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Navigating between socio-economic viability and environmental impacts: The sachets and sticks paradox

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Abstract :

Sachets and plastic sticks, single-use packaging primarily constructed from polyethylene terephthalate (PET), have proliferated globally for their convenience and multilayered construction that ensures product integrity. Especially prominent in emerging markets and amplified by pandemic-driven demand for hygiene products, these formats contribute significantly to fossil fuel industry revenue, aligning closely with petrochemical infrastructure developments such as fracking. While providing producers risk mitigation and cost-effective branding opportunities, these packaging types impose significant environmental tolls. The multimaterial layered composition of these materials hampers recycling efforts, and incineration releases toxins, exacerbating pollution. The plastics industry thus becomes an economic support for fossil fuel sectors facing declining oil demand. The growth of this sachet-stick economy represents a precarious balance between immediate economic benefits and long-term environmental ramifications. As global attention increasingly turns toward sustainability and pollution reduction, it becomes crucial to analyze the true environmental and socioeconomic costs of sachet and stick packaging.

Graphical abstract

Highlights

► Sachet and stick packaging are rising in global markets due to cost-effectiveness. ► Multi-layered structures in sachets and sticks hinder recycling. ► Incineration of these materials increases toxic emissions and CO_2 levels. ► The Global South represents nearly half of the worldwide sachet market. ► Sachet-stick economic gains vs. long-term environmental sustainability.

Keywords : Single-use packaging, Polyethylene terephthalate (PET), Environmental impact, Recycling challenges, Sachet stick economy

The rapid proliferation of plastics since the early 20th century reflects a dichotomy between technological advancement and environmental deterioration. Initially, engineered for short-term applications, the unique attributes of plastics—namely, their plasticity, light weight, durability, and flexibility—have rendered them essential in modern commodities, particularly in packaging (Derraik 2002). However, these properties also contribute to the environmental persistence of these products, complicating waste management and exacerbating pollution (Andrady 2022; Williams and Rangel-Buitrago 2022). Amid this context, plastic production is experiencing an alarming rise, with 475 million tons produced in 2021 and an estimated 550 million tons projected for 2026, posing both an imminent environmental threat and a societal challenge warranting immediate attention (UNEP 2021).

The symbiotic relationship between plastic production and the fossil fuel industry accentuates the multidimensional challenges confronting the oil sector (Stubbins et al. 2021). Essential to plastic manufacturing, fossil fuels are embroiled in a labyrinth of issues that span economic, environmental, and regulatory landscapes. Economic vulnerabilities, such as market instability, anticipated declines in oil demand, and high capital requirements, are exacerbated by environmental factors such as climate change and the growing impetus for sustainable practices. In addition, regulatory hurdles, including stricter environmental legislation and carbon pricing mechanisms, exist. Technological constraints, manifested as outdated infrastructure and digitalization deficiencies, along with cybersecurity threats,

further complicate the situation. These technical and regulatory challenges are amplified by social and ethical considerations, such as public skepticism and workforce transition dilemmas, rendering the sector highly stressed on multiple fronts.

As governmental initiatives increasingly favor clean energy and achieve milestones in the electric vehicle and renewable energy sectors, global awareness of the environmental repercussions of fossil fuel consumption has also risen. This has led to incremental policy changes and a surge in renewable-energy investments (Geyer 2020). However, rather than shifting away from hydrocarbons, the fossil fuel industry regards plastics as an economic lifeline, complicating efforts to reduce or eliminate the production of such materials (Williams and Rangel-Buitrago 2022). In the context of a myriad of challenges facing the trillion-dollar oil and gas industry, many giants in the sector are strategically shifting their focus toward single-use plastic items, such as sachets and sticks.

Both packet types usually serve as single-use, premeasured systems for granular, liquid, or powdered products but diverge in several key aspects (Plastics Europe 2022). Sachets are generally flat, and pillow shaped with three- or four-sided heat or adhesive seals; they are versatile in their application, accommodating liquids, gels, powders, and granules but may be cumbersome to open. On the other hand, elongated and tubular sticks feature back seals along their length and heat seals at both ends; they are mainly used for many types of products, offering ease in directional dispensing. Furthermore, sachets require more storage space due to their shape but generally offer better product protection, while sticks are more space-efficient and portable due to their slender form. While both sachets and sticks serve the purpose of single-use packaging for various products, they differ in design, functionality,

and specific applications. The choice between the two depends on various factors, including the product to be packaged and the ease of use.

Sachets and sticks have become a focal point in modern packaging, aligning with consumer demands for portability and affordability, particularly in emerging markets where consumers may face financial constraints, enabling them to make low-risk, cost-effective purchases (Williams and Rangel-Buitrago 2022). Additionally, the pandemic further promoted the utility of these products, especially for hygiene products, solidifying their role in the global market (Rai et al. 2023).

These packaging forms are integral to effective grassroots marketing owing to their broad distribution reach and versatility. Technological innovations in the sector allow for enhanced features such as easy-tear or resealable options, while their small size and low shipping weight offer economic advantages for large-scale distribution, particularly in urban "grab-and-go" settings (Ancheta et al. 2019).

However, the environmental and public health implications of such widespread use cannot be ignored. These lightweight materials contribute to ecosystem pollution and increased flood and disease risks (Fig. 1). Despite legislative attempts to mitigate these impacts, companies often sidestep regulations to maintain this lucrative line.

In terms of litter management, the multilayered composition of sachets, made of inexpensive materials bonded by adhesives, renders them virtually unrecyclable (Royal Society Te Apārangi, 2019). This lack of recyclability leaves waste pickers with little incentive to collect these items, as they offer no subsequent utility or value. When incinerated, sachets emit toxic chemicals that may cause cardiovascular diseases and cancer (Ancheta et al. 2019). Leaving them to degrade naturally contributes to the escalating microplastic crisis; contaminating soil,

water, and food systems; and ultimately infiltrating human organs and even soil formation (human-made soils, which are composed of litter items such as glass, plastics, and rubber—anthrosol—or solely plastics—plastisol). Fig. 1, Rangel-Buitrago et al. 2022).

Fig. 1. The widespread use of single-use sachets and sticks for granular, liquid, and powdered products presents a significant environmental challenge. Their complex, multilayered composition makes them virtually irreversible, providing little incentive for waste collection. As a result of this disposal inefficiency, these items contribute to ecosystem pollution, elevate flood and disease risks and are a source of microplastic contamination. They adversely affect fauna, soil, water, and food systems and ultimately pose risks to human health through organ infiltration and soil pollution.

This issue is further compounded by the larger problem of plastic recycling inefficiency. Despite a 200-fold increase in annual plastic production since 1950, only approximately 9% of plastic waste has been recycled (UNEP 2021). This dismal rate underscores the complexity and costs associated with recycling materials such as sachets and sticks with multiple layers of differing substances that make them environmentally hazardous and challenging to manage in a sustainable manner.

Amidst declining global oil consumption, plastics, particularly sachet packaging, are increasingly vital for revenue generation in the fossil fuel sector (UNEP 2021; Global Alliance for Incinerator Alternative, 2020). Sachet packaging experienced 19% market growth in 2017 and is predicted to drive nearly half of the total oil demand growth through 2050 (Global Alliance for Incinerator Alternative 2020). Petrochemical plants, which process crude oil and natural gas, produce polyethylene and polypropylene pellets for sachets as part of a diversified portfolio that also includes products such as fertilizers and digital devices. Investment in petrochemical infrastructure has surged, particularly in countries such as India, China, and the U.S., where fracking has produced cheap shale gas (UNEP 2021). Approximately $209 billion has been invested in U.S. petrochemical projects over the past decade. This expanding production capacity incentivizes consumer-goods companies to produce more single-use sachets, exacerbating environmental sustainability challenges.

Sachets' diversification strategy is deeply rooted in material synergies. Sachets and sticks are primarily made from polymers such as polyethylene and polypropylene, which are byproducts of the oil refining process (Young 1987; Rudolph et al., 2017). By diverting these byproducts to sachet production, oil companies can optimize resource use, increasing operational efficiency. This material synergy is complemented by existing infrastructures for polymer production in oil refineries, thus mitigating the need for substantial additional capital outlays.

Supply chain dynamics bolster the viability of sachet production as a financial diversification strategy for oil companies. The logistical advantage of locating sachet production near existing oil refineries is that it minimizes transportation costs and enhances supply chain efficiency. In emerging economies, the high demand for sachets—attributed to their

affordability and convenience—translates to a stable revenue source for oil companies engaged in sachet manufacturing (Global Alliance for Incinerator Alternative 2020).

Sachet and stick production offers significant advantages in risk mitigation and branding. The broad sectoral applications of sachets—from cosmetics and food to pharmaceuticals—provide a hedge against downturns in any single market. Geographically, the global demand for sachets, particularly in developing nations, serves to further mitigate economic risk. Regulatory frameworks for sachet production also tend to be less stringent than those for oil extraction, making them operationally simpler diversification strategies. Additionally, the relatively low investment required for integrating sachet production can yield a high-volume revenue stream, thereby making a compelling case in industrial cost–benefit analyses.

In 2018, an estimated 855 billion sachets and sticks were produced globally, of which only 10% were collected and recycled (Ancheta et al. 2019; Global Alliance for Incinerator Alternative 2020). The projected growth rates suggest that this number could increase to 1.3 trillion by 2027. This surge in production aligns with an overall increase in plastic consumption in developing economies. The Global South represents nearly half of the worldwide sachet market, with further growth anticipated. Specifically, Southeast Asia constitutes approximately 50% of this market.

In a country such as the Philippines, yearly plastic production is estimated at 3 million tons, with sachets accounting for 52% of this total (Ancheta et al. 2019). Daily usage is estimated at 164 million sachets, translating to nearly 60 billion annually (Global Alliance for Incinerator Alternative 2020). Given that 16% of the country's population lives below the poverty line, sachets and sticks, particularly for products such as shampoo, are marketed as affordable alternatives for low-income citizens. Priced at approximately $0.7, a sachet costs

less than a tenth of its bottled counterpart. The country's unique geography, comprising 7,000 islands, compounds the challenge of effective waste collection and recycling.

Another example can be observed in Colombia, where the average plastic consumption per person is 24 kg annually (Rangel-Buitrago et al. 2019). In this nation, the use and consumption of plastics are increasing at a rate of 24.2% annually (Rangel-Buitrago et al. 2021). Notably, 56% of this consumption comprises single-use plastics, surpassing the global average of 46% (Rangel-Buitrago et al. 2019 and 2021). A significant issue in Colombia is the prevalent use of sachets for cleaning products. These sachets, often found along beaches, are a major source of pollution. The majority are made from plastic #7 – Other (BPA, polycarbonate, and LEXAN), a category encompassing polycarbonate (PC) and various other plastics. This grouping lacks standardized reuse and recycling protocols. A primary concern with #7 plastics is the potential for chemical leaching from polycarbonate containers manufactured using bisphenol A (BPA), a xenoestrogen and known endocrine disruptor. Notably, #7 plastics are generally not suitable for reuse unless they are coded as PLA compostable, which is not common in Colombia. Like in the Philippines, these sachets are less expensive than their bottled counterparts are, facilitating their rapid market expansion and consumer adoption.

In 2018, the sachet-sticks packaging market was valued at US$7,796.1 million and grew to a market value of US$9,372.7 million in 2022, expanding at a compound annual growth rate of 4.7% (Global Alliance for Incinerator Alternative 2020). The demand for sachet/stick packaging remains stable, driven by its increasing utilization in a diverse range of products. Industries such as personal care, pharmaceuticals, home care, and food and beverages exhibit a strong preference for lightweight and compact packaging. Moreover, consumer lifestyles

characterized by a fast pace have augmented the demand for prepackaged and ready-to-eat products, further propelling the sachet packaging market.

Additional factors bolstering the market include the strategic use of sachets in promotional and advertising campaigns, rising personal disposable incomes, and a burgeoning urban population. A shift from conventional to advanced packaging techniques and an increasing number of retail industries are also expected to fuel growth in the market. Manufacturers increasingly favor sachet packaging due to its cost-effectiveness and utility in providing free samples that enhance brand awareness.

Regulatory efforts aimed at reducing plastic waste have been largely unsuccessful in curbing the rapid expansion of sachet and stick usage. Companies persist in exploiting legal loopholes, thereby prioritizing profit over environmental considerations. This calls into question both the effectiveness of current regulations and the commitment of corporations to social responsibility, especially in the realm of single-use plastics. The sachet economy is flourishing in developing economies, in part due to the absence of stringent environmental guidelines.

The environmental footprint of a single sachet, although often considered to be minimal, serves as an indicative case study for understanding the broader environmental implications within the fossil fuel sector. Current operating models within the oil industry suggest that the peak demand for plastic is likely to occur earlier than estimated owing to a societal transition toward circular economies (Williams and Rangel-Buitrago 2022). However, if this shift does not materialize as anticipated, projections indicate that annual global CO_2 emissions attributable to the manufacturing and incineration of plastics could increase to 2.8 gigatons by the year 2050 (Rudolph et al. 2017).

The sachet-stick economy poses a significant paradox in the context of global shifts toward sustainability (Global Alliance for Incinerator Alternative 2020). Although sachets offer immediate economic benefits, particularly to lower-income communities, their long-term environmental toll is cause for concern.

The sachet and stick problem demands a holistic approach that integrates shifts in consumer behavior, enhanced corporate responsibility, strategic policy enactment, technological innovation, and stringent industry standards. From a policy perspective, the following five aspects must be considered to eliminate, mitigate, or at least minimize this environmental issue:

Alternative Delivery Mechanisms: Endorsing Zero Waste retail outlets and refilling hubs aligns with the concerted efforts of the scientific fraternity to mitigate plastic pollution, with an emphasis on sachets and single-use plastics.

Extended Producer Responsibility (EPR) Framework: The advocacy for enforceable EPR regulations is congruent with international policy inclinations. This paradigm mandates that producers assume both fiscal and operational liabilities, catalyzing the conceptualization of environmentally benign products. Although the premise of this proposition is robust, its fruition is contingent upon meticulous legislative articulation and assiduous enforcement.

Corporate Transparency in Plastic Consumption: Ensuring transparency in corporate plastic consumption is imperative to gauge the magnitude of the challenge. Mandating such disclosures can engender a heightened sense of corporate responsibility, potentially steering entities toward environmentally sustainable practices.

Reassessment of waste-to-energy protocols: The complexities inherent to waste-to-energy methodologies, particularly the ecological ramifications of thermic procedures, warrant astute scrutiny. The proposition underscores the environmental limitations associated with specific disposal modalities and accentuates the importance of innovations that are effective at managing sachet waste in an ecologically responsible manner.

Sustainable Packaging Protocols: The promulgation of guidelines advocating sustainable packaging is instrumental in channeling industrial endeavors toward environmentally benign practices. Designating sachets as nonenvironmentally acceptable products (NEAPs) conveys an unambiguous directive to manufacturers. Concurrently, the transition away from sachets necessitates the ideation and assimilation of sustainable packaging alternatives that reconcile ecological integrity with economic feasibility.

Sachets and sticks exemplify the trade-off between immediate economic gains and long-term environmental repercussions. These products represent a strategic pivot for the fossil fuel industry but raise sustainability concerns. Amidst increasing environmental pressures, the reliance on plastics as a revenue source requires critical evaluation against the need for sustainable options. This issue extends to other rarely recycled, single-use plastic items, underscoring the broader environmental cost of such an economy.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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