Determinants of Sugarcane Production in Tanzania: 1980 – 2023

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Abstract: The sugar industry plays a crucial role in Tanzania's economy, but it is currently facing several challenges such as a decline in production, increasing input costs, and competition from imported sugar. This research aims to investigate the factors that determine sugarcane production in Tanzania from 1980 to 2023. Specifically, the study focuses on examining the impact of variability, extension services, and pest management on sugar cane production. To achieve this, the study utilizes the Cobb-Douglas model and time series analysis to analyze various factors including rainfall, imported refined sugar, area harvested, and the availability of sugarcane seeds. The results of the analysis reveal that rainfall has a significant effect on sugar cane production, highlighting the importance of climate stability and the implementation of effective irrigation strategies. Interestingly, the study finds that imported refined sugar does not have a significant impact on production. This suggests that there is a need for stricter regulations to control the importation of sugar and promote domestic production. Additionally, the study highlights the importance of high-quality sugarcane seeds, indicating the need for efficient seed supply chains to ensure optimal production. The policy implications of this research include the investment in irrigation systems, the development of climate resilience strategies, and support for small-scale sugarcane farmers. By controlling sugar imports, domestic production can be stimulated, leading to increased economic growth and food security in Tanzania. It is important to note that this study acknowledges the limitations of the available data and suggests that future research should explore additional variables such as soil quality and pest management. By considering these factors, policymakers and stakeholders can gain valuable insights to enhance the sustainability and productivity of Tanzania's sugar industry, ultimately contributing to the country's economic growth and food security.

Keywords: *Sugarcane Production, Tanzania Agriculture, Climate Variability, Cobb-Douglas Model, Irrigation and Input Management.*

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I. INTRODUCTION

Tanzania's economic growth experienced a relatively stable period from the mid-1960s to the mid-1970s, as stated by the World Bank (1994). During this time, the country's real GDP increased by nearly four percent, while agricultural growth was just over two percent. However, the economic performance weakened in the latter half of the 1970s due to both external shocks and increased state intervention in the economy, including widespread nationalization. Between 1976 and 1980, real GDP only rose by slightly over two percent, with agricultural growth being less than one percent. Nevertheless, there was a recovery in Tanzania's economy starting from the mid-1980s. This recovery was facilitated by the implementation of the World Bank-sponsored Economic Recovery Program (ERP) in 1986, which gradually introduced liberalization policies. As a result, between 1986 and 1992, both real GDP and agriculture experienced growth rates exceeding four percent. It is worth noting that sugar production is a significant industry worldwide, with over 100 countries producing sugar derived from sugar cane and sugar beet. The majority, approximately 79%, of global sugar production comes from sugar cane, while the remaining balance is sourced from sugar beet, primarily cultivated in the temperate zones of the northern hemisphere (Otieno et al., 2003).

According to COMTRADE data for the period between 2004 and 2013, the leading exporters of sugar in terms of value were Brazil (23.1%), France (7.0%), Thailand (5.8%), and Germany (5.2%). These countries played a significant role in the global sugar trade during that period.Tanzania's sugar industry faces various challenges due to the complex components of the current world sugar market. Products and by-products derived from sugarcane, such as sugar crystals, sugar syrup, molasses, bagasse, and filter scum, have multiple uses. However, countries like the European Union (EU), Japan, and the United States (US) are known for distorting the sugar market with protectionist measures and subsidies for their producers. This leads to distorted price signals for consumers and restrictive import policies, creating obstacles for Tanzania's sugar industry to compete effectively in the global market (Elobeid & Beghin, 2006; Mitchell, 2004).

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Between 1998 and 2001, all four companies referenced in the study conducted by Sulle et al. (2014) underwent a process of privatization. Nevertheless, the government retains a 25% stake in two of these enterprises, specifically KSCL and TPC. KSCL is predominantly owned by the South African corporation Illovo Sugar, a subsidiary of Associated British Foods. Conversely, TPC is now chiefly controlled by the Mauritian sugar conglomerate Alteo, as delineated by Sulle et al. (2014). Another Tanzanian entity, Super Group, acquired Mtibwa Sugar Estates, which concurrently possesses Kagera Sugar (Sulle et al., 2014). Since the privatization of these firms, the sugar industry has witnessed considerable advancement in terms of capital investments, the expansion of cane cultivation areas, and revenue accrued for the Treasury. The total sugar production from these four companies surged from 112,903 tons in 1995/96 to an apex of 304,135 tons in 2010/11. Despite these accomplishments, Tanzania continues to grapple with an annual sugar deficit estimated between 220,000 and 300,000 tons, as reported by Sulle et al. (2014). According to Sulle et al. (2014), the sugar industry in Tanzania is governed by the Sugar Board of Tanzania (SBT) under the auspices of the Ministry of Agriculture, Food Security, and Cooperatives, in accordance with the Tanzania Sugar Industry Act of 2001. The SBT's operations are overseen by a board of directors comprising representatives from the Tanzania Sugar Producers' Association (TSPA), the Tanzania Sugarcane Growers Association (TASGA), the consumer sector, the government, and the industry itself.

Furthermore, in light of escalating tensions between large and small growers' associations, a new entity known as the Council of Cane Growers Association has been established (Sulle et al., 2014). Kilombero Sugar Company (KSCL) operates two irrigated estates spanning a combined area of 8,022 hectares, alongside two processing facilities situated in Kidatu within the Kilombero District. As the preeminent sugar producer in Tanzania, KSCL produced 116,495 metric tons of sugar during the 2013/14 period, a decline from the 126,737 metric tons generated in 2012/13. This output fell short of the company's annual target of 200,000 metric tons as stipulated in its agreement with the government, as reported by Sulle et al. (2014).

Currently, the sugar industry in Tanzania is one of the largest agro-processing industries. It contributes around 35 percent of the gross output of the food-manufacturing sector and approximately 7 to 10 percent of the total manufacturing value added NDC (1992). However, the industry has encountered significant challenges over the past decade. These challenges include a decline in production and productivity, rising production costs due to increased prices of inputs such as fertilizer, pesticides, and farm implements, as well as falling export prices and increased competition from cheap, imported sugar Senkondo et al. (1991).

Despite its strategic importance, sugarcane production in Tanzania faces various obstacles, resulting in a substantial gap between production and national demand. Existing literature presents conflicting views on the main factors influencing sugarcane production by small-scale farmers. Some scholars emphasize factors like weather variability, climate change, extension services, and support from sugarcane production companies, while others focus on issues such as pest and disease management. However, there is no consensus on the primary drivers of sugarcane production, creating a critical knowledge gap. Although some studies have explored different aspects affecting sugarcane production, they often overlook the impact of crucial factors like weather variability, climate change, extension services, and pest and disease management. This incomplete perspective highlights the need for a targeted investigation to gain a comprehensive understanding of how these factors affect sugarcane production by small-scale farmers in Tanzania. Furthermore, there is a scarcity of recent research addressing this gap, indicating the necessity for updated insights into the core determinants of sugarcane production. The primary goal is to assess the factors that contribute to sugarcane production in Tanzania between 1980 and 2023, with a particular focus on the variables outlined in the model as the main objective and by investigate the impact of weather variability and climate change on sugarcane production in Tanzania from 1980 to 2023 as well as establish the correlation between sugarcane production, seed quality, harvested area, rainfall, and imported sugar in Tanzania.

II. OVERVIEW OF AGRICULTURE SUGARCANE SECTOR

The agriculture sector of sugarcane is a significant industry worldwide, with its cultivation being widespread due to its various applications and benefits. Sugarcane plays a crucial role in global sugar production, contributing to approximately 80% of the total output (Rumánková & Smutka, 2013). In addition to sugar, sugarcane is utilized in the production of alcohol, ethanol for fuel, bagasse for paper products, and press mud as a valuable source of organic matter and nutrients for crop cultivation (Waghmare & Khan, 2021; Arumugam et al., 2014). Major sugarcane-producing countries include Brazil, India, China, Pakistan, and Thailand, as reported by the FAO Food and Agriculture Organization of the United Nations (2023).

Sub-Saharan African nations collectively account for approximately 5% of the global sugar production, with six specific countries - South Africa, Sudan, Eswatini, Zambia, Mauritius, and Kenya - contributing to over 50% of the sugarcane production in the region (Ambetsa et al., 2020). Despite the relatively modest share in global sugar production, SSA countries are recognized for their significant production potential due to factors such as lower production costs, favorable growth rates, efficient sucrose conversion, and the presence of optimal growing conditions including undulating topography, clay soils, access to water for irrigation, and favorable weather conditions (Hess et al., 2016).

Despite the current limited production levels, Tanzania stands out as a country with the capacity to enhance its sugar exports to other African nations by an estimated $11.9 million annually, given the prevailing tariff conditions across the continent (International Trade Centre, 2021).Africa accounts

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for approximately 5% of the global sugar production, with a similar percentage for exports but a higher rate for imports, making the continent a net importer. Sandrey & Vink (2007) highlighted that everything but Arms (EBA) concession resulted in both winners and losers among African sugar producers. The higher-cost producers are expected to be significantly impacted and may even exit the sugar sector entirely. However, the potential markets for their sugar are crucial for the sustainability of these companies (Bruntrup, 2006). Recently, Tanzania's ministries (Industry and Trade, Finance, and East African Cooperation) along with the Sugar Board of Tanzania (SBT) have commissioned a study to evaluate the sugar market trends and export performance (URT, 2013).

The history of the Tanzania Sugar Industry can be traced back to the 1920s and 30s when smallholder cane juggery production began in the Kilombero and Mtibwa valleys (SBT, 2014). The production of granular sugar started in 1931 at Arusha Chini by the Tanganyika Planting Company, and later expanded to Karangai-Bukoba and Turiani Morogoro region. Following Tanzania's independence in 1961, the government implemented strategies to enhance sugar production on a commercial scale. This led to the establishment of the Msolwa sugar factory in Kilombero. In 1967, the government nationalized private firms, resulting in the National Food Corporation (NAFCO) taking charge of the sugar sector. This move led to the establishment of the Mtibwa Sugar Estates in 1973 and the Ruembe Sugar Factory (Kilombero II) in 1976. In 1978, the small Kagera sugar plant was damaged during a war but was later reconstructed into a large sugar plant commissioned in 1982 (SBT, 2014).

In 1974, the government replaced NAFCO with the Sugar Development Corporation (SUDECO) to oversee the development of the sugar industry and manage sugar distribution, exportation, and importation (SBT, 2014). In 1992, the sugar trade was liberalized, and the privatization of sugar companies began. Kilombero was the first to be privatized in 1997/98, followed by Mtibwa in 1998/99, TPC in 2000/01, and finally Kagera in 2001/2002 (SBT, 2014). The Tanzania Sugar Industry Act of 2001 established the Sugar Board of Tanzania (SBT) as the regulatory body for the sugar industry. The SBT operates under the Ministry of Agriculture, Food Security, and Cooperatives, and its activities are overseen by a board of directors representing various stakeholders, including the Tanzania Sugar Producers' Association (TSPA), the Tanzania Sugarcane Growers Association (TASGA), the consumer sector, the government, and the industry (SBT, 2014).

Following the escalation of tensions between large and small growers' associations, a new entity known as the Council of Cane Growers Association has been established (SBT 2014). The industry has experienced notable advancements in terms of capital investments, cane cultivation area, and revenue generation for the Treasury since the privatization process carried out between 1998 and 2001 (SBT, 2014). The combined production output of the four companies surged from 112,903 tons of sugar in 1995/96, before privatization, to a peak of 304,135 tons in 2010/11 (SBT, 2014). The primary purpose of sugarcane cultivation in Tanzania is to supply raw materials to the local sugar factories, aiming to bridge the gap between domestic sugar demand and supply. In order to reduce the need for sugar imports, the government has set a target to raise local sugar production from 320,000 tons to 420,000 tons annually (Masare, 2018) SBT (Sugar Board of Tanzania, 2021).

The growth in domestic sugar production is intricately linked to the expansion of domestic sugarcane production, as the sugar factories in Tanzania heavily rely on local sugarcane supply (Bélair, 2021). The sugar sector in Tanzania is tightly regulated, with only four operational sugar companies - Kilombero Sugar Company Limited (KSCL), Mtibwa Sugar Estate (MSE), Kagera Sugar Limited (KSL), and Tanganyika Planting Company (TPC) Andreoni et al. (2020). These companies are shielded from competition, which diminishes their incentive to invest in modern technologies (Eriksen, 2018). Consequently, the growth of sugarcane production remains the key determinant of sugar production in Tanzania, despite the sector's low levels of technology and productivity (Bélair, 2021).

The Tanzanian government has implemented various measures to encourage local sugar-producing companies to boost their production. Some of these measures, such as strict state control over sugar imports, have led to an increase in sugar import duty from 25% to 35% in 2019, potentially stimulating local sugar production. However, other interventions, like setting price caps for sugar to control domestic prices and occasionally granting sugar import licenses, may deter local sugar producers. Factors such as low land and labor productivity, along with conflicting government interventions, contribute to Tanzania's lower sugarcane production compared to countries like Kenya and South Africa. This raises concerns about the effectiveness of government interventions and the responsiveness of farmers to these measures.

Tanzania's sugar industry has emerged as the largest agro-processing industry in the country. Its origins can be traced back to 1924 when the Tanganyika Planting Company Limited in Moshi initiated its operations. Subsequently, two more sugar companies were established in Kilombero and Mtibwa in 1961 and 1962 respectively. Over time, the industry has expanded to include a total of five sugar producers in the country. According to available data, sugar production in Tanzania has witnessed a remarkable growth, surging from an initial output of 2,000 metric tons to over 300,000 metric tons. For the past 15 years, Tanzania has consistently ranked among the top 12 sugar producers in Sub-Saharan Africa (SSA).

However, recent FAOSTAT data indicates that the rate of production increase has been relatively smaller in Tanzania, as well as in other African countries like Madagascar, South Africa, and Zimbabwe. Sugarcane holds immense significance and plays a pivotal role in various aspects of daily life, making it a vital crop for both domestic and industrial purposes (Owino, 2019). It stands as a fundamental industrial crop, thriving in subtropical and

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tropical regions worldwide (Zulu et al., 2019). The production of sugarcane has historically been influenced by a multitude of factors, including financial constraints, weather variability, and inadequate government policies (Machimu & Kayunza, 2019). However, Achandi (2019) highlights pests and diseases as the primary obstacle faced by small-scale sugarcane farmers, whereas Ambetsa et al. (2020) argue that the production of sugarcane is hindered by inadequate extension services and a lack of effective government policy. These contrasting viewpoints regarding the key factors affecting sugarcane production create a complex and confusing situation, emphasizing the need for a comprehensive study with a precise perspective.

Moreover, there are conflicting opinions on the core factors influencing sugarcane production, with each scholar presenting different factors. For example, Sulle (2017) identifies land politics as the central factor, while Owino (2019) emphasizes social and economic factors such as age, gender, and income. On the other hand, Pretty and Bharucha (2018), Rondhi et al. (2020), and Ruml et al. (2021) emphasize the importance of inputs, extension services, and credit. Additionally, Rondhi et al. (2020) and Ruml et al. (2021) consider weather and climatic conditions as critical determinants, whereas Johnny et al. (2019) and Kangwiria & Gichuki (2017) highlight climate change, infrastructure, and land availability as core factors.

Mushi (2015) highlights the significant impact of weather and climatic conditions on sugarcane production and profitability. He points out that harsh weather conditions have contributed to the decrease in sugarcane production in the Morogoro Region, where small-scale farmers heavily rely on annual rainfall for cultivation. Metiso & Tsvakirai (2019) emphasize the importance of providing effective extension services and support to small-scale farmers to boost sugarcane production. Pretty & Bharucha (2018) discuss the benefits of Integrated Pest Management (IPM) as a sustainable approach to pest control, leading to a substantial increase in crop yield. These varying perspectives underscore the complexity of factors influencing sugarcane production, highlighting the need for further research to better understand and improve the situation. The Tanzanian government has implemented initiatives such as Contract Farming (CF) and support services to enhance the peIn the 1990s, the establishment of farmers' associations aimed to encourage direct communication and collaboration, ultimately enhancing the interaction between smallholder sugarcane farmers and the Kilombero Sugar Company Limited (KSCL) to boost sugarcane production (Isager et al., 2018). Performance of smallholder sugarcane farmers in Morogoro (Martiniello, 2021; Mpeta et al., 2017). (Anonymous, 1994), Tanzania, located in East Africa, is well positioned for sugarcane production due to its diverse climatic and weather conditions.

Covering an area of 945,087 km2 and with a population exceeding 27 million people, the majority of whom work in the rural sector (80%), the country offers favorable conditions for agriculture. While high mountain regions may pose some limitations, temperatures are generally not a significant constraint for sugarcane cultivation. Instead, rainfall plays a crucial role in crop production, including sugarcane. Approximately 21% of the country can anticipate a 90% chance of receiving slightly more than 750 mm of rainfall, while only around 3% can expect over 1250 mm. Moreover, one-third of the country, particularly the central plateau, experiences dry conditions with less than 500 mm of annual rainfall.

Evapotranspiration surpasses precipitation in the drier regions for the majority of the year. To address the seasonal shortfall in rainfall, sugarcane farms in Tanzania are strategically located along river valleys to facilitate supplementary irrigation during the appropriate season. Currently, only three regions meet the criteria for sugarcane production: Morogoro (Kilombero & Mtibwa Valleys), Kilimanjaro (under Irrigation Scheme), and Kagera (River Kagera Basin). In Morogoro, there are two prominent sugarcane estates, namely Kilombero Sugar Company and Mtibwa Sugar Estates, which collectively yield an annual output of over 80,000 tons of processed sugar. Plate 1 showcases a sugarcane field in Kilombero. In Kilimanjaro, the Tanganyika Planting Company (TPC) stands as one of the largest sugarcane estates in the country, producing over 35,000 tons of processed sugar each year. On the other hand, the Kagera Sugarcane Estates are relatively small, generating approximately 2,000 tons of processed sugar annually (Anonymous, 1994).

Over the past decade, sugar production in the Kilimanjaro Region has experienced significant fluctuations primarily due to unfavorable socio-economic and environmental conditions. Drought, coupled with inadequate irrigation infrastructure in the sugar estates, played a major role in the substantial decline in sugar production during the 1980s. Within this period, sugar production in the Kilimanjaro Region plummeted from over 40,000 tons in 1983/84 to a mere 26,000 tons in 1989/90. However, during the 1990s, sugar production rebounded in all regions except Kagera, where production figures generally declined. The lower sugar production statistics in Kagera may be attributed to factors other than biological, as sugarcane production remained relatively stable over the years. Non-delivery of processed sugar to the Sugar Development Corporation (SUDECO) go downs in Dar-es-Salaam could be among the contributing factors (Anonymous, 1994). Kilombero Sugar Company Ltd. is situated in Morogoro Region, specifically in the Districts of Kilombero and Kilosa. Kilombero (KI), also known as Msolwa, is located in Kilombero District, while Kilombero (KII), known as Ruembe, is situated in Kilosa District.

Following privatization, Illovo Sugar Limited acquired 75% of Kilombero Sugar Company, with the remaining 25% retained by the Government. The privatization of the company has led to various improvements, including enhancements in estate infrastructures, provision of technical support to outgrowers for clean seed cane resulting in increased cane production and deliveries to the factories. Furthermore, extensive factory expansion has been undertaken, covering areas such as cane unloading stations,

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cane preparation, milling, steam for power generation, pan floor, weighbridges, and instrumentation automation. The company has gained a strong reputation for its support of outgrowers, particularly through improvements in the cane payment system and incentive schemes. (SBT, 2014).

Following privatization and the first phase between 2000 and 2004, TPC Limited made significant investments in rehabilitating its plantation infrastructure, equipment, and buildings. However, in 2004, the company decided to enter an expansion phase, which required the replacement of major equipment such as boilers and generators. This expansion phase involved a much higher capital investment than initially anticipated (SBT, 2014).Mtibwa Sugar Estates Ltd is situated in Turiani Division, approximately 102km north of Morogoro town and 290km from Dar-Es-Salaam. Covering an expansive area of over 6000 hectares, this estate experiences two distinct rainy seasons.

The first, known as the short rains, occurs between October and December, while the second, referred to as the long rains, takes place from March to May. In 1999, the company underwent privatization and was acquired by Tanzania Sugar Industries Limited, a local Tanzanian company. Prior to privatization, Mtibwa Sugar Estates Ltd faced numerous challenges, including a lack of spare parts, inadequate maintenance work, outdated equipment, and subpar cane quality, all of which hindered its performance. However, since the privatization process, significant investments have been made in crucial areas of the factory.

Consequently, these investments have led to a remarkable improvement in the overall efficiency of the estate's operations (SBT, 2014). Kagera Sugar Limited underwent privatization on December 3, 2001, with the Government selling 89.47% of its shares. Prior to privatization, the company was non-operational, with the cane fields being overgrown and the factory abandoned. The main goals of privatization included enhancing the expansion of both local and regional markets, securing access to working capital and necessary investments for modernization, rehabilitation, expansion, and diversification, as well as ensuring continuous operations and increased efficiencies.

Following privatization, the company made significant investments in land preparation equipment such as bulldozers, excavators, tractors, ploughs, and graders. By 2008, around 9000 hectares were already cultivated with cane, and expansion efforts continued at a rate of 1,500 additional hectares per year. Additionally, new cane variDespite the collaborative efforts made by the government and various stakeholders, sugarcane production in the country continues to fall short of meeting the national demand (Mwakalobo & Mbeki, 2019). This situation raises concerns about the lack of a thorough understanding of the key factors affecting sugarcane production and the corresponding solutions. This research aims to bridge this knowledge gap. While previous studies by Isager et al. (2018), Mwakalobo & Mbeki (2019), and Maschimu & Kayunze (2019) have delved into the challenges faced by sugarcane production, they have overlooked crucial factors such as weather variability & climate change, extension services & support from sugarcane production companies, and pest & disease management. This oversight has led to an incomplete and uncertain perspective, underscoring the necessity for a focused study like the current one, which seeks to offer a precise, up-to-date, and accurate understanding of how these factors impact sugarcane production among small-scale farmers. Moreover, Makinde et al. (2018), Pretty & Bharucha (2016), and Kumah (2018) all agree that there is a lack of recent comprehensive studies on the main determinants of sugarcane production by small-scale farmers. Therefore, the purpose of this study is to address this research gap. The adoption of new techniques should be approached by considering factors such as relative advantage and compatibility.

Furthermore, observability plays a crucial role in showcasing the positive outcomes of adopting new practices. In summary, this theory offers a holistic framework for understanding the diffusion of innovative practices among small-scale sugarcane farmers, taking into account factors like perceived benefits, ease of adoption, and learning from peers (Ally & Ngaruko, 2018).eties from Mauritius, South Africa, and Kibaha were introduced and tested (SBT, 2014).

III. LITERATURE REVIEW

Various scholars have proposed theories and models that contribute to the understanding of the production function, which represents the relationship between inputs and output. The production function is typically denoted by the equation Q = f (L, K), where Q represents output, L stands for labor, K represents capital, and f signifies the functional relationship between inputs and output. In the short run, it is assumed that capital is fixed, making labor the only variable factor. To increase output, a firm must therefore increase the amount of labor. Inputs are considered independent factors, while output is viewed as a dependent factor. Consequently, any changes in the inputs can impact the output, leading to the analysis of total factor productivity, which examines the influence of inputs on production. Economists utilize the concept of total factor productivity (TFP) to assess the collective efficiency of all inputs in generating output (Helpman, 2004). This may prompt an inquiry into how one can measure the increased productivity of inputs. The answer to this question hinges on the specific definition of inputs and the careful specification of production relationships or the production function. Several economic models have been developed to expand our understanding of the production function. For instance, Gujarati (2003) employed the Cobb-Douglas production function, a well-known production theory, within the framework of multiple regression models**.**The Cobb Douglas production function, in its stochastic form, may be expressed as:

$$Yi = \beta 1X \beta 2\ 2i\ X \beta 3\ 3i\ eui \quad (1)$$

Where Y = output, X2 = labor input, X3 = capital input, u = stochastic disturbance term e = base of natural logarithm. We can convert nonlinear relationships (equation i) into linear ones (equation ii) so that we can work within the framework

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of the classical linear regression model (Gujarati, 2003). The relationship between output and the two inputs in equation (i) is nonlinear. However, if we log transform this model, we obtain:

$$\ln Y_i = \ln \beta_1 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + u_i \quad (2)$$

$$\ln Y_i = \beta_0 + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + u_i \quad (3)$$

Where $\beta_0 = \ln \beta_1$. Thus written, the model is linear with the parameters β_0, β_2, and β_3 and is therefore a linear regression model. Notice, though, it is nonlinear in the variables Y and X but linear in the logs of these variables. Thus Cobb Douglas production function gives out the relationship that exists between the inputs employed and output, and this simplifies the finding of the main determinants of the sugar cane production in Tanzania. Also note that whenever one has a log–linear regression model involving any number of ariables the coefficient of each of the X variables measures the (partial) elasticity of the dependent variable Y with respect to that variable (Gujarat, 2003). Coelli et al., (1995) cited by Nyanjong et al. (2012) proposed a single stage approach where efficiency is a function of farm specific variables and the random error term, the major assumption made in this approach is that the farm specific variables and the input variables interact between them. It thus enables one to express technical inefficiency effects in terms of various farm-specific variables. Nyanjong et al. (2012) used a parametric stochastic efficiency decomposition approach to measure the economic efficiency indices of sugarcane production in Sony out grower zone.

The methodology employed by Bravo-Ureta & Pinheiro (1997), as referenced by Nyanjong et al. (2012), is an expansion of the economic efficiency estimation procedure proposed by Kopp & Diewert in 1982. The key advantage of utilizing this approach is that the model's disturbance term specification encompasses various factors such as white noise, measurement error, and other external shocks that extend beyond a firm's production unit (Nyanjong et al., 2012). In a study conducted by Sundara (1998), it was observed that the cost structure in sugar cane farming locations is characterized by human labor accounting for 45%, pesticides consuming 4%, manure and fertilizers taking up 14%, and seed occupying 14% of the costs. Machine labor constitutes 17% of the costs, while interests account for 4%. Additionally, Sundara (1998) emphasized that the incurred costs are contingent upon the level of crop management by the farmer, their economic condition, and the availability of credit. This finding implies that sugar cane cultivation is labor-intensive, as nearly half of the costs are allocated to labor. Machine labor ranks second in terms of expenditure, while fertilizers, manure, and seed impose significant demands on the farmer's financial resources. It is important to note that such analyses are influenced by various determinants, including the economic situation of the area, environmental factors, farmers' skills, and soil fertility.

In order to achieve optimal production, it is crucial to have effective management of the resources involved. The management and implementation of these resources not only play a significant role in determining the output, but also contribute to reducing production costs and improving profitability. Clowes et al. (1998) emphasized the importance of various factors such as seed quality, fertilization, irrigation, transportation costs, and ratoon management in achieving high yields. Additionally, it is essential to select suitable crop varieties based on the climate and soil conditions, while also considering the irrigation method to ensure efficient water movement. Coelli et al. (1996) defined technical efficiency (TE) as the ability of a farm to maximize output using a given set of inputs. Allocative efficiency (AE), on the other hand, measures a farm's ability to utilize input ratios that minimize costs or maximize revenue. It is important to note that a farm must first achieve technical efficiency before it can attain allocative efficiency, and both are necessary for economic efficiency.

A research conducted by Jamil et al. (2014) investigated the factors that influence sugarcane production in Pakistan, specifically in the Punjab region. The study utilized the Cobb-Douglas production function to determine production efficiencies and found that the theory aligned well with the regression model. Adrian et al. (2013) also provided similar justifications for employing the Cobb-Douglas production function in their study on the factors affecting sugarcane production in Pakistan. Adeniji (1998) conducted a study on farm size and resource efficiency in small-scale agricultural production, focusing on rice farms in Kwara state, Nigeria. Adeniji justified the use of the Cobb-Douglas production function based on the a priori expectation that variable inputs have a positive influence on output. Clainos et al. (2011) supported the use of the Cobb-Douglas production function in their study, stating that it is superior on both theoretical and econometric grounds for analyzing the effects of variable inputs.

In a study by Mandla et al. (2012) on the productivity of smallholder sugarcane farms in Swaziland, specifically the Konati Downstream Development Program, the researchers employed the Cobb-Douglas production function. They chose this function because it provides a straightforward estimation of production elasticities with a wide range of inputs. Additionally, the Cobb-Douglas production function is an established theory widely used in the analysis of various production studies. It is known for its flexibility, ease of use, good empirical fit across different data sets, and its compatibility with regression under Ordinary Least Squares (OLS).

The review of studies conducted by the aforementioned researchers also revealed the widespread application of the Cobb-Douglas production function in various research contexts.According to Narayani (2004), the size of the area harvested has a significant impact on sugarcane production. The study suggests that if the area harvested increases by 1%, there will be a corresponding increase in sugarcane production by 0.97%. This finding is particularly relevant to the current land issues in Fiji. Since 1997, there has been a rapid expiration of sugarcane land leases, resulting in a large portion of unused land reverting back to bushland. This decline in land usage for sugarcane production is evident in

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the decrease of the area harvested, which dropped from 73,000 hectares in 1997 to 45,000 hectares in 2000.

Consequently, sugarcane production also declined from 3,280 thousand tonnes to 1,900 thousand tonnes during the same period (Fiji Bureau of Statistics, 2001). The empirical evidence strongly supports the notion that Fiji's land problem needs immediate attention. If not addressed promptly, sugarcane production will continue to decline. This could lead to a failure in meeting the export quota requirements, resulting in the loss of lucrative overseas markets. Such a scenario would have severe repercussions not only for farmers but also for the overall economy, given the significant role of the sugar industry in Fiji's economic development. Furthermore, Narayani (2004) also observed that other factors, such as the labor force estimate, fertilizer usage, and prices received by sugarcane farmers, also influence sugarcane production. The study found that a 1% growth in the labor force leads to an approximate 0.68% increase in sugarcane production. Similarly, a 1% increase in fertilizer usage results in a 0.1% increase in production. Additionally, higher prices paid to farmers, with a 1% increase, contribute to a 0.06% increase in production.

Therefore, econometric analysis confirms the significant impact of the area harvested on sugarcane production (Narayani, 2004). Chidoko et al. (2011) discovered that farmers generally possess extensive knowledge and experience in sugar cane farming. However, they face a lack of resources to complement their expertise. The Lowveld area was identified as having the most favorable climate for sugar cane growth, with irrigation serving as a valuable supplement to water availability. Consequently, Zimbabwe holds a comparative advantage in sugar cane production. On average, the breakeven point for sugar cane is 60 tonnes per hectare, although yields can reach as high as 115 tonnes per hectare (Chidoko et al., 2011). The research also revealed that farmers expressed dissatisfaction with the price offered for their sugar cane. For instance, 75 percent of the interviewed farmers reported that pricing was the major issue they encountered.

Therefore, it can be concluded that small-scale sugar cane farmers face various economic challenges, including low prices for their produce, limited access to fertilizers, high input costs, and lack of affordable financial resources, inadequate equipment, and limited extension services. In an unpublished study by Olujenyo, descriptive statistical and quantitative methods were employed to analyze the collected data. Descriptive statistics such as frequency distribution, mean, mode, and tables were utilized. Additionally, quantitative methods, specifically ordinary least square, were employed to capture the impact of farmers' socioeconomic variables on agricultural product production.

Net returns analysis was utilized to assess the level of profitability. The t-test was conducted to examine the statistical significance of the variables. Olujenyo's (unpublished) analysis of the production function indicates a positive correlation between total output and factors such as age, education, labor, non-labor input costs, and the type of season. This suggests that an increase in the employment of these variables will lead to a rise in the total output of maize. This discovery aligns with Ojo's (2000) findings as cited by Olujenyo (unpublished). The outcomes reveal an inverse relationship between output and farm size, years of experience, and the gender of respondents. The unexpected inverse relationship between output and farm size may be attributed to inadequate farm management and poor soil fertility resulting from the lack of land improvement.

Olujenyo (unpublished) also noted that the unexpected negative relationship between output and education could be due to the generally low level of formal education observed across the sample. This may have hindered the adoption of new production techniques. Furthermore, the negative coefficient for years of experience contradicts prior expectations, possibly because farmers with extensive experience are accustomed to outdated farming methods, traditional tools, and species that do not promote high output (Olujenyo, unpublished). Sulle et al. (2015) highlighted that successful agricultural investments do not necessarily require vast land holdings of up to 50,000 hectares, as proposed in the plans of the Southern Agricultural Growth Corridor of Tanzania (SAGCOT).

Instead, a moderate amount of land could suffice, encouraging investors to seek additional outputs from neighboring farmers, as demonstrated by the Kilombero Sugar Company (KSCL). In reality, all operational sugar estates in Tanzania have plantations of less than 10,000 hectares (Sulle et al., 2015). Aina et al. (2015) found that 47.5% of the respondents had farming experience ranging from 16 to 20 years, with 27.5% having 11 to 15 years of experience. Only 7.5% had farming experience between 1 to 5 years, while the remaining 17.5% had experience between 6 to 10 years. These percentages are expected to increase over time with more mobilization, sensitization, and incentives provided. The study also revealed that the majority (76.25%) of sugarcane producers had an average farm size of 1 to 2 hectares, followed by 3 to 4 hectares (17.5%), 5 to 6 hectares (3.75%), and 7 to 8 hectares (2.5%).

This aligns with Okigbo's (1998) assertion, as cited by Aina et al. (2015), that the majority of farm holdings in Nigeria are small-scale, below 5 hectares. Furthermore, 90% of sugarcane farmers were married, indicating the availability of family labor for production activities. The analysis showed that labor accounted for 51.72% of the total variable cost of production, highlighting the labor-intensive nature of sugarcane farming. Access to loans was limited among respondents, posing a significant constraint to expanding cane fields and achieving higher yields. In conclusion, Aina et al. (2015) emphasized that the majority of respondents were small-scale sugarcane farmers with limited farm holdings, relying heavily on family labor due to financial constraints.

Tarimo et al. (1998) noted a significant fluctuation in sugar production in the Kilimanjaro region over the past decade due to unfavorable socio-economic and environmental conditions. The decline in sugar production during the 1980s was primarily attributed to drought and inadequate irrigation infrastructure in the sugar estates, leading to a decrease from over 40,000 tons in 1983/84 to approximately 26,000 tons in 1989/90. However, in the 1990s, sugar production rebounded in all states except Kagera, where production figures generally decreased. The lower sugar production in Kagera may have been influenced by factors other than biological, as sugarcane production remained relatively stable. Possible reasons for this decline could include the non-delivery of processed sugar to the Sugar Development Corporation (SUDECO) go downs in Dar-es-Salaam. It is plausible that the sugar produced by this factory was either exported to neighboring countries or distributed directly to unregistered retailers within the country, a common practice with this commodity in Tanzania at the time. Rabobank (2013) proposed that by implementing widespread irrigation, utilizing improved varieties, and adopting better cultivation practices, the existing four sugar estates have the potential to increase their combined production by up to 200,000 tonnes of sugar annually.However, in order to establish itself as a sugar exporter, it is imperative to expedite agricultural advancements. The current policies regarding sugar imports necessitate immediate reassessment, as the excessive influx of imports poses significant financial challenges for sugar mills, while export permits are not readily granted. According to Sulle et al. (2015), following the privatization in 1998, SUDECO implemented various changes to enhance sugarcane production and improve the infrastructure for processing. Additionally, they revamped the payment system for out growers, giving more prominence to associations and local contractors, and secured funding from donors for training purposes. This expansion led to an increase in the number of farmers becoming out growers in the sugarcane area, thereby benefiting from sugarcane payments. However, Sulle et al. (2015) argue that this expansion was not meticulously planned, resulting in the company's failure to ensure that its factories can effectively harvest and process all the sugarcane produced by out growers. Furthermore, there is a lack of oversight regarding harvesting practices and transportation, and inadequate guidance provided to assist out growers in improving sucrose levels and managing their crops. The authors emphasize that although the government has encouraged an escalation in sugarcane production, it neglected to adequately plan for the inevitable strain on land caused by the expansion of sugarcane cultivation and the subsequent influx of workers and business individuals (Sulle et al., 2015).

Sambuo (2015) notes that between 1977 and 2008, the industries in Tanzania were able to produce an average of 142,347 tons of sugar annually, while the consumption rate was at 189,830 tons, resulting in a consumption deficit of 33 percent. The sugar sector in Tanzania offers direct employment opportunities to approximately 30,000 individuals, with an additional 16,768 secondary employments for sugar cane outgrowers (SBT, 2012). Furthermore, the industry generates significant indirect employment for individuals involved in sugar wholesale and retail trade, transportation services, and social services within the sugar estates townships. Additionally, sugar production provides sugar cane farmers with total earnings of around Tshs 29.4 billion, benefiting over 160,000 people. The impact of sugar production extends to rural areas, contributing to the development and provision of essential social amenities such as schools, hospitals, water supply, townships, and farm roads (SBT, 2012 as cited in Sambuo, 2015).

IV. RESEARCH METHODOLOGY

Research Methodology This research was carried out utilizing time series secondary data. The numerical information gathered from secondary sources was analyzed to draw conclusions and provide recommendations. Data Compilation The study's analysis utilized secondary production data, specifically annual time series data from 1980 to 2023, with the objective of determining the correlation between input factors and sugarcane production. The researcher compiled data from secondary sources such as books, journals, articles, and online materials relevant to the study's topic. Data Collection Approach The researcher utilized secondary data collection methods, including reviewing books, journals, articles, and other online resources related to the study's subject matter. Data Interpretation Following the data collection process, data analysis was conducted. The steps involved in this process included data organization, data segmentation, data processing, and data presentation. The collected data was then analyzed through regression analysis to derive meaningful results for data presentation. Data organization involved the compilation of secondary data for overall analysis.

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➢ *Conceptual Frame Work*

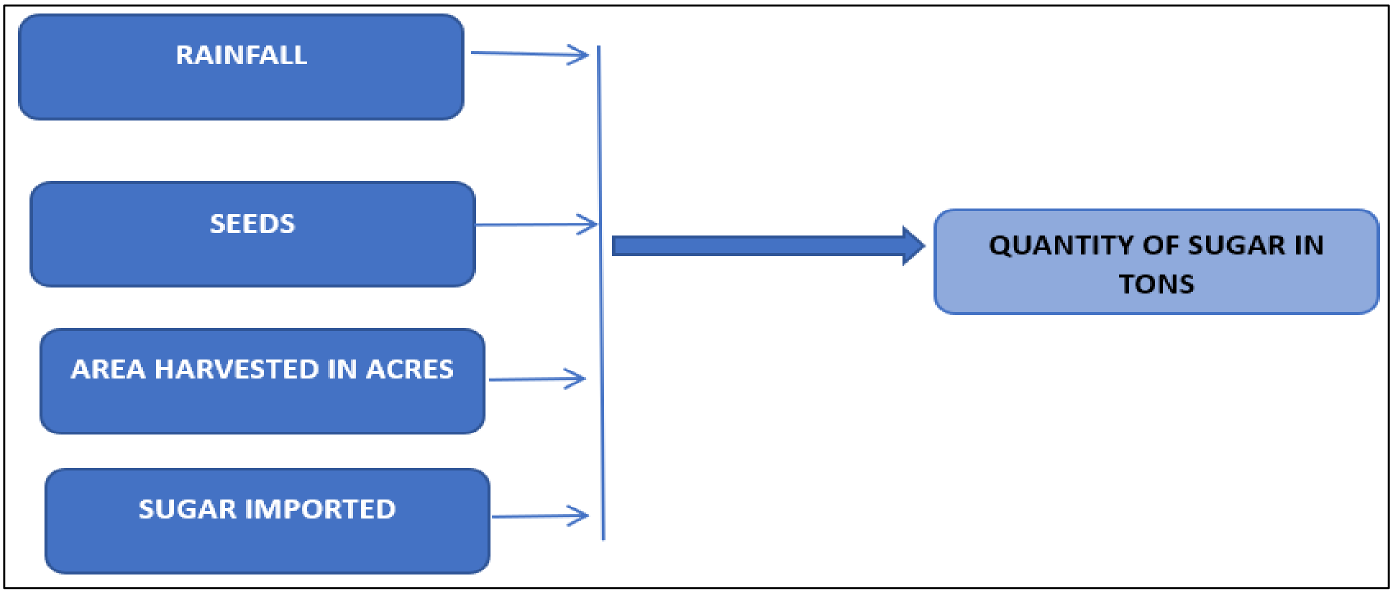

Fig 1 Conceptual Frame Work

The diagram presented below illustrates the conceptual framework, depicting the interconnections between rainfall, imported refined sugar, and sugarcane seeds. These factors collectively influence the overall impact on sugarcane production in Tanzania. The model utilized in this study is based on Narayan's (2004) work, which focuses on a Cobb-Douglas specification for sugar production in Fiji. In this model, two proxies for capital, namely area harvested and fertiliser usage, are considered. Additionally, the traditional labour force variable and the price paid to sugarcane farmers are included in the analysis. As a result, the long-run model for sugar cane production can be expressed as follows:

$$Qt = \alpha0 + \alpha1 In\ AHt + \alpha2 ln\ LABt + \alpha3 ln\ FERt + \alpha4 In\ Pricet + Ɛt \ldots\ldots (4)$$

α0 is a constant; In Qt signifies the natural logarithm of sugarcane production (000 tonnes) at time t; In AHt signifies the natural logarithm of the area harvested (000 hectares) at time t; In LABt signifies the natural logarithm of the labor force at time t; In FERt signifies the natural logarithm of fertilizer usage at time t; In PRt signifies the per tonne price paid to farmers; and Ɛt represents the error term.

Narayan modified specification to sugar cane production for Tanzania.

$$Qt = \alpha0 + \alpha1 In\ aht + \alpha2 ln\ rainft + \alpha3 ln\ sugarimpt + \alpha4 In\ sdt + Ɛt\ (5)$$

Where: α0 denotes a constant, In Qt denotes the natural logarithm of sugarcane production (000 tonnes) at time t, In aht denotes the natural logarithm of the area (000 hectares) at time t, In rainft denotes the natural logarithm of the amount of rainfall (000 mm) at time t, In sdt denotes the natural logarithm of the quantities of sugarcane seeds (000 tonnes) used at time t, and In sugarimpt denotes the natural logarithm of imported refined sugar (000 tonnes) at time t. Additionally, Ɛ1 represents the error term. It is anticipated that the amount of rainfall and the quantities of sugarcane seeds will have a positive impact on sugarcane production, with the exception of imported refined sugar. Therefore, the a priori expectation is that α1, α2, and α4 will be greater than zero. All variables have been converted to logarithms to facilitate the interpretation of the coefficients as elasticities.

V. FINDINGS AND ANALYSIS

In this section, an examination of the characteristics of each variable is conducted through statistical analysis, assessment of correlations between variables, and testing for unit roots in the variables. This section offers an overview of the characteristics of each variable through the generation of descriptive statistics. This aids in comprehending the behavior of the variable in Appendex Table 1 show cases the average, median, minimum, maximum, standard deviation, and tests for each variable which indicate that sugarcane production (qt) ranges from a minimum of 983,900 tons to a maximum of 3,021,314 tons.

The test for normality, assuming a normal distribution of sugarcane production, was accepted with a p-value of 0.0604. The average sugarcane production over the 43-year period observed is 1,638,033.28 tons. Rainfall (rainf) varied from a minimum of 85.721 to a maximum of 99.525, with a mean of 72.52303 and a standard deviation of 8.758653. The data for rainfall was normally distributed as the null hypothesis of normal distribution was not rejected, given the p-value of 0.9334. Imported refined sugar (sugarimp) was found to be not normally distributed, as indicated by a p-value

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of 0.0082, which is less than 0.05. This led to the rejection of the null hypothesis that imported refined sugar follows a normal distribution. The quantity of imported refined sugar ranged from 8,008 tons to 4,987,263 tons. The quantities of seeds available (sd) ranged from a minimum of 62,000 tons to a maximum of 548,000 tons, with an average of 46,633.41 tons. The standard deviation for seed quantities was 51,897 tons. The data for seed quantities was not normally distributed, with a p-value of 0.0082. The variable denotes the extent of land that was harvested (ah). The smallest area harvested was 897,600 hectares, while the largest area harvested reached 585,600 hectares. The average area harvested was calculated to be 83.59586, with a standard deviation of 60,171.69. The test conducted to assess the normality of the distribution of harvested areas yielded a p-value of 0.0046, leading to the acceptance of the hypothesis that the area harvested follows a normal distribution.

In Appendex the table 2 presents the outcomes of transforming variables using the natural logarithm in order to assess normality that variable lnqt, which represents the quantity of sugarcane produced, obtained a p-value of 0.0672. Consequently, we fail to reject the null hypothesis that the quantity of sugarcane produced follows a normal distribution. Similarly, the variable rainfall (rainf) was transformed into lnrainf, and it was found to be normally distributed with a p-value of 0.9289. Therefore, we also fail to reject the null hypothesis that the amount of rainfall is normally distributed. On the other hand, the variable representing sugar imports (lnsugarimp) became normally distributed with a p-value of 0.1939. Hence, we fail to reject the null hypothesis that imported refined sugar follows a normal distribution. In contrast, Table 2 demonstrates that the transformed quantities of seeds (lnsd) did not become normally distributed, as the p-value of 0.0345 is less than 0.05. Consequently, we reject the null hypothesis that seeds are normally distributed. Lastly, the variable area harvested (ah) was transformed into lnah, and it was found to be normally distributed with a p-value of 0.8721. Therefore, we fail to reject the null hypothesis that the amount of area harvested follows a normal distribution.

In Appendex the table 3 presents the correlation analysis of various variables. It is observed that most variables exhibit a positive correlation with each other, except for a few exceptions. The correlation between sugarcane production (lnqt) and rainfall (lnrainf) is negative, indicating that an increase in rainfall negatively affects the quantity of sugarcane production, leading to a reduction in output. The correlation coefficient for this relationship is -0.2056, suggesting a weak correlation strength of 20 percent. On the other hand, there is a strong positive correlation between sugarcane production (lnqt) and the quantity of sugarcane seeds available (lnsd), with a correlation coefficient of 0.9286. This implies that as sugarcane production increases, the quantity of seeds also tends to increase. The correlation strength for this relationship is 92 percent, indicating a strong association. Similarly, there is a reasonable positive correlation between sugarcane production (lnqt) and the quantity of imported refined sugar (lnsugarimp), with a correlation coefficient of 0.6428. This suggests that as sugarcane production increases, the quantity of imported refined sugar also tends to increase. The correlation strength for this relationship is 64 percent. Furthermore, the correlation analysis reveals that sugarcane production (lnqt) is positively correlated with the area harvested (lnah), sugarcane seeds available (lnsd), and quantity of imported refined sugar (lnsugarimp). This implies that as the harvested area increases, the quantity of sugar and sugar import also tend to increase. The correlation coefficient for the relationship between sugarcane production and harvested area is 0.7832, indicating a strong correlation strength of 78 percent.The Table 4 in Appendex presented above displays the results of unit root tests conducted on various variables. The first difference of sugarcane production (qt) yielded a computed absolute value of the t statistic equal to 4.16, while the ADF critical absolute tau value was 3.58. Consequently, the null hypothesis of a unit root or non-stationarity in the time series was rejected due to the computed absolute value exceeding the critical value.

Similarly, the Phillip Perron test confirmed these findings, with a computed absolute value of 6.59 surpassing the absolute critical value of 3.572. In the case of rainfall (lnrainf), the computed absolute value of the tau statistic was 7.470, which exceeded the ADF critical absolute tau value of 3.576. Furthermore, the PP test yielded a tau statistic of 17.429, significantly higher than the critical value of 3.57. As a result, the null hypothesis of non-stationarity in the time series was rejected. For sugar imports (lnsugarimp), the ADF test indicated a computed absolute value of the t statistic equal to 5.267, while the critical absolute value was 3.576. Similarly, the PP test yielded a computed absolute value of 5.627, surpassing the critical value of 3.568. Consequently, the null hypothesis of a unit root in sugar imports was rejected, indicating stationarity in the time series. Lastly, the quantities of sugarcane seeds exhibited a computed absolute value of 3.832, exceeding the critical value of 3.576. The PP test also supported this finding, with a computed absolute value of 5.247 surpassing the critical value of 3.572. As a result, the null hypothesis of a unit root was rejected.

The harvested area exhibited a computed absolute value of 5.354, surpassing the critical value of 3.576. Similarly, the PP test results revealed that the computed absolute value of 16.429 exceeded the critical value of 3.582. This enabled us to reject the null hypothesis of non-stationarity. Consequently, according to the findings in Tables 5, all variables demonstrated stationarity after undergoing first difference. The computed absolute values of the tau statistics surpassed the critical value for both tests, leading us to reject the null hypothesis. This implies that all variables possess an integration order of one [I (1)]. Moving on to the cointegration test, cointegration is a statistical property that pertains to a collection (X1, X2, X3…. Xk) of time series variables.

For cointegration to occur, all series must be integrated of order 1. Furthermore, if a linear combination of this collection is integrated of order zero, then the collection is considered to be co-integrated. In formal terms, if (X, Y, Z, W) are each integrated of order 1, and there exist coefficients a, b, c, and d such that $aX + bY + cZ + dW$ is integrated of order 0, then X, Y, Z, and W are cointegrated (Wikipedia, 2017). The results from Table 5 indicate that certain variables exhibit non-stationarity. To test for cointegration, the Engle Granger test for cointegration was conducted, and the results are presented in Table 5 in the Appendex it has illustrates that the residual is considered stationary as the test statistics in absolute terms exceed the critical values at 1, 5, and 10 percent significance levels. This indicates the presence of cointegration, suggesting that despite the non-stationarity of individual variables such as sugarcane production, amount of rainfall, imported refined sugar, and sugarcane seeds, a linear combination of these variables results in stationarity, implying a long-run or equilibrium relationship among them.

Given the cointegration, an error correction model (ECM) was employed to examine the short-run dynamics of the variables in determining sugarcane production. The trend of the estimated residual is depicted in Figure 1which showed in the Appendex. The presence of cointegration necessitates the development of an error correction model (ECM) to forecast the impact of specified variables on sugarcane production. In this study, the ECM employed the Engle Granger method to estimate the short-term relationship. Focusing on the determinants of sugarcane production in Tanzania from 1980 to 2023, a regression analysis was conducted using the ECM approach after confirming the stationarity of the residuals. To account for potential deviations of the model's variables from long-run equilibrium, the ECM incorporated a lagged error term from the previous period. The error correction model also included the lag of the residual obtained from the static regression as an error correction term. The final equation was derived by eliminating insignificant variables from the model. The summarized results of the final (parsimonious) equation can be found in Table 6 under the Appendex page

➢ *Results and the Interpretation of the ECM*

In the Appendex page the Table 5.1.7 illustrates that in the short term, the F-statistics test for the overall significance of the model is statistically significant at all levels, with a probability value of 0.0000. Additionally, the R-squared value is 0.8995, indicating that approximately 89 percent of sugarcane production can be explained by the explanatory variables. The independent variable of rainfall exhibited negative coefficients, suggesting an inverse relationship with sugarcane production. A one percent change in rainfall resulted in a 0.08 percent decrease in production in the short term. This implies that deviations from a certain threshold of rainfall can lead to a decline in sugarcane production by 0.08 percent. The significance of rainfall in influencing sugarcane production in the short term was confirmed by a p-value of 0.0000, which is less than 0.005. Consequently, the study rejected the null hypothesis that rainfall does not significantly impact sugarcane production, indicating that rainfall can indeed affect production in the short term. On the other hand, the quantity of imported refined sugar was deemed insignificant in influencing sugarcane production in the short term, as evidenced by a p-value of 0.717, which exceeds 0.005. This failure to reject the null hypothesis suggests that the quantity of imported refined sugar does not significantly affect sugarcane production. The positive coefficient associated with imported refined sugar implies that a one percent increase in imported refined sugar leads to a mere 0.002 percent increase in sugarcane production. This could be attributed to high domestic demand for sugar relative to the total quantities of domestically produced and imported refined sugar. Additionally, the low quantity of imported refined sugar, primarily utilized by the food and beverage processing industries, may not have a substantial impact on the domestic market.

Sugarcane seeds were found to be statistically insignificant at all levels, with a p-value of 0.513. Therefore, we fail to reject the null hypothesis that sugarcane seeds have no significant impact on sugarcane production. This suggests that a one percentage increase in sugarcane seeds leads to a mere 0.013 increase in sugarcane production, with a positive sign as expected. Similarly, the harvested area of sugarcane was also found to be statistically insignificant, with a p-value of 0.612. Hence, we fail to reject the null hypothesis that the area of sugarcane harvested has no significant effect on sugarcane production. The results indicate that a one percentage increase in the harvested area of sugarcane results in a 0.027 increase in sugarcane production, with the expected positive sign. Furthermore, the coefficient of the error correction term (L1. r) exhibits the expected sign, indicating that the rate of adjustment towards equilibrium in the long run is approximately 94 percent. This high rate of adjustment suggests that if sugarcane production exports deviate from the steady state in the long run, they will quickly converge back to equilibrium. It is important to note that the inclusion of lagged explanatory variables in the model is economically justified. This is because there is typically a significant time lag in the adjustment processes within the economy. In the case of sugarcane production, there is a time lag for the explanatory variables to impact the production. The Variable Inflation Factor (VIF) test revealed no issues of collinearity among the independent variables in the model. The mean VIF of 1.06, which is below 10, indicates that there is no significant multicollinearity present. Additionally, the Ramsey RESET test was conducted to assess the specification of the model. The results of the test indicated no significant evidence of model misspecifications and confirmed that the model was well-specified with no omitted variables at a 5 percent significance level. The probability value of the F statistic was 0. 0708.The regression analysis utilized the fitted values of the dependent variable to examine heteroscedasticity. The findings from the Breusch Pagan/Cook-Weisberg test revealed that there was no significant heteroskedasticity issue, as indicated by a p-value of 0.0964 for the chi-square test. Consequently, we were unable to reject the null hypothesis, which suggests that there is a constant variance (homoscedasticity). In relation to autocorrelation, the results obtained from the Breusch Godfrey LM test indicated the absence of serial correlation. This was demonstrated by a chi-square value of 0.864.

VI. CONCLUSION AND RECOMMENDATIONS

This study aimed to empirically analyze the factors contributing to the slow growth of sugarcane production in Tanzania between 1980 and 2023, despite improvements in

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the performance of the sugarcane industry to meet the increasing demand for sugar. The objective was to gain valuable insights into the determinants of sugarcane production in Tanzania, including the amount of rainfall, quantities of imported refined sugar, area available for harvesting, and availability of sugarcane seeds. These factors were found to explain the existing sluggishness in the performance of the sugarcane industry in Tanzania. The findings of this study can serve as a basis for making informed policy decisions and conducting future research to enhance the sustainability and productivity of the sugar industry.The primary objective of this study is to generate valuable findings that can assist policymakers in formulating appropriate and manageable policies. As a result of this study, the following policy recommendations have been identified. Firstly, it has been determined that rainfall plays a crucial role in influencing sugarcane production. Therefore, in order to promote sugarcane production in Tanzania, policies should prioritize the improvement of environmental protection to ensure climate stability and the effective management of rainfall variability and irrigation. This can be achieved through the implementation of participatory strategies and planning, which involve considering the predetermined precipitation levels during the season and addressing short-term weather fluctuations. Additionally, the introduction of alternative water sources for irrigation should be considered in cases of insufficient rainfall. Furthermore, the government should establish a robust regulatory system for ensuring the quality of sugarcane seeds and develop a comprehensive seeds policy. It is also recommended to establish research institutions dedicated to the development of efficient sugarcane seeds and enhancing sugarcane production. Moreover, the government should promote the adoption of an integrated approach to improve farmers' access to high-quality sugarcane seeds. This approach should encompass both the formal and informal seed sectors, including public and private entities, in order to develop national seed supply chains. The study also suggests that the importation of refined sugar should be strictly regulated by the government. This can be achieved through measures such as Tariff-Rate Quotas (TRQs) and other trade agreements, which set limits on the amount of sugar that can be imported into the country. Additionally, domestic cane growers should strive to increase sugar production to meet domestic demand and potentially explore opportunities for exportation.

Investing in irrigation infrastructure should be a top priority for governments in order to expand the cultivated area for sugarcane and minimize the negative effects of unpredictable rainfall patterns. At the same time, providing customized assistance to small-scale farmers, which includes access to credit, extension services, and market connections, can significantly improve productivity. By incorporating climate resilience strategies like promoting drought-tolerant sugarcane varieties and implementing water conservation techniques, sustainable growth can be achieved. These measures, in line with the observed positive relationship with the harvested area, contribute to the resilience and prosperity of Tanzania's sugarcane industry.Constraints and Prospects for Future Investigation: The research recognizes constraints like data accessibility, as the data utilized in this study did not originate from a uniform source. This could potentially affect the outcomes and conclusions as each source has its unique methods of data collection and analysis. Furthermore, the intricate nature of factors affecting sugarcane production was highlighted. Subsequent research endeavors could delve into supplementary variables, such as soil quality and pest control strategies, to gain a deeper understanding of their influence on production trends.

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APPENDIX:

Table 1 Descriptive Statistics

Variable	Observe	Mean	Std Deviation	Minimum	Maximum	Prob>chi2
Qt.	43	1,638,251	621,482	983,900	3,021,314	0.0604
Rain	43	72.52303	8.758653	85.721	99.525	0.9334
sugar imp	43	63,167.68	642947.69	8,008	4,987263	0.0082
SD	43	46,633.41	51,897	62,000	548,000	0.0082
Area harvested	43	83.59586	60,171.69	897,600	585600	0.0046

Source: STATA estimation

Table 2 Normality Test Results for Transformed Variables

Variable	adj chi2(2)	Prob>chi2
Lnqt	5.40	0.0672
Lnrainf	0.15	0.9289
lnsugarimp	3.28	0.1939
Lnsd	6.73	0.0345
LnAreah	4.26	0.8721

Source: STATA Estimation

Table 3 Correlation Analysis

	lnqt	lnrainf	lnsugarimp	lnsd	lnAreah
Lnqt	1.0000				
Lnrainf	-0.2056	1.0000			
lnsugarimp	0.6428	-0.2387	1.0000		
Lnsd	0.9286	-0.2041	0.6729	1.0000	
LnAreah	0.7832	-0.2083	0.6246	0.6823	1.0000

Source: STATA Estimation

Table 4 Unit Root Test (Level Variables)

Augmented Dickey-Fuller			Phillips-Perron		
Variable	Test Statistics	Critical Value at 5%	Test Statistics	Critical Value at 5%	Remarks
Dlnqt	-4.160	-3.576	-6.598	-3.562	Stationary
Lnrainf	-7.470	-3.576	-17.429	-3.573	Stationary
lnsugarimp	-5.267	-3.576	-5.627	-3.568	Stationary
Lnsd	-3.832	-3.576	-5.247	-3.572	Stationary
LnAreah	-5.354	-3.576	-16.429	-3.582	Stationary

Source: STATA Estimation

Table 5 Engle-Granger Test

Engle Granger Test for Cointegration				
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
r(ECT)	-5.980	-5.247	-4.456	-3.077
R(ECT)	-5.768	-5.235	-3.487	-3.006

Source: STATA Estimation

Number of observations =43. Note: consider 5% significance level.

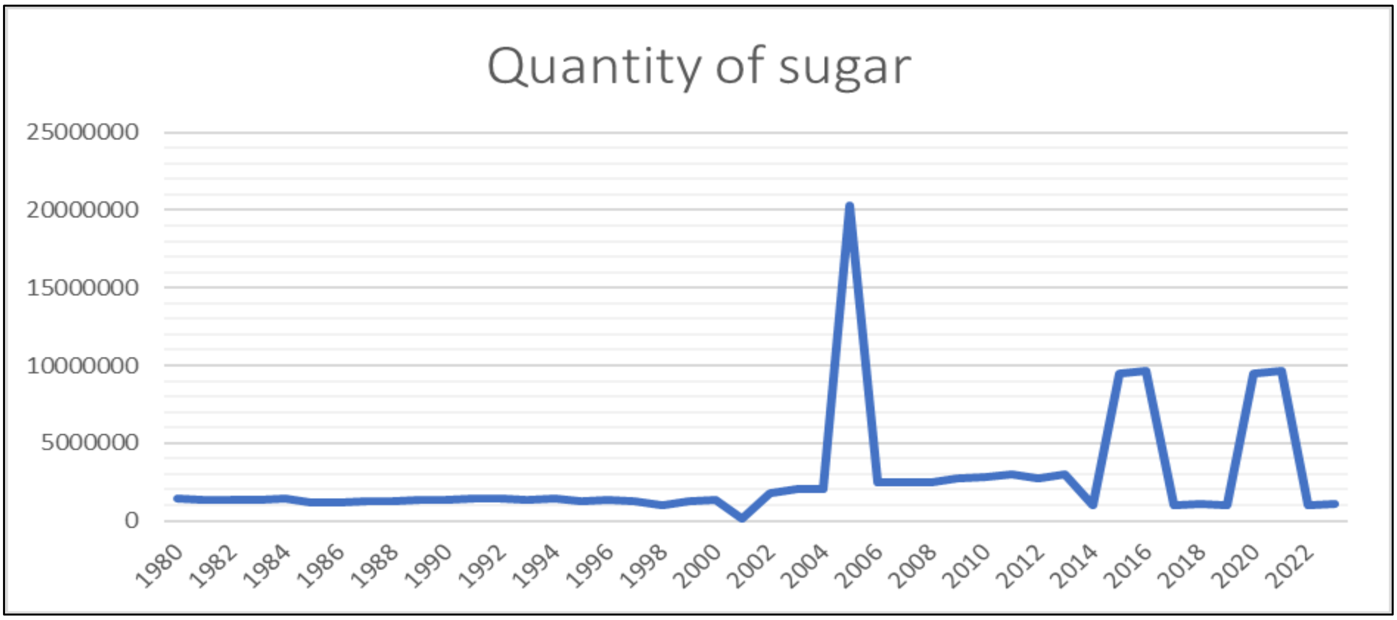

Fig 1 Trend of Estimated Residual

Table 6 Estimation Results for Parsimonious Model

Variable	Coefficient	T-Value	Probability of T-Value
Lnrainf	-0.069077	-5.33	0.000
lnsugarimp	0.0015398	0.37	0.717
Lnsd	0.0139539	0.66	0.513
LnAreah	0.0278188	0.85	0.612
L1 e	-0. 9405045	-35.09	0.000
Constant	.0203297	6.99	0.000

Source: STATA Estimation

Number of Observation =43; F (4, 26) = 310.74 [0.0000] R squared=0.8995; Root MSE = .01506