International Journal of Sustainable Agricultural Research
2025 Vol. 12, No. 1, pp. 54-66
ISSN(e): 2312-6477
ISSN(p): 2313-0393
DOI: 10.18488/ijsar.v12i1.4125

The interplay between sugarcane (*saccharum officinarum* l.) production and climate change in Fiji islands: Challenges and adaptation strategies

Shifadjzic Khan

Department of Food Security and Agricultural Development, Kyungpook National University, South Korea.
Email: ShifadjzicKhan@gmail.com

Article History
Received: 21 January 2025
Revised: 24 February 2025
Accepted: 3 March 2025
Published: 7 March 2025

Keywords
Climate change
Global Warming
Fiji Islands
climate-resilient cultivar
Eco-friendly
Sustainability

ABSTRACT

Sugarcane (Saccharum officinarum L.) has been a fundamental component of Fiji's economy; however, climate change presents considerable challenges, such as increasing temperatures, unpredictable precipitation, and severe weather occurrences. This research examines the effects of global warming on sugarcane yields in Fiji, identifies the primary factors contributing to decreased productivity, and explores adaptive strategies for sustainable cultivation. A systematic review of relevant literature was conducted utilizing academic databases, concentrating on climate-induced challenges and mitigation strategies. This analysis examines the environmental, agronomic, and economic implications, highlighting emissions from fertilizers, machinery, and vehicles as factors contributing to land degradation, human health risks, and resource depletion. Possible solutions encompass the development of climate-resilient cultivars, the adoption of eco-friendly farming practices, and the implementation of robust policy frameworks. The findings indicate that climate change has significantly diminished sugarcane yields in Fiji, while emissions from agricultural practices have intensified ecosystem degradation. Adaptive measures, including enhanced agronomic practices and resilient crop varieties, demonstrate potential in addressing these challenges. Collaborative policymaking and active stakeholder engagement are critical for enhancing resilience and ensuring long-term sustainability. In summary, Fiji's sugarcane industry necessitates immediate interventions via sustainable agricultural practices, strategic planning, and policy integration to adapt to climate changes and maintain its economic importance.

Contribution/Originality: The study provides significant insights into the relationship between sugarcane (Saccharum officinarum L.) production and climate change in the Fiji Islands, highlighting challenges and adaptation strategies while offering fresh discoveries. It addresses deficiencies in current research, offering a novel viewpoint on the effects of climate change on sugarcane production in the Fiji Islands. This research enhances theoretical frameworks and practical applications, facilitating further studies and breakthroughs in the subject.

1. INTRODUCTION

Sugarcane had replaced copra as Fiji's primary export crop by 1883, after the establishment of the sugar industry in 1882 (Dean, 2022). Economic prosperity in the South Pacific Island country of Fiji is sustained by its long-established sugarcane industry. The country's economy was reliant on sugarcane production, which occurred rapidly since sugar was first produced in Fiji more than a century ago. Its impact on the nation's financial stability and development has been substantial. A vital aspect of Fiji's economy and a key factor in its upward trajectory since sugar was initially grown (Vaniqi, 2012). The economic and social circumstances of the cane belt's inhabitants,

particularly those residing in rural regions, have been greatly enhanced by this sector. In addition to easing commercial agriculture, it has boosted medical progress, health, and credit possibilities while also establishing market merchants, cash crop farming techniques, and small and medium-sized company employment (Singh, 2020). Subsistence farming and sugarcane production are the mainstays of Fiji's agricultural industry (Presterudstuen, 2024). When the preferential sugar price contracts expired in 2017, the once-viable Fijian sugar industry collapsed. This business had benefited from a plethora of treaties and agreements dating back to 1975. Several issues are contributing to the decrease in sugarcane output. These include labor cost increases, a younger population gravitating towards white-collar occupations, a loss of interest in the business, and lower acreage due to late or non-renewed land leases. Other variables include a decrease in sugar recovery, an increase in agricultural expenditures (such as agricultural products, transportation, and harvest), and a rise in the demand for labor (Singh, 2018). Sugarcane has been Fiji's principal crop since 1874, shaping the country's economy, culture, and way of life. It was difficult for the British administration to enlist the help of natives and inhabitants of nearby Pacific Island countries in the early days of colonial control to cultivate sugarcane. The British refrained from employing Fijians on a large scale as wage laborers to preserve the traditional way of life (Macnaught, 2016). Natural catastrophes are a constant threat to Fiji. Hurricanes, storms, and floods have become more common, which has affected the sugar sector for a long time. Not to mention the deadly storms (four or six) and two years of chronic drought that have struck the country since 2010 (Service, 2024). For more than ten years, sugarcane output has been falling as a result of altered weather patterns putting lives and economies at risk (Kumar et al., 2024).

Figure 1. Major export destination of sugar from Fiji (USA, Germany, China and South Korea).

Figure 1 depicts the primary destinations for sugar exports from the Fiji Islands to markets across the globe. These destinations include the United States, Germany, China, and South Korea. Fiji is the only nation in the Pacific Islands that produces a significant quantity of sugar. This allows it to expand its global market and generate revenue from other nations.

For the Fiji Islands, agriculture has been the backbone of the economy for the past decades. With no other South Pacific nations growing sugar, Fiji is ripe with opportunities to expand its market to other parts of the world and increase foreign earnings, improving the nation holistically. Being a developing nation in the Pacific, it has proven

that the relevant stakeholders have utilized the resources and favorable environmental conditions to produce mass sugar for export.

2. METHODOLOGY

To complete this review paper, a systematic approach was employed. Relevant literature was identified using academic databases such as Google Scholar and Scopus. The papers had to be relevant to the study goals. Articles were screened thoroughly based on titles and abstracts, followed by a detailed review of selected full texts. Key information from each study, including objectives, methods, findings, and limitations, was extracted and organized using citation management tools. A thematic analysis was conducted to synthesize findings, identify patterns, and highlight gaps in the existing literature. This methodology ensured a comprehensive and unbiased review process.

Figure 2 depicts the geographical distribution of sugar mills over the two main islands of Fiji. The Western Division of Fiji mostly cultivates sugarcane, which serves as the primary source of income for households. This has facilitated the establishment of two mills on Viti Levu, namely the Lautoka and Rarawai mills. The third mill, known as Labasa mill, facilitates sugarcane production for five sectors on Vanua Levu.

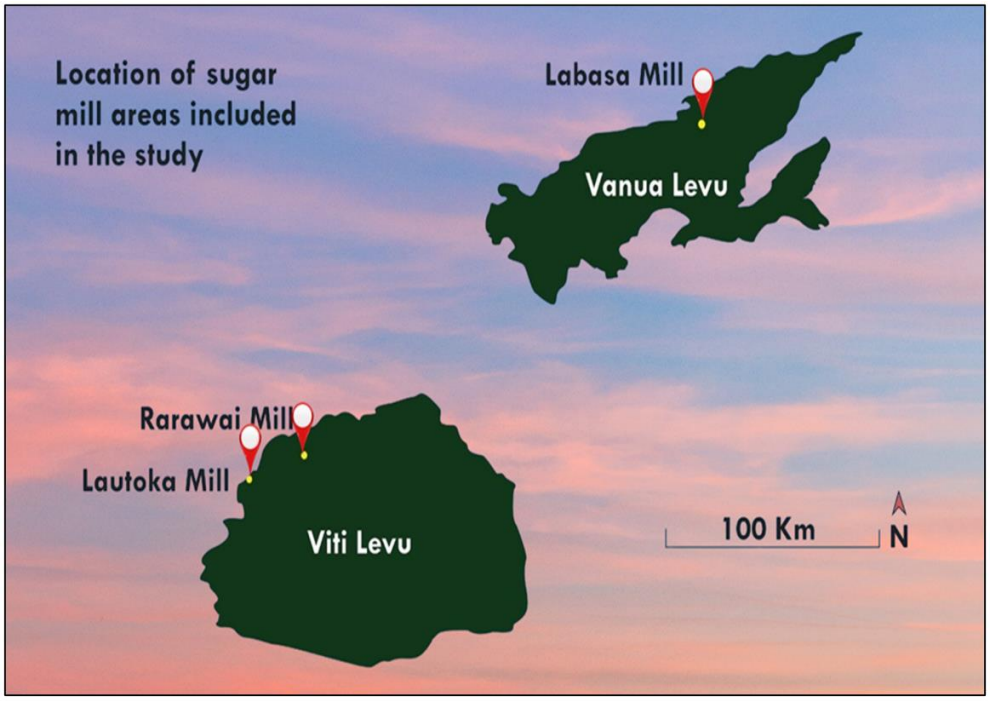

Figure 2. Demographic information of mill locations in Fiji Islands.
Source: Medina Hidalgo, Mallette, Nadir, and Kumar (2024).

Table 1. Number of farmers and mill sectors in Fiji.

Lautoka mill sector	Number of farmers	Rarawai mill sector	Number of farmers	Labasa Mill Sector	Number of farmers
Cuvu/Olosara	27	Varoko/Rarawai	46	Wailevu/ Waiqele	54
Lomawai	43	Mota/ Naloto	45	Labasa/ Vunimoli	57
Nawaicoba/Yako	50	Koronubu/ Veisaru	45	Natua/Solove/Bulivou	69
Malolo/Qeleloa	41	Varavu/ Tagitagi	45	Daku/Wainikoro	65
Meigunyah/legalega	33	Drumasi/ Yaladro	45	Bucaisau	55
Saweni/Natova	35	Malau/ Nanuku	43		
Lovu/Lautoka/Drasa	71	Elington1/ Elington 2	31		

Table 1 provides demographic statistics on the three sugar mills located in Fiji. The data also show how many farmers in each mill sector contribute to the development of the sugar business in Fiji. The three mills are running at full capacity throughout the crushing season in order to manufacture sugar for both the local and international markets.

2.1. Overview of Sugarcane Farming in Fiji Islands

On the two main islands of Fiji, you may find one of three sugar mills that are presently in operation. The cane harvesting on both Viti Levu and Vanua Levu is accommodated by three sugar mills: Lautoka, Rarawai, and one in Vanua Levu, Labasa Mill. Sugarcane growing is prevalent on the western side of Viti Levu and provides a substantial income for the locals. Sugarcane harvesting machines and laborers alike work in the flatlands of both regions to harvest cane. According to the Fiji Sugarcane Corporation report, there are a total of 10,594 active growers in the Fiji Islands, and the area under cultivation is 33,802 ha (Corporation, 2024). Some of the reasons presented in the Fiji Sugar Corporation (FSC) annual report factor in the fact that most individuals do not see farming as an appealing or financially rewarding career option. Furthermore, the unfavorable climate was highlighted as the key factor whereby crop farms were ruined by catastrophic weather events like prolonged droughts and heavy downpours.

Figure 3 depicts the drop in sugarcane output over the previous four decades. A considerable decline has been observed over the past 40 years, which is concerning for the sugar industry in Fiji. From 2006 to 2018, sugar output did not exceed 250,000 metric tons. This decline necessitates a comprehensive inquiry into the mechanisms, both direct and indirect, leading to the reduction of sugarcane output in a country that was once the cornerstone of Fiji's economy.

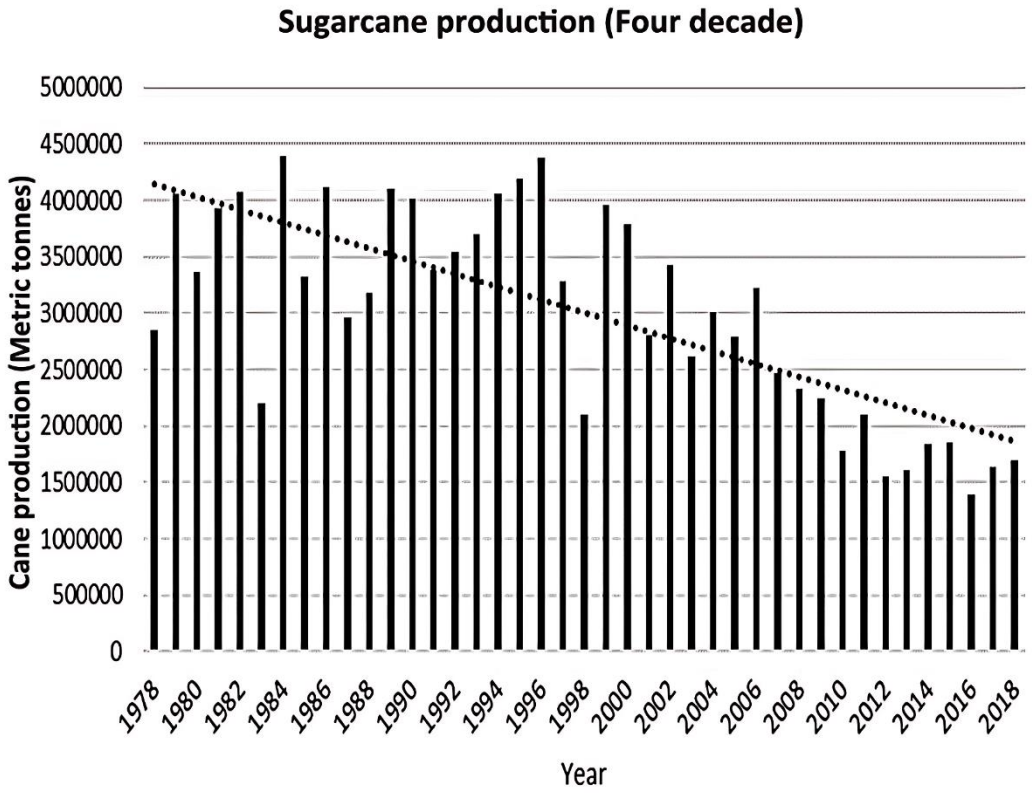

Figure 3. A decline sugarcane production trend in Fiji Islands from 1978 t0 2018.

Source: Dean (2022).

The graph above depicts that Fiji's sugar sector, which had been the country's backbone, isn't being revived effectively or efficiently. There are several reasons that have contributed to the precipitous fall in sugarcane output

in the Fiji Islands. Some of the reasons presented in the FSC annual report 2023 are that most individuals do not see farming as an appealing or financially rewarding career option and the severe loss and damage of crops due to adverse weather conditions. Furthermore, the unfavorable climate was highlighted as the key factor whereby crop farms were ruined by catastrophic weather events like prolonged droughts and heavy downpours.

Figure 4 depicts the quantity of active sugarcane growers in Fiji over a period of 17 years. The graph illustrates a rapid decrease in the quantity of active farmers in Fiji. This pertains to the sugarcane crop seen in Figure 3. The reduction in the number of active sugarcane cultivators has directly affected the whole sugar business in Fiji. Numerous factors may contribute, although the primary explanation noted in the literature is that farmers are becoming disenchanted with sugarcane cultivation owing to the losses and damages sustained during annual natural disasters.

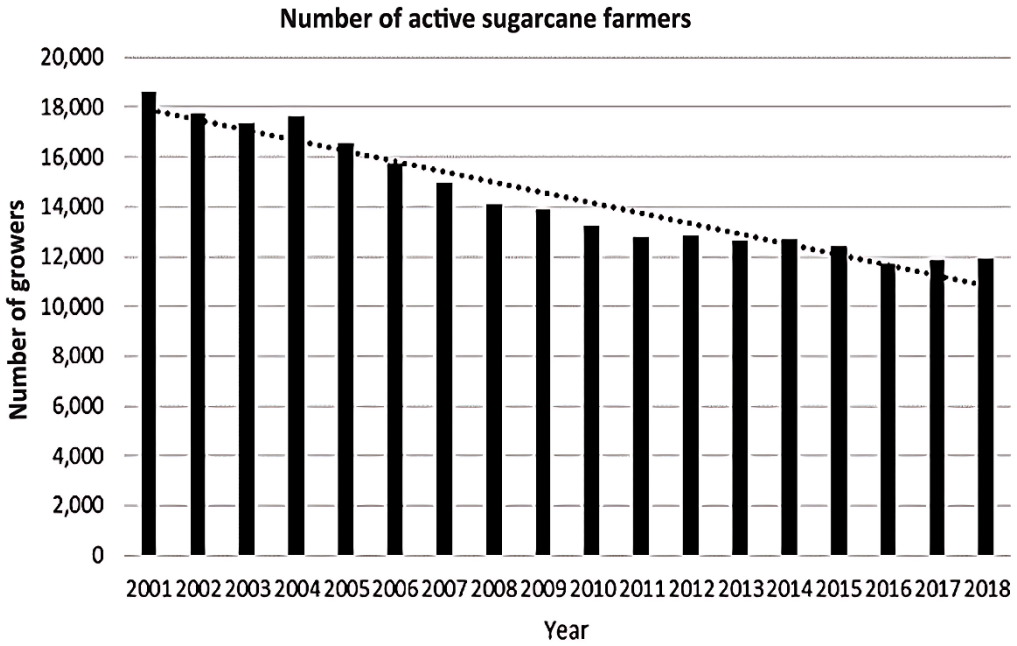

Figure 4. A decline in active sugarcane farmers in Fiji Islands from 2001 t0 2018.

Source: Dean (2022).

Referring to the Fiji Sugar Corporation 2024 annual report, it presents many challenges that the industry is facing. The study emphasized climate change as one of its primary concerns. Continuous rain and the resultant waterlogged condition of fields well into the harvest season resulted in a decrease in production. Climate change has an annual effect on agricultural yields due to soil fertility loss via leaching, erosion, and weed growth. Most projections imply a decrease in rainy conditions with a rise in dry conditions in the coming years (Corporation, 2024).

2.2. Obstacles Encountered with the Development of Fiji's Sugar Industry

The Pacific is where most of the effects of global warming are taking place. Climate change poses significant risks to the way of life for people residing in maritime nations. These dangers include, but are not limited to, higher sea levels, erosion of coastlines, incursion of saltwater, warmer oceans, and more frequent and severe droughts and floods. Natural resources deteriorate and become limited, threatening food and water security (Baleinakorodawa & Boege, 2024). The amount of climate change is quantified by analyzing the full long-term patterns of rainfall, temperature, air pressure, and moisture, among other factors. Another widely acknowledged result of global climate change is the dramatic rise of rising seas brought on by more intermittent weather patterns together with the melting of glaciers (Michel, Eriksson, & Klimes, 2021). Both actual and projected climatic shifts in the 21st century have taken place in the previous sixty years. Climate change impacts ecology, society, economy, and politics worldwide (Feliciano et al., 2022). As a result of global warming, Fiji's marine and terrestrial ecosystems are in jeopardy, as are the livelihoods

of the local inhabitants. The whole nation of Fiji is in grave danger given that the worldwide average for sea level rise is 1.5 millimeters per year, and the current pace of six millimeters annually is much higher (Taylor, 2021). The nationwide supply of essentials is reduced, and people are forced to move at a high cost when coastal flooding destroys crops and animals. As a percentage of Gross Domestic Product (GDP) and the total economy, in 2025, 11.73291% of the country's agricultural output came from agriculture (Fiji - Agriculture, Value Added (% Of GDP), 2025). The disastrous implications of climate change following the 1997–1998 El Niño drought throughout Fiji resulted in noticeable effects on the agricultural industry, especially on agriculture for subsistence and the sugar farms in the Western Division. The sugarcane industry lost F$104 million as a direct result of climatic events. Roughly 90% of the people in the worst-hit areas, including the Yasawas, Viti Levu Western region, and Vanua Levu, received food and water (Foerster et al., 2024). However, variations in rainfall will undoubtedly impact sugarcane production. In Fiji, rainfall is a key component of sugarcane production. Cane output is impacted because El Niño and La Niña have a major impact on rainfall, subsequently affecting the South Pacific Convergence Zone's position and intensity (SPCZ) close to Fiji. According to published sources, the sugarcane industry in Fiji collapsed for causes other than climate change (Jai Gawander, Salinger, Jyotika Prasad, Rounds, & Renil Kumar, 2018).

The peculiarities of Fiji's land tenure system are among the most often mentioned concerns. The Agriculture Landlord and Tenant Agreement (ALTA) began issuing non-renewable 30-year leases to farmers in 1967 (Singh, 2020). Sugarcane output has plummeted for several reasons: a fall in output prices; a rise in production costs (including chemical fertilizers, transport, and harvesting); a reduction in cultivated hectares due to land leases not being renewed; workforce scarcity; and growing animosity among sugarcane growers and the industry (Singh, 2020). Additionally, there has been a persistent scarcity of laborers since 1999, even though there has been a significant decrease of over 50% in sugarcane yield due to the younger generation losing interest in working on sugarcane farms. As a result of the sugar industry's downturn, Fijian farmers are looking for work in fields other than sugarcane and diversifying their crop production. Consequently, many sugarcane farmers have sought out simpler and higher-paying employment in Fijian and international urban centers during the last two decades. Nowadays, most sugarcane fields are farmed by middle-aged and older farmers. Their offspring, who are more equipped for white-collar employment, leave to attend college. As a result, farmers in their mid- to late-life do not feel safe enough to pass their farms on to their children and grandchildren. The sugar sector is currently facing a crisis due to its unresolved issues, especially those involving sugarcane farmers (Dean, 2022). The sugar sector in Fiji has a bleak future, and small-scale producers are growing more vulnerable to climate change due to budgetary constraints to implement realistic strategies to mitigate these impacts (Eshetu, Johansson, Garedew, & Yisahak, 2021). This calls for immediate action to strategize and come up with positive solutions to revive the rewarding sugar industry amidst climate change.

2.3. Fiji's Sugar Industry and Global Warming

Rising emissions from developing economies have been the primary driver of the worldwide trend toward steadily increasing GHG emissions since the new century began. Greenhouse gas concentrations in the atmosphere have increased as a result, making the Earth's inherent greenhouse effect much more pronounced, which may have detrimental effects on life. Fiji's role in human-induced (anthropogenic) global warming is negligible owing to its limited geographical size and low degree of development. Despite these constraints, Fiji must continue to participate in global initiatives to prevent the most catastrophic cases of climate change (Duarte, 2024). According to the current climate trend in Fiji, it is projected that the temperature will rise by about 0.9 °C by 2050 and 1.5 °C by 2100, respectively (Igbal, 2022). In accordance with Agrawala et al. (2003), this predicted consequence shows how climate change affects several sectors, such as water and food security, reef and fishery production. According to theoretical estimates based on data acquired from the EDGAR database, Commission et al. (2024) project a total Greenhouse Gas Emissions (CO_2 equivalent) for Fiji Islands in 2023 of 3.40 M/t CO_2, an increase of 1.19 M/t compared to 2.21 M/t carbon dioxide in 1990. These figures reveal that over the span of three decades, a 65% increase in greenhouse

gas emissions has been noted from Fiji Islands. The alarming figure illustrates that anthropogenic activities are contributing to climate change, and an increase is expected over the coming years. Tropical cyclones (TCs) are prevalent in the Fiji Islands and may bring catastrophic winds, coastal erosion, seawater inundation, flooding, and rain (PCRAFI, 2011).

The destruction and loss brought on by global warming is a serious risk to the Fiji Islands. This section highlights the difficulties faced by rural sugarcane farming communities in Indo-Fiji in reducing, avoiding, and dealing with loss and damage caused by cyclones (Nand, Bardsley, & Suh, 2023). Tropical cyclones and other forms of severe weather may disproportionately affect the South Pacific (Esler, 2016; Magee, Verdon-Kidd, Kiem, & Royle, 2016). According to the PCRAFI (2011) report, the damage from tropical cyclones and earthquakes is estimated to cost Fiji an annual average of 79 million USD. Fiji has a 50% likelihood of suffering a loss of more than 750 million USD and more than 1,200 fatalities in the next 50 years, and a 10% likelihood of suffering a loss of more than 1.5 billion USD and more than 2,100 casualties. Recently, tropical cyclones and other forms of natural disasters in the Pacific Island Countries have had devastating effects on people's lives, homes, livelihoods, ecosystems, services, and vital infrastructure (Esler, 2016). The low-lying atolls of Fiji make it susceptible to cyclones and floods. Fiji has previously suffered climatic events whereby tropical cyclones near the coast cause sea flooding. Seas from deep depressions and high-pressure systems have also flooded low-lying coastal regions.

Figure 5 demonstrates the substantial effect of natural catastrophes on the agricultural industry in 2016. This year exhibits a significant decrease in agricultural production, with the sector seeing the most substantial fall relative to previous years. This decline may be ascribed to the catastrophic impacts of natural disasters, such as cyclones and floods, which harmed crops, interrupted agricultural operations, and resulted in extensive losses. The graph underscores agriculture's susceptibility to natural catastrophes, highlighting the need for enhanced disaster planning and resilience policies within the industry.

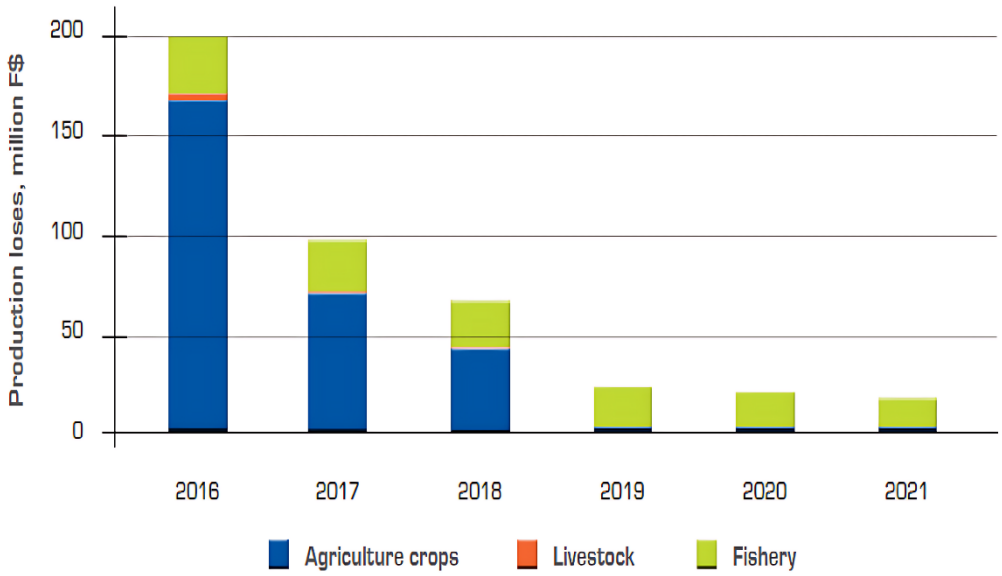

Figure 5. The agriculture sector's projected production losses over time.

Source: Esler (2016).

The figures above elucidate that the agriculture sector has been greatly impacted due to climatic events over time. The production cycle, which includes sugarcane planting, production, and quality of sugarcane, was all impacted by unfavorable weather, which included extended periods of drought and unexpectedly heavy rains throughout the most important parts of the growing season. The crushing season in 2023 yielded 139,628 metric tons of sugar from 1.57 million metric tons of sugarcane, a decrease in production in comparison to past years (Corporation, 2024).

2.4. Agronomic Practices to Mitigate Climate Change in Sugarcane farming

The sugarcane industry is actively promoting a variety of sustainable practices to solve production difficulties and ensure a more sustainable future. The development of integrated soil fertility management is a crucial strategy for the sustainability of sugarcane production in Fiji.

One issue with sugarcane harvesting is the process of burning the cane. The methods of harvesting, however, are fundamental to both the harvest and the harvesting issues. Sugarcane is typically harvested in two main ways: green and burnt. While the former involves burning sugarcane fields prior to manual cutting, the latter makes use of mechanized harvesters. The green harvesting method yields sugarcane that is fresh, while the burnt harvesting method yields sugarcane that is burnt. It should be noted that "green" in this context only means sugarcane that has not been burned, and not sustainable techniques. Sugarcane burning is known to cause environmental difficulties, according to several reports (Junpen, Pansuk, & Garivait, 2020).

There is a great quantity of smoke produced when sugarcane is burned, which greatly affects the environment. When a lot of different gases are released during the pre-harvesting of sugarcane fields, particularly greenhouse gases (GHG), they are emitted into the air and have a negative effect on the ecosystem. According to theoretical estimates (CHAND, 2023), the burning of cane might give off carbon dioxide at about 23M/t per acre. Consequently, the phenomenon of climate change will be greatly impacted, whereby many harmful gases, including methane (CH4), nitrous oxide (N2O), and carbon monoxide (CO), are discharged into the air because of burning. Therefore, the atmospheric chemical composition changes, and the environmental quality is affected by the emission of these gases.

Without a doubt, human actions, namely the release of greenhouse gases, are responsible for global warming. Enhancing the accuracy of event projections linked to climate change while expanding our understanding of how to solve climate-related difficulties may be achieved through policies that prioritize adaptation, mitigation, and comprehension of climate change (Gounder, 2024). Recent research has shown that sugarcane and further processes involving plants are crucial in decreasing carbon dioxide emissions (CO2), which helps to mitigate the impacts associated with climatic change. Plant stone carbon, also known as phytolith obstructed carbon, describes this. Plant stone carbon has prevented the annual loss of approximately 300,000,000 metric tons (Mt) of CO2 in the atmosphere for thousands of years (Kumar, Singh, Thakur, Meena, & Rai, 2022). The sugarcane industry is actively promoting a variety of sustainable practices to address production difficulties and ensure a more sustainable future. The development of integrated soil fertility management is a critical strategy for the sustainability of sugarcane production in Fiji. To lessen their reliance on synthetic fertilizers—which degrade soil and cause pollution—farmers are being incentivized to use organic fertilization techniques like composting and green manuring (Msomba, Ndaki, & Joseph, 2024). Farms in Fiji are often set on fire to harvest sugarcane, and the sugarcane is transported there by road and rail after harvesting (Chandra, Hemstock, Mwabonje, De Ramon N'Yeurt, & Woods, 2018).

In most parts of the world where sugarcane is cultivated, sugarcane is "burnt" harvested, while the remaining crops are "green" picked, with waste being either burned later or left in place to serve as mulch (Pereira, Chagas, Dias, Cavalett, & Bonomi, 2015). According to Mendoza (2017), studies revealed that increased carbon sequestration may be achieved by cultivating sugarcane without tilling the soil and keeping straw on top of the soil. Soil is improved in physical, chemical, and biological ways by composting sugarcane debris rather than by burning it (Galdos, Cerri, & Cerri, 2009). Research has shown that keeping sugarcane crop leftovers in the soil instead of burning them might lead to a rise in soil carbon levels, possibly two grams per kilogram (ranging from 0 to 200 millimeters) after six years (Robertson & Thorburn, 2007). Soil organic carbon reserves below the 0.1 m layer were found to have increased with an annual rise of 0.93 metric tons of carbon dioxide in the Brazilian state of São Paulo after 14 years of green manuring, as reported by researchers (Machado Pinheiro et al., 2010). Thus, substantial biomass of sugarcane in both the upper and lower soil levels may significantly sequester carbon, aiding climate change mitigation in the sugar industry.

There have been major shifts in the sugarcane cultivation process in the last few decades, moving away from environmentally damaging human harvesting and toward more sustainable mechanical collecting methods. Both agronomic and ecological considerations suggest that this green harvesting method is preferable (Carvalho et al., 2017). Soil compaction, a serious problem in sugarcane production, has resulted from the growing use of technology during mechanized harvesting and transportation (Cherubin et al., 2016). By contrast, annual crop soils are better protected against physical degradation by conservation tillage (also known as reduced tillage) when used in lieu of conventional tillage. The reason being, while most of the land is still under crop cover, soil disturbance is kept to a minimum, particularly in the planting rows (Blanco-Canqui & Ruis, 2018). Conservation tillage has been shown to improve soil biological processes, nutrient cycling, carbon capture and storage, erosion inhibition, and crop output. The advantages, especially in terms of carbon sequestration and agricultural productivity, might vary in magnitude depending on environmental variables, soil composition, and other management strategies (Sun et al., 2020). Modern technologies like automated traffic management and pre-sprouted plant transplantation may reduce disturbance of the soil during sugarcane planting. Consequently, there is a greater chance of soil carbon accumulation, and greenhouse gas emissions (GHGEs) will be reduced. Another way to reduce greenhouse gas emissions is to stop using tillage while growing sugarcane (Pande & Moharir, 2023). Research into the transformation of biomass into biochar and biofuel, which are products of added value, is receiving a lot of attention around the globe. Causes for this include increasing demand for energy, concerns about global soil deterioration, and emissions of greenhouse gases (Wani et al., 2023). Biochar, made from animal excreta, municipal waste, and waste from agriculture, is a fine-grained, porous C-nacreous substance that is pyrolyzed at 350–600 °C without oxygen (Wani et al., 2023). Literature has highlighted the benefits of biochar technology, particularly for soil carbon sequestration (Ghosh & Maiti, 2021; Layek et al., 2022). Pyrolysis-produced sugarcane bagasse biochar is eco-friendly and durable. It boosts cane, sugar, and total theoretical recoverable sucrose (TRS). Biochar increases soil carbon, improves permeability and aeration, and provides nutrients for sugarcane (Lima & White, 2017).

One way to increase yields and restore Soil Organic Carbon (SOC) in soils that have been depleted

Selected text in Word: is via integrated natural management (INM). Sugarcane is an exhausting crop that grows for an extended period of time; thus, it needs a lot of nutrients from the soil to thrive (Dang, Verma, & Pannu, 1995). By optimizing the benefits, integrated nutrient management ensures that soil fertility and the plant distribution of nutrients remain optimal for sustaining the desired output from all possible sources of organic, inorganic, and biological components in an integrated way. Consequently, to improve soil quality, it is essential to grow high-biomass crops over an extended period, such as sugarcane. This is because these soil physical, chemical, and biological properties are affected by crop types, which in turn impact the dynamics of nutrients and moisture, as well as the behavior of roots (Srivastava et al., 2018). Integrated Nutrient Management seeks to maximize crop yields while minimizing soil erosion and maximizing the utilization of both natural and artificial soil nutrients. Integrative Nutrient Management seeks to maximize nutrient consumption on a crop-rotation or crop-system basis rather than concentrating on nutrition management strategies for a single crop. Because of this, farmers are more likely to consider the long-term effects on the environment and to prepare accordingly. A number of factors contribute to nutrient management, including fertilizer type, application rate, timing, and positioning (Fiji, 2020). This integrated method maintains soil and crop production, soil health, carbon storage, and nutrient availability (Umesh, Kumar, Alam, Sinha, & Verma, 2013).

Research conducted by Udayakumar, Basker, Bakiyathu Saliha, and Jemila (2017) has shown that ratoon sugarcane, in conjunction with other materials such as bio-fertilizers and bio-compost, may be treated using a mixture consisting of 350–375 kilograms of nitrogen, 100–150 kilograms of potassium hydroxide, 150 kilograms of potassium hydroxide, and fifty kilograms of iron sulfate per hectare. This mixture improves soil fertility and stimulates nutrient absorption. To improve soil carbon levels and reduce the yield gap between actual and future yields, sparingly use chemical fertilizers with organic manures. Utilizing specific on-farm resources and the integrated management of

nutrients method may improve soil quality and sequester organic carbon components, which is beneficial for sugarcane farming (Kaur, Brar, & Dhillon, 2008). Diversifying livelihoods, implementing technological solutions like sea barriers or robust crop varieties, changing resource use, and relying more on social networks are among the adaptation techniques highlighted in Loss and Damage research (Monnereau & Abraham, 2013; Warner & Van der Geest, 2013). The Fijian government in 2021 spearheaded and passed a bill on the Climate Change Act, which focused on establishing a systematic strategy to combat climate change (Government, 2021). One of the promising policies formulated because of the Climate Change Act 2021 was REDD+, an initiative to reduce greenhouse gases from forest destruction and forest degradation. It is part of a system that measures, reports, and authenticates greenhouse gas emissions in the country, among other projects to safeguard the agricultural industry and promote sustainability. According to the Sugar Institute of Research annual report (Fiji, 2020), in order for the mills to produce high-quality sugar, varieties are crucial. The Sugar Research Institute of Fiji (SRIF) is committed to maintaining its breeding program of early maturing, disease-resistant, high-sugar, drought-tolerant cultivars. The traits are shared by the new varieties Viwa and Qamea. When compared to Qamea, which matures early and grows rapidly, Viwa is ideal for mechanical harvesting because of its intermediate to late maturity. Drought-resistant varieties were engineered to enhance the sugar production need despite the unfavorable climatic conditions.

3. CONCLUSION

Recent years have witnessed a drop in Fiji's sugarcane yield, a century-old industry. Low market growth and a conglomeration of ecological, geopolitical, economic, and other causes have contributed to this decline. Farmers experience instability due to climate change, which has increased droughts and other extreme weather events. To safeguard the Fijian sugarcane industry, productivity and environmental sustainability must be improved through targeted interventions. The sustainable agriculture policy should reward farmers who adopt climate-resilient crops and practices. Research into new sugarcane varieties with high yields and resistance to climate change, as well as innovative farming techniques, could boost output while reducing negative effects on the environment. Climate resilience could be enhanced by training integrated managers and practicing conservation agriculture among farmers. Sustainable farmers may reduce the impact of climate change on their sector by sequestering carbon from the atmosphere and storing it in the soil. Conserving tillage, employing sugarcane bagasse biochar, retaining crop residues, and rotating crops may increase productivity and profitability. Integrated nutrient management should be promoted to enhance soil health and agriculture. Sustainable sugarcane production in Fiji requires a balanced environmental and agricultural approach. Infrastructure and logistics will help farmers earn fair prices and remain in rural areas. Through comprehensive sustainability evaluations and life cycle assessments, sugarcane farming must integrate with various ecological land uses and benefits. A tracking and analysis system strategy execution will keep policies effective and adaptable. A strong sugarcane production system may help Fiji overcome climate challenges and preserve its agricultural tradition and farmers' livelihoods. These concrete steps may assist policymakers and business partners in reviving the Fijian sugarcane sector and ensuring its sustainability and resilience despite ongoing issues. This comprehensive plan benefits farmers and Fiji's economy.

4. RECOMMENDATION

To lessen the effects in the medium to long term, Fiji Sugar Corporation has recommended, with the backing of the Sugar Research Institute of Fiji, that they implement measures related to drainage, additional irrigation systems, innovative weed control, and soil management of nutrient technologies. Reducing the effects of climate change will need substantial investment in drainage infrastructure to overcome the harvesting of sugarcane during adverse weather conditions. To combat climate change, the Ministry of Agriculture Fiji, along with Fiji Sugar Corporation, must thoroughly engage with farmers to raise awareness and educate them on sustainable growing practices. Reviving Fiji's sugar sector would need a concerted effort from all parties involved in highlighting the urgent issues

arising from climatic events via strategic planning and implementation. Further research is needed to develop varieties more adapted to various weather patterns with high yield.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The author declares that the manuscript is honest, truthful and transparent, that no important aspects of the study have been omitted and that all deviations from the planned study have been made clear. This study followed all rules of writing ethics.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

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