Indian Journal of Natural Products and Resources
Vol. 16(1), March 2025, pp. 60-70
DOI: 10.56042/ijnpr.v16i1.13163

Reviving industrial hemp in Bangladesh: Opportunity, challenges, and prospects

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Received 14 August 2024; revised received 14 January 2025; accepted 29 January 2025

This review explores the potential of reviving and cultivating industrial hemp, hereafter hemp only, in Bangladesh, highlighting its historical background and current trends. Despite facing some global challenges, hemp significantly contributes to environmental suitability, economic development, and industrial growth. Different parts of hemp are useful for industrial purposes and some components of it are beneficial for health and ingredients for the drug industry as well, such as CBD oil. The review is based on information from published literature, thematic synthesis, comparative policy analysis, and in-person interviews with semi-structured questionnaires. A regulatory framework named "*Ganja Mahal*" was established over 150 years ago and functioned properly in Bangladesh; a similar model is also used in other hemp-growing countries worldwide. However, in Bangladesh, the cultivation of hemp is banned due to negative social attitudes and knowledge gaps. Even though hemp can generate vast employment opportunities in agriculture, processing, manufacturing, research, marketing, transportation, and retail sectors. The global market for hemp-derived products is rising gradually; reviving in Bangladesh will boost the country's export earnings and could lead to a position as a prominent supplier of superior hemp goods. This review would apprise policymakers, scholars, and agricultural stakeholders of the importance of hemp in fostering sustainable development to achieve the United Nations' sustainable development goals.

Keywords: Economic benefits, Industrial hemp, Legal frameworks, Renewable resources, Trends

IPC code; Int. cl. (2021.01)−AO1

Introduction

The term "hemp" refers to *Cannabis sativa* L. in its entirety, encompassing all constituent parts. Industrial hemp, hereafter hemp only, is a variety of *C. sativa* used for industrial purposes rather than any psychoactive or therapeutic effects. Hemp plants are characterized by their tall, and thin stems, branching near the top; palmately compound leaves are narrow and sparse, with seven leaflets. On the contrary, cannabis plants are short, and bushy, and have buds around the stem; palmately compound leaves are numerous, with nine leaflets. Hemp, an ancient crop with low delta-9-tetrahydrocannabinol (THC) levels, typically below 0.3%, is non-intoxicating and suitable for various industrial applications[1]; the concentration of THC on dry matter basis is 1% in hemp, while it is 3-15% in marijuana, which distinguishes the two crops[2].

The taxonomic classification of hemp plant is as follows: Kingdom: Plantae, Division: Magnoliophyta, Class: Equisetopsida, Order: Rosales, Family: Cannabaceae, Genus: *Cannabis* L., Species: *Cannabis sativa* L.

It is distributed across various regions of the world, thriving in temperate climates. The phenology of hemp, from germination to flowering and harvest, is influenced by environmental factors[3]. In traditional practices, such as Ayurveda, cannabis has been recognised for its medicinal properties, and is used to treat various ailments and promote overall wellness[4]. Ethnobotanicaly, it has been utilised by different cultures for centuries serving purposes from fibre production to medicinal use[3]. Historically, cannabis was cultivated legally for narcotic drug purposes, especially in the *Ganja Mahal* area, a unique model system was developed by the colonial British government[5], in Naogaon district (the then "Mohakuma" of Rajshahi district), Bangladesh[6]. Entire procedures were controlled and managed by the "*Ganja* Society", established in 1917[7]. *Ganja Mahal*, situated in a remote region in Bangladesh, once played a significant role in the global market for narcotic

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drugs[6]. However, a global movement for the prohibition of narcotics began in the 1870s; through long diplomatic correspondence, western powers were able to impose global restrictions on recreational drug use between 1907 and 1925. Cannabis was eventually regulated under the 1925 International Opium Convention in Hague, and cultivation and use of it was banned over time in various parts of the world, including the Indian sub-continent. In Bangladesh, cannabis cultivation ceased in 1987, and all kinds of sales in 1989[6].

In recent decades, there has been a renewed interest and authorized cultivation of hemp due to its potential for environmental sustainability and economic advantages[1]. Hemp production technology and industrial research have revolutionized its production, promoting versatile, eco-friendly products and boosting global social attitudes towards sustainable agriculture and renewable resources[2,8]. Bangladesh can benefit from the current global trends of hemp, as it has expertise in cannabis cultivation through the *Ganja Mahal* system, used only for narcotic drug production. This model was developed 150 years ago[5] but remains relevant today compared to other countries like the US, Canada, and the EU. This review seeks the revival potential for hemp production by examining its historical consequence, current challenges, and social, economic, and legal circumstances, aiming to inform policymakers, academic, and agricultural stakeholders with a comprehensive understanding of the advantages and challenges associated with hemp production.

Methodology

A comprehensive literature survey was conducted from March 2020 to July 2024 using various databases, including Research Gate, Google Scholar, Science Direct, Scopus, and PubMed, to comprehend historical background, environmental benefits, legal frameworks, socio-economic aspects, and market value of hemp. In addition, Government reports, historical archives, and books from the late 18th century to the present on global hemp trends act as data sources. This study also used the thematic synthesis approach to determine the market value, compare the policies of different nations with those in Bangladesh, analyze the environmental benefits, and investigate the promising economic benefits of hemp. The comparative policy analysis approach was employed to compare the historical and present policies of Bangladesh with the regulatory frameworks for hemp that have been implemented recently in other nations. Furthermore, stakeholder engagement techniques and semi-structured questionnaires were used to collect qualitative information from farmers, experts, and policymakers regarding perceptions of and challenges with hemp cultivation.

Historical background

Hemp's origin is debated, with most suggesting it may originate in the Himalayas, central Asia, India, Pakistan, or China[9,10]. In India, people have been using hemp as a source of drugs, fibre and food for more than 3500 years. Moreover, hemp is cultivated for its fibre, and seeds, which are roasted for food in the northwestern Himalayas, and its fibres and stalks in the Kumaon region of Uttaranchal state[3]. Furthermore, hemp played a vital role in preserving the murals of Ellora Caves for its natural insect-repellent and humidity-regulating properties[11]. On the other hand, historical records indicate that the early utilization of this substance can be traced back to ancient civilizations, such as China and Egypt, where it was valued for its fibre and psychotropic characteristics[9,10,12]. The oldest use of hemp fibre is reported as 26,900 BC in former Czechoslovakia[3].

Nevertheless, cannabis has an extensive history of being cultivated as a profitable crop in Bangladesh[7]. Cannabis cultivation for drugs in Bangladesh was legally permitted under a government license system starting in the late 18th century and lasted until 1989. The first documented evidence of its cultivation in Bengal dates back to 1722[7,13]. During that time, the East India Company conducted experimental trials of hemp cultivation as a fibre crop[7]. The plant's intoxicating and therapeutic qualities were identified in 1839, and it became popular as a drug[14]. Traditionally, people in Bangladesh across various districts and regions have used it for therapeutic purposes[4]. Notably, the districts of Chittagong stand out for their distinctive historical engagement with this plant, encompassing its utilization in veterinary practices[15].

Colonial Era

After revealing the medical potential of cannabis, interest in its fibre utilization decreased, and it garnered interest as a narcotic substance[7,14]. The British came to India to make money, and they sought profits from the cannabis habits of India[14]. According to their desires, the British Government introduced a monopoly licensing system in 1876 to manage and

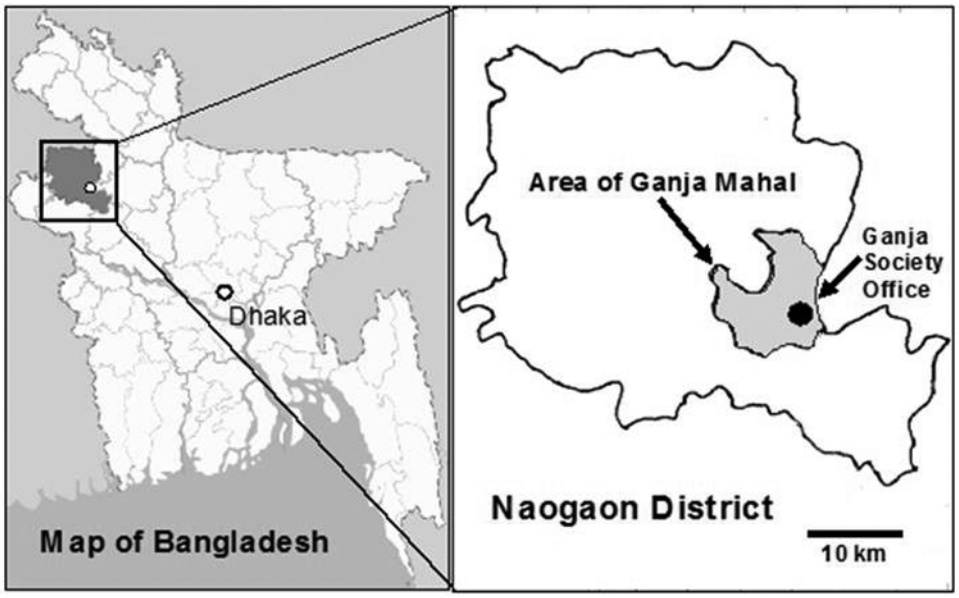

Fig. 1 — Location of Ganja Mahal area in Naogaon (source[6])

Fig. 2 — Photo of Ganja Society office: Front side of the office.

control the cultivation of cannabis[6,7]. Cannabis was generally grown on abandoned fields in the Jashore district of southern Bangladesh, and then the cultivation region was moved to the Naogaon district in northwestern Bangladesh (Fig. 1) because of the suitable climate[13]. The British restricted its cultivation to a specific area known as the *Ganja Mahal* for administrative purposes. Its cultivation and production were strictly controlled by the *Ganja* Society, established in 1917, and its headquarter was located at Naogaon[14] (Fig. 2). Ganja Society also developed a robust distribution and supply chain system to smoothly operate their activities. Society established 17 sales (Fig. 3) points in different places in Bangladesh to monitor and control the sales of cannabis[7]. This society aimed to support cannabis

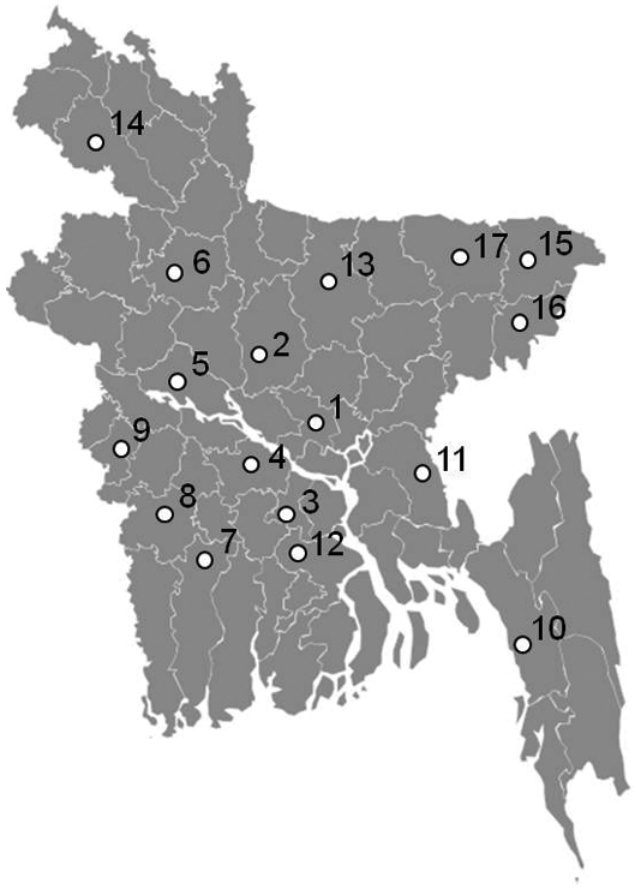

Fig. 3 — Map of cannabis sales points in Bangladesh; 1. Dhaka, 2. Tangail, 3. Madaripur, 4. Faridpur, 5. Pabna, 6. Santahar, 7. Khulna, 8. Jessore, 9. Darsona, 10. Chittagong, 11. Comilla, 12. Barishal, 13. Mymensingh, 14. Parbotipur, 15. Sylhet Sador, 16. Sunamgonj, 17. Srimongal (source[7]).

Fig. 4 — Photo: a) Ganja society's storage facilities at Muktir More, Naogaon, and b) Ganja society's storage facilities at Muktir More, Naogaon.

cultivation, processing, storage, warehousing, and marketing, playing a vital role in the well-being of farmers and the socio-economic development of Naogaon (Fig. 4a and b).

Post-Colonial Era

In 1947, the Pakistan Government assumed control of the colonial drug policy, collecting revenue from the cultivation of cannabis. Following independence, the Bangladesh government maintained the practice of allowing cultivation in Naogaon, following Pakistan's policy, without making any significant alterations. Bangladesh entered a drug control agreement as part of the Geneva Convention in 1974[13]. This agreement mandated the cessation of cannabis cultivation within 15 years, especially by 1990. Consequently, cannabis cultivation in Naogaon was discontinued in 1987, ending the history of over 200 years[7].

Current global trends of hemp industry and changing legal framework

Hemp has been renowned for its agricultural and sustainable food/energy potential for thousands of years across several continents and continues to be accepted by modern society worldwide[1]. The cannabis industry, on a global scale, has experienced substantial expansion[16], establishing itself as a crucial economic sector. In 2020, the global market value of the cannabis industry, especially focusing on high-tetrahydrocannabinol (THC) and its derivatives, was over $415 billion. Data from New Frontier in 2021 shows largest regional market share belongs to Asia (45%), followed by North America (22%), and Europe (19%)[17]. The legal framework surrounding cannabis is rapidly changing, significantly impacting worldwide cultivation of cannabis. As of 2021, seventy nations have officially authorized the use of cannabis for medical reasons, while 26 countries permit medical patients to access cannabis products with high levels of THC legally. According to New Frontier[17], ten countries have enacted laws to legalize recreational use by adults, and out of these, six have established a framework to regulate its distribution. In India, cannabis and its various forms, like ganja, charas, and hashish, are classified as narcotic drugs under section 2 (xiv) of the Narcotic Drugs and Psychotropic Substances Act (NDPSA) 1985, making their use legally prohibited. Only Government-authorized dealers are allowed to sell bhang in some states, and its cultivation for industrial purposes is legal. Though Canada has legalized hemp research since 1994. The inclusion of new regulations in the Canadian Controlled Drugs and Substances Act in 1998 permitted the commercial cultivation of hemp under the licensing and control of Health Canada. Similarly, the US Farm Bill 2018 amended the Controlled Substances Act (CSA, 21 U.S.C. 802(16)) to exclude hemp from the definition of marijuana. This provision effectively legalises the cultivation, processing, marketing, and sale of hemp and its derivatives, provided the THC content does not exceed 0.3%[18].

Current legal framework and status of hemp in Bangladesh

Historically, cannabis cultivation in Bangladesh is deeply rooted and integrated with local customs, rituals, economic practices, and community regulations, demonstrating its cultural and economic significance. The *Ganja Mahal* system, a well-structured blueprint for cannabis cultivation and trade, represents a

historical model that confirms the benefits and governance of the community. Despite its historical significance, there is no legal framework for hemp cultivation in Bangladesh at present. The social attitude of Bangladeshi people and some international agreements also pose the main challenges to introducing a legal framework for hemp[6,13]. Although the British colonial Government instituted a licensing system in 1876 to control the growing of cannabis, hemp cultivation and sales are now illegal. Under the Narcotic Act of 1990, marijuana is classified as a B-class narcotic. However, Section 9 of the Act permits the production, processing, importation, exportation, supply, acquisition, and sale of pharmaceuticals for authorized medical use or scientific research, provided the necessary licenses and permits are obtained[4]. Therefore, reviving this legacy could provide invaluable insights for integrating traditional practices with contemporary legal, economic, and sustainability goals. Reviving hemp in Bangladesh promotes its usage for eco-friendly products, renewable energy, and sustainable agriculture, all of which are in line with global trends. Additionally, it will create opportunities for exports, diversify the agriculture sector, and create jobs, among other possible economic benefits.

Opportunity and challenges in Bangladesh

Environmental benefits

Hemp is essential as a rotational crop and can be intercropped with other crops[19]. It plays a significant role in protecting the soil surface erosion[19]. In Bangladesh, year-round agriculture is practiced, and farmers rarely leave their land fallow. Such practice has resulted in a progressive decline in soil fertility and production output. In this case, hemp can sustain soil fertility through mulch that effectively manages soil moisture levels, mitigates soil erosion, regulates soil temperatures, and inhibits weed proliferation[20]. In addition, there is little or no pesticide, herbicides, or fertilizers needed for cultivating hemp[21].

However, at present, climate change is a global issue that demands immediate attention. In Bangladesh, a country vulnerable to the impacts of climate change, hemp emerges as a promising resource with multifaceted benefits. Hemp plants are uniquely able to sequester carbon dioxide from the atmosphere, making them a valuable tool in climate change adaptation and mitigation[22,23]. Through a process known as carbon sequestration, hemp absorbs atmospheric CO_2 during its rapid growth, effectively reducing greenhouse gas emissions and mitigating climate change[22]. The entire world is now searching for a safe and inexpensive replacement for fossil fuels because of the massive emission of greenhouse gases that have a detrimental impact on the environment and contribute to climate change. Researchers are now, therefore, exploring potential sources of biomass for bio-energy production. Hemp is also used for the production of biofuel in different parts of the world[24].

Moreover, hemp looks to be a satisfactory source of biodiesel, with a reported 75.9% conversion rate from hemp seed oil to biodiesel utilizing a potassium hydroxide catalyst[25]. Using various conversion technologies, hemp biomass may be transformed into bio-fuels like bio-diesel and bio-ethanol[20,22,26], due to its high cellulose and lignin content[27]. Furthermore, bio-energy from hemp provides a sustainable alternative to fossil fuels and helps to lower greenhouse gas emissions, which ultimately contributes to a more environmentally friendly bio-energy market. The use of hemp as a bio-pesticide is also another potentiality of hemp. Hemp plants contain naturally occurring substances known as cannabinoids, which can destroy pests[22,28]. Moreover, it is also possible to produce bio-pesticides from hemp extract. In conjunction with preserving biodiversity and fostering healthier ecosystems, this sustainable strategy lessens the reliance on potentially hazardous chemicals. By utilizing the potentiality of hemp, Bangladesh can overcome different difficulties related to climate change by using bio-energy from hemp and pest management by using hemp extract, which ultimately will make the environment safe.

Economic benefits

Hemp plants are used to make a diverse array of products for various purposes, including textiles, pharmaceuticals, food products, and construction materials[29-31]. The global market for hemp-derived products is expected to experience significant growth, with over 25,000 goods made from hemp now accessible[16,32]. By utilizing its past expertise in hemp growing, Bangladesh can take advantage of this industry to create significant revenue and enhance its national economy. Historically, in the fiscal year 1914-15, the Government generated a total revenue of Rs. 309,000 from narcotic drugs in Rajshahi districts, with 34% attributed to hemp alone[13]. Conversely, the revenue from hemp in four districts of East Bengal in 1929-30 was approximately Rs. 590,000[33].

Potential applications sectors

Hemp is a versatile plant valued for its multiple applications, including pharmaceuticals, food and oil,

cosmetics and personal care goods, animal bedding and feed, textile, paper, building construction, plastics production, and agriculture[29,31]. More than 25,000 hemp-based goods are reportedly available globally[16,32]. Fig. 5 demonstrates the multiple usual prospects of hemp. Bangladesh can leverage its previous experience in hemp cultivation to enhance its use in the following sectors and earn significant foreign exchange.

Opportunities in established sectors

Pharmaceuticals

Bangladesh's pharmaceutical industry could benefit significantly from hemp, especially regarding raw material shortage. The demand for medicinal and pharmaceutical products, both domestically and internationally, is rising, and hemp offers a sustainable source for developing cutting-edge medications. Integrating traditional practices with contemporary research presents a promising avenue for achieving remarkable results, particularly in regions such as Bangladesh, where a significant portion of the populace depends on traditional remedies.

Cannabidiol (CBD) oil

The emergence of CBD oil has attracted significant attention and generated widespread interest in the global market. Due to its diverse therapeutic properties and potential advantages for human health[4], CBD has caused a surge of opportunities for both agriculturalists and business persons[19]. CBD oil contains Linoleic Acid omega-6 polyunsaturated fatty acid and Linolenic Acid omega-3 polyunsaturated fatty acid, essential against anticancer and anti-inflammatory problems. It also contains gamma-linolenic acid, which has nutritional significance[34]. Production of CBD oil, combined with modern pharmaceutical methods, will contribute significantly to developing traditional medicine. However, Bangladesh, possessing a notable heritage in the cultivation of cannabis[7], finds itself in a favourable position to exploit the increasing market demand for CBD oil. By incorporating contemporary cultivation and extraction methodologies while upholding customary practices, the nation can fully harness the inherent capabilities of this valuable resource and facilitate the progression of economic development. Hemp plants exhibit significant potential in various well-established sectors in Bangladesh, extending beyond their conventional use in CBD oil.

Textiles

The textile and garment manufacturing sectors play a significant role in developing nations. Bangladesh ranks second in the world as the largest apparel producer, with a $20 billion business, 80% of which comes from exports[35]. Nearly 4 million people are

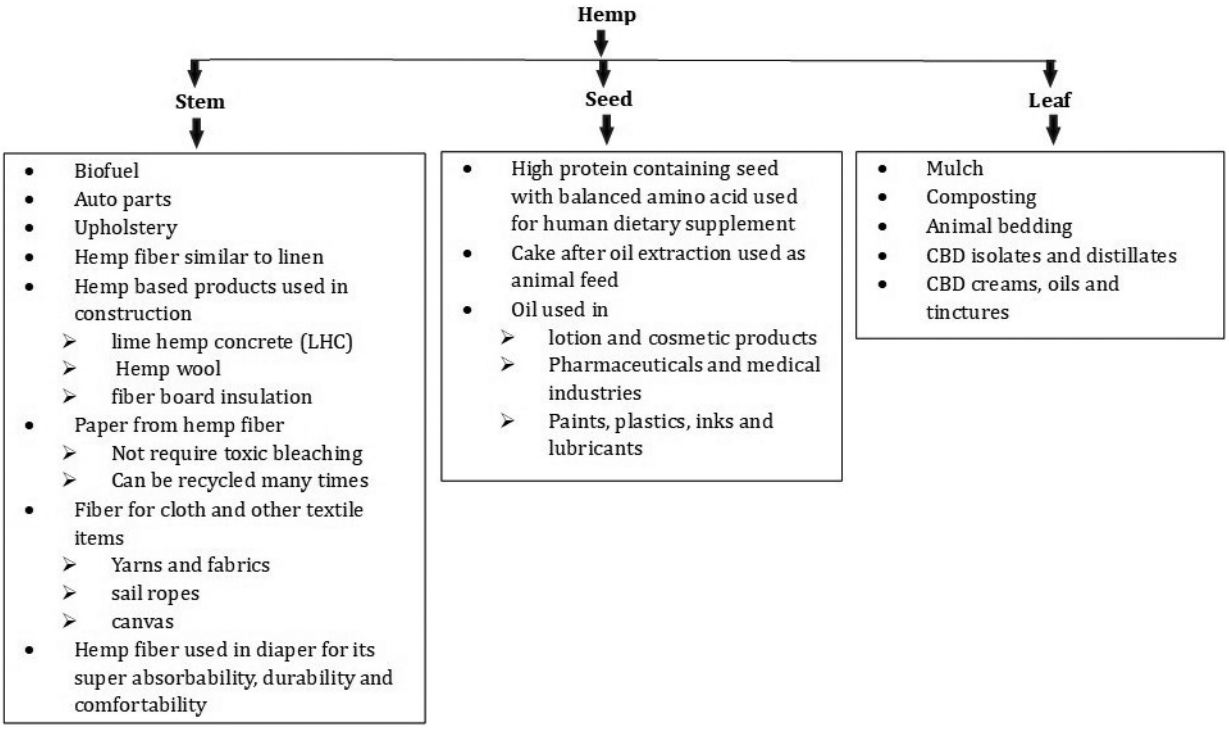

Fig. 5 — Multipurpose use of different parts of *Cannabis*.

working in the textile industry. Currently, the textile industry accounts for 45% of all industrial employment in the country and contributes 5% of the total national income[35]. Even though it is one of Bangladesh's biggest sectors, its dependency on raw cotton and synthetic fibres—the essential raw materials required in the spinning industry—makes it difficult to compete globally. Therefore, the country must produce more necessary raw materials for these sectors. Regrettably, over recent years, the essential resources that form the backbone of the textile industry have become increasingly challenging and defiant[35]. However, hemp fibre is gaining popularity gradually in the modern fashion industry. Consequently, it has the potential to enhance the prospects of the textile industry and create new opportunities for farmers in Bangladesh.

Paper

Hemp offers significant opportunities in the paper industry, catering to various paper types and applications. Its long fibres are ideal for producing high-quality paper used in magazines, books, and stationery, while shorter fibres are suitable for tissue, newspaper, and packaging material. Notably, hemp paper exhibits remarkable durability and resistance to decomposition, maintaining its colour over time[22]. In Bangladesh, the paper industry comprises around 80 mills, including the Karnaphuli Paper Mills, the only integrated pulp and paper industry in the country, with an annual capacity of 30,000 MT. However, other mills struggle with adequate fibrous raw materials, mainly wood and bamboo. Globally, 90% of fibrous raw materials come from wood; the remaining 10% are non-wood raw materials, of which approximately 80% of non-wood raw materials are used in Asia[36]. Bangladeshi paper mills face challenges in importing sufficient long fibre pulp. In this context, hemp cultivation can be sustainable, providing the necessary raw material for high-quality paper production. Bangladesh's environment is conducive to hemp cultivation, given its historical cultivation of hemp for drug and fibrous purposes from the late 18th century until 1987[6]. By leveraging the potential of hemp, the Bangladeshi paper industry can overcome raw material challenges and explore a greener and more sustainable future.

Health care and cosmetics

Since Bangladesh has historical experience in hemp cultivation, it will be helpful for them to innovate new eco-friendly alternatives. Moreover, Bangladesh has the opportunity to grab the world market by improving its skills for the development of new healthcare and cosmetics products. Moreover, the beauty and skincare business gains economically innovate and sustains itself. The Bangladeshi skincare industry reached $1.23 billion in 2020. Allied Market research predicts (AMR) an 8.1% CAGR from 2021 to 2027, reaching $2.12 billion by 2027. Due to the rising demand for skincare and cosmetics, hemp production in Bangladesh will be profitable. The skincare product industry is expected to generate $960 million between 2020 and 2027[37].

Challenges

The cultivation, sale, purchase, transport, and possession of all forms of hemp are currently illegal in Bangladesh. Currently, reforming the existing laws to legalise and regulate hemp cultivation is one of the key challenges. Modifying a clear legal framework that differentiates hemp from narcotic drugs is needed to solve this obstacle. The lack of public acceptance of hemp is low due to misconceptions and limited awareness of its benefits. Hemp is widely misunderstood in Bangladesh, leading to a negative reputation in society. Public awareness and educational campaigns will be helpful to alter and reshape the perception of society. The current infrastructural conditions are not adequate to start hemp farming in Bangladesh. Initially, a substantial investment is required to facilitate processing units, research centres, etc., for hemp farming. The cultivation and processing of hemp require various tools and machinery to facilitate harvesting, handling and extracting compounds. The large-scale machinery used to extract oils, waxes, and other products may face operational challenges. Shortages of skilled persons to run and maintain this machinery make the circumstances more complicated. A well-organised and functioning supply chain is necessary for smoothly maintaining and controlling the cultivation, processing, and distribution of hemp products. The present supply chain system in Bangladesh is inadequate to meet the demands of a rapidly increasing hemp industry. Cannabis-related rules, agreements, and policies are needed for Bangladesh to compete in the world market. Preparing regulations that align with international standards will require expertise both in legal and technical areas. In Bangladesh, ensuring the safety and quality of hemp products will be another key challenge. Regulating

the product's potency and purity, preventing misuse, restricting access to children, and disseminating information on safe consumption practices will require strict monitoring and enforcement mechanisms.

Prospects

Job creation

Many industries in Bangladesh have the potential to generate employment opportunities through the hemp business. Potential job opportunities can arise from agricultural activities, processing facilities, and manufacturing industries that utilize hemp. For instance, the cultivation and processing of hemp can provide employment opportunities for farmers, labourers, and technicians. Furthermore, the industry can create indirect employment prospects in research and development, marketing, transportation, and retail. Following the legalization and regulation of hemp in Colorado, numerous employment prospects emerged in various sectors. There has been a substantial increase in job prospects in the hemp cultivation and product manufacturing industry in the state of Colorado, U.S.A. The figures encompass 471 cultivators, 763 businesses engaged in cannabis cultivation (such as suppliers of nursery and garden products, farm labourers, traders of irrigation systems, and suppliers of agricultural input), 512 cannabis medical business centres, 372 shop and stores, 132 business manufacturing cannabis-derived products, 183 businesses manufacturing cannabis-infused/ flavoured products and 19 testing facilities[26].

Previously, more than 7,000 farmers in the Naogaon district of Bangladesh were involved in cultivating hemp in *Ganja Mahal* areas[6]. The Ganja Society supervised this effort with a staff of 85 personnel. Due to the cessation of cultivation, all activities have been postponed. Through the reintroduction of hemp cultivation, we have the potential to revive these job opportunities and further enhance employment as well. By using historical expertise and integrating modern techniques, Bangladesh has the potential to generate significant employment prospects in the hemp industry, resulting in economic advancement and establishing the country as an important player in the global hemp market. A technical and working group comprising researchers, educators, farmers, legislators, industry leaders, and stakeholders might be helpful to enhance development of hemp industries in Bangladesh.

Export opportunities

The global market for hemp-derived products is gradually growing, particularly in Africa, North America, Europe, and Asia, where hemp consumption percentages are high by region. In 2020, the number of hemp consumers amounted to 59.2 million in Africa, 49.6 million in North America, 44.2 million in Europe, and 93.8 million in Asia, the highest number. Additionally, the countries with large hemp consumer populations are the USA with 44.6 million, China with 32.3 million, India with 29.8 million and Nigeria with 13.3 million[17]. Bangladesh has an opportunity to benefit from this increasing demand by utilizing its advantageous climate conditions, suitable land and current agricultural expertise. The nation's economically efficient labour market further strengthens its competitive edge in hemp production. Bangladesh can establish itself as a significant participant in the global hemp market by implementing effective export strategies similar to those employed by successful countries such as the USA and Canada. This strategic movement will not only boost the country's earnings from exports but also position it as a prominent supplier of superior hemp goods, targeting the varied and extensive markets influenced by worldwide consumption patterns.

Synthesis and implications

This review emphasizes the comprehensive significance of hemp, highlighting its historical, economic, and cultural importance along with its present global revival efforts, as well as developing legal frameworks. It played a crucial role in the colonial economies and the modern revival of industrial and environmental uses. These insights draw attention to the untapped potential for reviving hemp in Bangladesh. The cultivation and regulation history of cannabis in Bangladesh provides a critical foundation for understanding its potential revival. The *Ganja Mahal* system played an essential role as a regulatory framework, representing efficient governance throughout licensing, quality monitoring, crop rotation, and incentivization from the late 18th century to 1989. These practices were made to ensure the control of production, distribution and continued rural economies. However, cannabis cultivation was prohibited in Bangladesh in 1989, which not only disrupted the local people's livelihoods but also affected traditional knowledge and practices[7]. In the series of our previous studies on cannabis in Bangladesh[6,7], we have expansively documented the entire history of cannabis

cultivation, production, and distribution system, as well as ethnobotanical information and folk customs associated with cannabis from the late 18th century to 1989. Furthermore, gathered information on the social transformation and subsequent functioning of the Ganja Society after the prohibition of cannabis cultivation. However, the earlier studies provide an operational history of cannabis production in Naogaon, but these studies did not address its revival potential from the contemporary perspective.

This review bridges the gap by synthesizing insights from global regulatory frameworks and evaluating their application to Bangladesh. By comparing the operational methods and the regulatory framework of the *Ganja Mahal* systems with other countries, like the US Farm Bill 2018, Canada's regulatory framework for controlled substances and agricultural practices, Integration of the European Union's agricultural policy underscores precious approaches that could notify a reimagined hemp industry in Bangladesh. For example, the farm bill provides explicit legal guidelines for the growing of hemp, including establishing acceptable quantities of THC and implementing rigorous compliance criteria[18]. This is consistent with the licensing and inspection procedures of *Ganja Mahal*. The Farm Bill supports hemp research, much to the incentive mechanisms of *Ganja Mahal*, which foster innovation and expansion in the industry. Similarly, Canada's licensing system is comprehensive, focusing on detailed licensing and traceability to guarantee product quality and safety[38]. This aligns with *Ganja Mahal*'s commitment to maintaining and monitoring the quality of its products. Traceability and compliance are prioritized in Canada to guarantee the lawful and secure distribution of hemp products, like the distribution system of *Ganja Mahal*.

On the other hand, the EU is expanding hemp growth as part of its efforts to attain carbon neutrality by 2050, as described in the Green Deal[39]. Hemp offers significant environmental benefits, including erosion avoidance, biodiversity enhancement, and high carbon sequestration, aligning with the sustainability goals of the EU[39]. As a result, the EU incorporates hemp into its agricultural plans, emphasizing crop rotation and sustainability, mirroring the crop rotation tactics employed by the *Ganja Mahal*. The European Union offers economic assistance and incentives to hemp growers, comparable to the social benefit and incentive frameworks in the *Ganja Mahal* system. By the comparative analysis of these legal frameworks, it's clear that the foundational elements of the *Ganja Mahal* system remain relevant today, which could serve as an outline for re-establishing the cannabis industry and adapting it to address contemporary challenges in Bangladesh. This review also explores that cultivation of hemp also plays a significant role in the environmental and economic benefits, especially its use in soil erosion prevention, carbon sequestration, and industrialization. Globally, hemp has been valued for centuries due to its multipurpose use and economic significance. Such as India, Egypt, and China utilised hemp for its fibre, paper, textiles, medicine[3,9,10] and even cultural preservation[11]. Bangladesh's historical knowledge and expertise in the cultivation of hemp can position itself well by adopting these opportunities. However, understanding these perspectives needs a complementary approach that includes both historical lessons and contemporary innovations.

In the cultivation of hemp in Bangladesh, one of the main challenges is reforming the existing laws and regulations that ensure safe, controlled production and distribution. However, by integrating lessons from the *Ganja Mahal* system and the international models, Bangladesh can mitigate current legal and operational challenges. While most of the literature has turned its attention to the legal challenges and economic perspective of hemp from Western perspectives, this review broadens the discussion to South Asia, particularly in Bangladesh, offering socio-economic and environmental opportunities specific to Bangladesh. It also draws attention to the applicability of historical frameworks such as the *Ganja Mahal* to updated policy. Revival hemp cultivation in Bangladesh can solve the rural unemployment problem, improve industrial capability, and play a significant role in environmental sustainability. Future research should explore the socio-economic impacts of reintroducing hemp cultivation at a large scale and its incorporation into worldwide value chains. Policymakers must prioritize its reforms to facilitate safe and sustainable industry growth.

Conclusion

The revival of hemp farming in Bangladesh requires removing societal stigma and promoting its economic, environmental and medical benefits. Public education campaigns should highlight the non-intoxicating nature of hemp and its potential to boost sustainable economic development. Hemp cultivation can create jobs, reduce dependence on imported raw materials, and offer opportunities in CBD oil production and biofuels.

Collaboration among researchers, policymakers, farmers, industry leaders, and stakeholders is crucial to addressing knowledge/information gaps, revising regulations, and encouraging sustainable farming practices. Establishing processing facilities and distribution networks is vital for industry expansion. Initially, significant investments in technology, training, and infrastructure are needed, but a well-organized supply chain is necessary for sustainability and efficiency.

Bangladesh has valuable historical knowledge, specialized skills, and a favorable climate, offering prospects for a thriving industrial economy. A hybrid approach incorporating the regulatory rigour of Bengal *Ganja Mahal* system with components from the US Farm Bill, Canada, and EU can be adopted to revitalize the hemp industry. This comprehensive model will ensure adherence to legal requirements, product safety, economic expansion, employment opportunities, and environmental sustainability, establishing Bangladesh as a key player in the global hemp industry.

Conflict of interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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