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RESEARCH

Unlocking the Potential of Sudan's Gum Arabic Industry: A Comprehensive Analysis of Challenges and Opportunities for Sustainable Development

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ABSTRACT

PURPOSE: This article examines Sudan's gum arabic (GA) industry, evaluating its potential and trade, livelihood, peacebuilding, and green finance challenges. It then suggests sustainable development strategies.

DESIGN/METHODOLOGY/APPROACH: A literature review methodology underpins this study, exploring published research on the production, trade, socio-economic impacts, and environmental sustainability of GA within Sudan.

FINDINGS: Sudan, a leading GA exporter, mainly ships raw gum, thus restricting economic gains. Low production, poor trade terms (including lengthy negotiations and low prices), political instability, drought, and local market problems hinder progress. This industry is a significant source of income, particularly for women. Exploring peacebuilding and green finance potential, the study highlights challenges such as market volatility and unsustainable harvesting.

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ORIGINALITY/VALUE: This study offers a novel, holistic sustainable development strategy for Sudan by integrating the multifaceted contributions of GA to trade, livelihoods, peace, and green finance. Specific negotiation strategies and case studies add to the paper's value.

RESEARCH LIMITATIONS/IMPLICATIONS: Empirical analysis is shallower due to limitations in the literature review. To validate findings and explore specific details, further primary data collection is necessary. Without specific quantitative data, drawing precise conclusions about economic impacts is restricted.

Practical Implications: Policy-makers, stakeholders, and international organisations can use the findings for practical guidance. Policy reforms, infrastructure investment, skill development programmes, and sustainable harvesting techniques are all included. The study also emphasises how green finance can boost sustainable investment and safeguard the environment.

KEYWORDS: *Gum Arabic; Sustainable Development; Value Addition; Trade Bargaining Power.*

INTRODUCTION

Gum arabic (GA) is a polysaccharide gum consisting mainly of arabinose, galactose, rhamnose, glucuronic acid, and other structural polysaccharides linked by glycosidic bonds. Acacia trees (Acacia senegal and Acacia seyal) are grown in the drier areas of over a dozen African countries, the most important being Sudan. Gum arabic is widely used in the food, beverage, nutritional, pharmaceutical, cosmetic, and industrial sectors, providing a large market opportunity worldwide (Hamouda, 2017). Historically, GA has been highly valued, being associated with ancient Egyptian civilisation. It was regarded as the primary export of Sudan and the treasure of ancient Kush kingdoms. Virtually all GA in the world currently comes from wild trees from the arid and semi-arid lands of the Sahelian belt in a reverse latitude of 5-18°N. More than half the GA tree species are present in the Ethiopian region, being generally distributed in the arid and semi-arid areas of the country (Tadese *et al.*, 2018). Legume trees fascinated biologists because of their unique terminal flowers opposed to foliage; this is thought to enhance reproductive efficiency despite the higher metabolic cost to the plant.

The study of GA, a natural plant product, offers opportunities in chemistry, polysaccharide nanotechnology, nutrition, and plant biomedicine. Gum arabic samples were collected from both rustic and nursery cultivated *A. senegal* trees in Sudan for the screening of quality. Different physicochemical parameters of isolated gums, such as pH, moisture content, total soluble solids, protein, α-amino acid, sugar composition, viscosity, and ash, were determined (Musa *et al.*, 2025). The overall quality tests revealed that *A. senegal* gums from cultivated trees were superior in quality. This is not only sustainable for the producer but will also help in establishing plantation

industries of the gum because GA is harvested from well-managed plantations for industries such as food emulsion. This experimentation led to the claim that GA from cultivated trees has great potential in fine food industries and beverages, and will open avenues for bio-prospecting and patenting possibilities of functional polysaccharides. Further work relating to the extraction and characterisation of different polysaccharides from Ethiopian gum is needed.

GUM ARABIC: A GLOBAL COMMODITY WITH SUDANESE ROOTS

Gum arabic, known as the sap or resin of the acacia tree, offers a world of possibilities for product innovation in food, beverages, pharmaceuticals, and more. This natural polysaccharide, primarily harvested from acacia species, has economic value as an edible gum and offers various uses in the application and production of emulsions, encapsulation of flavours, sweeteners and oils, stabilisation of particles and foams, and more, depending on the properties of the gum class. In foods, GA can primarily be used as an emulsifier that coats and protects oils and other materials (Hamouda, 2017). It serves as a stabiliser in many products, including soft drinks (crucially preventing settling) and dairy emulsions. Gum arabic can encapsulate flavours and colours for novel applications and storage of these materials. Other uses include thickening, adhesion, filtration, etc. Although GA has various broad applications, each class of gum has different properties: for instance, in food applications, Class I gum is used, in which acacia gum has become the classic GA, used as a confection coating or found in many beverages.

As GA has many uses, it also has a vast and growing market. In 2023, the world market value of gums used as food additives was approximately US$10 billion annually, of which GA and locust bean comprised about US$1.2 billion (about 12%) of this total. During the 1990s, expenditures for GA and locust bean increased 5-10% per year, with similar patterns evident across the globe in other decades (Tadese *et al.*, 2018). The world estimate of international demand for GA is between 55,000 and 70,000 metric tonnes annually. Demand continues to increase for this gum, primarily in beverages, pharmaceuticals, confections, and health foods, including sugar-free cakes and mixed juices. Upscale new applications using GA have surfaced in soft micro-encapsulation of flavours, sweeteners, colours, oils, and antibacteroidal agents (Ashour *et al.*, 2022). In the younger British gum grades, worth US$25-50 million per year, there are now novel uses in adhesives, anti-foaming, emulsification and finishing agents in the production of the coating of pickles.

The GA under the umbrella of Arabic gum trees has been one of the few communities to benefit from knowledge that preserves its usage characteristics. Generally, classification is based on the tree species from which the gum is harvested. Sudan alone produces two major grades: *A. senegal* (Hashab) and *A. seyal* (Talha). The gum river creates linear joints along primary limbs (Talha); these are of lower quality and cheaper grades (worth US$800-2,000/tonne). Hashab gum is more valuable, cutting across such lower linear joints in thicker lines and bulging to form larger

knots. Hashab gum is ultimately more valued because it is more stout, succulent, yellowish, and bitter, while Talha gum is white and insipid. Of the over 11,000 tonnes of GA processed in Sudan, *A. senegal* comprises about 75-80% of the total. Sorting and cleaning of low grade GA are done following collection by local traders, who are the first to inspect the gum: they realise close to 90% of the profit from turning gum over to export markets. The hand-picked selection (HPS) gum is the dominant flavour and most valuable commodity going from Sudan to international markets.

ANALYSING THE CURRENT STATE OF THE GA INDUSTRY IN SUDAN

GA is one of Sudan's most important economic crops on which many people depend for their living. However, the gum industry has suffered from neglect, falling trade and production because of the loss of trust by the farmers in purchasing gum. While its buried resources are being utilised elsewhere around the world, the position in Sudan gets worse. There are many aspects of GA (production, trading, use of modern technology, and product competition) that are untapped and that can enhance the positive contribution of this economic resource both at the household and national levels; however, the opposite is taking place now in the country. This research addresses the problem of assessing the current state of the GA industry in Sudan in many of its aspects (production, trading, modern technology, use in the industry, and recent competition). The importance of the research stems from the fact that GA is a great economic and natural resource commodity but has remained largely under-evaluated and neglected (Hamouda, 2017).

In Sudan, although known to be a vital resource, GA has been mismanaged and neglected because of interstate and intrastate policies; farmers have lost hope, and global competition has seen other countries improve their gum. This has led to the raw GA being exported with low added value. However, research into GA has advanced greatly in the fields of extraction, characterisation, and application possibilities worldwide. While the complicated supply chain and many parties are involved around the world to maintain such an important commodity, there are significant loopholes, defects, and shortcomings in Sudanese laws and regulations to execute such a resource sustainably. Lack of foreign reserves is not an excuse for not conducting GA research since there are known ways of generating resources by which foreign reserves can be generated through sustainable GA production.

PRODUCTION AND SUPPLY CHAIN ANALYSIS

The main sources of GA are semi-arid areas with an associated acacia intercontinental dry belt in both the northern and southern hemispheres, and the Sahelian zone extending from Senegal along the southern edge of the Sahara to Chad, to East Sudan and into the central plateau of Ethiopia. GA is a natural, polysaccharide, hydrophilic gum obtained from the bark of trees such as acacia. It is widely used as an emulsifier, thickener, and stabiliser in food, cosmetics, paint, pharmaceuticals

and other industrial purposes. Ethiopia is home for diverse acacia species, and there is an estimated annual production of GA of 73,000 tonnes. Investments and commercial production of this high demand, high value and high profit natural renewable raw material will significantly improve the livelihood of rural communities (Tadese *et al.*, 2018).

After the Senegal gum trade was disturbed due to drought in the region, many countries began to intensively tap local gum sources to fill the gap. During this time, it was found that gumming could be practiced even as far away as India and Myanmar, and various species of acacia were found to be tapped at different places around the world. However, some of these gums are either not water soluble or not water dispersible, and some of them are not edible. Nonetheless, the import of GA into the US flourished and expanded; today GA is estimated to be in more than 2,000 different products and restrictions on the imposition of quantitative quotas on imported GA have been lifted in all countries. Limits on GA duties were lowered to 0.8%, and premiums on saccharomyces and powdery F38-22 rose. As the price of GA dropped considerably throughout this trade-wide algorithm, business, rejection waves, and warehousing unemployment surged in some cases.

MARKET DYNAMICS AND TRADE

GA, produced primarily from Acacia senegal, is an invaluable commodity with unique properties that sets it apart from other natural gums. This unique plant exudate has been recognised for its high emulsification properties, and it has become an essential ingredient in various products including soft drinks, cosmetics and confectionery. Ingredients derived from other species of the genus Acacia have been known for centuries but are devoid of this unique property. Due to the vast area that is suitable for its production in Sudan, GA is virtually dedicated to a single prime product. This raises an intriguing question about other genera's existence in other arid or semi-arid regions where acacias are considered to be important alternatives. It should be noted that the embargo on GA imports from Sudan to the USA, and failure of Sudanese exporters to meet the insatiable and expanding demand, led to a further rise in world prices (Hamouda, 2017).

With sophisticated pre- and post-harvest techniques and equipment being developed in collaboration with the World Health Organization (WHO) and the US Food and Drug Administration (FDA), GA was safe-guarded from alternative sources to manufacture the per caput use level equalling 4-5kg onwards. As a result, an elaborate investment structure from wild gathering to primary processing to export and a highly versatile application spectrum evolved. As Sudan succeeded in producing and processing GA at comparable international standards, GA seeds are now considered a new commodity alongside Acacia senegal, targeted for export to a rapidly expanding market. Although mid-traders monopolise seed collection, international seed brokers and exporters now approach primary processors and associations of nut and GA producers. It seems that a third tier of bitter competition has evolved between seed exporters, traders and processors to dominate the developing sector market (Tadese *et al.*, 2018).

SOCIO-ECONOMIC IMPACTS

The GA sector is one of the rapidly growing sectors, but its potential is untapped. The products have high market demand for export. For many decades, this sub-sector has attracted increasing attention from the State and the business community for increased production. The State has targeted dry land forests in the country to diversify export goods and secure foreign currency (Williams and Phillips, 2021). Among other dry land forest products, GA is one of the products exploited for economic purposes. GA is produced from the tree species Acacia senegal (family: legume) and is the main foreign currency earner in Ethiopia after coffee. The contribution of GA to the local and national economy is multifaceted, including provision of employment, source of income diversification, contribution to livestock production, and contribution to a country's ecological health (Abebe *et al.*, 2021).

One of the benefits of GA is earning foreign currency through export; it is estimated that one unit of GA sold in an international market brings about US$3, except the unregistered cross-border trade that is common in the sector. If the potential of the sector is fully realised, the contribution of this sector to the economy would be boosted significantly. GA and its products are also part of the culture of the local communities situated around GA producing areas. This cultural aspect has been used positively for the resurgence of this sector. The improvement to local livelihoods is another important benefit as GA is a source of employment. Huge numbers of fringe communities and women are involved in processing GA and retailing the processed gum. It is estimated that around 800,000 people are engaged in one way or another in the GA sector; employment is provided throughout the year, and tapping, collection, and transportation of raw GA requires a huge labour force. Processing, marketing, and storage/semi-processing are other activities involving a very large labour force. In some cases, GA is either the only or primary source of income for a household. It serves as a safety net for communities and thus becomes a part of their livelihood. The economic value of GA has been huge in mitigating risks covariate with crop and fodder failures, mostly encountered in the drought-prone areas of Ethiopia (Tadese *et al.*, 2018).

STRATEGIES FOR VALUE ADDITION AND MARKET ENHANCEMENT

There is no universal method for increasing the financial and commercial value of the base GA product as the methods differ from country to country, and processing centres differ widely in how they operate. In Sudan, all processing depends on the size and capacity of the raw material sorting materials that are produced in large quantities, e.g., soapy water. These facilities have developed simplified processing practices using structures made from locally available materials, unlike many processing centres with larger installations in more developed countries. For example, a gum processing centre in Chad comprises small, rusty tanks with no filtration units where raw GA is submerged in soapy water. The imports have high dirt content due to the rudimentary structure built out of concern for optimal water filtration (Hamouda, 2017).

In Sudan, poor sorting procedures seem to be more common than in Chad. A large part of the gum is cleaned using old-fashioned methods, including a plastic sack and hammering. First, processed gum is treated using different size screens. In this stage, the gum will be sorted into three sections: gross gum (which is still very dirty), inconspicuous gum pieces, and tiny particles. The gum is left in water-filled plastic bags for days. After some time, the fine dirt should float to the surface where it is then removed. Finally, gum processing employs an additional selection stage in formal factories, where a camera detects dirt particles among the gum. While some factories process only cleaned GA, others use additional tumbling methods for purified grades; cleaning also drives commercial grades (Tadese *et al.*, 2018).

It is impossible to know the level of purity at which difficulties occur. Despite sustainability concerns, biodegradation agents also seem natural and safe for processing standards; although these sweeteners are accepted as ingredients in the food industry, their use for adhesive purposes seems questionable. More generally, the GA products are treated and filtered with soapy water. The treatment and access to water are vital to ensure survival and performance after artificial setups and the environment. Re-extracting GA might be questionable because of water scarcity, and GA production is generally more reliant on rainfall availability than accessibility to sweeteners. The obvious advantage of purchasing them was that they were more ready and usable than processed gum.

VALUE-ADDED PRODUCTS AND PROCESSING

GA, the exudate of acacia trees, is well-known as the best natural emulsifier and stabiliser that contributes to the palatability and stability of many food and beverage products. Additionally, it is rich in dietary fibre and prebiotic oligosaccharides that provide health benefits. Consequently, a variety of GA grades are sought in food, beverage, nutraceutical and pharmaceutical markets. Since the early 1990s, a drastic transformation of the commercial GA market has occurred. Although the GA trade was controlled by only a few multinationals until the 1950s, countries such as Ethiopia and India, which were previously small GA producers, have developed their own direct export markets. Importantly, however, hemp, potato and other replacements, although lower in functionality compared to GA, are penetrating markets that were traditionally GA applications. As a result, this tofu or tree product is at the crossroads of either improving markets or dwindling opportunities. This text elaborates on the parameters of GA quality and their implications to market value (Hamouda, 2017).

Parameters of GA Quality

Variety and composition

GA consists of natural sugars (65%), uronic acid (22%), protein (0.5%) and ash (4%). Its large polysaccharide structure with alternate D-galactose/D-glucuronic acid makes it a branching heteropolysaccharide. The monosaccharides in commercial GA are composed of L-arabinose, D-galactose, D-glucuronic acid and D-glucose in the ratio of 12:26:43:1, respectively. Major grades of GA are *A. senegal* (Hashab) and *A. seyal* (Talha) (Tadese *et al.*, 2018). Hashab GA is a fixed commodity, but Talha gum is variable. Both grades of GA have been referred to by brand names derived from countries where they originate, for example, "Sudan gum" and "Senegal gum" for Hashab gum and "Niger" for Talha GA. Recognised sub-grades of GA varieties are Arabacran® and Janel® (GA grades) having low congeners and polysaccharides, respectively.

Bulk density

Bulk density is determined by dividing the weight of a specific GA sample by its volume (ml). The gum must be poured into a volume-measuring container and levelled by a spatula without any compaction. Since bulk density affects the price at which the gum is sold, it must be considered when negotiating gum prices.

ENHANCING TRADE BARGAINING POWER

The considerable economic potential tied to intensive GA production, together with the wider socio-economic chances it offers, demands a carefully planned approach for its sustainable realisation. To genuinely harness these benefits, it is imperative that comprehensive strategies are developed for the thorough mapping and strategic provision of ecosystem services. Such planning is not merely an administrative exercise; it is fundamental to ensuring the prioritisation of public health and the establishment of a robust environmental risk management framework. These critical decisions, resting with local authorities, will determine the long-term viability and ethical footprint of GA production.

The intricate balance between economic gain and ecological stewardship underscores the critical need for a multidisciplinary approach to GA research. To this end, studies concerning GA must integrate expertise from diverse scientific disciplines. This includes, but is not limited to:

- *taxonomy,* which provides foundational knowledge of species identification and classification;
- *ecology,* which examines the interactions between organisms and their environment;
- *evolutionary biology,* offering insights into adaptation and genetic diversity; and
- *conservation science,* which focuses on protecting biodiversity and natural resources.

By weaving together these specialised perspectives, GA research can achieve a level of completeness and scientific rigour that allows its findings to withstand the most stringent scrutiny. This comprehensive approach is vital not only for meeting the exacting standards of the scientific community but also for addressing the legitimate expectations and concerns of society regarding sustainable resource management.

Gum arabic, derived from the dried sap of certain legumes, holds significant international trade value, making its production and management a matter of global economic and environmental importance. The global demand for this versatile commodity, used in various industries from food to pharmaceuticals, amplifies the urgency of adopting best practices. Without an holistic framework that considers the full spectrum of environmental impacts and societal benefits, pursuing short-term economic gains could lead to ecological degradation, jeopardising both the resource itself and the well-being of communities dependent on it. Therefore, integrating scientific rigour, ethical considerations, and community engagement into all facets of GA production and research is not merely advisable but essential for fostering a truly sustainable and fair industry. This proactive stance ensures the benefits derived from GA production are not only substantial but also enduring, contributing positively to both local livelihoods and global ecological health.

BRANDING AND MARKETING

A new announcement from the Agricultural Research Institute of Senegal highlights a feasibility study of outsmarting the artificial GA proliferation of Asia as a major natural GA producer. The technological evolvement from the extensive efforts applied during the green revolution era to biotechnology is shifting priority from the major cereals to the neglected sub-tropics agroforestry trees, nuts, roots, and tubers. This is different from Coffea arabica and F. vulgare that cannot be dual in their ecogeographic domain and climate under man's bioengineering and biotechnological efforts. Acacia senegal could be bioengineered and genetically tweaked to grow well in all these critical ecogeographic rangelands, grazing lands, farmland, and agroforestry systems. Despite being the top producers of *A. senegal* over centuries, the Sahelian countries are not able to address the high camel death mortality rates due to the inability of the national universities to generate their locally adoptable feeds and feed supplements from the indigenous feed resources. In addition, there is wear and tear on the gigantic research GA coolers due to electrical power interruption. Biotechnological remedies could be worked out for developing east-west and north-south countries links for knowledge, and feed and GA exchanges. As more than half of this eroding GA sector is found in Ethiopia (but less than 0.2% is documented), GA should be promoted globally.

A robust restrictive examination and utilisation study could define the research priorities and options. Since Ethiopia is a potential top producer of GA, it should diversify its utilisation dramatically, and outline feasibility and quick-win domestic as well as export market potentials.

Issues to scientifically tackle these areas include coverage of the resource base, recent trends in tapping natural GA from the acacia tree, use of natural GA as a source of commercial income for forestry farm households, marketing quality standards and gambling custodian institutions, and recent technological and financial needs of the predominantly Acacia GA sector in Ethiopia (Tadese *et al.*, 2018). A possible collaboration across production, extraction, banking, and processing institutions promotes internal growth and generates export opportunities. Substantial branding is urgently needed across all silos and avenues.

SUSTAINABLE PRODUCTION AND ENVIRONMENTAL STEWARDSHIP

GA is a unique natural product that is a source of income for millions of people, supporting the livelihood of farmers and nomadic tribes who harvest it. It is traditionally tapped and marketed in its natural state without processing, making it a premium product compared to many other raw materials from the African Sahel that suffer from marketing problems in their export and up-country trade. Industrial and scientific interest in GA has grown since the 1990s, and prospective users may use conventional procurement methods that can exacerbate supply and quality problems.

GA is a natural product harvested from the Sudanese Acacia senegal trees predominantly found in the Kordofan and Darfur provinces of Sudan. It is an exudate of commingled polysaccharides produced from the sapwood of healthy trees: approximately 36% of the world's GA production is exported from Sudan. GA exporting countries have faced challenges affecting the flow of this commodity in regional and international markets, such as droughts, wars, and the continuing debate over the environmental effects of GA production.

Despite numerous studies of various aspects of GA production and marketing, there is a lack of comprehensive investigations of this developing commodity chain from tree to global market. It is a semi-arid or arid region commodity produced in the fringe area of the pastoral/ agricultural zone. The socio-political context of GA producing regions in North Kordofan and Darfur states and the historical evolution of GA production in this area, particularly in Sudan, need to be considered (Tadese *et al.*, 2018).

SUSTAINABLE HARVESTING TECHNIQUES

For millennia, acacia species in arid and semi-arid regions have been tapped to harvest gum without seriously damaging the trees. However, attempts to develop a gum production system based on contemporary forestry principles in the 1980s and 1990s in several countries across West and Central Africa proved disastrous. This is reflected in the still-prevalent traditional tapping methods, which are similar to those used by ancient Egyptians.

The notion that repeatedly removing bark from around the tapping wound hastens gum flow must be shown to be correct. Gum production is often limited by wind-induced breakage of tapping wounds in the upper stems. Although tapering cut size and wound depth will lessen the situation, it will still be an issue. Exposed parts of upper taps will slowly rot, allowing bad weather to penetrate and cause mechanical failure of the wounds. Exposed tapping wounds will also promote canker formation (Tadese *et al.*, 2018), and stress may well alter gum amounts and properties. Gum harvesters cite examples of changing quality in response to rainfall patterns and other weather variables. Seasonal drought is reported to yield lumps of gum instead of grains, and fires are frequently mentioned as producing "crazy" gum. Finally, protection from inadvertent tawny mole attack is essential to maintaining steady gum throughput.

To be worthy of serious consideration, alternative production methods must also be viable socially and economically. The up-front cost of planting must be justifiable both in the context of today's gum prices and the expectations of farmers. To be sustainable long term, production systems must also be equitable across time. Larger and less dynamic farmers must be able to access systems with a guaranteed productive future. Global initiatives aimed at revitalising industry and increasing gum importance may present the necessary conditions to bring this productive resource back into the global resource base.

ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

A well-designed Environmental Impact Assessment will ensure that all ridge regressions are within acceptable limits to mitigate the impact of GA production on biodiversity and other environmental parameters. The design of a comprehensive study should acknowledge multiple routes of potential exposure to ensure that human and environmental risks are addressed adequately. Therefore, the sub-disciplines of eco-toxicology and other areas of biodiversity exploration, such as macro-biodiversity, microbial, and metabolic diversity, must be incorporated into the study design. Furthermore, the huge expectations of benefits from intensive GA production and other socio-economic opportunities can only be addressed if total mapping and provision of benefits from ecosystem services are planned for the prioritisation of public health; there is also a need for good instruction manuals regarding environmental risks to be prepared by the local authorities. GA research should bring in the expertise of taxonomy, ecology, evolution and conservation disciplines so that the studies can stand the test of completeness and scrutiny by both scientific and societal expectations (Tadese *et al.*, 2018).

GA, the dried sap of certain legumes, is an important internationally traded natural product used as an additive in food and pharmaceutical applications. It is produced by gatherers based on wild trees in Africa that need to be sustainably managed for other products and services. Work on sustainability management will include an in-depth analysis of the production, processing, trade,

and marketing of GA. It should address concerns about recently reported quality problems and on the upscaling expectations, which have not been rooted in development. For its verification, any prospective GA programme should contain a consulting type of co-operative research, involving regional colleague institutions as partners. Methods should focus on a systematic, expert-driven analysis of potential problem areas. Sustainable production is seen as commercially using the full price of an existing good while recognising and respecting the operational and evolutionary rules that ensure the on-going availability of this good. GA harvesting, which depends on wild trees growing in natural or semi-natural forests on publicly owned land, will be assessed against this framework. Consumer and producer countries consciously avoid regulating this public domain, assuming that both the shrub-lands and communities that inhabit them are sustainable.

GREEN FINANCE AND INVESTMENT

Meanwhile, alongside the burgeoning global market for GA, concern for the environment is leading to greater emphasis on green investments in emerging markets. However, most GA producers are sufficiently removed from major financial markets to be absorbed under the growing global priorities communicating responsible investments and green bonds. Both cocoa and GA benefit in a similar manner from heightened investor awareness towards the ESG-related effects of commodities. Analytics around sustainable cocoa supply chains will view GA, among other commodities with similar dynamics, as a feasible investment option towards engagement with UN Sustainable Development Goals (SDGs) concerned with gender and biodiversity (Tadese *et al.*, 2018).

On the production side, the socio-ecological implications of these global investments construct pathways for greater levels of sector organisation and stronger relationships between financiers and indigenous geographies and producers. Meanwhile, on the consumption side, analytical frameworks on vulnerability, equity, and attention spillovers will allude to the polysemicity of GA in discussions about commodities and health. Scandals surrounding GA will simultaneously affect cocoa in the event of the emergence of an investible cohort of smallholder commodities. The US$223.5 million of annual GA exports from Chad pre-date either of these industrial trajectories and thus did not benefit from the investments made surrounding these emergences. Meanwhile, Sudan, the first producer country, registers US$148.5 million in GA revenue, despite a larger domestic market dominated by the large-scale production of cocoa powder. With GA signalling the sustainability and provenance of traded goods, attention is diverted from the linkages through which such goods filter down to small producers. Nevertheless, a pool of relatively large firms in Sudan and Chad emerged around the growth in inquiries for GA.

CONCLUSIONS

The examination of Sudan's GA industry reveals significant but under-utilised economic potential. While Sudan leads global GA production, exporting raw gum limits economic returns and fails to leverage the industry's full benefits. Challenges include low production yields due to adverse climates and political instability, unfavourable trade conditions, and minimal value addition through processing. These factors weaken Sudan's global negotiating power, hindering revenue and job creation. However, GA production offers substantial socio-economic benefits, especially for women in rural areas. The industry has a notable role in peacebuilding and green financing, presenting conflict resolution and environmental protection opportunities. Exploring green finance options highlights sustainable investment opportunities.

To harness GA's potential, a comprehensive approach that integrates economic, social, and environmental factors is necessary. This includes policy reforms for better market access, investments in processing infrastructure, skill development for improved production, and sustainable harvesting practices for environmental conservation. Strengthening producer organisations and enhancing negotiation strategies are essential for improving trade capacity. Implementing green finance can promote sustainable development and attract investment. A cohesive strategy is needed to address the complex challenges and opportunities in GA's value chain. Further research and data collection are vital for validating findings and informing policy. By adopting these strategies, Sudan can transform its GA industry into a key driver for economic growth, social advancement, and environmental sustainability.

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REFERENCES

Abebe, M., Eshete, A. and Yilma, Z. (2021): Perception, traditional knowledge, uses, and status of gum Arabic production from *A. senegal* tree in rural households of Amibara and Liben District. International *Journal of Innovative Science and Research Technology*, Vol. 6, No. 2, pp.692-701.

Ashour, M.A., Fatima, W., Imran, M., Ghoneim, M.M., Alshehri, S. and Shakeel, F. (2022): A review on the main phytoconstituents, traditional uses, inventions, and patent literature of gum Arabic emphasizing Acacia seyal. *Molecules*, Vol. 27, No. 4, p.1171.

Hamouda, Y. (2017): *Factors affecting the quality of Acacia senegal gums*. Doctoral dissertation, University of Chester. Available at: http://hdl.handle.net/10034/620895

Musa, K.H., Nour, A.H., Elnour, A.A.M., Ibrahim, H.S. and Adam, I.M. (2025): Acacia Gums (AGs): Characterization and Applications. In: Elnour, A.A.M. (Eds): *Gum Arabic and Breast Cancer Biology* (pp.1-46). Springer, Singapore. Available at: https://doi.org/10.1007/978-981-97-8518-6_1

Tadese, S., Soromessa, T., Bekele, T., Berta, A. and Abebe, G. (2018): Production and Challenges of gum arabic in Ethiopia: Review. *Journal of Natural Sciences Research*, Vol. 8, No. 24, pp.33-45.

Williams, P.A. and Phillips, G.O. (2021): Gum arabic. In Phillips, G.O. and Williams, P.A. (Eds): *Handbook of Hydrocolloids* (pp.252-273). Woodhead Publishing.

BIOGRAPHY

Elsayed Elhassan Abdalla Elsedig is a seasoned expert in food, beverage, and herbal manufacturing technology, with decades of hands-on experience in extraction, evaporation, and drying techniques. His journey into this specialised field began in the 1990s when he had the opportunity to study under Mr Hardjo, a distinguished student of Professor Dr Schmutterer, renowned as “The Father of Modern Neem”. This mentorship in Indonesia laid a strong foundation for his expertise in traditional and modern processing methods. Over the course of more than two decades, Mr Elhassan has honed his skills in various extraction and drying technologies, mastering the use of diverse equipment and methodologies. His extensive practical experience has been complemented by rigorous scientific research, particularly focusing on key Sudanese agricultural products such as gum Arabic, hibiscus, and baobab. Collaborating with biochemistry researchers, he has contributed to advancing the understanding and processing of these valuable natural resources. Through his dedication to innovation and knowledge-sharing, Mr Elhassan has established himself as a respected figure in the field, blending traditional techniques with modern scientific advancements to enhance food, beverage, and herbal product manufacturing.