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Determinants of agricultural exports in Somalia: the impacts of exchange rates, foreign direct investment, and institutional quality

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ABSTRACT

Globally, the exportation of agricultural products plays a critical role in driving economic growth and stability, often acting as a substantial contributor to gross domestic product (GDP), employment, and foreign exchange earnings in agrarian economies. As a vital pillar of many developing countries' economies, the agricultural sector's export dynamics have remained understudied, particularly in integrating climatic, economic, and institutional-related factors. Thus, this study explores the determinants of agricultural exports in Somalia between 1985 and 2017. While the evidence from the ARDL bounds-testing cointegration analysis indicates that precipitation improves agricultural exports in the long-run, the role of agricultural production was insignificant. The analysis indicates that currency depreciation can boost export competitiveness in the long-run, whereas currency depreciation may lead to reduced exports in the short-run. Moreover, short-run domestic investments positively impact exports, but this effect diminishes over the long-run. Remarkably, institutional quality and FDI inflows are consistently identified as significant enhancers of agricultural exports. In addition, the Granger causality analysis indicates that exchange rates, institutional quality, and FDI inflows unidirectionally predict agricultural exports. Following the outcomes of this exploration, the study recommends enhancing rainwater harvesting and irrigation systems, focusing on value addition and market diversification, stabilizing currency for competitive advantage, and improving institutional quality by streamlining FDI policies.

IMPACT STATEMENT

This analysis profoundly advances the discourse on Somalia's agricultural export potential by presenting an incisive linkage between institutional quality, FDI, and climatic factors such as precipitation. It stresses the transformative capacity of robust governance structures and strategic economic policies to elevate Somalia's agricultural sector as a pivotal driver of sustainable economic growth and global competitiveness. By providing evidence-based insights into institutional reform and external investment roles, the study handles critical bottlenecks in agricultural productivity and trade. Moreover, the research indicate the broader socioeconomic and environmental implications of enhancing agricultural exports, including rural development, job creation, and improved resilience to climate challenges. It positions Somalia's agricultural sector not merely as an economic asset but as a cornerstone for national stability and international integration. The findings are of particular importance to policymakers, development agencies, and global investors, equipping a strategic framework for facilitating sustainable growth in a region disproportionately affected by climate change and economic volatility. By articulating a clear pathway to amplify agricultural exports while addressing structural vulnerabilities, this study lays a foundation for subsequent research and policy interventions aimed at assuring that Somalia's agricultural sector becomes a model for resilience, innovation, and inclusive growth in sub-Saharan Africa.

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1. Introduction

Over the past few decades, foreign direct investment (FDI) and governance structures have been pivotal forces in reshaping the agricultural sector. By introducing advanced technologies, management practices, and expertise to farmers globally, FDI has facilitated not only the fulfillment of the growing demand for agricultural products but also the production of export surpluses (UNCTAD, 2020). Additionally, foreign investments have paved the way for entry into new markets and distribution networks, creating avenues for the growth of agricultural exports (Kandilov, 2008). Moreover, the infusion of FDI into the agricultural sector has been instrumental in facilitating knowledge transfer and enhancing skills (OECD, 2020). This has resulted in the adoption of improved agricultural practices, enhanced quality control measures, and increased overall competitiveness, leading to higher agricultural exports. On the other hand, better institutional frameworks, characterized by reduced corruption levels and stronger property rights, can enhance export quality (Faruq, 2011; Lin et al., 2020). In addition, Bojnec et al. (2014) highlight that institutional quality is critical to enhancing agro-food exports in developing countries. Thus, it is crucial to investigate the critical role of FDI and governance structures in enhancing agricultural exports in order to guide policy insights that boost economic growth and competitiveness in global markets.

FDI has emerged as a pivotal force in propelling agricultural exports and fostering economic growth within developing nations (Raeskyesa & Suryandaru, 2020). Theoretically, FDI contributes to agricultural expansion through the infusion of capital, the integration of new inputs, and the transfer of foreign technology into the production processes of local enterprises, thereby offering tangible benefits to both local farmers and domestic investors. Enhanced communication infrastructures, facilitated by FDI, empower farmers to scale up production and improve storage and transportation capabilities, consequently elevating agricultural exports and farm incomes (Slimane et al., 2016). Furthermore, FDI's critical contributions to the development of agricultural infrastructure, such as transportation networks, storage facilities, and processing plants, have been instrumental in minimizing post-harvest losses and ensuring efficient access to international markets (Akande et al., 2017). Moreover, FDI has focused on value addition and processing activities, transforming raw agricultural products into higher-value processed goods that meet international quality standards, have a longer shelf life, and command higher prices globally (Msuya, 2007). The role of FDI in enhancing local firms' innovation, technology, and product quality highlights why developing countries are attractive destinations for FDI (Younus et al., 2014). Besides, FDI enhances a country's export potential by capitalizing on its comparative advantages, such as abundant agricultural land and lower production costs (Gunasekera et al., 2015).

The crucial role of institutions and their quality in influencing agricultural exports is becoming increasingly recognized. In environments where institutions are underdeveloped and inefficient, elevated trade costs emerge, directly impacting the volume of agricultural trade (Abdi et al., 2024a). In contrast, strong and efficient institutions are instrumental in reducing transaction costs and mitigating uncertainty, thereby fostering increased trade activities (Abreo et al., 2021). The poor institutional quality of developing countries is often attributed to the low level of trade in these nations (Briggs, 2013). This is because countries prefer engaging in trade with partners with higher institutional quality, offering lower transaction costs and greater trade facilitation (Abdi et al., 2023b). The presence of robust legal systems, impartial enforcement of property rights, and a conducive environment for contracting and trading significantly reduce transaction costs and encourage trade (LiPuma et al., 2013). Moreover, good governance is vital for augmenting agricultural trade by lowering transaction costs and improving access to high-value agricultural markets. Consequently, institutions can support the transition from trading low-value primary products to exporting high-value products (Lin et al., 2020). Furthermore, Álvarez et al. (2018) demonstrated the significance of the institutional framework within destination countries and the institutional discrepancies between exporters and importers as crucial elements influencing bilateral trade.

Fluctuations in exchange rates significantly impact international trade, especially agricultural exports. A strong domestic currency typically results in decreased exports and increased imports because higher prices for domestic goods make them less competitive globally (Cooper, 2019). Conversely, a weaker currency boosts exports and reduces imports as domestic goods become cheaper for foreign buyers. This dynamic affects domestic prices, influencing production, consumption, and trade incentives. For instance, when a country focused on agricultural exports experiences a currency devaluation, the domestic price received

for exported goods increases, encouraging producers to enhance production and exportation (Liefert, 2009). Maintaining stable exchange rate regimes and reducing volatility is crucial for sustaining export performance in both developed and emerging markets. Evidence from several African countries shows a direct positive relationship between exchange rates and agricultural exports (Ogunjobi et al., 2022). However, exchange rate volatility negatively impacts agricultural exports in trade flows between developed countries (Kafle, 2011). In the African context, the impact of exchange rates is particularly significant because a considerable portion of manufacturing expenses in African countries are denominated in the local currency (Allen et al., 2011). This reliance on the home currency makes exchange rate fluctuations detrimental to economic growth and presents challenges for exporters competing in the global market (Isse & Ibrahim, 2017). As the local currency fluctuates, it can increase production costs for manufacturers, reducing their competitiveness and making it harder to maintain stable export levels.

UNCTAD (2020) highlights nations' strategic utilization of FDI as a cornerstone for sustained development by adopting more open economic policies to expand their economic landscapes. Despite a rebound in global FDI flows to USD 727 billion in the first half of 2023, these figures were still 30% lower than the same period in 2022 (OECD, 2020). African nations, in particular, grapple with hurdles in bolstering domestic agricultural investment, attributed to constrained savings and a heavy dependence on aid funding. Since 2012, FDI in Somalia has primarily flowed into the healthcare, education, and banking sectors, while the agriculture sector has not benefited from such investments, indicating its exclusion from the primary focus of FDI activities during this period (National Economic Council, 2023). Gunasekera et al. (2015) identified the scant investment in agriculture as a critical barrier to its growth within the continent, with public budget allocations to agriculture dipping below 10% (Cleaver, 2012). The reduction in aid and public agricultural investment has led to a significant disparity between the investment demands and the available resources (Benin et al., 2008). While there has been an uptick in FDI flows to developing regions, the fraction directed towards the agrifood sector is still minor, with a considerable emphasis on downstream activities over primary agricultural production (Liu et al., 2013). Remarkably, FDI emerges as a vital mechanism to bridge the investment gap in African agriculture, notably enhancing agricultural export capabilities.

The agricultural domain stands as a cornerstone of Somalia's livelihood, underpinning the sustenance of its populace, contributing significantly to the nation's income and employment, and providing raw materials to other sectors (Ali Warsame & Hassan Abdi, 2023). It plays a pivotal role in import and export dynamics while preserving biodiversity and ecological equilibrium. However, the sector faces multifaceted challenges undermining farmers' welfare, including recurrent droughts, a deficit in agricultural extension services and farmer education, suboptimal access to high-quality seeds, and inadequate irrigation infrastructure (Mohamed & Abdi, 2024). Ongoing conflicts, political instability, and security concerns have led to limited levels of FDI in Somalia (National Economic Council, 2023). Additionally, Adam Smith International (2019) notes that Somalia's weak institutional capacities challenge the enhancement of agricultural value chains. Figure 1 showcases the trends of FDI inflows and agricultural exports from 1990 to 2020 in millions of U.S. dollars, revealing a general upward trend over the three-decade period. Initially, agricultural exports grew steadily with slight fluctuations until the early 2000s, while FDI inflows were stable with a gradual increase. A notable surge in both FDI and agricultural exports is observed post-2000, with FDI inflows experiencing a

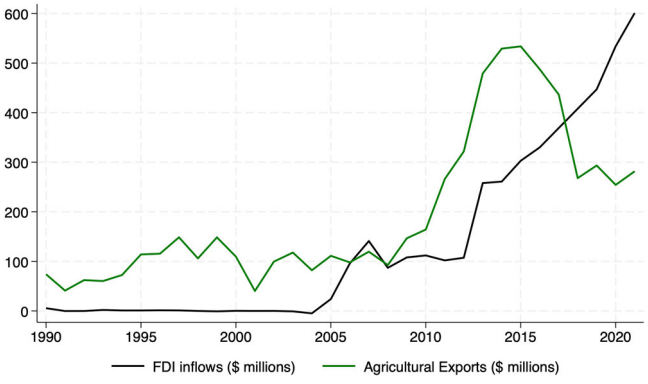

Figure 1. Trends of agricultural exports and FDI inflows in Somalia.

significant jump post-2010, markedly surpassing the growth rate of agricultural exports. Around 2015, a decline in agricultural exports contrasted with the continued rise in FDI inflows, which peaked in 2020, reaching the highest level within the observed period. Although agricultural exports also increase towards 2020, their growth is modest compared to the pronounced rise in FDI inflows.

In the literature, several studies have recognized the pivotal role of FDI and governance in bolstering agricultural exports, highlighting the technological, managerial, and infrastructural advancements that FDI brings to the agricultural sector (Ali, 2020; Bojnec et al., 2014; Engemann et al., 2023; Hassan & Abd-Elmotaal, 2021; Lin et al., 2020). However, a notable gap persists regarding the direct impact of FDI on agricultural productivity and export enhancement in developing countries, particularly within the context of varying institutional qualities. While studies have examined the effects of FDI on agricultural exports broadly, the impact of institutional frameworks remains under-explored, especially in the African context, where agriculture plays a critical economic role but suffers from underinvestment. This is more pronounced in Somalia, where lower institutional quality acts as a barrier to agricultural exports and hinders the development of the agriculture sector. The increased exchange rate volatility negatively impacts exports by making it difficult for Somali exporters to price their goods competitively and predictably in international markets. In addition, despite agriculture's paramount importance to the country, FDI has not been significantly channeled towards improving the agricultural sector.

Hence, this study investigates the effects of exchange rates, foreign direct investment, and institutional quality on agricultural exports in Somalia using time-series data from 1985 to 2017. This period was marked by significant events such as the civil war, recurrent droughts, bans on agricultural exports, and the collapse and gradual re-establishment of government. Combined with unregulated exchange rates, these events profoundly influenced agricultural production and export activities. Unlike previous studies that considered only some determinants of agricultural exports, such as FDI (Alnafissa et al., 2022; Hassan & Abd-Elmotaal, 2021; Kastratović, 2024), institutional quality (Bojnec et al., 2014; Lin et al., 2020), exchange rates (Ali, 2020; Alnafissa et al., 2022; Engemann et al., 2023; Hassan & Abd-Elmotaal, 2021), this study will incorporate these variables into climatic factor, i.e., rainfall, agricultural production, and domestic investments. Moreover, to ensure reliable results, this study employs a range of econometric methodologies, such as tests for unit roots, bounds testing, the autoregressive distributed lag (ARDL) framework, and Granger causality analysis. Consequently, the study's findings will guide evidence-based policy insights about how targeted FDI and improved governance structures can significantly enhance agricultural productivity and exports through strategic interventions to bolster economic growth and global market competitiveness.

The subsequent sections of our paper are structured as follows: The second section reviews the literature surrounding FDI, institutional quality, exchange rates, and agricultural exports. Proceeding with this, the methodology section elucidates our model specifications and the econometric methodologies. Subsequently, the fourth section scrutinizes the data analysis and engages in a detailed discussion regarding the findings. Lastly, the study provides a conclusion and actionable policy recommendations derived from the study's outcomes.

2. Literature review

Recent research predominantly reveals a positive link between FDI and agricultural exports, particularly in developing nations, although variations exist due to specific country contexts and factors. For instance, Hassan & Abd-Elmotaal (2021) and Alnafissa et al. (2022) examine the impact of FDI on agricultural exports in Arab nations, indicating a potential linkage between foreign investments and increased agricultural trade. Investigating the impact of FDI inflows on agricultural exports in a sample of 80 developing countries, Kastratović (2024) reveals that FDI inflows positively influence agricultural exports in both the short- and long-run. Similarly, Oloyede (2014) investigates the impact of FDI on Nigeria's agriculture sector, finding favorable effects in both the short- and long-run. Edeh et al. (2020) also focus on Nigeria, providing further evidence of the positive impact of FDI on the agricultural sector's output. Moreover, Gunasekera et al. (2015) take a broader perspective by using the Global Trade Analysis Project model to study the potential impact of FDI and land productivity on African agriculture. Their research emphasizes the potential for increased agricultural exports and output through FDI, supporting the positive relationship observed in previous studies. The collective analysis from various studies predominantly

indicates a positive linkage between FDI and agricultural exports, particularly in developing nations. However, contrasting findings by Epaphra & Mwakalasya (2017) in Tanzania's agricultural sector show that FDI inflows did not significantly affect agricultural output, which highlights potential variations in this relationship across different countries and contexts.

Contemporary studies highlight the critical influence of robust governance and institutional integrity in promoting agricultural productivity and exports. Gelgo et al. (2023) found that government effectiveness positively impacts agriculture value-added in East Africa. This aligns with Uduma et al. (2023), who observe that institutional quality significantly increases agricultural yield across African countries. Improved institutional quality enhances agricultural production, suggesting that better governance structures can increase agricultural trade. Engemann et al. (2023) investigated the role of institutional quality in maintaining trade relations between sub-Saharan African countries and the European Union. They found that trade relationships endure longer when trading partners have similar institutional quality and exporters have efficient institutional structures. Farooq et al. (2019) similarly found that institutional quality positively impacts the growth of Pakistan's agriculture industry. In addition, Lin et al. (2018) explored the impact of institutional quality on bilateral coconut trade, finding that different dimensions of institutional quality, such as voice and accountability, government effectiveness, and control of corruption, have varying effects on different types of coconut products. Moreover, Bojnec et al. (2014) explored the role of institutional quality in exporting and importing nations and its effect on the agro-food exports of BRIC countries. They concluded that well-functioning institutions facilitate trade in the agricultural sector. Briggs (2013) found similar results, emphasizing that inadequate institutional quality hinders the broadening of trade activities and necessitating policy measures that bolster foreign institutional frameworks in alignment with domestic export goals.

Furthermore, the investigation of the effects of exchange rates on agricultural exports reveals significant variation across different countries and products. For example, Shane et al. (2008) examined the effects of the real trade-weighted exchange rate and trade partner income on U.S. agricultural exports. They found that increased trade partner income positively influences total agricultural exports, while a stronger dollar relative to trade partner currencies negatively impacts exports. Essien et al. (2011) focused on exchange rate fluctuations and cocoa exports in Nigeria. They found that greater exchange rate volatility can positively impact the export of specific agricultural products. Additionally, Wang & Barrett (2007) explored the impact of exchange rates on Taiwan's export volume to the United States. They reveal a positive relationship between the exchange rate and the value of agricultural exports, but not other sectors. This suggests that currency depreciation makes a country's agricultural exports cheaper and more competitive internationally.

However, a comprehensive analysis by Kandilov (2008) found that developing nations' agricultural exports are disproportionately affected by exchange rate instability compared to their developed counterparts. It is notable that the devaluation of the exchange rate plays a significant role in promoting agricultural exports. Buguk et al. (2003) investigated the effects of exchange rate volatility on Turkish agricultural exports. They conclude that exchange rate variability does not significantly impact Turkish agricultural exports. However, Mukaila (2023) examined the impact of exchange rate misalignment and various economic fundamentals on cocoa exports. They found that the equilibrium real exchange rate positively affects cocoa exports. Also, Ali (2020) studied the impact of domestic currency depreciation on agricultural exports from Pakistan. The study indicates that currency depreciation positively affects both intensive and extensive margins of agricultural exports. Additionally, Ogunjobi et al. (2022) assessed the impact of exchange rates on agricultural exports in Nigeria. They reveal a significant impact of exchange rates on agricultural exports and a positive long-term relationship between the two variables. This suggests that an increase in the exchange rate is expected to result in a corresponding increase in agricultural exports over time.

Research consistently shows that extreme weather conditions have a multifaceted impact on agricultural productivity and exports. Abdi et al. (2023a) investigated the effects of climate change on cereal crop production in East African countries. They found that rainfall plays a significant role in long-run agricultural production. Besides, despite observing a positive effect, Olayide et al. (2016) found that rainfall alone may not be a significant determinant of agricultural production. This suggests that other factors beyond rainfall, such as soil quality, agricultural practices, and input availability, influence agricultural output outcomes. These studies indicate that rainfall variations adversely affect agricultural output, potentially leading to decreased agricultural exports. In addition, Ciccone & Ismailov (2022)

found an inverted U-shaped relationship between rainfall and agricultural productivity, with both extreme droughts and excessive wet conditions harming agricultural output. Their study also suggests that the impact of rainfall on agricultural output is temporary or transitory. Amare et al. (2018) focused on the effects of rainfall shocks on agricultural productivity and household consumption in Nigeria. They reveal heterogeneous impacts of adverse rainfall shocks on crop-specific agricultural productivity across different geographical zones. Similarly, Ndamani & Watanabe (2015) assessed rainfall variability and its relationship with crop production, observing a negative relationship between annual rainfall and crop production for all crops studied. At the seasonal level, sorghum, millet, and groundnut showed negative correlations with rainfall, indicating that different crops respond differently to rainfall patterns.

Generally, the literature on FDI's impact on agricultural exports reveals a favorable linkage, particularly in developing countries, but findings vary due to unique national and crop-level contexts. Additionally, governance and institutional quality are essential to agricultural productivity and exports, with studies pointing to the importance of efficient governance structures. While exchange rates are shown to affect agricultural exports differently, their effects vary across countries and products. The studies on extreme weather conditions emphasize their significance but varied impact on agricultural productivity. Nevertheless, detailed research on how rainfall, exchange rates, agricultural output, domestic investment, FDI, and specific governance aspects influence agricultural exports in Somalia is lacking. Addressing these gaps could provide pivotal insights for policymakers aiming to leverage FDI for agricultural development and resilience in the face of global economic and climatic challenges. Hence, this study uses various contemporary econometric approaches in order to address these gaps in the literature.

3. Materials and methods

3.1. Theoretical framework

The Export-Led Growth Theory posits that economies can achieve long-term sustainable growth by focusing on expanding their export sectors. This theory is particularly relevant in the context of developing countries where agriculture plays a critical role in economic development. For many of these nations, agricultural exports serve as a crucial source of foreign exchange and employment, which directly contributes to economic expansion. According to the Export-Led Growth Theory, prioritizing agricultural exports can drive overall economic growth by stimulating related sectors and enhancing economic productivity (Balassa, 1978). This theory relates various aspects of exchange rates, FDI, and institutional quality to agricultural exports. Firstly, competitive exchange rates play a significant role in boosting agricultural exports. A weaker domestic currency makes exports cheaper and more attractive to foreign buyers, thus increasing demand for agricultural goods (McKinnon, 1963). Secondly, FDI in agriculture can significantly improve the production capacity of a country through technology transfer, infrastructure development, and access to international markets. This increased capacity boosts export volumes, thus supporting the growth of agricultural exports. FDI also plays a role in upgrading the value chain of agricultural products, leading to higher export competitiveness. Finally, institutional quality, such as good governance, regulatory stability, and the protection of property rights, is essential for supporting export-led growth. Countries with high institutional quality are better positioned to engage in global trade, particularly in agriculture, as they offer more stable and predictable business environments (Acemoglu & Robinson, 2020).

3.2. Variables and data sources

Although agricultural exports have historically been the cornerstone of Somalia's economy, the absence of stable and efficient institutional structures and foreign investment has hindered their growth. Consequently, Somalia's agricultural exports suffer from inadequate capital inflows, underdeveloped infrastructure, limited technology adoption, restricted market access, weakened supply chains, and unmitigated risks (Abdi et al., 2024a). Despite challenges from climatic variations, political instability, and exchange rate volatility, agricultural exports remain a key contributor to Somalia's economy, driven by improved FDI and institutional quality. Therefore, this research utilizes time series data from 1985 to 2017 to examine the impact of exchange rates, FDI, and institutional quality on agricultural exports in

Table 1. Variables, symbols, descriptions, and data sources.

Variable	Symbol	Description	Source
Agricultural exports	AE	Export value (Millions USD)	FAO
Rainfall	RF	Average annual precipitation (mm)	CCKP
Agricultural production	AGP	Cereal production (metric tons)	WDI
Exchange rate	EXR	USD per Somali shilling	UNCTAD
Domestic investment	DI	Gross Capital Formation, Constant 2015 Prices, Annual Change	SESRIC
Institutional quality	IQ	Rule of law: Assessment of legal system strength and law adherence.	ICRG
Foreign direct investment	FDI	Inward FDI (% of GDP)	UNTCAD

Somalia. The study employs agricultural exports as the dependent variable, impacted by factors like FDI inflows and institutional quality (Engemann et al., 2023; Kastratović, 2024; Lin et al., 2020). To ensure a comprehensive understanding of agricultural exports, this study identifies explanatory variables such as rainfall, agricultural production, exchange rates, and domestic investments as crucial determinants (Abdi et al., 2024b; Ali, 2020; Alnafissa et al., 2022). This study relies on data from various sources, including the Food and Agriculture Organization (FAO), Climate Change Knowledge Portal (CCKP), World Development Indicators, International Country Risk Guide dataset (ICRG), United Nations Conference on Trade and Development (UNCTAD), and SESRIC databases. Table 1 summarizes the symbols, descriptions, and data sources for each variable under consideration.

3.3. Empirical strategy

The econometric model of this undertaking builds upon the established frameworks of Engemann et al. (2023), Hassan & Abd-Elmotaal (2021), Edeh et al. (2020), and Abdi et al. (2024a). These recent studies enriched their analyses by incorporating variables such as agricultural exports, rainfall, agricultural output, exchange rates, domestic investment, institutional quality, and FDI inflows. To be careful with the heterogeneity issues, biased coefficient estimates, misspecification of nonlinear relationships, and interpretation of a percentage way, the variables used in the study are transformed in a logarithm form except for domestic investment and FDI. Hence, the following specification is employed for this study:

$$lnAE_t = \beta_0 + \beta_1 lnRF_t + \beta_2 lnAGP_t + \beta_3 lnEXR_t + \beta_4 DI_t + \beta_5 lnIQ_t + \beta_6 FDI_t + \varepsilon_t \tag{1}$$

where AE, RF, AGP, EXR, DI, IQ, and FDI stand for agricultural export, rainfall, agricultural production, exchange rate, domestic investment, institutional quality, and FDI inflows, respectively. β_0 is constant term, β_1, β_2, β_3, β_4, β_5, and β_6 are coefficients to be estimated, *ln* represents the logarithm transformation, and ε signifies the error term.

To investigate the presence of cointegration among the analyzed variables, this study employs the ARDL bound test formed by Pesaran et al. (2001). It is a dynamic econometric approach, which is utilized to analyze the long-run relationships among the variables within a time-series framework. The ARDL approach provides distinct advantages compared to conventional cointegration testing techniques. Notably, it is well-suited for scenarios with limited sample sizes and adeptly handles a mixture of I(0) and I(1) data. Additionally, the ARDL model is advantageous due to its simplicity in implementation and interpretation, as it involves a single-equation setup. Furthermore, the flexibility of the ARDL model allows for different lag lengths to be assigned to individual variables as they enter the model. Fundamentally, our analysis aims to explore the potential long-term relationships among the studied variables through the estimation of the conditional ARDL model, as illustrated in Equation (2) below:

$$\begin{aligned}\Delta lnAE_t = {} & \alpha_0 + \Omega_1 lnAE_{t-1} + \Omega_2 lnRF_{t-1} + \Omega_3 lnAGP_{t-1} + \Omega_4 lnEXR_{t-1} + \Omega_5 DI_{t-1} + \Omega_6 lnIQ_{t-1} + \Omega_7 FDI_{t-1} \\ & + \sum_{i=1}^{p} \phi_1 \Delta lnAE_{t-i} + \sum_{i=1}^{q} \phi_2 \Delta lnRF_{t-i} + \sum_{i=1}^{q} \phi_3 \Delta lnAGP_{t-i} + \sum_{i=1}^{q} \phi_4 \Delta lnEXR_{t-i} + \sum_{i=1}^{q} \phi_5 \Delta DI_{t-i} \\ & + \sum_{i=1}^{q} \phi_6 \Delta lnIQ_{t-i} + \sum_{i=1}^{q} \phi_7 \Delta FDI_{t-i} + \varepsilon_t\end{aligned} \tag{2}$$

where α_0 stands for the constant term, Ω and ϕ symbolizes the long- and short-run coefficients, respectively, *i* refers to the lagged values, Δ indicates the first difference, and *p* and *q* exemplify the optimal lag lengths of the variables.

To begin, we apply the ordinary least squares (OLS) regression technique to assess Equation (2), intending to identify long-term cointegration relationships among the key variables. Hence, a crucial aspect of the ARDL approach involves ascertaining the long-run linkages between the variables through the bounds test F-statistic. The null hypothesis, denoted as $H_0 : \Omega_1 = \Omega_2 = \Omega_3 = \Omega_4 = \Omega_5 = \Omega_6 = \Omega_7 = 0$, posits no cointegration, while the alternative hypothesis suggests otherwise $H_1 : \Omega_1 \neq \Omega_2 \neq \Omega_3 \neq \Omega_4 \neq \Omega_5 \neq \Omega_6 / = \Omega_7 \neq 0$. The decision to accept or reject the null hypothesis hinges on comparing the calculated F-statistic with critical values corresponding to the lower bound I(0) and the upper bound I(1). Typically, three potential outcomes arise: firstly, if the F-statistic surpasses the upper bound, the null hypothesis of no cointegration is refuted; secondly, if the F-statistic falls below the lower bound, the null hypothesis is retained; thirdly, if the F-statistic falls within the bounds, determining the presence of cointegration remains inconclusive. Following the cointegration analysis outlined in Equation (2), we explore the short-run dynamics between the predictors and dependent variables utilizing error correction models (ECM). In these models, the symbol η represents the coefficient linked to the error correction term (ECT), allowing Equations (3) to be reinterpreted within an error correction framework as follows:

$$\begin{aligned}\Delta lnAE_t = \alpha_0 + \sum_{i=1}^{p} \phi_1 \Delta lnAE_{t-i} + \sum_{i=1}^{q} \phi_2 \Delta lnRF_{t-i} + \sum_{i=1}^{q} \phi_3 \Delta lnAGP_{t-i} + \sum_{i=1}^{q} \phi_4 \Delta lnEXR_{t-i} + \sum_{i=1}^{q} \phi_5 \Delta DI_{t-i} \\ + \sum_{i=1}^{q} \phi_6 \Delta lnIQ_{t-i} + \sum_{i=1}^{q} \phi_7 \Delta FDI_{t-i} + \eta ECT_{t-1} + \varepsilon_t\end{aligned} \tag{3}$$

4. Empirical results and discussion

4.1. Summary statistics

Table 2 illustrates the descriptive summary of the series along with the correlation analysis of the variables. In Segment A, key statistics such as average, maximum, minimum, and standard deviation are depicted. Notably, the agricultural exports indicator exhibits the highest mean (5.138) and maximum value (5.727). Although institutional quality records the lowest average (-0.029), domestic investment demonstrates the smallest minimum value (-26.31). Moreover, domestic investment demonstrates the highest standard deviation (9.931), indicating considerable variability. However, rainfall data points exhibit a lower standard deviation (0.041), which suggests minimal variability around the mean. Additionally, the data distribution exhibits a mild rightward skew, with the exceptions being agricultural production, exchange rates, and domestic investments. As the Jarque–Bera statistic indicates, the statistics, corroborated by probabilities surpassing the conventional 0.05 significance level, do not provide grounds to refute the normality of the variable distributions. Nevertheless, Segment B highlights the correlation between the variables. Notably, rainfall, exchange rates, domestic investment, and FDI display

Table 2. Descriptive statistics and correlation analysis.

	lnAE	lnRF	lnAGP	lnEXR	DI	lnIQ	FDI
Segment A: Descriptive statistics							
Mean	5.138	2.438	5.439	4.073	3.845	−0.029	1.795
Maximum	5.727	2.542	5.645	4.499	25.610	0.318	6.580
Minimum	4.605	2.362	5.075	3.242	−26.31	−0.301	−0.12
Std. Dev.	0.327	0.041	0.152	0.326	9.931	0.275	2.300
Skewness	0.511	0.501	−0.619	−0.723	−0.658	0.159	0.864
Kurtosis	2.361	3.752	2.581	2.688	4.804	1.233	2.199
Jarque-Bera	1.696	1.833	1.997	2.553	5.821	3.758	4.232
Probability	0.428	0.399	0.368	0.278	0.054	0.152	0.120
Observations	28	28	28	28	28	28	28
Segment B: Pairwise correlation							
lnAE	1.000						
lnRF	0.488	1.000					
lnAGP	−0.252	−0.097	1.000				
lnEXR	0.616	0.313	−0.069	1.000			
DI	0.567	0.206	−0.345	0.609	1.000		
lnIQ	−0.571	−0.245	0.402	−0.589	−0.389	1.000	
FDI	0.860	0.411	−0.382	0.643	0.574	−0.775	1.000

Table 3. Unit root tests.

ADF Unit root test				
	Level		At first difference	
Variables	Intercept	Intercept with trend	Intercept	Intercept with trend
lnAE	−1.008	−2.572	−7.127***	−6.934***
lnRF	−4.354***	−5.718***	−6.601***	−6.450***
lnAGP	−3.958***	−4.010**	−8.173***	−8.095***
lnEXR	−2.896*	−2.811	−5.132***	−5.064***
DI	−3.234**	−5.885***	−7.195***	−7.037***
lnIQ	−1.375	−2.666	−3.613**	−3.187
FDI	0.136	−1.412	−1.661	−5.363***
PP Unit root test				
	Level		At first difference	
Variables	Intercept	Intercept with trend	Intercept	Intercept with trend
lnAE	−0.732	−2.535	−7.285***	−7.082***
lnRF	−4.361***	−5.716***	−16.859***	−17.182***
lnAGP	−3.954***	−4.008**	−10.503***	−13.658***
lnEXR	−2.811*	−2.811	−5.121***	−5.054***
DI	−3.118**	−5.893***	−26.688***	−26.393***
lnIQ	−1.379	−1.848	−3.283**	−3.160
FDI	1.243	−2.004	−6.621***	−13.919***

Note. *, **, *** represent significance at 10%, 5% and 1%, respectively.

positive associations with agricultural exports, whereas crop production and institutional quality exhibit negative correlations.

4.2. Unit root tests

To effectively implement the ARDL cointegration technique, it is crucial to ensure the stationarity of variables to prevent biased outcomes (Abdi et al., 2024b). The initial step involves analyzing the time-series data to determine the integration order of the series. This was accomplished by employing various unit root tests, including the Augmented Dickey-Fuller (ADF) and Philips–Peron (PP) tests. The null hypothesis (H_0) of both tests posits the presence of a unit root in the series, while the alternative hypothesis (H_1) suggests stationarity. As depicted in Table 3, the results indicate that most series exhibit a unit root at the level, but they are all stationary at I(1). This proposes the applicability of the ARDL technique in this study, as it can be utilized regardless of whether the variables are stationary at I(0), I(1), or a combination of both.

4.3. Bounds test

Once the stationarity of the variables at different orders of integration is found and the optimal lag length is determined, the next step is to test for cointegration to ascertain whether the relevant variables exhibit long-run cointegration. The bounds testing approach was adopted for this purpose to ascertain the long-run cointegration among the series. Table 4 presents the results of the F-bounds cointegration test. The model outcomes indicate that the estimated F-statistic is 5.339, exceeding the upper bound critical value at the 5% significance level. This proposes the presence of a long-run cointegration linkage among the variables.

4.4. Long-run and short-run results

The study conducted estimations of the long-run and short-run coefficients subsequent to verifying cointegration relationships among the variables. Utilizing the ARDL technique, Table 5 showcases the long-run elasticities of the coefficients. Notably, the findings reveal a robust connection between the explanatory and dependent variables, all of which exhibit statistical significance at the 1% and 5% thresholds, except agricultural production. More specifically, the analysis reveals a positive impact of rainfall on long-run agricultural exports in Somalia. Interpretively, a 1% rise in average rainfall corresponds to a 0.916% surge in agricultural exports. The significant favorable relationship between rainfall

Table 4. F-bounds test.

			Bounds test critical values		
			k = 6		
Model	F-statistic	Signif	I(0)	I(1)	Decision
lnAE=*f*(lnRF, lnAGP, lnEXR, DI, lnIQ, FDI)	5.339	1%	3.976	5.691	Cointegration
		5%	2.794	4.148	
		10%	2.334	3.515	

Note. The critical values, at the 1%, 5%, and 10% significance levels, are based on Narayan (2005).

Table 5. Long-run elasticities.

Variable	Coefficient	Std. Error	t-Statistic
lnRF	0.916***	0.197	4.635
lnAGP	−0.133	0.096	−1.384
lnEXR	0.352***	0.102	3.437
DI	−0.012**	0.004	−3.073
lnIQ	0.359**	0.136	2.644
FDI	0.092***	0.016	5.520

and agricultural exports suggests that agricultural productivity is highly sensitive to climatic conditions, which directly influences export volumes. This indicates that agricultural exports in Somalia may remain vulnerable to climate variability, and their performance is closely tied to favorable weather patterns. Conversely, our long-run results suggest a negative correlation between crop production and agricultural exports in Somalia, albeit lacking statistical significance at the 5% level.

Moreover, the long-run analysis reveals that the exchange rate coefficient is favorable for agricultural exports. This means a percentage increase in the exchange rate corresponds to a 0.352% enhancement in agricultural exports over the long-run. This implies that currency depreciation positively influences Somalia's agricultural exports, as it enhances the competitiveness of Somali products in global markets. A weaker Somali shilling makes agricultural exports more affordable to international buyers, which leads to increased demand and higher export volumes. This suggests that agricultural exporters benefit significantly when the domestic currency depreciates, as it improves their market position and boosts foreign exchange earnings. Conversely, the long-run findings indicate a negative relationship between domestic investment and agricultural exports in Somalia. Interpretively, a one percentage point increase in domestic investment yields a 0.012% decrease in Somalia's agricultural exports. Although small, the observed negative relationship between domestic investment and agricultural exports raises important questions about the alignment between domestic investments and export-enhancing activities. It implies that domestic investment may not be directly fueling agricultural export growth, which could signal inefficiencies or a lack of focus on export-driven agricultural production.

Another striking result from the study is the positive impact of institutional quality on agricultural exports in the long-run. This implies that a 1% improvement in institutional quality results in a 0.359% increase in Somalia's agricultural exports. Additionally, the constructive and significant impact of institutional quality on agricultural exports highlights the importance of stable and transparent institutions in supporting agricultural trade. Strong institutional frameworks appear to enhance the export capabilities of the agricultural sector, which implies that countries with improved governance systems are likely to experience more robust export growth. Similarly, FDI exhibits a significant positive effect on agricultural exports in the long-run. This can be interpreted as a percentage increase in FDI inflows corresponding to a 0.092% rise in Somalia's agricultural exports. This positive linkage demonstrates the important role that external capital plays in expanding export capacity. FDI appears to not only boost production but also help integrate Somalia into global markets, which indicates that agricultural exports benefit from both technological transfer and access to international networks.

In addition to examining the long-run dynamics, our analysis assesses the short-run estimates of the explanatory variables alongside the ECT, as presented in Table 6. The findings suggest that, in the short-run, rainfall and crop production do not exert statistically significant effects on agricultural exports in Somalia. However, institutional quality, domestic investment, FDI, and exchange rates significantly influence agricultural exports in the short-run. This implies that a percentage change in the current and previous year's exchange rates decreases agricultural exports by 0.993% and 0.973%, respectively. Conversely, a

Table 6. Short-run elasticities and the error correction model.

Variable	Coefficient	Std. Error	t-Statistic
Constant	1.986***	0.548	3.623
$\Delta lnAE_{t-1}$	−0.282	0.245	−1.151
$\Delta lnRF_{t-1}$	−0.449	0.692	−0.649
$\Delta lnAGP$	0.000	0.196	0.001
$\Delta lnAGP_{t-1}$	−0.184	0.233	−0.788
$\Delta lnEXR$	−0.993**	0.400	−2.485
$\Delta lnEXR_{t-1}$	−0.973*	0.488	−1.993
$\Delta lnIQ$	1.114**	0.408	2.732
$\Delta lnIQ_{t-2}$	1.010**	0.420	2.406
ΔDI_{t-1}	0.011**	0.005	2.126
ΔDI_{t-2}	0.005	0.004	1.338
ΔFDI	0.175**	0.062	2.826
ΔFDI_{t-1}	0.086	0.052	1.649
ΔFDI_{t-2}	0.042	0.042	0.984
ECT_{t-1}	−0.924***	0.264	−3.502
R^2	0.688		

Table 7. Diagnostic tests.

Test type	Statistic
Serial correlation – LM test	5.488
	[0.139]
Heteroscedasticity – BPG test	20.584
	[0.3009]
Normality test – Jarque-Bera	0.388
	[0.823]
Ramsey RESET test	0.044
	[0.966]

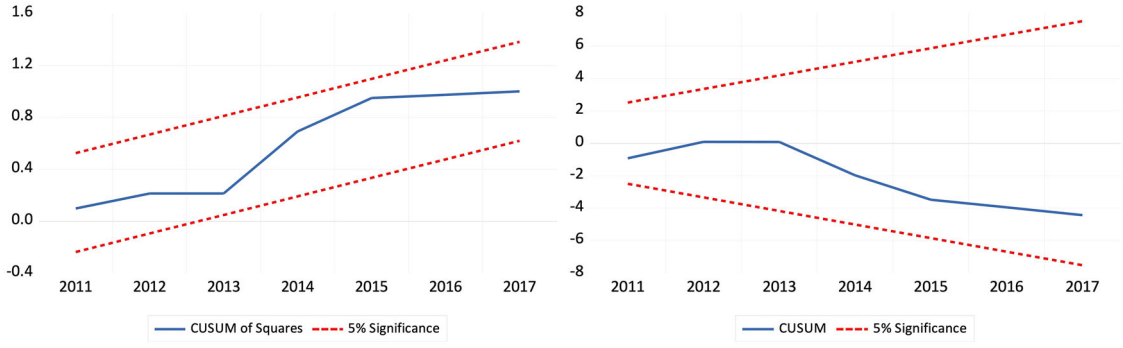

Figure 2. CUSUM and CUSUM of Squarse tests.

percentage change in the current and previous year's institutional quality boosts agricultural exports in the short-run by 1.114% and 1.010%, respectively. Similarly, a growth in domestic investments in Somalia enhances agricultural exports in the short-run by 0.011%. Also, the country's FDI inflows contribute to agricultural exports in the short-run by 0.175%. Moreover, the estimated value of the ECT in Table 6 exhibits a statistically significant negative coefficient of -0.924. This indicates that the long-run equilibrium adjusts at a yearly rate of 92.4% in response to short-run shocks causing disequilibrium. Additionally, the R^2 value of 0.688 signifies that those variations in rainfall, crop production, exchange rate, domestic investment, and FDI jointly explain 68.8% of the variability in agricultural exports in Somalia.

Residual diagnostic tests were conducted to ensure the robustness and soundness of the model, as delineated in Table 7. The empirical findings affirm that the model passed the diagnostic examinations, as evidenced by the normal distribution of the series and the absence of serial correlation, heteroscedasticity, or functional form misspecification. Additionally, stability tests were employed using the cumulative sum of recursive residuals (CUSUM) and CUSUM of squares tests for estimated parameters, as depicted in Figure 2. The graphical depiction of these tests illustrates that both the CUSUM and CUSUM of squares fall within the critical boundaries at the 5% significance level for stability testing. This indicates that the model outcomes are stable and dependable, thereby providing a reliable basis for policymaking.

Table 8. Granger causality outcomes.

Null Hypothesis:	Obs	F-Statistic	Prob
lnRF→lnAE	27	2.214	0.150
lnAE→lnRF		6.201	0.020
lnAGP→ lnAE	27	0.061	0.806
lnAE→lnAGP		1.072	0.311
lnEXR→ lnAE	27	4.773	0.039
lnAE→lnEXR		0.002	0.963
DI→lnAE	27	0.254	0.619
lnAE→DI		13.817	0.001
lnIQ→lnAE	27	4.300	0.049
lnAE→lnIQ		0.099	0.756
FDI→lnAE	27	4.296	0.049
lnAE→FDI		0.945	0.341

Notes: → symbolize that variable 'X' does not Granger cause variable 'Y'.

4.5. Causality analysis

To identify if there is a causality between variables, we conducted a Granger causality, as shown in Table 8. The findings suggest that the null hypothesis of no causality is rejected if the p-value is less than 0.05. The causality direction from rainfall to agricultural exports with an insignificant p-value indicates that rainfall does not Granger-cause agricultural exports. In contrast, the null hypothesis that agricultural exports do not Granger-cause rainfall is rejected at the 5% threshold level. This suggests a unidirectional causality from agricultural exports to rainfall in Somalia. In addition, the Granger causality tests reveal no statistical evidence to support the causal linkage between agricultural production and exports, indicating other factors may be influencing the export dynamics. There is no evidence of causality from domestic investments to agricultural exports because of the insignificant p-values, whereas agricultural exports to domestic investments are significant at the 1% threshold level. This implies that increases in agricultural exports could forecast growth in domestic investments, which demonstrates the potential of agricultural exports as an indicator for mobilizing domestic investments.

Similarly, the null hypothesis that exchange rates do not Granger cause agricultural exports is rejected at the 5% significance level, although the reverse causality is not significant. This suggests that exchange rate policies could be pivotal in influencing the agricultural export sector. Therefore, policymakers should consider the exchange rate's predictive power when strategizing for the agricultural sector's growth. Furthermore, institutional quality appears to Granger cause of agricultural exports at the 5% level but not vice versa. This proposes that enhancements in governance could potentially bolster agricultural export performance in Somalia. On the FDI front, the finding is that FDI Granger causes agricultural exports, which is significant at the 5% level, but the reverse is not significant. This suggests that policies encouraging FDI could have a positive effect on agricultural exports.

4.6. Discussion of the results

In the long-run, several factors have been found to impact agricultural exports. Higher levels of rainfall positively affect agricultural exports by increasing crop yields, as rainfall provides the necessary water supply for crops. This positive relationship is consistent with previous research by Abdi et al. (2023b), who found that rainfall positively affects agricultural production. However, it contradicts the findings of Ndamani & Watanabe (2015) and Ciccone & Ismailov (2022). Both the long-run and short-run results are inconsequential for agricultural production, indicating that it does not significantly impact the availability of cereal crops for export. This contradicts the findings of Abdi et al. (2024a), who found a positive linkage between crop production and export volumes in Somalia. This result can be attributed to several factors unique to Somalia's agricultural sector. High post-harvest losses, driven by inadequate storage and transportation infrastructure, significantly reduce the production volume available for export. Additionally, prioritizing domestic consumption due to food security concerns often diverts agricultural output from export markets. Furthermore, limited market access and underdeveloped export infrastructure further weaken the relationship between production and exports. Moreover, the findings of the study suggest that currency depreciation can enhance the competitiveness of agricultural exports in Somalia. A depreciated currency makes agricultural products more affordable to international buyers, stimulating demand and potentially increasing export volumes. This

finding aligns with the study by Wang & Barrett (2007) and Ali (2020), who found a positive relationship between the exchange rate and agricultural exports. In the short-run, currency appreciation can hinder agricultural export performance by reducing the competitiveness of agricultural products and limiting export volumes. Comparably, Kandilov (2008) found that exchange rate fluctuations significantly impact agricultural exports from developing countries.

Although the adverse long-run effects, increased domestic investments positively impact agricultural export performance in the short-run. Higher levels of domestic investment may divert resources from export-oriented activities or prioritize domestic consumption, limiting the availability of agricultural products for export. However, increased investments improve productivity, technology adoption, and infrastructure development, enhancing the availability and quality of agricultural products for export. Our long- and short-run results suggested that institutional quality, specifically law and order, positively affects agricultural exports. When institutions ensure law and order, they create a secure environment for agricultural activities, including production, storage, transportation, and trade. This reliability encourages investment, reduces transaction costs, and facilitates smooth trade, which increases Somalia's agricultural export performance. This observation is in line with the findings of Uduma et al. (2023), Farooq et al. (2019), and Bojnec et al. (2014), who also observed that institutional quality significantly increases agricultural exports across different countries. In addition, FDI inflows enhance long- and short-run agricultural export performance in Somalia. This finding is consistent with Hassan & Abd-Elmotaal (2021) and Alnafissa et al. (2022), who found a positive association between FDI and agricultural exports. FDI brings in capital, technology, and expertise, which enhance productivity and competitiveness in international markets (Abdi et al., 2024b).

5. Conclusion and policy recommendations

Agricultural exports are a crucial component of economic growth, particularly in Somalia, where the sector significantly contributes to the nation's GDP and employment. Despite its acknowledged importance, the comprehensive determinants of agricultural export performance have not been exhaustively explored in the existing literature. Thus, this study investigates the determinants of agricultural exports, including rainfall, agricultural output, exchange rates, domestic investments, institutional quality, and FDI inflows in Somalia from 1985 to 2017. To ensure robust regression analysis and avoid spurious results, the ADF and PP tests were utilized to determine the integration levels of the variables, revealing a mixed stationarity, i.e., I(0) and I(1). Subsequently, the study applied the bounds testing approach to validate the long-run cointegration among the variables. To estimate the long-run and short-run coefficients, the study utilized the ARDL model and the Granger causality test to ascertain directional influences. The model satisfied all stability and diagnostic checks, which affirms its reliability.

The results indicate that precipitation positively impacts long-run agricultural exports in Somalia, which indicates its vital role in sustainable agricultural productivity. However, the influence of agricultural production on exports proves to be minimal, challenging the assumption that higher production directly translates to increased exports in both the short- and long-run. The analysis further reveals that while long-run economic benefits are seen from currency depreciation through enhancing export competitiveness, currency appreciation conversely dampens exports in the short-run. In addition, short-run domestic investments are found to boost exports, yet this positive relationship does not hold in the long-run, which suggests complexities in investment strategies for agriculture. Notably, the institutional quality and FDI inflows consistently promote agricultural exports in both the short- and long-run, indicating their importance in enhancing Somalia's export sector. Granger causality tests underline one-directional causation from exchange rates, institutional quality, and FDI inflows towards agricultural exports, which highlights the proactive role of these factors in shaping export outcomes. In contrast, agricultural exports Granger cause rainfall patterns and domestic investments.

In light of these findings, the study provides several policy suggestions. Given precipitation's positive impact on agricultural exports, investing in rainwater harvesting and advanced irrigation infrastructure can mitigate the risks of erratic rainfall, ensuring a consistent water supply for agriculture. Besides, since higher production alone does not guarantee increased exports, policies should encourage the development of value-added agricultural products and diversify export markets to enhance competitiveness and

export volumes. Moreover, to capitalize on the long-term benefits of currency depreciation for export competitiveness, the exchange rate should be strategically managed to prevent excessive short-term fluctuations that could harm export potential. While short-term domestic investments boost exports, focusing on sustainable, long-term investment strategies is essential. This includes fostering public-private partnerships and investing in agricultural research and development. Finally, strengthening institutional frameworks and creating favorable conditions for FDI inflows can significantly enhance the agricultural sector's export capacity. Simplifying regulations and ensuring transparent processes will attract more FDI into agriculture.

Authors' contributions

Abdikafi Hassan Abdi: Conceptualization, methodology, data collection and analyzing, writing, improving and editing the original draft. Amir Mohamud Mohamed: contributed to the introduction and literature review.

Ethical approval

This study follows all ethical practices during writing. We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

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Data availability statement

The datasets used and/or analyzed during the current study are available from the author on reasonable request.

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