

Article

Climate Impacts on Barley Cultivation and Production in Syria (2013-2022)

Ghaith Amin Ali¹, Sliman Nedal Moualla²

¹ Agriculture Economics. Dep. Agricultural Eco. Fac. Agric., Latakia (Tishreen) Univ., Latakia, Syria

² Agriculture Economics. Dep. Agricultural Eco. Fac. Agric., Tehran Univ., Tehran, Iran.

* Correspondence: gali.syria@gmail.com , ghaith.ali@latakia-univ.edu.sy (Syria),
sulaiman1998.8@gmail.com (Iran).

Abstract: This study quantitatively analyzes the state of barley production and food security in Syria from 2013 to 2022, a period marked by conflict and significant climate variability. The methodology involved a descriptive analysis of key food security indicators and a comparative analysis of barley production against annual rainfall data. The findings reveal high volatility in barley production and directly impacted by rainfall fluctuations, with a simple linear regression confirming a strong, positive, and statistically significant correlation ($R = 0.712$). Rainfall variability alone explains 50.7% of the variance in barley output. The analysis quantitatively links major production collapses, such as in 2017 and 2021, to years with significant rainfall deficits compared to the 10-year average. Conversely, peak production in 2019 corresponds to the highest recorded rainfall. The study finds a critical feed gap deficit peaking at -1,518 thousand tons and an average self-sufficiency rate of 50.4%. The data-driven analysis concludes that rainfall variability, compounded by conflict and economic sanctions, has critically undermined Syria's barley sector.

Keywords: Barley, food security, self-sufficiency, rainfall, climate change, Syria.

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1. Introduction

Globally, barley ranks fourth in area and production after wheat, rice, and maize, serving as a cornerstone for food security. Approximately 70% of its production is utilized for animal feed, with the remainder contributing to human consumption and beverage industries. Effective cultivation of this vital grain is increasingly challenged by global climate change, which threatens agricultural stability worldwide, particularly in arid and semi-arid regions (Abbas et al., 2023).

In the national context of Syria, barley is a strategic crop, historically central to the country's policy of food self-reliance (Jusoor for Studies, 2024). It also represents one of the most important animal feeds globally, especially for livestock in Syria, underscoring its crucial role in the agricultural economy (Alahmad, 2022). Barley is primarily cultivated in the Third and Fourth Stability Zones,

which are predominantly rainfed areas characterized by extreme sensitivity to climatic conditions, particularly fluctuations in rainfall and temperature (Hormuz et al., 2015; Al-Hassoun et al., 2016). While climate change is often viewed as a future crisis globally, its impacts are a present reality for conflict-affected communities, the impacts of climate change on Syrian agriculture are evident, having led to an increased intensity and frequency of extreme weather events, thereby threatening regional food security (IRC, 2024; Fayad, 2025). The effect of recurrent drought over the last decade has been severe and destructive, as climate pressures have interacted with the protracted crisis to define the specific problem this study addresses: the collapse of Syrian barley production (IRC, 2024). For instance, between 2010 and 2021, the area cultivated with barley decreased from 1.527 million hectares to 1.44 million hectares, while production dropped more sharply from 680 thousand tones to 252.3 thousand tones (Jusoor for Studies, 2024). In 2022, barley was cultivated on 1.11 million hectares, yielding only 0.18 million tons, with productivity plummeting to 0.2 tons/hectare—a stark contrast to the 1.5 tons/hectare achieved in 2020 (Annual Agricultural Statistical Abstract, 2023). These figures demonstrate that barley has been subject to significant fluctuations in productivity influenced by climatic factors (Hormuz et al., 2015), which highlights the urgent need for comprehensive quantitative analysis.

Despite existing documentation by international bodies regarding Syria's food security challenges, a significant gap remains in quantitatively analyzing the key performance indicators (KPIs) for a strategic and highly climate-sensitive crop like barley over the entire crisis period (2013–2022). Existing studies often address conflict or climate pressures in isolation, but they rarely synthesize official data to track the long-term performance trajectory of the barley sector. The novelty of this study lies in its synthesis of available official statistics and economic data to present a comprehensive, quantitative analysis of this sector's decline. By establishing clear metrics on production, self-sufficiency, and deficits, this research provides the essential evidence base needed to inform climate-smart agricultural interventions.

1. Aims and objectives:

Syria's agricultural sector has faced significant challenges due to the protracted crisis and environmental pressures, which have destroyed agricultural infrastructure, reduced barley production, and negatively impacted national food security. Based on this, the study aims to:

- Analyze the current reality of barley production in Syria by examining trends in cultivated area and production.
- Evaluate the reality of the strategic stock of barley by studying and interpreting key food security indicators.
- Quantitatively determine the impact of rainfall variability on barley production to understand the climatic factors affecting the sector's long-term performance and decline.

2. Materials and Methods:

2.1. Study Area

The research focused on the Syrian Arab Republic. Barley cultivation is concentrated in the country's agricultural stability zones, which are defined by rainfall levels. As shown in Figure 1, Zones 3 and 4, which are mostly rainfed, are the primary areas for barley cultivation and are highly vulnerable to drought.

Zone 3: Annual rainfall of 250 to 350 mm with not less than 250 mm during half of the monitored years. It is possible to grow one or two crops every three years. The main crop is barley but legumes

may also be grown. The area of this zone, 1 306 000 ha, accounts for 7.1 percent of the total national area (FAO, 2003).

Zone 4: A marginal zone between the arable zones and the desert zone with an annual rainfall between 200 and 250 mm and not less than 200 mm during half of the monitored years. This zone is suitable only for barley or for permanent grazing. The area of this zone, 1 823 000 ha, forms 9.8 percent of the national area (FAO, 2003).

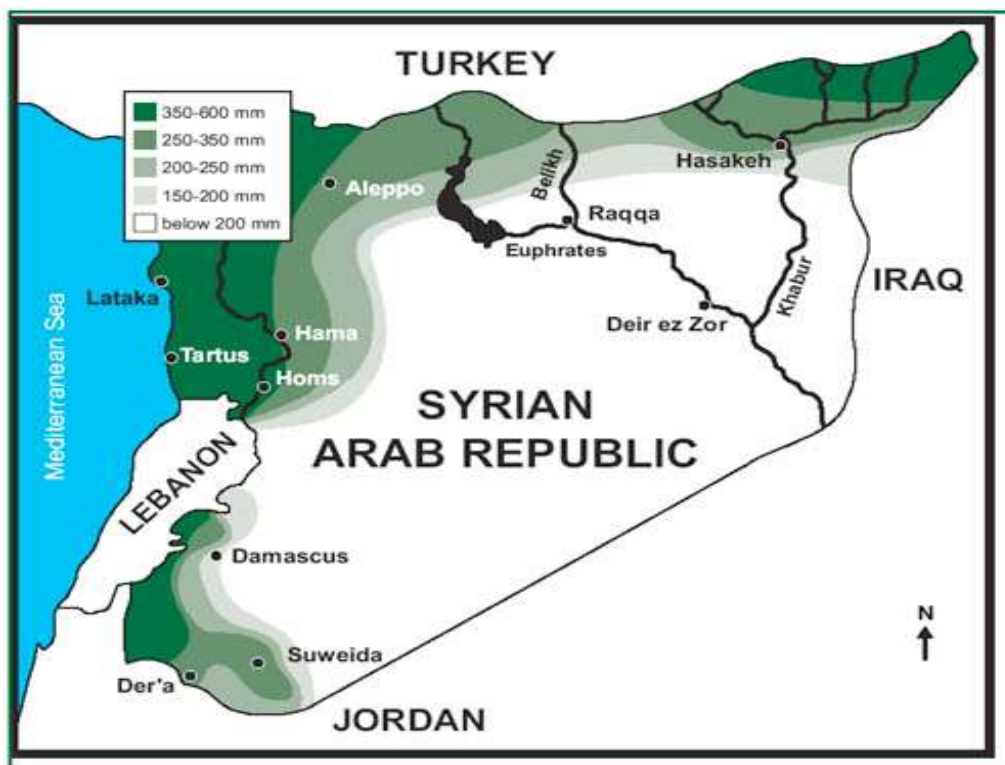


Figure 1. Agricultural stability zones in the Syrian Arab Republic, (map from FAO, 2003)

2.2. Data Sources

Data were compiled from specific, publicly available sources:

- The annual Syrian Statistical Abstract (2013-2023) from the Central Bureau of Statistics (CBS) for barley production (tones) and cultivated area (hectares) data. This served as the official national source for agricultural metrics.
- A series of Special Reports from the FAO/WFP Crop and Food Security Assessment Mission to the Syrian Arab Republic (2013-2021) for food balance sheet data.
- Annual rainfall data (mm) for Syria for the study period were obtained from the General Directorate of Meteorology (GDM), as provided by the authors. This data is collected through the GDM's established network of weather stations using standardized meteorological protocols. The GDM is considered the authoritative source for long-term climatic records in Syria, ensuring the reliability and consistency of the data used for agricultural modeling.

2.3. Research Methodology

A descriptive and quantitative analytical approach was employed in this study. To precisely quantify the relationship between annual rainfall and barley output, a simple linear regression

analysis was conducted. This analysis was performed using SPSS (Statistical Package for the Social Sciences), which was utilized to calculate the coefficient of determination (R^2) to measure the strength of the correlation, and the p-value (significance level) to determine the statistical significance of the relationship between the two variables. The study incorporated a quantitative analysis comparing annual rainfall data with annual barley production to identify correlations. A combined time-series chart was created to visually analyze this relationship, and years with significant rainfall deviation from the 10-year average were identified and linked to production outcomes. Microsoft Excel was primarily used for initial data cleaning, organization, calculation of descriptive statistics (such as the 10-year average and deviations), and the generation of the time-series charts for visual analysis.

2.4. Statistical Indicators Used

The following indicators were chosen to meet the research objectives:

2.4.1. Self-sufficiency Ratio (SSR %): This indicator was chosen to measure the country's ability to meet its own barley needs from domestic production.

$$\text{Self-sufficiency ratio} = \frac{\text{Production}}{\text{Total use}} * 100$$

2.4.2. Import Dependency Ratio (IDR %): This ratio was used to quantify the extent to which the country relies on external sources to meet its needs.

$$\text{IDR} = \frac{\text{Imports}}{\text{Total use}} * 100$$

2.4.3. Compound Annual Growth Rate (CAGR %): CAGR was used to calculate the smoothed average annual growth rate of production and availability over the period, using the following formula:

$$\text{CAGR} (\%) = \left[\left(\frac{Y_t}{Y_0} \right)^{\frac{1}{N}} - 1 \right] \times 100$$

Where:

- Y_t : Final value of the variable at the end of the period (e.g., Production in tons or Availability in thousand tons).
- Y_0 : Initial value of the variable at the start of the period (e.g., Production in tons or Availability in thousand tons).
- N : Number of years in the analyzed period.

3. Results

3.1. Current reality of barley production in Syria

Barley production over the past decade reflects the volatility of the climatic conditions. Table 1. shows the cultivated area, production, and productivity from 2013 to 2022.

Table 1. Development of Barley Area, Production, and Productivity in Syria (2013-2022).

Year	Area (thousand hectares)	Area index	Production (thousand tons)	Production index	Productivity (tons/hectare)
2013	1262.9	100	910.9	100	0.7
2014	1220.5	96.6	600.1	65.9	0.5
2015	1120.3	88.7	1614.9	177.3	1.4
2016	1244.2	98.5	954.4	104.8	0.8
2017	1181.0	93.5	990.1	108.7	0.8
2018	1187.2	94.0	408.1	44.8	0.3
2019	1480.9	117.3	3053.1	335.2	2.1
2020	1502.9	119.0	2245.8	246.5	1.5
2021	1440.0	114.0	252.3	27.7	0.2
2022	1114.8	88.3	178.5	19.6	0.2

Source: Based on statistical data for the years 2013-2023.

Interpretation of Table 1: Barley production in Syria exhibited significant volatility throughout the 2013–2022 period. Production peaks were recorded in 2019 (3,053.1 thousand tons) and 2020 (2,245.8 thousand tons), which stand in stark contrast to the lowest production figures recorded in 2022 (178.5 thousand tons) and 2021 (252.3 thousand tons)¹¹. This high volatility is reflected in productivity, which ranged from a peak of 2.1 tons/hectare in 2019 to a low of 0.2 tons/hectare in both 2021 and 2022. The data further indicates that pronounced declines in both output and productivity were observed during the years 2013, 2014, 2018, 2021, and 2022.

3.2. Relationship between Rainfall and Barley Production

Figure 2. Description of a dual-axis chart visualizing the relationship between barley production (blue bars, thousand tons) and annual rainfall (red line, mm) in Syria, 2013-2022. The chart clearly shows production peaks aligning with high-rainfall years and troughs aligning with low-rainfall years.

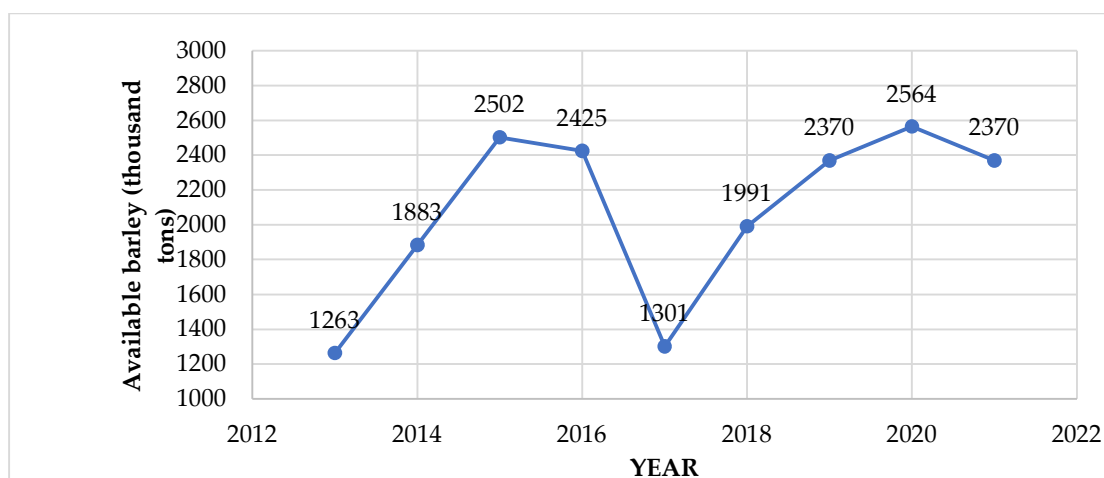


Figure 2. The relationship between barley production (thousand tons) and annual rainfall (mm) in Syria (2013-2022).

To quantify this relationship, a simple linear regression analysis was performed. The results are presented in Tables 2, 3, and 4 below

Table 2. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.712 ^a	0.507	0.445	691.5582

a. Predictors: (Constant), Annual Rainfall (Mm)

Table 3. Anova

Model	Sum of Squares	DF	Mean Square	F	Sig.	
1	Regression	3927641.387	1	3927641.387	8.212	0.021 ^b
	Residual	3826022.489	8	478252.811		
	Total	7753663.876	9			

a. Dependent Variable: Production (thousand tons)

b. Predictors: (Constant), Annual Rainfall (Mm)

Table 4. Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1	(Constant)	-2328.147	1223.224	-1.903	0.093
	Annual Rainfall (Mm)	11.792	4.115	0.712	2.866

a. Dependent Variable: Production (thousand tons)

The statistical analysis revealed a strong positive correlation (R = 0.712) between annual rainfall and barley production. This relationship is statistically significant (Sig. = 0.021), indicating it is not attributable to chance. Rainfall accounts for 50.7% of the variance in barley production. The analysis shows that each 1 mm increase in precipitation predicts a corresponding increase of 11.792 thousand tons in yield. The resulting regression equation is:

$$Y (\text{Production}) = -2328.147 + 11.792 X (\text{Rainfall})$$

3.3. Strategic Stock of Barley: Food Security Indicators

The scarcity of rainfall, high cost of inputs, and limited water for irrigation have collectively reduced the area and output of grain cultivation. The following data presents the commodity balance sheet for barley in Syria. The "Stocks" column refers to barley held in storage from previous seasons, while "Field and post-Harvest Losses" represents quantities lost during and after harvesting.

Table 5. Barley Production, Availability, and Use in Syria (2013-2021, thousand tons).

Year	Total Availability			Total use				Import		Shortage
	Production	Stocks	Food	Feed	Seed	Field & post-Harvest Losses	Stocks	Commercial Imports	Food Aid	
2013	933				1263				270	6
2014	933	0	200	700	214	149	0	0	0	3
	951				1883				902	
2015	951	0	100	1359	210	147	0	0	0	0
	968				2502				1534	
2016	968	0	0	2017	205	145	0	0	0	0
	877				2425				1548	
2017	877	0	0	2044	250	132	0	0	0	0
	777				1301				524	
2018	777	0	0	934	250	117	0	0	0	0
	640				1991				1351	
2019	390	250	0	1679	254	58	0	0	0	0
	2249				2370				121	
2020	1999	250	0	1816	254	300	0	0	0	0
	2564				2564				0	
2021	2254	310	0	1853	255	388	118	0	0	0
	298				2370				50	
2022	268	30	0	1816	254	300	0	0	0	2022

Source: Compiled by the authors based on FAO/WFP Special Reports (2013-2021).

Table 5. shows that the total availability of barley fluctuated during the years (2013 to 2021) due to the conditions we mentioned previously, but it rose significantly in 2019 and 2020 to decline again in 2021 and reach its lowest level (298 thousand tons), as production and imports were in a state of decline and recorded the highest deficit of (2022 thousand tons).

Table 6. Growth indicators for available barley (2013-2021, thousand tons, %).

Average Availability (thousand tons)	Minimum Availability (thousand tons)	Maximum Availability (thousand tons)	Annual growth rate %	
			Compound Annual Growth Rate	Average Annual Growth Rate
2074	1263	2564	8.2	13.2

Source: Based on study data.

Table 6. shows an increase in the availability of barley during the period 2013-2021, as the availability of barley increased at an average growth rate of about 13.2, and the compound annual growth rate reached 8.2%. If we calculate the feed gap by measuring the amount of barley used as feed to the total amount of barley available (which includes: local production + what is in stores), The data indicates a surplus in 2013, followed by the emergence of a feed gap in 2014. This gap

evolved into a large deficit in 2015, 2016, and 2018, peaking in 2021. In contrast, surpluses were observed in 2019 and 2020, as shown in Table 7.

Table 7. Barley Feed Availability, Use, and Gap (2013-2021, thousand tons).

Year	Total Availability (Production + Stocks)	Feed Usage	Feed Gap
2013	933	700	233
2014	951	1359	-408
2015	968	2017	-1049
2016	877	2044	-1167
2017	777	934	-157
2018	640	1679	-1039
2019	2249	1816	433
2020	2564	1853	711
2021	298	1816	-1518

Source: Based on study data

Interpretation of Table 7: Analysis of the barley feed gap reveals pronounced fluctuation throughout the period. The data indicates a critical deficit that culminated at -1,518 thousand tons in 2021. Pronounced shortages were also recorded in 2016 (-1,167 thousand tons) and 2015 (-1,049 thousand tons). Conversely, the highest surpluses were observed in 2020 (+711 thousand tons) and 2019 (+433 thousand tons). This variability underscores the sector's reliance on achieving high annual production to cover feed requirements.

Table 8. Production, imports, self-sufficiency rate of barley, and dependence on imports between (2013-2021)

Year	Production	Total usage	Self-sufficiency ratio	Imports	Import dependency ratio
2013	933	1263	73.8	270.0	21.4
2014	951	1883	50.5	902.0	47.9
2015	968	2502	38.7	1534.0	61.3
2016	877	2425	36.2	1548.0	63.8
2017	777	1301	59.7	524.0	40.3
2018	390	1991	19.6	1351.0	67.9
2019	1999	2370	84.3	121.0	5.1
2020	2254	2564	87.9	0.0	0.0
2021	268	2370	11.3	50.0	2.1
Average	9417	18669	50.4	6300.0	33.7

Source: Based on study data. Averages calculated by authors.

Table 8. shows that the average self-sufficiency rate of barley in Syria during the period (2013-2021) amounted to about 50.4%, as this number remains, "The average self-sufficiency rate of barley in Syria during the period (2013-2021) amounted to about 50.4%. While this average is below full sufficiency, it highlights the strategic importance of domestic production. The average dependency rate on imports also amounted to about 33.7%, which confirms the importance of barley as a strategic crop in Syria and its role in the commodity and trade balance.

4. Discussion

This analysis underscores the critical importance of water management and reliance on rain-fed agriculture in Syria, particularly for a vital crop such as barley. The quantitative data confirms the severe impact of rainfall variability on the barley sector, indicating that any alteration in precipitation patterns will have a direct and adverse impact on production. The sharp decline in the self-sufficiency ratio to a low of 11.3% in 2021 (Table 8) can be directly attributed to the exceptionally low rainfall of that year, which was nearly 19% below the decade's average. This figure represents a critical failure in the domestic food system's ability to provide essential feed for the livestock sector, which is vital for many rural livelihoods (ACLEED, 2023). Our results, which align with reports from international bodies (e.g., FAO and WFP, 2021), are now substantiated by direct climatic data. The statistical analysis emphasizes that annual rainfall remains the primary driver of production volume, explaining over 50.7% of the variance in output ($R^2 = 0.507$) in a statistically significant model. This finding validates regional evidence. The strength of our correlation aligns with the findings of (Yau and Ryan, 2013) and (Hormuz et al, 2016) regarding rainfed barley yields in semi-arid Mediterranean conditions, reinforcing the conclusion that rainfall fluctuation is the most severe climatic factor affecting rainfed agricultural stability zones. This is also consistent with global warnings issued by (Abbas et al, 2023) concerning the challenges posed by climate change to crop stability in arid and semi-arid regions.

While economic sanctions and conflict certainly disrupt supply chains and input availability, the data demonstrates that climatic factors exert the strongest single influence. To explain the remaining variability, other significant factors must be considered, including variables such as temperature, humidity, soil type, disease prevalence, and fertilizer application. Our findings resonate with the detailed modeling work by (Cammarano et al, 2019) in the Mediterranean basin, which also identified maximum temperature (heat stress) and inadequate soil water content during the reproductive stage as key contributors to yield reduction, even in years with otherwise favorable rainfall. Crucially, the combination of climate-induced stress and conflict has created a compound crisis, a phenomenon observed across the Middle East where climate change acts as a "threat multiplier" in politically fragile regions (Al-Ahdal et al, 2024).² This conclusion is supported by the analysis of (Salem, 2024) and (Urfeh et al, 2023), which link global and regional crises (such as conflict) to their impact on food security by disrupting supply chains and inflating input costs. Consequently, the acute self-sufficiency deficit (11.3% in 2021) is not explained by the climatic factor alone but by the complex interaction with conflict/sanctions, which prevents mitigation of drought effects, a point also emphasized by reports from the (IRC, 2024) concerning Syria. Therefore, the need to adopt a long-term vision for improving irrigation capacity to buffer against these climatic shocks is more critical than ever. In this context, studies like (Saretto et al, 2024) highlight that climate adaptation strategies, such as controlled irrigation and mulching, are viable pathways to significantly reduce yield losses in arid rainfed systems, providing a clear policy direction for Syria.

5. Conclusion

This study provides a quantitative and data-driven analysis of the Syrian barley sector from 2013–2022, effectively linking its performance to annual rainfall patterns during a period of complex crises. The main scientific contribution is the statistically significant finding that annual rainfall is the primary driver of output volatility, explaining over 50.7% of the variance in barley production ($R^2 = 0.507$). The analysis confirms an average self-sufficiency ratio of 50.4% that critically masks

extreme year-to-year fluctuations driven by rainfall deficits, leading to a widening feed gap that culminated at -1,518 thousand tons in 2021. This demonstrates that while conflict acts as a threat multiplier, climatic factors remain the fundamental constraint on food security for the livestock sector. Based on these findings, we offer two main directions for future research and policy:

- **Modeling and Adaptation:** Future research should aim to build upon this analysis by incorporating other climate variables (e.g., temperature, evapotranspiration) and disaggregating data by agricultural zone to create more granular predictive models. This is crucial for developing robust, site-specific adaptation strategies, such as optimizing irrigation and planting dates, as highlighted by regional studies.
- **Socio-economic Resilience:** Policy efforts must prioritize farm-level resilience. This necessitates further research through farm-level surveys to capture valuable insights into existing farmer coping and adaptation strategies, ensuring that aid and investment are strategically directed towards mitigating combined climate and conflict-induced shocks.

6. Recommendations

- **Policy & Investment:** Prioritize investment in rehabilitating irrigation infrastructure to reduce reliance on rainfall and build resilience to drought.
- **Agricultural Research:** Promote the development and adoption of drought-tolerant and early-maturing barley varieties suited to Syria's changing climate.
- **Economic Support:** Implement policies to stabilize the costs of essential agricultural inputs (seeds, fertilizer, fuel) and provide financial support for farmers to mitigate production risks.
- **Future Research:** Conduct further studies using econometric modeling to precisely quantify the separate and combined impacts of climate change, conflict, and economic policy on crop production.

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Data availability statement: The data presented in this study are available on request from the corresponding author.

7. References

1. Abbas G, Amjath-Babu TS, Kächele H, Müller K (2023): Climate change, its impact on crop production, challenges, and possible solutions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 51(1), 13020.
2. Ahmad F (2022): A study on the economic impacts and uncertainty on food security and crop composition in Egyptian agriculture during the period (2019-2022). *Journal of the Faculty of Economics and Political Science, Cairo University, Egypt* 23(3), 45-85.
3. Al-Ahdal T, Al-Shami A, Al-Ghaithi A, Al-Hashedi A (2024): A systematic review on the outcomes of climate change in the Middle-Eastern countries: The catastrophes of Yemen and Syria. *Cureus* 16(1), e51433.

4. Alahmad A (2022): The Effect of the Replacement of Dry Barley Beans with Sprouting Barley on the Productive Efficiency of the Awassi Lambs. Master Thesis. Faculty of Veterinary Medicine. Hama University. Syria. Pp 68.
5. Albakeh E (2019): Evaluation of the self-sufficiency status of wheat and barley crops in Libya and the extent of dependence on foreign countries during the period 2000-2016. *Al-Jami'i Journal, Libya* (30), 242-251.
6. Al-Hassoun HS, Abdullah A, Habib W (2016): Impact of the changes in the production costs and prices on cultivation barley in Hama. *Damascus University Journal of Agricultural Sciences* 32(2), 275-291.
7. Alhsenoi J (2022): The impact of climate change on food security. Wheat and barley production in Iraq 2019-2021 as a model. *Hammurabi Journal of Studies, Iraq* (41), 75-92.
8. Almajeed M, Helmi M (2021): The role of the most important food grain crops in achieving Egyptian food security. *Al-Azhar Journal of Agricultural Research, Egypt* 46(1), 348-360.
9. Annual Agricultural Statistical Abstract (2023): Ministry of Agriculture and Agrarian Reform, Syria.
10. Cammarano D, Ceccarelli S, Grando S, Romagosa I, Benbelkacem A, Akar T, Al-Yassin A, Pecchioni N, Francia E, Ronga D (2019): The impact of climate change on barley yield in the Mediterranean basin. *European Journal of Agronomy* 106, 1–11. <https://doi.org/10.1016/j.eja.2019.03.002>.
11. Central Bureau of Statistics (2012-2023): Syrian Statistical Collections. Syria.
12. FAO (2003): Fertilizer use by crop in the Syrian Arab Republic, first version. Published by FAO, Rome, Italy. <https://www.fao.org/4/Y4732E/y4732e00.htm#Contents>
13. FAO (2017): Counting the cost: Agriculture in Syria after six years of crisis. Food and Agriculture Organization of the United Nations, Rome, Italy.
14. FAO, WFP (2013): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
15. FAO, WFP (2014): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
16. FAO, WFP (2015): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
17. FAO, WFP (2016): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
18. FAO, WFP (2017): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
19. FAO, WFP (2018): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
20. FAO, WFP (2019): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
21. FAO, WFP (2020): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.

22. FAO, WFP (2021): Special report, crop and food security assessment mission to the Syrian Arab Republic. Rome, Italy.
23. Fayad R (2025): The Role of Climate-Smart Agriculture in Adapting to Climate Change. *Syrian Journal of Agriculture Research- SJAR* 12(1), 300-314.
24. Hamzeh R (2016): The reality of food security in Syria during the crisis. National Center for Agricultural Policies, Food and Agriculture Department, Damascus, Syria. p. 69.
25. Hormuz N, Jalab A, Ghadhban O (2016): The impact of climatic elements (Rain, Dry Heat, Drought) on wheat and barley production (Irrigated and Rain-Fed) in the eastern region: An Empirical Study in al-Hasakah station during the period 2001-2010. *Tishreen University Journal for Research and Scientific Studies - Economic and Legal Sciences Series* 37(4).
26. International Rescue Committee (IRC) (2024): Seed Security in Fragile and Climate Vulnerable States: System Failures and Solutions for Niger, Pakistan, South Sudan, and Syria.
27. Jusoor for Studies (2024): The Status of Main Agricultural Crops in Syria After 2010.
28. Kamarah S, Jamelah A, Hasan G (2020): Measuring the impact of losses on agricultural economic resources and food security of the most important cereal crops in Egypt. *Menoufia Journal of Agricultural Economics and Social Sciences, Menoufia University, Egypt* 5(4), 181-193.
29. Matok S (2015): Production of strategic grains in Iraq and its impact on food security. *Scientific Journal of Maysan, Iraq* 11(21), 236-246.
30. Salem Q (2024): The problem of food security during crises: The Russian-Ukrainian war as a model. *Journal of Law and Human Sciences, Algeria* 17(4), 115-134.
31. Saretto F, Roy B, Encarnação Coelho R, Reder A, Fedele G, Oakes R, Brandimarte L, Capela Lourenço T (2024): Impacts of Climate Change and Adaptation Strategies for Rainfed Barley Production in the Almería Province, Spain. *Atmosphere* 15(5), 606. <https://doi.org/10.3390/atmos15050606>.
32. Conflict and Hunger Group (2023): The Links between Conflict and Hunger in Syria: Conflict, Hunger and Aid Access. April 2023 Report.
33. United Nations, ESCWA (2018): Special report: Agricultural policy gap analysis study. Beirut, Lebanon.
34. Urfeh S, Hasan H, Shaltot S (2023): A reference study of the repercussions of global crises on agriculture and food, the cases of the Corona virus (Covid-19 pandemic) and the Russian-Ukrainian war crisis. Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.
35. Yau SK, Ryan J (2013): Differential impacts of climate variability on yields of rainfed barley and legumes in semi-arid Mediterranean conditions. *Archives of Agronomy and Soil Science* 60(4), 543–558. <https://doi.org/10.1080/03650340.2013.774436>.