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REVIEW

Sudanese Gum (SG): A Sustainable Resource for Rebuilding Sudan through Biotechnology and Innovation

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ABSTRACT

PURPOSE: This paper examines the multifaceted value of Sudanese gum (SG) as a natural polysaccharide with wide commercial applications, focusing on Sudan's position as a global leader in its production. This paper highlights how the strategic development of this sector can contribute to achieving multiple Sustainable Development Goals (SDGs) while addressing critical challenges in sustainable production, technological innovation, and fair economic benefits for rural communities.

DESIGN/METHODOLOGY/APPROACH: This study employs a mixed-methods approach, combining a literature review of SG's scientific properties, an analysis of Sudan's production data, and an evaluation of emerging biotechnological applications. Data were collected from academic sources, industry reports, and field studies conducted in Kordofan Province and internationally.

FINDINGS: This study identifies SG as an economic lifeline for rural Sudan and a versatile biomaterial with growing applications in food, pharmaceuticals, and advanced medical technologies. Biotechnology has the potential for yield improvement and drought resistance, while sustainable agroforestry practices have dual benefits for carbon sequestration and biodiversity. Systemic challenges, including taxation policies and limited investment in research and development, however, constrain sector growth.

ORIGINALITY/VALUE: This study provides a comprehensive analysis bridging SG's scientific properties with its socio-economic impact, offering novel insights into how this traditional commodity can drive modern biotechnological innovation. This uniquely positions SG at the intersection of sustainable development, advanced material science and pro-poor economic policy.

Research Limitations/Implications: Field data collection was limited by security challenges in the production regions. This paper addresses this gap by synthesising global research on Acacia species and conducting a comparative analysis with other natural gum economies.

PRACTICAL IMPLICATIONS: The findings support policy reforms for sustainable production, recommend R&D investment in value-added applications, and propose SDG-aligned strategies to maximise the contribution of SG to rural livelihoods, climate resilience, and Sudan's bio-economy. The framework is adaptable to other developing nations with similar natural-product economies.

KEYWORDS: *Acacia Gum; Tissue Engineering; Bio-Adhesive; Encapsulation; Probiotics; Enzymes*

INTRODUCTION

Sudan, a nation actively pursuing sustainable development following a period of prolonged conflict, possesses a valuable and often overlooked asset: Sudanese gum (SG) (Jaafar, 2019). This natural polysaccharide, primarily derived from Acacia senegal (ASN) and Acacia seyal (ASY) trees, offers significant potential to stimulate economic growth, enhance environmental sustainability, and foster social progress (Patel and Goyal, 2015). As the world's leading producer of SG, Sudan is uniquely positioned to leverage this resource for post-conflict reconstruction and contribute substantially to the achievement of multiple Sustainable Development Goals (SDGs) (Wani *et al.*, 2011). Therefore, the strategic development of the SG sector is crucial for Sudan's future prosperity. SG's widespread applicability across diverse sectors stems from its unique properties, including low viscosity, indigestibility, and excellent emulsifying and stabilising capabilities (Nemmar *et al.*, 2019). These characteristics make it a highly sought-after ingredient in the food, pharmaceutical, and cosmetic industries, as well as in various industrial sectors. SG is attracting increasing attention due to its potential in emerging fields such as nanotechnology, drug delivery, and tissue engineering (Jarrar *et al.*, 2021). SG's adaptability makes it a versatile biomaterial fostering Sudanese innovation.

The SG sector in Sudan is under-developed despite its economic importance. Systemic challenges, including outdated marketing systems, burdensome taxation, insufficient investment in research and development, and inadequate support for local producers, significantly impede the growth of the sector (Yousif *et al.*, 2018). Sustainable development strategies ignore SG's ecological impact (Akanbi and Adesina, 2024). Addressing these challenges is crucial to unlocking the full benefits of SG in Sudan. SG's potential for Sudanese sustainable development is analysed in this paper. The study covers SG science, Sudan's production, and biotech applications. This paper explores the socio-economic impacts of SG production, highlighting its role in poverty reduction, improved rural livelihoods, and economic expansion: we also investigate the ecological impact of SG production.

This paper analyses Sudan's SG sector and proposes a growth framework. This framework integrates biotechnological innovations, sustainable production methods, and strategic policy recommendations to maximise the economic, social, and environmental benefits of SG production.

SG PROPERTIES, APPLICATIONS, AND ECONOMIC SIGNIFICANCE

GA, a complex polysaccharide exudate harvested from ASN and ASY trees, is a globally valuable natural resource with diverse applications (Mahmoud *et al.*, 2014). Africa and Western Asia source SG, whose unique properties fuel widespread industrial use (Aguilar *et al.*, 2019). FDA approval secured SG's place in the food and pharmaceutical industries (Nasir, 2016), and its versatile properties make it a popular food additive. Its complex polysaccharide structure underpins its functional versatility (Patel and Goyal, 2015). SG is vital to Sudan's rural livelihoods and national economy. Poor product market participation hinders Sudanese SG marketing in key areas, including El Obeid (Mahmoud, 2014). Sustainable development needs fair benefit sharing and market access. In addition to its economic value, SG is promising for biomedical uses such as drug and tissue engineering. Biotechnology offers potential for drought-resistant plants, combatting Sahel degradation (Nasir, 2016). Therefore, SG is a multifaceted resource with significant potential for future development and innovation.

ECONOMIC SIGNIFICANCE AND PRODUCTION CHALLENGES IN SUDAN

SG's economic value stems from its versatile applications and unique properties. It's emulsifying, stabilising, and binding properties make it a desirable food ingredient. SG also shows promise in nanotechnology and other sectors (Padil *et al.*, 2016). Sudan, particularly the Kordofan province, dominates the global SG market, supplying over 90% of the world's SG (Nasir, 2016). This dominance underscores the economic importance of SG in Sudan, as it provides vital income for rural communities. Studies have shown that income from gum commercialisation significantly contributes to household income in certain regions, ranging from 14% to 23%, and even reaching 38% of the net direct-use value from agroforestry systems in Eastern Sudan (Abtew *et al.*, 2014). SG represents a substantial portion of the net direct-use value of agroforestry systems in Eastern Sudan, reaching up to 38% (Eltahir and Vishwanath, 2015). SG serves as a critical safety net and means of poverty alleviation for these communities.

Challenges hamper SG's potential, despite its economic significance (Eltahir and Vishwanath, 2015). Producers often lack direct access to key markets, limiting their earnings and preventing them from realising the value of their products (Mahmoud *et al.*, 2014). Production and profitability suffer because of high taxes and a lack of resources. This sector is not reaching its full potential because of systemic and marketing problems (Abulgasim, 2024); policy adjustments and better resource management are crucial for SG's economic potential and growth. The positive correlation between income from gum production and effective resource management underscores the importance of secure land tenure and access to resources for maximising economic benefits, especially for women, who often rely on open-access resources (Abtew *et al.*, 2014).

BIOTECHNOLOGY AND INNOVATION: EXPANDING THE APPLICATIONS OF SG

Drug Delivery Systems

SG's versatility extends to biomedical applications, particularly in drug delivery systems. The use of nanoparticles allows for single-dose administration, improving patient compliance and therapeutic efficacy (Putro *et al.*, 2023). For instance, curcumin-loaded SG-sodium alginate nanoparticles (Cur/ALG-GANPs) have demonstrated effective radical scavenging capacity and significant anticancer activity against various human cancer cell lines (Putro *et al.*, 2023). Researchers increasingly use natural gum polysaccharides, such as SG, in drug delivery due to their biocompatibility, biodegradability, and cost-effectiveness (Ambrosio *et al.*, 2022). SG's ease of functionalisation with other natural polymers further enhances its suitability for creating targeted drug delivery systems (Bowsher *et al.*, 2021). Therefore, SG offers a versatile and sustainable platform for the advancement of drug delivery technologies.

SG's biocompatibility also makes it suitable for hydrogels used in controlled drug release. SG hydrogels, enabled by hydroxyl/carboxylate groups, provide localised, sustained drug delivery

(Gutierrez-Reyes *et al.*, 2022). Beyond drug delivery, SG improves the drug release properties of various therapeutic agents (Hassani *et al.*, 2020). SG's versatility in advanced drug delivery is shown by its use in magnetic nanocarriers (Schleiff *et al.*, 2023). SG's green approach expands its environmental remediation applications. Specifically, SG has shown promising results in adsorbing heavy metals such as lead, cadmium, and chromium from aqueous solutions, making it a viable option for water purification and environmental clean-up efforts. SG-based hydrogels can sequester radionuclides, highlighting their potential for treating radioactive waste and decontaminating polluted sites (Padil *et al.*, 2016). SG's versatility and sustainability make it a valuable resource for biomedical and environmental applications.

Tissue Engineering Scaffolds

Scientists increasingly recognise natural gums such as SG as promising biomaterials for tissue engineering because of their biocompatibility (Gutierrez-Reyes *et al.*, 2022). The ability of SG to form hydrogels, facilitated by its hydroxyl and carboxylate groups, creates matrices suitable for the controlled release of therapeutic agents and support for tissue regeneration (Goyal *et al.*, 2014). SG's biocompatibility minimises adverse reactions to implantation, making it ideal for creating scaffolds that support cell growth and tissue repair. Injectable hydrogels from Sudan offer a less invasive way to repair tissues, leading to less patient discomfort and faster recovery. The combination of biocompatibility, biodegradability, and cell growth support renders SG-based hydrogels highly suitable for regenerative medicine applications. Injectable SG hydrogels offer a minimally invasive approach, broadening the spectrum of treatable conditions and enhancing patient outcomes (Putro *et al.*, 2021).

These hydrogels' hydrated micro-environments enhance cell survival and proliferation, supporting their use in tissue engineering (Putro *et al.*, 2021). Therefore, SG-based biomaterials hold significant promises for advancing tissue engineering and regenerative medicine, with the potential to revolutionise various medical treatments and improve patient quality of life (Bani *et al.*, 2025; Elnour, 2025). The architectures of scaffolds proposed for in situ tissue regeneration, using SG as a novel biopolymer, are depicted in Figure 1.

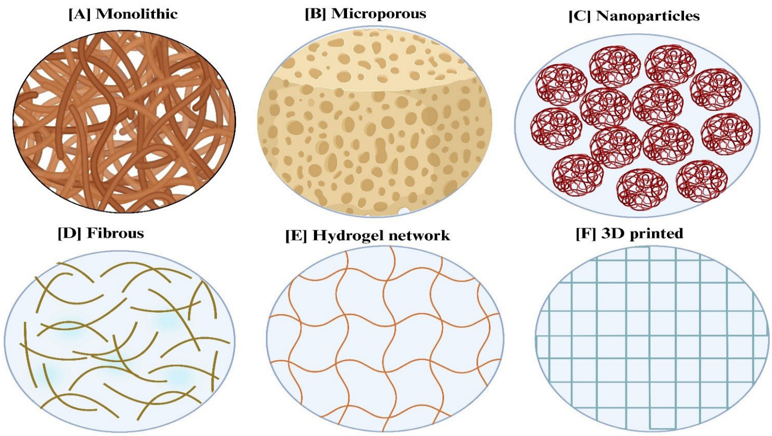

Figure 1: The Proposed Novel Sudanese Gum (SG) Biopolymer Scaffolds Designed for Tissue Regeneration

Notes: [A] Monolithic, [B] Microporous; [C] Nanoparticles; [D] Fibrous; [E] Hydrogel network, and [F] Three dimensions (3D) printed.

Source: Created by the authors

ALIGNING SG PRODUCTION WITH THE SDGs

Contribution to Poverty Alleviation (SDG 1) and Economic Growth (SDG 8)

The commercialisation of SG has significantly contributed to improving rural livelihoods in dryland regions (Dawson *et al.*, 2020). SG production provides a crucial economic lifeline in areas where other crops struggle to thrive, substantially boosting household income (Abtew *et al.*, 2014). Studies have shown that SG commercialisation accounts for 14% to 23% of household income in some regions, and even up to 38% in Eastern Sudan (Abulgasim, 2024). This economic contribution acts as a vital safety net and alleviates poverty. Promoting sustainable practices and developing the SG value chain can further enhance the income of local actors and ensure long-term sustainability (Abtew *et al.*, 2014). Addressing challenges such as local taxes and fees, providing production inputs, and ensuring access to basic services can significantly improve SG production and the income and livelihoods of producers (Abulgasim, 2024). Therefore, the SG sector plays a pivotal role in poverty reduction and economic growth in rural areas.

The resilience of Senegalia senegal (SS), the primary source of SG, in challenging environments makes it a valuable commodity for smallholder farmers (Dawson *et al.*, 2020). The economic benefits derived from gum commercialisation significantly impact livelihood improvement, helping families escape poverty (Bakhoum *et al.*, 2018). Promoting sustainable practices and addressing local challenges are crucial for maximising the economic benefits of SG production (Eltahir and

Vishwanath, 2015). An holistic approach that combines sustainable practices with targeted support can maximise the poverty alleviating potential of SG production, consequently offering a sustainable pathway for poverty reduction and economic empowerment in vulnerable communities.

Food Security and Sustainable Agriculture (SDG 2)

Integrating SG production into agroforestry systems offers a promising approach to enhance livelihoods and promote sustainable agriculture (Bakhoum *et al.*, 2018). These systems, which combine trees and shrubs with crops and/or livestock, provide multiple benefits, including improved soil fertility, water conservation, and increased biodiversity (Chepkorir *et al.*, 2024). The nitrogen-fixing capabilities of ASN trees enrich the soil, reducing the need for synthetic fertilisers and their associated negative environmental impacts (Ali *et al.*, 2025). SG agroforestry systems contribute to long-term land conservation and improvement, enhancing soil health and mitigating soil erosion (Eltahir and Vishwanath, 2015). These systems effectively balance short-term food and livelihood needs with long-term conservation and land improvement, promoting regional and national growth through integrated resource management and gender-specific development (Omokhafe *et al.*, 2019). Therefore, SG agroforestry systems offer an holistic approach to improving rural livelihoods and fostering economic development in the region. The ecological suitability and marketability of SG make it a key component of sustainable agroforestry. These systems create a synergistic environment that boosts agricultural output and diversifies income streams, leading to increased sustenance and income at the community level (Eltahir and Vishwanath, 2015). Therefore, SG agroforestry represents a sustainable and resilient approach to land management that addresses both economic and environmental objectives. SG's potential contribution to Sudan's post-war reconstruction is summarised in Table 1.

Table 1: SG's Impact on Sudan's Post-War SDGs Alignment

SDG	*Potential Impact*
SDG 1 (No Poverty)	SG production provides a vital source of income for rural communities, contributing 14-23% of household income in some regions SG serves as a safety net and means of poverty alleviation for vulnerable communities in arid environments
SDG 2 (Zero Hunger)	The integration of SG production into agroforestry systems enhances food security by improving soil fertility, water conservation, and biodiversity Nitrogen-fixing SS trees enrich the soil, reducing the need for synthetic fertilisers and supporting sustainable crop production in the long term
SDG 8 (Decent Work and Economic Growth)	SG commercialisation provides stable income and economic opportunities, particularly in regions with limited alternative livelihoods Promoting sustainable practices and value chain development can maximise the economic benefits for local actors
SDG 13 (Climate Action)	SG Agroforestry systems incorporating SG production help balance short-term livelihood needs with long-term conservation goals

Source: Created from the database used in this paper by the authors

BIOTECHNOLOGY APPROACHES TO ENHANCE SG PRODUCTION

Genetic Improvement of ASN Trees

Biotechnology offers significant potential for enhancing SG production and addressing challenges such as Sahelian Savannah degradation. Genetic improvement of ASN trees can lead to more resilient and productive varieties that better withstand harsh environmental conditions, ensuring a more stable and sustainable SG supply (Putro *et al.*, 2021). Biotechnology can accelerate the selection and propagation of desirable traits, such as increased gum yield and drought resistance; these are crucial for enhancing the economic viability of SG production for local communities (Putro *et al.*, 2021).

The development of drought-resistant ASN varieties is essential for sustaining SG production in arid climates. These multipurpose trees are valued for reforestation because their nitrogen-fixing ability enriches the soil and supports sustainable ecological agriculture (Bakhoum *et al.*, 2018). Biotechnology can significantly expedite the development and deployment of these improved varieties, ensuring the long-term viability of SG production in the face of increasing environmental challenges (Padil *et al.*, 2016). Advances in biotechnology have provided a range of powerful tools for enhancing both the production and application of SG, such as genetic engineering, tissue culture, and marker-assisted selection (Banerjee and Chen, 2008). These innovative techniques allow for the rapid development of new ASN tree cultivars with desirable traits, enabling more efficient and resilient SG production to support the livelihoods of local communities in Sudan (Ren *et al.*, 2025).

Biotechnology can aid in the conservation and sustainable management of existing ASN tree populations, ensuring the long-term availability of this vital natural resource. Biotechnology offers a comprehensive approach to improving SG production and addressing environmental challenges in Sudan (Putro *et al.*, 2021). Therefore, SG is a valuable resource for economic development and environmental sustainability because of its combination of biotechnological, sustainable practices, and innovative applications (Table 2).

Table 2: Biotechnology's role in Rebuilding Sudan's SG Output

Biotechnology Approach	*Potential Impact*
Genetic Improvement of ASN	1. Develop more resilient and productive SG tree varieties 2. Enhancing drought resistance to ensure stable and sustainable SG supply 3. Increasing gum yield can improve the economic viability of production
Development of Drought-Resistant Varieties	1. Sustainable SG production in arid and semi-arid regions 2. Restoring degraded soils and providing commercial products for smallholder farmers 3. Contribute to climate change mitigation and adaptation through improved land management practices

Biotechnology Approach	*Potential Impact*
Green Synthesis of Nanoparticles and Nanofibers	1. Creation of environmentally friendly nanomaterials for water treatment and pollution control 2. Advanced drug delivery systems can be developed using SG-based nanocarriers 3. The applications of SG have been expanded to various industries, including medicine and environmental remediation
Agroforestry Integration	1. Soil fertility is enhanced through nitrogen fixation by ASG trees 2. Mitigating soil erosion and land degradation 3. A balanced approach to addressing short-term livelihood needs and long-term conservation goals is required 4. Promoting biodiversity conservation and ecosystem resilience
Policy and Regulatory Support	1. Incentivising sustainable SG production and fair-trade practices 2. Provide financial and institutional support to local producers 3. Eliminate barriers, such as high taxes and a lack of production inputs 4. Integrate SG strategies into national development plans for economic diversification and environmental sustainability

Source: Created from the database used in this paper by the authors

Development of Drought-Resistant Varieties

Drought-resistant ASN tree varieties are crucial for sustaining SG production in arid climates (Bakhoum *et al.*, 2018). These varieties contribute to climate action and sustainable agriculture, aligning with the SDGs (Allouzi *et al.*, 2022). The application of biotechnology can significantly accelerate the development and deployment of improved ASN varieties (Bakhoum *et al.*, 2018). Drought-resistant varieties are essential for supporting livelihoods and promoting sustainable agriculture in arid environments (Padilla-Diaz *et al.*, 2016). The multipurpose tree species ASN is highly valued for reforestation because of its nitrogen-fixing abilities; these enrich the soil and support sustainable ecological agriculture (Ren *et al.*, 2025). Biotechnology offers powerful tools for improving the resilience and productivity of SG trees. Developing drought-resistant ASN varieties is crucial for ensuring the long-term viability of SG production in arid and semi-arid regions (Omokhafe *et al.*, 2019). These varieties are essential for supporting livelihoods and promoting sustainable agriculture in arid environments (Patel and Goyal, 2015). The use of SG in green synthesis methods for creating nanoparticles and nanofibres further expands its potential for environmental applications (Patel and Goyal, 2015). Therefore, drought-resistant SS and the versatile applications of SG promise economic and environmental sustainability in arid and semi-arid regions.

CHALLENGES AND OPPORTUNITIES IN SCALING UP SG PRODUCTION

Post-War Rebuilding Efforts

Revitalising Sudan's SG industry is crucial for post-conflict economic recovery, stability, and long-term growth. Addressing the systemic challenges within the current marketing system is essential to ensure fair benefit-sharing among stakeholders. The limited direct market access for sufficient producers at the El Obeid Crops Market significantly impedes their ability to capture the full worth of their products (Mahmoud *et al.*, 2014). Enhancing market access and diminishing the role of intermediaries are vital steps to ensure that a greater proportion of profits reach local communities (Omokhafe, 2019). This has caused a concerted effort to improve infrastructure, streamline marketing processes, and empower producers to participate more effectively in the market (Eltahir and Vishwanath, 2015). The existing system, characterised by restricted produce participation and the dominance of intermediaries, requires substantial reform to guarantee fair prices and equitable distribution of benefits (Abulgasim, 2024). This reform should concentrate on strengthening produce organisations, improving the dissemination of market information, and promoting transparent and competitive trading practices (Patel and Goyal, 2015). The objective is to create a more inclusive and efficient market system that empowers local producers and augments their economic wellbeing.

Developing the SG value chain is critical for boosting local income and ensuring the industry's long-term sustainability (Elkhatim and Alobeid, 2016). This involves investing in processing facilities, improving transportation, and training local communities to manage and market their products better (Patel *et al.*, 2021). Processing facilities allow raw SG to be transformed into higher-value goods, thereby increasing profits for producers (Jundi, 2024). Better transportation reduces logistical issues and ensures timely product delivery, thereby minimising losses and expanding market access. Training programmes equip producers with skills in sustainable harvesting, quality control, and marketing, thereby helping them compete globally (Slom, 2024). A comprehensive approach that provides technical, financial, and institutional support is essential to maximise the economic and social benefits of the SG industry in the future. Building an efficient and robust value chain is crucial for the long-term viability and sustainability of the SG sector in Sudan, and expanding the SG value chain can unlock additional economic opportunities and social benefits for Sudanese communities. Investments in processing, transportation, and training can help propel the industry to new heights, generating greater income and strengthening the long-term prospects of this critical natural resource (Raj *et al.*, 2015). Promoting local processing and exploring innovative applications are key strategies for maximising economic and environmental benefits. The challenges, opportunities, and strategies for scaling post-war Sudanese gum production are presented in Table 3.

Table 3: Challenges, Opportunities, and Scaling Strategies for SG Post-War

Challenges	*Opportunities*	*Strategies*
Local Negligence: - High local and state taxes and fees (over 50% of the production costs) - There is a lack of adequate production inputs and basic utilities, such as water - Disconnect between producers and key markets, such as the El Obeid Crops Market	**Global Demand:** - SG is highly valued as a food additive and for industrial applications - Unique properties, such as emulsifying, stabilising, and binding capabilities, drive global demand	**Policy Reforms:** - Eliminate high local and state taxes and fees to improve produce profitability - Provide the necessary production inputs and basic utilities to support sustainable management - Improving market access and integration for producers through a more inclusive system
Unsustainable Practices - Over-harvesting of ASG trees because of low pricing and financial pressure - Deforestation threatens long-term SG supply and causes ecological damage, such as soil erosion and biodiversity loss	**Agroforestry Integration ASN** - The nitrogen-fixing ability of ASN	**Sustainable Production Practices:** - Promote environmentally friendly harvesting techniques and ASG regeneration to ensure long-term viability - Integrating SG production into agroforestry systems can help balance economic and ecological needs
Limited Value Addition - Over reliance on exporting raw SG rather than local processing and value addition	**Biotechnology Innovation** - Genetic improvement of ASG can be used to develop drought-resistant varieties to enhance resilience - Green synthesis methods using SG can be used to create nanoparticles and nanofibres for environmental applications	**Value Chain Development:** - Invest in local processing facilities to capture a larger share of the global market value - Provide technical, financial, and institutional support to empower local actors to manage and market SG - Biotechnology innovations should be leveraged to improve production and explore new applications

Source: Created from the database used in this paper by the authors

Market Demand and Economic Potential

SG is a globally traded commodity with diverse applications across various industries, particularly in the food and pharmaceutical sectors (Musa *et al.*, 2018). Its unique emulsifying, stabilising, and binding properties make it a highly sought-after ingredient in food products (Patel *et al.*, 2021). Its versatility extends to green synthesis methods for creating nanoparticles and nanofibres for environmental applications (Padil *et al.*, 2016). Given its wide range of uses and global demand, SG presents a significant economic opportunity for Sudan. Non-oil exports, including SG, can contribute substantially to Sudan's gross domestic product (GDP), underscoring the importance of economic diversification (Abulgasim, 2024). Diversifying the economy and reducing reliance on oil revenues are crucial for achieving sustainable economic growth (Fleacă *et al.*, 2018). The current structure of the SG subsector in Sudan is heavily influenced by its marketing systems and existing policy interventions (Mahmoud, 2014). The lack of direct market access for sufficient producers at the El Obeid Crops Market highlights the need for a more inclusive and efficient system (Mahmoud, 2014). Therefore, addressing these structural challenges is essential to maximise the economic potential of SG.

Diversifying exports and fostering the local processing of agro-based raw materials, particularly SG, can significantly enhance value addition and bolster Sudan's economic potential (Abulgasim, 2024). Localised processing allows Sudan to capture a greater share of the global market value and create domestic employment opportunities (Eltahir and Vishwanath, 2015). This strategy aligns with the broader objectives of economic diversification and sustainable development. Technical, financial, and institutional support are crucial for increasing the contribution of local actors and ensuring sustainable product supply (Eltahir and Vishwanath, 2015). Policy reforms, such as eliminating local taxes and fees, providing production inputs, and ensuring access to basic services, can further improve SG production (Abulgasim, 2024).

A multifaceted approach encompassing local processing, targeted support, and policy reform is essential for maximising the economic benefits of SG (Mahmoud, 2014). The distinctive properties of SG, coupled with its global demand, make it a valuable commodity for Sudan's economic development (Goyal, 2014). Non-oil exports, including SG, can play a pivotal role in Sudan's GDP and economic diversification (Abulgasim, 2024). Focusing on commodities such as SG is vital for reducing reliance on oil revenues and building a more resilient economy (Elkhatim and Alobeid, 2016). Addressing market access challenges and providing adequate support to local actors are essential for strengthening the SG value chain (Mahmoud, 2014). Local SG processing can leverage its unique properties to create a range of value-added products, capture a larger share of the global market value, and generate domestic employment opportunities (Slom, 2024). This approach aligns with the SDGs, promoting economic growth, decent work, and sustainable agricultural practices (Abulgasim, 2024). Therefore, SG sees economic and environmental benefits from local processing and innovation.

SG BETWEEN LOCAL NEGLIGENCE AND GLOBAL ATTENTION

Local Negligence

A primary obstacle confronting Sudan's SG industry is local disregard, which significantly impacts productivity and sustainability. Producers face significant financial strain because of excessive local and state taxes and levies that often surpass 50% of the total production costs (Abulgasim, 2024).

This excessive taxation diminishes profitability, discouraging investment and expansion within the sector (Omokhafe, 2019). The inadequate provision of production inputs and essential utilities, such as water, further exacerbates these challenges, impacting plantation management and yields (Omokhafe, 2019). The limited involvement of producers in key markets, such as the El Obeid Crops Market, underscores the disconnect between producers and the market, emphasising the need for a more inclusive and efficient system (Mahmoud, 2014). Although gum and resin production contribute significantly to household earnings in certain East African regions, the prevailing limitations in Sudan impede the growth of this sector. Addressing these issues is paramount to enhancing the sector's productivity and sustainability (Abtew *et al.*, 2014). High taxes and insufficient support have led to unsustainable practices such as the excessive harvesting of ASN trees. Financial pressures have driven down prices, resulting in the felling of trees, jeopardising the long-term supply of SG and causing severe ecological consequences, including soil erosion and biodiversity loss (Abulgasim, 2024). Addressing these challenges requires a concerted effort to ease the financial burden on producers, provide the necessary resources for sustainable SG production management, and promote environmentally friendly harvesting practices (Bakhoum *et al.*, 2018). This reduces taxes, supplies production inputs and basic utilities, and enhances market access for producers. An holistic approach that considers both economic and ecological factors is crucial for the long-term sustainability of the SG sector in Sudan.

Global Attention

Despite the challenges at the local level, SG's diverse applications and unique properties have garnered significant global attention. Derived from ASN or ASY trees, SG is highly valued as a food additive and for various industrial applications (Nasir, 2016). Its emulsifying, stabilising, binding, and shelf-life-enhancing characteristics contribute to its widespread use in food products (Patel and Goyal, 2015). The high soluble fibre content of SG makes it a valuable dietary fibre source. The global demand for SG is driven by its functional properties and nutritional benefits (Nasir, 2016).

Several interventions have been recommended to address local challenges and capitalise on global interest (Omokhafe, 2019). These include eliminating local taxes and fees, ensuring adequate production inputs, providing essential services, and implementing regulations to protect ASN trees (Abulgasim, 2024). Biotechnology can further enhance SG agroforestry, in alignment with the SDGs (Omokhafe, 2019). Implementing these interventions can create a more supportive and sustainable environment for SG production, benefiting Sudan both economically and environmentally (Abulgasim, 2024). The global demand for SG, coupled with its potential for sustainable development, presents a significant opportunity for Sudan to revitalise its SG sector and contribute to its post-conflict reconstruction efforts (Mahmoud, 2014). Therefore, addressing these challenges is crucial for improving the livelihoods of SG producers and ensuring the sustainability of the sector.

CONCLUSIONS

Sudanese Gum (SG), a natural polysaccharide derived from Acacia senegal and Acacia seyal trees, has significant potential to stimulate economic growth, enhance environmental sustainability, and foster social progress in Sudan. As the world's leading producer of SG, Sudan can leverage this resource for post-conflict reconstruction and contribute to achieving multiple Sustainable Development Goals. SG's unique properties make it a highly sought-after ingredient in various industries, and its adaptability positions it as a versatile biomaterial capable of fostering innovation and economic diversification. However, systemic challenges impede the growth of the SG sector in Sudan, requiring a comprehensive approach that integrates biotechnological innovations, sustainable production methods, and strategic policy recommendations to maximise the economic, social, and environmental benefits of SG production.

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