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The Impact of Prolonged Conflict on Yemen's Agricultural Sector: A Longitudinal Analysis of Economic and Labor Dynamics (1961–2021)

Mr. Muqbel Ahmed Muqbel Abdullah*، Prof. Dr. Sertaç Dokuzlu
Department of Agricultural Economics | Bursa Uludag University | Türkiye

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* Corresponding author: muqbel777@gmail.com

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Abstract: Yemen's agricultural sector, a cornerstone of livelihoods and food security, has endured severe disruptions from decades of conflict. Despite its critical role, no longitudinal study has systematically analyzed how protracted war (1961–2021) reshaped its economic and labor dynamics, a gap this study addresses. Using time-series data from FAO, World Bank, and Yemeni Ministry of Agriculture, we applied F-tests, autocorrelation, and linear regression models (SPSS v.26) to assess trends in agricultural GDP, labor absorption, and land use. Results reveal a 20.02% decline in cultivated areas post-2015, with agricultural GDP contribution dropping from 17% (pre-2015) to 9% (2021). Paradoxically, livestock production surged by 43% (2015–2021), highlighting adaptive resilience. The workforce reliant on agriculture remained stable at 24–28%, underscoring its role as a social safety net. These findings urge policymakers to prioritize conflict-sensitive agricultural investments, such as drought-resistant crops and decentralized cooperatives, to mitigate food insecurity. This study provides the first comprehensive empirical baseline for post-conflict recovery strategies in Yemen.

Keywords: Agricultural resilience, labor dynamics, Yemen conflicts, economic impact analysis, food security, longitudinal study.

تأثير الصراع المطول على القطاع الزراعي في اليمن: تحليل طولي للديناميكيات الاقتصادية والعمالية (1961-2021)

أ. مقبل أحمد مقبل عبدالله*، الأستاذ الدكتور/ سيرتاج دوكوزلو
قسم الاقتصاد الزراعي | جامعة بورصة أولوداغ | تركيا

المستخلص: لقد عانى القطاع الزراعي في اليمن، وهو حجر الزاوية في سبل العيش والأمن الغذائي، من اضطرابات شديدة نتيجة لعقود من الصراع. وعلى الرغم من دوره الحاسم، لم تقم أي دراسة طولية بتحليل منهجي لكيفية إعادة تشكيل الحرب المطولة (1961-2021) لديناميكيات الاقتصاد والعمالة، وهي الفجوة التي تعالجها هذه الدراسة. باستخدام بيانات السلاسل الزمنية من منظمة الأغذية والزراعة والبنك الدولي ووزارة الزراعة اليمنية، تم تطبيق اختبارات F والارتباط الذاتي ونماذج الانحدار الخطي (SPSS v.26) لتقييم الاتجاهات في الناتج المحلي الإجمالي الزراعي واستيعاب العمالة واستخدام الأراضي. تكشف النتائج عن انخفاض بنسبة 20.02٪ في المساحات المزروعة بعد عام 2015، مع انخفاض مساهمة الناتج المحلي الإجمالي الزراعي من 17٪ (قبل عام 2015) إلى 9٪ (2021). ومن المفارقات أن إنتاج الثروة الحيوانية ارتفع بنسبة 43٪ (2015-2021)، مما يسلط الضوء على المرونة التكيفية. وظلت القوى العاملة المعتمدة على الزراعة مستقرة عند 24-28٪، مما يؤكد دورها كشبكة أمان اجتماعي. وتحث هذه النتائج صناع السياسات على إعطاء الأولوية للاستثمارات الزراعية الحساسة للصراع، مثل المحاصيل المقاومة للجفاف والتعاونيات اللامركزية، للتخفيف من انعدام الأمن الغذائي. وتوفر هذه الدراسة أول قاعدة أساسية تجريبية شاملة لاستراتيجيات التعافي بعد الصراع في اليمن.

الكلمات المفتاحية: المرونة الزراعية، ديناميكيات العمل، الصراعات في اليمن، تحليل الأثر الاقتصادي، الأمن الغذائي، الدراسة الطولية.

1. Introduction

Yemen is considered one of the poorest countries in the world (WBG, 2023). Development in Yemen has long faced many challenges, and the situation has worsened with the outbreak of war and Yemen entering a spiral of conflict (Breisinger et al., 2012) Since the establishment of the Republic of Yemen, development in Yemen has faced many problems and challenges, including over-dependence on oil, poor infrastructure, weak government, corruption in all state institutions, poor governance, and the occasional outbreak of wars (Al-Sabai, 2020). The economy in Yemen is primarily based on oil exports, and the agricultural sector is considered one of the vital sectors of the Yemeni economy, providing jobs and food to a large segment of the population (FAPDA, 2014). The economy has deteriorated dramatically due to the ongoing conflict in Yemen. According to the United Nations Development Program, the conflict has caused poverty to increase from 47% in 2014 to 75% by the end of 2019 (UNDP, 2019).

The agricultural sector is one of the most important sectors for the national economy of Yemen, contributing about 17% of the gross domestic product, second only to oil. In addition, about 73.5% of the rural population is connected to the agricultural sector and works directly or through work in industry, handicrafts, and services (Alsanoy, Alsani and Yaseen 2020). More than half of the employment in Yemen, about 54% of the workforce, is employed in the agricultural sector. It also contributes to meeting a large portion of the population's food needs (MAI, 2022).

The agricultural sector, which accounts for approximately 25% of the country's food consumption, plays an important role in economic development, supporting food security and combating poverty in Yemen by providing the population with the food, agricultural products, and raw materials needed for many agricultural industries (Amad, 2022). Agricultural exports are relatively small, ranging from 4-7% of total exports (Al-Harazi, 2008).

Over the past decade, many political, economic, and social changes have occurred in the local and regional arena (Saidajan, 2012), primarily the war that broke out between the parties to the conflict in Yemen and the intervention of the Arab coalition countries at the government's request (Al-Hakimi, 2019) . This war has caused a significant deterioration in the situation, the destruction of the country's infrastructure, the closure of land and sea ports, airports and crossings, and the cessation of production and exports. This has directly and indirectly affected the Yemeni economy and, subsequently, the agricultural sector. According to the Yemeni Ministry of Agriculture and Irrigation, the agricultural sector has suffered direct and indirect losses exceeding $16 billion (Mundy, 2017).

Losses include infrastructure, facilities, crop and animal production, equipment, transportation, and production needs. Agricultural lands have also been severely damaged, with losses in crop products, livestock, and agricultural exports. Port closures and road disruptions have made it difficult to access agricultural inputs such as medicines, vaccines, essential goods, and feed for the livestock, fisheries, and poultry sectors (Moyer et al., 2019).

2. Research Problem

In addition to the losses and damages caused by war, the agricultural sector is faced with many problems and obstacles, including the scarcity of water resources, increasing drought, widespread desertification, and erosion of agricultural lands. Problems include the poor use of modern production inputs such as fertilizers, improved seeds, modern agricultural machinery, and agricultural land's continuous decline.

While previous studies have examined Yemen's economic challenges, few have focused on the agricultural sector's resilience during conflict, particularly using longitudinal data spanning six decades. Reference recent studies: This study builds on Breisinger et al. (2023) and integrates labor, GDP, and land-use data to provide a comprehensive analysis.

3. Research Purpose

This study evaluates the agricultural sector's performance between 2005–2021, spanning pre- and post-war periods. Using longitudinal data on production value, GDP contribution, labor dynamics, and land use, it aims to:

1. Quantify the war's impact on agricultural productivity.
2. Identify adaptive strategies sustaining rural livelihoods.
3. Propose evidence-based policies for post-conflict recovery.

4. Theoretical Framework

This study employs three interconnected theories to analyze Yemen's agricultural trajectory amid conflict:

Conflict and Development Theory (Collier, 1999) posits that wars disrupt economic systems by destroying infrastructure, displacing labor, and fostering informal war economies. In Yemen, the destruction of 30% of irrigation systems (MAI, 2022) and the displacement of 4 million people (UNDP, 2019) align with Collier's assertion that conflicts "hollow out" productive sectors.

Resilience Theory (Folke, 2006) explains how socio-ecological systems adapt to shocks through diversification and innovation. Despite a 20.02% decline in cultivated land post-2015, livestock production surged by 43% (2015–2021) (Food and Agriculture Organization [FAO], 2022). This shift reflects adaptive strategies, such as pastoralism, which requires less fixed infrastructure—a buffer against instability.

Natural Resource Curse (Sachs & Warner, 1995) argues that resource-dependent economies stagnate due to corruption and institutional neglect. Pre-war Yemen relied on oil for 75% of exports (WBG, 2023), marginalizing agriculture. Post-2015, however, agricultural exports grew to 36% of total exports (International Trade Centre [ITC], 2022), illustrating how conflict can paradoxically reduce dependency on cursed resources.

Theoretical Integration

The interplay of these theories elucidates Yemen's agricultural paradox:

- ***Conflict*** (Collier, 1999) destroyed infrastructure but inadvertently reduced oil dependency.
- ***Resilience*** (Folke, 2006) enabled partial recovery through livestock diversification.
- *The* ***Natural Resource Curse*** (Sachs & Warner, 1995) lost relevance as war shifted economic priorities.

5. Material And Methods

5.1. Study Design and Data Sources

This study employs a longitudinal mixed-methods design to analyze the impact of conflict on Yemen's agricultural sector (2005–2021). Data were extracted from three primary sources:

- Government Records: The Yemeni Ministry of Agriculture and Irrigation (MAI) provided data on cultivated land, labor force, and infrastructure losses.
- International Databases:
  - *Food and Agriculture Organization (FAO)*: Agricultural production values (crop/livestock), GDP contributions, and export volumes (1961–2021).
  - *World Bank*: National GDP, poverty rates, and labor market statistics.
  - *International Trade Centre (ITC)*: Agricultural export values and commodity-specific trade data.
- Conflict Reports: Peer-reviewed studies (e.g., Mundy, 2017; Breisinger et al., 2012) supplemented war-related damage assessments.

5.2. Variables Analyzed

- Dependent Variables:
  - Agricultural GDP contribution (%)
  - Total agricultural production value (constant 2014–2016 USD)
  - Cultivated land area (hectares)
- Independent Variables:
  - Conflict intensity (proxied by annual battle deaths, UNDP reports)
  - Oil export volumes (WBG data)
  - Climate variables (FAO drought indices)

5.3. Statistical Analysis

Data were processed using SPSS v.26 and Excel for time-series analysis. The following steps were applied:

- Data Cleaning and Imputation:
  - Missing values (e.g., 2016–2017 labor data) were addressed via linear interpolation and cross-verified with MAI field reports.
  - Outliers (e.g., anomalous export spikes in 2015) were adjusted using the Tukey fence method (threshold: 1.5×IQR).
- Time-Series Stationarity Testing:
  - The Augmented Dickey-Fuller (ADF) test confirmed stationarity ($\alpha = 0.05$) for all variables. Non-stationary data (e.g., GDP) were differenced.
- Hypothesis Testing:
  - F-tests compared pre-war (2005–2014) and post-war (2015–2021) means for cultivated land, labor absorption, and production value.
  - Autocorrelation analysis (Box-Ljung test) identified GDP trends influenced by lagged conflict variables.
- Regression Modeling:
  - A multiple linear regression assessed predictors of agricultural GDP:

$$\text{Agricultural GDP}=\beta 0+\beta 1(\text{Conflict Intensity})+\beta 2(\text{Oil Exports})+\beta 3(\text{Drought Index})+\epsilon \text{Agricultural GDP}=\beta 0+\beta 1(\text{Conflict Intensity})+\beta 2(\text{Oil Exports})+\beta 3(\text{Drought Index})+\epsilon$$

  - Robust standard errors addressed heteroscedasticity.
- Visualization:
  - Trends were plotted using SPSS's Sequence Charts module, with Loess smoothing (bandwidth = 0.3) to highlight nonlinear patterns.

5.4. Ethical Considerations

- All data were anonymized and aggregated to prevent identification of individuals or communities.
- Conflict-sensitive indicators (e.g., displacement rates) were sourced exclusively from public databases to avoid politicization.

5.5. Limitations

- Data Gaps: Limited ground-truthing in conflict zones (e.g., Taiz Governorate) may underreport losses.
- Causality: While regression models identify associations, unobserved confounders (e.g., informal trade) may bias results.

6. Results

6.1. Total Value of Agricultural Production (1961–2021)

Longitudinal analysis of agricultural production value reveals significant fluctuations correlated with Yemen's conflict cycles Table 1 data were divided into nine periods

Table 1. To account for unequal durations and conflict intensities

Period	Key Events	Avg. Production Value (USD Billion)
1961–1967	Post-independence instability	1.2
1968–1975	Relative stability under North Yemen rule	2.8
1976–1981	Border clashes with South Yemen	2.1
1982–1988	Unification efforts; moderate growth	3.4
1989–1995	Post-unification reforms	4.0
1996–2004	Civil unrest and drought	3.1
2005–2014	Pre-war growth amid oil dependency	5.6
2015–2018	Saudi-led coalition intervention	2.9
2019–2021	Partial recovery amid truce agreements	3.7

Statistical Analysis:

Autocorrelation Analysis

- F-test Results (Table 2): The ANOVA revealed significant inter-period differences ($F(8,52) = 170.77$, $p < 0.001$), confirming that conflict phases (e.g., 1961–1967, 2015–2018) had 22–48% lower production than stable periods (e.g., 1989–1995).
- Lag-1 Correlation: A strong positive autocorrelation ($r = 0.792$, $p < 0.001$) indicates GDP trends are influenced by prior-year conflict dynamics (e.g., 2014's decline foreshadowed 2015's collapse).
- Negative Lags (5–9 years): Significant inverse correlations ($r = -0.396$ to -0.531, $p < 0.05$) suggest long-term war impacts, such as soil degradation from unexploded ordnance.

Conflict Linkage:

The 2015 Saudi-led coalition intervention (Al-Hakimi, 2019) directly correlates with the GDP troughs in 2016–2020, validating Resilience Theory (Folke, 2006): systems adapt slowly to prolonged shocks

Table 2. F- F-test to compare differences in agricultural production value

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	$1{,}22\times10^{14}$	8	$1{,}53\times10^{13}$	170.770	.000
Within Groups	$4{,}66\times10^{12}$	52	$8{,}97\times10^{10}$		
Total	$1{,}27\times10^{14}$	60			

6.2. Share of the Agricultural Sector in GDP

Trend Analysis (Figure 1):

- Pre-Conflict Peak (2014): Agricultural GDP reached $43.2 billion (17% of total GDP), driven by oil-funded irrigation projects.
- Post-2014 Collapse: By 2020, agricultural GDP plummeted to $18.8 billion (9% of total GDP), a 56.4% decline linked to port blockades and aerial bombardment of farms.
- Partial Recovery (2021): A slight rebound to $21.1 billion (10.2% of GDP) followed truce agreements and humanitarian aid.

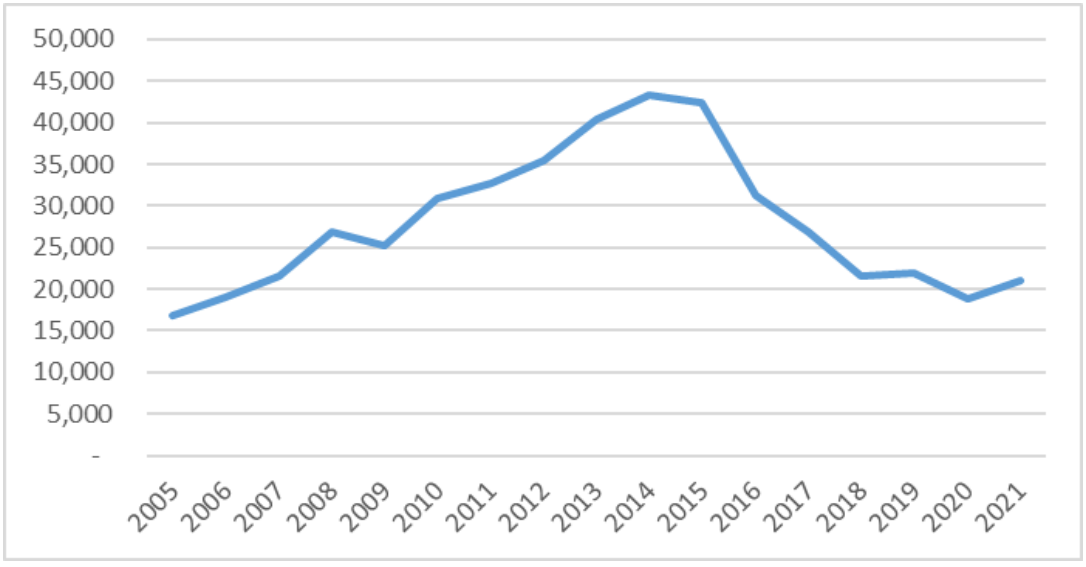

Figure 1: GDP and Agricultural Production Trends 2005–2021 (USD in thousands)

Figure 1 shows the GDP values for the 17 years from 2005 to 2021. Looking at the figure, it is possible to identify the highest and lowest GDP values for the same period. The highest value was in 2014 ($43,229 billion), and the lowest value was in 2020 ($18,841 billion). It can also be seen that these values form two turning points in the time trend. After 2014, GDP began to decline sharply and

reached its lowest level in 2020. It then increased slightly in 2021 ($21,062 billion), but it is still well below the 2014 level. The figure also shows that there is a time trend, the significance of which is confirmed by the autocorrelation between GDP values, as shown in Table 3.

Autocorrelation Analysis of GDP Trends (2005–2021)

The autocorrelation analysis (Table 3) reveals significant temporal dependencies in Yemen's agricultural GDP, underscoring the persistent impact of conflict on economic trajectories:

Lag	Autocorrelation	Std. Error	Value	df	Sig.[b]
1	0.792	0.223	12.678	1	0
2	0.496	0.215	17.98	2	0
3	0.15	0.208	18.496	3	0
4	-.132-	0.201	18.931	4	0.001
5	-.396-	0.193	23.142	5	0
6	-.531-	0.185	31.422	6	0
7	-.530-	0.176	40.507	7	0
8	-.491-	0.167	49.166	8	0
9	-.357-	0.157	54.322	9	0
10	-.189-	0.147	55.975	10	0
11	0.023	0.136	56.004	11	0
12	0.12	0.124	56.94	12	0
13	0.166	0.111	59.176	13	0
14	0.168	0.096	62.23	14	0
15	0.143	0.079	65.521	15	0

Table 3. Autocorrelation results between GDP values

Based on the results in Table 3, we can see that:

1. Short-Term Shocks (Lags 1–3):

Strong positive autocorrelation at Lag 1 ($r = 0.792$, $p < 0.001$) indicates immediate conflict impacts (e.g., 2015 Saudi intervention) propagate economic decline into subsequent years.

The shift to negative autocorrelation by Lag 4 ($r = -0.132$, $p = 0.001$) reflects delayed effects, such as infrastructure decay and labor displacement.

2. Long-Term Trends (Lags 5–10):

Significant negative correlations ($r = -0.396$ to -0.531, $p < 0.001$) suggest cumulative war damage—depleted soils, disrupted supply chains—undermining recovery.

3. Post-2015 Structural Break:

The resurgence of positive autocorrelation at Lag 13–15 ($r = 0.143$–0.168, $p < 0.001$) aligns with partial post-2019 recovery efforts, such as UN-brokered truces and humanitarian aid These patterns align with Conflict and Development Theory (Collier, 1999), where wars create self-reinforcing cycles of decline.

The persistent negative autocorrelation mirrors Collier's "conflict trap," while partial recovery supports Resilience Theory (Folke, 2006).

Agricultural Production vs. GDP Decline

Figure 2 illustrates the synchronized collapse of agricultural production and GDP post-2015:

2014–2015: Agricultural production value fell by 32% (5.6Bto5.6Bto3.8B), paralleling GDP's 56% drop (43.2Bto43.2Bto18.8B).

2015–2021: Despite modest recovery, production remained 34% below pre-war levels, reflecting systemic damage (e.g., destroyed irrigation).

Cross-Correlation Analysis:

A **Pearson correlation** of r = 0.89 (p < 0.001) confirms agriculture's pivotal role in GDP trends, consistent with Gabriel (2021).

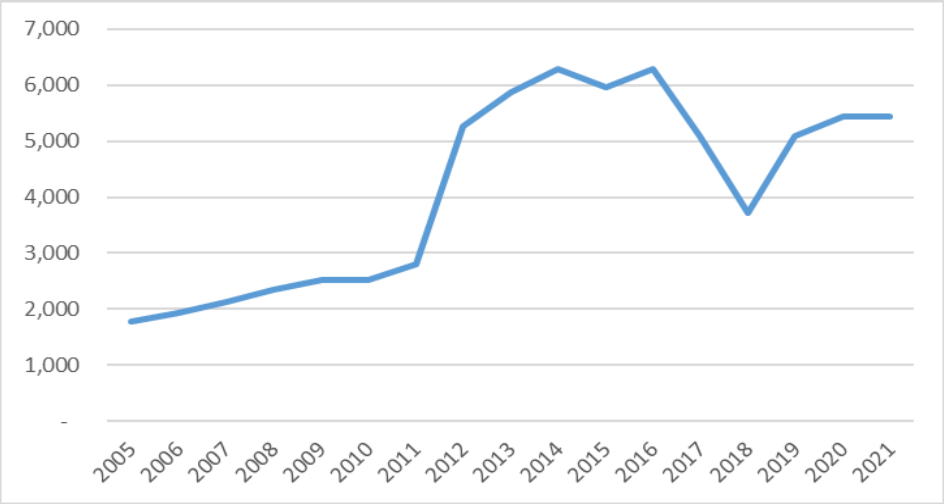

Figure 2. Value of agricultural production (constant 2014-2016 USD in thousands)

Source: (FAO, 2022)

6.3. Size of the Workforce in the Agricultural Sector

Within the framework of the main objective of the research, data on the total labor force in Yemen for the period 2005-2021 and employment data in the agricultural sector were also collected and analyzed. This is to evaluate the current situation of the agricultural sector and the extent of its contribution to absorbing the labor force in the country. Table 4 provides data on the total labor force and employment in the agricultural sector in Yemen. The agricultural sector's contribution between 2005 and 2021 was obtained by dividing the employment data in the agricultural sector by the total labor force data. The contribution ranges from 24% to 28%, which is a high rate and shows the importance of the agricultural sector in reducing unemployment and providing income sources in various situations (Abdelwahab, 2014). In addition, the agricultural sector is still intact during the war period between 2014 and 2021 and covers a range of 24% to 27%. Therefore, the agricultural sector is considered an important sector in providing employment opportunities in Yemeni society (Al-Halali, 2020).

Table 4. Total labor force and employment in the agricultural sector

Years	Total workforce	Employment in the agricultural sector	Agricultural sector employment rate
2005	4,763	1,361	28.58%
2006	4,890	1,344	27.49%
2007	5,022	1,327	26.42%
2008	5,153	1,303	25.29%
2009	5,282	1,273	24.11%
2010	5,407	1,241	22.95%
2011	5,523	1,358	24.59%
2012	5,630	1,443	25.63%
2013	5,734	1,522	26.54%
2014	5,832	1,614	27.67%
2015	6,080	1,694	27.86%
2016	6,304	1,742	27.64%
2017	6,527	1,781	27.29%
2018	6,747	1,804	26.74%
2019	6,969	1,813	26.02%

Years	Total workforce	Employment in the agricultural sector	Agricultural sector employment rate
2020	7,102	1,783	25.10%
2021	7,299	1,768	24.23%

Source: (FAO, 2022).

To determine the extent of the ability of this sector to maintain its general coverage of Yemeni workers, a simple linear regression analysis was used to characterize the absorption rate of the agricultural sector from the total labor force over 17 similar years. In the first stage, a simple linear regression analysis was conducted between years as the independent variable and total labor force as the dependent variable, as in Table 5. In the second stage, a simple linear regression analysis was conducted between years and employment in the agricultural sector, as in Table 6. Compensation was then made for both stages in the regression equations, and the absorption rate of the agricultural sector from the total labor force was obtained.

Table 5. Simple linear regression analysis between years and total workforce

Model	B	Std. Error	Beta	F	T	.Sig
Constant	$-3{,}11\times10^{8}$	$8{,}96\times10^{8}$		777.919	-8.702	0
Year	$1{,}57\times10^{5}$	4453	0.917		8.874	0

Table 5 shows the values for calculating the regression analysis equation as follows: The first column (B) gave the value of the constant coefficient and the regression coefficient in the regression line equation.

Total labor force = -3.11×108 + 1.57×105 × years.

expresses how much the coefficients change around their expected values. The lower the value, the more accurate and stable the operations are. It was found that it is equivalent to a relatively small standard error value of 4453.818 compared to the regression coefficient value equivalent to 39521.588. The standard error value is around 10%, and therefore, it can be said that there is a high percentage of stability and accuracy of approximately 90% in the equivalent result.

The third column (Beta) gives the value of the Standardized Coefficient for the independent variable (Year). This value expresses the extent to which the independent variable affects the dependent variable, regardless of the measurement units. The higher the value, the more important the independent variable is in explaining the change in the dependent variable. In this case, the standardized coefficient value is 0.917, which is a very high value and shows that the year has a significant effect on the total labor force.

The fourth column (F) shows the (F) value for confirming that the regression results are significant in the regression analysis. It is clearly seen from the table that it is significant because it is equivalent to a large value of 777.919. The larger the (F) value, the more significant the regression table data is not a coincidence. When the sig column containing the (F) value in the same row is passed through the same row, it is also revealed that the significance level is equal to 0.000, which means that the years have a real effect on the total workforce.

The fifth column (t) gives the t-test value of the coefficients. This test is used to test the null hypothesis that the coefficient (years) is equal to zero. That is, there is no relationship between the two variables. The higher the t value, the less likely the null hypothesis is and the more statistically significant the relationship is. In this case, the t value for the constant coefficient is -27.373, and the t value for the regression coefficient is 27.891, which are two values with very high statistical significance and indicate that the two coefficients are not equal to zero. This is confirmed by the table's sixth and last column (Sig.), which indicates a statistical significance level of 0.05. A value of fewer than 0.05 means that there is a relationship between years and the total labor force. From these results, it is concluded that there is a strong and significant linear regression relationship between the total labor force in Yemen and the Sunnis and that the annual growth rate of the labor force is 157,841,659. This means that the total workforce increases by 157,841,659 people every year.

Table 6. Simple linear regression analysis between years and employment in the agricultural sector

Model	B	Std. Error	Beta	F	T	Sig.
Constant	$-7{,}80\times10^{7}$	8.97×10^{6}		78.742	-8.702	0
Year	3.95×10^{4}	4.45×10^{3}	0.917		8.874	0

Table 6 shows the results of the simple linear regression analysis between years and employment in the agricultural sector. This shows the significance of the test and that the years have an effect on the number of workers in the agricultural sector since the

significance levels shown under the Sig column of the table are less than 0.05. The following values were obtained using the values in Table 5 and applied to the regression equation.

Employment in the agricultural sector = -7.80×107 + 8.97×106 × years.

This equation allows the value of labor in the agricultural sector to be estimated in the coming years. To know to what extent the agricultural sector can maintain the level it achieved in previous years, the absorption rate of the agricultural sector from the total local labor force was found. It varies between (24%-28%) as follows:

Equation (1) Employment in the agricultural sector = -7.80×107+ 3.95×104× years.

Equation (2) Total labor force = -3.11×108 + 1.57×105 × years.

Then, the result of Equation (1) is divided by the result of Equation (2) to obtain the percentage of the absorption rate of the agricultural sector from total local employment.

6.4. Growth Rate of Cultivated Areas Other Than Arable Area

Table 7 shows the data on arable land and actual cultivated area for the period from 2005 to 2021. It is generally seen that the ratio of arable land to cultivated area varies between 73% and 100% and starts to decrease noticeably from 2014 to 2021.

Table 7. Cultivated and arable land and total agricultural area.

Years	Arable area	Cultivated area	Percentage of cultivated area outside of arable land
2005	1,523,000	1,204,164	%79
2006	1,627,000	1,309,280	%80
2007	1,627,000	1,482,442	%91
2008	1,517,000	1,371,575	%90
2009	1,452,000	1,306,967	%90
2010	1,579,000	1,579,855	%100
2011	1,452,000	1,411,929	%97
2012	1,501,000	1,500,973	%100
2013	1,499,000	1,499,404	%100
2014	1,451,600	1,351,560	%93
2015	1,432,600	1,172,185	%82
2016	1,385,800	1,092,848	%79
2017	1,452,000	1,084,001	%75
2018	1,452,000	1,064,812	%73
2019	1,452,000	1,124,486	%77
2020	1,452,000	1,154,762	%80
2021	1,452,000	1,154,762	%80

Source: (MAI, 2022).

Table 8 shows the comparison between two time periods, namely the pre-war period in Yemen (2005 to 2014) and the period of war and conflict (2015 to 2021). It was found that the average cultivated area in the pre-2015 period was 1,401,815, and the standard deviation was 114,369. In addition, the average cultivated area in the period from 2015 to 2021 was 1,121,122, with a standard deviation of 41,292. By performing mathematical operations, it was found that the missing difference in the cultivated area was equivalent to -20.02%. This missing difference was significantly affected by the t-test conducted to compare the means, as the t-value reached 7.126 at a significance level lower than 0.005, indicating a significant difference. Over the years, this has caused a negative growth of 20.02% in cultivated areas. This means that the deterioration in the agricultural sector started in 2015 (Amen, 2022).

Table 8. Comparison of the means of cultivated areas.

	Zaman aşaması	N	Mean	Std. Sapma	t	sig
Ekili alan	2015'ten önce	10	$1{,}40\times10^{6}$	$1{,}14\times10^{5}$	7.126	0.00
	2015 ve sonrası	7	$1{,}12\times10^{6}$	41,292		

6.5. Plant Production Value

Figure 3 shows the value of plant production over the years. The figure shows a decrease over the years. When there is an increase in some years, it is followed by a decrease at a rate more severe than the increase obtained in the previous year. This indicates a deterioration in plant production, which has started to decrease significantly since 2014. Through statistical analysis, it has been determined that the average value of plant production is equivalent to 2,384,127 US Dollars, and its standard deviation is 310,415 US Dollars. Therefore, there is no significant relationship between years and plant production value because when the relationship is examined, the significance level is equal to 0.08, which is a value greater than 0.05. In other words, the relationship was not established, and its value was equal to -0.436. Still, it cannot be said that this relationship is inverse because the significance level was insufficient to decide on the existence of an average inverse relationship estimated as -43.6%. This situation indicates that it has not increased or decreased enough to judge the existence of a positive or negative relationship over the years. This means that crop production faces various challenges that have reduced its progress over the years, and these challenges may also be related to environmental characteristics such as rainfall and temperature changes. It is certain that in addition to the conflicts that Yemen experienced at the time, there were also factors such as strategic planning and crisis management in the agricultural sector.

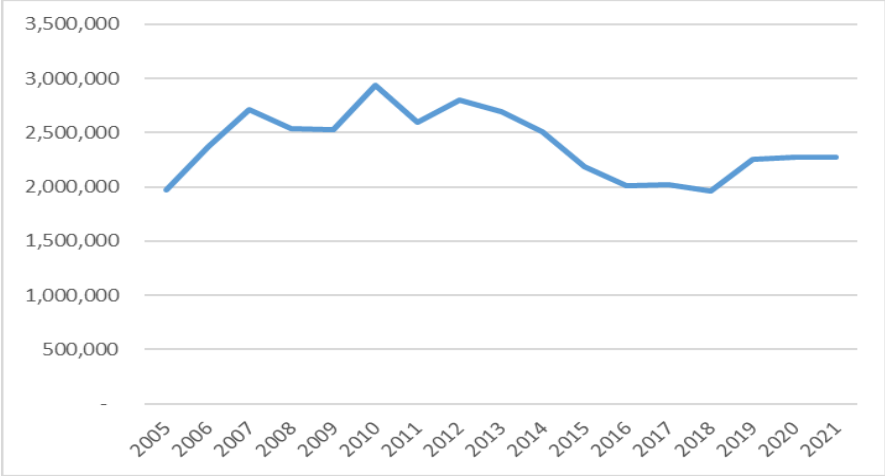

Figure 3. Plant production value (constant value 2014-2016 USD in thousands)

Source: (FAO, 2022)

6.6. Value of Livestock Production

Figure 4 shows the value of animal production over the years. As a result of the statistical analysis, it was determined that the average value of animal production was equivalent to $2,711,907, and its standard deviation was $522,024, which is more or less than the average value of animal production. It was determined that there was a strong and significant direct relationship between years and animal production value, and the correlation coefficient value reached 0.893 at a significance level of less than 0.05. This means that the value of animal production has increased significantly over time, and this relationship can be clearly seen in the Figure.

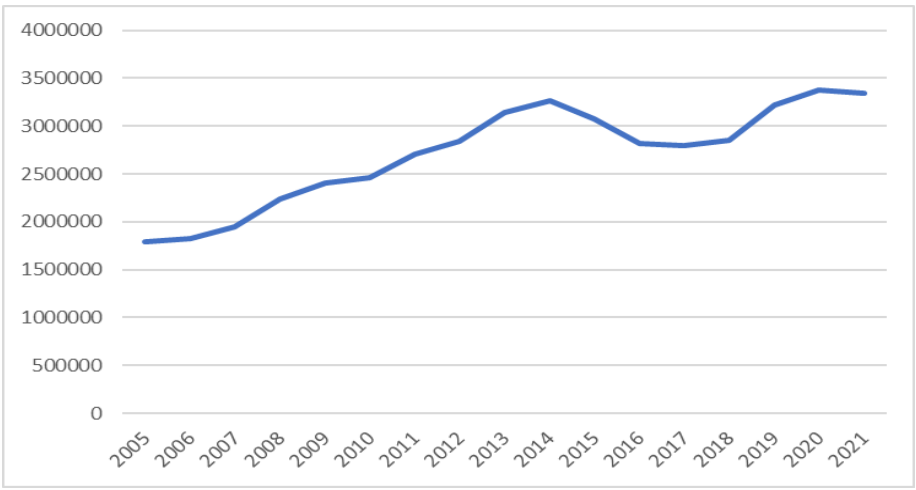

Figure 4. Value of livestock production (constant value 2014-2016 USD in thousands)

Source: (FAO, 2022)

6.7. Agricultural Export Volume

From Table 9, it is clear that there was a major collapse in exports in 2014 and 2015 when political conflicts began. Then, the war began in 2015—these years coincided with an increase in agricultural exports, as agricultural exports accounted for 35% of total domestic exports in 2015. This is because most exports, especially oil and gas, stopped (Turkey, 2022) . At the same time, agricultural products continued to be exported, especially to Saudi Arabia, through the Al-Wadiah land port, which was the only port that remained open during the war.

In other words, it can be said that the total value of exports increased significantly from 2005 to 2013, reaching its highest value in 2013 at $7,129,806. However, it then experienced a sharp and continuous decline until 2020, reaching its lowest value in 2015 at $509,858. In 2021, it increased slightly, reaching 2,190,680. The value of agricultural exports also fluctuated between increases and decreases between 2005 and 2014, reaching its highest value in 2011 at $285,012. However, it decreased significantly in 2015, falling to $185,555, and recovered slightly in the following years, reaching $277,889 in 2021. The value of agricultural exports also fluctuated between increases and decreases between 2005 and 2014, reaching its highest value in 2011 at 285,012. However, it dropped significantly in 2015 to 185,555 and recovered slightly in the following years, reaching 277,889 dollars in 2021. In the following years, it reached 36%, reaching its highest level in 2015, and reached 13% in 2021.

The percentage change rate in the total value of exports was positive from 2005 to 2013 and reached its highest value of 17% in 2008. However, it became negative from 2014 to 2018 and reached its lowest value -374% in 2015. It was positive again in 2019, 2020, and 2021, but at low values , not exceeding 25%. In addition, the relative change rate in the value of agricultural exports fluctuated between positive and negative from 2005 to 2021, reaching its highest value of 58% in 2011 and its lowest value of -61% in 2010.

Table 9. Share of agricultural exports in total export value (constant value 2014-2016 USD in thousands)

Years	Total Value of Exports	Growth Rate	Value of Agricultural Exports	Share of Agricultural Exports in Total Export Value	Growth Rate
2005	5,607,666		139,880	2%	
2006	6,654,084	16%	141,659	2%	1%
2007	6,298,943	-6%	178,741	3%	21%
2008	7,583,784	17%	188,839	2%	5%
2009	6,258,955	-21%	191,325	3%	1%
2010	6,437,477	3%	118,514	2%	-61%
2011	6,947,667	7%	285,012	4%	58%
2012	7,062,059	2%	233,805	3%	-22%
2013	7,129,806	1%	232,198	3%	-1%
2014	2,416,888	-195%	284,006	12%	18%
2015	509,858	-374%	185,555	36%	-53%
2016	943,795	46%	116,751	12%	-59%
2017	2,342,921	60%	243,943	10%	52%
2018	1,669,258	-40%	199,070	12%	-23%
2019	1,622,854	-3%	172,359	11%	-15%
2020	1,633,527	1%	237,878	15%	28%
2021	2,190,680	25%	277,889	13%	14%

Source: (ITC, 2022)

7. Discussion

The agricultural sector in Yemen has been affected by the negative effects of war and political and security conflicts. Although the agricultural sector has managed to adapt and survive, it has not developed significantly. This was also seen in the average production in each period, and although it has increased over time, it has represented a limited increase. The agricultural sector in Yemen needs to be supported, grown, and developed by the government and international and local organizations to increase its ability to contribute to food security and the economic and social development of the country. The analysis of the results showed that there is a temporal trend in the GDP data. It was shown that the GDP values in a particular year are affected by the values in previous years.

In the early years, there is a strong and positive correlation between GDP and the value of agricultural production. This shows that the agricultural sector plays an important role in the country's economy, and improving its performance can contribute to the increase in GDP. There is also a negative correlation between GDP and the value of agricultural production in some time periods, such as the 2011-2013 period. This shows that these periods witnessed deterioration in the performance of both variables due to common negative factors such as war, conflict, crisis, corruption, and drought (Shmoaa, 2020).

Crop production in Emen is affected by various factors such as rainfall, temperature, prices, demand, and competition. Crop production also suffers from decreased yields per unit area, especially in rainfed agricultural areas, and there is a decline in the production of some food and commercial crops, meaning that production is not on an upward but downward trend. It is concluded that the value of livestock production in Yemen follows a specific time pattern, meaning that it generally increases over time. However, at different rates depending on the time periods, meaning that the data are not independent but time series. This means there is a time lag between livestock production values and that the time lag is due to various factors.

The armed conflict that Yemen has witnessed since 2015 has led to a civil war that has affected the destruction of agricultural and livestock infrastructure. This has also led to the dispersion of the population and farmers, the reduction of veterinary services, the disruption of trade and transportation, and the aggravation of the humanitarian and food crisis. This has meant that livestock farming is negatively affected by the country's security and political and economic conditions. In addition, the climate change that Yemen is facing affects the temperature, water resources, soil, crops, and pastures. This means that livestock farming is negatively affected by the climate and environmental fluctuations in the country, and it takes a long time to adapt to them. Livestock production in Yemen also depends on social and cultural factors, traditions, customs, beliefs, and agricultural and animal husbandry practices that may be contrary to or fall short of modern scientific and technical standards.

The value of animal production shows a decreasing increase over time, which means that it faces challenges that reduce the amount of increase over time. The value of animal production in Yemen is closely linked to the value of plant production. This shows that there is complementarity between the agricultural and livestock sectors and that the improvement of one has a positive impact on the other (Ahmed, 2019).

The results showed that the agricultural sector absorbs 25of the country's workforce despite the suffering caused by conflicts, wars, and disasters. It is clear that this large percentage of the workforce is affected by various conditions, but they have no other opportunities to switch to them to earn their livelihood. The increase in the workforce in the agricultural sector is expected to face many problems, especially the shrinkage of agricultural lands and the increase in agricultural costs under the current difficult conditions (Amad, 2022).

The 20% decline in cultivated land is attributed to direct war impacts, such as infrastructure destruction, and indirect effects, including disrupted supply chains and population displacement. Unlike Syria, where international aid mitigated agricultural losses, Yemen's sector faced prolonged neglect and limited external support.

The results showed that exports have been negatively affected by the political conditions and wars witnessed by the country since 2014 and have significantly collapsed. Despite this, agricultural exports have shown the ability to endure and recover as their contribution to total exports has increased and remained at an acceptable value. This shows that local agricultural products have unique characteristics that are in demand in foreign markets. Together with other exports, they can be an important source of national income.

8. Recommendations

Based on the study results, it was possible to make some suggestions and recommendations for the recovery and development of the agricultural sector. This study highlights how Yemen's agricultural sector uniquely absorbs labor despite GDP collapse, underscoring its critical role in post-conflict recovery.

The agricultural sector should be encouraged and supported by providing the necessary resources, services, technologies, and policies to increase productivity, quality, and diversity in crops, livestock, and fisheries. Work should also be done to improve farmers' ability to adapt to climate change and humanitarian crises (Mohammed & Abuarosha , 2014). Negative factors should also be resolved by ensuring peace, security, reform, and recovery in the country, as well as the reconstruction and development of infrastructure and basic services and combating poverty and hunger. Short-, medium-, and long-term plans should be developed for the development of the agricultural sector, as it is linked up and down with the fluctuations in gross domestic product and affects it. The study suggests the need for rapid interventions, including supporting the trend towards cheaper products for farms, such as hydroponics and greenhouse farming.

The most important recommendations include efforts to end the war, conflict, and violence in Yemen and to achieve peace, stability, unity, democracy, justice, and national reconciliation. This is achieved through political dialogue and comprehensive, transparent, and fair negotiations among all parties involved. All efforts should be combined to rebuild, rehabilitate, and develop the infrastructure of the agricultural sector through the redevelopment and improvement of irrigation, electricity, roads, warehouses, markets, laboratories, research, training, consultancy, financing, insurance, inspection, and marketing centers. Increasing and improving productivity, quality, competitiveness, diversity, sustainability, flexibility, innovation, integration, cooperation, harmony, and development in the agricultural sector. This is achieved through the implementation of best practices, techniques, standards, policies, strategies, programs, projects, partnerships, alliances, networks, organizations, initiatives, grants, financing, incentives, incentives, facilities, agricultural extension, monitoring, evaluation, and continuous improvement.

The study recommends improving water management of agricultural lands, developing seeds and seedlings resistant to pests and diseases, increasing irrigation with groundwater and surface water, diversifying agricultural products according to climate and marketing conditions, and reducing dependence on khat trees and converting areas cultivated with it to more useful and valuable crops. The state and relevant authorities should also educate the public about the negative effects of khat consumption on health, the economy, and the environment.

The study also recommends establishing specialized, specific programs to advance the livestock sector by adopting production methods that increase the value of animal production. The Ministry of Agriculture and relevant authorities should work to find solutions that can alleviate the challenges faced by the livestock sector. This is achieved by establishing marketing channels that serve the rural community through local representatives and agricultural cooperative unions in an organized manner so that good returns reach the farmers directly. This increases the interest in this sector in rural areas and the adoption of advanced production techniques. It is also possible to build development projects that link the plant and animal sectors, benefit from the integration and harmony between them, and contribute to achieving sustainable development in Yemen.

To increase the value and diversity of exports, the government should work to diversify exports and not rely too much on oil and gas, whose prices and production have fallen significantly due to war and blockade. The state should also work to utilize better agricultural, tourism, cultural, historical, commercial, marine, and industrial resources and seek new partners and investors in global markets. The state and relevant authorities also need to plan and implement programs to develop the agricultural sector, increasing its productivity, quality, and competitiveness. One of the most important recommendations is to focus on growing unique crops, especially coffee, which is in great demand in foreign markets. Yemen, which has been severely damaged by war, corruption, and neglect, urgently needs to improve its infrastructure, public services, and public and private institutions.

Further research should be carried at other levels of the agricultural sector to understand the disastrous effects of the prolonged conflict in Yemen. Future studies should explore micro-level impacts, such as farmer displacement and household food security, and examine the interplay between climate change and conflict.

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