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Original Research Article

The Effect of Climate Shocks on Coffee Export Revenues: The Case of East Africa (1995–2025)

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Abstract: This study examined the effects of climate shocks on coffee production, yield, and export revenues in East Africa from 1995 to 2024 using secondary data. Climate indicators included annual and seasonal rainfall, rainfall anomalies, temperature trends, and ENSO phases, analyzed alongside coffee production, yield per hectare, and export revenue data for Kenya, Ethiopia, Uganda, Tanzania, Rwanda, Burundi, and the Democratic Republic of the Congo. Descriptive statistics, trend analysis, correlation analysis, and ENSO-based comparisons were used to assess long-term trends and short-term climate variability. Results indicate a clear warming trend across the region, with steadily rising mean temperatures, while rainfall variability linked to ENSO cycles strongly influenced year-to-year fluctuations in production and export performance. During neutral years, average export revenue was approximately USD 379 million. El Niño years were associated with lower export revenues, declining by about 1.6 percent due to excess rainfall, disease pressure, and post-harvest challenges. In contrast, La Niña years recorded export revenues about 6.6 percent above neutral levels, reflecting more stable moisture conditions that support flowering, harvesting, and bean quality. Despite increasing climate pressure, production, yield per hectare, and export revenues increased over time, indicating improvements in farm management, processing systems, and market integration. The findings confirm that climate shocks significantly influence coffee export performance in East Africa, underscoring the importance of climate-smart practices and quality-focused value chains for long-term resilience.

Keywords: Climate Shocks, ENSO, Coffee Production, Export Revenue, East Africa.

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INTRODUCTION

Coffee is one of the most traded agricultural commodities in the world. It supports the livelihoods of over 25 million farming households worldwide. According to FAOSTAT (2025), coffee production remains a central component of rural economies and a significant source of export earnings across many tropical countries. For the 2025–2026 season, global coffee output is projected at approximately 10.7 million tonnes, with Arabica accounting for slightly more than half of total production (USDA FAS, 2025). Beyond its trade value, coffee generates employment and foreign exchange and connects smallholder farmers to global markets. According to the International Coffee Organization, coffee remains a crucial contributor to food security and economic stability in producing countries (ICO, 2025).

In Africa, coffee remains one of the continent's most valuable export crops. Annual production is estimated at approximately 1.86 million tonnes, accounting for roughly 17 percent of global output (FAOSTAT, 2025). Countries such as Ethiopia and Uganda depend heavily on coffee for rural income and export revenue. Most African coffee is grown by smallholder farmers under rainfed systems. This makes production highly sensitive to rainfall and temperature conditions. Lemma and Megersa (2021) explain that climate shocks have become a significant risk to African coffee systems, particularly in areas where irrigation and risk protection are limited.

Within Africa, East Africa stands out as the core coffee-producing region. Ethiopia, Uganda, Kenya, Tanzania, Rwanda, Burundi, and the Democratic Republic of the Congo together account for more than 70

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percent of Africa's coffee production (USDA FAS, 2025). Ethiopia dominates Arabica production, while Uganda leads Robusta exports. Coffee supports millions of smallholder farmers across the region and contributes significantly to national income and export earnings. Majani Sunguti *et al*., (2024) note that coffee is not only an economic crop in East Africa, but also a key pillar for rural livelihoods and regional trade.

Despite its importance, East Africa's coffee sector is under increasing pressure from climate change. Rainfall timing is changing. Temperatures are rising, and droughts and floods are becoming more frequent. The World Bank Climate Change Knowledge Portal reveals clear warming trends and increasing rainfall variability across coffee-producing regions in the area (World Bank, 2021). Because most farms rely on natural rainfall, producers are highly vulnerable to climate extremes associated with El Niño and La Niña events. NOAA (2025) reports that ENSO cycles significantly influence rainfall distribution in East Africa, often resulting in floods in some areas and droughts in others. These shocks disrupt yields and reduce bean quality, leading to unstable production and export outcomes.

Arabica coffee, which dominates production in much of East Africa, performs best in mild temperatures and stable rainfall conditions. Even small changes in climate conditions can affect the flowering and ripening stages. Gagliardi *et al*., (2020) demonstrate that temperature and rainfall disturbances result in irregular flowering and fruit development, thereby reducing bean quality. Bilen *et al*., (2023) further confirmed that climate change is already affecting coffee agroecosystems worldwide, with increasing risks of yield losses and quality decline in sensitive regions, such as East Africa. When quality drops, export prices often fall, even during periods of strong global demand.

Most existing studies focus on how climate change affects coffee yields or farm-level quality. While this work is important, it often stops at production outcomes. There is still limited empirical evidence on how climate shocks translate into changes in export revenue over time, especially in East Africa. This gap is critical because coffee remains a significant source of foreign exchange for the region, and climate shocks have become more frequent over the past three decades (Lemma & Megersa, 2021; ICO, 2025).

This study aimed to address this gap by examining how climate shocks: rainfall variability, temperature change, and El Niño cycles affect coffee production and export revenues in East Africa from 1995 to 2025. By combining long-term climate data with production and trade statistics, the study aims to demonstrate how climate shocks propagate through the coffee system and manifest in economic outcomes. This is highly relevant now, as climate risks are increasing, coffee markets remain volatile, and policymakers need clear evidence to support climate-resilient agricultural and trade policies in the region.

MATERIALS AND METHODS

This study used only secondary data collected from reliable international and regional sources. Climate data included rainfall and temperature indicators. Annual and seasonal rainfall totals, as well as rainfall anomalies, were obtained from CHIRPS v2.0 and the World Bank Climate Change Knowledge Portal. Mean temperature and temperature anomalies were sourced from the ERA5 Reanalysis Dataset and the NASA POWER Project. ENSO phases, including El Niño, La Niña, and neutral years, were identified using the NOAA Oceanic Niño Index.

Coffee sector data covered production volume, yield per hectare, land use, and export performance. Production, yield, and land area data were collected from FAOSTAT and processed datasets available through Our World in Data. Export volumes and export revenue data were obtained from the International Coffee Organization, the UN Comtrade Database, the IMF Direction of Trade Statistics, and the World Bank's World Development Indicators. National reports from the Uganda Coffee Development Authority and Rwanda's National Agricultural Export Development Board were used to cross-check and validate country-level trends.

The analysis covered the period from 1995 to 2024 for seven East African countries. Descriptive statistics, trend analysis, correlation analysis, and ENSO-based comparisons were applied to examine long-term patterns and short-term climate shocks. All datasets were harmonized to ensure consistency across countries and years.

RESULTS AND DISCUSSION

Over the thirty years from 1995 to 2024, the combined data show clear changes in total land area, total coffee production, and the average yield per hectare across East Africa. Land under cultivation increases steadily from approximately 1.29 million hectares in 1995 to more than 1.52 million hectares in 2024, indicating a continued expansion of coffee farming despite frequent climate disturbances, as shown in Table 1.

Table 1: Combined Coffee Land Area, Production, and Yield in East Africa (1995–2024)

Year	Total Land Used (ha)	Total Coffee Produced (tonnes)	Average Yield (tonnes/ha)
1995	1,288,000	680,998	4.062
1996	1,295,800	784,506	4.315
1997	1,305,600	664,954	3.521
1998	1,314,900	613,949	3.104
1999	1,320,700	680,636	3.761
2000	1,328,500	652,259	4.678
2001	1,334,800	588,434	4.453
2002	1,342,600	721,306	7.727
2003	1,350,400	466,359	3.070
2004	1,359,200	703,668	8.177
2005	1,369,000	555,736	3.355
2006	1,376,800	661,035	6.430
2007	1,385,600	629,560	3.227
2008	1,392,400	710,164	5.278
2009	1,402,200	649,449	3.098
2010	1,410,000	760,656	4.926
2011	1,417,800	760,659	3.748
2012	1,426,600	654,756	3.172
2013	1,433,400	796,572	3.285
2014	1,442,200	793,614	2.901
2015	1,450,000	842,012	3.232
2016	1,458,800	887,130	3.301
2017	1,466,600	926,006	3.643
2018	1,474,400	969,772	3.841
2019	1,481,200	1,005,506	3.825
2020	1,491,000	1,123,317	3.692
2021	1,498,800	1,154,464	3.977
2022	1,506,600	1,033,888	3.666
2023	1,515,400	1,154,238	4.020
2024	1,524,200	1,179,981	4.091

Sources: *FAOSTAT (2025); Our World in Data (2025); National Coffee Boards (UCDA, NAEB, Tanzania Coffee Board); the thirty years (2024).* (Ethiopia, Uganda, Tanzania, Kenya, DR Congo, Rwanda, Burundi — aggregated totals)

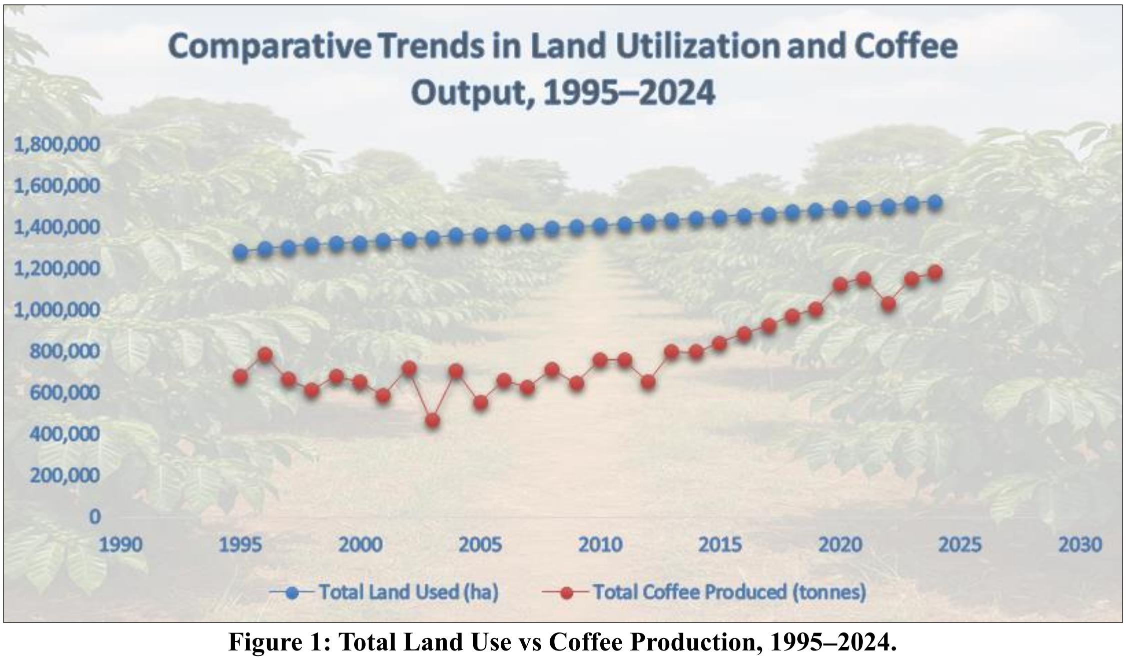

Figure 1: Total Land Use vs Coffee Production, 1995–2024.

As shown in Figure 1, production follows an unstable pattern. Sharp declines in 2003, 2012, and 2014 reflect the effects of drought and irregular rainfall. This finding aligns with earlier research by Lemma and Megersa (2021), who noted that East African coffee output declines rapidly during periods of rainfall imbalance and temperature stress. The average yield exhibits a similar irregular trend. In some years, such as 2002, 2004, and 2006, record-high yields are observed, while in others, there are apparent declines linked to extreme climate events. Drops in 1998, 2003, and 2014 align with ENSO-related weather anomalies. This sensitivity is also supported by Bilen *et al*., (2023), who found that small changes in rainfall timing can significantly reduce coffee yields and negatively impact export quality.

Figure 2 shows that the average coffee yield in East Africa follows an uneven trend over time. Periods of higher yield appear in the early 2000s and again in the late 2010s, suggesting continued investment and commitment to coffee farming despite climate stress. However, yields drop during drought-affected years, especially between 2012 and 2014, which coincides with strong ENSO events. These patterns show that while farmers continue to expand and maintain production, climate shocks still interrupt productivity and limit stable yield growth across the region.

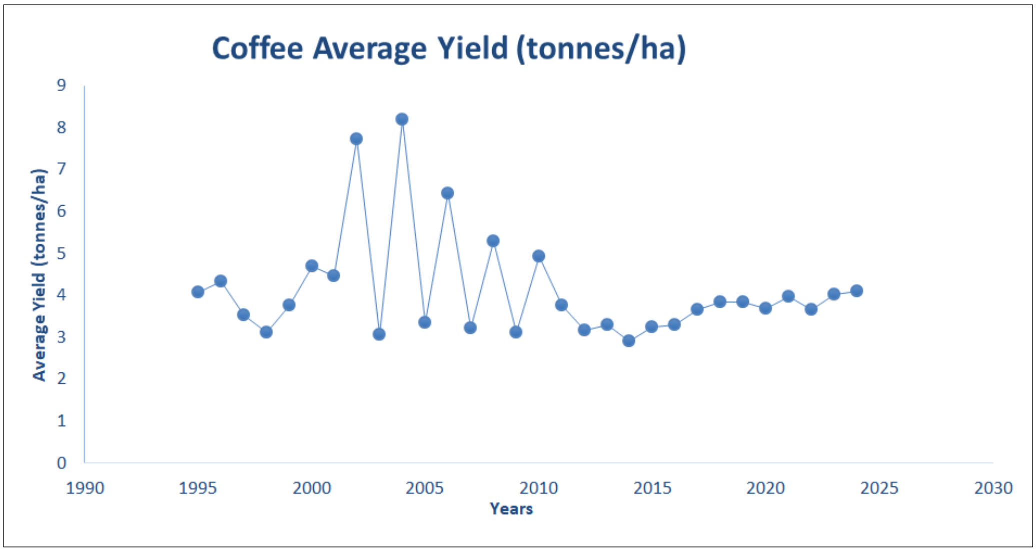

Figure 2: East Africa Coffee Average Yield (tonnes/ha)

Combined Coffee Land Area, Production, Yield, Export Revenue, and Revenue per Hectare in East Africa (1995–2024)

The combined data from 1995 to 2024 shows a steady increase in the land used for coffee production across East Africa, rising from just over 1.28 million hectares to about 1.51 million hectares, as shown in Table 2. This long-term expansion suggests that coffee remains a central economic crop for the region despite growing climate risks. Production, however, does not follow the same steady pattern. Instead, it fluctuates sharply from year to year. Some seasons exhibit strong recovery, while others experience significant declines due to droughts, irregular rainfall, and pest outbreaks. These fluctuations are consistent with earlier studies' descriptions of the region's high exposure to variable rainfall and temperature stress, which disrupts both yield and farm income (Lemma & Megersa, 2021).

Table 2: Combined Coffee Land Area, Production, Yield, Export Revenue, and Revenue per Hectare in East Africa (1995–2024)

Year	Total Land Used (ha)	Total Coffee Production (tonnes)	Average Yield (tonnes/ha)	Export Revenue (USD million)	Revenue per Hectare (USD/ha)
1995	1,288,000	680,998	4.062	1,223	949
1996	1,296,000	784,506	4.315	1,356	1,046
1997	1,298,000	664,954	3.521	1,307	1,007
1998	1,305,000	613,949	3.104	1,263	968
1999	1,315,000	680,636	3.761	1,144	870
2000	1,319,000	652,259	4.678	908	688
2001	1,322,000	588,434	4.453	805	609
2002	1,326,000	721,306	7.727	851	642
2003	1,330,000	466,359	3.070	849	639
2004	1,338,000	703,668	8.177	993	742
2005	1,369,000	555,736	3.355	1,456	1,064

Year	Total Land Used (ha)	Total Coffee Production (tonnes)	Average Yield (tonnes/ha)	Export Revenue (USD million)	Revenue per Hectare (USD/ha)
2006	1,380,000	661,035	6.430	1,589	1,152
2007	1,395,000	629,560	3.227	1,779	1,275
2008	1,406,000	710,164	5.278	1,887	1,342
2009	1,412,000	649,449	3.098	1,679	1,189
2010	1,410,000	760,656	4.926	2,713	1,924
2011	1,420,000	760,659	3.748	4,515	3,179
2012	1,425,000	654,756	3.172	3,584	2,516
2013	1,432,000	796,572	3.285	3,004	2,098
2014	1,439,000	793,614	2.901	3,805	2,646
2015	1,450,000	842,012	3.232	3,701	2,551
2016	1,460,000	887,130	3.301	3,405	2,333
2017	1,470,000	926,006	3.643	3,476	2,364
2018	1,480,000	969,772	3.841	3,633	2,454
2019	1,487,000	1,005,506	3.825	3,776	2,537
2020	1,492,000	1,123,317	3.692	3,803	2,550
2021	1,496,000	1,154,464	3.977	5,094	3,406
2022	1,499,000	1,033,888	3.666	5,621	3,748
2023	1,505,000	1,154,238	4.020	5,328	3,541
2024	1,515,000	1,179,981	4.091	5,337	3,522

Sources: FAOSTAT (2025); ICO (2025); National Coffee Boards (2024); Our World in Data (2025); Author's Computation (2024).

As shown in Figure 3, export revenue follows the same pattern of instability. While earnings grow from about 1.2 billion USD in 1995 to more than 5.3 billion USD in 2024, the path is uneven, with sharp rises and drops that mirror production swings. Revenue per hectare increases over time, indicating improvement in market value and demand; however, it remains heavily affected by climate shocks. These patterns support earlier findings that climate shocks lead to income instability and reduce the competitiveness of East African coffee in global markets (Chemura *et al*., 2020).

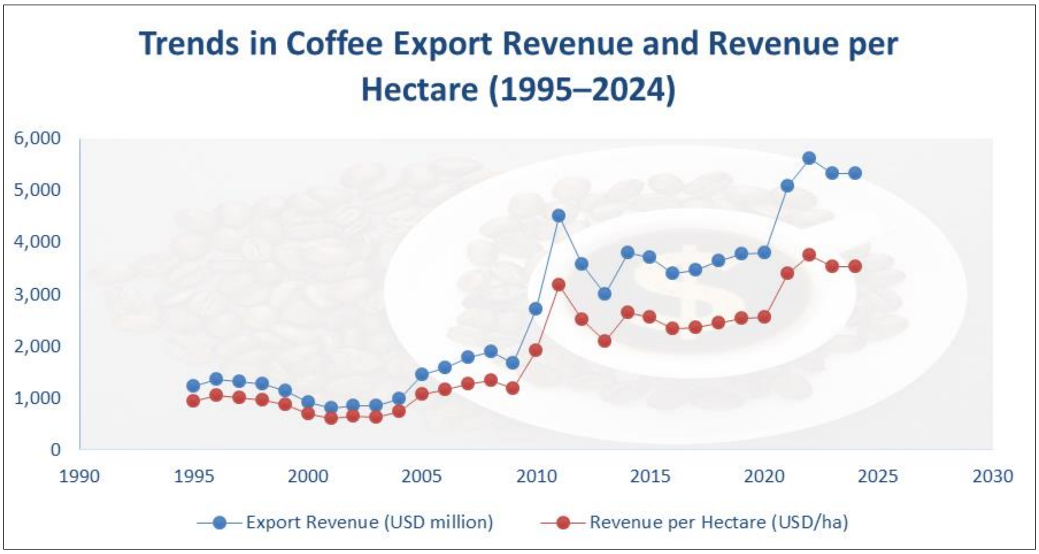

Figure 3: Trends in Coffee Export Revenue vs Revenue per Hectare

Country-Level Climate and Coffee Performance in East Africa (1995–2024)

Table 3 shows that all seven coffee-producing countries in East Africa experienced a clear warming trend between 1995 and 2024, with temperature increases ranging from about 0.7 to 1.1 degrees Celsius. This rise occurred alongside substantial differences in rainfall patterns, production outcomes, and export performance. The table illustrates that climate exposure alone does not determine outcomes; instead, the interaction between climate conditions, production systems, and institutional capacity shapes long-term performance.

Table 3: Country-Level Climate and Coffee Performance Overview (1995–2024)

Country	Change in Mean Temperature (°C)	Typical Annual Rainfall (mm)	Production Trend (t)	Yield Range (t/ha)	Export Revenue Range (USD M)	Revenue per Hectare (USD/ha)	Climate Sensitivity Summary
Ethiopia	+0.8	1,000–1,250	230,000 → 576,000	0.31–1.30	281–472	1,110–1,885	Sensitive to excess rainfall during El Niño; strong recovery under stable conditions
Uganda	+0.9	1,150–1,400	181,000 → 394,000	0.33–0.90	222–359	960–1,426	Rainfall-dependent system with strong volume growth
Tanzania	+1.0	1,030–1,280	42,000 → 64,000	0.24–0.68	110–142	882–1,090	Highly sensitive to rainfall timing and ENSO extremes
Kenya	+1.1	820–1,330	95,000 → 50,000	0.22–0.75	117–180	795–1,364	High vulnerability to floods and drought
DR Congo	+0.9	1,550–1,900	85,000 → 64,000	0.14–0.32	110–140	836–956	Excess rainfall disrupts harvest and drying
Rwanda	+0.8	1,100–1,360	22,000 → 28,000	0.29–0.78	79–98	1,160–1,370	High resilience driven by quality upgrading
Burundi	+0.7	1,130–1,390	26,000 → 10,000	0.21–4.08	70–155	1,110–1,580	Extreme volatility linked to climate and institutions

Source: Author calculations based on FAOSTAT, ICO, USDA FAS, NOAA, CHIRPS, and national statistics.

Ethiopia and Uganda are experiencing substantial production growth despite rising temperatures. As shown in Table 3, Ethiopia's production more than doubled over the period, accompanied by a significant increase in yield and revenue per hectare. This suggests that yield improvements, expansion of cultivated area, and post-harvest investments helped offset climate stress. However, the wide rainfall range indicates that El Niño years still introduce short-term instability through excess moisture and disease pressure. Uganda follows a similar pattern, where strong volume growth dominates revenue trends, but rainfall variability continues to influence year-to-year performance. These patterns align with earlier findings that volume-driven systems can grow under climate pressure but remain exposed to rainfall shocks (Ahmed *et al*., 2021).

In contrast, Kenya and Tanzania display weaker long-term performance. Table 3 shows that Kenya experienced a sustained decline in production despite relatively high revenue per hectare in some years. This reflects the sensitivity of Kenya's Arabica system to both drought and excess rainfall, where climate shocks directly affect flowering, quality, and prices. Tanzania shows modest production growth, but low yields and narrow revenue ranges indicate limited productivity gains. These outcomes suggest that climate variability, combined with slower adoption of adaptive practices, constrains long-term growth.

Rwanda stands out as the most stable system. Although its production volumes are small, Table 3 shows consistently high revenue per hectare and gradual yield improvement. This reflects the buffering role of quality-focused value chains and wet processing, which reduce vulnerability to climate shocks. Burundi and the Democratic Republic of the Congo exhibit the highest volatility. In both cases, rainfall extremes coincide with weak yields and stagnant revenues, indicating that climate stress compounds structural and institutional constraints rather than acting alone (Chemura *et al*., 2020).

Comparative Climate and Coffee Economy Indicators

Table 4 provides a comparative perspective that clarifies regional differences in climate sensitivity and economic response. As illustrated in the table, Kenya shows the highest ENSO impact severity, reflecting its dependence on narrowly timed rainfall during critical growth stages. Tanzania exhibits similarly high sensitivity, though with lower overall revenue exposure due to smaller production volumes. Ethiopia and Uganda fall into a medium-impact category, where firm production growth cushions short-term climate shocks but does not eliminate them.

Table 4: Comparative Climate and Coffee Economy Indicators in East Africa (1995–2024)

Indicator	Ethiopia	Uganda	Tanzania	Kenya	DR Congo	Rwanda	Burundi
Temperature Increase (°C)	0.8	0.9	1.0	1.1	0.9	0.8	0.7
Rainfall Variability	Moderate	High	High	Very High	Very High	Moderate	High
Production Trend	Strong increase	Strong increase	Modest increase	Long-term decline	Decline then recovery	Gradual increase	Decline
Yield Stability	Improving	Improving	Moderate	Low	Very low	High	Very unstable
Revenue Growth	Strong	Strong	Moderate	Weak	Stagnant	Stable	Volatile
ENSO Impact Severity	Medium	Medium	High	Very High	High	Low to Medium	High

Source: Synthesized from country-level datasets used in this study.

Rwanda's low-to-medium ENSO impact severity highlights the stabilizing effect of quality differentiation and post-harvest control. Burundi and the Democratic Republic of the Congo remain highly exposed, with low yield stability and weak revenue growth. The table shows that countries with improving yield stability also tend to display stronger revenue performance, reinforcing the role of productivity growth in climate adaptation. These patterns are consistent with broader regional assessments of climate resilience in African coffee systems (Davis *et al*., 2021).

Descriptive Statistics of Climate and Coffee Variables

Table 5 shows that temperature exhibits the most consistent long-term trend among all variables, confirming sustained warming across the region. Rainfall variables display relatively narrow means but substantial standard deviations, indicating that variability rather than absolute levels drives production shocks. The significant standard deviation in total production and export revenue reflects repeated climate-induced downturns followed by recovery phases.

Table 5: Descriptive Statistics for Key Climate and Coffee Variables (1995–2024)

Variable	Mean	Minimum	Maximum	Std. Dev.	Long Term Trend
Annual Rainfall (mm)	1,210.8	1,160	1,269	28.4	ENSO-driven variability
Rainfall Anomaly (%)	1.0	–4.0	+8.0	2.8	High interannual fluctuation
MAM Rainfall (mm)	380.0	352	415	16.4	Slight upward shift
OND Rainfall (mm)	332.0	299	368	15.8	ENSO-linked variation
Mean Temperature (°C)	22.0	20.9	23.2	0.7	Strong increase
Temperature Anomaly (°C)	0.99	0.2	1.9	0.42	Sustained warming
Total Production (t)	1,405,700	1,034,600	1,890,000	234,000	Clear upward trend
Average Yield (t/ha)	1.02	0.84	1.26	0.14	Gradual improvement
Export Revenue (USD M)	1,872	1,165	2,438	380	Strong long-term growth
Revenue per Hectare (USD/ha)	1,258	945	1,626	180	Rapid increase

Source: Author calculations based on compiled climate and coffee datasets, 1995–2024.

Despite these shocks, average yields and revenue per hectare increased steadily over time, indicating that productivity gains and market improvements partially offset the effects of climate stress. However, the wide range between minimum and maximum values confirms that climate shocks continue to generate significant short-term losses. This combination of long-term improvement and short-term instability highlights the dual challenge facing East African coffee systems: sustaining productivity growth while managing increasing climate volatility. These findings are consistent with regional climate economy assessments reported by the World Bank Group (2021).

Climate–Coffee Economy Linkages

Table 6 presents the correlation structure between key climate variables and coffee economy indicators for East Africa over the study period.

Table 6: Correlation Matrix for Climate and Coffee Economy Variables in East Africa (1995–2024)

Variable	Annual Rain	Rain Anom	MAM Rain	OND Rain	Mean Temp	Temp Anom	Production	Yield	Export Revenue	Revenue/ha
Annual Rain	1.000	0.742	0.891	0.911	0.603	0.599	0.552	0.515	0.551	0.527
Rain Anomaly	0.742	1.000	0.676	0.694	0.498	0.485	0.514	0.481	0.527	0.512
MAM Rain	0.891	0.676	1.000	0.812	0.612	0.596	0.566	0.551	0.583	0.561
OND Rain	0.911	0.694	0.812	1.000	0.604	0.588	0.559	0.533	0.567	0.548
Mean Temp	0.603	0.498	0.612	0.604	1.000	0.987	0.991	0.982	0.994	0.981
Temp Anomaly	0.599	0.485	0.596	0.588	0.987	1.000	0.989	0.978	0.992	0.980
Production	0.552	0.514	0.566	0.559	0.991	0.989	1.000	0.997	0.999	0.998
Yield	0.515	0.481	0.551	0.533	0.982	0.978	0.997	1.000	0.997	0.997
Export Revenue	0.551	0.527	0.583	0.567	0.994	0.992	0.999	0.997	1.000	0.998
Revenue per ha	0.527	0.512	0.561	0.548	0.981	0.980	0.998	0.997	0.998	1.000

Source: Author calculations based on FAOSTAT, ICO, CHIRPS, ERA5, and NOAA datasets.

As shown in Table 6, rainfall variables display moderate positive correlations with production, yield, and export revenue, indicating that rainfall availability and timing are central to short-term coffee performance. Seasonal rainfall, particularly during the MAM and OND periods, shows stronger correlations than annual totals, underscoring the importance of the seasonal distribution rather than cumulative rainfall. Temperature variables show extremely high correlations with production and revenue, reflecting shared long-term upward trends rather than productivity gains from warming. Export revenue is almost perfectly correlated with production, confirming that volume remains the primary driver of earnings across the region, consistent with Lemma and Megersa (2021).

ENSO Effects on Export Performance

ENSO phases provide further insight into short-term revenue volatility by grouping years according to large-scale climate conditions.

Table 7: ENSO–Revenue Impact Summary for East Africa (1995–2024)

ENSO Condition	Average Export Revenue (USD Million)	Percent Change from Neutral Years
Neutral Years	379	—
El Niño Years	373	–1.6%
La Niña Years	404	+6.6%

Source: Author calculations using ENSO classifications from NOAA and export data from ICO and UN Comtrade.

Table 7 shows that El Niño years are associated with lower export revenues compared to neutral conditions. Excess and poorly timed rainfall during these periods increases disease pressure, disrupts drying, and reduces bean quality, leading to export losses. In contrast, La Niña years record higher revenues, reflecting relatively drier and more stable conditions that support improved harvesting and post-harvest handling. Neutral years represent a balanced climatic baseline, indicating that the absence of ENSO extremes generally favors export stability, in line with Ahmed *et al*., (2021).

Country-Level Climate Resilience

Climate impacts varied substantially across countries, reflecting differences in production systems, institutional capacity, and adaptation strategies.

Table 8: Climate Resilience Indicators for East African Coffee Countries (1995–2024)

Country	Production Change	Yield Range	Rainfall Anomaly Range	Temp Change	Revenue Range	Revenue/ha	ENSO Impact	Overall Resilience
Rwanda	+26%	0.30–0.78	–-9 to +21	+0.8	79–102	1,160–1,370	Low–Moderate	Very High
Uganda	+117%	0.34–0.94	–10 to +32	+0.9	235–359	1,007–1,426	Low–Moderate	High
Ethiopia	+151%	0.31–1.30	–10 to +22	+0.7	281–472	1,110–1,885	Moderate	Moderate

Country	Production Change	Yield Range	Rainfall Anomaly Range	Temp Change	Revenue Range	Revenue/ha	ENSO Impact	Overall Resilience
Tanzania	+53%	0.24–0.68	–-9 to +20	+1.0	110–142	882–1,090	Moderate–High	Moderate–Low
Kenya	–48%	0.22–0.75	–-18 to +35	+1.1	117–180	799–1,364	High	Low
DR Congo	–25%	0.14–0.32	–-8 to +14	+0.9	110–139	837–956	High	Low
Burundi	–62%	0.15–4.08	–-9 to +22	+0.7	70–155	1,110–1,580	Very High	Very Low

Source: Synthesized from FAOSTAT, ICO, CHIRPS, ERA5, and NOAA.

As illustrated in Table 8, Rwanda and Uganda exhibit the highest climate resilience, supported by stable production growth, strong recovery capacity, and high revenue per hectare. Ethiopia and Tanzania show moderate resilience, combining long-term expansion with continued sensitivity to rainfall extremes. Kenya, the Democratic Republic of the Congo, and Burundi are the most vulnerable, experiencing persistent production declines and high revenue volatility under climate shocks. These differences underscore the importance of institutional strength, investment in quality upgrading, and adaptive capacity in moderating climate impacts on export performance, consistent with World Bank Group (2021).

Export Revenue Stability and Climate-Induced Volatility in East Africa

While earlier sections demonstrate how climate variability affects production, yield, and revenue levels, an equally important dimension is the stability of export earnings over time. For coffee-exporting economies, income volatility directly influences farmer livelihoods, foreign exchange planning, and investment decisions. Examining revenue stability alongside climate exposure provides a clearer picture of economic risk under increasing climate uncertainty.

Table 9 synthesizes country-level indicators of export revenue volatility, yield variability, and ENSO exposure for the seven East African coffee producers between 1995 and 2024. The table integrates information from earlier results to identify which countries experience relatively stable export performance and which face persistent climate-induced income instability.

Table 9: Export Revenue Stability and Climate-Induced Volatility in East Africa (1995–2024)

Country	Export Revenue Range (USD M)	Revenue Volatility	Yield Stability	ENSO Sensitivity	Dominant Source of Instability
Ethiopia	281–472	Moderate	Improving	Moderate	Rainfall extremes during El Niño affect the quality
Uganda	222–359	Moderate	Improving	Moderate	Rainfall variability influencing Robusta yields
Tanzania	110–142	High	Moderate	High	Rainfall timing and disease pressure
Kenya	117–180	Very High	Low	Very High	Floods and droughts affect flowering and quality
DR Congo	110–140	High	Very Low	High	Excess rainfall is disrupting harvest and drying
Rwanda	79–102	Low	High	Low–Moderate	Limited, buffered by quality upgrading
Burundi	70–155	Very High	Very Unstable	Very High	Climate shocks combined with institutional constraints

Source: Author synthesis based on FAOSTAT, ICO, CHIRPS, ERA5, NOAA, and national statistics.

As illustrated in Table 9, export revenue stability varies widely across East Africa despite shared exposure to climate change. Rwanda displays the lowest revenue volatility, reflecting stable yields and effective buffering through quality differentiation and controlled post-harvest processing. Although absolute export values are modest, income stability remains high, underscoring the role of value chain structure in moderating climate risk.

Uganda and Ethiopia occupy an intermediate position. Both countries experienced strong long-term growth in export revenue, but still show moderate volatility linked to rainfall anomalies and ENSO events.

In these systems, expanding production volumes help offset short-term losses, yet year-to-year income remains sensitive to climate shocks that affect yield and quality.

In contrast, Kenya, Burundi, Tanzania, and the Democratic Republic of the Congo exhibit high to very high revenue volatility. In these countries, climate extremes translate more directly into economic losses due to weak yield stability, limited buffering capacity, and high sensitivity to rainfall timing. Kenya's premium Arabica system is particularly exposed, where both excess rainfall and drought reduce quality and prices, amplifying income instability. Burundi and the DRC exhibit the strongest interaction between climate stress and institutional constraints, leading to sharp revenue fluctuations even when market prices are favorable. The evidence indicates that climate change in East Africa's coffee sector manifests primarily as increased economic volatility rather than uniform declines in export revenue. Countries with stronger productivity growth, quality upgrading, and post-harvest control exhibit greater income stability under climate pressure, while those lacking these buffers face amplified climate-induced export risks.

Conclusions and Policy Recommendations

This study examined the effects of climate variability and climate shocks on coffee export revenues in East Africa over the period 1995 to 2024. The results demonstrate that although the region experienced sustained long-term growth in coffee production, yields, and export earnings, this progress remained highly vulnerable to short-term climate disturbances. Rainfall variability, ENSO cycles, and rising temperatures consistently influenced production outcomes and export performance. El Niño events were associated with recurrent declines in export revenues due to excess rainfall, disease pressure, and post-harvest disruptions. At the same time, La Niña conditions generally supported more stable or improved export outcomes. These findings confirm that climate shocks already exert a measurable and economically significant influence on the East African coffee sector.

The analysis revealed substantial cross-country differences in resilience, indicating that climate impacts are mediated by institutional capacity, production systems, and investment in quality upgrading rather than climate exposure alone. Rwanda and Uganda exhibited the highest resilience. Rwanda's emphasis on specialty coffee, wet processing, and quality premiums stabilized revenue per hectare despite climate variability. At the same time, Uganda's expansion of Robusta production, supported by extension services and institutional programs, enabled strong, long-term growth despite fluctuating rainfall. In these countries, policy efforts should prioritize maintaining quality investments, strengthening climate information services, and expanding traceability and specialty market access to protect export earnings during shock years.

Ethiopia and Tanzania demonstrated moderate resilience. Both countries achieved growth in production and revenue over time, yet remained sensitive to ENSO-related rainfall and temperature extremes. In Ethiopia, improved post-harvest handling, disease management during wet years, and broader adoption of climate-adapted Arabica varieties in vulnerable highland zones are critical. In Tanzania, targeted investments in irrigation, soil moisture conservation, and farmer training are necessary to reduce dependence on rainfall timing. Aligning extension services with seasonal climate forecasts would further enhance resilience in both systems.

Kenya, the Democratic Republic of the Congo, and Burundi emerged as the most vulnerable coffee economies. Kenya's prolonged production decline reflects high sensitivity to rainfall extremes, rising temperatures, and aging tree stocks. Priority interventions include accelerated replanting with heat-tolerant and disease-resistant varieties, improved water management during flowering, and incentives for farm-level rejuvenation. In the Democratic Republic of the Congo, excess rainfall, weak infrastructure, and institutional constraints continue to suppress yields and export performance. Policy efforts should focus on basic plantation rehabilitation, improved drying and transport infrastructure, and targeted regional support to reduce climate-related losses. Burundi's extreme volatility reflects the combined effects of climate stress and governance challenges, underscoring the need for cooperative strengthening, rehabilitation programs, and improved access to climate-smart inputs.

Across the region, several common policy priorities emerge. Strengthening climate monitoring and early warning systems can help producers anticipate ENSO events and adjust production and post-harvest practices accordingly. Scaling climate-smart agriculture practices, including agroforestry, shade management, mulching, and soil moisture conservation, can reduce exposure to heat and rainfall extremes. Investment in drying, storage, and processing infrastructure is significant during wet El Niño years. Climate-linked financial instruments, such as insurance and adaptive credit, can stabilize farm incomes during periods of shocks. Expanding value-addition and specialty markets further buffer export revenues against climate-driven production losses.

In conclusion, climate shocks are already reshaping coffee export performance in East Africa by increasing economic volatility rather than uniformly reducing output. While some countries have demonstrated strong adaptive capacity, others remain highly exposed. Country-specific strategies that integrate climate adaptation, institutional strengthening, and market upgrading are essential to safeguard coffee export revenues and rural livelihoods under increasing climate uncertainty.

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