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BAGASSE FIBER AS A SUSTAINABLE PACKAGING: A CASE STUDY OF KISUMU COUNTY, KENYA

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ABSTRACT

Background: Growing worldwide demand for environmentally friendly and sustainable materials has prompted a re-evaluation of traditional raw materials used in various industries, particularly in packaging production. Bagasse-based packaging holds significant potential for Kenya. Bagasse has attracted a lot of interest because its eco-friendly, compostable, and is cost-effective, making it a good substitute for conventional plastic and paper-based packaging (Kumar et al., 2021). **Problem:** Seventy five percent (75%) percent of bagasse goes to waste and is dumped in the fields. (Verte Environmental Solutions 2021). This dumped bagasse poses great environmental concerns as the juice from the bagasse's 'leachate' destroys the quality of water in wells and rivers and burns crops in nearby farms (Atieno 2022). Furthermore, the Government of Kenya imposed a ban on plastic bags in 2017, which forced businesses to seek alternative packaging solutions such as bagasse. **Objective:** The main objective of the study was to assess the current state of the packaging industry in Kenya and establish the gaps that could be filled with alternatives such as bagasse. **Design:** the study adopted a qualitative research design relying on semi- structured interviews. **Setting:** the study was carried out in Kisumu County in Kenya. **Subject:** The subjects of this study were key stakeholders in the packaging industry in Kisumu including manufacturers, suppliers and distributers of packaging materials. **Results:** The data suggests Kisumu's industry is at a tipping point; reliance on paper reflects a makeshift post-ban fix, not a solution. High demand exceeds supply capacity, creating a niche for bagasse to bridge durability and sustainability gaps. **Conclusion:** The study concluded that The Kenyan packaging industry is experiencing a growing demand for sustainable alternatives, yet it remains overly reliant on traditional materials like paper

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and plastic. Bagasse emerges as a viable eco-friendly solution, particularly for food packaging, due to its biodegradability, renewability, and durability.

Keywords: Bagasse, Sugar Mills, Packaging, Sustainable, Design

INTRODUCTION

Innovation in the packaging sector has been fuelled by increased concerns about environmental sustainability and plastic litter, leading to the adoption of biodegradable and renewable materials. One such material is bagasse, the fibrous by-product of sugarcane processing. Bagasse has attracted a lot of interest because of its eco-friendly, compostable, and cost-effective properties, making it a good substitute for conventional plastic and paper-based packaging (Kumar et al., 2021). With increasing global regulations restricting single-use plastics, businesses are exploring bagasse-based packaging solutions for food containers, trays, and disposable tableware (Singh et al., 2023).

Bagasse is highly valued for its biodegradability and sustainability. Unlike petroleum-based plastics, which take centuries to decompose, bagasse products break down within a few months under proper composting conditions (Sharma & Gupta, 2022). Additionally, its production requires less water and energy than traditional paper-based alternatives, reducing the overall carbon footprint (Patel & Mehra, 2024). The material's natural heat resistance and durability further improve its effectiveness for use in food packaging applications, particularly in fast-food and takeaway industries (Li et al., 2021).

The need for biodegradable and ecological packaging on a worldwide scale continues to rise, encouraging manufacturers to invest in bagasse-bas

Figure 2.1.1: Sugarcane Plantation by Benjamin Freeman Kolley



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innovations. However, challenges such as limited large-scale production, cost concerns, and consumer awareness remain obstacles to its widespread adoption (Rodriguez et al., 2023). Ongoing research focuses on improving strength, coating technologies, and scalability to make bagasse packaging more competitive against traditional packaging materials (Zhang & Wang, 2025).

This paper explores the current advancements, benefits, and challenges of bagasse in the packaging industry, with an emphasis on sustainability, economic feasibility, and regulatory impacts. By analysing recent developments, this study highlights the potential of bagasse-based packaging as a key solution in reducing plastic waste and promoting circular economy practicesin Kenya.

OBJECTIVES

This research aimed to examine the potential of bagasse fibre as a raw material for packaging production in Kisumu, Kenya. Specifically, the study was:

1. To assess the current state of the packaging industry in Kenya
2. To establish the gaps that could be filled with alternatives such as bagasse.
3. To identify the applications of bagasse-based packaging.

Figure 2.1.2: Bagasse by Modern Art Aesthetic



THEORY

Bagasse is a by-product of the sugar industry. After the sugarcane is squeezed out using a press, a fibrous residue that contains cellulose and lignin is left behind. Bagasse is produced in vast quantities during the large-scale industrial manufacture of cane sugar; its yield varies based on the sugarcane variety and pressing conditions, but it typically represents 25% to 30% of the sugarcane's weight.

The Sugar Industry

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Globally, the production of sugar is an essential agricultural sector that provides a necessary component for a variety of consumer goods. Sugarcane and sugar beets are grown and processed in nations all over the world. From the expansive fields in India and the US to the tropical plantations of Thailand and Brazil. According to Sagarbi et al. (2023), this industry not only caters to the increasing demand for sugar across various sectors such as food and beverage but also provides employment opportunities and contributes to the economies of many nations (wisevoter.com).Today, "sugarcane is grown mainly in four districts in Kenya: Nyanza, South Nyanza, Mumias, and Busia. The area under cane is currently 120,000 hectares, producing between 400,000 and 500,000 tonnes annually" (Kabeyi, 2022). The rest originates from large plantations, while about half is generated on smallholdings. About 250,000 metric tons (42%) of the estimated 600,000 metric tons of sugar produced annually in Kenya are produced by Mumias Sugar Company Limited, the country's largest sugar manufacturer. According to www.tuko.co.ke, "Butali Sugar Mills is the second-largest sugar-producing factory in Kenya, with a market share of about sixteen percent (16.07%). The mill was established in January 2011, and has a capacity of 2,500 tonnes crush capacity per day (TCD)." (Ruto, 2024).The sugar industry in Kenya generates 2.4 million tons of bagasse annually, according to Verte Environmental Solutions (2021). Atieno (2021) observes that despite the fact that bagasse can be utilized to generate power (cogeneration), paper production, composting, and as a raw material for other industries, only a small proportion is actually utilized.

The Current State of Bagasse Utilization

One hundred percent (100%) of the energy produced by sugar mills in Brazil comes from sugarcane bagasse, with any extra energy being sold back to the grid. However, barely fifteen percentage (15%) of sugarcane's potential for producing electricity, known as bioelectricity, is being used. (Sagarbi Et Al 2023) According to Britannica and CourseHero, in the Middle East and other sugar-producing countries with limited forest resources, bagasse is a crucial raw material for producing pressed building board, acoustical tiles, and other construction materials. Additionally, bagasse can be utilized to

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produce a variety of biodegradable polymers (Britannica; CourseHero, n.d.). Furfural, a clear, colorless liquid that is used to generate chemicals like solvents, nylons, and even medications, is another product made from bagasse. Nationally, "bagasse and bagasse residue are primarily used as a fuel source for boilers in the generation of process steam" (Kabeyi, 2022). By utilizing bagasse to generate electricity and steam, the sugar industry has the potential to produce excess electricity beyond its internal needs. However, Kenyan sugar firms have been unable to fully utilize energy sourced from bagasse due to legal regulations and other restrictions on the sale of electricity among other things. As a result, excess bagasse is currently treated as waste (Kabeyi, 2022).

Packaging in Africa

Africa, especially in West African nations, experiences the highest birth rates of any continent, where, according to the Brookings Institution (2020), "on average, one woman bears 7.2 children." This rapid population growth is expected to increase the demand for food and consumer products, which may subsequently lead to a rise in packaging needs. This trend is especially evident in Fast-Moving Consumer Goods (FMCG), defined by McKinsey (2019) as "consumer goods that are purchased frequently, at low prices, sold in large quantities, and have a short shelf life." Food products constitute the largest share, accounting for fifty percent (50%) of all packaged goods in the North American market, while the growth of beverage packaging has slowed. This decline is partly due to decreasing consumption of soft drinks or carbonated beverages, driven by health concerns (Chiang Mai University, 2021).

Packaging in Kenya

The demand for Kenya packaging bags is anticipated to experience a CAGR of about five percent (5.3%) between 2020 and 2026. The rising demand for plastic and paper packaging bags stemming from sectors such as food and beverages, home care, personal care, pharmaceuticals, and consumer goods is stimulating the advancement of the Kenyan packaging bag market. Furthermore, expanding disposable income coupled with an expanding retail sector has further propelled this trend. Moreover, advancements in technology have enabled flexible wrapping solutions that make it easier to carry items without fear of damage

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or contamination. This factor is also anticipated to contribute significantly towards market growth over the forecast period. Furthermore, government initiatives promoting eco-friendly products have increased the availability of biodegradable bagasse, which is likely to benefit the industry in the future years ahead. (6w research 2023)

Because more people have access to the internet, Kenya has developed to become the third largest e-commerce industry in Africa, which attracts investment. According to Business daily Africa (2024), "Kenya ranks third in the continent's e-commerce market penetration at 46.7%, behind Egypt (55.4%) and South Africa (49.4%)." The convenience and growth of M-Pesa contributed significantly to Kenya's e-commerce expansion. (https://www.propakeastafrica.com)

The demand for Kenya's flexible packaging was predicted to rise at a CAGR of 3.60% between 2023 and 2033. This rise was owed to the expanding demand for convenient and sustainable packaging solutions in various end-user industries, particularly in the food and beverage sector. As stated by Kenya Forecast (2024). The increasing use of advanced printing technologies for product distinctiveness, the expanded usage of eco-friendly materials like paper and bioplastics, and the incorporation of smart packaging solutions to improve traceability and decrease food waste are some of the major market trends.

International Exemplars of Bagasse in the Packaging Industry

The global shift toward sustainable packaging has spotlighted bagasse, a fibrous sugarcane byproduct as a viable alternative to traditional materials like plastic and paper. Its adoption in various international contexts offers practical lessons for its potential application in Kisumu, Kenya, where sugarcane abundance and sustainability demands align.India, a leading sugarcane producer (approximately 350 million tons annually, FAO, 2023), has pioneered bagasse-based packaging since the early 2010s. A 2024 study by Dulal et al., (2024) explored the feasibility of manufacturing biodegradable tableware from sugarcane bagasse in India. The research emphasized lean manufacturing processes, cost-effectiveness, and environmental benefits, proposing bagasse as a viable alternative to Styrofoam in food packaging. Yash Pakka, based in Uttar Pradesh, exemplifies this trend,

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producing compostable tableware and food packaging from bagasse since 2012. By 2022, the company reported exports to over 40 countries, displacing 15,000 tons of plastic annually (Kumar et al., 2021). Key to its success are proximity to sugarcane mills reducing transport costs and government subsidies under India's National Biofuel Policy, though high initial investment remained a challenge.

Brazil: As the world's top sugarcane producer (746 million tons in 2022, FAO), Brazil leverages bagasse for industrial packaging, notably through Klabin, a major pulp and paper firm. Since 2015, Klabin has integrated bagasse into corrugated boxes and trays, achieving a 30% reduction in waste by 2020 (Rodriguez et al., 2023). This success hinges on Brazil's circular economy policies, including tax breaks for sustainable materials, and a robust sugarcane supply chain.

In 2022, a study conducted by the Federal University of Jequitinhonha and Mucuri Valley proposed the production of new bio-packing materials using sugarcane bagasse and recycled PET bottles. The research focused on applications in the agroindustry, particularly for transporting agricultural products. The developed materials were defined by their thermal, chemical, morphological, mechanical, antifungal, and hydrophobic qualities, demonstrating potential as sustainable alternatives to conventional packaging.

In Australia, Queensland, EcoPak has produced bagasse-based clamshell

Table 2.4.3: The top ten bagasse-based packaging manufacturers globally, by Sumkoka.

Position	Brand Name	Year of Establishment	Location
1.	Sumkoka	2012	China
2.	Vegware	2006	UK
3.	Bio & Chic	2010	USA
4.	Bio Futura	Over 10 years	Netherlands
5.	Takeaway Packaging	Over 30 years	UK
6.	Green Paper Product	2009	USA
7.	Kingdom Coffee	1998	UK
8.	Canada Brown	2018	Canada
9.	Duboxx	2016	UAE
10.	Kalyani Materials & Co.	2011	India

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containers for food service since 2018, capitalizing on Australia's growing eco-conscious market. These products offer a 50% faster biodegradation rate than Styrofoam (Patel & Mehra, 2024), EcoPak's output, however, is constrained by limited bagasse availability beyond sugarcane regions. Australia's success in marketing bagasse as a premium sustainable option suggests results from targeted awareness campaigns.

The 2024 Finefood Australia Fair showcased innovative bagasse-based tableware products, including compostable cups, bowls, and containers. These products demonstrated enhanced durability, heat resistance, and suitability for various foodservice applications, reflecting Australia's growing interest in sustainable packaging solutions. sincerepacking.com_(Another notable innovation on display was the Fully Disposable High-End Container. Made from sugarcane bagasse, this high-end disposable container

is designed for upscale dining events. It combines aesthetic appeal with functionality, offering a sleek appearance while being robust enough to handle hot and oily foods. The container's eco-friendly properties align with the growing demand for sustainable dining solutions without compromising on quality (Sincere Eco Tech (2024).

Application of Bagasse-based Packaging Solutions

Tech Packaging

Technology can take many different forms, which is why bagasse is such a versatile material. Tech packaging can be square, cylindrical, rectangular, round, or fully customized to meet your demands.

Figure 2.4.4: Bagasse-based cell phone packaging, by Roo.



Cosmetic Packaging

Rooland (2022) maintains that "the cosmetic industry is the top offender of plastic waste, contributing to 120 billion units of plastic waste annually." The good news is that bagasse packaging may be used to create environmentally friendly cosmetics

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such as Lipstick, skincare, makeup, hair care, and so much more.

Figure 2.4.5: Bagasse-based cosmetic packaging, by yankodesign.com

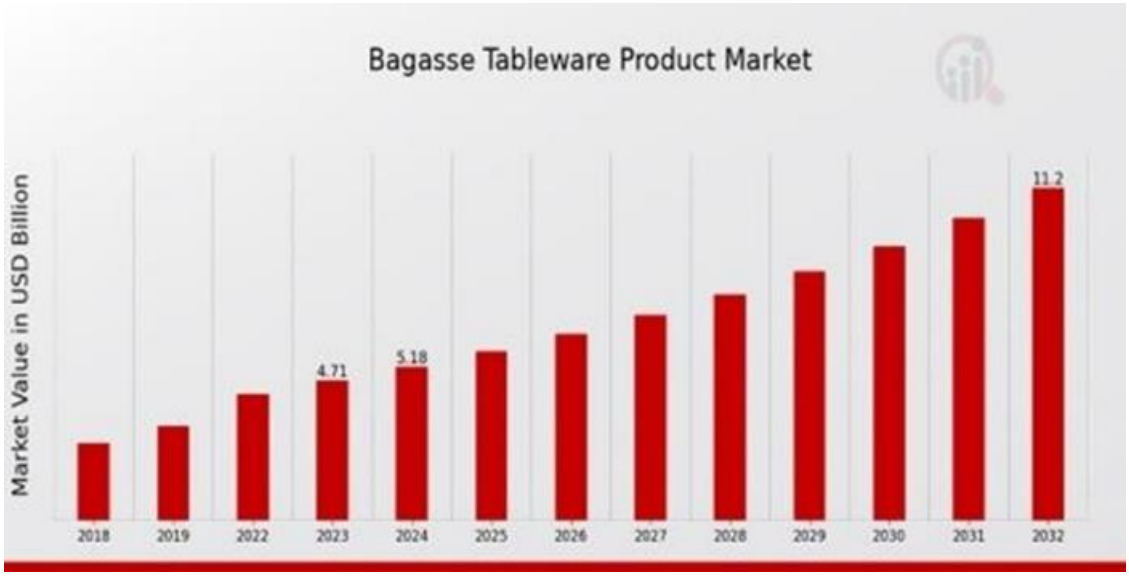


Food and Beverage Packaging

Bagasse tableware is most used in commercial settings like restaurants and food delivery because these businesses need disposable, eco-friendly products to meet customer demand and comply with plastic bans. Its durability, cost-effectiveness, and suitability for hot and greasy foods make it ideal for high-volume usage in the food service industry. Due to these factors, the commercial end-use is expected to capture more than 62% of the total market share over the forecast period.

The global bagasse tableware products market recorded a CAGR of 5.2% during the historical period between 2020 and 2024. Market growth of bagasse tableware products was positive as it reached a value of USD 2,962.0 million in 2024 from USD 2,392.3 million in 2020.

Figure 2.4.5: Bagasse-based cosmetic packaging, by Tejas Chaudhary.



Global sales of bagasse tableware products continued to grow from 2020 through 2024, with steady growth supported by increasing bans on

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AFRIDEJ VOL 2 ISSUE 1 OCTOBER 2025

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Figure 2.4.7: Bagasse based tableware, byupkgs.com

single-use plastics and rising environmental awareness. Demand for eco-friendly disposables from a growing foodservice industry in urban areas fueled expansion, but growth was limited by relatively high costs to broader adoption in emerging markets, with plates and containers leading the market. (FMI)

Apparel and Accessories Packaging

Fashion stores have a role to play in the fight against plastic, especially as more and more apparel and fashion adornments are being shipped to clients encased in a series of plastic packaging due to the growing popularity of online orders.

RayPax (2022) asserts that Gucci was one of the first luxury brands to embrace sustainability, having been utilizing recycled cardboard for its boxes since 2010. The writer further explains that by 2025, the apparel business PVH, which is the parent company of well-known brands such as Calvin Klein and Tommy Hilfiger, hopes to have all of its packaging sourced ethically and be environmentally conscious. Zara, a leading fast-fashion retailer, now ships its online orders in fully recycled cardboard boxes crafted from previously used store packaging. Their objective is to achieve zero waste across their stores, offices, and logistics centres by 2025. As pre Weavable's (2019) view, Pink Boutique is another fashion company making

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notable progress in sustainable packaging by replacing polythene shipping bags with an eco-friendly option made from sugarcane. RePack, a packaging service, is another project seeking to cut down on fashion waste by giving online retailers an easy way to deal with garbage.

The company collaborates with brands such as Filippa K and the eco-friendly denim brand MUD Jeans. It ships customer orders using reusable and returnable packaging available in three adjustable sizes. Durable and functional, the packaging is built to withstand at least 20 uses, Weavable (2019) further asserts.

Environmental Benefits of Bagasse-Based Packaging Manufacture

Bagasse management is the biggest challenge facing the sugarcane industry in the country. The bagasse contains high levels of cellulose, which makes it difficult to decompose quickly. Despite this, the rate of production remains high (Atieno, 2022).

Traditional papermaking involves pulping from hardwood or softwood trees, including pine, eucalyptus, fir, subabul, and others. Although the cellulose content of these trees is high and crucial for the production of paper, there are several significant problems with these conventional techniques, which are as follows.

According to Solanki et al (2024), each year, around 14% of deforestation happens to meet the high-growing demand of paper production, which is the main raw material for packaging production. Solanki further denotes that, major trees producing paper takes years to grow and each year the gap keeps increasing between demand and supply by significant margins for example-Eucalyptus (5 - 7 years), Pine (10 - 25 years), Poplar (6 - 10 years), Spruce (20 years), Acacia (6 - 10 years). Six tons of bagasse produce one ton of paper, while three tons of trees produce one ton of 30% reused wood fiber paper. This leads to a number of environmental problems such as deforestation, soil erosion, habitat loss, global warming, and disruption of the ecosystem.

Bagasse, a by-product of the sugarcane industry, is unquestionably a renewable resource. The source of bagasse, sugarcane, may be a renewable resource with a short development cycle that is collected on an annual basis. After being harvested, the stalks of the sugarcane undergo preparation in order to extract the

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juice, which is essential for the production of sugar. Bagasse is positioned as a lucrative and practical option for various uses due to its status as a renewable resource and its abundance as a by-product of handling sugarcane. Its enduring nature supports its use by companies seeking environmentally responsible alternatives to non-renewable resources.

In industrial facilities, bagasse products can be composted to break them down into organic

matter without releasing toxic pollutants into the environment.

An environmentally safe biodegradable solution.

Bagasse breaks down naturally, lessening the load on landfills and oceans, in contrast to plastic, which can remain in the environment for generations. In addition to its environmental benefits, sugarcane bagasse packaging offers economic advantages for businesses in that bagasse is plentiful and renewable, which lowers the possibility of material shortages and price fluctuations.

In addition to other paper products, bagasse packaging can be recycled, which further reduces waste and conserves resources. Brands that embrace sustainable packaging can attract environmentally conscious consumers and differentiate themselves in the market. (Fresh 2023)

FINDINGS

The study revealed that the market heavily relies on Khaki paper and cardboard as the go-to packaging solutions. Limited sustainable options were noted to be the biggest challenge ailing the packaging industry. The study further noted that there is an inconsistent supply of sustainable packaging materials, leading to a high cost of materials. These results are a reflection of the post-plastic ban shift, exposing a gap for locally available, affordable, and durable material, where bagasse could be a timely solution.

An increase in local production of eco-friendly packaging solutions, Awareness campaigns to address knowledge gaps, and the need for the government to support eco-friendly packaging initiatives in the country were some of the solutions proposed to fill the existing gaps in the packaging industry. Waste

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management systems were also noted as an area that needs to be looked into with keenness, since despite the ban on plastic packaging materials, waste management is still a nightmare for the City of Kisumu. These results indicate that Kisumu could leverage its most abundant resource, 'Bagasse', to increase its local production capacity of packaging solutions.

Since the existing packaging solutions are not sustainable, high demand for sustainable solutions, coupled with consumer-driven pressure signaling market readiness. The gap in sustainable options aligns with cost concerns, suggesting economic barriers temper enthusiasm.

Kumar et al. (2021) document a global shift to bio-packaging post-plastic bans, mirroring Kisumu's high demand, but Sharma & Gupta (2022) highlight cost as a universal adoption barrier, consistent with 44.4% here. Unlike urban India's tech-driven transitions (Patel & Mehra, 2024), Kisumu's sugarcane-rich context offers a localized advantage for bagasse, unexploited due to limited options.

The data suggests Kisumu's industry is at a tipping point; reliance on paper reflects a makeshift post-ban fix, not a solution. High demand exceeds supply capacity, creating a niche for bagasse to bridge durability and sustainability gaps. This is only possible if cost issues are addressed.

High consumer influence points to a demographic shift (e.g., younger buyers) a trend worth exploring further.

CONCLUSSION

The Kenyan packaging industry is experiencing a growing demand for sustainable alternatives, yet it remains overly reliant on traditional materials like paper and plastic. Bagasse emerges as a viable eco-friendly solution, particularly for food packaging, due to its biodegradability, renewability, and durability. However, limited awareness, high production costs, and a lack of strong policy support hinder its adoption. The feasibility of establishing bagasse-based production is promising, especially near sugar mills, with minimal sourcing challenges. Greater awareness and targeted incentives could bridge the gap between interest and implementation

RECOMMENDATION

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Based on the findings and conclusions of the papers, it is recommended that government should introduce subsidies or tax breaks for local manufacturers producing bagasse-based packaging to reduce production costs and encourage adoption.

It should also implement stricter regulations or taxes on non-biodegradable packaging materials (e.g., plastics and non-recycled paper) to create a competitive market for sustainable alternatives like bagasse.

Government should encourage Public-Private Partnerships for Local Production by fostering collaborations between sugar mills, packaging manufacturers, and research institutions to optimize bagasse processing and develop cost-effective packaging solutions.

It should also establish pilot projects near sugar-producing regions (e.g., Kisumu) to demonstrate the feasibility and economic benefits of bagasse-based packaging, addressing supply chain gaps.

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AFRIDEJ VOL 2 ISSUE 1 **OCTOBER 2025**

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