertwined social and gender issues that affect the agricultural sector as a whole, and therefore both the olive oil and cereal value chains. More specifically, this section focuses on the main challenges faced by women in Tunisia's agriculture sector, including difficult working conditions, limited access to social protection and wage discrimination. The section also examines women's exclusion from land ownership. It highlights the declining interest in farming among young people and the ageing of the agricultural workforce. Despite these challenges, the section underscores the emergence of female leadership in the olive oil value chain in Tunisia.

4.1 The female workforce in Tunisian agriculture and olive production: A tale of hardship and insecurity

Statistics from the 2018 Annual Crop Year Monitoring Survey show that the agricultural sector plays an important role for agricultural labor, with approximately 1.483 million workers, and that family labor plays a dominant role in the agricultural sector, accounting for up to 83% of all workers. This high proportion highlights the importance of family structures in the operation of agricultural activities in Tunisia (Figure 21).

However, while on average women account for 38% of the family agricultural workforce, the number of women who are full-time agricultural employees remains limited, representing only 14% of full-time employees in the sector, i.e. just 6.6 thousand women out of a total of 48 thousand full-time employees in 2018.

Figure 21. Distribution of the agricultural workforce in Tunisia (in thousands)



Source: Authors, based on data from the Annual Agricultural Season Monitoring Survey (2018).

Rural women are a predominantly temporary and seasonal source of labor, accounting for 43% of part-time employees in the agricultural sector, i.e. 85.6 thousand women out of a total of 199.8 thousand temporary employees. This situation reflects the precariousness of women's employment, where female labor is a resource that is more or less available depending on the seasonal needs of agricultural activities.

Furthermore, figures from the National Institute of Statistics reveal a more precarious situation for women in the agricultural sector, since the proportion of women who have worked in this sector for less than three months is much higher than that of men *[38]*. This is true in the olive-growing sector, where women are mainly seasonal or temporary workers.

In fact, almost 63.6% of jobs offered in the agricultural sector for less than a month are filled by women. The same figures also reveal that agricultural workers have the lowest level of education of all sectors, with an illiteracy rate of 28%, 42% of whom are women.

This low level of education reflects the ageing of the agricultural workforce, barriers to access to education in rural areas, particularly after primary school, and the migration of young people to other sectors *[39]*.

In addition, the political representation of women is a key factor in decision-making that takes account of their specific needs in the light of agricultural risks. Although this representation has increased in recent years, it is still insufficient to give them significant and lasting decision-making power. In 2019, women represented only 26.2% of elected members of parliament and 38.5% of ministers and secretaries of state in 2021 (compared with only 8.1% in 2011). However, by 2023, women's representation in parliament had fallen to just 16.2%. This presence of women in political decision-making is nevertheless a crucial opportunity to make their specific issues related to agricultural risks heard, thus ensuring more inclusive and equitable decisions.

4.2. Difficult working conditions, poor access to social protection and wage discrimination against women

In the labor-intensive agricultural production sectors, where working conditions are often difficult, the recruitment of women is high in Tunisia. This preference persists despite the regulations in force, for a number of reasons. Women are often seen as a submissive and undemanding workforce, prepared to take seasonal jobs and accept lower wages than men. They often find themselves involved in unpaid tasks such as domestic and care work, absorbing considerable time and energy that could be invested in their education, training,

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[38] According to data from the 2012 National Population and Employment Survey (NIS, 2013), the distribution of workers according to the number of days worked highlights precarious employment in the agricultural sector, highlighting the predominance of seasonal jobs. Only 75.5% of the workforce employed in agriculture worked more than nine months a year, compared with 83.5% of all workers. This precariousness mainly affects women, and the situation is even more pronounced in the agri-food industries: only 21% of women employed in this sector work between 271 and 365 days a year. Appendix 14 shows the breakdown of the employed population by sector of activity according to the number of days worked.

[39] Appendix 15 provides an overview of the distribution of the employed population by sector of activity and level of education.

paid employment and well-being. According to the summary report on agriculture in Tunisia *[40]*, unpaid work by male heads of rural households accounts for 48% of the average daily time budget for productive activities, while that of their wives is much higher, at 97%. Women spend 11 times more time on unpaid care work than men *[41]*.

The average monthly pay of women living in rural areas remains systematically lower than that of men, with an average gap of 31% in favor of men compared to women, as highlighted by the ATFD study in 2014 *[42]*. This gender-based exploitation and discrimination, in which women are made to work for less or for free, represents unacceptable economic violence that must be stopped. Economic violence is one of the forms of gender-based violence (GBV) that around half of all women report having experienced in their lifetime *[43]*. Since climate change is exacerbating the prevalence of GBV *[44]*, particularly in rural areas, it seems necessary to strengthen the applicability of the 2017 law aimed at combating violence against women and girls *[45]*, as well as that of the National Gender and Climate Change Plan adopted in 2022 *[46]*.

Furthermore, according to a study carried out by the Ministry for Women, the Family and Childhood (MFFE) in 2016, 62% of women work in arduous conditions, and almost 19% of them in very arduous conditions *[47]*. In general, women are involved in the harvesting, collecting and strapping activities, which are often carried out very early in the morning, during seasons with a harsh climate (such as winter), on hilly or mountainous terrain, and often far from population centres, as is the case in olive groves, for example *[48]*.

This makes access to these areas extremely challenging, tiring and risky. Women working in the agricultural sector are particularly exposed to accidents. In fact, between 2015 and 2023, according to the Tunisian Forum for Economic and Social Rights (FTDES, 2023) *[49]*, 796 women were injured and 55 died in road accidents on their way to work.

[40] Chebbi, Houssem Eddine (2019) Summary report on agriculture in Tunisia.

[41] *Unpaid work (in the form of family help) carried out by male rural heads of household corresponds to 48% of the average daily time budget devoted to productive activities (representing 100%). On the other hand, the amount spent by their wives is much higher, at 97% of this time budget. The imbalance is also apparent among children: on average, girls spend 89% of their daily time budget on unpaid productive activities, while boys spend just 61%.*

[42] *It should be noted that, in the absence of official statistics for the agricultural sector, the wage gap between women and men reached 0.9 times the Guaranteed Minimum Interprofessional Wage (SMIG) in Tunisian micro-enterprises in 2016, according to the NIS.*

[43] UN Women, Gender profile Tunisia, 2022, https://arabstates.unwomen.org/sites/default/files/2023-01/Rapport-PGT-2022.pdf

[44] Castañeda Camey, I., Sabater, L., Owren, C. and Boyer, A.E. (2020). Gender-based violence and environment linkages: The violence of inequality. Wen, J. (ed.). Gland, Switzerland: IUCN. 272pp.

[45] UN Women, Gender profile Tunisia, 2022 https://arabstates.unwomen.org/sites/default/files/2023-01/Rapport-PGT-

[46] http://www.femmes.gov.tn/fr/2023/01/23/la-ministre-de-la-famille-et-la-ministre-de-lenvironnement-lancent-le-processus-de-la-mise-en-oeuvre-du-plan-national-genre-et-changement-climatique-en-tunisie/

[47] *According to a study on women's work in rural areas and their access to social protection in 2016 carried out by the Ministry for Women, the Family and Childhood, in partnership with UN Women and the OHCHR, based on a sample of 1,700 rural women living in the governorates of Siliana, Nabeul, Kasserine, Mahdia and Jendouba.*

[48] *Women account for almost 90% of the olive-picking workforce (EU, 2021).*

[49] *According to a note from the Forum for Economic and Social Rights (FTDES, 2023)*

Rural women in Tunisia have little social protection, which poses a major challenge to their well-being and financial security. In fact, only 12% of women working in agriculture are affiliated to the social security system, whereas this rate is 72% in the industry sector, 32% in the craft sector and 30% in the trade and services sector (MFFE, 2016). The low rate of affiliation for women in agriculture is partly explained by the short periods of activity they devote to it, which rarely reach the average of 45 days required to be affiliated to a social security scheme *[50]*.

This lack of affiliation leads to limited access to social safety nets such as health insurance, pensions and family benefits for farm women, whose status is often informal and precarious. This vulnerability is exacerbated by the lack of recognition of their contribution to the agricultural sector and the obstacles they face in accessing social services.

4.3 Exclusion of women from land ownership

Land ownership in Tunisia remains heavily skewed in favour of men, with only 5% of all landowners being women. The issue of inheritance, the equitable distribution of wealth and women's right to own and benefit from land is widely considered to be one of the main vectors of discrimination against women in the country. According to the results of the ATFD study (2014), more than half (52%) of the women surveyed said they had given up their share of the inheritance to the men in their family in exchange for symbolic compensation.

This exclusion from land ownership, especially in rural areas, maintains the disparities between men and women in terms of property ownership and economic power. It limits rural and agricultural women's access to resources and opportunities in the agricultural sector, often trapping them in economic dependency and exacerbating their exposure to and impact of risks. In the event of shocks, particularly climatic ones, women are particularly vulnerable due to their lack of access to land ownership. They may find it impossible to obtain insurance cover if they do not own the land, even if they are responsible for its day-to-day management. This situation also perpetuates discriminatory social norms and limits women's participation in decision-making.

In addition, the fact that only 3% of women run agricultural projects (Chebbi, 2019) underscores the persistent barriers to women's access to resources (finance, agricultural inputs, ...) and economic opportunities in the agricultural sector.

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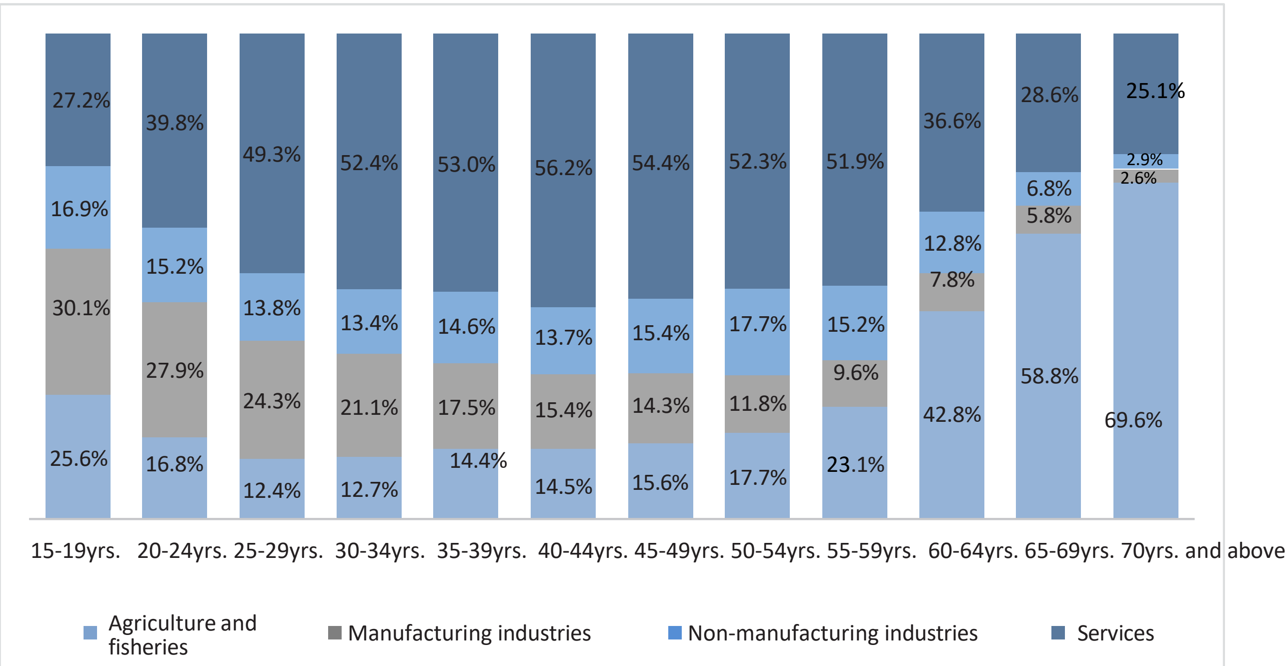
[50] *The number of women in rural areas working in the agricultural sector and benefiting from coverage will not exceed 93,500, while the number of men will be close to 377,000 in 2020 (European Union, 2021).*

4.4 Declining attractiveness of farming to young people and ageing agricultural workforce

The demographic distribution of the working population by age bracket reveals two striking trends. Firstly, the number of young people under the age of 30 entering the agricultural sector gradually decreases with age, suggesting a production disinterest in this profession. Although the agricultural sector employs an average of 19.8% of the working population under the age of 30, this figure falls from 26% in the 15-19 age group to 16.8% in the 20-24 age group, and 12% in the 25-29 age group. Secondly, the high proportion of workers aged over 60 in agriculture reflects the ageing of this workforce compared with other economic sectors (Figure 22) *[51]*.

The lack of interest by young people in agriculture and the ageing of the agricultural workforce are clear signs of a significant migration of young men aged between 18 and 35 from rural areas to urban areas and abroad. This trend has led to an ageing population, a predominance of women and a shortage of young, skilled farm labor *[52]*.

Figure 22. Breakdown of workforce by sector of activity and age bracket (%)



Source: Compiled from the 2012 National Population and Employment Survey (NIS, 2013).

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[51] *Appendix 16 shows the demographic breakdown of agricultural workers by age group according to data from the 2012 National Population and Employment Survey.*

[52] *Buccotti et al. (2018) consider that the decline in agricultural productivity and income from farming activities and the increasing fragmentation of agricultural land are the main factors explaining the rural exodus and emigration of young people who left after 2011 (in the three governorates of Siliana, Jendouba and Médenine).*

4.5 The rise of female leadership in the olive oil value chain in Tunisia

Although rural and agricultural women remain traditionally marginalised in many contexts, Tunisia is nevertheless witnessing a significant development in women's leadership, particularly in the olive oil value chain. This development is significant because it reveals the economic opportunities for women in agriculture, illustrating their ability to revitalise and boost this sector *[53]*.

A number of stories and analyses highlight the production involvement of women in all aspects of olive oil production. Initiatives such as those of the women leaders in Sidi Bou Said bear witness to the emergence of influential women in this sector. These women, regarded as pioneers and role models, are coming together to share their experiences, discuss challenges and opportunities, and develop strategies to enable women thrive in the olive oil industry. These women play an increasingly vital role in all stages of olive oil production, from production the olive trees to marketing the finished products. They now hold key positions in cooperatives, processing and marketing companies, as well as in agricultural development initiatives.

These women leaders not only play an active role in olive oil production, they also help to boost the rural economy and strengthen women's economic empowerment. Their production involvement in this strategic sector bears witness to the growth of female entrepreneurship in Tunisia and the progress towards gender equality in the agricultural sector.

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[53] Several stories highlight the changing role of women in Tunisia's olive oil industry, as reported by various articles on the subject: i) RFI, In Tunisia, women bring breath of fresh air to the olive sector, 2023 : https://www.rfi.fr/en/podcasts/reportage-afrique/20230126-en-tunisie-les-femmes-apportent-un-nouveau-souffle-au-secteur-de-l-olive; ii) WillAgri, Organic olive oil led by women, 2019 : https://www.willagri.com/2021/01/12/lhuile-dolive-bio-se-feminise-en-tunisie/; iii) Olive oil women leaders in Sidi Bou Said, 2023: https://universnews.tn/les-femmes-leaders-de-lhuile-dolive-a-sidi-bou-said/ and https://www.letemps.news/2023/12/03/leaders-mondiales-de-tunisie-reunit-les-femmes-oleicultrices-a-sidi-bou-said/ and iv) Olive oil in Tunisia, an industry dominated by women, 2023: https://kawa-news.com/lhuile-dolive-en-tunisie-une-industrie-dominee-par-les-femmes/lhuile-dolive-en-tunisie-une-industrie-dominee-par-les-femmes

5 Risk assessment in the cereals value chain

5.1 Risk overview

For the assessment of risks in the cereals value chain in Tunisia, a set of 26 systemic risks was determined as likely to have a significant impact on this value chain (Table 3).

Table 3. Overview of risks in the cereals value chain

Production	Climate risks	1	Drought during the agricultural season caused by rainfall that falls short of cereal requirements during the hydrological year (September-June). This climatic risk can lead to a drop in production and loss of yield caused by water stress.
		2	Spring drought (March, April and May). Cereals need the most water in spring.
		3	Drought in March, which could coincide with the start of cereal bolting.
		4	Grain scalding. This is the alteration in the filling of cereal grains, which remain small as a result of the high spring temperatures. Rising spring temperatures and heat waves are likely to have an impact on the quality and quantity of cereals.
		5	Spring heat stress: Maximum temperature during the spring season (March, April and May).
		6	Intensity of grain scalding (number of scaling days between April and June (maximum temperature > 25°C))
		7	Shortening the development cycle. The bolting date is defined as the first day after which the sum of the degree days accumulated from 15 November (set sowing date) reaches 1450 degree days. The base temperature for calculating degree-days is 0°C.
		8	Advance maturity date. The maturity date is defined as the first day after which the sum of the degree days accumulated from 15 November (fixed sowing date) reaches 2450 degree days. The base temperature for calculating degree-days is 0°C.
		9	Intense rainfall: heavy to extreme rainfall (number of days during the agricultural season when rainfall exceeds the 70mm threshold).
		10	Spring frost (number of days with spring frost). Spring frost can pose a risk to cereals when the ears are at 1 cm, although it is rarer than winter frost.
	Phytosanitary	11	Fungal diseases
	Fire hazards	12	Fires
Market, price and financial risks		13	Rising raw material prices for fertilizer production
		14	Increase in fertilizer prices
		15	Increase in seed prices
		16	Unavailability of certified seeds
		17	Unavailability of fertilizers
		18	Disruption to the collection season
		19	Increase in cereal import prices
		20	Foreign exchange risk
		21	Access to credit
		22	Financing the grain harvest
		23	Credit risk exposure
Logistics risks		24	Blockade of production sites
		25	Increase in demurrage charges
Corporate risks		26	Sustainability of regulation and compensation

Production risks mainly affect cereal producers, who are the first to be hit by falls in production and income. These risks put pressure on the Cereals Office, which is responsible for meeting the needs of the national market through imports.

As all cereals are compensated, the fall in production also leads to an increase in the compensation costs borne by the General Compensation Fund (CGC).

Ten climatic risks likely to affect cereal production in Tunisia have been identified. The selection of these climate-related risks specific to the cereals sector was based on consultation with experts in bioclimatology *[54]* and various study reports produced for the Ministry of Agriculture, Hydraulic Resources and Fisheries (MARHP) *[55]*.

To assess plant health risks, the data used relates to cereal areas affected by various fungal and treated diseases (such as Septoria leaf spot, powdery mildew, net stripe, rust, rhynchosporium in barley, tan spot, helminthosporium leaf spot, crown rust in oats and brown rust). The data provided by the DGPA for the period 2006-2023 was used in the analysis. For the fire risk assessment, the relevant data was also obtained from the General Directorate for Agricultural Research and Development (DGEDA).

As regards price and financial risks, eleven major risks likely to affect the market were identified. These market risks have an impact on virtually all actors, but to varying degrees.

As far as logistical risks are concerned, there are two main types likely to affect the cereals value chain in Tunisia. The main institutional risk concerns the sustainability of pricing policy at the various levels of the value chain because of its budgetary impact. This policy protects producers and processors from market risks, but in doing so it isolates them from market signals and therefore makes them dependent on policy.

All these identified risks were then analysed using the PARM methodology (Table 4) in terms of:

- Probability score obtained from information on the frequency of a risk;
- Average impact score, which is derived from the average loss and
- Maximum impact score which is determined from the maximum loss, applying the same rating categories as for the average impact.

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[54] To obtain monthly data, the authors extracted and processed statistics from the Prediction of Worldwide Energy Resources (POWER) database of the National Aeronautics and Space Administration (NASA). All the indicators for these climatic risks were calculated by the authors in consultation with expert researchers from Tunisia's INRGREF. Appendix 16 presents the descriptive statistics for these indicators.

[55] These include the report "TUNISIA - Contribution to the elements of the preparatory phase of the process of the National Adaptation Plan. MARHP and AFD (2022)" and the report titled "Study on risk management and the implementation of an agricultural insurance system in Tunisia". FINACTU, DGFIOP/MARHP (2018)

Table 4: Example of categories for establishing the probability score and the impact score

Probability score			Impact score		
Category	**Criteria**	**Score**	**Category**	**Criteria**	**Score**
High probability	The event is likely to occur every 3 to 7 years. [14%-33%]	**3**	**Catastrophic**	– Decrease of more than 50% in the value chain's production or revenues – Significant loss of revenue affecting 50% or more of the actors in the value chain – Significant impacts suffered by at least 90% of women or young farmers – Temporary or permanent interruption of part or all of the value chain	**5**
			Critical	– 30 to 50% reduction in value chain production or revenue – Significant loss of revenue affecting 30% or more of the actors in the value chain – Significant impact felt by at least 70% of women or young farmers – Serious disruption to the value chain	**4**
Average probability	The event is likely to occur every 7 to 15 years. [7%-14%]	**2**	**Considerable**	– 15-30% reduction in value chain production or revenue – Major revenue losses affecting 20 to 30% of value chain actors – Significant impact felt by at least 50% of women or young farmers – Short-term disruptions to the value chain	**3**
			Moderate	– 5 to 15% reduction in value chain production or revenue – Significant revenue losses affecting 10 to 20% of value chain actors – Significant impact felt by at least 30% of women young farmers. – Gaps in key indicators such as costs, demand, and logistics.	**2**
Low probability	The event is likely to occur every 15-40 years. [3%-7%]	**1**	**Negligible**	– 0 to 5% reduction in value chain production – Significant revenue losses affecting less than 10% of value chain actors. – Significant impact felt by less than 30% of women or young farmers. – Minor variations in key indicators such as costs, demand and logistics.	**1**

Source: Assessing value chain risks to design agricultural risk management strategies: A practitioner's toolkit (PARM, 2021).

Some risks do not apply to certain actors in the value chain due to a number of factors, including the specific position and role of each player and their level of involvement.

For example, farmers are mainly concerned with production-related risks, such as weather or crop disease. On the other hand, distributors or exporters may be less exposed to these specific risks, as they are mainly focused on logistics, storage or product marketing.

Similarly, certain actors in the value chain may have a different level of involvement in certain activities or processes. For example, suppliers of agricultural inputs may not be directly involved in managing the risks associated with harvesting or storing agricultural produce, as their business focuses on supplying inputs such as seeds, fertilizers or crop protection products.

In this report, only the risks that directly impact the actors at each stage of the value chain are taken into account. The term “NA” (not applicable) is used to indicate that the risk in question does not directly concern the actors in this specific stage of the value chain. The inapplicability of a risk to a group of stakeholders is determined by the literature or by interviews with the stakeholders concerned.

Where statistical data is available, the assessment of the impact of risks is based on econometric estimates. If the impact is significant, the average and maximum economic losses are quantified in monetary terms, by volume or as a percentage. If the impact of the risk is not significant, "not significantly different from zero" is indicated.

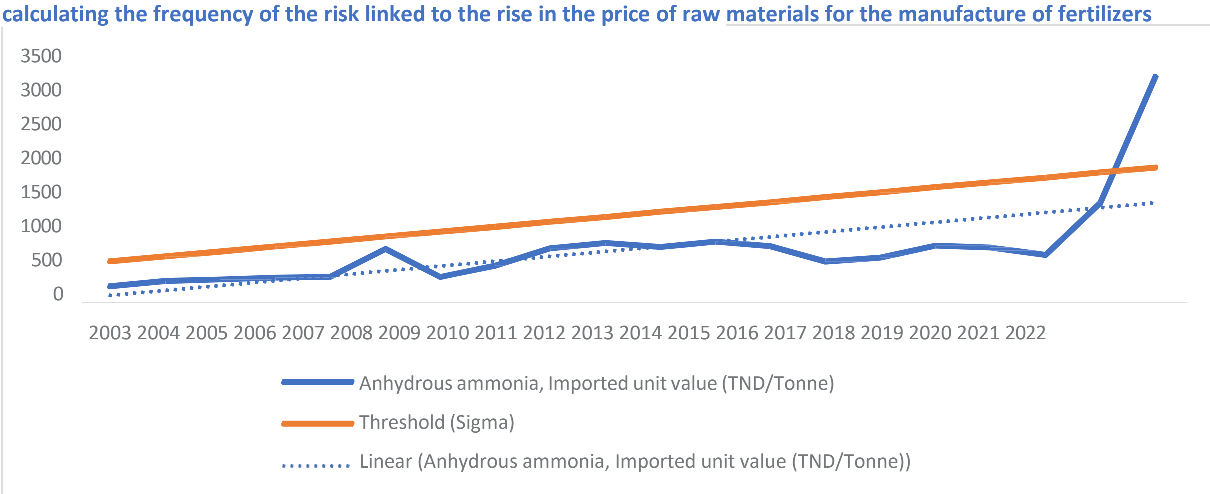
If statistical information is unavailable or insufficient, the risks are assessed qualitatively according to what the actors say. The probability and impact scores are then established on the basis of the categories and criteria defined by the PARM methodology, presented in Table 4.

5.2 Risk assessment and prioritization at input supplier level

In order to assess the risk of an increase in the price of raw materials for the production of fertilizers, data on the evolution of unit import prices of anhydrous ammonia, the basic product used in the production of ammonium nitrate, were used for the period 2003-2022. These data are extracted from the TRADE MAP database (HS code 281410).

Figure 23 plots the evolution of the unit value of Tunisian imports of anhydrous ammonia (TND/Ton) and the threshold defined by one standard deviation for calculating the frequency (orange line) of the risk linked to the rise in the price of raw materials for fertilizer manufacture.

Figure 23. Evolution of the unit value of Tunisian imports of anhydrous ammonia (HS code 281410) and threshold for calculating the frequency of the risk linked to the rise in the price of raw materials for the manufacture of fertilizers



Source: Authors, based on TRADE MAP data.

This threshold indicates that, over the period 2003-2022, a rise in prices has only been observed one year in twenty, in this case in 2022, and that the probability of risk associated with this rise in commodity prices remains low (5%). This risk, posed by the above standard deviation variation in prices in 2022, was triggered by the war in Ukraine *[56]*.

With regard to the risk of production sites being blocked, it should be noted that TCG, the main supplier of phosphate fertilizers for the national market, has been experiencing difficulties in continuing its fertilizer production for several years with the post-2011 social crisis in the mining sector. The blockades at production sites have resulted in disruptions to the supply and distribution of fertilizers for cereal production (and for the entire agricultural sector) *[57]*. Table 5 shows the risks faced by input suppliers.

[56] According to World Bank data on commodity prices (The Pink Sheet), the increase in prices in 2021, compared with 2020, was approximately 62% for rock phosphate (f.o.b. North Africa), 92% for DAP (spot, f.o.b. Gulf of the USA), 103% for TSP (spot, import Gulf of the USA) and 111% for urea (Ukraine, f.o.b. Black Sea). Only potassium chloride (f.o.b. Vancouver) recorded a slight decline of 3%.

[57] In the past, Tunisian industry was able to revalue chainer almost 85% of the country's rock phosphate production. As a result, the Tunisian Chemical Group (TCG) was able to process nearly 6.5 million tons of rock phosphate annually to produce Merchant Phosphoric Acid, Di-Ammonium Phosphate, Triple Super Phosphate and Calcium Phosphate.

Table 5: Prioritization of risk exposure for input suppliers in the cereals value chain

	Risks	Probability	Probability Score	Medium impact		Maximum impact		Risk score
				Loss	Average impact score (SIave)	*Loss*	Maximum impact score (SImax)	
13	Rising raw material prices for fertilizer production	4,8%	1	- *Loss of revenue affecting < 10% of actors*	1	- *Loss of revenue affecting < 10% of actors*	1	1,0
24	Blockade of production sites	*Qualitative*	1	- *Loss of revenue affecting < 10% of actors*	1	- *Loss of revenue affecting < 10% of actors*	1	1,0

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*SImoy) + 0.3* (SImax)*
Source: Authors' calculations.

5.3 Risk assessment and prioritization at cereal production level

Assessing the impact of climate risks

The assessment of climatic risks on cereal production and the quantification of economic losses were approached in two stages.

1. **The first stage was dedicated to assessing the impact of climatic risks on each of the cereal crops: durum wheat, common wheat, barley and triticale.**

   a. A threshold equal to one standard deviation was used to identify at-risk climatic events and an econometric estimate of the impact of the occurrence of these risks on losses in terms of production was carried out to statistically evaluate the impact of these climatic risks *[58]*.

   b. Where the impact of climate risk is statistically significant, the loss in terms of production volume for durum wheat, common wheat and barley is estimated as the difference between expected production (trend) and harvested production. Where the impact of climate risk is statistically significant, the loss in terms of production volume for durum wheat, common wheat and barley is estimated as the difference between expected production (trend) and harvested production.

   c. The frequency of each of the climatic risks, the probability scores, the impacts (average and maximum) of these risks on each cereal crop (durum wheat, common wheat and barley) and the quantification of the economic losses are presented exhaustively in Appendix 19.

2 **Second, the impacts of each climate risk on each production were aggregated**, taking into account the average contribution of each cereal to national production for the period 1982-2023, in order to determine the overall impact of each climate risk on cereal production in Tunisia.

Table 6 summarizes the climatic risks whose impact is statistically significant.

[58] *Details of the econometric estimates are presented in the appendices.*

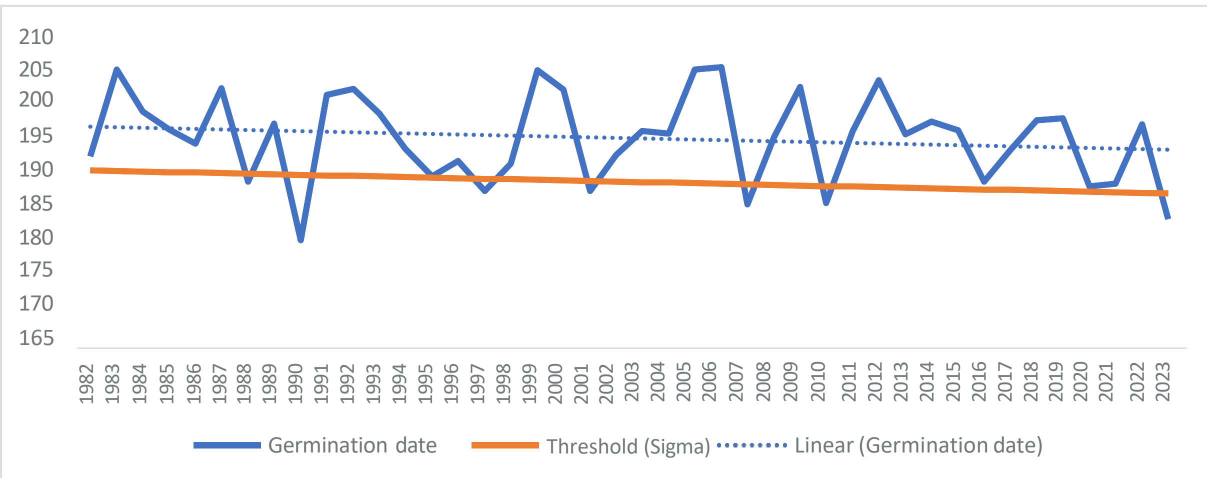
Table 6: Impact of climate risks on cereal production as a whole and quantification of economic losses

	Probability	Probability Score	Medium Impact		Maximum impact		Risk Score
			Loss	Average impact score (SIave)	*Loss*	Maximum impact score (SImax)	
Shortening the development cycle Setting date	**16.7%**	3	*-372 thousand tons -473 million TND* (152 million USD)	3	*-665 thousand tons 823 million TND (265 -MUSD)*	4	**7.5**
Agricultural season drought P_H	**16.7%**	**3**	*-344 thousand tons 393 million TND -(127 million USD)*	3	*-605 thousand tons 691 million TND -(232 million USD)*	4	**7.5**
Advance ripening date Ripening date	**14.3%**	**2**	-556 *thousand tons 679 million TND (219 -million USD)*	4	*-733 thousand tons* 900 *million TND (290 -million USD)*	4	**6.8**
Severity of scalding Nech	**9.5%**	**2**	-328 thousand *tons 459 million TND (148 -million USD)*	3	*-339 thousand tons 475 million TND (153 -million USD)*	3	**5.1**
Spring thermal stress Tmax_PriH	**19.0%**	**3**	*-74 thousand tons 67 million TND (22 -million USD)*	2	*-103 thousand tons -93 million TND (30 million USD)*	2	**4.8**
March drought P_March	**14.3%**	**2**	*-242 thousand tons 233 million TND (75 -million USD)*	2	*-284 thousand tons -272 million TND (88 million USD)*	2	**3.4**
Scalding grain T_PriH	**16.7%**	**3**	*-64 thousand tons 58 million TND (19 -million USD)*	1	*-94 thousand tons -84 million TND (27 million USD)*	2	**2.7**

N.B. Only risks with a statistically significant impact are shown in this table.
Risk score = 0.7 (Probability score*SImoy) + 0.3* (SImax)*
Source: Authors.

Taking all cereals together, the risk of shortening the cereal development cycle is the leading risk in terms of negative impact on Tunisian production for the period 1982-2023, with a risk score of 7.50. The frequency of this risk is around 16.7% (Figure 24), and when this risk occurs, it leads to an average drop in production of around 372 thousand tons for all cereals combined (a loss of around TND 473 million). The maximum loss could reach 665 thousand tons, representing a loss of around TND 823 million.

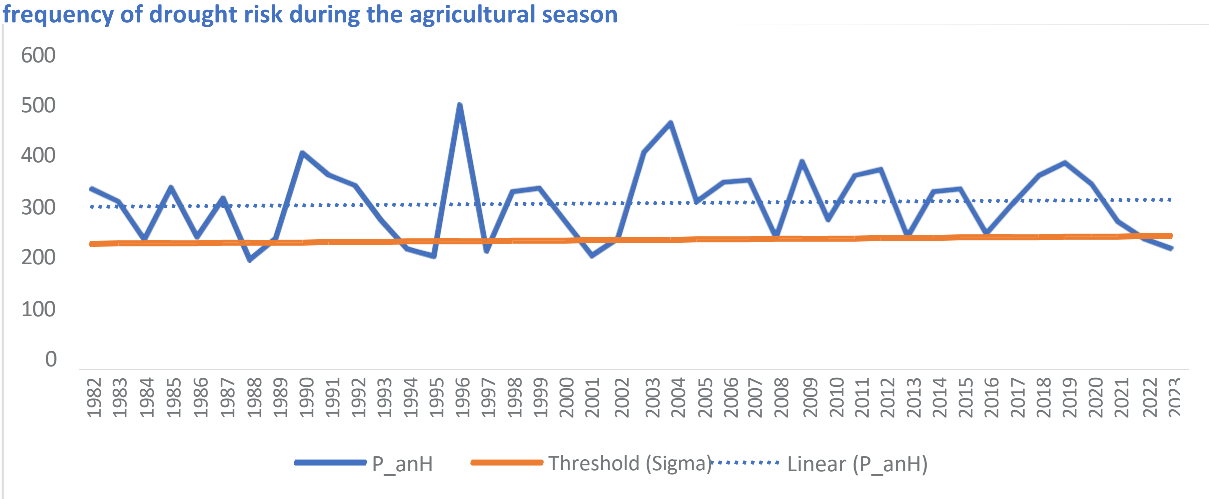
Figure 24. Changes in the shortening of the development cycle of cereals and threshold for calculating the frequency of the risk of this shortening (Harvest date)



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER) – National Aeronautics and Space Administration (NASA).

Severe to extreme agricultural drought, defined as a drop in rainfall of at least one standard deviation from its long-term trend, has a probability of occurrence of around 16.7% for the period 1982–2023 (Figure 25). This risk, which also scores 7.50 for cereals as a whole, results in an average loss of 344,000 tons of harvest when it occurs in Tunisia, at a cost of almost TND 393 million. The maximum loss caused by drought (severe to extreme) during the 2022–2023 season was 605 thousand tons, at a cost of around TND 691 million for cereal production as a whole.

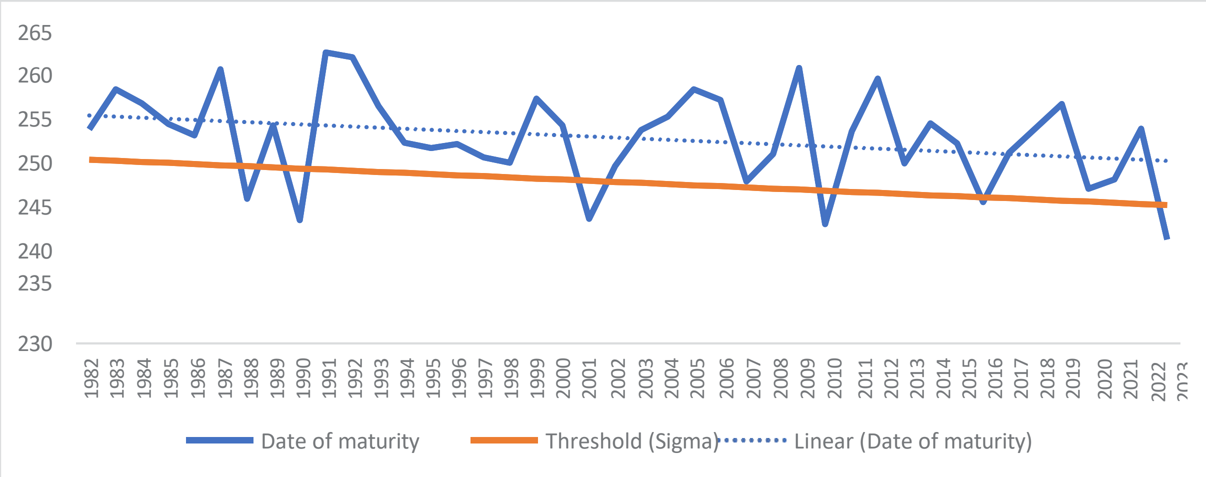
Figure 25. Changes in precipitation during the agricultural season (P_anH) and threshold for calculating the frequency of drought risk during the agricultural season



Source : Compiled and compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

For cereal production as a whole, the risk of early maturity date has a probability of occurrence (risk frequency) of around 14.3% (Figure 26) and a risk score of 6.80 for the period 1982–2023. This risk of early ripening date could result in an average production loss of around 556 thousand tons (i.e. an average loss of around 679 million dinars).

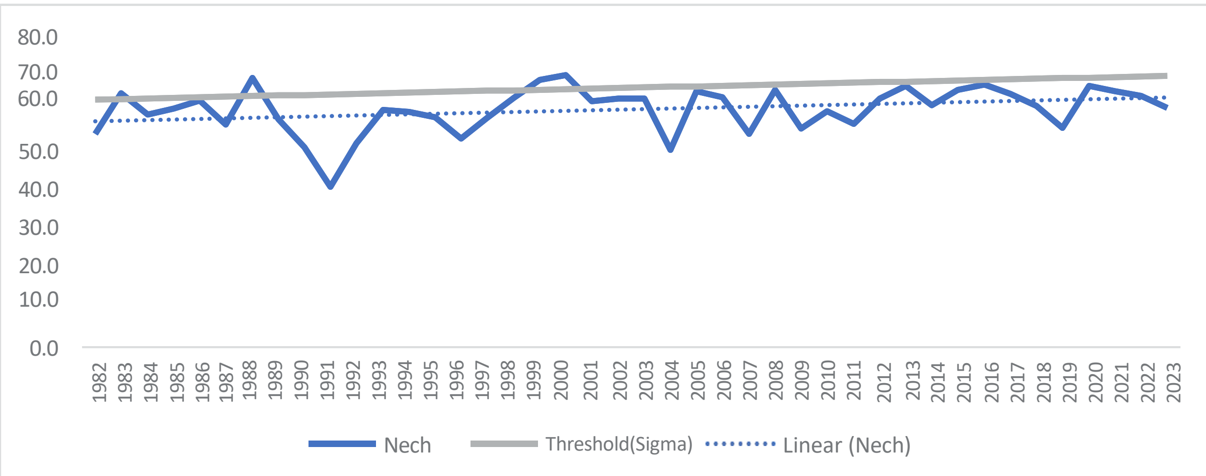
Figure 26. Changes in the early maturity of cereals and threshold for calculating the frequency of the risk of early maturation (maturity Date)



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

The risk of an increase in the severity of scalding, which is defined as a sharp increase in the number of scalding days (Nech) greater than one standard deviation, has a probability of occurrence of around 9.5% for the period 1982–2023 (Figure 27). This risk could lead to average losses of around 328,000 tons of total cereal production in Tunisia (i.e. an average loss of around TND 459 million) and a maximum loss of around 339,000 tons (i.e. a maximum loss of around TND 475 million). The risk score attributed to the increase in the severity of scalding for cereal production as a whole is 5.1.

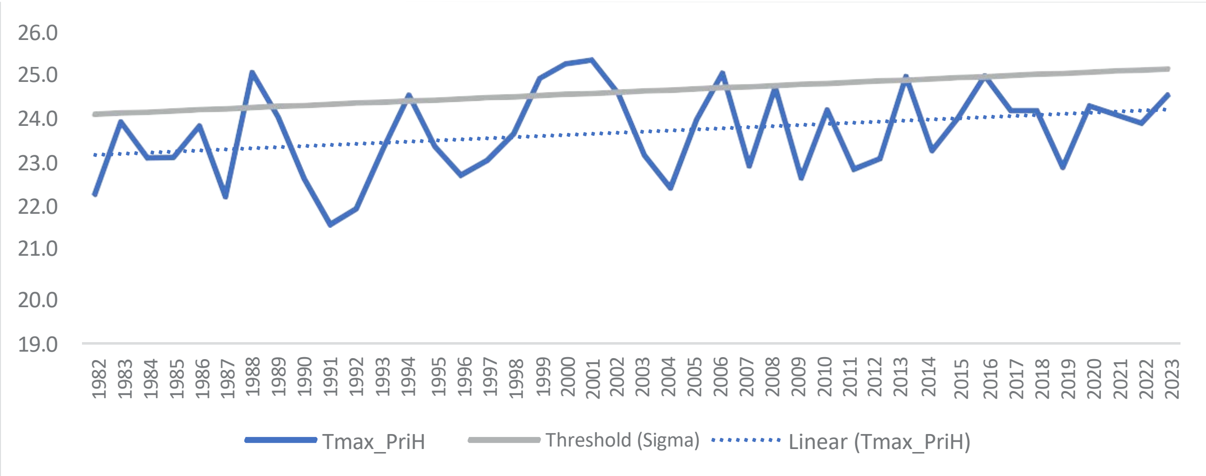
Figure 27. Trend in the number of scalding days (Nech) and threshold for calculating the frequency of the risk of an increase in the severity of grain scalding



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

Spring heat stress, defined as an increase in maximum spring temperature of more than one standard deviation from its long-term trend, has a probability of occurrence of around 19% (Figure 28). This risk, which has a score of 4.8 for all cereals, could lead to an average loss of 74 thousand tons of harvest when it occurs in Tunisia, at a cost of almost TND 67 million. The maximum loss caused by this risk could reach 103,000 tons, at a cost of around 93 million dinars for cereal production as a whole.

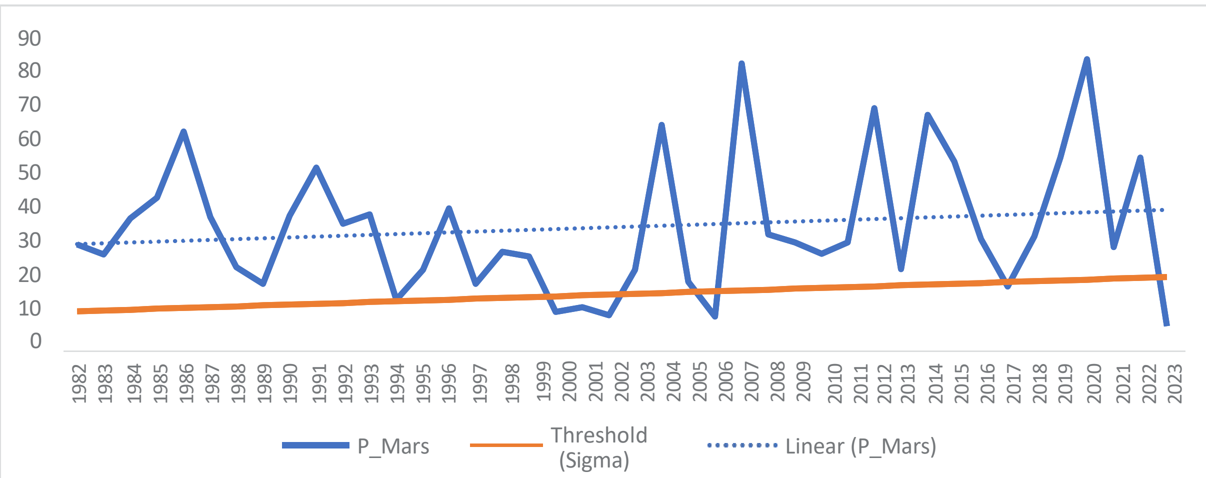
Figure 28. Changes in maximum temperature during the spring season (Tmax_PriH) and threshold for calculating the frequency of the risk of spring heat stress



Source: Compiled and compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

With regards to the severe to extreme drought during the month of March (P_Mars), this risk, the frequency of which is 14.3% (Figure 29), can lead to losses of around 242 thousand tons on average, and a maximum loss of around 284 thousand tons for cereal production as a whole.

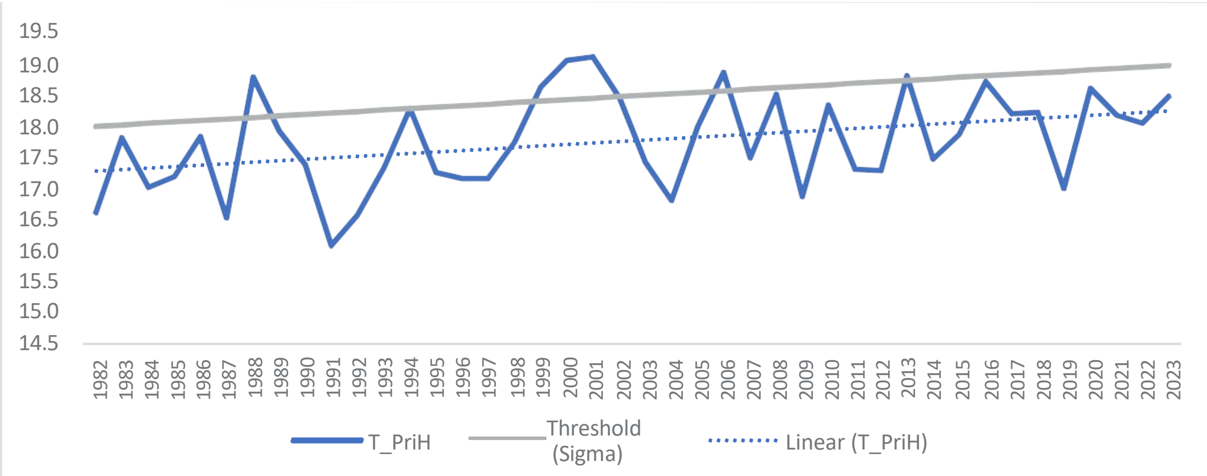
Figure 29. March rainfall pattern (P_Mars) and threshold for calculating the frequency of drought risk in March



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

The risk of thermal scalding, defined as a rise in average spring temperatures of more than one standard deviation (Figure 30), has a probability of occurrence of around 16.7%. This risk, which results in a blockage of grain filling, generates an average loss of around 64 thousand tons over the period 1982–2023 (an average loss of 58 million dinars), and could lead to a maximum loss of 94 thousand tonnes of Tunisia's cereal production (i.e. a maximum loss of 84 million dinars).

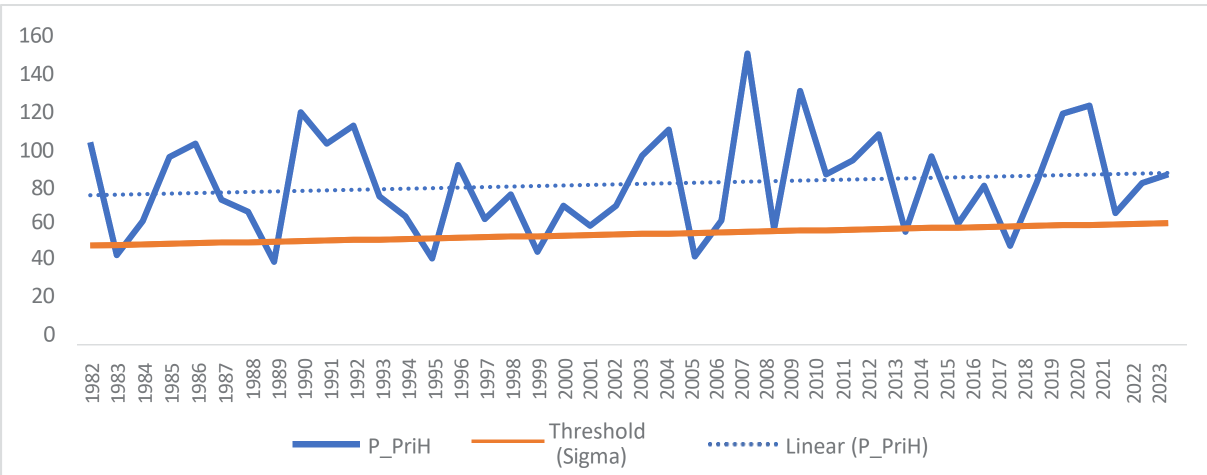
Figure 30. Changes in spring temperature (T_PriH) and threshold for calculating the frequency of grain scalding risk



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

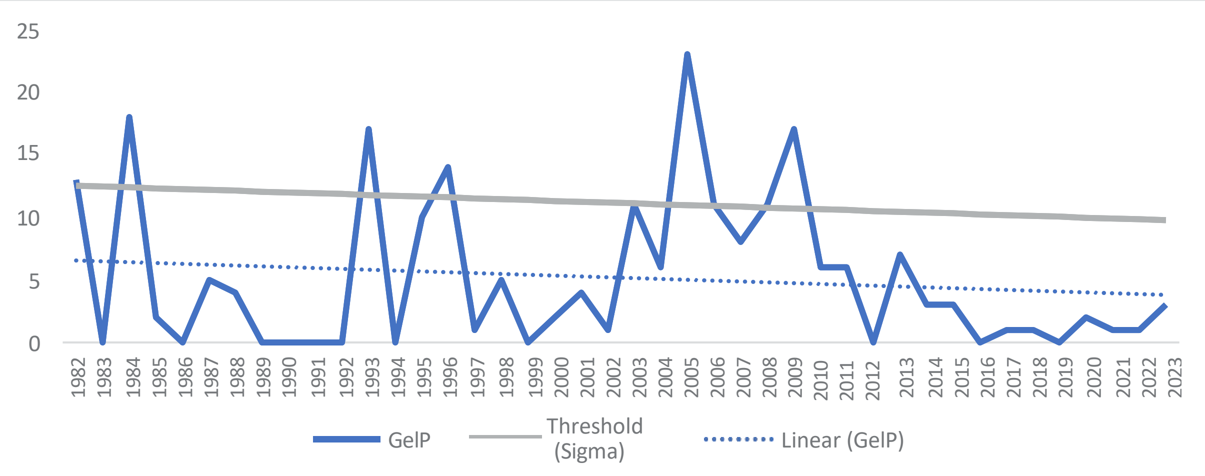
Finally, the frequencies of the risks of spring drought, spring frost and heavy rainfall are 16.7%, 19% and 9.5% respectively (Figures 31, 32 and 33). Nevertheless, but their impact on cereal production losses is not statistically significant over the period 1982–2023, according to the thresholds defined for climatic risks and production losses.

Figure 31. Spring rainfall pattern (P_PriH) and threshold for calculating the frequency of spring drought risk



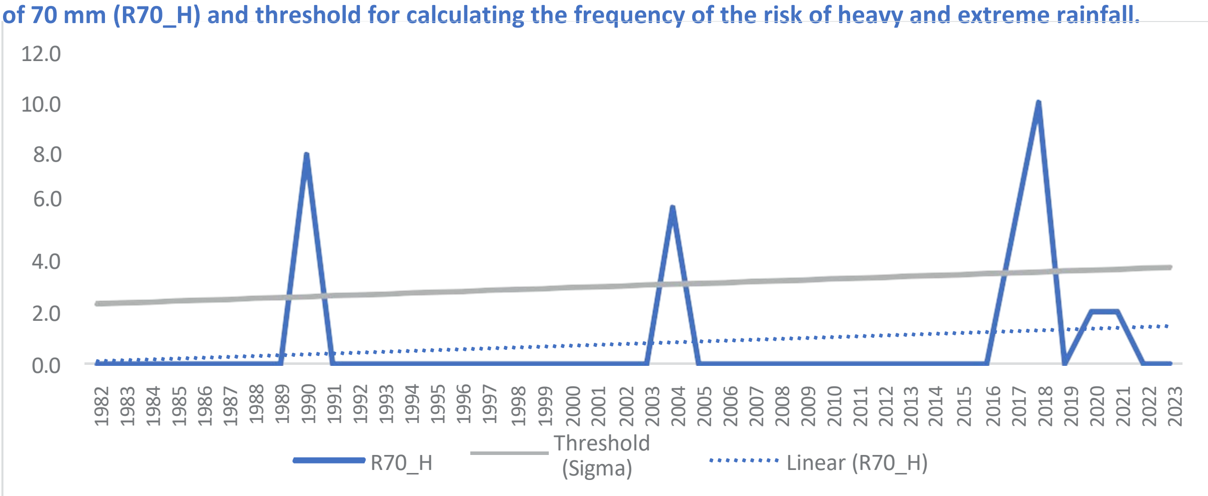
Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

Figure 32. Changes in the number of days with spring frost (GelP) and threshold for calculating the frequency of severe and extreme frost risk



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

Figure 33. Changes in the number of days during the agricultural season when rainfall exceeds a threshold of 70 mm (R70_H) and threshold for calculating the frequency of the risk of heavy and extreme rainfall.

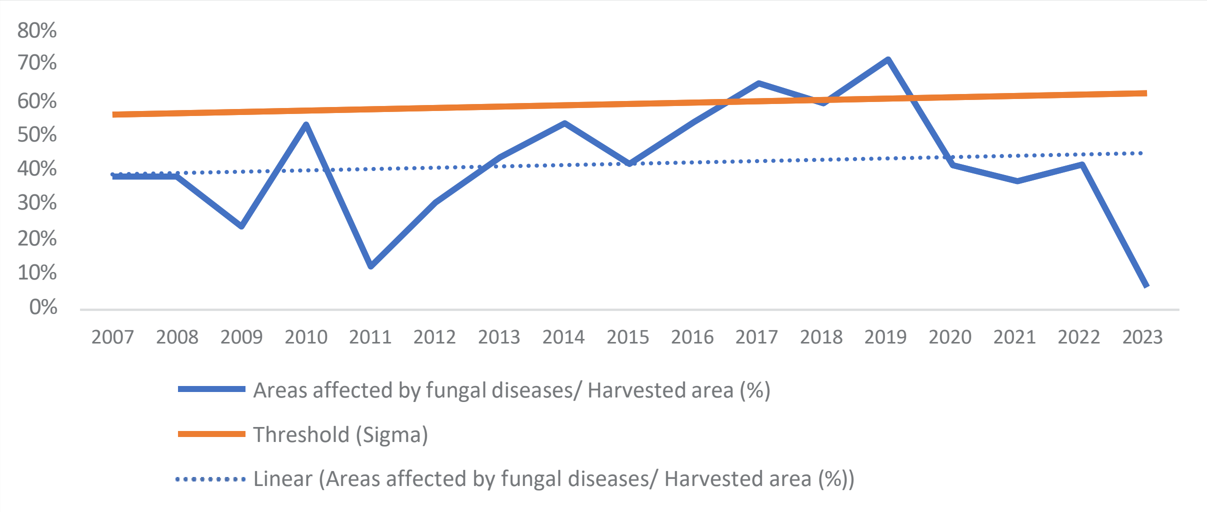


Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER)- National Aeronautics and Space Administration (NASA).

Assessing the impact of other production risks

Figure 34 shows the change in areas affected by fungal diseases as a proportion of harvested areas and presents the threshold for calculating the frequency of pest risk for the period 2007–2023. This phytosanitary risk has a probability of occurrence of 11.8%. However, analysis of the periods in which this risk occurs does not allow it to be linked directly to the years in which significant falls in production result in major losses for cereal producers on a national scale. In particular, the sharp increase in the percentage of areas affected by fungal diseases in relation to harvested areas observed in 2014, 2017 and especially 2019 does not coincide with the years in which production was below the threshold at which a loss is considered to be due to a risk event (according to the PARM methodological approach) *[59]*.

Figure 34. Areas affected by fungal diseases as a proportion of harvested areas and threshold for calculating the frequency of phytosanitary risk



Source: Authors, based on DGPA data (MARHP).

Concerning the risk of fire, even though the frequency of occurrence of this risk is 11.1%, with a probability score equal to 2 (Figure 35), analysis of the distribution of this risk and the periods during which it occurs does not allow it to be linked directly to periods that reflect falls in production at the threshold above which a loss is considered to be due to a risk event and that, on average, the areas burnt represent only the equivalent of 0.054% of harvested areas (average for 2015–2023) *[60]*. However, it is worth pointing out that the fire phenomenon has increased in scale in 2019, with almost 853 ha of cereal crops burnt (the highest figure in the last decade). For 2019, the Tunisian Union of Agriculture and Fisheries (UTAP) has estimated fire losses at 1.5 thousand tons of cereals (around 0.06% of national production). Although they are minimal on a national scale, the consequences on the loss of income of some farmers are disastrous in certain regions, and they are often only timidly compensated.

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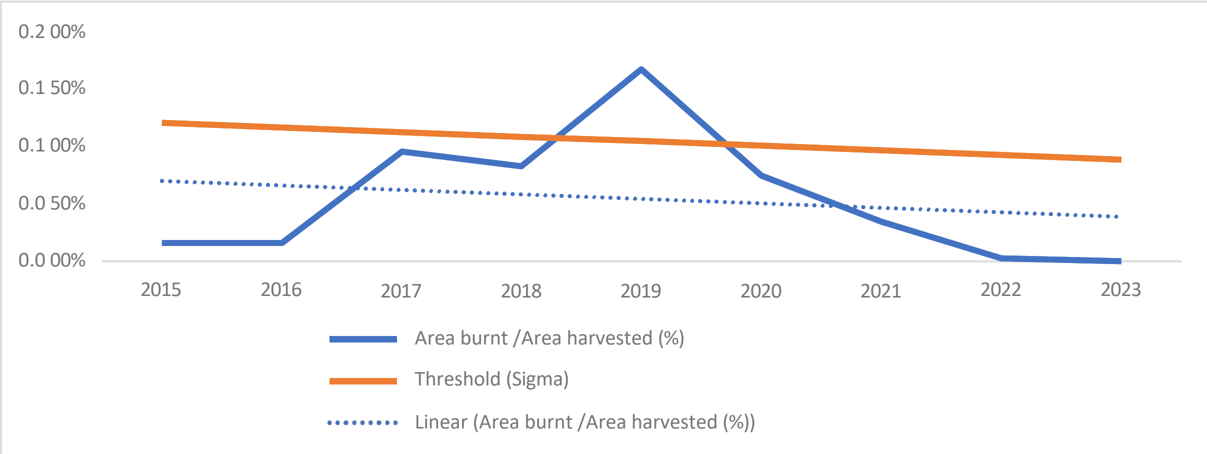
[59] *Agronomists in Tunisia estimate that cereal yield losses can range from 10 to 30% for harvested areas.*

[60] *For the same year, according to a press release from the Ministry of the Interior, civil protection units intervened during the period from 4 June to 13 June 2019 alone to extinguish 84 fires, causing 550.5 hectares to burn, compared with 72 fires and 211.2 hectares burnt during the same period in 2018.*

Figure 35. Areas burnt as a proportion of harvested areas and threshold for calculating fire risk frequency



Source: Authors, based on DGPA data (MARHP).

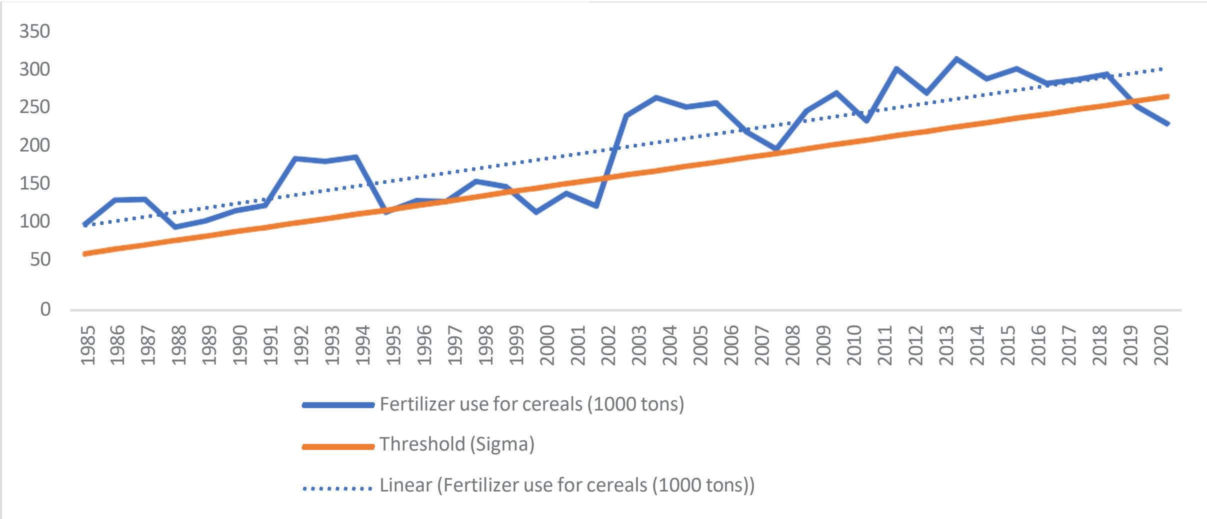
Assessing the impact of other market, price and financial risks

Figure 36 shows the trend in the quantities of fertilizer used for cereal production in Tunisia and the threshold for calculating the frequency of the risk of fertilizer unavailability. With a risk frequency of 18.9% and a probability score of 3, the likelihood of fertilizer being unavailable during the periods needed to grow cereals is high in Tunisia.

This risk is reflected in an estimated average loss of around 59,000 tons in terms of cereal production, with a maximum loss of up to 118,000 tons for all cereals combined (durum wheat, common wheat and barley). The unavailability of fertilizers can lead to this considerable maximum loss, the reasons being mainly economic. It should be noted that the disruptions to the fertilizer market since 2020, particularly for agricultural ammonium nitrate and diammonium phosphate, and certain frictions in distribution channels in 2021 and 2022, have resulted in a drop in the volume of fertilizer used for cereal crops *[61]*.

[61]*Tunisian fertilizer consumption fell to just 9,000 tons in Super 45%, 153,000 tons for ammonium nitrate and 71,000 tons for DAP in the 2020–2021 cereal season (Chebbi et al., 2022).*

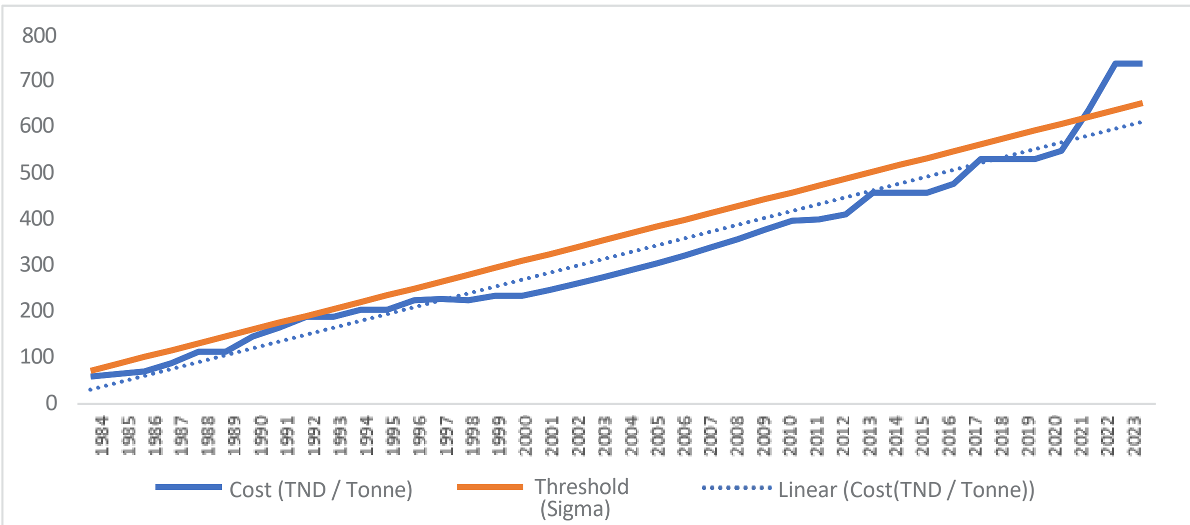
Figure 36. Changes in the quantities of fertilizer used in cereal production and threshold for calculating the frequency of the risk of fertilizer being unavailable



Source: Authors, based on MARHP data

With regard to fertilizer prices, the frequency of risk associated with an increase in the price of fertilizers sold on the Tunisian market by companies sourcing directly from TCG is around 7.5% (Figure 37). However, an analysis of this risk shows that it corresponds to only one single period, reflecting a significant drop in production, leading to a substantial loss for cereal producers in 2023. This risk of an increase in the price of chemical fertilizers sold by companies sourcing directly from the Tunisian Chemical Group (GCT) could result in a maximum production loss of 248 thousand tons for all cereals combined (durum wheat, common wheat and barley).

Figure 37. Changes in the prices of fertilizers sold by companies sourcing directly from TCG and threshold for calculating the frequency of risk associated with fertilizer price rises



Source: Authors, based on MARHP data.

In Tunisia, cereal producers need around 200,000 tons of seed per season. The risk of unavailability of certified seeds (or a disruption in the supply of certified seeds) for the cereals sector causes an average production loss of around 25.3 thousand tons and a maximum loss of 39.5 thousand tons for cereals production as a whole. Table 7 details the impact of the risk of unavailability of certified seed and the losses for each cereal crop (durum wheat, common wheat and barley).

Table 7. Impact of the risk of non-availability of certified seed on each cereal crop

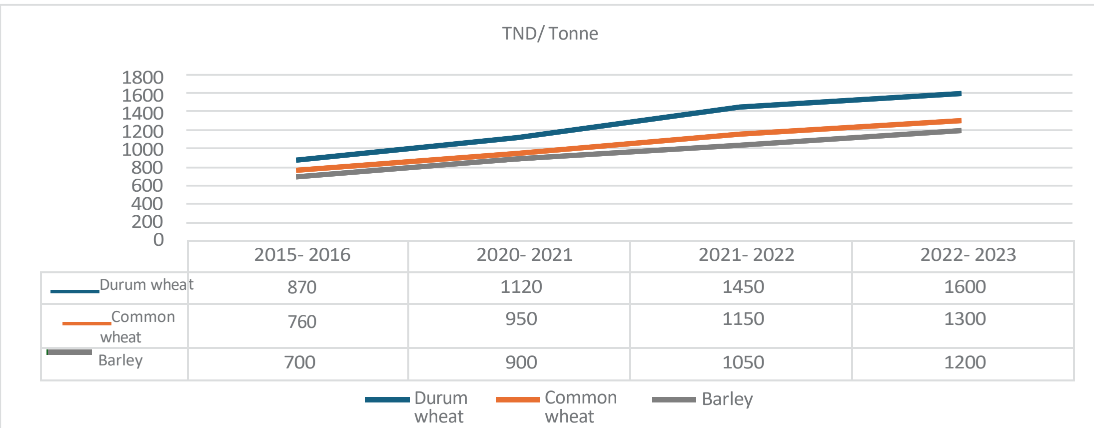
				Average Impact		Maximum Impact		
	Weighting	**Probability**	**Probability**	*Loss*	**Average (Iave)**	*Loss*	**maximum (Imax)**	**Risck Score**
Durum wheat	*60%*	**17%**	3	*- 4.3 thousand tons*	1	*- 4.3 thousand tons*	1	**2.40**
Common wheat	*12%*	**23%**	3	*- 5.4 thousand tons*	1	*- 7.5 thousand tons*	1	**2.40**
Barley and triticale	*28%*	**15%**	3	*- 15.6 thousand tons*	1	*- 27.6 thousand tons*	2	**2.70**
All cereals		**17%**	3	*- 25.3 thousand tons*	1	*- 39.5thousand tons*	1	**2.48**

Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

With regard to the risk of an increase in the price of seeds, and even though the prices of selected cereal seeds are subsidised and set by the central government at the start of each cereal season, the farming unions estimate that the increase in the price of seeds and farming equipment in 2021 has contributed to a 20% rise in the cost of production. It should be noted that, in reality, the selected cereal seed prices set for the 2023–204 marketing year are 84% higher for durum wheat and 71% higher for common wheat and barley than the reference prices for the 2015–2016 marketing year.

Nevertheless, the risk associated with a surge in seed prices remains low due to the intervention of public authorities, and the likely impact of these increases remains limited on a national scale and has not led to a fall in production beyond the threshold at which a loss is considered to be due to a risk event, in accordance with the PARM method *[62]*. Figure 38 provides an overview of the changes in prices for pedigree cereal seed set by MARHP.

Figure 38. Trends in prices for selected cereal seeds set by MARHP (TND/ton)



Source: Authors, based on MARHP data.

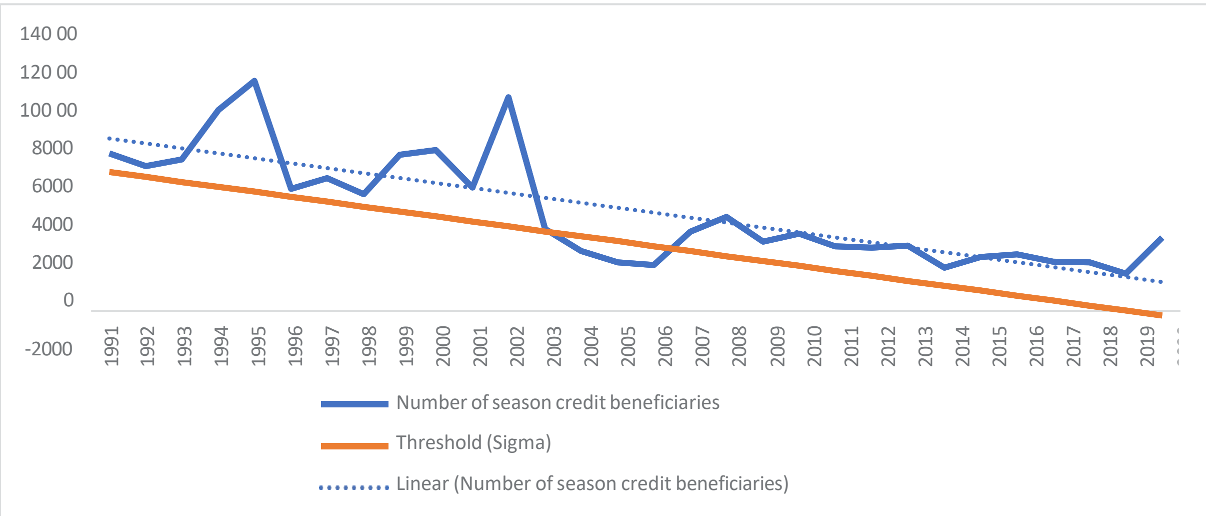
[62] *The data available to the team did not allow us to calculate the frequency of this risk or to apply the methods of statistical and econometric analysis of time series to assess it.*

Finally, the ability of grain farmers to obtain loans from financial institutions is reflected in the risks associated with accessing credit and the challenges encountered in meeting the credit criteria set by lenders, such as banks or microfinance institutions. The change in the number of season credit beneficiaries was considered as a variable for capturing this type of risk.

Even if the frequency of this risk is equal to 10% (with a probability score of 2), the analysis of the occurrence of this risk over the period 1991-2022 does not allow it to be matched to the falls in production, resulting in a significant loss for cereal producers. It should be noted, however, that there is a statistically significant downward trend in the number of credit beneficiaries.

Figure 39 shows the evolution of the number of credit beneficiaries for the cereal season and the threshold for calculating the frequency of risk linked to access to credit.

Figure 39. Trend in the number of credit beneficiaries per crop year and threshold for calculating the frequency of credit access risk



Source: Authors, based on MARHP data.

In conclusion, Table 8 ranks the risks facing cereal producers (durum wheat, common wheat and barley) in Tunisia.

Table 7. Risk exposure hierarchy for agricultural producers in cereal value chain

		Probability	Probability Score	Average Impact		Maximum Impact		Risk score
				Loss	Average impact score (SIave)	Loss (1000 tons)	Maximum impact score (SImax)	
7	Shortening the development cycle	16.7%	3	• *372 thousand tons* • *473 million TND (152 million USD)*	3	• *665 thousand tons* • *823 million TND (265 million USD)*	4	7.50
1	Dry agricultural season	16.7%	3	• *344 thousand tons* • *393 million TND (127 million USD)*	3	• *605 thousand tons* • *691 million TND (232 million USD)*	4	7.50
8	Early maturity date	14.3%	2	• *556 thousand tons* • *679 million TND (219 million USD)*	4	• *733 thousand tons* • *900 million TND (290 million USD)*	4	6.80
6	Severity of scalding	9.5%	2	• *328 thousand tons* • *459 million TND (148 millionUSD)*	3	• *339 thousand tons* • *475 million TND (153 million USD)*	3	5.10
14	Increase in fertilizer prices	7.5%	2	• *15.5%* • *248 thousand tons (17 million USD)*	3	• *15.5%* • *284 thousand tons (17 million USD)*	3	5.10
5	Spring heat stress	19.0%	3	• *74 thousand tons* • *67 million TND (22 million USD)*	2	• *103 thousand tons* • *93 million TND (30 million USD)*	2	4.80
3	March drought	14.3%	2	• *242 thousand tons* • *233 million TND (75 MUSD)*	2	• *284 thousand tons* • *272 million TND (88 million USD)*	2	3.40
4	Grain scalding	16.7%	3	• *64 thousand tons* • *58 million TND (19 million USD)*	1	• *94 thousand tons* • *84 million TND (27 million USD)*	2	2.70
17	Unavailability of fertilizers	18.9%	3	• *3,6%* • *59 thousand tons(4 million USD)*	1	• *7.2%* • *118 thousand tons* • *(8 million USD)*	2	2.70
16	Unavailability of certified seeds	17.1%	3	• *25 thousand tons (2 million USD)*	1	• *39 thousand tons (3 million USD)*	1	2.40
2	Spring drought	16.7%	3	• *Not significantly different from zero*	1	• *Not significantly* • *different from zero*	1	2.40
10	Spring frost	19.0%	3	• *Not significantly* • *different from zero*	1	• *Not significantly* • *different from zero*	1	2.40
9	Intense rainfall	9.5%	2	• *Not significantly* • *different from zero*	1	• *Not significantly* • *different from zero*	1	1.70
11	Fungal diseases	11.8%	2	• *Not significantly* • *different from zero*	1	• *Not significantly* • *different from zero*	1	1.70
12	Fires	11.1%	2	• *Not significantly* • *different from zero*	1	• *Not significantly* • *different from zero*	1	1.70
21	Access to credit	10.0%	2	• *<5% of production*	1	• *<5% of production*	1	1.70
15	Increase in seed prices	*Qualitative*	1	• *<5% of production*	1	• *<5% of production*	1	1.00

N.B. Only risks directly affecting this link in the value chain are presented in this table.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

5.4 Risk assessment and prioritization at the level of grain collection

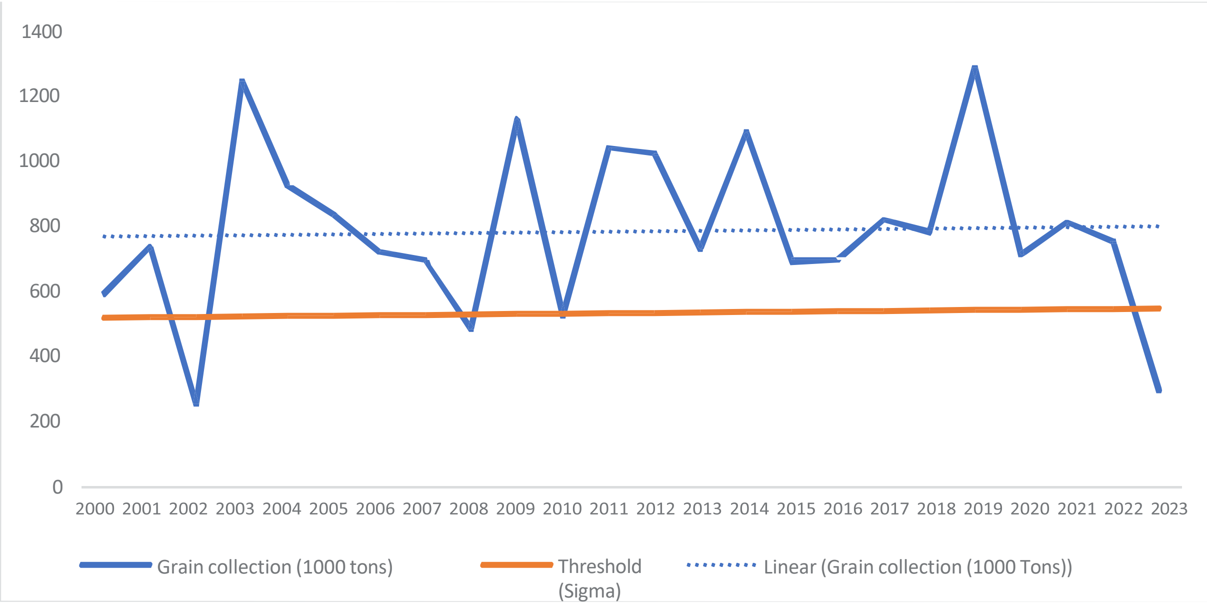
The risk of disruption to the season for collecting and purchasing cereals on behalf of the Office is reflected in the risk of a drop in the volume of cereals collected. This implies a loss of income for cereal collectors, who are remunerated according to the volumes collected on behalf of the Cereals Office *[63]*.

[63] It should be noted that cereal collectors in Tunisia act as agents for the Cereals Office, and their remuneration is linked to the volume of cereals collected on behalf of the Office. Collectors thus receive a collection premium, a storage premium (which covers the costs of storing, maintaining and preserving cereals) and a transport premium (the amount and calculation method of which are set out in the framework agreement defining relations between the Cereals Office and collectors). The operation method of the Tunisian cereals industry implies any production risk affecting the production link also affects the collection link in the same proportions.

Figure 40 plots the evolution of cereal collection and the threshold for calculating the frequency of risk linked to the risk of disruption to the collection season. This risk of disruption to harvesting operations, which occurs at a rate of 11.8%, particularly affects the durum branch.

When this risk occurs, it leads to an average fall in the volume of cereals collected of around 20.8%. The maximum risk linked to the disruption of the collection season could result in a loss of 36.5% of cereals collected.

Figure 40. Cereal collection trends and threshold for calculating the frequency of risk of disruption to the collection season



Source : Authors, based on data from the Cereals Office.

Cereal collectors also face the risk of fire, which also affects some grain collection centers, but damage remains limited in terms of frequency and impact *[64]*. The risk score assigned qualitatively for the latter is 1, corresponding, according to the categories used to establish the PARM methodology's probability score and impact score, to revenue losses affecting less than 10% of stakeholders (see Table 4).

For the cereals value chain in Tunisia, it is worth noting that collectors often act as suppliers (sellers) of inputs to cereal producers, and both the risks associated with the unavailability of fertilizers and the unavailability of certified seeds. Both risks, linked to the unavailability of fertilizers and the unavailability of certified seeds, can result in a loss of sales for the input sales activity carried out by collectors, due to higher operating costs, reduced demand as a result of disruptions, and cancelled orders. According to exchanges with value chain operators, the information gathered classifies these risks as low, and the risk scores assigned are 1.

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[64] *The statistical information available does not allow us to quantify the impact of fire hazards on the collection business.*

The financing risk of the cereal season remains low in Tunisia for collectors. In fact, the Cereals Office is responsible for financing the entire season based on agreements signed with financial institutions (notably the Banque Nationale Agricole) for the benefit of central agricultural service cooperatives, which can thus benefit from Advances on Merchandise (ASM).

Table 9 prioritizes the main risks faced by collectors.

Table 9. Prioritization of risk exposure for collectors of the cereals value chain in Tunisia

Risks		Probability	Probability Score	Medium Impact		Maximum Impact		Risk Score
				Loss	Average impact score (Slave)	Loss	Maximum impact score (SImax)	
18	Disruption to the collection season	11.8%	2	*- 20.8%*	3	*- 36.5%*	4	5.4
12	Fires	*Qualitative*	1	*- Loss of revenue affecting < 10% of actors*	1	*- Loss of revenue affecting < 10% of actors*	1	1.0
16	Unavailability of certified seeds	*Qualitative*	1	*- Loss of revenue affecting < 10% of actors*	1	*- Loss of revenue affecting < 10% of actors*	1	1.0
17	Unavailability of fertilizers	*Qualitative*	1	*- Loss of revenue affecting < 10% of actors*	1	*- Loss of revenue affecting < 10% of actors*	1	1.0
22	Financing the grain harvest	*Qualitative*	1	*- Minor deviations in key indicators*	1	*- Minor deviations in key indicators*	1	1.0

N.B. *Only risks that directly affect this link in the value chain are presented.*
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

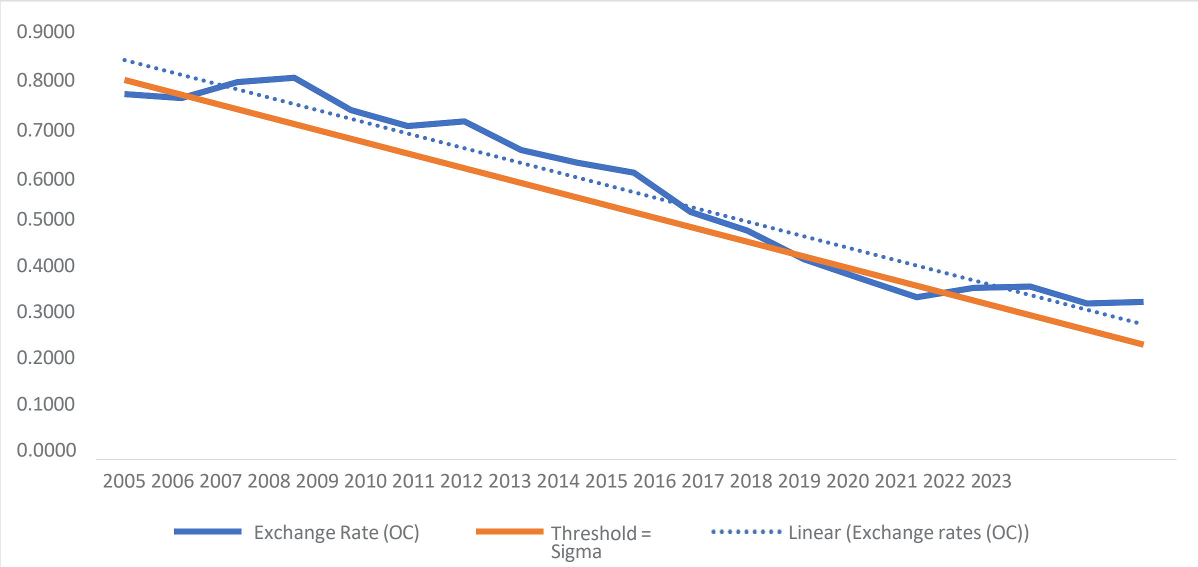
5.5 Risk assessment and prioritization for industrial processing and distribution

The system of subsidies, quotas, price administration and margins are such that industrial processing and distribution companies do not run any risks directly, and that all risks at this level are borne by the General Compensation Fund. Thus, all the market risks involved in industrial processing and distribution are borne by the CGC.

If we consider of the evolution of the exchange rate over the period 2005-2023 and taking into account the threshold for calculating the frequency of risk, the probability of this risk of depreciation of the Tunisian dinar is 26.3% (Figure 41).

This risk translates on average into an increase in the cost of cereal imports of around 303 million dinars. The maximum impact of the loss in value of the dinar against the dollar was observed in 2022, resulting in an additional cost of Tunisian imports by the Cereals Office of around 6.2% (or 210 million dinars).

Figure 41. Exchange rate trends and threshold for calculating the frequency of currency risk

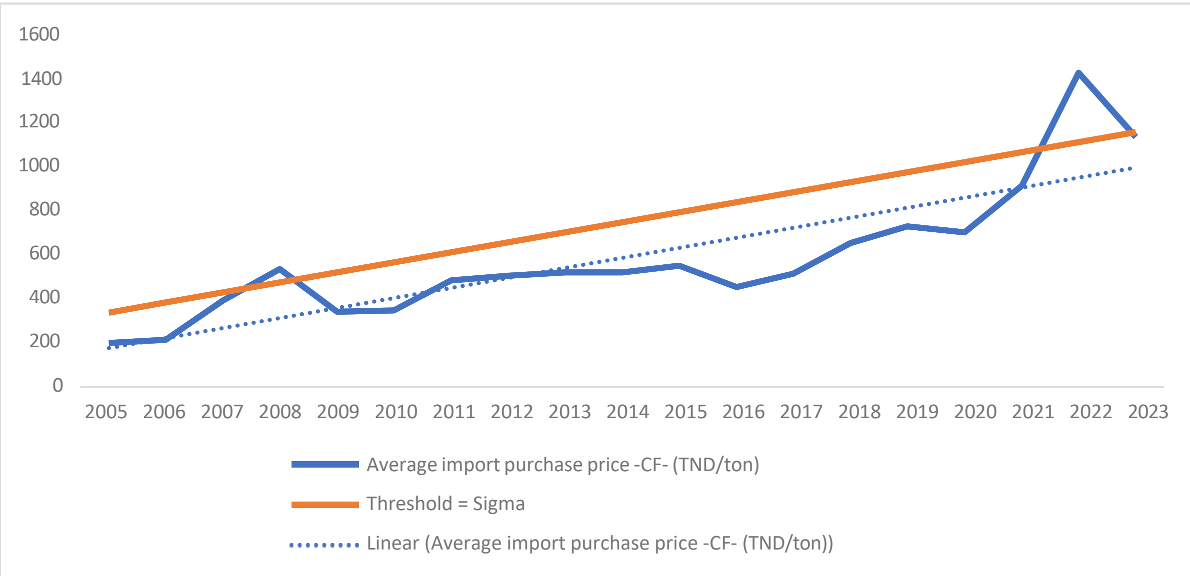


Source: Authors, based on based on data from the Cereals Office.

Taking into consideration the risk of rising cereal import prices over the period 2005-2023, the probability of this risk occurring is 10.5% (Figure 42). For cereals as a whole, this risk associated with international price movements translates on average into an increase in the cost of OC imports of around 303 million dinars.

The surge in international prices in 2022 as a result of the war in Ukraine has led to an additional cost of 644 million dinars in the value of Tunisia's cereal imports (i.e. 19% of the value of the country's cereal imports in 2022).

Figure 42. Evolution of the average import purchase price of cereals (TND/Ton) and threshold for calculating risk frequency

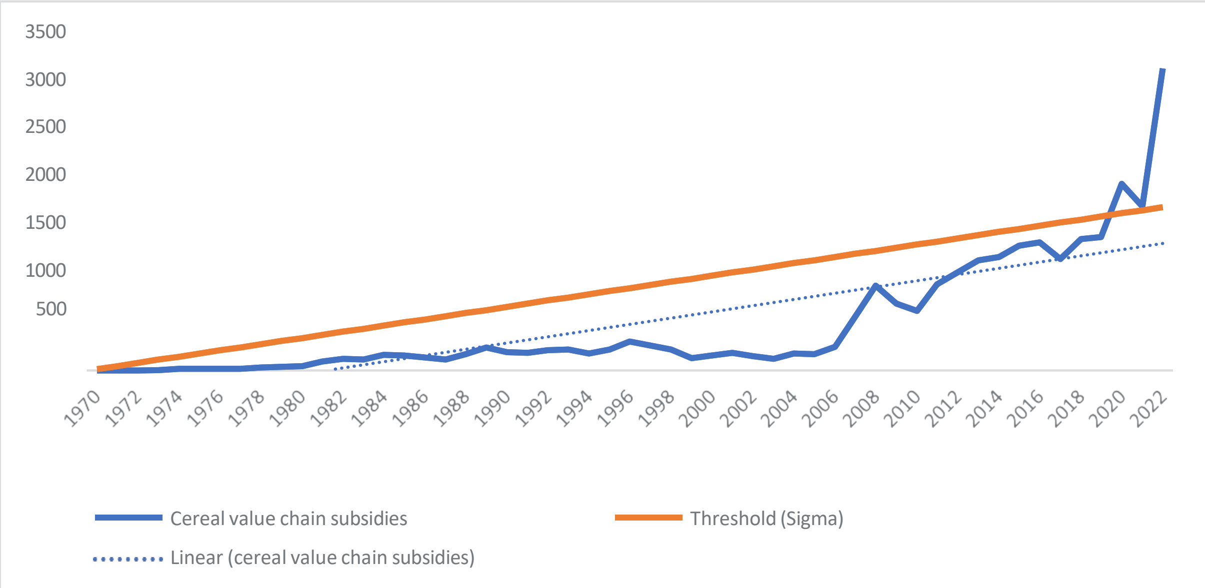


Source: Authors, based on data from the Cereals Office.

For several years now, Tunisia has been facing the risk of rising demurrage costs. This risk arises from delays in immobilization at the port and the compensation that the Cereals Office would have to pay to shipowners when the time taken to unload grain imported by Tunisia exceeds the immobilization time stipulated in the grain purchase contract.

Lastly, the increase in compensation expenditure for cereal products in Tunisia and the risk associated with the sustainability of the regulation and compensation system is 5.7% over the period 1970-2022 (Figure 43).

Figure 43. Evolution of compensation expenses for cereal products (million TND) and threshold for calculating the frequency of the risk associated with the sustainability of the regulation and compensation system



Source: Authors, based on GSC data.

Table 10 ranks the main risks faced by actors in the industrial processing and distribution of cereal products.

Table 10. Prioritization of risk exposure for industrial processing and distribution at the level of the cereal value chain

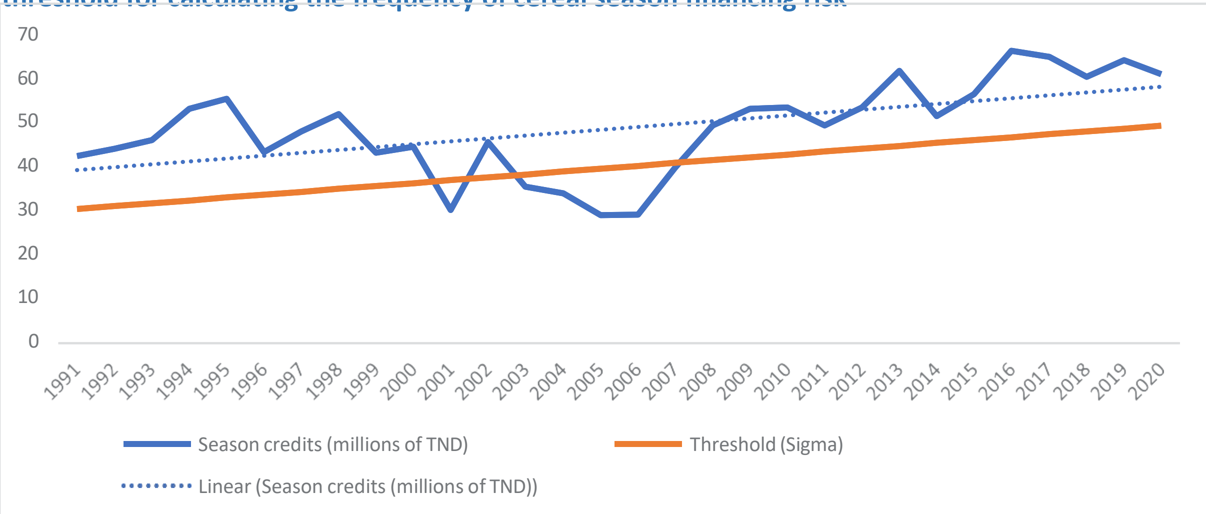
		Probability	Probability Score	Average Impact		Maximum Impact		Risk score
				Loss	Average impact score (Slave)	*Loss*	Maximum impact score (SImax)	
20	Foreign exchange risk	26.3%	3	*- 78 million TND (25 million USD)* *- 4.0%*	1	*- 210 million TND (67 million USD)* *- 6.2%*	2	2.70
19	Increase in cereal import prices	10.5%	2	*- 303 million TND (98 million USD)* *- 18.1%*	1	*- 644 million TND (208 million USD)* *- 28.0%*	3	2.30
26	Sustainability of regulation and compensation	5.7%	1	*- Minor deviations in key indicators*	1	*Minor deviations in key indicators*	1	1.00
25	Increase in demurrage charges	*Qualitative*	1	*Minor deviations in key indicators*	1	- Minor deviations in key indicators	1	1,00

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

5.6 Risk assessment and prioritization at financial services level

For financial institutions are concerned, the risk to their ability to finance the cereal season is closely linked to the contraction of financial resources intended to finance the cereal season. The drop in resources could make it difficult for farmers in particular to obtain the funds they need to finance the purchase of inputs (seeds, fertilizers, pesticides) and to cover their operating costs. The evolution of the volume of season credits for cereal production (in millions of dinars) was considered as a variable to capture this type of risk (Figure 44). This risk has a frequency of 20% (probability score of 3).

Figure 44. Evolution of the volume of season loans for cereal production (millions TND) and threshold for calculating the frequency of cereal season financing risk



Source: Authors, based on MARHP data.

With regard to the risk linked to the high exposure to credit risk, it should be noted that the commitments of public companies to the National Agriculture Bank (BNA) amounted to 6.170 billion dinars at June 30, 2023, 80% of which is held by the Cereals Office and refinanced with the Tunisia Central Bank to the tune of 3.737 billion dinars *[65]*. In Tunisia, cereal value chain activities are mainly financed by BNA through seasonal and investment loans. The National Agriculture Bank also finances the grain supply operations (local and imported) of the Cereals Office.

This level of exposure to credit risk may be a cause for concern, as it indicates that state-owned companies have accumulated a significant debt to the BNA, presenting a potential risk for the bank if these companies fail to honor their commitments. However, the Cereals Office commitments to BNA continue to explode, reaching TND 4.957 billion at June 30, 2023, i.e. around 28% of total customer commitments, and significantly exceeding the threshold of 25% of the National Agriculture Bank's net equity, imposed by the BCT *[66]*.

[65] *Information collected from the Tunis Stock Exchange website. https://www.bvmt.com.tn/*

[66] *See article 51 of BCT circular no. 2018-06 of June 05, 2018, which stipulates that the risks incurred on a single beneficiary must not exceed 25% of the net equity of the reporting institution.*

Although the Cereals Office commitments to BNA (consisting of principal, agios and interest) are covered by the State guarantee, the financing of the Cereals Office has had a significant impact on BNA's cash position, with a negative balance of 5.057 billion dinars on June 30, 2023.

Table 11 prioritizes the main risks facing financial services at the cereals value chain.

Table 11. Prioritization of risk exposure for financial services of the cereal value chain

Risks		Probability	Probability Score	Average Impact		Maximum Impact		Risk Score
				Loss	Average Impact Score (SIave)	*Loss*	Maximum Impact Score (SImax)	
22	Financing the grain harvest	20.0%	3	- *Minor deviations in key indicators*	1	- *Minor deviations in key indicators*	1	2.40
23	Credit risk exposure	*Qualitative*	2	- *Minor deviations in key indicators*	1	- *Minor deviations in key indicators*	1	1.70
26	Sustainability of regulation and compensation	*Qualitative*	1	- *Minor deviations in key indicators*	1	- *Minor deviations in key indicators*	1	1.00

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

5.7 Prioritization of risk exposure at the level of the cereal value chain as a whole

Risks are prioritized at the level of the entire cereal value chain by averaging the risk scores of the actors for each of the 26 identified risks. This prioritization shows that the main risks to the development of the cereal value chain are 1) shortening of the development cycle; 2) drought during the agricultural season and 3) bringing forward the maturity date of cereals.

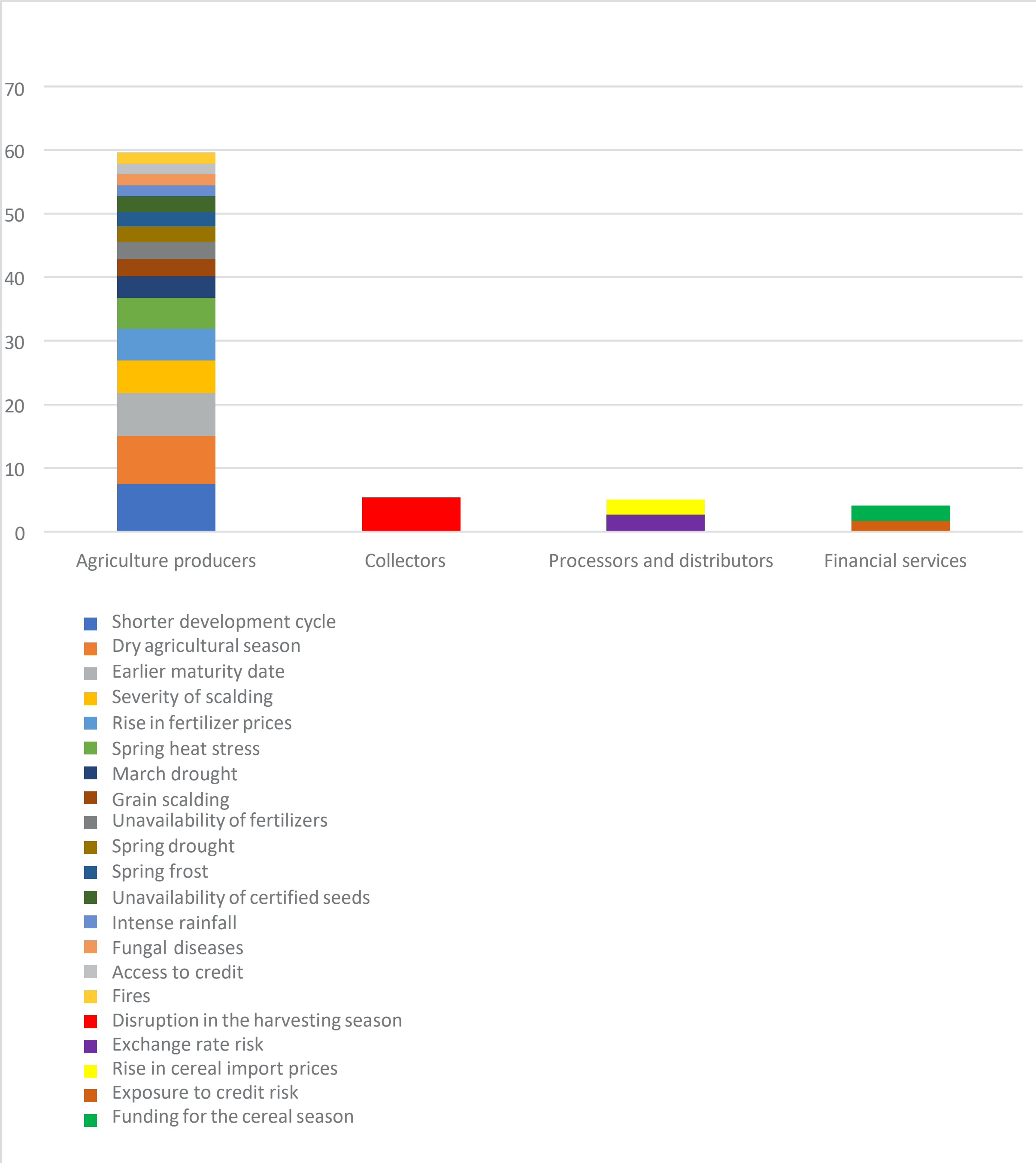
As far as the actors in the cereals value chain are concerned, those most exposed to risk are 1) cereal producers, 2) collectors and 3) the Cereals Office in the processing and distribution chain.

Table12. Prioritization of risk exposure at stakeholder level and across the cereals value chain

	Risks	Input suppliers	Agricultural producers	Collectors	Processing and distribution	Financial Services	Value chain
7	Shortening the development cycle	NA	7.50	NA	NA	NA	7.50
1	Dry agricultural season	NA	7.50	NA	NA	NA	7.50
8	Early maturity date	NA	6.80	NA	NA	NA	6.80
18	Disruption to the collection season	NA	NA	5.40	NA	NA	5.40
6	Severity of scalding	NA	5.10	NA	NA	NA	5.10
14	Increase in fertilizer prices	NA	5.10	NA	NA	NA	5.10
5	Spring heat stress	NA	4.80	NA	NA	NA	4.80
3	March drought	NA	3.40	NA	NA	NA	3.40
4	Grain scalding	NA	2.70	NA	NA	NA	2.70
20	Foreign exchange risk	NA	NA	NA	2.70	NA	2.70
2	Spring drought	NA	2.40	NA	NA	NA	2.40
10	Spring frost	NA	2.40	NA	NA	NA	2.40
19	Increase in cereal import prices	NA	NA	NA	2.30	NA	2.30
17	Unavailability of fertilizers	NA	2.70	1	NA	NA	1.85
9	Intense rainfall	NA	1.70	NA	NA	NA	1.70
11	Fungal diseases	NA	1.70	NA	NA	NA	1.70
16	Unavailability of certified seeds	NA	2.40	1	NA	NA	1.70
21	Access to credit	NA	1.70	NA	NA	NA	1.70
23	Credit risk exposure	NA	NA	NA	NA	1.70	1.70
22	Financing the grain harvest	NA	NA	1	NA	2.40	1.70
12	Fires	NA	1.70	1	NA	NA	1.35
13	Rising raw material prices for fertilizer production	1	NA	NA	NA	NA	1.00
15	Increase in seed prices	NA	1	NA	NA	NA	1.00
24	Blockade of production sites	1	NA	NA	NA	NA	1.00
25	Increase in demurrage charges	NA	NA	NA	1	NA	1.00
26	Sustainability of regulation and compensation	NA	NA	NA	1	1	1.00
	Average per Actor	1.00	3.56	1.88	1.75	1.70	

N.B. NA (not applicable) indicates that according to our surveys and literature review, the risk in question does not directly affect the actors in this link of the value chain.

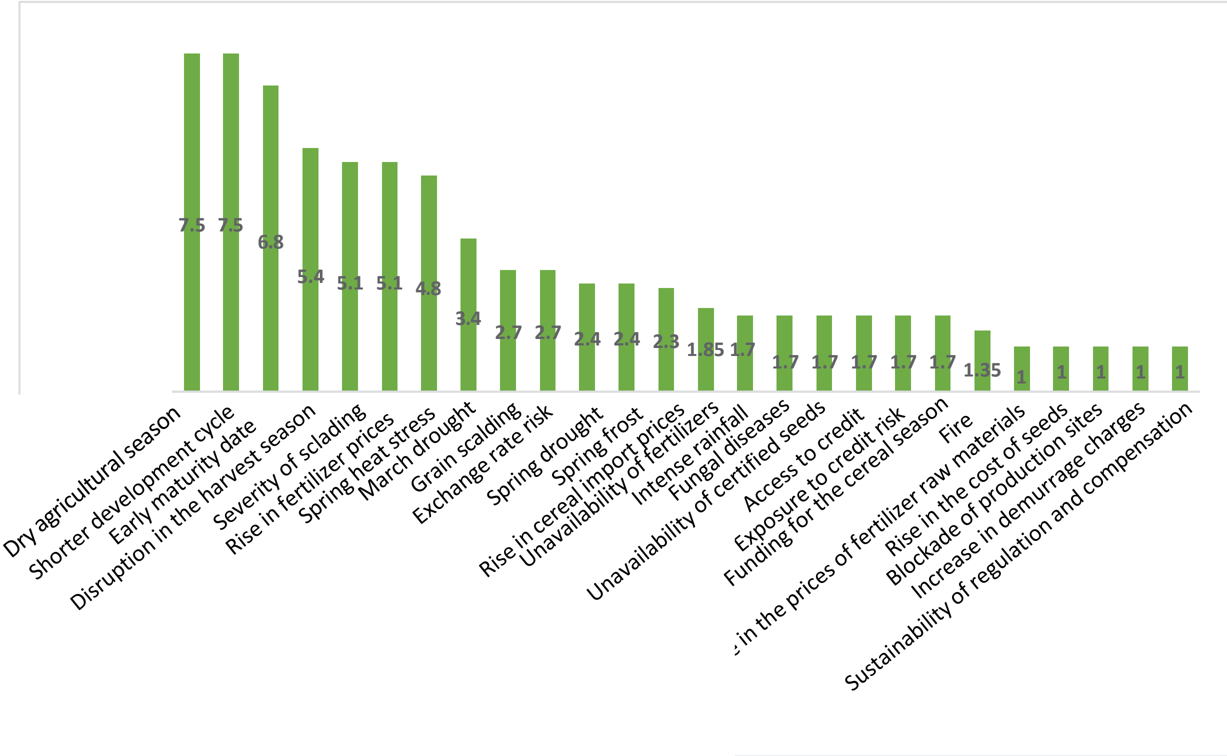
Fig.45 Cumulative risk scores by type of stakeholder and by type of risk across the cereal value chain



Source: Authors

Note: The maximum score for each risk is 12. For ease of reading, only scores >1 are shown here.)

Fig.46 Prioritization of risk exposure in the cereal value chain



Source: Authors

6 Risk assessment in the olive oil value chain

6.1 Risk overview

As part of this study on risk assessment in the Tunisian olive oil value chain, a total of 21 risks were identified, impacting various aspects of this value chain. Among these risks, five climatic risks likely to affect olive production in Tunisia have been identified. The selection of these climatic risks specific to the olive sector in Tunisia was based on consultation with experts in bioclimatology and several study reports produced for the Ministry of Agriculture, Water Resources and Fisheries (MARHP).

Similarly, two phytosanitary risks have been specifically selected for this analysis because of their potential impact on olive crops. Price and financial risks are also major factors to consider, with ten risks identified as potentially affecting the Tunisian olive oil market. As far as logistical risks are concerned, only one major risk has been identified in the olive oil value chain. Finally, two institutional risks were identified, underlining the importance of taking regulatory and administrative aspects into account when managing the risks associated with this industry. Table 13 shows the risks identified.[*68*]

Table 13. Presentation of risks in the olive oil value chain

Production risks	Climate risks	1	Agricultural drought (Rainfall abnormally below olive tree requirements)
		2	Unmet cooling requirements (Percentage of olive-production areas in Tunisia where olive trees' cooling requirements are not met (cooling requirement = 30 days from December to March with average temperatures below 12°).
		3	Spring frost during flowering (minimum daily temperature below 0°C)
		4	Heatwave: Number of days with temperature >40°C in summer (June, July and August)
		5	Intense rainfall: Number of days with rainfall over 70 mm
	Phytosanitary	6	Pests
		7	Xylella fastidiosa threat
Market, price and financial risks		8	Rising raw material prices for fertilizer production
		9	Rise in fertilizers' prices
		10	Unavailability of fertilizers
		11	Fall in producer prices for olives (price of olives -20%)
		12	Rise in producer prices for olives (price of olives +20%)
		13	Credit repayment difficulties
		14	Reduction in export prices
		15	Loss of international market share
		16	Loss of market share-EU
		17	Farm labor shortage
Logistics risks		18	Regulation and storage of production and export surpluses
		19	Blockade of production sites
Corporate risks		20	Changes to EU export quota rules
		21	Theft and vandalism (stocks, equipment and materials, etc.)

[67] *In consultation with expert researchers from INRGREF, Tunisia.*

[68]*Appendix 24 presents descriptive statistics on the climatic and agroclimatic indicators used to assess these risks at the level of the olive-production value chain.*

6.2 Risk assessment and prioritization at input supplier level

Input suppliers in the olive oil value chain face the same risks (rising costs of raw materials needed for fertilizer production and blockade of production sites), both in frequency and impact, as those encountered in the cereal value chain. fertilizer production and interruption of activity at manufacturing sites), both in frequency and impact, to those encountered in the cereal value chain. Table 14 ranks the risks faced by input suppliers.

Table 14. Prioritization of risk exposure for input suppliers at the olive oil value chain

	Risks	Probability	Probability Score	Average Impact		Maximum Impact		Risk Score
				Loss	Average Impact Score (SIave)	Loss	Maximum Impact Score (SImax)	
8	Rise in raw material prices for fertilizer production	4.8%	1	- *Loss of revenue affecting < 10% of actors*	1	- *Loss of revenue affecting < 10% of actors*	1	1.0
19	Blockade of production sites	*Qualitative*	1	- *Loss of revenue affecting < 10% of actors*	1	- *Loss of revenue affecting < 10% of actors*	1	1.0

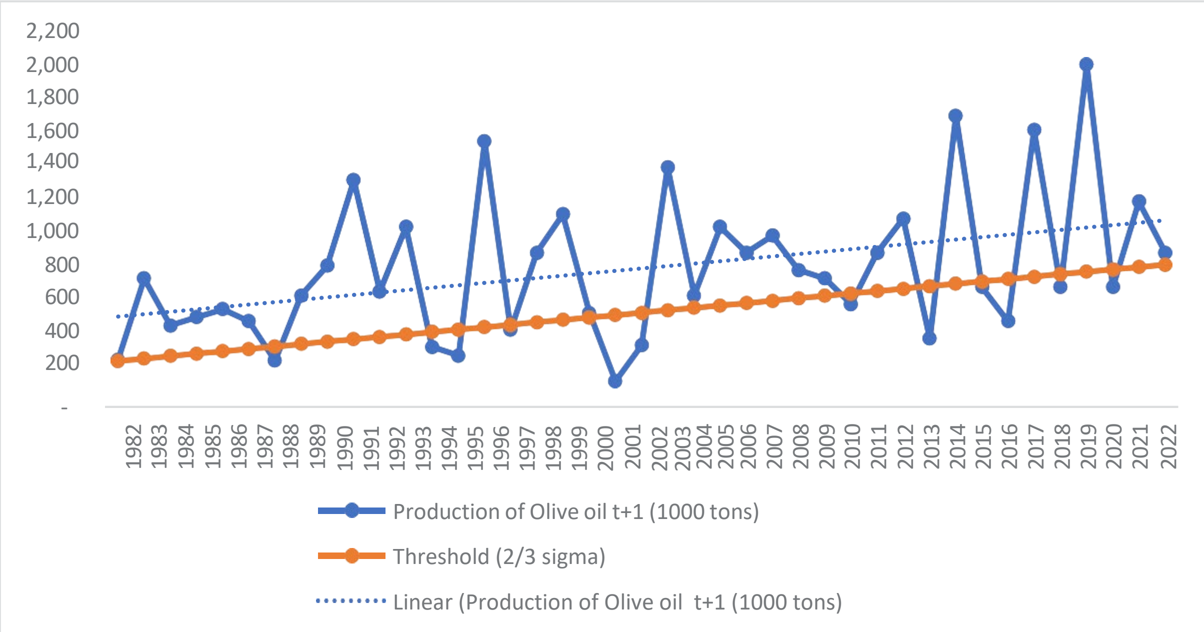
N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*SIave) + 0.3* (SImax)*
Source: Authors.

6.3 Risk assessment and prioritization for oil olive producers

The following steps were taken to assess oil olive production losses in Tunisia over the period 1982 to 2022 and to determine the threshold for calculating losses:

- The blue curve shows annual variations in oil olive production in Tunisia over the period 1982-2022.
- The dotted blue line represents the linear trend in production as a function of time, i.e. the level of production expected in the absence of volatility.
- The orange line represents the threshold, two-thirds of a standard deviation, below which it is assumed that risky events have occurred. This threshold takes into account production drops that represent a significant loss for oil olive producers, and any production below this threshold is considered a loss due to a risk event. Over the period 1982-2022, production losses were recorded 12 years out of 41 (29%).
- Lost production is calculated as the difference between expected (trend) production and actual (realized) production. Finally, the monetary value of the loss is quantified for the years of loss alone, by multiplying it by the prices.

Figure 47. Oil olive production losses in Tunisia (1000 tons) over the period 1982-2022



Source: Authors, based on DGEDA-MARHP data.

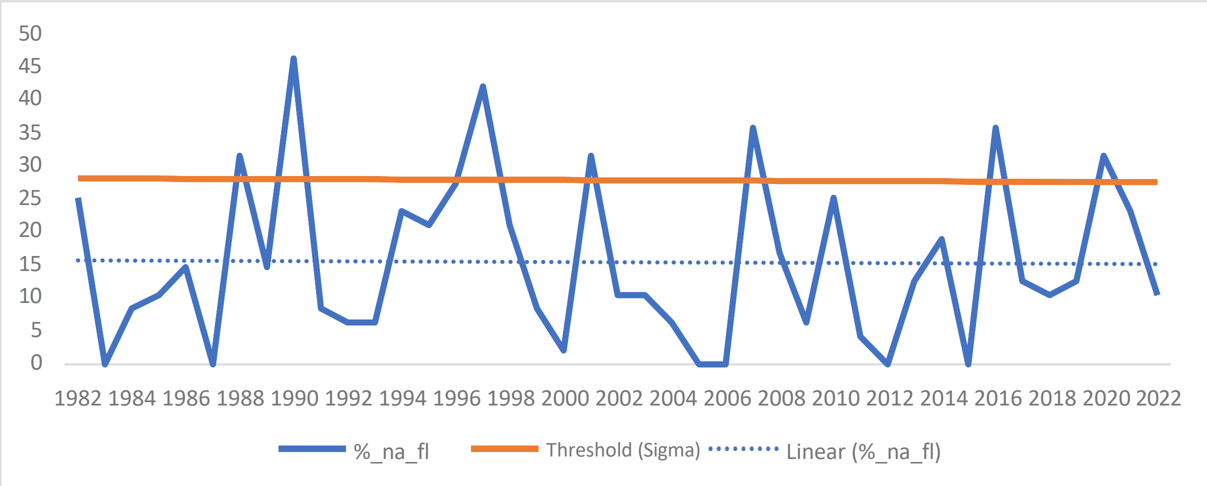
Assessing the impact of climate risks

The assessment of climatic risks (severe to extreme shocks) was based on an econometric analysis designed to estimate the impact of these risks on production losses. This econometric analysis indicates that only the failure to satisfy the cold needs of olive trees and drought have a statistically significant impact on the loss of national oil olive production over the period examined. Details of the econometric estimates are given in Appendix 25.

Thus, the probability of a decrease in the percentage of olive-production areas in Tunisia where the cold needs of olive trees are not met, defined as the proportion of areas where average temperatures are below 12 degrees Celsius for at least 30 days from December to March, is estimated at around 17.1% (Figure 48).

This risk of cold needs not being met, with a score that reaches 9.90, could result in an average loss of 305 thousand tons of harvest in Tunisia, equivalent to a drop of almost 37.7% in national oil olive production. This average loss would entail an estimated cost of around 1 155 million dinars. Worryingly, the maximum loss resulting from this risk could reach 757 thousand tons, equivalent to a maximum cost of 2,866 million dinars.

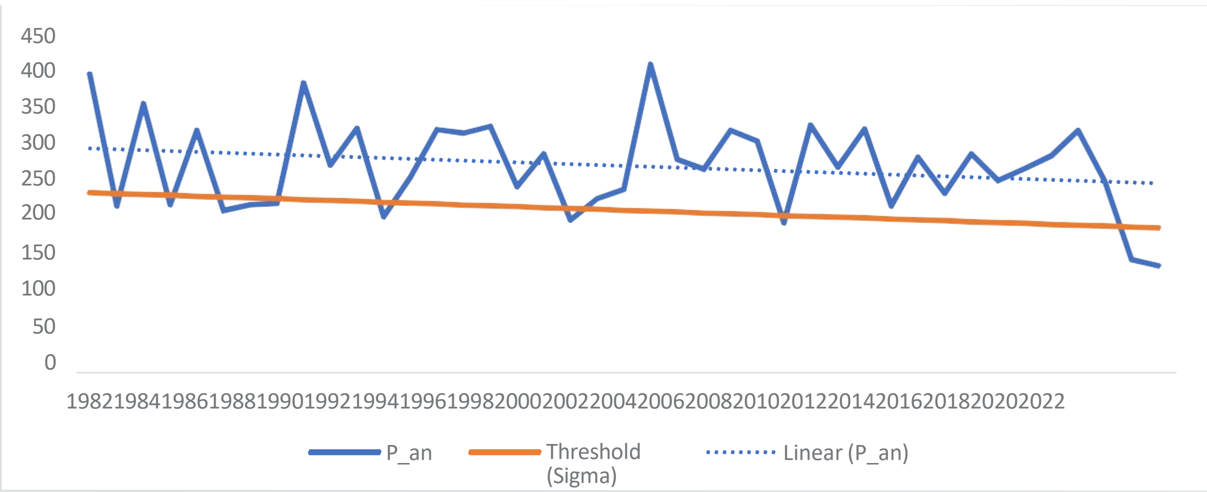
Figure 48. Evolution of the percentage of olive groves in Tunisia where cooling requirements are not met (P_%_na_fl) and threshold for calculating the frequency of the associated risk



Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER) – National Aeronautics and Space Administration (NASA).

Severe to extreme agricultural drought has a probability of occurrence of around 24.4% (Figure 49). This risk, with a score that also reaches 9.9%, results in an average loss of 345,000 tons of harvest when it occurs, at a cost of almost 1 338 million dinars. The maximum loss caused by the drought (severe to extreme) could reach 737 thousand tons, at a cost of around 2 789 million dinars.

Figure 49. Changes in rainfall during the agricultural season (P_year) and threshold for calculating the frequency of the risk of agricultural drought (rainfall abnormally below the needs of olive trees)

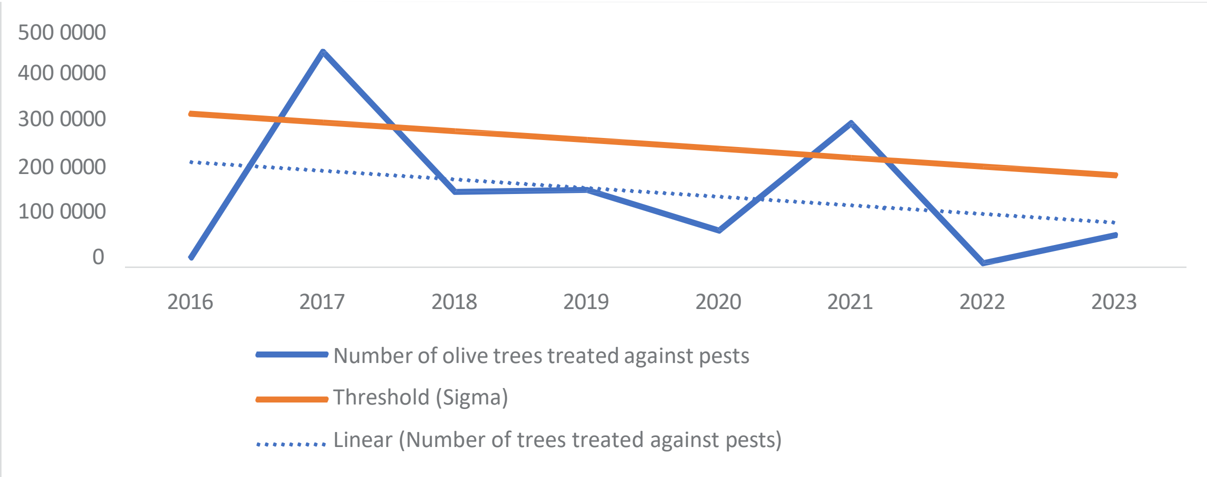


Source: Compiled by the authors based on data from Prediction of Worldwide Energy Resources (POWER) – National Aeronautics and Space Administration (NASA).

Assessing the impact of phytosanitary risks

Concerning phytosanitary risks related to olive pests (Figure 50), the econometric evaluation shows that phytosanitary risks have no statistically significant impact on the loss of national oil olive production for the period 2016-2023. [69]

Figure 50. Trend in the number of olive trees treated against pests and threshold for calculating the frequency of phytosanitary risk



Source: Authors, based on DGPA data (MARHP).

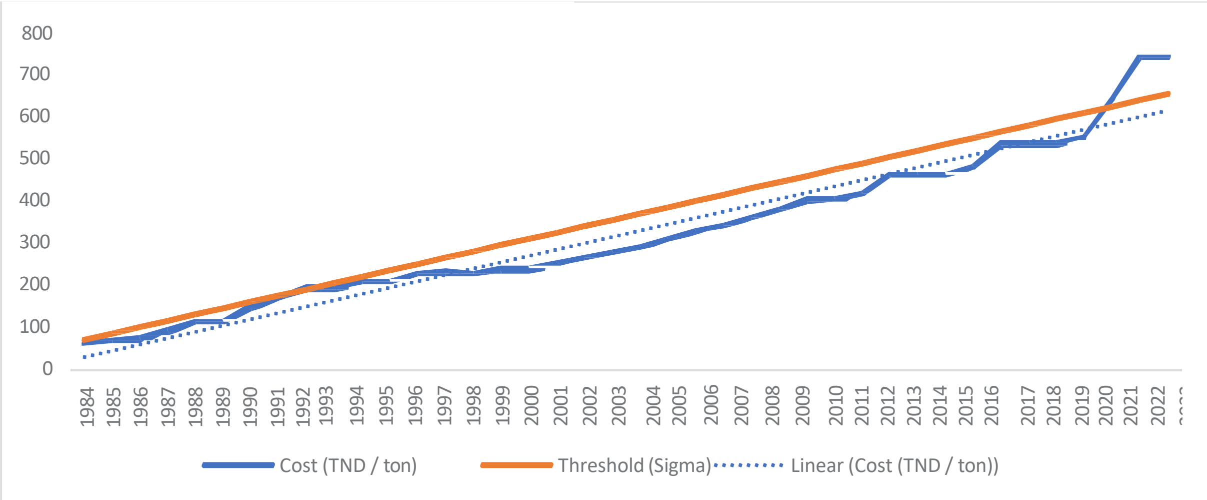
For the risk linked to the threat of entry and spread of Xylella fastidiosa, and even if Tunisia is not affected by the syndrome of rapid decline of the olive tree, the risk of entry of the Xylella fastidiosa bacterium into the territory and its spread is very real. The economic impact on the olive oil value chain could be significant, as the olive tree is a key crop for the country. Crop losses, reduced olive oil production for the domestic and export markets and the costs of measures to combat Xylella would have an impact on the entire value chain.

Assessing the impact of risks associated with rising fertilizer prices

For fertilizer prices, the frequency associated with this risk is around 7.5% (Figure 51). However, econometric analysis of the impact of higher fertilizer prices on oil olive production does not confirm the existence of a statically significant impact (Appendix 26).

[69] *Details of the econometric estimation are given in Appendix 20.*

Figure 51. Trends in fertilizer prices sold by companies sourcing directly from GCT and threshold for calculating the frequency of risk associated with fertilizer price rises



Source: Authors, based on MARHP data.

Assessment of the impact of the risk of unavailability of fertilizers at the production level

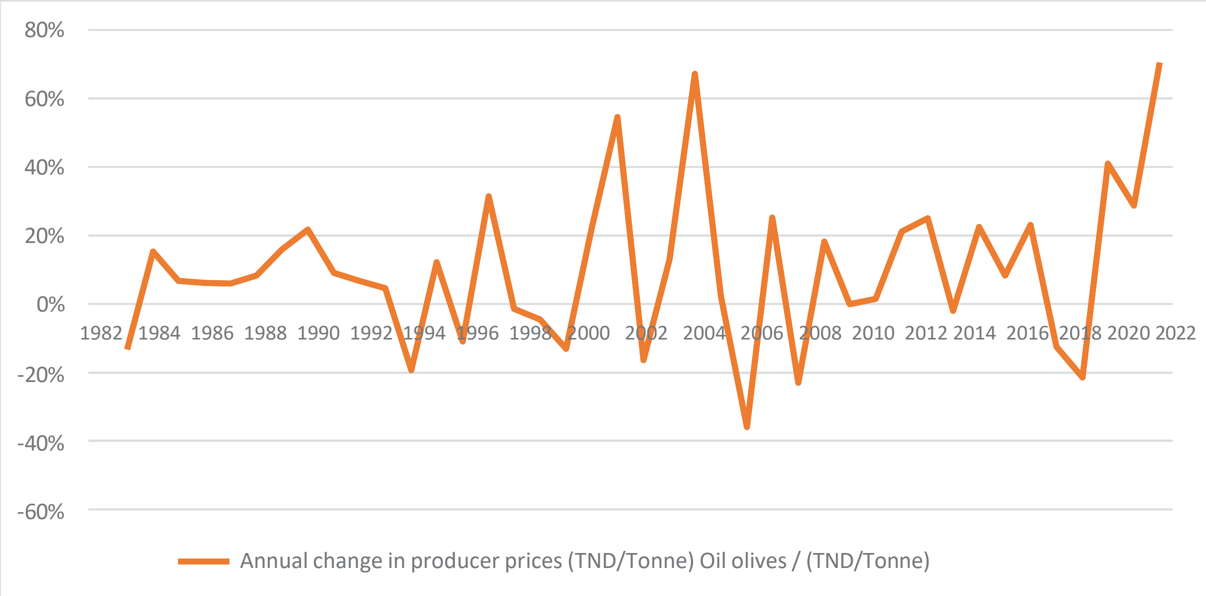
For this risk, given the lack of statistical data on the precise use of fertilizer quantities for olive cultivation in Tunisia and on fertilizer supply deficits, the same risk exposure levels as for cereal production were taken into account.

Assessment of the impact on production of the risk associated with a fall in the producer price of olives (20% drop in the price of olives).

The risk of a fall in farm-gate olive prices (corresponding to an annual drop in olive prices of -20%) has a probability of occurrence of around 7.3%. This price risk could lead to an average loss of income for producers of around 14.50% (i.e. a loss of revenue of around 428 million dinars). The maximum loss caused by a collapse in producer prices could reach around 1,062 million dinars for all oil olive production (i.e. a drop in producers' income of around 35.96%).[*70*]

[70] This risk analysis was complemented by an assessment of the risk of volatility in producer prices for olives on five wholesale markets (Sfax -Gremda-, Centre, Sahel, Nord and Sud) and for three seasons 2019/2020, 2020/2021 and 2021/2022. Price volatility of between 10% and 20% is considered low and has little impact. When volatility reaches or exceeds 20%, price risk is considered significant and has a greater impact. Analyses of this variability between markets are presented in Appendix 28.

Figure 52. Trend in annual change in farm-gate prices for oil olives



Source: Authors, based on MARHP data.

Assessing the impact of theft and vandalism risk

Tunisia is experiencing an increase in acts of theft and vandalism affecting the agricultural production apparatus, particularly the olive production sector. According to the testimonies of several farmers, these crimes include the cutting up of olive tree trunks, the degradation of trees and the theft of olive harvests. These are then sold illegally at prices well below market rates, often in remote areas.

These incidents are particularly frequent in olive plantations located mainly in the governorates of Mahdia and Sfax (the probability score assigned is 2). For example, 10 kilograms of stolen olives are commonly sold for just 15 dinars. This trend can be explained in part by the geographical location of the olive groves most targeted by criminals, which are located in remote, unsupervised areas.

The table below prioritizes the main risks faced by olive producers in Tunisia's olive-production value chain.

Table 15. Prioritization of risk exposure for oil olive producers in the value chain

	Risk	Probability	Probability socre	Average Impact		Maximum Impact		Risk score
				Loss	Average impact score (SIave)	*Loss*	Maximum impact score (SImax)	
2	Unmet cooling needs	17.1%	3	*- 37.71% - 305 thousand tons 1,155 million TND (372 million USD)*	4	*- 93.56% - 757 thousand tons 2.866 million TND (924 Million USD)*	5	9.90
1	Agricultural	24.4%	3	*- 43.68% - 354 thousand tons 1,338 million TND - (431 million USD)*	4	*91.07% - 737 thousand tons 2.789 million TND (899 Million USD)*	5	9.90
11	Falling producer prices production prices (price of olives -20%)	7.3%	2	*- 14.50% 428 million - TND (138 million USD)*	2	*- 35.96% - 1.062 million TND (342 million USD)*	4	4.00
10	Unavailability of fertilizers		3	*- <5% of production*	1	*Between 5 and 15% of production*	2	2.70
6	Pests	25.0%	2	*- <5% of production*	1	*<5% of production*	1	2.40
3	Spring frost	19.5%	3	*- <5% of production*	1	*<5% of production*	1	2.40
4	Heatwave	12.2%	2	*- <5% of production*	1	*<5% of production*	1	1.70
5	Intense rainfall	9.8%	2	*- <5% of production*	1	*<5% of production*	1	1.70
6	Pests	25.0%	2	*- <5% of production*	1	*<5% of production*	1	1.70
9	Rising fertilizer prices	7.5%	2	*- <5% of production*	1	*<5% of production*	1	1.70
21	Theft and vandalism (stocks, equipment and materials, etc.)	*Qualitative*	2	- <5% of production	1	- <5% of production	1	1.70
7	Threat of Xylella fastidiosa	*Qualitative*	1	- <5% of production	1	- <5% of production	1	1.00
13	Difficulties in repayment of loans	*Qualitative*	1	*- <5% of production*	1	*- <5% of production*	1	1.00

N.B.Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

6.4 Risk assessment and prioritization at the level of collectors and oil producers

Higher producer prices for olives (20% increase in olive tree prices)

The risk of a rise in farmgate olive prices (corresponding to an annual increase in olive prices of over 20%) mainly affects collectors and oil millers and has a probability of occurrence of around 31.7%. This risk of a rise in the price of the raw material for oil extraction could result in an average loss of 21.05% (over 622 million dinars) due to additional costs for collectors and oil producers. The maximum increase in costs caused by the explosion in producer prices could reach around 70.49%, for an overall cost of around TND 2,083 million for the whole of the collectors and oil millers sector.

Risks associated with regulating and storing surplus production (and exports)

Problems of falling olive oil processing and export prices due to excess production have hit the Tunisian olive oil value chain. The Tunisian government, through the Office National de l'Huile (ONH), has stepped in to launch a specific regulation program and subsidize the storage of 100,000 tons of olive oil for the 2019-2020 season, which saw record national olive oil production of around 400,000 tons, through premiums for farmers, processors and exporters (for a fixed period of 6 months).

Table 16. Prioritization of risk exposure for collectors and olive producers in the olive oil production value chain

	Risk	Probability	Probability score	Average Impact		Maximum Impact		Risk score
				Loss	Average impact score (Iave)	*Loss*	Maximum impact score (Imax)	
12	Rising producer prices for olives (price of olives +20%)	31.7%	3	- *21,05%* - *622 million TND* - *(200 million USD)*	3	- *70.49%* - *2.083 million TND* - *(671 million USD)*	5	7.80
13	Difficulties in repayment of loans	*Qualitative*	1	*Loss of income affecting < 10% of actors*	1	*Loss of income affecting < 10% of actors*	1	1.00
17	Shortage of agricultural agricultural	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.00
18	Regulation and storage of production and export export surpluses	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.00

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors.

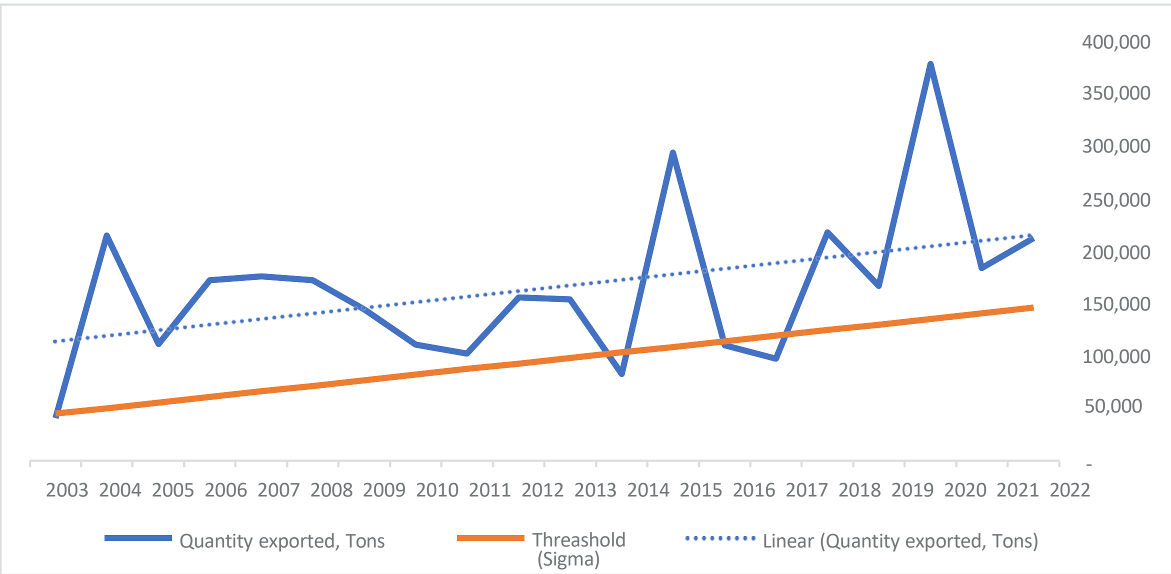
6.5 Risk assessment and prioritization for distributors and exporters

Risks of market loss for Tunisian exporters

To assess the two risks of market loss for the olive oil exporting sector (on a global scale and at the level of the European Union market), a standard error threshold was used to identify significant falls in olive oil export volumes (Quantity exported, tons) that would lead to a significant loss on the part of exporters. Export losses for olive oil (HS code 1509, olive oil and its fractions) in terms of quantities are estimated as the difference between the expected export volume (trend) and the actual export *[71]*. Economic losses for Tunisian exporters are then determined by converting volume losses into monetary terms, based on average unit export price data.

For the world market (Figure 53), the frequency of the risk of losing market share due to a drop in export quantities is 20%. If this risk materializes, it will be accompanied by an average drop in Tunisian exports of 8%, i.e. an average loss of around 12.493 thousand tons (150 million dinars or the equivalent of 48 million USD). The maximum drop could reach 21.724 thousand tons, representing a loss of around 260 million dinars (84 million USD).

Figure 53. Evolution of the volume of olive oil exports (HS code 1509) from Tunisia to the rest of the world and threshold for calculating the frequency of risk linked to the loss of world market share

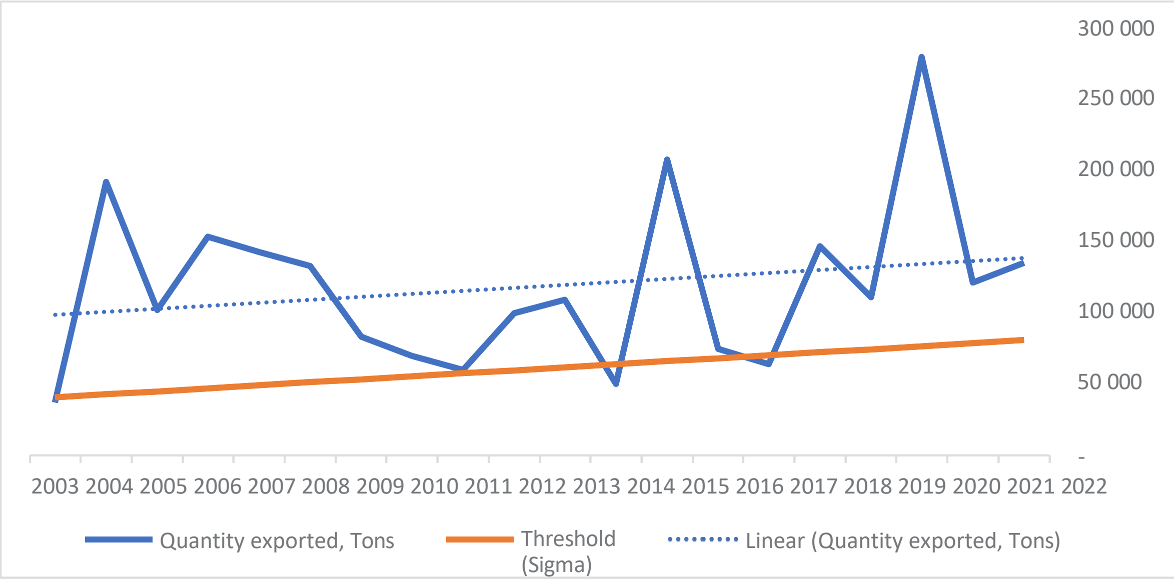


Source: Authors, based on TRADE MAP data.

[71] SH code 1509. Olive oil and its fractions - obtained from the fruit of the olive tree solely by mechanical or physical processes, under conditions that do not alter the oil - whether or not refined, but not chemically modified.

In Europe, Tunisia's largest market, this risk is 15%. The average impact of this risk of market loss due to a drop in export quantities could amount to 97 million dinars (a loss of export volumes to the EU of around 7%, or 8.064 thousand tons), while the maximum loss of this risk could reach 13.988 thousand tons (a loss of 168 million dinars). Figure 54 shows the evolution of the volume of olive oil exports (HS code 1509) from Tunisia to the EU (28) and the threshold for calculating the frequency of risk linked to the loss of European market share.

Figure 54. Evolution of the volume of olive oil exports (HS code 1509) from Tunisia to the EU (28) and threshold for calculating the frequency of risk linked to the loss of European market share



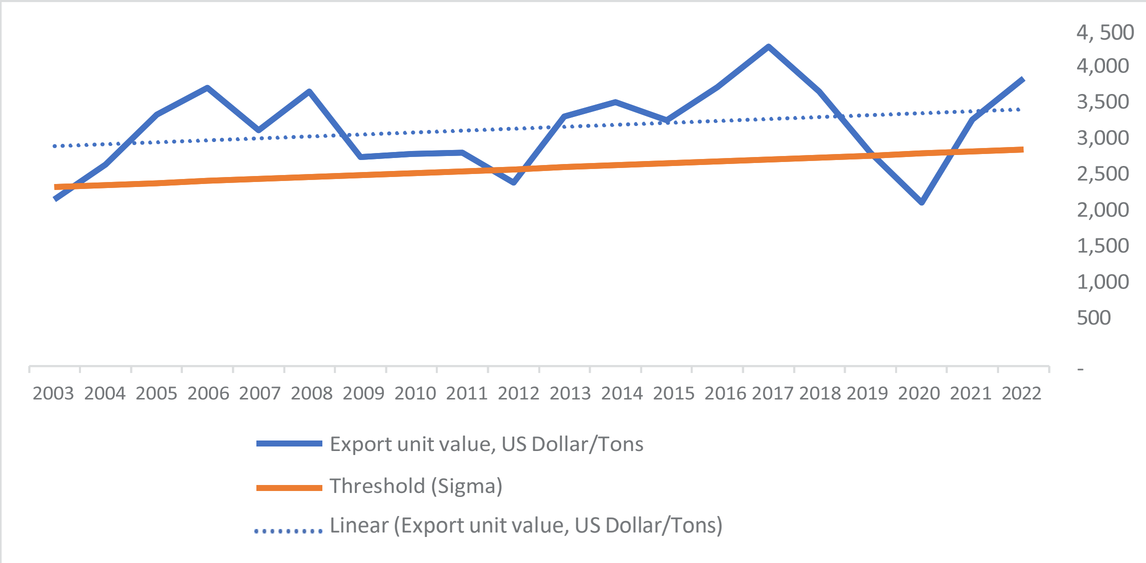
Source: Authors based on TRADE MAP data.

Risk of falling export prices

The risk of a fall in olive oil export prices is around 15%. In the event of a drop in export unit value, companies can incur an average loss of USD 336/ton (i.e. an average loss of 250.2 million dinars). The maximum fall in export prices could reach 656 USD/Ton (i.e. a maximum loss of 488.5 million TND in export revenues).

Figure 55 plots the evolution of the unit value of oil exports and the threshold for calculating the frequency of risk linked to falling export prices.

Figure 55. Evolution of the unit value of Tunisia's olive oil exports (HS code 1509) and threshold for calculating the frequency of risk linked to a fall in the export price



Source: Authors, based on TRADE MAP data.

Credit repayment difficulties

For the 2019-2020 olive production season and following the collapse of prices on the domestic and export markets, the government has decided to reschedule loans contracted by crushers, while abolishing interest on arrears, applied to bank loans granted to oil mill owners and olive oil exporters due to the financial difficulties encountered during both the 2018-2019 and 2019-2020 seasons. In addition, the government has lowered the interest rate for olive producers applying for bank loans (a preferential interest rate of minus 3 points compared with the normal rate).

Table 17. Prioritization of risk exposure for distributors and exporters in the olive oil value chain

	Risks	Probability	Probability score	Average Impact: Loss	Average impact score (Iave)	Maximum impact: Loss	Maximum impact score (Imax)	Risk score
14	Falling export prices	15.0%	3	- 336 / ton - 10,54% - 250.2 million TND (81 million USD)	2	- 656 ton - 20.59% - 488,5 million TND (157 million USD)	3	5.1
15	Loss of international market share	20.0%	3	- 12.493 thousand tons - 1.8% -150 million TND (48 million USD)	2	- 21.72 thousand tons - 260 million TND (84 million USD)		4.8
16	Loss of market share-EU	15.0%	3	- 8.064 thousand tons - 7% (export volumes V97 million TND (31 million USD)	2	- 13.988 thousand tons (export volumes) -168 million TND (54 million USD)	2	4.8
13	Credit repayment difficulties	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.0
18	Regulation and storage of production and export surpluses	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.0
20	Changes to EU export quota rules	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	Loss of revenue affecting < 10% of actors	1	1.0

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7* (Probability score*Iave) + 0.3* (Imax)
Source: Authors.

6.6 Risk assessment and prioritization at financial services level

Situations of olive theft and vandalism have a significant impact on financial services. The increase in these crimes in the agricultural sector, particularly in olive and oil production, is reducing insurers' risk management capacity, exposing them to significant financial losses.

As a result, insurance premiums are rising and the number of actors in the sector is falling. In addition, credit repayment difficulties are putting further pressure on financial services.

Table 18 prioritizes the main risks to which financial services in the olive oil value chain are exposed.

Table 18. Prioritization of risk exposure for financial services at the olive oil value chain level

	Risks	Probability	Probability score	Average Impact: Loss	Average impact score (Iave)	Maximum impact: Loss	Maximum impact score (Imax	Risk score
21	*Theft and vandalism (stocks, equipment and materials, etc.)*	*Qualitative*	2	- PLoss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.7
13	*Credit repayment difficulties*	*Qualitative*	1	- Loss of revenue affecting < 10% of actors	1	- Loss of revenue affecting < 10% of actors	1	1.0

N.B. Only risks that directly affect this link in the value chain are presented.
Risk score = 0.7 (Probability score*Iave) + 0.3* (Imax)*
Source: Authors

6.7 Prioritization of risk exposure for the whole olive farming value chain

At the level of the entire olive oil value chain, the 21 risks are prioritized by averaging the risk score of the actors for each of the identified risks. This prioritization shows that the main risks to the development of this value chain are 1) the failure to meet cooling needs; 2) agricultural drought and 3) rising producer prices for olives.

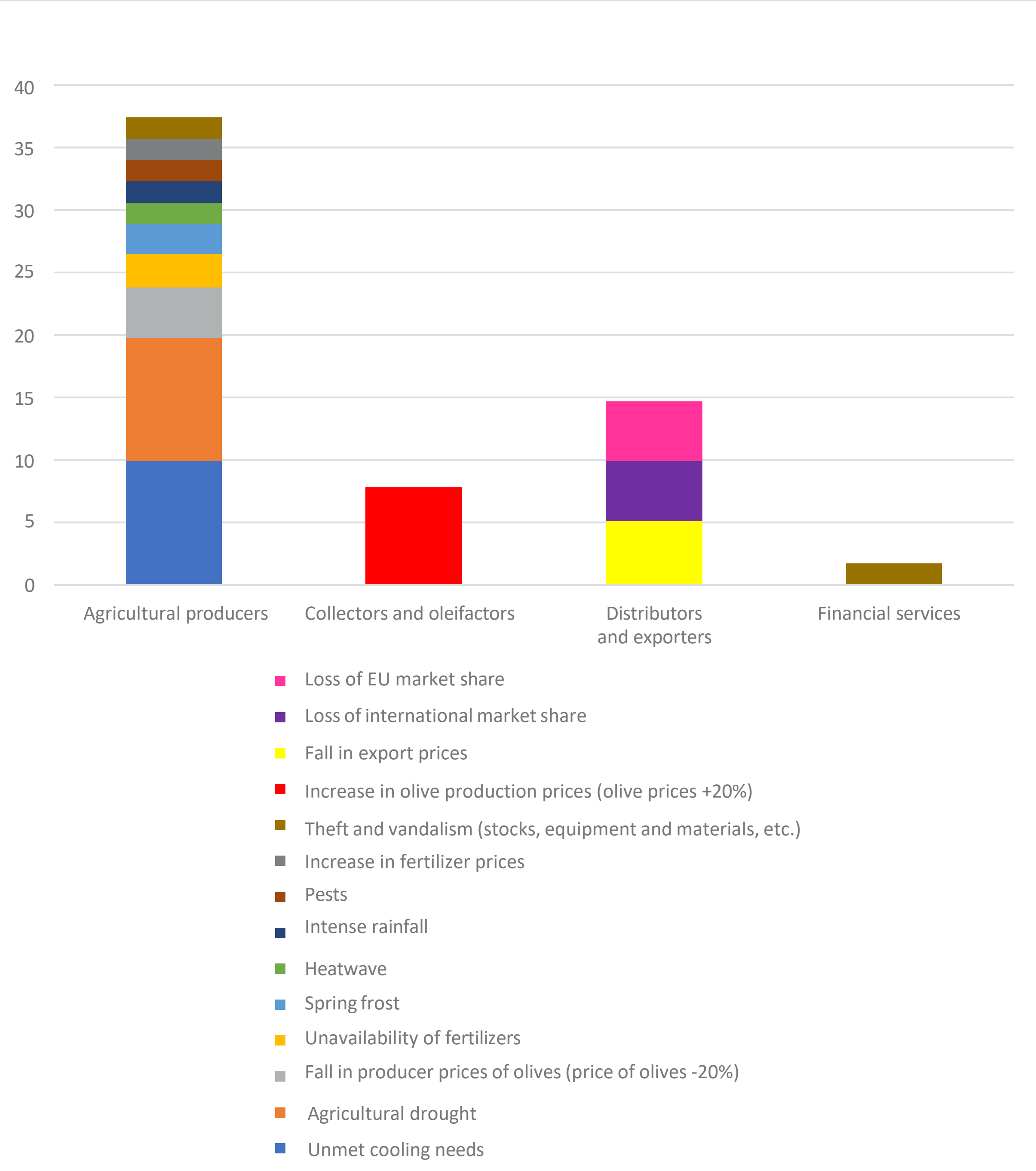
In terms of actors in the olive oil value chain, those most exposed to risk are 1) oil olive producers, 2) distributors and exporters, and 3) collectors and oil processors.

Table 19. Prioritization of risk exposure at stakeholder level and across the olive oil value chain

	Risks	Input suppliers	Agricultural producers	Collectors and oleifactors	Distributors and exporters	Financial Services	Value chain
2	Unmet cooling needs	NA	9,90	NA	NA	NA	9.90
1	Agricultural drought	NA	9,90	NA	NA	NA	9.90
12	Increase in producer prices for olives (price of olives +20%)	NA	NA	7,80	NA	NA	7.80
14	Falling export prices	NA	NA	NA	5,10	NA	5.10
15	Loss of international market share	NA	NA	NA	4,80	NA	4.80
16	Loss of market share-EU	NA	NA	NA	4'80	NA	4.80
11	Fall in producer prices for olives (price of olives -20%)	NA	4,00	NA	NA	NA	4.00
10	Unavailability of fertilizers	NA	2.70	NA	NA	NA	2.70
6	Pests	NA	2,40	NA	NA	NA	2.40
3	Spring frost	NA	2.40	NA	NA	NA	2.4
4	Heatwave	NA	1,70	NA	NA	NA	1.70
5	Intense rainfall	NA	1,70	NA	NA	NA	1.70
9	Rising fertilizer prices	NA	1,70	NA	NA	NA	1.70
21	Theft and vandalism (stocks, equipment and materials, etc.)	NA	1,70	NA	NA	1.70	1.70
7	Xylella fastidiosa threat	NA	1	NA	NA	NA	1.0
8	Increase in raw material prices for fertilizer production	1	NA	NA	NA	NA	1.0
13	Credit repayment difficulties	NA	1	1	1	1	1.0
17	Farm labor shortage	NA	NA	1	NA	NA	1.0
18	Regulation and storage of production and export surpluses	NA	NA	1	1	NA	1.0
19	Blockade of production sites	1	NA	NA	NA	NA	1.0
20	Changes to EU export quota rules	NA	NA	NA	1	NA	1.0
	Average per actor	1.00	3.34	2.70	2.95	1.35	

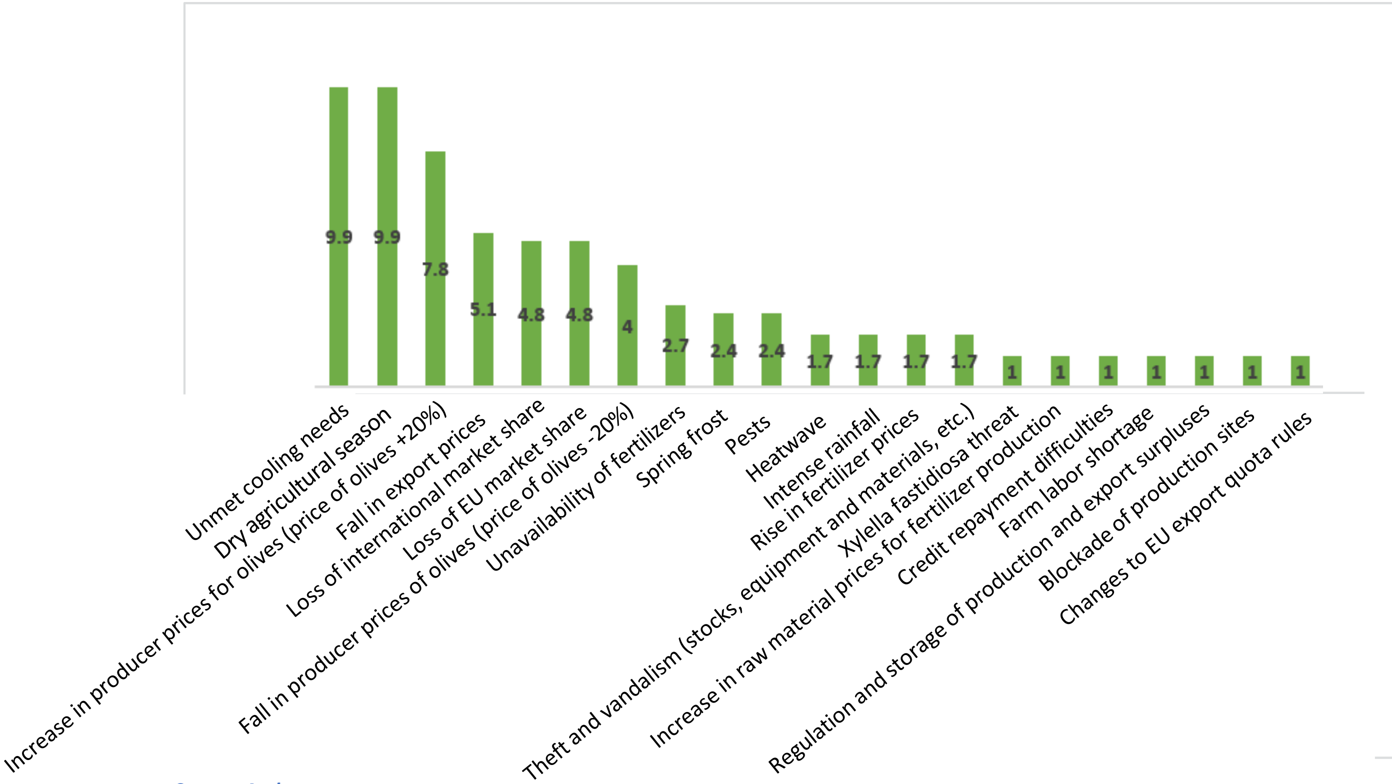
N.B. NA (not applicable) indicates that according to our surveys and the literature, the risk in question does not directly affect the actors in this link of the value chain.

Fig.56 Cumulative risk scores by type of stakeholder and by type of risk in the olive farming value chain



Note: The maximum score for each risk is 12. For ease of reading, only scores >1 are shown here.

Fig.57 Prioritization of risk exposure in the olive oil production value chain



Source: Authors

7 Inventory of existing agricultural risk management solutions in Tunisia

7.1 Country context and process of developing the National Strategy for Disaster Risk Reduction to 2030

Tunisia is in the process of setting up a national framework for risk management and disaster risk reduction in order to anticipate, prevent, mitigate and respond to the various risks it may face. The process of drawing up the National Strategy for Disaster Risk Reduction (DRR) to 2030 and its action plan was initiated by the Ministry of the Environment (ME) as one of the five pillars of the National Strategy for Ecological Transition *[72]*.

This new strategy takes account of the risks involved in achieving the objectives of the Agenda 2030 and the Sendai Framework for Disaster Risk Reduction (2015-2030), and defines the main national guidelines for DRR in Tunisia, the objectives to be achieved by 2030, as well as the strategic priorities and actions to be implemented.

The national strategy for DRR by 2030 should be a response to the need to update the 1991-1993 disaster risk reduction system, which no longer meets the various challenges facing the country. These challenges are compounded by multidimensional vulnerability (poverty in rural and peri-urban areas, spontaneous or anarchic construction, dysfunctional land-use planning, etc.), making the impact of any hazard more severe.), making the impact of any hazard very high and very costly for the population.

It is worth noting that prior to 1990, Tunisia had not developed an institutional framework specifically linked to DRR, with the exception of the National Institute of Meteorology and the Directorate General of Civil Protection (ME, 2021), and it was not until 1991 that the country adopted a number of legal provisions, following the launch of the International Decade for Natural Disaster Reduction (1990-1999) *[73]*.

Implementation of the national strategy for DRR would require funding of 550 million dinars (175.5 million USD), and Tunisia has already begun to implement it with a budget of around 360 million dinars (115 million USD) *[74]*.

The strategy document drawn up in 2021 provides the main national guidelines for DRR, taking into account the diversity of the actors involved. It also provides the national framework for coordinating and guiding DRR, in line with public development policies and sectoral policies relating to DRR. Figure 18 summarizes the main strategies, programs and action plans for disaster risk reduction in Tunisia.

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[72] This strategy was adopted on February 3, 2023.

[73] Since 1991, the country has adopted important legal provisions, such as Law 91-39 of June 8, 1991 on disaster prevention and relief, and Decree no. 93-942 of April 26, 1993, laying down the procedures for drawing up and implementing national and regional plans for disaster prevention and relief. In addition, Law 93-121 of December 27, 1993 transformed the General Directorate for Civil Protection into the National Office for Civil Protection (ONPC), and Law 96-29 of April 3, 1996 introduced a national emergency response plan to combat marine pollution incidents.

[74] According to a statement by the head of the Tunisian government at the Arab-African Forum on Science and Technology for Disaster Risk Reduction, held in Tunis in October 2023

Figure 58. Main disaster risk reduction strategies, programs and action plans in Tunisia

Nationally Determined Contribution	Tunisia 2050 Water Vision Strategy	Tunisia 2030 National strategy to combat desertification	Strategy and National Action Plan for Biodiversity 2018-2030
2030 Strategy for Integrated Coastal Zone Management	2030 Blue Economy Strategic Plan	2030 Green Economy Strategic Plan	National environmental protection strategy post 2020
National climate change adaptation plan	Local disaster risk reduction strategies and action plans RRC in the townships of Gabes, Mateur, Ain Drahem and Tataouine	Action plan for post-flood recovery in Nabeul governorate (2019)	Emergency Response Plans for Djerba Island and Ghar El Melh/Kalaât El Andalous

Source: Based on the National Strategy for Disaster Risk Reduction 2030 and Action Plan (ME, 2021).

7.2 Schemes benefiting the agricultural sector

7.2.1 Ministry of Agriculture departments involved in risk management

In Tunisia, at institutional level, several departments and services within the ministry in charge of agriculture are involved in risk management:

- The Directorate General of Plant Health and Control of Agricultural Inputs (DGSVCIA), through its Directorate of Plant Protection, is responsible for monitoring the situation of quarantine organisms, setting up programs to control these organisms, limiting their spread, diagnosing and identifying plant diseases, issuing alerts if necessary to combat harmful organisms, and conducting national pest control campaigns to diagnose and identify plant diseases, to issue pest control alerts where necessary, monitor their implementation and evaluate their results. It is also responsible for verifying the phytosanitary situation of plant products intended for import and export, monitoring the situation of locusts, rodents and birds, and organizing control campaigns where necessary and monitoring and analyzing residues of agricultural products.

- The Directorate General of Veterinary Services (DGSV) is responsible for monitoring and assessing the health status of livestock, combating contagious diseases common to animals and humans, collecting, analyzing and disseminating health data, monitoring the evolution and spread of animal diseases, and formulating the guidelines and procedures needed to control the health risks arising from the import of animals and animal products (Directorate of standardization and health control at the borders).

- The Directorate General of Forests (DGF), through its forest conservation department, is responsible for monitoring forests and protecting them against fire and disease.
- The General Directorate of Dams and Water Works (DGBGTH) (and more specifically its water mobilization studies department) is responsible, among other things, for studying and carrying out works to protect rural and agricultural areas against wadi flooding.
- The Bureau de la Planification et des Equilibres Hydrauliques (BPEH), which reports to the Cabinet of the Ministry of Agriculture, is responsible, among other things, for proposing plans and programs for the allocation of water resources to the various users, taking into account the supply of available and exploitable water resources and the demand of the various socio-economic sectors.

7.2.2 Public financial instruments for risk protection: Budget allocation mechanisms

7.2.2.1 National Guarantee Fund

The National Guarantee Fund (FNG) was created by Law n°100 of December 31, 1981, the Finance Law for 1982, is placed under the supervision of the Ministry of Finance and managed by the Tunisian Guarantee Company (SOTUGAR).

To encourage credit institutions, development associations and venture capital companies to finance the creation and expansion of economic projects and to control the risks incurred, the National Guarantee Fund guarantees the settlement of:

- certain loans granted by credit institutions ;
- loans granted by Banque Tunisienne de Solidarité (BTS);
- microloans granted by associations;
- certain types of investments made by venture capital companies.

Table 20. Loans declared for guarantee and rescheduled agricultural loans benefiting from the assumption of related interest by the National Guarantee Fund (FNG)

		2016	2017	2018	2019	2020
Loans declared for guarantee						
Number of loans declared	Total	28,560	30 185	37 176	42 735	38 232
	Agriculture and fishing	4 010	4 057	3 714	3 091	2 325
Value of loans declared fo	Total	199,146	204,757	194,369	214,607	194,472
	Agriculture and fishing	53,094	57,079	60,004	55,064	46,535
Rescheduled agricultural loans benefiting from the assumption of the related interest by the Fonds National de Garantie (National Guarantee Fund)						
Number		1036	1001	918	1725	1300
Total value of rescheduled agricultural loans		12, 786	12, 274	5 ,564	11, 143	
Amounts spent on interest resulting from drought loan rescheduling (MDT)		1, 272	1, 960	1, 881	2, 222	1, 534

Source: Ministry of Finance. Report on Special Funds activity for 2020

It should be noted that the Fund's resources come mainly from the following amounts:

- the 0.3125% guarantee commission deducted by banks and applied to bank statements; the contribution of beneficiaries of loans value chain by the Fund's guarantee, levied by
- the banks at a rate of:

    i. 3% of the amount of the loan granted to small businesses operating in the manufacturing and services sector benefiting from the Fonds de Promotion et de Décentralisation Industrielles (Industrial Promotion and Decentralization Fund),

    ii. 1.5% of the amount of the loan guaranteed by the Société de Garantie Mutuelle Agricole to which the loan beneficiary belongs,

    iii. 1% of the loan amount for short-term farm loans

    iv. 2% of the loan amount for other loans guaranteed by the Fonds National de Garantie

    v. 1% of the loan amount for loans granted by associations.

- A contribution from venture capital companies of 3% of the total amount of equity investments they make, and which benefit from the Fund's guarantee; - any other resources that may be allocated to the Fund in accordance with the laws and regulations in force.

7.2.2.2 *Insured Guarantee Fund*

The Fonds de Garantie des Assurés (FGA) was created by law no. 98 of December 25, 2000, the Finance Act for 2001. It is supervised by the Ministry of Finance (MF) and managed by the STAR insurance company.

This fund guarantees policyholders in the event of insurance company insolvency by paying the compensation owed by these companies at the request of the Minister of Finance[75].
The resources of this fund consist of:

- Company contributions: 1% of non-life insurance premiums net of cancellations, taxes and reinsurance.
- Policyholder contributions: 3 dinars for each premium receipt issued when policies are taken out or renewed.
- Any other resources that may be allocated to it by the laws and regulations in force.

7.2.2.3 *Agricultural Damage Compensation Fund*

Created by Law no. 66 of December 18, 2017, on the 2018 Finance Act, the Fonds d'Indemnisation des Dommages Agricoles Causés par les Calamités Naturelles (FIDAC) (Agricultural Damage Compensation Fund for Natural Calamities) has the ministry in charge of agriculture as its supervisory structure and the CTAMA mutual insurance company as its managing body.

The purpose of this fund is to provide member farmers and fishermen with a compensation mechanism for agricultural damage. The activities concerned are irrigated and rain-fed farming, livestock breeding, agricultural production and fishing.

This fund only covers damage caused by floods, storms, wind, drought, frost and snow. These risks only give rise to compensation if the loss:

- is not covered by a commercially available insurance policy,
- is due to climate change,
- is exceptionally intense,
- is inevitable and irrepressible,
- caused heavy material losses.

The resources of this fund come from:

- from the State budget through a subsidy of 30 million dinars per year;
- an insurance contribution to the Fund of 2.5% of the value of insured production or expenses incurred;
- and a solidarity contribution of 1% levied on a list of agricultural products, i.e. fruit and vegetables, cereals collected by the Cereals Office, olives and fish products...

[75] The fund's value chain of intervention has been broadened under law no. 2019-24 to enable it, on a purely exceptional basis, to compensate for direct material damage resulting from the 2018 Nabeul floods that affected economic institutions and their activities. The management of this section has been entrusted to the national reinsurer Tunis Re. In this respect, 173 economic entities benefited from compensation from the fund for a total amount of TND 7.01 million

To trigger compensation, three major conditions must be met:

1. 25% is the loss threshold corresponding to the minimum rate of observed damage triggering compensation.
2. Confirmation by government decree of the occurrence of the natural disaster, the areas affected, the activities affected and the period of time.
3. Commission Nationale des Catastrophes Naturelles Agricoles (CNCNA) approval of compensation payments.

7.2.3 Insurance financial instruments: Agricultural insurance

The available data highlight the persistent challenges facing the agricultural insurance sector in Tunisia, underlining the crucial importance of finding effective solutions to protect farmers against the risks they face *[76]*.

In 2016, Tunisia had around 516,000 farmers, of whom only 40,000 were insured, representing less than 8% of all farmers. Despite a turnover of 6.4 million TND (2.6 million USD) recorded in 2017 in the agricultural insurance sector, this represented only 0.31% of the total volume of insurance premiums for that same year. The three companies CTAMA, ASTREE and COMAR dominate the Tunisian agricultural insurance market.

Despite initiatives to encourage agricultural insurance, nearly 92% of Tunisian farmers are still uninsured. This low rate is partly explained by the fragmentation of landholdings, the absence of compulsory coverage, farmers' lack of interest and the high rates charged by insurers.

[76] This section is based in part on the information available in these two references: "Tunisie : le secteur agricole face aux catastrophes naturelles" - Available at: https: //www.atlas-mag.net/article/tunisie-le-secteur-agricole-face-aux-catastrophes-naturelles and "L'assurance des risques agricoles en Tunisie" - Available at: https: //www.atlas-mag.net/article/l-assurance-des-risques-agricoles-en-tunisie.

Table 21. Main agricultural insurance products in Tunisia

	Risks	Branches / Categories	Details on the insurance cover
Plant	Hail	Standing crops, including cereals, irrigated crops, fruit trees, citrus, wine and vegetables	Reimbursement for the destruction of products caused by the mechanical action of hailstones on standing crops.
	Fire	Standing cereals, forage crops and pulses	Coverage of crops and buildings, forage in the open air and in sheds
	Multi-risk	Greenhouse and open-field crops	Compensation for damage to greenhouses and crops resulting in crop loss
Animal	Livestock	Cattle, sheep, goat, horse, camel, poultry and fish farming	In the event of illness, accident, death due to reproductive failure or emergency slaughter
	Accidents and Fire	Poultry	In the event of fire and malfunction of ventilation and heating equipment
Farm	Fire and natural phenomena	Silos, greenhouses, product loss in cold stores	In the event of accidental fire and exceptional weather conditions
	Accidents and breakdown of Machines	Agricultural equipment and machinery, product loss in cold stores	In the event of accident, breakdown/malfunction damage or bodily injury: driver's liability, vehicle replacement/rental reimbursement

Source: Authors, based on the Study on risk management and the introduction of an agricultural insurance system in Tunisia. FINACTU, DGFIOP/MARHP (2018).

7.2.4 National Adaptation Plan

In close collaboration with the Ministry of Agriculture, Water Resources and Maritime Fishing and the Ministry of the Environment, the FAO began work on the National Adaptation Plan (NAP) after the Green Climate Fund (GCF) responded favorably to a request for funding. work on the National Adaptation Plan (NAP) after the Green Climate Fund (GCF) *[77]* responded positively to the request for its funding *[78].*

This National Adaptation Plan (NAP) "Food security and adaptation priorities for agriculture" aims to improve food security and resilience to climate change (CC) by formulating adaptation options in the agricultural sector (water, land, crops, livestock, fisheries, aquaculture, forests and pastures) *[79]*.

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[77] *The FVC is the financial mechanism of the United Nations Framework Convention on Climate Change.*

[78] *With a budget of $954,068, this project is scheduled to run from August 2021 to January 2025.*

[79] *The process of developing the National CC Adaptation Plan in Tunisia was officially launched on August 16, 2018. This NAP is the first measure to be undertaken under Priority 2 of the updated 2021 Nationally Determined Contribution (NDC) to strengthen food resilience (FR) in Tunisia by 2030. The updated 2021 NDC makes it possible to communicate efforts to mitigate greenhouse gas (GHG) emissions and adapt against the impacts of Climate Change (CC) to contribute to the global response to the threat of climate change and achieve the objectives set out in Article 2 of the Paris Climate Agreement.*

https://unfccc.int/sites/default/files/NDC/2022-06/Tunisia%20Update%20NDC-french.pdf

It also aims to promote the planning of adaptation actions, notably by clarifying the roles and contributions of stakeholders, including the private sector. The implementation of this PNA should lead to the following results:

(i) Strengthening knowledge of CC adaptation for informed decision-making;

(ii) Strengthening the resilience of the agricultural sector through climate-smart investments and the development of Public-Private Partnerships (PPPs);

(iii) Strengthening the adaptive capacities of the most vulnerable rural communities through the implementation of social protection mechanisms and digital innovation.

7.2.5 Cooperation with TFPs to prevent domestic market supply disruptions

In a difficult budgetary context and faced with rising commodity prices on the international market as a result of the war in Ukraine, Tunisia has requested budgetary support from several technical and financial partners to cover the risk of grain supply disruptions and to support the country's food security in order to avoid shortages of cereal products on the national market.

In this respect, the credits contracted by the country to finance cereal imports for the year 2022 have reached more than 360 million USD (i.e. more than 1.14 billion TND) and several of the country's public companies (Office des Céreales, Office National de l'Huile and Office du Commerce de la Tunisie), responsible for ensuring the regular supply of food products (cereals, vegetable oil, sugar, rice, coffee, etc.) to the national market, are experiencing difficulties in terms of cash flow.), are experiencing difficulties in terms of the pace of supply to the national market compared with previous years.

8 Risk management capacity and vulnerability assessments

8.1 Risk management capacity assessment for the cereal value chain

Table 22 provides an overall perspective on the ability of cereal value chain actors to manage risk by examining the different risk management options identified during the collective discussions on their risk management capabilities.

In Tunisia, the financial services sector has the highest risk management capacity at value chain level. In addition, certain risk management options identified and proposed by stakeholders could strengthen the resilience of cereal producers.

On the other hand, Tunisia's cereal collection sector, which also acts as an input supplier to the cereal industry, has the lowest risk management capacity score.

8.2 Risk management capacity assessment for the olive oil value chain

The analysis of the capacity of olive oil value chain actors to manage risks through the assessment of risk management options identified during collective discussions on risk management capacities is presented in Table 23.

As a result, the risk management capacity of financial services (insurers) is the least developed among actors in the Tunisian olive oil value chain. When acts of theft and vandalism target this value chain, they have a detrimental effect on the insurance business, resulting in higher insurance premiums and lower customer loyalty. To face up to this risk, government intervention is crucial to implement safety measures, support awareness-raising programs and reinforce the protection of agricultural activities.

On the other hand, according to the participants in the collective reflection on risk management, olive oil distributors and exporters in Tunisia have various options for maintaining their operations. They are also considered to have the highest risk management capability within this value chain.

Table 22. Risk management options and capacity in the cereal value chain

Risks	Risk management options	Input suppliers: EF (1-3)	Input suppliers: AP (1-4)	Input suppliers: Risk management capability	Agricultural producers: EF (1-3)	Agricultural producers: AP (1-4)	Agricultural producers: Risk management capability	Collectors: EF (1-3)	Collectors: AP (1-4)	Collectors: Risk management capability	Processing and distribution: EF (1-3)	Processing and distribution: AP (1-4)	Processing and distribution: Risk management capability	Financial Services: EF (1-3)	Financial Services: AP (1-4)	Financial Services: Risk management capability
Dry agricultural season	Agricultural risk map for the development of climate insurance schemes				2	2	4									
Spring drought	Improving the dissemination of techniques by strengthening extension services and upgrading agents' skills		NA		2	3	6									
March drought	Choice of techniques				1	3	3									
Grain scalding	Complementary irrigation				3	1	3									
Spring heat stress	Choosing the right varieties				3	2	6									
Severity of scalding	Complementary irrigation				3	1	3		NA							
Shortening the development cycle	Scientific research				3	3	9									
early maturity date	Adopting a strategic perspective on climate change and cereal maturity				3	3	9									
Intense rainfall	Increased phytosanitary treatment, fertilizer inputs and storage development				3	2	6					NA				
Spring frost	Development of insurance systems				1	1	1									
Fungal diseases	Variety selection and technical package				3	3	9								NA	
Fires	Development of insurance solutions				3	3	9	1	1	1						
Increase in raw material prices for fertilizer production	Subsidy mechanisms	1.5	2	3	3	3	9									
Increase in fertilizer prices	Developing fertilizer storage and strengthening price monitoring to prevent volatility				2	1	2		NA							
Increase in seed prices	Strengthening seed production				3	1	3									
Unavailability of certified seed	Subsidy + seed production + extension				3	3	9	1	1	1						
Unavailability of fertilizers	Extension and support with subsidies				3	3	9	1	1	1						
Disruption to the collection season	Storage development		NA					3	3	9						
Increase in cereal import prices	Better management of choices concerning cereal import dates					NA					3	3	9			
Foreign exchange risk	Strengthening local production								NA		1	1	1			
Access to credit	Strengthening financing and microfinance				3	3	9									
Financing the grain harvest	Easier credit procedures							1	1	1		NA		3	3	9
Credit risk exposure	Development of insurance systems													3	3	9
Blockade of production sites	Resolving social conflicts	3	1	3		NA										
Increase in demurrage charges	Increase the financial autonomy of the grain board								NA		3	2	6		NA	
Sustainability of regulation and compensation	Flexible governance										1	1	1	1	1	1
	Average per player			**3.00**			**6.06**			**2.60**			**4.30**			**6.30**

N.B. NA (not applicable) indicates that according to our interviews and literature review, the risk in question does not directly affect the actors in this link of the value chain
Source: Authors.

Table 23. Risk management options and capacity at the olive oil value chain level

Risks	Risk management options	Input suppliers			Agricultural producers			Collectors and oleifactors			Distributors and exporters			Financial Services		
		EF (1-3)	AP (1-4)	Risk management capabilities	EF (1-3)	AP (1-4)	Risk management capability	EF (1-3)	AP (1-4)	Risk management capability	EF (1-3)	AP (1-4)	Risk management capability	EF (1-3)	AP (1-4)	Risk management capability
Agricultural drought	Water and soil conservation Efforts	NA			2	4	8									
Unsatisfied cooling requirements	Use of biostimulants				1	1	1									
Spring frost	Crop insurance				2	2	4									
Heatwave	Complementary irrigation				2	2	4									
Intense rainfall	Water and soil conservation Efforts				2	4	8									
Pests	Phytosanitary treatment and integrated pest management				3	4	12									
Xylella fastidiosa threat	State intervention				1	1	1		NA							
Rising raw material prices for fertilizer production	Spreading margines and recycling pruning wood	1.5	2	3		NA						NA			NA	
Rising fertilizer prices	Adding compost				1	1	1									
Unavailability of fertilizers	Greater awareness and encouragement				3	4	12									
Fall in producer prices for olives (price of olives -20%)	Storage				3	3	9									
Increase in producer prices for olives (price of olives +20%)	Export					NA		3	4	12						
Credit repayment difficulties	Credit insurance				1	1	1	3	4	12	3	4	12	2	2	4
Falling export prices	Forward sales	NA									3	4	12			
Loss of international market share	Marketing strategy								NA		2	4	8			
Loss of market share-EU	Increase in the share of packaged olive oil										2	4	8			
Farm labor shortage	New mechanization and capacities							1	1	1		NA				
Regulation and storage of production and export surpluses	On-farm storage					NA		3	4	12	3	4	12		NA	
Blockade of production sites	Resolving social conflicts	3	1	3												
Changes to EU export quota rules	Market diversification								NA		3	4	12			
Theft and vandalism (stocks, equipment and materials, etc.)	State intervention				1	1	1					NA		1	1	1
	Average per player			**3.00**			**5.17**			**9.25**			**10.67**			**2.50**

N.B. NA (not applicable) indicates that according to our interviews and literature review, the risk in question does not directly affect the actors in this link of the value chain.
Source: Authors' calculations

8.3 Measuring vulnerability

According to the methodology defined by PARM, vulnerability assessment should lead to the calculation of a vulnerability index (IV) based on two key dimensions:

- ExpRisk exposure (RE): the nature or degree of exposure of a value chain to significant risks, measured by the risk score.
- Risk management capability (RMC): the ability of value chain actors to manage identified risk events, i.e. the capacity of existing measures to avoid, reduce, mitigate or transfer risks, or the ability to value chain with the consequences of risks by accepting and preparing for them. avoid, reduce, mitigate or transfer risks, or the ability to value chain with the consequences of risks by accepting and preparing for them.

Thus, the vulnerability index can be calculated from the risk score and the risk management option score by applying the following formula:

Vulnerability index IV= Risk score × 0.7 +12 - CGR score) × 0.3

Moderate vulnerability occurs when risk is low and/or adaptive capacity is high, while high vulnerability is characterized by high risk and limited adaptive capacity.

At the end of the vulnerability assessment, a vulnerability index is assigned to each value chain, stakeholder group and risk. facilitating a direct comparison for prioritizing and developing a targeted and effective Agricultural Risk Management (ARM) strategy.

8.3.1 Vulnerability assessment for cereal value chain

Within the cereals value chain, farmers and collectors are the links most exposed to risk. Their high vulnerability is mainly due to high exposure to climatic risks coupled with limited capacity to manage these risks (Table 24). As a whole, the cereal value chain is particularly sensitive to production risks, with a vulnerability index exceeding 5.5 for five major risks: drought during the agricultural season, rising fertilizer prices, the severity of scalding, the shortening of the development cycle, and the earlier maturity date of cereals.

8.3.2 Vulnerability assessment for the olive oil value chain

As in the cereals value chain, oil olive producers are the most vulnerable to the risks that can impact the olive oil value chain (Table 25). Unsatisfied cooling needs and agricultural drought stand out as the most significant risks for this value chain, with vulnerability indices exceeding a score of 8.

Table 24. Vulnerability by risk and by stakeholder in the cereals value chain

<table>
<tr><th></th><th>Risks</th><th>Input</th><th>Agricultural</th><th>Collectors</th><th>Processing and distribution</th><th>Financial services</th><th>V C</th></tr>
<tr><td>1</td><td>Dry agricultural season</td><td rowspan="12">NA</td><td>7.7</td><td rowspan="11">NA</td><td rowspan="18">NA</td><td rowspan="21">NA</td><td>7.7</td></tr>
<tr><td>2</td><td>Spring drought</td><td>3.5</td><td>3.5</td></tr>
<tr><td>3</td><td>March drought</td><td>5.1</td><td>5.1</td></tr>
<tr><td>4</td><td>Grain scalding</td><td>4.6</td><td>4.6</td></tr>
<tr><td>5</td><td>Spring heat stress</td><td>5.2</td><td>5.2</td></tr>
<tr><td>6</td><td>Severity of scalding</td><td>6.3</td><td>6.3</td></tr>
<tr><td>7</td><td>Shortening the development cycle</td><td>6.2</td><td>6.2</td></tr>
<tr><td>8</td><td>Advance ripening date</td><td>5.7</td><td>5.7</td></tr>
<tr><td>9</td><td>Intense rainfall</td><td>3.0</td><td>3.0</td></tr>
<tr><td>10</td><td>Spring frost</td><td>5.0</td><td>5.0</td></tr>
<tr><td>11</td><td>Fungal diseases</td><td>2.1</td><td>2.1</td></tr>
<tr><td>12</td><td>Fires</td><td>2.1</td><td>4,0</td><td>3.0</td></tr>
<tr><td>13</td><td>Increase in raw material prices for fertilizer production</td><td>3.4</td><td>0.9</td><td rowspan="3">NA</td><td>2.2</td></tr>
<tr><td>14</td><td>Increase in fertilizer prices</td><td rowspan="10">NA</td><td>6.6</td><td>6.6</td></tr>
<tr><td>15</td><td>Increase in seed prices</td><td>3.4</td><td>3.4</td></tr>
<tr><td>16</td><td>Unavailability of certified seeds</td><td>2.6</td><td>4.0</td><td>3.3</td></tr>
<tr><td>17</td><td>Unavailability of fertilizers</td><td>2.8</td><td>4.0</td><td>3.4</td></tr>
<tr><td>18</td><td>Disruption to the collection season</td><td rowspan="3">NA</td><td>4.7</td><td>4.7</td></tr>
<tr><td>19</td><td>Increase in cereal import prices</td><td rowspan="3">NA</td><td>2.5</td><td>2.5</td></tr>
<tr><td>20</td><td>Foreign exchange risk</td><td>5.2</td><td>5.2</td></tr>
<tr><td>21</td><td>Access to credit</td><td>2.1</td><td rowspan="4">NA</td><td>2.1</td></tr>
<tr><td>22</td><td>Financing the grain harvest</td><td rowspan="5">NA</td><td>4.0</td><td>2.6</td><td>3.3</td></tr>
<tr><td>23</td><td>Credit risk exposure</td><td rowspan="4">NA</td><td>2.1</td><td>2.1</td></tr>
<tr><td>24</td><td>Blockade of production sites</td><td>3.4</td><td rowspan="2">NA</td><td>3.4</td></tr>
<tr><td>25</td><td>Increase in demurrage charges</td><td rowspan="2">NA</td><td>2.5</td><td>2.5</td></tr>
<tr><td>26</td><td>Sustainability of regulation and compensation</td><td>4.0</td><td>4.0</td><td>4.0</td></tr>
<tr><td></td><td>Average per actor</td><td>3.4</td><td>4.1</td><td>4.1</td><td>3.6</td><td>2.9</td><td></td></tr>
</table>

N.B. NA (not applicable) indicates that the risk in question does not directly affect the actors in this link of the value chain.

Source: Authors.

Table 25. Vulnerability by risk and by stakeholder in the olive oil production value chain

<table>
<tr><th></th><th>Risks</th><th>Input suppliers</th><th>Agricuture Producers</th><th>Collectors</th><th>Distributors and exporters</th><th>Financial services</th><th>value chain</th></tr>
<tr><td>1</td><td>Dry agricultural season</td><td rowspan="7">NA</td><td>8.1</td><td rowspan="11">NA</td><td rowspan="12">NA</td><td rowspan="12">NA</td><td>8.1</td></tr>
<tr><td>2</td><td>Unmet cooling needs</td><td>10.2</td><td>10.2</td></tr>
<tr><td>3</td><td>Spring frost</td><td>4.1</td><td>4.1</td></tr>
<tr><td>4</td><td>Heatwaves</td><td>3.6</td><td>3.6</td></tr>
<tr><td>5</td><td>Intense rainfall</td><td>2.4</td><td>2.4</td></tr>
<tr><td>6</td><td>Pests</td><td>1.2</td><td>1.2</td></tr>
<tr><td>7</td><td>Xylella fastidiosa threat</td><td>4.0</td><td>4.0</td></tr>
<tr><td>8</td><td>Rise in raw material prices for fertilizer production</td><td>3.4</td><td></td><td>3.4</td></tr>
<tr><td>9</td><td>Increase in fertilizer prices</td><td rowspan="10">NA</td><td>4.5</td><td>4.5</td></tr>
<tr><td>10</td><td>Unavailability of fertilizers</td><td>1.9</td><td>1.9</td></tr>
<tr><td>11</td><td>Fall in producer prices for olives (olive prices -20%)</td><td>3.7</td><td>3.7</td></tr>
<tr><td>12</td><td>Increase in producer prices for olives (olive prices +20%)</td><td></td><td>5.5</td><td>5.5</td></tr>
<tr><td>13</td><td>Credit repayment difficulties</td><td>4.0</td><td>0.7</td><td>0.7</td><td>3.1</td><td>2.1</td></tr>
<tr><td>14</td><td>Fall in export prices</td><td rowspan="7"></td><td rowspan="3">NA</td><td>3.6</td><td rowspan="7">NA</td><td>3.6</td></tr>
<tr><td>15</td><td>Loss of international market share</td><td>4.6</td><td>4.6</td></tr>
<tr><td>16</td><td>Loss of EU market share</td><td>4.6</td><td>4.6</td></tr>
<tr><td>17</td><td>Farm labor shortage</td><td>4.0</td><td>0.7</td><td>4.0</td></tr>
<tr><td>18</td><td>Regulation and storage of surplus production production and export surpluses</td><td>0.7</td><td>NA</td><td>0.7</td></tr>
<tr><td>19</td><td>Blockade of production sites</td><td>3.4</td><td rowspan="3">NA</td><td>0.7</td><td>3.4</td></tr>
<tr><td>20</td><td>Changes to the rules governing export quotas to the EU</td><td rowspan="2">NA</td><td>NA</td><td>0.7</td></tr>
<tr><td>21</td><td>Theft and vandalism (stocks, equipment and materials, etc.)</td><td>4.5</td><td></td><td>4.5</td><td>4.5</td></tr>
<tr><td></td><td>Average per actor</td><td>3.4</td><td>4.3</td><td>2.7</td><td>2.5</td><td>3.8</td><td></td></tr>
</table>

N.B. NA (not applicable) indicates that the risk in question does not directly affect the actors in this link of the value chain.
Source: Authors.

9 Proposed risk management actions and strategies

9.1 Risk management in the cereals industry

The action strategies listed below are recommended to complement each other and are, in PARM's experience, more effective together than separately.

9.1.1 New, tailored and innovative insurance products to strengthen resilience against weather-related risks

While progress still needs to be made in setting up climate insurance mechanisms in Tunisia, this study shows the seriousness of the risks associated with rising temperatures, both in terms of frequency and impact, adding to the challenges posed by water stress. For cereal production in Tunisia, the shortening of the development cycle, early maturity date and the increase in the severity of grain scalding are all major risks. It is imperative to envisage solutions adapted to these risks, in particular through the development of insurance programs specific to these particular risks. New insurance products could be designed to offer financial protection to producers and collectors against losses linked to these risks, especially in cereal-production areas with significant potential for gains in productivity and profitability. These insurance products will also be combined with other services that enhance the profitability of the insurance business. Reforming the framework governing the operation of markets, particularly with regard to agricultural pricing policy, is an essential prerequisite for the success of any Agricultural Risk Management (ARM) solution, guaranteeing the economic profitability of agricultural activity and stimulating investment.

Based on climate projections and changes in cereal-production suitability areas, it is crucial to encourage the creation of new insurance products in close collaboration with policymakers, financial services and agricultural research centers, and by involving producers and end-beneficiaries in order to facilitate financial inclusion. Decision-makers, financial services and agricultural research centers, and by involving producers and end-beneficiaries to facilitate financial inclusion, a customer-centric design that responds to their needs, particularly those specific to gender. The aim of this partnership is to provide effective risk protection that is profitable for farmers, in line with the future challenges facing the Tunisian cereals sector. It is essential to coordinate these initiatives in close collaboration with political decision-makers, financial institutions and agricultural research centers.

The development of suitable insurance products will focus on areas favorable to wheat production. In less favorable areas, we can offer incentives for conversion to hardier cereals - such as barley - or to crops suited to irrigation where possible - such as rapeseed - or to other crops such as arboriculture.

9.1.2 Strengthening the supply system for adapted seeds to improve cereal productivity

There is an urgent need to step up research and development into cereal varieties and seeds adapted to the risks associated with rising temperatures. This priority should focus on characteristics such as resistance to shortening of the development cycle, adaptability to earlier maturity dates and reduction of the effects of grain scalding.

Such an effort should be accompanied by the implementation of a policy to support the production of adapted seeds and their adoption by cereal producers and implies the implementation of incentives and policies that actively encourage the use of these resilient seeds by farmers.

It is also crucial to strengthen collaboration between agricultural research and extension in order to promote innovative practices such as agroecology. This integrated approach takes climatic risks into account and aims to optimize yields in response to water stress. This synergy between research and agricultural extension will enable us to effectively disseminate the knowledge and techniques needed for more sustainable and resilient agriculture in the face of climate challenges.

9.2 Risk management in the olive sector

9.2.1 Strengthen inter-trade groups to increase added value in the olive oil value chain

The creation of an inter-trade group for olive oil represents a major strategic opportunity to bring together the various actors (producers, oil processors, distributors, exporters and public authorities) and strengthen the sustainability and competitiveness of the olive oil value chain.

In Tunisia, despite its crucial economic and social role and the efforts made by the State through bodies such as the Office National de l'Huile, the olive oil value chain lacks an inter-trade grouping guided by the actors in the olive oil value chain and defending their interests.

In addition, acting as a forum for dialogue with public authorities, the inter-trade group would be tasked with engaging in agronomic, technical, economic, regulatory and communication activities, and addressing the specific challenges of the value chain. At the same time, it is recommended that consideration be given at national level to the development of a legal status aimed at strengthening the associative system of professional agricultural organizations, with the aim of enabling them to enhance their capacity to access financing, which is one of the key tools for better financial risk management. This initiative could foster better coordination between stakeholders, and help develop quality standards, promote innovation, and boost the visibility and competitiveness of Tunisian olive oil on national and international markets.

Alongside the strengthening of inter-trade, the creation of a market and price observatory could help develop the quality and traceability of Tunisian olive oil. This observatory could serve as a platform for technical collaboration on issues relating to the flow of information on price trends, including olive oil production prices at mill level, and the distribution of margins and added value along the olive oil value chain.

Indeed, for oil olive producers, reducing the risks of price volatility could help stabilize farm incomes and ensure greater economic security for producers and the most vulnerable populations. Similarly, the availability of information on production prices can encourage oil olive producers to invest in modernizing their farming techniques and equipment. This would encourage the adoption of more efficient farming practices, reduce risks and increase the sector's overall productivity.

Greater price transparency at mill level in Tunisia could also encourage oil millers to compete on quality rather than production costs. So, with more information on prices, oil producers are encouraged to adopt high quality standards to preserve the reputation and competitiveness of Tunisian products on the international market. This approach to maintaining consistent, reliable quality can play a key role in the appeal of Tunisian products, strengthening their position on the world market and moving olive oil upmarket. In addition, quality-oriented incentive mechanisms, such as those encouraging the expansion of the organic oil label, could be considered as agricultural risk management (ARM) tools to promote quality and high-end niche markets.

9.2.2 Development of insurance tailored to women, targeting rising temperatures and unsatisfied cooling needs

For the olive oil value chain, where the risk of not satisfying cold needs can lead to worrying losses, as this study shows, it is useful to develop climatic insurance adapted to this specific risk. This would enable value chain stakeholders, and in particular olive producers, to be better protected against negative consequences, thereby strengthening the sustainability and resilience of the entire value chain, which is vital to the Tunisian economy.

These new insurance products can be enhanced by the development of a climatic risk card and an insurance premium card along the lines of the agricultural card.

In addition, particular attention could be paid to adapting insurance products to the specific needs of women, including specific clauses relating to their land rights, fair remuneration, the arduous nature of their tasks, and gender-based violence (including economic violence). Capacity-building sessions can accompany the delivery of these products to improve women's financial, economic and insurance skills, thus encouraging them to develop their agricultural activities. It is encouraged to engage in joint work with the Ministry of Family, Women, Children and the Elderly may promote the development of these insurance products and the applicability of the 2017 law on violence against women and girls.

To make insurance products more effective and efficient in contributing to the resilience of small-scale producers, these insurance products will also be combined with other value-adding services, such as those for olive oil mentioned above, as well as credit access and savings diversification services to boost the attractiveness of insurance, value-added services, such as those for olive oil mentioned above, as well as credit access and savings diversification services to boost the attractiveness of insurance.

9.3 Cross-functional risk management tools

9.3.1 Investing in improved climate observation and information systems to strengthen agricultural risk management

To increase the resilience of the agricultural sector in the face of climatic hazards, it is essential to invest in the development of world-class systems for collecting meteorological observations. In concrete terms, it is important to work on standardizing Tunisian climate data on a uniform spatial scale for better understanding and management of climate risks.

In addition, setting up a standardized system for disseminating statistical-climatic information would enable stakeholders in the agricultural sector to make informed decisions and devise appropriate strategies in response to climate trends and risks. This option would make it possible to produce detailed, localized climate projections, as well as to set up a weather monitoring system tailored to the sectors concerned, in order to anticipate climatic conditions and effectively plan farming activities.

As early warning systems are already mentioned in the National Gender and Climate Change Plan, it is recommended to ensure that the dissemination of data and information is equitably accessible to women, men, young people, the elderly, migrants and people with disabilities. A partnership with the team working on the implementation of this Plan could foster the inclusive integration of agricultural risk management with climate information and warning systems (the team being split between the Ministry of Family, Women, Children and the Elderly, the Ministry of the Environment and UNDP). All these improvements could also benefit the development of agricultural weather insurance in Tunisia.

9.3.2 Create an investment-friendly environment and facilitate private sector involvement in building resilience to agricultural risks

To ensure the resilience of the olive oil and cereal value chains in the face of risk, it is crucial to integrate more agricultural risk management tools into the regulatory framework. Thus, an update of the 2016 regulatory framework for encouraging and improving the investment climate to incorporate agricultural impacts and risks, including a revision of the premium granted for "increasing added value and competitiveness for direct investment operations", is necessary to encourage the private sector’s participation in better preparing for and responding to climate challenges and competitiveness for direct investment operations" is necessary to encourage private sector participation in better preparing for and responding to climate challenges.

In addition, to guarantee the sustainability of agricultural practices and strengthen the resilience of small-scale and family farming to climatic and environmental challenges, it is imperative to strengthen the subsidies granted by the Fonds spécial de développement l’agriculture et pêche (FOSDAP) for actions to combat erosion and conserve water and soil (CES).In addition, to ensure the sustainability of farming practices and strengthen the resilience of small-scale and family farming to climate and environmental challenges, it is imperative to reinforce the subsidies granted by the Fonds spécial de développement de l’agriculture et de la pêche (FOSDAP) for actions to combat erosion and conserve water and soil (CES).

By providing financial support for these initiatives, FOSDAP could help prevent soil degradation and promote sustainable agricultural practices. At the same time, it is essential to step up efforts to maintain the efficiency of water-saving irrigation systems, particularly for small-scale and family farming. By financing ESC work, FOSDAP can play a crucial role in preserving water resources and promoting the efficiency of agricultural practices, thus ensuring sustainable food production that is resilient to environmental change.

Strengthening the work of the Fonds d'Indemnisation des Dommages Agricoles Causés par les Calamités Naturelles (FIDAC) is crucial to protecting farmers against the risks associated with climatic hazards and other natural disasters and ensuring the country's food security.

By raising awareness of FIDAC's role, increasing its available resources and expanding its value chain of action and intervention mechanisms, it would be possible to compensate farmers affected by losses more quickly and effectively. This would help mitigate the economic losses suffered by farmers, ensure their financial stability and preserve the viability of their farms. In addition, by guaranteeing an adequate response to agricultural crises, strengthening FIDAC would boost farmers' confidence in the State and its institutions.

9.3.3 Strengthen institutional and human capacities, particularly those of women, for ARM

To guarantee effective agricultural risk management, it is imperative to strengthen institutional and human capacities, with particular emphasis on the inclusion of women. This involves a number of essential measures. First of all, we need to educate the actors and operators in the agricultural sectors about agricultural risks, to raise their awareness and prepare them to face up to potential challenges.

In addition, it is crucial to develop training, including certification, for extension agents in Agricultural Risk Management (ARM), so that they can provide adequate support to farmers. Encouraging professional groups to integrate risk into their interventions at value chain level is also important for strengthening the resilience of the agricultural sector.

There is also a need to facilitate the transfer of knowledge, including the sharing of experience, by promoting dialogue between farmers, development and agricultural research actors in the field of ARM. Discussions could be opened on the possibility of mentoring programs between, on the one hand, women leaders in agricultural entrepreneurship (particularly in the olive oil sector) and, on the other hand, less experienced women farmers. This will contribute to the transfer and sharing of knowledge. Through the support and guidance of female agricultural entrepreneurs, integrating agricultural risk management into the mentoring program, capacities can be strengthened, as well as job creation and solidarity networks. The women's organizations that could emerge would have the opportunity to influence political decision-making, taking into account their needs in the inclusive management of agricultural risks. In addition, to overcome the exclusion of women from land tenure analyzed in the study, it is encouraged to open the discussion around the possibility of a program of titling and securing land tenure for women. It would aim to guarantee women's access to land ownership and secure their land rights to encourage investment in agriculture and reduce their exposure to risk. This would involve mapping and surveying the land used by women, and then providing legal support in association with local authorities in order to grant land certification to women.

Awareness-raising campaigns will be encouraged to accompany this work, to promote the alignment of social norms and customary law with positive law, in favor of women's secure access to land. Subsidies for the purchase of land by women could be considered, in conjunction with suitable insurance products. Women's cooperatives could also buy land jointly, thus promoting their economic power as well as networking and support. These collective structures could emerge from the mentoring programs mentioned above.

Finally, integrating ARM considerations into agricultural education would help to raise awareness and train agricultural technicians in the climatic and environmental challenges they will face in the future.

9.3.4 Strategic actions for rural financial inclusion

Following PARM's holistic approach, it is recommended to develop a rural financial inclusion strategy tailored to the specific needs of small agricultural producers, women and young people.

The development of financial savings and credit products adapted to small-scale producers, as well as initiatives to improve market access (such as warrantage, and synergies with other players in the value chain, notably the private sector) can promote the financial inclusion of small-scale producers and increase their resilience in the face of risk. Offering savings products to small farmers, complemented by financial training and technology integration programs, could boost the dynamism of their activities and those of other players in agricultural value chains.

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11 Appendices

Appendix 1. Tunisia's job market: Position of the agricultural and agrifood sectors

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Changes in the working population	3769	3877	3914	3953	3970	4004	4052	4095	4140	4171	4175	4157	4066
Change in the male workforce	2758	2830	2848	2868	2825	2877	2890	2917	2947	2964	2969	2856	2834
Change in the female workforce	1011	1047	1066	1085	1145	1128	1163	1178	1193	1207	1205	1301	1232
Change in the employed population	3277	3155	3234	3327	3375	3395	3424	3465	3500	3540	3479	3425	3436
Employed population (Male)	2458	2400	2439	2487	2477	2518	2530	2556	2578	2601	2559	2429	2457
Employed population (Female)	820	756	796	839	898	877	894	910	922	939	920	997	979
Breakdown of workforce by sector of activity													
Working population in Tunisia	3277	3155	3234	3327	3402	3395	3424	3465	3500	3540	3479	3425	3436
Agriculture and fishing	576	522	532	514	505	511	511	507	501	487	504		495
Manufacturing industries	598	575	601	624	645	628	628	636	648	652	641		686
Food and beverage industries	71	70	80	82	83	83	88	92	96	98	100		
Building materials, ceramics and glass	39	36	39	40	40	43	40	39	39	38	33		
Mechanical and electrical industries	118	122	123	135	151	148	149	154	156	156	154		
Chemical industry	29	28	29	30	30	29	30	29	30	31	33		
Textiles, clothing and footwear	250	232	242	249	259	239	235	235	243	237	232		
Labour force employed in other manufacturing industries	92	87	88	89	81	85	85	87	84	92	89		
Non-manufacturing industries	474	466	461	483	494	487	503	518	528	549	521		470
Mining and energy workforce	34	32	38	42	41	35	37	38	36	39	37		
Construction and public works workforce	441	434	423	442	453	452	466	481	492	510	484		
Services	1599	1576	1627	1693	1751	1768	1770	1798	1816	1835	1807		1846
Trade	387	388	398	406	445	467	459	462	460	441	435		
Transport and telecommunications	194	179	194	198	198	194	187	190	191	197	186		
Hotels and restaurants	125	110	115	120	124	113	116	128	142	155	136		
Banking and insurance	27	26	28	26	28	31	32	35	33	35	38		
Repair, real estate and other institutional services	132	137	147	152	154	166	174	176	180	187	189		
Social and cultural services	143	136	128	143	136	138	140	145	148	156	156		
Education, health and administrative services	592	600	617	648	667	659	661	662	661	664	667		
Undeclared activities	30	16	13	12	7	2	13	7	7	16	22		

Source: Authors, based on NIS data.

Appendix 2. Summary of simulations with RCP4.5 and 8.5 scenarios in 2050 and 2100 for the cereals sector

	Reference Period 1981-2010		RCP 4.5		RCP 8.5	
			2050	2100	2050	2100
Durum wheat						
Production	*9148*	*(1000 qx)*	-14%	-7%	-6%	-30%
Yield	*12.26*	*(qx/ha)*	-14%	-14%	-9%	-26%
Areas of climatic suitability			-5%	-4%	-4%	-8%
Production according to areas of climatic suitability			-20%	-12%	-12%	-33%
Common wheat						
Production	*2079*	*(1000 qx)*	-18%	-18%	-3%	-34%
Yield	*13.69*	*(qx/ha)*	-17%	-19%	-13%	-33%
Areas of climatic suitability			-11%	-13%	-7%	-26%
Production according to areas of climatic suitability			-32%	-35%	-24%	-67%
Barley						
Production	*3890*	*(1000 qx)*	-13%	-15%	-9%	-29%
Yield	*7.35*	*(qx/ha)*	-14%	-15%	-11%	-32%
Areas of climatic suitability			-7%	-5%	-5%	-13%
Production according to areas of climatic suitability			-16%	-16%	-13%	-34%

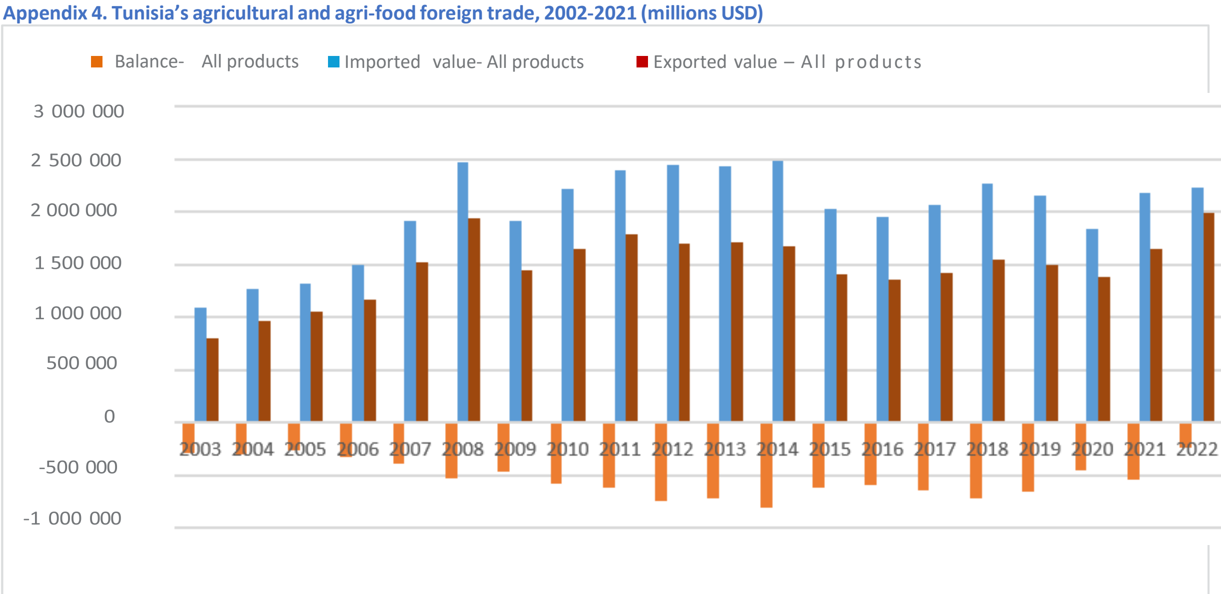
Source: Based on "TUNISIA - Contribution to the preparatory phase of the National Adaptation Plan process". MARHP and AFD (2022).

Appendix 3. Tunisia's agricultural and agri-food foreign trade, 2002-2021 (millions USD)

	Reference Period 1981-2010		RCP 4.5		RCP 8.5	
			2050	2100	2050	2100
Production	*1033*	*(1000 tons)*	-11%	-20%	-28%	-60%
Yield	*663*	*(kg/ha)*	-17%	-26%	-32%	-61%
Areas of climatic suitability			-8%	-5%	-5%	-14%
Production according to areas of climatic suitability			-23%	-28%	-35%	-70%

Source: Based on "TUNISIA - Contribution to the preparatory phase of the National Adaptation Plan process." MARHP and AFD (2022).

Appendix 4. Tunisia's agricultural and agri-food foreign trade, 2002-2021 (millions USD)



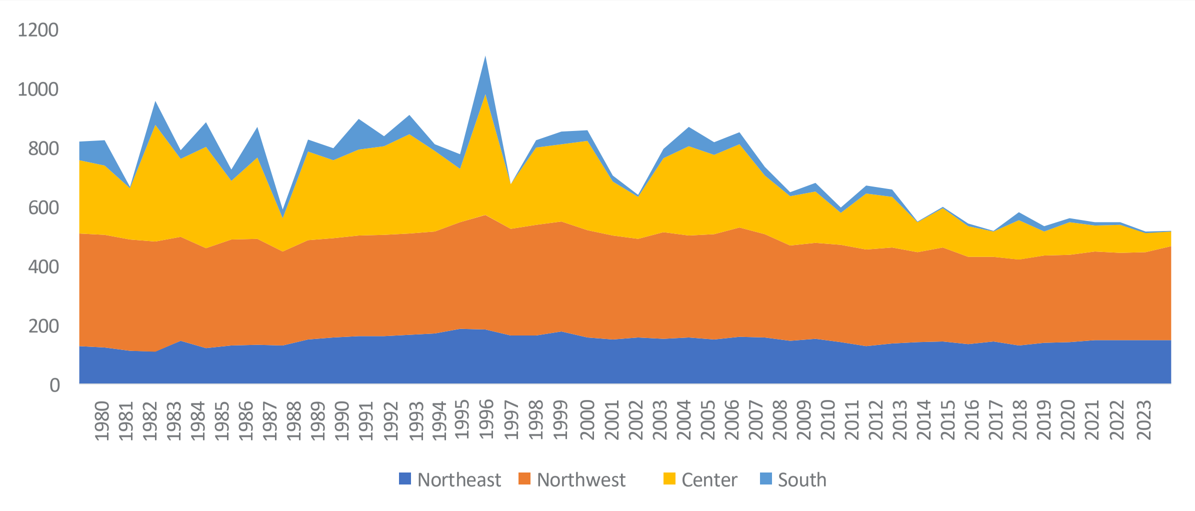
Source: Authors, based on Trade Map data.

Appendix 5. Distribution of the number of working days in the cereals sector

Unit: 1000 days/year		Average 2002-2006	Average 2007-2011	Average 2012-2016
Cereals	Permanent employees	*7%*	*6%*	*6%*
	Temporary employees	*10%*	*8%*	*7%*
	Family workforce	*6%*	*5%*	*6%*
	Total working days	*7%*	*6%*	*6%*
Total	Permanent employees	*12605*	*12755*	*12724*
	Temporary employees	*17165*	*19154*	*18356*
	Family workforce	*98101*	*109141*	*109771*
	Total working days/Agricultural sector	*127872*	*141050*	*140851*

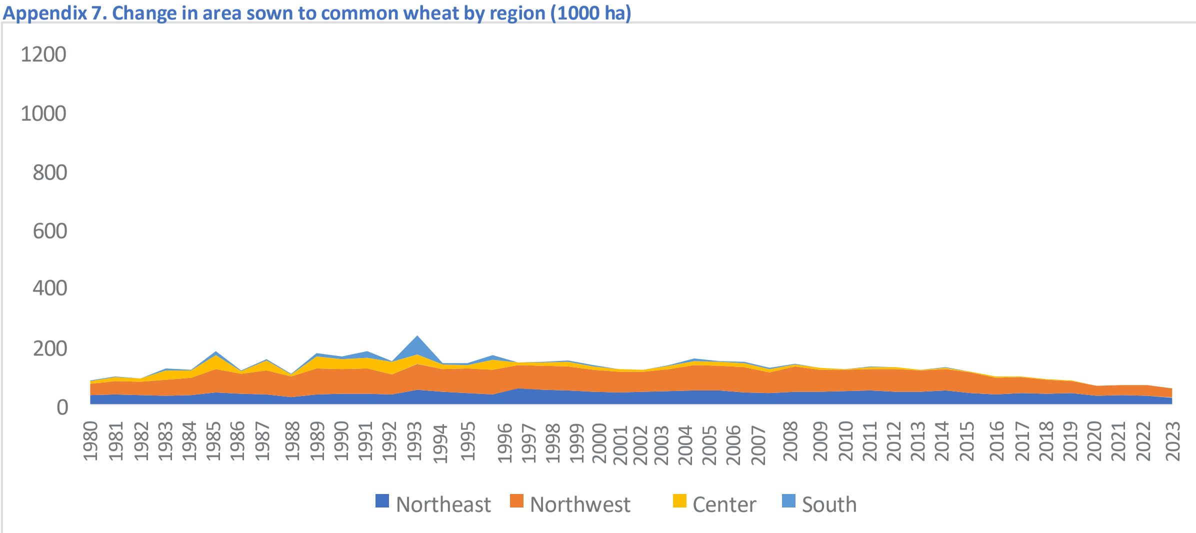
Source: Authors, based on MARHP data.

Appendix 6. Area sown to durum wheat by region (1000 ha)



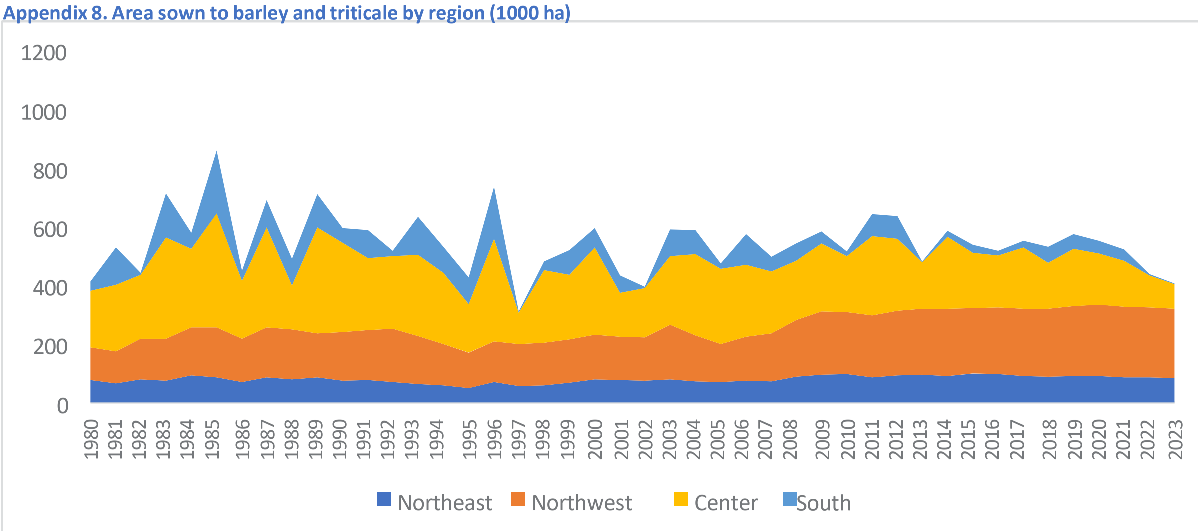
Source: Authors, based on MARHP data.

Appendix 7. Change in area sown to common wheat by region (1000 ha)



Source: Authors, based on MARHP data.

Appendix 8. Area sown to barley and triticale by region (1000 ha)



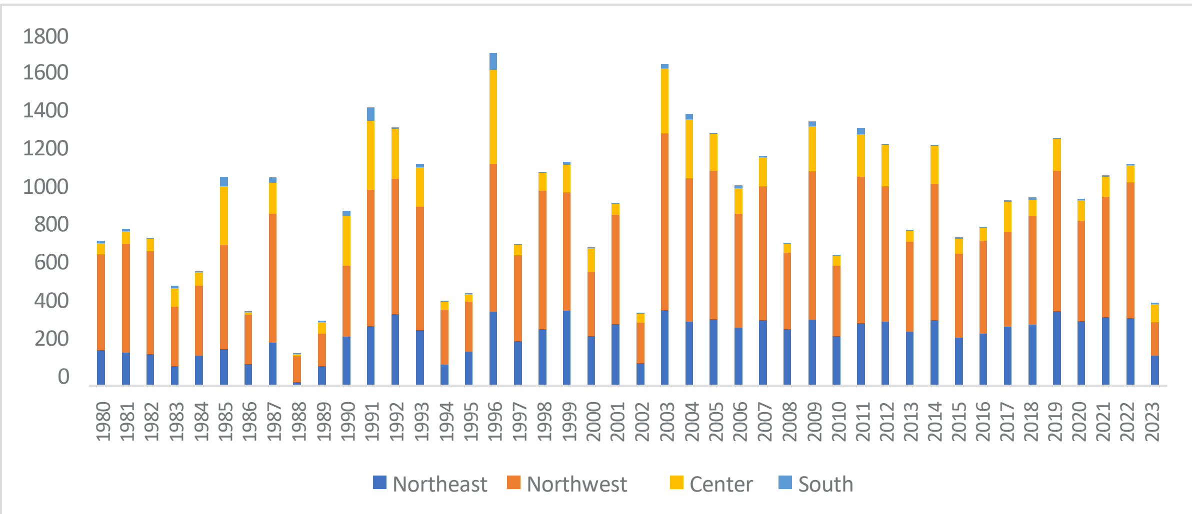
Source: Authors, based on MARHP data.

Appendix 9. Main characteristics of cereal acreage distribution by region in Tunisia

	North-East	Northwest	North	Center	South	National Total
Durum wheat						
Average 2004-2013	145,789	334,755	480,544	196,003	29,682	706,229
Standard deviation	10,118	19,400	27,162	69,029	17,125	108,003
Coefficient of variation	7%	6%	6%	35%	58%	15%
Average 2014-2023	141,142	298,646	439,789	94,635	9,842	544,265
Standard deviation	6,017	11,042	14,444	26,912	7,775	27,464
Coefficient of variation	4%	4%	3%	28%	79%	5%
Common wheat						
Average 2004-2013	42,843	77,874	120,717	8,379	2,904	132,000
Standard deviation	2,967	6,573	8,004	4,089	2,922	12,703
Coefficient of variation	7%	8%	7%	49%	101%	10%
Average 2014-2023	33,275	47,992	81,267	2,101	0,231	83,598
Standard deviation	6,643	15,470	21,274	2,158	0,294	23,163
Coefficient of variation	20%	32%	26%	103%	128%	28%
Barley and triticale						
Average 2004-2013	83,404	188,246	271,650	229,446	52,423	553,519
Standard deviation	10,758	35,077	45,414	37,915	33,405	61,041
Coefficient of variation	13%	19%	17%	17%	64%	11%
Average 2014-2023	89,850	234,055	323,906	169,456	28,071	521,433
Standard deviation	4,850	7,053	4,881	47,194	18,316	57,131
Coefficient of variation	5%	3%	2%	28%	65%	11%

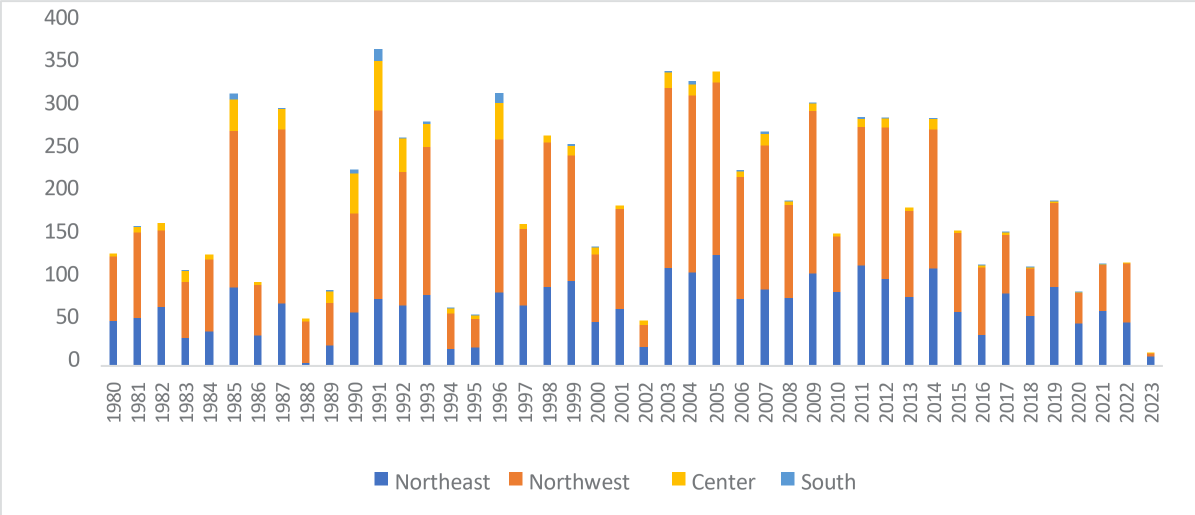
Source: Authors, based on MARHP data.

Appendix 10. Trend in durum wheat production by region in Tunisia (thousands of tons)



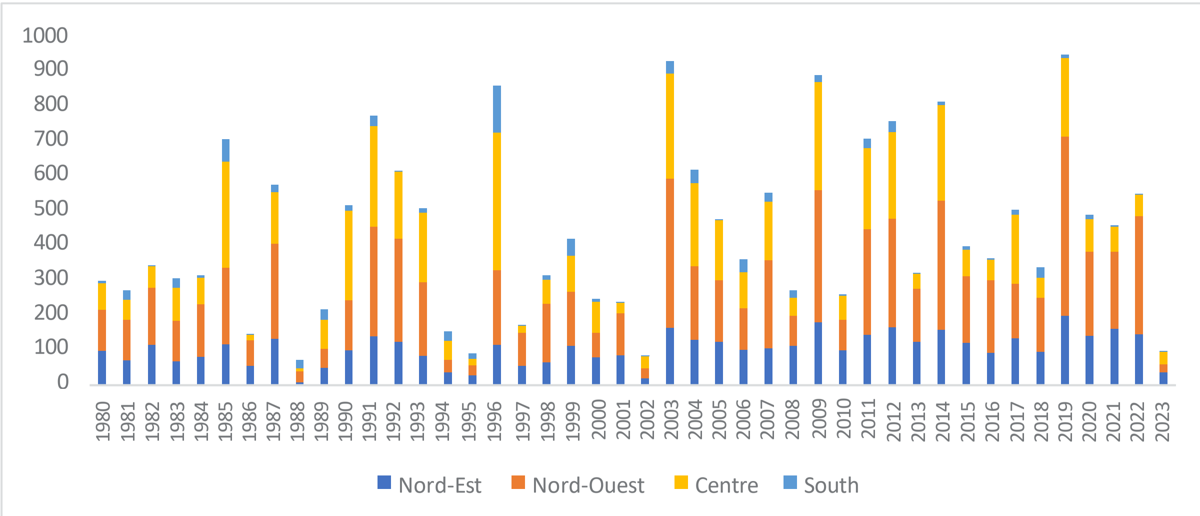
Source: Authors, based on MARHP data.

Appendix 11. Trend in common wheat production by region in Tunisia (thousands of tons)



Source: Authors, based on MARHP data.

Appendix 12. Trends in barley and triticale production by region in Tunisia (thousands of tons)



Source: Author, based on MARHP data.

Appendix 13. Main characteristics of cereal production distribution by region in Tunisia

	North-east	North-west	North	Center	South	Total (National)
Durm wheat						
Average 2004-2013	311,987	616,390	928,377	158,744	11,385	1098,506
Standard deviation	29,982	158,061	186,408	86,484	11,454	273,948
Coefficient of variation	10%	26%	20%	54%	101%	25%
Average 2014-2023	303,768	535,596	839,364	112,106	5,836	957,306
Standard deviation	65,971	164,197	227,655	42,755	3,034	249,097
Coefficient of variation	22%	31%	27%	38%	52%	26%
Common wheat						
Average 2004-2013	958,931	1488,878	2447,809	82,389	11,212	2541,410
Standard deviation	174,811	461,599	602,973	39,883	13,887	642,875
Coefficient of variation	18%	31%	25%	48%	124%	25%
Average 2014-2023	610,541	702,350	1312,892	23,651	0,848	1337,390
Standard deviation	285,878	410,722	668,403	35,885	1,518	697,762
Coefficient of variation	47%	58%	51%	152%	179%	52%
Barley and triticale						
Average 2004-2013	127,977	205,654	333,630	162,312	19,882	515,824
Standard deviation	27,194	99,930	124,105	92,389	13,457	217,143
Coefficient of variation	21%	49%	37%	57%	68%	42%
Average 2014-2023	127,834	239,580	367,414	114,042	9,128	490,584
Standard deviation	44,795	134,496	175,062	83,152	7,753	237,384
Coefficient of variation	35%	56%	48%	73%	85%	48%

Source: Authors, based on MARHP data.

Appendix 14. Breakdown of workforce by sector of activity, by number of days worked in the previous year

(%)		From 271 to 365 days		From 181 to 270 days		From 91 to 180 days		From 61 to 90 days		From 31 to 60 days		From 31 to 60 days		Total	
Agriculture and fisheries		75.5		12.9		8.7		1.4		0.7		0.4			
M	*F*	*79,0*	*21,0*	*83,0*	*17,0*	*66,9*	*33,1*	*46,7*	*53,3*	*41,5*	*58,5*	*36,4*	*63,6*	*77,7*	*22,3*
Manufacturing industries		**93.2**		**2.6**		**2.2**		**0.5**		**0.7**		**0.7**			
M	*F*	*58,0*	*42,0*	*50,0*	*50,0*	*45,7*	*54,3*	*37,9*	*62,1*	*41,0*	*59,0*	*45,5*	*54,5*	*57,1*	*42,9*
Food processing industries		**93.1**		**2.9**		**2.4**		**0.5**		**0.4**		**0.5**			
M	*F*	*79,0*	*21,0*	*52,2*	*47,8*	*57,9*	*42,1*	*50,0*	*50,0*	*66,7*	*33,3*	*25,0*	*75,0*	*77,5*	*22,5*
Non-manufacturing industries		**46.5**		**32.0**		**18.6**		**1.7**		**0.8**		**0.3**			
M	*F*	*97,0*	*3,0*	*99,0*	*1,0*	*99,0*	*1,0*	*98,8*	*1,2*	*100,0*	*0,0*	*93,3*	*6,7*	*98,1*	*1,9*
Services		**93.4**		**3.2**		**2.1**		**0.4**		**0.4**		**0.4**			
M	*F*	*75,0*	*25,0*	*79,1*	*20,9*	*71,1*	*28,9*	*58,6*	*41,4*	*59,1*	*40,9*	*54,2*	*45,8*	*74,9*	*25,1*
Total		**83.5**		**8.9**		**5.6**		**0.8**		**0.6**		**0.4**			
M	*F*	*74,0*	*26,0*	*89,0*	*11,0*	*82,0*	*18,0*	*66,0*	*34,0*	*59,8*	*40,2*	*54,3*	*45,7*	*75,1*	*24,9*

Note: M (Males) and F (Females).

Source: Authors, based on the 2012 National Population and Employment Survey (INS, 2013).

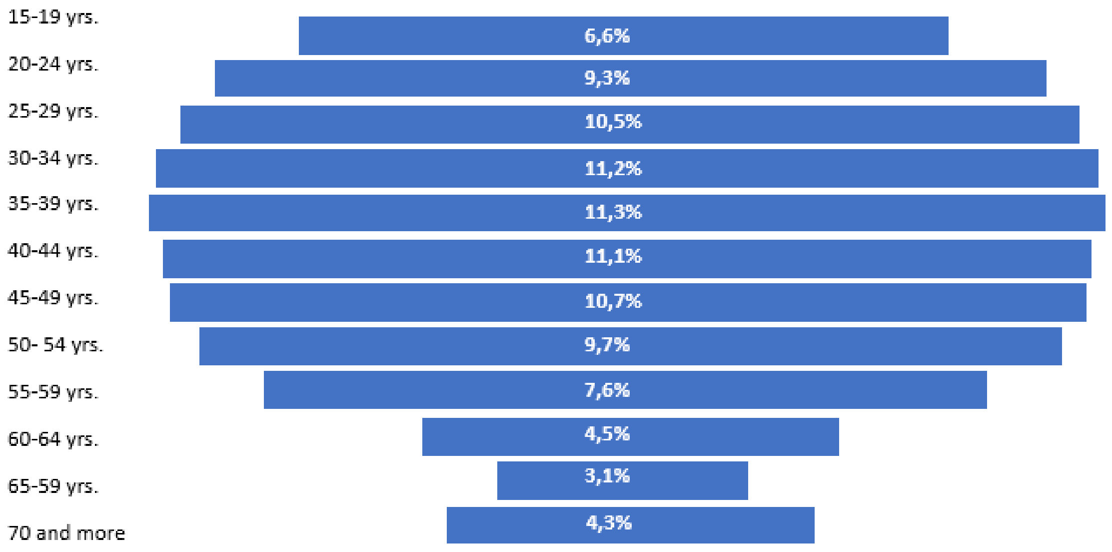
Appendix 15. Distribution of the employed population by sector of activity by level of education (%)

(%)		Upper level		Secondary		Primary		Illiterate		Total	
Agriculture and fisheries		**3.0**		**22.0**		**47.0**		**28.0**			
M	*F*	*80,0*	*20,0*	*88,1*	*11,9*	*83,8*	*16,2*	*58,1*	*41,9*	*77,7*	*22,3*
Manufacturing industries		**10.0**		**46.0**		**41.0**		**3.0**			
M	*F*	*70,2*	*29,8*	*56,0*	*44,0*	*57,1*	*42,9*	*40,0*	*60,0*	*57,1*	*42,9*
Food processing industries		**10.0**		**42.0**		**43.0**		**5.0**			
M	*F*	*75,0*	*25,0*	*81,3*	*18,8*	*76,5*	*23,5*	*50,0*	*50,0*	*77,5*	*22,5*
Non-manufacturing industries		**5.0**		**31.0**		**55.0**		**10.0**			
M	*F*	*85,7*	*14,3*	*97,9*	*2,1*	*98,8*	*1,2*	*100,0*	*0,0*	*98,1*	*1,9*
Services		**27.0**		**41.0**		**27.0**		**4.0**			
M	*F*	*61,0*	*39,0*	*78,0*	*22,0*	*85,0*	*15,0*	*63,2*	*36,8*	*74,9*	*25,1*
Total		**16.0**		**37.0**		**37.0**		**9.0**			
M	*F*	*63,0*	*37,0*	*76,0*	*24,0*	*82,0*	*18,0*	*65,1*	*34,9*	*75,1*	*24,9*

Note: M (Males) and F (Females).

Source: Authors, based on the 2012 National Population and Employment Survey (INS, 2013).

Appendix 16. Demographic profile of the agricultural workforce: Age distribution



Source: The 2012 National Population and Employment Survey (NIS, 2013)

Appendix 17. Major floods and their repercussions since 1973

Period	Region	Number of deaths	Damages	Cost
March 1973	North of the country, in particular the Medjerda basin	100	Extensive property damage	
March 1979	Médenine, south of the country		7,600 sheep lost and 1,400 km of farm tracks damaged	
October 1982	City of Sfax		Nearly 1,000 homes completely destroyed + 8,500 homes damaged	
January 1990	Sidi Bouzid, Gafsa, Kairouan, Jeffara	60	7,800 livestock lost and 50,000 hectares damaged	90 million TND
September 1995	Tataouine	20		More than 6 million TND
May 2000	Jendouba Plain		1170 people affected + material damage	
January - February 2003	Northern Tunisia and Greater Tunis		85% crop damage	20 million TND
September 2003	Greater Tunis	4	2500 people left homeless + significant material damage	
October 2007	Greater Tunis, in particular the Sabelet Ben Ammar area	16		
September 2009	Redayef	17	Extensive property damage	
September 2011	North of the country, Zaghouan, Lower Medjerda valley		3000 hectares of farmland damaged	30 million TND
September 2018	Nabeul, Cap Bon and Kasserine	5	1791 farmers affected	250 million TND

Source: Based on "TUNISIA - Contribution to the preparatory phase of the National Adaptation Plan process". MARHP and AFD (2022).

Appendix 18. Descriptive statistics of climatic and agro-climatic indicators used for risk assessment in cereal value chain in Tunisia (agricultural seasons 1982-2023)

Variable	Average	Median	Minimum	Maximum	Ec. type	Coefficient of Variation	Asymmetry	Ex. kurtosis	PC. 5%	PC 95%	IQ
P_anH	312,6	319,2	204,2	500,2	71,3	0,2	0,4	-0,3	210,6	458,3	112,1
P_PriH	83,6	80,5	43,9	150,2	25,9	0,3	0,4	-0,5	45,7	130,1	40,0
P_Mars	34,8	30,4	6,4	83,0	19,5	0,6	0,8	0,0	9,1	79,9	23,8
T_PriH	17,8	17,8	16,1	19,1	0,8	0,0	-0,1	-0,9	16,5	19,0	1,3
Tmax_PriH	23,7	23,9	21,7	25,3	1,0	0,0	-0,1	-0,9	22,1	25,2	1,6
Germination Date	195,2	196,1	180,6	205,4	6,3	0,0	-0,2	-0,7	183,9	205,1	10,1
Date of maturity	252,9	253,8	241,6	262,5	5,2	0,0	-0,3	-0,4	243,4	261,8	6,7
Nech	60,8	61,8 0,0	41,0	69,5	5,8	0,1	-1,1	1,5	50,5	68,8	8,1
R70_H	0,8	3,0	0,0	10,0	2,2	2,9	3,0	7,8	0,0	7,7	0,0
GelP	5,2		0,0	23,0	6,0	1,2	1,2	0,6	0,0	17,9	8,5

Source: Authors

Appendix 19. Details of the impact of climatic risks on each cereal crop (durum wheat, common wheat and barley) and quantification of economic losses.

		Probability (Risk Frequency)	Probability score	Average impact				Maximum Impact				Risk score
				Loss (1000 tons)	Loss (%)	Loss (TND million)	Average Impact Score (Iave)	Loss (1000 tons)	Loss (%)	Loss (TND millions)	Maximum impact score (SImax)	
Durum wheat												
Dry agricultural season	P_anH	**16,7%**	3	155	17%	217	3	277	30%	388	3	**7,2**
Spring drought	P_PriH	**16,7%**	3	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**2,4**
March drought	P_Mars	**14,3%**	2				1				1	**1,7**
Grain scalding	T_PriH	**16,7%**	3				1				1	**2,4**
Spring heat stress	Tmax_PriH	**19,0%**	3				1				1	**2,4**
Severity of scalding	Nech	**9,5%**	2	328	35%	459	4	339	35%	475	4	**6,8**
Shortening of the development cycle	Germination date	**16,7%**	3	278	30%	389	3	450	48%	629	4	**7,5**
Early maturation date	Maturation date	**14,3%**	2	328	35%	460	4	450	48%	629	4	**6,8**
Intense rainfall	R70_H	**9,5%**	2	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**1,7**
Spring frost	GelP	**19,0%**	3				1				1	**2,4**
Common wheat												
Dry agricultural season	P_anH	**16,7%**	3	28	14%	31	2	40	21%	44	3	**5,1**
Spring drought	P_PriH	**16,7%**	3	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**2,4**
March drought	P_Mars	**14,3%**	2	74	38%	81	4	83	43%	91	4	**6,8**
Grain scalding	T_PriH	**16,7%**	3	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**2,4**
Spring heat stress	Tmax_PriH	**19,0%**	3				1				1	**2,4**
Shortening of the development cycle	Germination date	**16,7%**	3				1				1	**2,4**
Early maturation date	Maturation date	**14,3%**	2	75	39%	83	4	79	41%	86	4	**6,8**
Severity of scalding	Nech	**9,5%**	2	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**1,7**
Intense rainfall	R70_H	**9,5%**	2				1				1	**1,7**
Spring frost	GelP	**19,0%**	3				1				1	**2,4**
Barley and triticale												
Dry agricultural season	P_anH	**16,7%**	3	161	36%	145	4	288	65%	259	5	**9,9**
Spring drought	P_PriH	**16,7%**	3	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**2,4**
March drought	P_Mars	**14,3%**	2	169	38%	152	4	201	45%	181	4	**6,8**
Grain scalding	T_PriH	**16,7%**	3	64	15%	58	2	94	21%	84	3	**5,1**
Spring heat stress	Tmax_PriH	**19,0%**	3	74	17%	67	3	103	23%	93	3	**7,2**
Severity of scalding	Nech	**9,5%**	2	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**1,7**
Shortening of the development cycle	Germination date	**16,7%**	3	94	21%	85	3	215	49%	194	4	**7,5**
Early maturation date	Maturation date	**14,3%**	2	152	34%	137	4	205	46%	184	4	**6,8**
Intense rainfall	R70_H	**9,5%**	2	*Non significantly different from zero*			1	*Non significantly different from zero*			1	**1,7**
Spring frost	GelP	**19,0%**	3				1				1	**2,4**

Appendix 1. Details of econometric estimates of climatic risks on durum wheat production

P_anH***

Model 1: MCO, using observations from 1982-2023 (T = 42)
Dependent Variable: BDProd1000tons

	Coefficient	*Error Std*	*T of Student*	*p. critic*	
const	1003,69	58,1099	17,27	<0,0001	***
P_anH_aab	−390,169	142,340	−2,741	0,0091	***

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	4727471	Ec. type regression	343,7830
R2	0,158137	R2 adjusted	0,137091
F(1, 40)	7,513682	P. critic (F)	0,009109
Log likelihood	−303,8513	Akaike criteria	611,7026
Schwarz criteria	615,1779	Hannan-Quinn	612,9764
rho	−0,031926	Durbin-Watson	2,042673

P_PriH (NS)

Model 2: MCO, using observations from 1982-2023 (T = 42)
Dependent Variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	969,408	62,2036	15,58	<0,0001	***
P_PriH_aab	−184,461	152,367	−1,211	0,2331	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5417004	Ec. type regression	368,0015
R2	0,035346	R2 adjusted	0,011230
F(1, 40)	1,465646	P. critic (F)	0,233139
Log likelihood	−306,7105	Akaike criteria	617,4210
Schwarz criteria	620,8963	Hannan-Quinn	618,6948
rho	−0,024849	Durbin-Watson	1,983931

P_Mars (NS)

Model 3: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	972,503	60,8215	15,99	<0,0001	***
P_Mars_aab	−236,871	160,919	−1,472	0,1488	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5326934	Ec. type regression	364,9292
R2	0,051386	R2 adjusted	0,027670
F(1, 40)	2,166765	P. critic (F)	0,148848
Log likelihood	−306,3584	Akaike criteria	616,7167
Schwarz criteria	620,1921	Hannan-Quinn	617,9906
rho	0,037273	Durbin-Watson	1,899798

T_PriH (NS)

Model 4: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	977,599	61,5116	15,89	<0,0001	***
T_PriH_aab	−233,608	150,672	−1,550	0,1289	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5297149	Ec. type regression	363,9076
R2	0,056690	R2 adjusted	0,033107
F(1, 40)	2,403859	P. critic (F)	0,128913
Log likelihood	−306,2406	Akaike criteria	616,4812
Schwarz criteria	619,9566	Hannan-Quinn	617,7551

rho	−0,016065	Durbin-Watson	1,963426

Tmax_PriH (NS)
Model 5: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	982,470	62,2670	15,78	<0,0001	***
Tmax_PriH_aab	−229,980	142,672	−1,612	0,1148	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5272959	Ec. type regression	363,0757
R2	0,060997	R2 adjusted	0,037522
F(1, 40)	2,598393	P. critic (F)	0,114836
Log likelihood	−306,1445	Akaike criteria	616,2890
Schwarz criteria	619,7643	Hannan-Quinn	617,5629
rho	−0,028668	Durbin-Watson	1,985362

Germination date*
Model 6: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	983,678	60,8862	16,16	<0,0001	***
Datemontaison_aab	−270,082	149,140	−1,811	0,0777	*

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5189981	Ec. type regression	360,2076
R2	0,075774	R2 adjusted	0,052668
F(1, 40)	3,279454	P. critic (F)	0,077667
Log likelihood	−305,8114	Akaike criteria	615,6228
Schwarz criteria	619,0982	Hannan-Quinn	616,8967
rho	−0,007867	Durbin-Watson	1,989341

Maturation date**
Model 7: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	986,534	59,1492	16,68	<0,0001	***
Datematuration_aab	−335,087	156,494	−2,141	0,0384	**

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5038032	Ec. type regression	354,8955
R2	0,102833	R2 adjusted	0,080404
F(1, 40)	4,584782	P. critic (F)	0,038403
Log likelihood	−305,1874	Akaike criteria	614,3748
Schwarz criteria	617,8501	Hannan-Quinn	615,6487
rho	−0,069844	Durbin-Watson	2,117407

Nech*
Model 8: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	970,987	58,4821	16,60	<0,0001	***
Nech_aab	−339,388	189,504	−1,791	0,0809	*

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5198632	Ec. type regression	360,5077
R2	0,074233	R2 adjusted	0,051089
F(1, 40)	3,207434	P. critic (F)	0,080874
Log likelihood	−305,8464	Akaike criteria	615,6928

Schwarz criteria	619,1681	Hannan-Quinn	616,9666
rho	−0,060303	Durbin-Watson	2,047555

R70_H (NS)
Model 9: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	926,984	60,4863	15,33	<0,0001	***
R70_H_aab	122,640	195,998	0,6257	0,5351	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5561056	Ec. type regression	372,8624
R2	0,009693	R2 adjusted	-0,015064
F(1, 40)	0,391529	P. critic (F)	0,535051
Log likelihood	−307,2616	Akaike criteria	618,5233
Schwarz criteria	621,9986	Hannan-Quinn	619,7971
rho	−0,031090	Durbin-Watson	2,008891

GelP _H (NS)
Model 10: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BDProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	907,275	63,2433	14,35	<0,0001	***
GelP_aab	164,793	144,909	1,137	0,2622	

Average variable dependent	938,6644	Ec. type dep. Var.	370,0853
Sum of squared residuals	5439616	Ec. type regression	368,7688
R2	0,031319	R2 adjusted	0,007102
F(1, 40)	1,293275	P. critic (F)	0,262212
Log likelihood	−306,7980	Akaike criteria	617,5959
Schwarz criteria	621,0713	Hannan-Quinn	618,8698
rho	0,007309	Durbin-Watson	1,924783

Appendix 2. Details of econometric estimates of climate risks for soft wheat production

P_anH ***

Model 2: MCO, using observations from 1982-2023 (T = 42)

Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
Const	211,886	14,4463	14,67	<0,0001	***
P_anH_aab	−118,350	35,3862	−3,345	0,0018	***

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	292175,8	Ec. type regression	85,46576
R2	0,218535	R2 adjusted	0,198999
F(1, 40)	11,18593	P. critic (F)	0,001800
Log likelihood	−245,3917	Akaike criteria	494,7834
Schwarz criteria	498,2587	Hannan-Quinn	496,0572
rho	0,018953	Durbin-Watson	1,933483

P_PriH (NS)

Model 3: MCO, using observations from 1982-2023 (T = 42)

Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	196,942	16,2367	12,13	<0,0001	***
P_PriH_aab	−28,6865	39,7716	−0,7213	0,4749	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	369082,0	Ec. type regression	96,05753
R2	0,012839	R2 adjusted	-0,011840
F(1, 40)	0,520248	P. critic (F)	0,474931
Log likelihood	−250,2986	Akaike criteria	504,5972
Schwarz criteria	508,0726	Hannan-Quinn	505,8711
rho	0,119217	Durbin-Watson	1,689826

P_Mars*

Model 4: MCO, using observations from 1982-2023 (T = 42)

Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	203,012	15,4608	13,13	<0,0001	***
P_Mars_aab	−75,9539	40,9055	−1,857	0,0707	*

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	344213,2	Ec. type regression	92,76492
R2	0,079354	R2 adjusted	0,056338
F(1, 40)	3,447761	P. critic (F)	0,070713
Log likelihood	−248,8337	Akaike criteria	501,6674
Schwarz criteria	505,1427	Hannan-Quinn	502,9413
rho	0,136966	Durbin-Watson	1,694786

T_PriH (NS)

Model 5: MCO, using observations from 1982-2023 (T = 42)

Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	199,253	16,1095	12,37	<0,0001	***
T_PriH_aab	−42,5509	39,4600	−1,078	0,2873	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	363320,6	Ec. type regression	95,30485
R2	0,028249	R2 adjusted	0,003955
F(1, 40)	1,162801	P. critic (F)	0,287346
Log likelihood	−249,9682	Akaike criteria	503,9364
Schwarz criteria	507,4118	Hannan-Quinn	505,2103

rho	0,156203	Durbin-Watson	1,619449

Tmax_PriH (NS)
Model 6: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	201,743	16,2131	12,44	<0,0001	***
Tmax_PriH_aab	−50,3021	37,1489	−1,354	0,1833	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	357495,6	Ec. type regression	94,53777
R2	0,043828	R2 adjusted	0,019924
F(1, 40)	1,833498	P. critic (F)	0,183316
Log likelihood	−249,6288	Akaike criteria	503,2576
Schwarz criteria	506,7329	Hannan-Quinn	504,5315
rho	0,150240	Ec. type dep. Var.	1,626798

Germination date (NS)
Model 7: MCO, using observations 1982-2023 (T = 42)
Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	200,412	16,0265	12,51	<0,0001	***
Datemontaison_aab	−49,5012	39,2568	−1,261	0,2146	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	359588,5	Ec. type regression	94,81409
R2	0,038231	R2 adjusted	0,014187
F(1, 40)	1,590019	P. critic (F)	0,214629
Log likelihood	−249,7514	Akaike criteria	503,5028
Schwarz criteria	506,9781	Hannan-Quinn	504,7766
rho	0,141229	Ec. type dep. Var.	1,676598

Maturation date*
Model 8: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	203,583	15,3887	13,23	<0,0001	***
Datematuration_aab	−79,9521	40,7146	−1,964	0,0565	*

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	341007,4	Ec. type regression	92,33194
R2	0,087928	R2 adjusted	0,065127
F(1, 40)	3,856204	P. critic (F)	0,056539
Log likelihood	−248,6372	Akaike criteria	501,2744
Schwarz criteria	504,7498	Hannan-Quinn	502,5483
rho	0,085406	Ec. type dep. Var.	1,795494

Nech (NS)
Model 9: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	197,876	15,4079	12,84	<0,0001	***
Nech_aab	−60,0065	49,9271	−1,202	0,2365	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	360850,9	Ec. type regression	94,98038
R2	0,034854	R2 adjusted	0,010726
F(1, 40)	1,444520	P. critic (F)	0,236477
Log likelihood	−249,8250	Akaike criteria	503,6500

Schwarz criteria	507,1253	Hannan-Quinn	504,9238
rho	0,126066	Ec. type dep. Var.	1,674872

R70_H (NS)
Model 10: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: BTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	190,896	15,6702	12,18	<0,0001	***
R70_H_aab	13,2837	50,7772	0,2616	0,7950	

Average variable dependent	192,1614	Ec. type dep. Var.	95,49388
Sum of squared residuals	373243,7	Ec. type regression	96,59758
R2	0,001708	R2 adjusted	-0,023249
F(1, 40)	0,068439	P. critic (F)	0,794966
Log likelihood	−250,5341	Akaike criteria	505,0682
Schwarz criteria	508,5435	Hannan-Quinn	506,3420
rho	0,117910	Ec. type dep. Var.	1,698437

Appendix 3. Details of econometric estimates of weather risks on barley and triticale production

P_anH***
Model 1: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	491,871	37,2671	13,20	<0,0001	***
P_anH_aab	−298,177	91,2853	−3,266	0,0022	***

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	1944368	Ec. type regression	220,4750
R2	0,210572	R2 adjusted	0,190836
F(1, 40)	10,66959	P. critic (F)	0,002239
Log likelihood	−285,1938	Akaike criteria	574,3875
Schwarz criteria	577,8629	Hannan-Quinn	575,6614
rho	−0,310765	Ec. type dep. Var.	2,601833

P_PriH (NS)
Model 2: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	464,622	41,0331	11,32	<0,0001	***
P_PriH_aab	−134,680	100,510	−1,340	0,1878	

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2357200	Ec. type regression	242,7550
R2	0,042959	R2 adjusted	0,019033
F(1, 40)	1,795503	P. critic (F)	0,187820
Log likelihood	−289,2370	Akaike criteria	582,4741
Schwarz criteria	585,9494	Hannan-Quinn	583,7479
rho	−0,218966	Ec. type dep. Var.	2,349270

P_Mars**
Model 3: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	473,788	39,1859	12,09	<0,0001	***
P_Mars_aab	−221,289	103,676	−2,134	0,0390	**

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2211168	Ec. type regression	235,1153
R2	0,102249	R2 adjusted	0,079805
F(1, 40)	4,555794	P. critic (F)	0,038988
Log likelihood	−287,8940	Akaike criteria	579,7880
Schwarz criteria	583,2634	Hannan-Quinn	581,0619
rho	−0,222791	Ec. type dep. Var.	2,421741

T_PriH**
Model 4: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	479,354	39,3948	12,17	<0,0001	***
T_PriH_aab	−223,074	96,4972	−2,312	0,0260	**

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2172730	Ec. type regression	233,0628
R2	0,117855	R2 adjusted	0,095801
F(1, 40)	5,344024	P. critic (F)	0,026026
Log likelihood	−287,5258	Akaike criteria	579,0515

Schwarz criteria	582,5269	Hannan-Quinn	580,3254
rho	−0,278803	Ec. type dep. Var.	2,444313

Tmax_PriH**
Model 5: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	482,829	39,9264	12,09	<0,0001	***
Tmax_PriH_aab	−213,433	91,4828	−2,333	0,0248	**

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2167995	Ec. type regression	232,8087
R2	0,119778	R2 adjusted	0,097772
F(1, 40)	5,443061	P. critic (F)	0,024761
Log likelihood	−287,4799	Akaike criteria	578,9599
Schwarz criteria	582,4352	Hannan-Quinn	580,2337
rho	−0,286381	Ec. type dep. Var.	2,455818

Germination date**
Model 6: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	476,682	39,7578	11,99	<0,0001	***
Datemontaison_aab	−207,041	97,3864	−2,126	0,0397	**

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2212957	Ec. type regression	235,2104
R2	0,101523	R2 adjusted	0,079061
F(1, 40)	4,519764	P. critic (F)	0,039729
Log likelihood	−287,9110	Akaike criteria	579,8220
Schwarz criteria	583,2973	Hannan-Quinn	581,0959
rho	−0,200155	Ec. type dep. Var.	2,373084

Maturation date**
Model 7: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	473,253	39,2607	12,05	<0,0001	***
Datematuration_aab	−217,547	103,874	−2,094	0,0426	**

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2219615	Ec. type regression	235,5639
R2	0,098820	R2 adjusted	0,076290
F(1, 40)	4,386235	P. critic (F)	0,042611
Log likelihood	−287,9741	Akaike criteria	579,9482
Schwarz criteria	583,4235	Hannan-Quinn	581,2220
rho	−0,194026	Ec. type dep. Var.	2,364358

Nech (NS)
Model 8: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	461,524	39,0145	11,83	<0,0001	***
Nech_aab	−203,161	126,421	−1,607	0,1159	

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2313634	Ec. type regression	240,5012
R2	0,060647	R2 adjusted	0,037163

F(1, 40)	2,582512	P. critic (F)	0,115916
Log likelihood	−288,8453	Akaike criteria	581,6906
Schwarz criteria	585,1659	Hannan-Quinn	582,9644
rho	−0,272755	Ec. type dep. Var.	2,450777

R70_H (NS)
Model 9: MCO, using observations from 1982-2023 (T = 42)
Dependent variable: OTProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	437,349	40,1782	10,89	<0,0001	***
R70_H_aab	50,6750	130,192	0,3892	0,6992	

Average variable dependent	442,1750	Ec. type dep. Var.	245,0987
Sum of squared residuals	2453715	Ec. type regression	247,6749
R2	0,003773	R2 adjusted	-0,021132
F(1, 40)	0,151502	P. critic (F)	0,699169
Log likelihood	−290,0797	Akaike criteria	584,1595
Schwarz criteria	587,6348	Hannan-Quinn	585,4333
rho	−0,203060	Ec. type dep. Var.	2,336213

Appendix 4. Details of econometric estimates of the risks of unavailability of fertilizers on cereal production

Model 2: MCO, using observations from 1985-2021 (T = 37)
Dependent variable: CEREALESProd1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	945,323	341,213	2,770	0,0089	***
ENGRAISUTILISES1000tonnes	3,37504	1,58228	2,133	0,0400	**

Average variable dependent	1636,047	Ec. type dep. Var.	685,5894
Sum of squared residuals	14974592	Ec. type regression	654,0990
R2	0,115039	R2 adjusted	0,089754
F(1, 40)	4,549752	P. critic (F)	0,040012
Log likelihood	−291,3533	Akaike criteria	586,7065
Schwarz criteria	589,9283	Hannan-Quinn	587,8424
rho	−0,191431	Ec. type dep. Var.	2,342455

Annexe 5. Descriptive statistics of climatic and agro-climatic indicators used for risk assessment in olive farming value chain in Tunisia (agricultural seasons 1982-2022)

Variable	Average	Median	Minimum	Maximum	Ec. type	C.V.	Assymetry	Ex. kurtosis	PC. 5%	PC 95%	Q
P_an	272,2	270,3	138,2	408,7	61,3	0,2	0,1	-0,2	151,1	394,3	98,6
na_fl	15,3	12,5	0,0	45,8	12,3	0,8	0,7	-0,4	0,0	41,0	17,7
GelP	5,2	3,0	0,0	23,0	6,1	1,2	1,2	0,5	0,0	17,9	9,0
N40	13,1	12,8	1,9	32,5	5,9	0,5	0,8	1,6	4,3	25,4	7,3
R70	0,8	0,0	0,0	10,0	2,3	2,8	2,9	7,5	0,0	7,8	0,0

Source: Data from Authors

Annexe 6. Evaluation of the impact of climatic risks on national oil olive production losses

Model 3: MCO, using observations from 1983-2022 (T = 40)
Dependent variable: ProductionOlivesAhuilet1

	Coefficient	*Error Std*	*t of Student*	*p. critc*	
const	902,484	71,5345	12,62	<0,0001	***
P_anR	**−353,595**	**150,808**	**−2,345**	**0,0244**	**

Average variable dependent	822,9250	Ec. type dep. Var.	420,6258
Sum of squared residuals	6028037	Ec. type regression	398,2870
R2	0,126386	R2 adjusted	0,103396
F(1, 40)	5,497486	P. critic (F)	0,024370
Log likelihood	−295,2186	Akaike criteria	594,4372
Schwarz criteria	597,8149	Hannan-Quinn	595,6585
rho	−0,360532	Ec. type dep. Var.	2,682010

MCO, using observations from 1982-2022 (T = 41)
Dependent variable: ProductionOlivesAhuilet1

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	861,676	70,8286	12,17	<0,0001	***
na_fl	**−305,248**	**171,416**	**−1,781**	**0,0827**	*

Average variable dependent	809,5610	Ec. type dep. Var.	424,0583
Sum of squared residuals	6652139	Ec. type regression	412,9984
R2	0,075195	R2 adjusted	0,051482
F(1, 40)	3,171040	P. critic (F)	0,082745
Log likelihood	−304,1125	Akaike criteria	612,2249
Schwarz criteria	615,6521	Hannan-Quinn	613,4729
rho	−0,090318	Ec. type dep. Var.	2,128634

MCO, using observations from 1982-2022 (T = 41)
Dependent variable: ProductionOlivesAhuilet1

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	798,242	74,6468	10,69	<0,0001	***
GelP	58,0076	168,989	0,3433	0,7332	

Average variable dependent	809,5610	Ec. type dep. Var.	424,0583
Sum of squared residuals	7171350	Ec. type regression	428,8132
R2	0,003012	R2 adjusted	-0,022552
F(1, 40)	0,117829	P. critic (F)	0,733244
Log likelihood	−305,6531	Akaike criteria	615,3063
Schwarz criteria	618,7334	Hannan-Quinn	616,5543

rho	−0,151776	Ec. type dep. Var.	2,254558

MCO, using observations from 1982-2022 (T = 41)
Dependent variable: ProductionOlivesAhuilet1

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	810,889	71,5742	11,33	<0,0001	***
N40	−10,8889	204,957	−0,05313	0,9579	

Average variable dependent	809,5610	Ec. type dep. Var.	424,0583
Sum of squared residuals	7192496	Ec. type regression	429,4449
R2	0,000072	R2 adjusted	-0,025567
F(1, 40)	0,002823	P. critic (F)	0,957901
Log likelihood	−305,7135	Akaike criteria	615,4270
Schwarz criteria	618,8541	Hannan-Quinn	616,6750
rho	−0,166206	Ec. type dep. Var.	2,292239

MCO, using observations from 1982-2022 (T = 41)
Dependent variable: ProductionOlivesAhuilet1

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	779,730	68,9266	11,31	<0,0001	***
R70	305,770	220,673	1,386	0,1737	

Average variable dependent	809,5610	Ec. type dep. Var.	424,0583
Sum of squared residuals	6855520	Ec. type regression	419,2643
R2	0,046920	R2 adjusted	0,022482
F(1, 40)	1,919962	P. critic (F)	0,173734
Log likelihood	−304,7298	Akaike criteria	613,4597
Schwarz criteria	616,8868	Hannan-Quinn	614,7076
rho	−0,164413	Ec. type dep. Var.	2,288863

Appendix 7. Evaluation of the impact of phytosanitary risks on oil olive production losses

Model 1: MCO, using observations from 2016-2023 (T = 8)
Dependent variable: Production1000tonnes

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	1186,17	198,798	5,967	0,0010	***
TRAITEMENT	−586,167	397,596	−1,474	0,1908	

Average variable dependent	1039,625	Ec. type dep. Var.	526,1895
Sum of squared residuals	1422741	Ec. type regression	486,9533
R2	0,265920	R2 adjusted	0,143573
F(1, 40)	2,173497	P. critic (F)	0,190846
Log likelihood	−59,70613	Akaike criteria	123,4123
Schwarz criteria	123,5711	Hannan-Quinn	122,3406
rho	−0,388391	Ec. type dep. Var.	2,508384

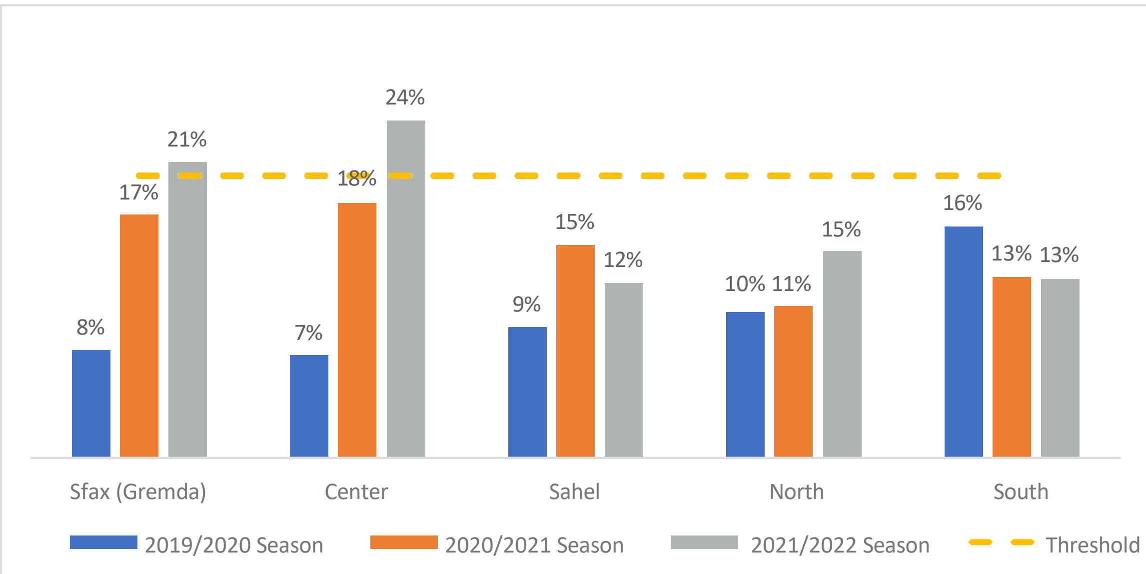
Appendix 8. Assessing the impact of risks associated with rising fertilizer prices in terms of lost oil olive production

Model 1: MCO, using observations from 1984-2023 (T = 40)
Dependent variable: ProductionOlivesAhuile100

	Coefficient	*Error Std*	*t of Student*	*p. critic*	
const	813,973	69,8534	11,65	<0,0001	***
PrixTNDtonne	119,360	255,069	0,4680	0,6425	

Average variable dependent	822,9250	Ec. type dep. Var.	420,6258
Sum of squared residuals	6860582	Ec. type regression	424,9019
R2	0,005730	R2 adjusted	-0,020435
F(1, 40)	0,218981	P. critic (F)	0,642491
Log likelihood	−297,8060	Akaike criteria	599,6120
Schwarz criteria	602,9898	Hannan-Quinn	600,8333
rho	−0,207578	Ec. type dep. Var.	2,414331

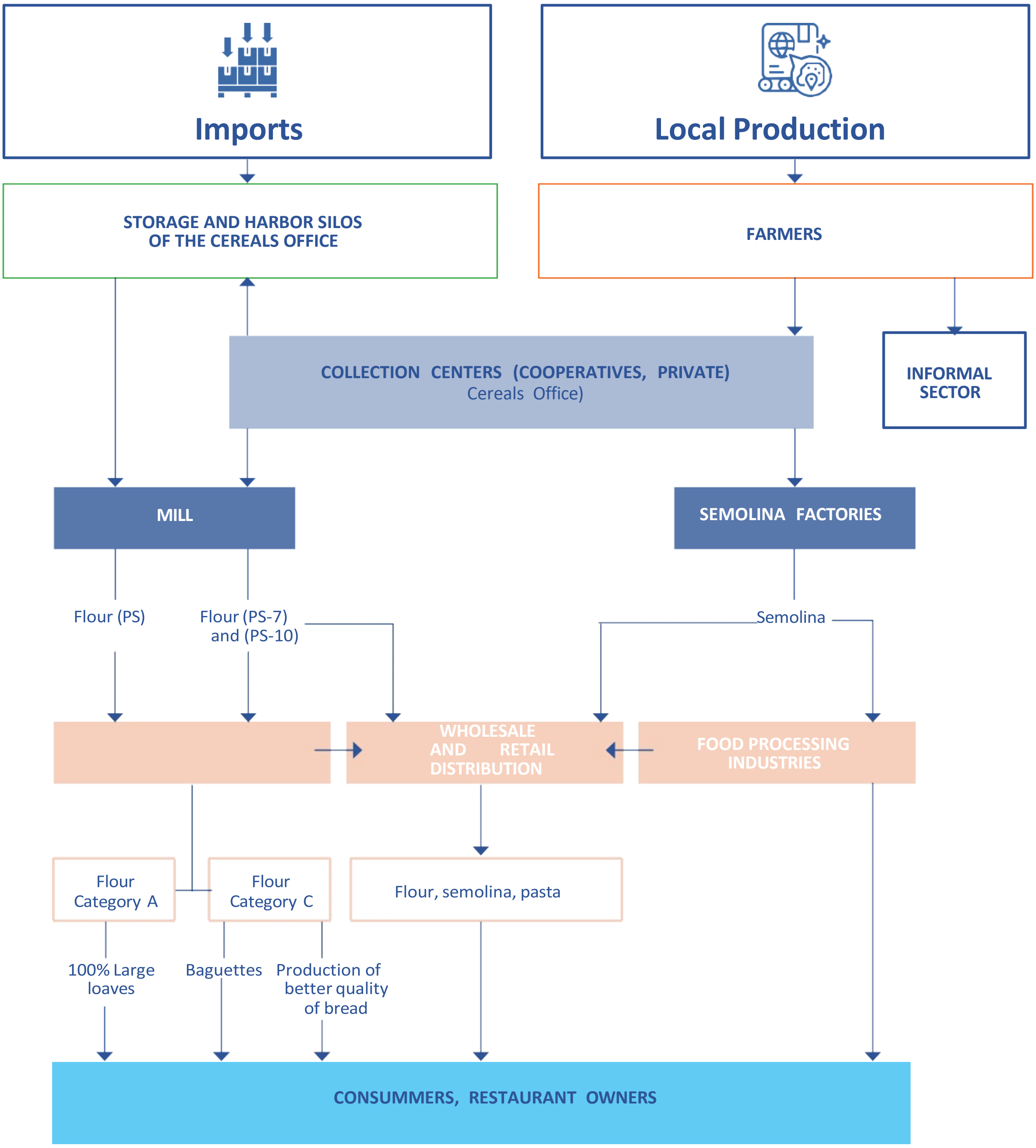
Appendix 28. Analysis of olive price volatility on regional markets



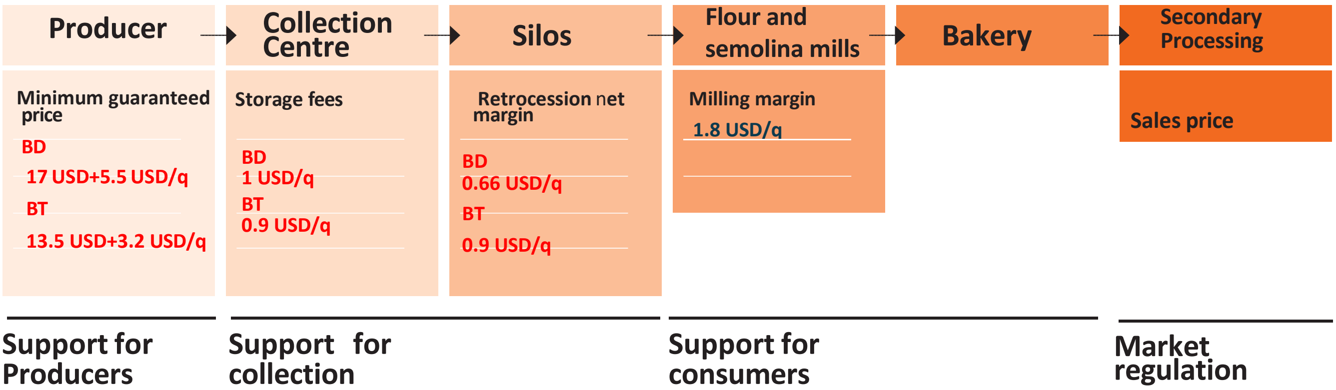
Appendix 29. List of semolina mills

- Modern Mills of Tunis Tunis Rue Ennil Sidi Fath Allah 71 100 790
- The Great Mills of Tunis (G.M.T) Tunis Route of the National Army 1005 El Omrane Tunis 71 898 112 - 71 898 117
- The Society of Food Industries and Mills (SIAM) Tunis Route Lakania 1011 El Ouardia 71 490 984 - 71 393 222
- The Tunisian Milling Company (MEUNIERE) Tunis Industrial Zone Ben Arous 71 382 333
- Sadok Bey Milling and Semolina Company (SADOK BEY) Tunis Industrial Zone Bir El Kassâa 2059 71 382 742 - 71 382 729
- The Tunisian Milling and Semolina Company (SOTUMIS) Tunis Route de Sousse Km5 1011 El Ouardia Tunis 71 399 004 - 71 390 343
- Soukra Mill (SOUKRA) Tunis 81 Avenue Louis Braille 1082 Tunis 71 906 344 - 71 901 368
- The Tunisian Semolina Company (COTUSEM) Tunis 1 Rue 9007 Jebel Jelloud 1011 El Ouardia Tunis 71 397 639 - 70 837 332
- The Maghrebine Mills of Tunis (S.M.M.T) Manouba 1 Rue Hédi Chaker 2010 Manouba 71 602 049
- The Great Mills of Cap Bon (G.M.N - CAP BON) Nabeul 51 Avenue Hédi Chaker 8000 Nabeul 72 272 094
- The General Food Industrial of the North (GIAN) Beja Industrial Zone Route d'Amdoune 9000 Béja 78 454 244
- The Mills of the Center and Sahel United (CENTRE SAHEL) Sousse Route de Monastir 4003 Sousse 73 215 600
- The Milling Company of the Center (SOMEC) Sousse Route de Monastir 4000 Sousse 73 222 649
- New Pasta Unit (EPI D'OR) Sousse Route de M'saken 4002 Sousse 73 233 055
- The Milling and Diverse Industries Company (SMID SOUSSE) Sousse Sidi Abdelhamid 4002 Sousse 73 322 582
- Dorra of Maghrebine Food Industries (DIMA GAFSA) Gafsa Route de Lalla 2121 Gafsa 76 215 710 - 76 215 712
- The Sidi Tlil Mills (SIDI TLIL) Kasserine Thelepte 1215 Feriana Kasserine 74 286 496 - 74 286 700 - 74 286 688
- The Great Mills of the South (G.M.SUD) Sfax Industrial Zone Poudrière 3000 Sfax 74 286 600 - 74 286 688
- The Southern Food Products Production Company (SPASS) Sfax Route La Poudrière BP 698- 3000 Sfax 74 287 745
- The Tunisian Food Production Company (STPA) Sfax Route La Poudrière BP 67- 3000 Sfax 74 287 777
- The Tunisian Milling and Semolina Company Gabès (SOTUMIS) Gabes Route de Medenine Km16 Kettana Gabès 75 237 680
- The Great Mills of Gabès (G.M.G) Gabes Mareth Gabès 75 322 470 - 75 320 200
- The Great Mills of the Gulf (G.M. GOLFE) Gabes Industrial Zone Gannouche Gabès 75 278 311

Appendix 30. Diagram of the cereal milling and semolina production chain

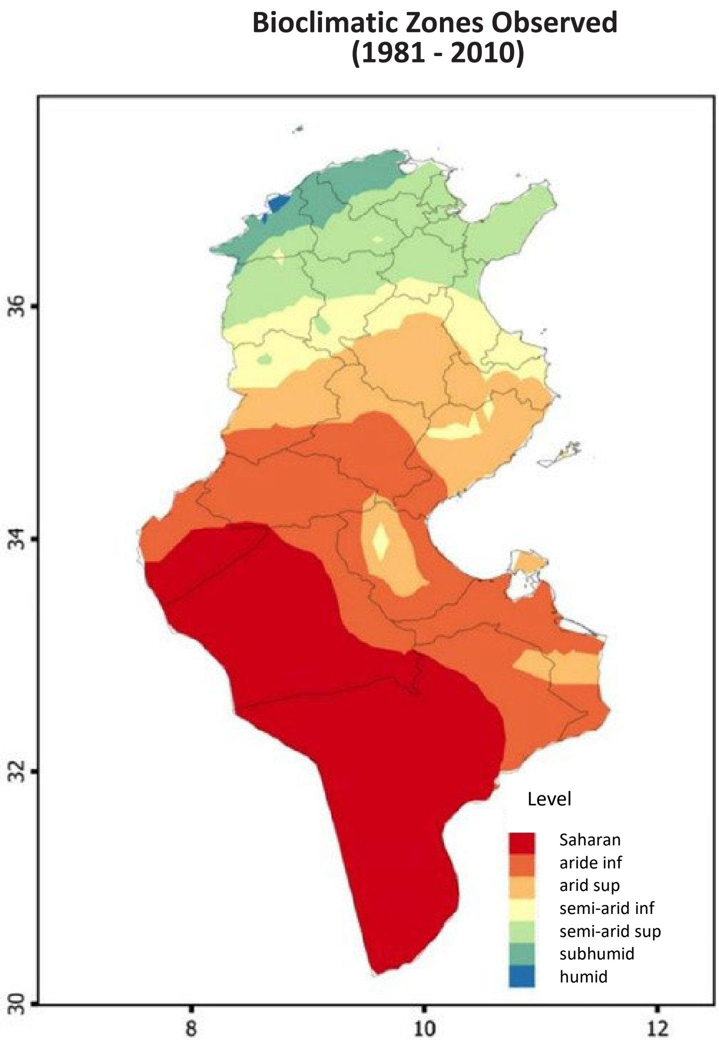


Appendix 31. State intervention in the cereals sector



Source: Khaldi and Saidia, Analysis of the Tunisian cereal industry and identification of the main dysfunctions causing losses.

Appendix 32. Bioclimatic zones



Source : https://climat-c.tn/INM/web/changementClimatique

Notes

Managing risks to improve the livelihoods of producers

Platform for Agricultural Risk Management

PARM Secretariat
International Fund for Agricultural Development (IFAD)
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