

***Irrigated Perimeters as a Mechanism for Enhancing
Agricultural Production and Achieving Sustainable Water and
Food Security: A Case Study of Oum El Bouaghi and Mila
(2018-2022)***

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Abstract:

The study emphasizes the role of irrigation perimeters in boosting agricultural productivity and ensuring sustainable water and food security. These perimeters help improve food quality and increase production by mitigating the effects of climate challenges that threaten food and water security. The close link between water availability and agricultural output is highlighted, with clean, sustainable water being essential for meeting food demands. Using a descriptive-analytical approach, the study examines the Beni Haroun Dam and irrigation systems in Oum El Bouaghi and Mila, alongside grain production from 2018-2022. Key findings indicate that irrigation perimeters enhance agricultural production and act as water reserves for various uses.

Keywords: Food security; Water security; Agricultural production; Irrigation perimeter, Drought.

Jel Classification Codes : Q10, Q18.

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1. Introduction:

The entire world is grappling with the issue of food scarcity, with hunger affecting one-sixth of humanity. This has driven countries into a continuous and ongoing struggle to provide basic food necessities, whether related to plant production or animal products such as red meat, poultry, fish, eggs, and other items. The underlying causes of this issue are numerous, with some of the most prominent being the scarcity and degradation of natural resources. Additionally, climate change and the rising costs of inputs related to plant health, which protect crops from climatic fluctuations like floods that carry harmful weeds and high temperatures that lead to drought and crop damage, further exacerbate the problem.

Among the obstacles limiting the achievement of food security is the poor management of natural environmental resources, such as water. Despite the various available water resources—rainwater, permanent and seasonal surface water, groundwater, and unconventional water sources—the issue of water security remains a persistent gap and a conflict that many countries around the world face.

It can be said that there is a connection between the terms "food security" and "water security," both of which represent global challenges that most countries have suffered from and continue to face. Climate change is a crucial common factor that affects both water and food security on global and local levels. Changes in rainfall patterns and increased weather extremes lead to water scarcity and a decline in water quality, negatively impacting food production and agriculture. Additionally, water shortages reduce crop yields and disrupt food supply chains. Consequently, climate serves as a critical link between the problems of water and food security, exacerbating existing challenges and increasing pressures on food and water systems.

Based on the aforementioned, the following issue can be raised: Many countries resort to various methods, including building dams, to achieve water security, and around these dams, farms are established to contribute to achieving food security.

1.1 Study problem:

How can irrigated oceans enhance agricultural productivity amidst various climatic challenges to achieve sustainable water and food security?

To simplify the main problem, we propose the following sub-questions:

- Does agricultural production get affected by drought in the presence of irrigated oceans?
- To what extent does the decrease in water levels in dams impact the province's ability to provide water for agricultural use?
- Drought is considered one of the major issues affecting food security; can an increase in rainfall be a solution to this problem?

To delve deeper into the research topic and to answer the sub-questions, we propose the following additional sub-questions:

- First Hypothesis: Even with irrigation systems in place, drought can lead to reduced agricultural production due to the lack of available water.
- Second Hypothesis: The decline in water levels in dams can negatively impact the province's ability to provide water for agricultural use.
- Third Hypothesis: Drought is indeed one of the major challenges facing food security; however, abundant rainfall is not necessarily a solution to this problem.

1.2 Study Aim:

- Analyze the factors affecting water security and food safety.
- Understand the impact of alterations in the climate on water availability and food production.
- Assess the effects of population growth and economic development on the demand for water and food.
- Provide recommendations for improving water sustenance and security through the use of sustainable agricultural techniques and effective water management.
- Examine the effects of altered precipitation patterns and severe meteorological phenomena on water and food security.
- Investigate the role of dams in storing large quantities of water and distributing it in a way that supports agriculture and ensures agricultural production.

1.3 Study Methodology:

The descriptive method was adopted to cover all the concepts under study. For the applied aspect, we relied on data analysis provided by the agricultural services directorates and water resources directorates of the provinces of Mila and Oum El Bouaghi to support the study.

2. First Section: Fundamental Concepts on Food Security and Water Security

2.1 Food Security:

2.1.1 Definition:

The notion of food security originated in the mid-1970s during worldwide dialogues over the global food crisis. The primary emphasis of food security concerns was initially on food supply challenges, namely ensuring the accessibility of essential foodstuffs and relatively stable prices at both the international and national levels (Habtamu, 2013, p. 04).

Food security is a condition in which all persons, consistently, has physical, social, and economic access to enough, safe, and nutritious food that satisfies their dietary requirements and preferences for a vigorous and healthy existence (Wen & Elliot, 2018, p. 01).

Four aspects of food security may be discerned from these definitions (Food and Agriculture Organization of the United Nations, 2015, p. 03):

- Food Availability: Food availability is enhanced through improvements in agricultural practices.
- Economic and Physical Accessibility to Food: Food access encompasses both physical and economic aspects. Infrastructure, including ports, highways, and trains, is crucial for the transportation of food from producing regions to market hubs. The same facilities are needed to move agricultural inputs like seeds, fertilizers, and chemicals to rural areas at the right time and in the required quantities to support agricultural production.
- Utilization of Food: The usage of food signifies the significance of optimal health. For example, malnourished children or those suffering from diarrhea cannot absorb all the nutrients in their food, making improvements in food aspects critical to health.
- Stability: Stability involves vulnerability and exposure to shocks over time. For example, the cultivation of primary food crops might fluctuate due to changes in precipitation patterns, inundations, arid conditions, or insect infestations in critical production regions, and these occurrences can impact national food security.

Seasonal food security exists between chronic and acute food insecurity. It mirrors chronic food insecurity as it is often foreseeable and adheres to a sequence of recognized occurrences. Seasonal food insecurity is transient and may therefore be classified as a recurrent, short-term food insecurity, arising from a cyclical pattern of insufficient food supply and access, often associated with periodic variations in temperature and agricultural cycles, employment

opportunities, and diseases. The distinction between chronic and temporary food insecurity can be summarized as follows:

Table 1: The distinction between chronic and temporary food insecurity

Aspect	Chronic and Acute Food Insecurity	Temporary Food Insecurity
Time	Long-term and continuous	Short-term and temporary
Cause	Sudden decrease in production capacity	Inability to meet minimum food needs over an extended period
Results	Long periods of poverty and loss of assets	Short-term shocks and fluctuations in food supply

Source: Prepared by the researchers based on data from An Introduction to the Basic Concepts of Food Security.

Based on the previous definitions, it can be stated that food security pertains to the sense of assurance people feel regarding the continuous and sufficient availability of food for all members of society, ensuring they are not subjected to hunger or nutritional deficiencies. This indicates a nation's capacity to generate sufficient food to satisfy the demands of its population without relying on food imports, which is known as self-sufficiency. Acute food insecurity, on the other hand, occurs when individuals or communities face a severe shortage of food due to temporary circumstances such as natural disasters or wars. Chronic food insecurity, however, refers to a prolonged lack of food availability due to multiple factors such as poverty and malnutrition. Meanwhile, temporary food insecurity occurs when communities experience a short-term food shortage due to temporary conditions like a drop in agricultural production or rising prices.

2.2 Drivers of Food Insecurity:

Since 2017, the State of Food Security and Nutrition in the World report has identified and examined the primary factors

contributing to the rising trends of hunger, food insecurity, and malnutrition worldwide. Compelling evidence identifies wars, climatic variability, severe weather occurrences, economic downturns, and recessions as the three main external factors contributing to food insecurity impacting millions of people. The negative impact of these drivers is exacerbated by poverty on one hand, and inequality on the other, both of which are major causes of food insecurity. Additionally, the inability to afford healthy diets further aggravates the situation (Máximo, 2023, p. 05).

2.3 Water Security:

2.3.1 Definition:

Over the past two decades, water security has garnered heightened focus in policy and development, and academic discussions, largely due to the significant focus it has received in research fields. Moreover, the examination of water security within prospective social, economic, and environmental contexts has made it a prevalent topic in sustainable development studies and future risk assessments. Lastly, water security plays a crucial role in supporting and addressing sustainable development goals (Xanthe, 2022, p. 206).

Water security encompasses the sustainable utilization and safeguarding of water systems, as well as the pursuit of the sustainable development of water resources and the mitigation of water-related hazards, including droughts and floods. It also entails the safeguarding of the functions and services of water for both humans and the environment, ensuring that there is an adequate supply to satisfy the basic requirements of individuals. The primary driver for enhancing and improving water security is human intervention, as the management and rational use of water systems fall under human responsibility. The goal of water security is to promote the advantageous and sustainable use of water for diverse applications, including water supply, irrigation, drainage, and hydropower. Often,

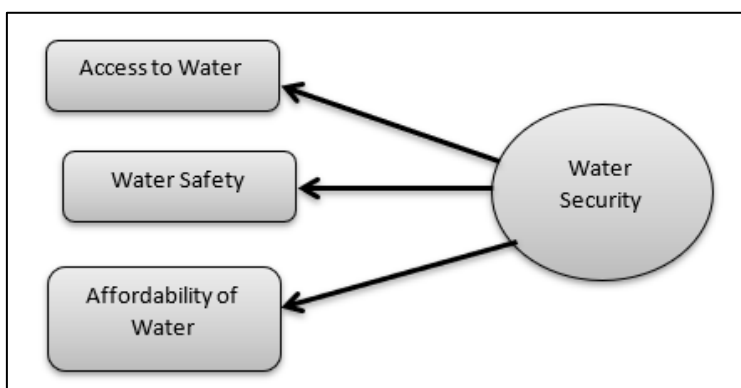
interventions in water systems are necessary to meet the needs of both society and the environment, and these interventions must take into account their broader impact on water users to address the challenges posed by different types of changes (Bart & Stefan, 2007, p. 02).

From the above, we can conclude that water security denotes the capacity to guarantee permanence and sustained access to clean resources, usable water in sufficient quantities for all members of society, as well as for agricultural and industrial use, without negatively impacting the environment or human health.

2.3.2 Elements of Water Security: (Chamhuri & Ferdoushi, 2013, p. 04)

Several studies have highlighted the elements of water security, with the goal of enabling individuals to live in a clean, healthy, and productive environment while ensuring and enhancing the protection of the natural environment. These elements can be illustrated as shown in the following figure:

Figure.1. The elements of water security



Source: Prepared by the researchers based on the aforementioned information.

- Access to water is the first element of water security and is crucial for ensuring water security. All members of society

must have access to clean water in sustainable quantities and quality throughout the year; otherwise, communities will face negative impacts on health and livelihoods. Water services should also be available in homes, educational institutions, workplaces, healthcare facilities, and public spaces.

- Water safety is a fundamental aspect of water security and represents the second element. Water must be safe for personal and domestic use, meaning it should be of good quality or at least acceptable in terms of appearance and odor to prevent diseases. Additionally, wastewater must be properly disposed of to ensure both water quality and public health.
- Affordability of water is a crucial aspect of water security, indicating that persons must have access to clean and enough drinking water at a fair cost to satisfy their fundamental requirements. The primary standard is that tariffs and delivery costs should be designed in a way that makes them affordable for everyone, including those living in extreme poverty.

2.3.3 Challenges to Water Security: (Sadoff & Others, 2015, p. 38)

The main objective of water security is to optimize possibilities for sustainable water use while managing the risks associated with it. This is essential for achieving sustainable growth and enhancing social and economic well-being. Policies and investments aim to develop the infrastructure needed to achieve these goals, such as building dams, water stations, and sewage networks. These efforts aim to ensure the provision of water in specified quantities and quality at the right times and locations at reasonable prices, as well as to protect people and property from hydrological hazards, including inundations and water contamination, and water shortages.

The growing risks associated with water are due to several factors, encompassing demographic and economic expansion, which put increasing pressure on water resources, thereby exposing an increased number of individuals and assets at danger. Climate variability further exacerbates these risks by making water availability less predictable. The accumulation of these risks intensifies the

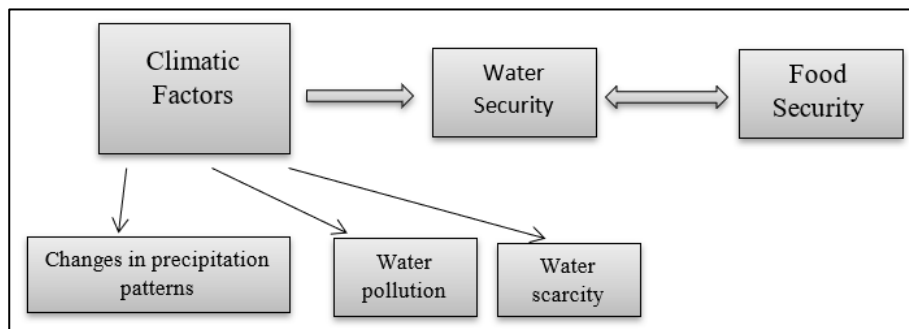
challenge of achieving water security, i.e., ensuring the safe and sustainable provision of water for current and future individual uses.

3. Relationship Between Water Security and Food Security:

Irrigation is the essential factor for augmenting food output and agricultural revenue while improving resistance to climatic variability. Water influences food security and nutrition in several ways and across several dimensions. More precise irrigation management not only increases the volume of food that can be produced but also increases its diversity, comprising arid season crops and nutrient-dense foods, including fruits and vegetables. This therefore conserves time and enhances health. Conversely, proficient management of diverse water applications and wastewater diminishes pollution exposure and the likelihood of infectious illnesses (Mark, 2019).

3.1 Drivers of Pressure on the Water-Food Relationship:

Figure.2. The impact of climate on food security and water security



Source: Prepared by the researchers based on the aforementioned information.

Based on the figure above, the relationship between water security and food security can be explained by the fact that water is an essential element for food production. Agriculture relies heavily on water for irrigating various crops, and without adequate water,

agricultural productivity and food production may be negatively impacted. Additionally, water is used for livestock farming and in various food industries. A lack of water available for agricultural irrigation can reduce agricultural output, leading to shortages in food supply and higher food prices, thereby affecting food security. Moreover, water pollution caused by chemicals and organic contaminants can damage crops and fishery resources, diminishing both the volume and quality of accessible food. Water pollution can also have adverse effects on human health if contaminated water is used for crop irrigation or drinking. Changes in rainfall patterns can increase the frequency of droughts or floods, which may spread diseases among plants, impacting agricultural production and reducing access to fresh water.

Therefore, ensuring access to water contributes to increased food production and improved food security, as it stabilizes agricultural production, fish stocks, and sustainable food systems. Achieving water security is thus vital for attaining long-term food security.

4. Applied Study:

The study was conducted at the level of the Directorate of Water Resources for the province of Mila and the Directorate of Agricultural Services for the provinces of Mila and Oum El Bouaghi. It involved presenting the state of irrigated areas in these provinces as a model to illustrate the importance of irrigation areas for agricultural production. The study focused on the years 2018, 2019, 2020, 2021, and 2022, due to the climatic factors prevalent during this period, which were marked by drought and low agricultural productivity. Special reference is made to the Beni Haroun Dam, which is considered the main source for providing drinking water and irrigation to the neighboring districts.

4.1 Overview of the Beni Haroun Dam:

The Beni Haroun Dam is the largest dam in Algeria, with a storage capacity of 1 billion cubic meters, providing an annual water supply of 425 million cubic meters. The dam took approximately 20 years to complete and is the central component of the major water diversion project, which ensures the delivery of 310 million cubic meters of water annually, equating to a minimum of 150 liters per person per day for the neighboring regions of the Mila province.

Located in the Beni Haroun area of the Hamala municipality, in the Karrarem Gouga district of the Mila province, the dam is bordered to the north by Sidi Marouf, Jijel province; to the south by the Karrarem Gouga municipality; to the east by the hamlet of Beni Haroun; and to the west by the Chekara municipality. It spans an area of 1,000 hectares and is state-owned, boasting a strategic tourist location due to its proximity to National Road 27, which connects the provinces of Constantine and Jijel via Mila.

The dam is also near Oued El Dhib Bridge, located at the northernmost point of the Mila province, in the Hamala municipality, and close to one of Algeria's most important ports, the Jijel port of Djen Djen. Additionally, the area contains Roman ruins that are still relatively unknown, as well as one of the most significant thermal springs in the Mila province, the Beni Haroun Spring. The dam is located 15 kilometers from the provincial capital of Mila and 500 kilometers east of the Algerian capital, Algiers. This scenic site houses the largest dam in Algeria, covering a vast area of eastern Algeria. The total basin area spans 6,595 hectares, with the dam covering 1,392 hectares: 50% in Karrarem Gouga, 25% in Sidi Marwan, 10% in Chekara, 5% in Zaghaya, 5% in Benain, and 5% in Aras. The dam is built using roller-compacted concrete and is considered one of Algeria's most significant and important water infrastructure projects. It is also utilized for tourism, given its proximity to many tourist attractions. (Daas, 2020, p. 214).

Figure.3. Districts Benefiting from the Beni Haroun Dam

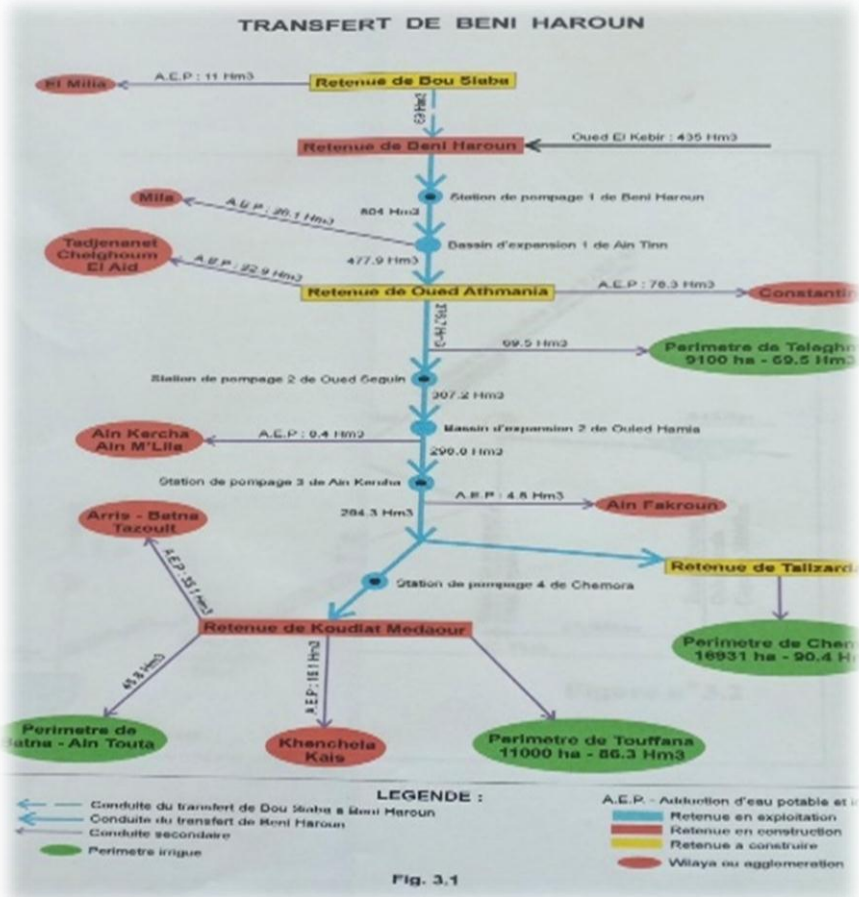


Fig. 3.1

Source: Data from the Directorate of Water Resources, Mila Province.

4.2 Diagram Translation:

The diagram illustrates the major water diversion from the Beni Haroun Dam, which transports water northward toward the Bou Saïfa reservoir (shown at the top of the map) via a gravity system. This reservoir supplies drinking water (AEP) to the city of El Milia to the south. The dam also supplies the city of Mila (shown in the center of the map, where the transport lines branch out) via a pumping station

that also feeds Constantine, Chelghoum El Aïd, Oued Athmania, and Tadjenanet from the Oued Athmania complex. The latter supplies the irrigation area of Teleghma. The Oued Sighoun pumping station pumps water towards Kharsha and Ain M'lila to provide them with drinking water (AEP). After this station, we have the Ain Kharsha station, which pumps water to Ain Fekroun for drinking water supply. Water is also transported to the Talzeradan complex to ensure irrigation for the Chimora region. The last pumping station is the Chimora station, which transports water to the Koudiat Medaouer complex to provide drinking water (AEP) to Ares, Batna, and Tazoult, as well as drinking water to Khenchela and Kais. On the other side, it ensures irrigation for the Batna-Ain Touta and Toufana irrigation areas.

4.3 Diagram Analysis:

- The extensive geographic distribution represents a system that spans a large area, covering many urban and agricultural regions, highlighting the importance of Beni Haroun as a key water source in the region.
- The advanced infrastructure, with multiple pumping stations and diversion reservoirs, enhances the efficiency of water distribution and ensures it reaches distant areas.
- The focus on potable water, with many lines dedicated to supplying cities and towns with drinking water, reflects the critical role of water in supporting the daily lives of the population.
- Large agricultural areas, such as the Teleghma and Chimora zones, show the significance of this system in supporting agriculture and food production in the region.
- The reliance on technology, using modern techniques like pumping stations and multiple reservoirs, indicates substantial investment in water infrastructure.

5. Overview of the Teleghma Irrigation Area:

The Teleghma irrigation area is located in the southern part of the province and includes the municipalities of Oued Athmania, Oued

Segan, Teleghma, and M'Chira, covering an area of 4,447 hectares. It is part of the larger network of the Beni Haroun Dam and is divided into three (3) sectors:

5.1 Northern Sector:

- Includes the municipalities of Oued Athmania and Oued Segan, covering an area of 1,142 hectares.
- Became operational on 25/03/2018.
- Number of registered farmers: 107.
- Irrigated area during the 2022-2023 agricultural season: 1,735 hectares, of which 800 hectares were used for grain.

5.2 Central Sector:

- Includes the municipality of Teleghma, covering an area of 1,739 hectares.
- Became operational on 25/04/2018.
- Number of registered farmers: 429.
- Irrigated area during the 2022-2023 agricultural season: 1,907 hectares, of which 700 hectares were used for grain.

5.3 Western Sector:

- Includes the municipalities of Teleghma and M'Chira, covering an area of 1,566 hectares.
- Theoretically became operational on 31/07/2018.
- Number of registered farmers: 281.
- Irrigated area during the 2022-2023 agricultural season: 1,860 hectares, of which 953 hectares were used for grain.

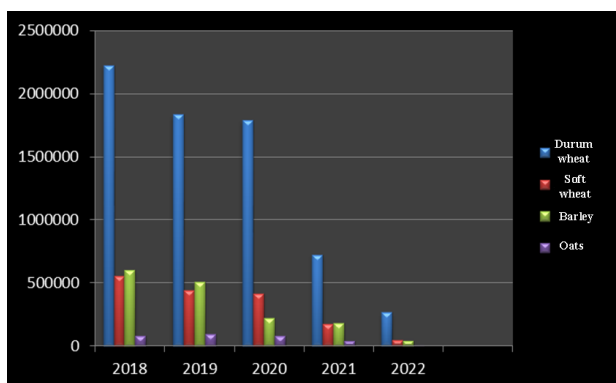
The irrigation system here relies on the central pivot irrigation method for all types of grains.

Table 2. Agricultural Production Overview for the Grain Sector in Mila Province from 2018-2022

2022		2021		2020		2019		2018		
Harvested Production	Cultivated Area	Harvested Production	Cultivated Area	Harvested Production	Cultivated Area	Harvested Production	Cultivated Area	Harvested Production	Cultivated Area	
264841	70288	720942	73370	1790295	70019	1832228	66964	2225000	69221	Durum wheat
45574	20236	174164	21137	414400	20253	441072	19302	553000	19100	Soft wheat
42666	21669	181568	18589	218080	22142	505614	23383	597836	22350	Barley
2282	4499	38100	4432	77225	4895	96140	5260	81140	4185	Oats

Source: Database of the Directorate of Agricultural Services for the Province of Mila (Department of Agricultural Statistics and Economic Accounting).

Fig.4. Agricultural Grain Production from 2018 to 2022 in the Province of Mila



Source: Prepared by the researchers based on the aforementioned information

Based on the figure above and the table illustrating the agricultural grain production in the province of Mila, the following can be observed:

Mila province recorded variable production levels of durum wheat from 2018 to 2022, with production reaching approximately 2,225,000 quintals in 2018, gradually decreasing to 264,841 quintals

in 2022. As for soft wheat, its production fluctuated, peaking at 553,000 quintals in 2019 before dropping to 45,574 quintals in 2022. Barley production showed relative stability with some fluctuations, reaching its highest level in 2019 with approximately 505,614 quintals and its lowest in 2022 with 42,666 quintals. Lastly, the production of oats was limited compared to other grains, peaking at 96,140 quintals in 2020 and falling to a low of 2,282 quintals in 2022. It can be said that Mila province relied heavily on the production of durum wheat.

5.5 Calculating Yield Per Hectare for Each Year:

$$\text{Yield} = \frac{\text{Production (quintals)}}{\text{Cultivated Area (hectares)}}$$

Table .3. Yield per Hectare (Grain Yield in Mila Province)

Year	Durum Wheat	Soft Wheat	Barley	Oats
2018	32.3	29	26.7	19
2019	27	23	22	18
2020	26	10	10	25
2021	13	11	12	12
2022	12	10	10.5	11.7

Source: Prepared by the researchers based on the aforementioned information.

Based on the calculation of the yield for each type of grain, the following can be concluded:

- Durum Wheat: The yield of durum wheat decreased significantly from 32.3 quintals/hectare in 2018 to 12 quintals/hectare in 2022.
- Soft Wheat: The yield of soft wheat also declined from 29 quintals/hectare in 2018 to 10 quintals/hectare in 2022.
- Barley: The yield of barley fluctuated between 26.7 quintals/hectare in 2018 and 10.5 quintals/hectare in 2022.
- Oats: The yield of oats decreased from 19 quintals/hectare in 2018 to 11.7 quintals/hectare in 2022.

5.6 Overview of the Irrigation Areas in the Province of Oum El Bouaghi:

5.6.1 Oulad Hamla Irrigation Area:

- Water Source: Beni Haroun Dam
- Irrigated Area: 2,350 hectares (grains)
- Operational Since: 2014

5.6.2 Ksar Sobihi Irrigation Area:

- **Water Source:** Foum El Kheneg Dam, Souk Ahras Province
- **Irrigated Area:** 1,970 hectares (grains)
- **Operational Since:** 2014

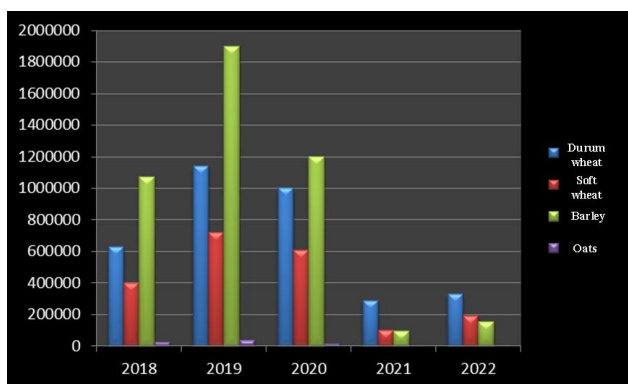
Table .4. Agricultural Grain Production Overview for the Province of Oum El Bouaghi from 2018-2022

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	2018		2019		2020		2021		2022	
	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Cultivated Area (hectares)	Harvested Production (quintals)
Durum wheat	51774	630000	62900	1140000	63000	1004000	29000	290000	65.45	332730
Soft wheat	34838	400000	44900	720000	47000	610000	16600	99600	64770	191789
Barley	71864	1074500	104700	1900000	94000	1200000	19200	96000	58.84	155461
Oats	1*485	25500	2000	40000	930	15000	494	3460	930	6597

Source: Database of the Directorate of Agricultural Services for the Province of Oum El Bouaghi (Department of Agricultural Statistics and Economic Accounting).

Figure.5. Agricultural Grain Production from 2018 to 2022 in the Province of Oum El Bouaghi



Source: Prepared by the researchers based on the aforementioned information.

Based on the figure above and the table illustrating the agricultural grain production in the province of Oum El Bouaghi, the following can be observed:

The province of Oum El Bouaghi experienced fluctuating production of durum wheat, with the highest level recorded in 2019 at 1,140,000 quintals, dropping to 332,730 quintals in 2022. For soft wheat, production ranged from 400,000 quintals in 2018 to 191,789 quintals in 2022. Barley had the highest production among the other grains, reaching 1,900,000 quintals in 2019 but decreasing to 155,461 quintals in 2022. Lastly, oats production was relatively low, with 25,500 quintals in 2018, falling to 6,597 quintals in 2022. It can be said that the province of Oum El Bouaghi heavily relies on barley for its production, as shown by its dominance in the first three years.

5.7 Calculation of Yield per Hectare for Each Year:

Table .5. Yield per Hectare (Grain Yield in the Province of Oum El Bouaghi)

	Durum wheat	Soft wheat	Barley	Oats
2018	12	11.4	14.95	17
2019	18.12	16	18.14	20
2020	15.93	12.97	12.76	16.12
2021	10	6	5	7
2022	5	2	2	7

Source: Prepared by the researchers based on the aforementioned information

Based on the calculation of yield for each type of grain, the following can be concluded:

- Durum wheat: The yield of durum wheat fluctuated between 12 quintals/hectare in 2018 and 5 quintals/hectare in 2022.
- Soft wheat: The yield of soft wheat decreased from 11.4 quintals/hectare in 2018 to 2 quintals/hectare in 2022.
- Barley: The yield of barley decreased significantly from 14.95 quintals/hectare in 2018 to 2 quintals/hectare in 2022.
- Oats: The yield of oats declined from 17 quintals/hectare in 2018 to 7 quintals/hectare in 2022.

From the analysis of both provinces, it can be said that irrigation areas play a vital role in supporting agricultural production in Mila and Oum El Bouaghi. These areas help to provide a sustainable supply of irrigation water, especially in light of the climatic challenges the regions have faced in recent years, such as droughts and low rainfall, which have contributed to the decline in agricultural production. The irrigation areas, represented by agricultural lands irrigated by dams like Beni Haroun and Foum El Kheneg, are the primary sources of water for these provinces' irrigation systems, aiming to achieve

optimal production. Despite the challenging conditions in recent years, the irrigation areas have helped ensure that production did not decline significantly. While the output is not as high as in previous years, it remains relatively acceptable.

6. Conclusion:

From the above, it is evident that a robust correlation exists between water security and food security, highlighting the critical link between providing clean and sustainable water and achieving sufficient agricultural productivity to meet the population's food needs. These two factors interact directly and influence one another. In terms of water and agriculture, agriculture relies heavily on water, especially in areas that lack sufficient natural water resources. Providing sustainable irrigation and efficiently using water contributes to increased agricultural productivity and improved quality of crops and agricultural products. As for food security, it pertains to ensuring the availability of enough and nourishing sustenance for all individuals in a sustainable manner. If there is insufficient water for agriculture, this can lead to a reduction in agricultural production, and consequently, a shortage of available food, thereby affecting food security. Among the techniques that assist in addressing this challenge are dams and irrigation areas, which act as reserve reservoirs capable of providing adequate water supplies for various uses. This provides a convincing answer to both the first and second hypotheses: when water levels drop, reserve storage and the ability to provide sufficient quantities of water for different uses can be affected, potentially leading to water shortages for agriculture, and in the end, this could impact agricultural production. Regarding the third hypothesis, floods may cause crop destruction and the loss of agricultural resources, while excessive rainfall may exacerbate drainage issues, cause chemical seepage and pollution, and transfer weed seeds among plants, all of which negatively affect agricultural production.

The study reached several conclusions:

- A clear fluctuation in grain production in the provinces of Mila and Oum El Bouaghi was observed from 2018 to 2022, reflecting the impact of climatic factors and economic conditions on production.
- A significant decline in agricultural production yield was noted in both provinces, highlighting the need to improve farming techniques and provide technical support to farmers.
- Irrigation areas play an essential function in facilitating agricultural output, as they contribute to providing the necessary water for irrigation, which enhances productivity and quality.
- Drought and climate changes have negatively affected agricultural production in both provinces, necessitating the adoption of sustainable agricultural strategies to face these challenges.

6.1 Study Recommendations:

- Emphasize the importance of proper planning and efficient water resource management to ensure the sustainability of agricultural production and achieve food security.
- Highlight the importance of innovation and investment in sustainable irrigation and agricultural techniques to boost productivity and achieve agricultural sustainability in the provinces of Mila and Oum El Bouaghi.
- Rely more on the irrigation areas project due to its significance in maintaining environmental sustainability.
- Adopt multiple strategies aimed at better water resource management and developing drought-resistant farming techniques.

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