

Hemp as a Sustainable Solution for Climate Crisis Action and the Opportunities and Implications for Indigenous Communities: A Review of Literature

Mimika Hazra¹, Tiara Ranasinghe², Apt'sq'i'g'n'n² , Michael Brown², Sabina Mirza² , Clayton Shirt², Ethsi Stewart²

¹ University of Toronto, ² Waakebiness Institute for Indigenous Health, University of Toronto

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Indigenous youth are disproportionately impacted by the climate crisis. Researchers at the Waakebiness Institute for Indigenous Health engaged with approximately 200 Indigenous youth in Tkaronto, Ontario, Turtle Island through talking circles and surveys about the impacts of the climate crisis on youth mental health and exploring possible solutions; connection to land, sustainability, and taking further action were amongst some of major themes that arose. With the guidance of Elders and Traditional Knowledge Keepers alongside youth, industrial hemp was identified as a potential avenue to implement Land-based programming through a long-term solutions approach. This literature review explores current uses of industrial hemp highlighted in both academic and grey literature, specific case examples, and the feasibility and sustainability of industrial hemp.

Introduction

Research from Turtle Island has demonstrated that the climate crisis has direct negative health impacts for Indigenous Peoples from all generations (Brown et al., 2024). Moreover, establishing and practicing sustainable lifestyles that rebalance our relationship with the earth – treating the earth as the Mother to all life, including humans as her children (Redvers et al., 2020) - are necessary shifts for public health and beyond have emerged from recent research at the Waakebiness Institute for Indigenous Health (WIIH) (Brown et al., 2024). The recent research at WIIH involved mixed methods consultations between 2023-2025 with 200 First Nations, Métis, and Inuit (FNMI) youth from Tkaronto. From these consultations—which asked Indigenous youth about the impacts of the climate crisis on their mental health and what could be done to help—many themes and meta-themes emerged in the analyses. Included among the themes was the discussion of having more land-based and culturally based programs. Another theme was the need to establish more sustainable ways of living and relating to Mother Earth, particularly regarding consumerism and capitalism. Put together, these findings indicate an urgent need to explore alternative ways of modern living that reinforce a healthy and balanced relationship between Mother Earth and human beings. As a result, it was suggested by an Elder from the community to explore industrial hemp as a starting point (Shirt,

2025). The research on industrial hemp - also referred to in this article as 'hemp' - and its uses are manifold, addressing multiple key areas of interest regarding climate crisis and Indigenous youth mental health.

It is important to note that although industrial hemp and recreational marijuana derive from the same plant species (*Cannabis Sativa L.*) (Government of Canada, 2021), industrial hemp differs from recreational marijuana by the concentration of tetrahydrocannabinol (THC; the psychoactive ingredient in many cannabis species) (Parvez et al., 2021). Marijuana usually consists of 3%-15% THC, whereas industrial hemp has less than 1% THC (Kaur & Kander, 2023). There have been major legal barriers globally regarding the use of this plant to its full potential because of the association of growing hemp for its THC content, (Parvez et al., 2021).

The lack of extensive research in this field is a direct result of the historic criminalisation and , stigmatisation of all forms of the cannabis plant (Parvez et al., 2021), and racially motivated policies that restricted industry development (Vance, 2018). The outlawing of hemp in the 20th century led to decades of lost research opportunities in Canada, resulting in limited data on best practices suited to Canada's diverse climates, long-term environmental impacts, and economic feasibility compared to conventional materials (Parvez et al., 2021). The 2018 Cannabis Act includes Industrial Hemp Regulations, requiring a Health Canada license for activities such as cultivation, processing, and export (Government of Alberta - Agriculture and Forestry, 2020). All commercial hemp must be grown from Health Canada-approved certified seeds, prohibiting seed saving and the use of common seed (Government of Alberta - Agriculture and Forestry, 2020). To feasibly create an economically and environmentally sustainable hemp production process in Canada, further research is required. This literature review aims to investigate how industrial hemp could be used to action climate justice and how industrial hemp might be integrated into sustainable living practices. It describes examples of successful hemp uses and economies, especially those oriented to climate action and Indigenous self-determination, discussing the feasibility and sustainability for each.

Methods

We are two non-Indigenous researchers and students. Mimika is a Bengali settler, who was born, grew up on, and living on Williams Treaty Territory, which is the traditional lands of the Mississaugas of the Credit, the Anishnaabe, the Chippewa, the Haudenosaunee and the Wendat peoples. Tiara is a Sri Lankan settler who grew up on Treaty 13 lands of the Mississaugas of the Credit First Nation and the traditional territory of the Huron-Wendat and the Haudenosaunee people. We work together as part of the Waakebiness Institute for Indigenous Health team, at the Dalla Lana School of Public Health, University of Toronto, on territory subject to the Dish with One Spoon Wampum Belt Covenant. We approach this work with

humility and a commitment to anti-colonial and anti-oppressive practices, recognising that our non-Indigenous identities limit our understandings of the nuances of Indigenous cultures and lived experiences. To address these limitations, we work within our relations to Indigenous community members, Elders, Knowledge Users, and experts. We choose to do this work because we hope to support Indigenous self-determination and sovereignty, including research which explores various pathways to self-determination (i.e. use of hemp to address disproportionate impacts of the climate crisis).

To conduct this literature review, article databases including SCOPUS and Google Scholar were explored using search terms such as hemp, industrial hemp, climate, climate change, climate crisis, global warming, sustainability, eco-friendly, production, industry application, material, Indigenous, Canada, global. The abstracts of the articles were then used to narrow down the identified articles based on relevance to sustainability and having a recent publication date (i.e., up-to-date research), intentionally selecting articles that would provide a wide scope of applications. Reference lists of any included studies and relevant reviews were hand searched to identify additional articles. Articles were also intentionally selected to ensure the scale included local, national and global relevance, limited to articles published in the English language. Ultimately, 18 articles were included in the review. These 18 articles were then reviewed in full, organised by the application of industrial hemp and its specific industries (see the list below):

Current Hemp Industries

- Hemp-Based Nutrition
- Hemp Textiles
- Hemp Plastics
- Building Materials
- Pharmaceuticals and Medicine
- Hemp Paper
- Hemp Composites
- Agriculture
- Biofuel and Bioenergy
- Cosmetics

Findings: Current Uses of Industrial Hemp

Our review of the literature found that hemp is already being used in sustainable ways. Hemp is used in a variety of industries, including: the production of nutritional products for people and animals, hemp paper, textiles, composites, plastics, agriculture, building materials, biofuel and bioenergy, pharmaceuticals and medicine, and cosmetics. For each of these industries, examples, details of applications, and the relation to sustainability are described below.

Hemp-Based Nutritional Products

Hemp is a sustainable resource being used in nutrition industries (Ahmed et al., 2022; Dhondt & Muthu, 2021). Hemp leaves can be used for tea and nutrient purposes, and seeds can be used in animal feed (e.g., birds, fish, cattle, sheep, goats, pigs, horses, poultry, pigeons), as well as human food products (Dhondt & Muthu, 2021). Products like hemp oil, leaf tea, butter and margarine, beer, lemonade, tofu, and milk have been commercially available since the 1990s (Dhondt & Muthu, 2021), while some more recent newer products include flour, and the use of hemp in olive oil and salad dressings (Kaur & Kander, 2023). Its high nutritional value also has also allowed it to be integrated into breads, energy bars, dairy and meat products (Leonard et al., 2020).

Hemp is ideal for incorporation into food. Most of the seed is rich in oils, proteins, carbs, natural antioxidants, essential fatty acids (omega-6 and omega-2) and gamma-linolenic acid (which aids in osteoporosis prevention) (Ahmed et al., 2022; Kaur & Kander, 2023; Leonard et al., 2020). More specifically, the whole hemp seed consists of 20-25% protein, 20-30% carbs, 10-15% insoluble fibres, and is high in minerals including phosphorus, potassium, magnesium, sulfur, and calcium (Karche & Singh, 2019). They also contain nutritionally adequate amounts of vitamin E, B, folate, vitamin D3, chlorophyll, and phytosterols (Karche & Singh, 2019). Of note, Edestin is a protein found uniquely in hemp seeds which is similar to the globular proteins found in human blood plasma and edestin supports immune function, organ function and metabolism (Karche & Singh, 2019; Leonard et al., 2020). Edestin is found uniquely in hemp seeds, which distinguishes them positively amongst all other plantae, and additionally, hemp seeds they contain a digestible balance of all essential amino acids (Karche & Singh, 2019; Leonard et al., 2020). The healthy fats in hemp are especially ideal for people who do not eat fish or eggs (Karche & Singh, 2019). The nutrients are also beneficial as feed for dairy and poultry livestock, as those fed hemp seeds and seed cakes provided milk with higher fat and energy content, as well as larger and heavier eggs (Dhondt & Muthu, 2021). A downside, however, is that hemp seeds also contain some anti-nutritional factors which are compounds found in most food substances that may inhibit or limit the availability of nutrients to the body (Thakur et al.,

2019). Such compounds in hemp include phytic acid (which hinders protein absorption) and trypsin inhibitors (which negatively impact the digestive system) (Leonard et al., 2020). Despite the negative effects of anti-nutritional factors, some (including phytic acid) still have beneficial health effects in low concentrations (Thakur et al., 2019). Further research is needed to make use of the full nutritional potential of hemp (Leonard et al., 2020). Currently some relatively recent studies have suggested that hempseed peptides show potential could be used for use in prevention against hypertension and cardiovascular diseases (Leonard et al., 2020). Animal trials and in- vitro experiments have also shown a potential for preventing metabolic syndrome, skin disorders and neurologic disorders, but more research is needed as current results are contradictory (Leonard et al., 2020). There is also the environmental benefit of hemp being an efficient agricultural crop in terms of land use (Government of Alberta - Agriculture and Forestry, 2020). As the demand increases for hemp protein in human food, pet foods, and for certified organic hemp products – as part of a wider call for more healthy and environmentally sustainable products – Canadian growers can benefit from the additional access to market avenues (Government of Alberta - Agriculture and Forestry, 2020) - especially as Canada is one of the largest hempseed producers globally (Parvez et al., 2021).

Hemp Paper

Hemp has been a significant raw material used for paper production for over two millennia (Ahmed et al., 2022). The shift to wood-based paper in the 20th century has placed immense pressure on forests, leading to deforestation and environmental degradation, as trees are being harvested at three times their growth rate (Ahmed et al., 2022; Karche & Singh, 2019). Hemp however, offers numerous advantages over wood, including a cellulose content of up to 77% which is 3 times higher than wood, allowing for 4 times more paper per acre (Ahmed et al., 2022). Furthermore, hemp is a fast-growing crop that can be harvested in just 4 months, compared to 8–12 years for hardwood and up to 80 years for softwood trees (Ahmed et al., 2022; Dhondt & Muthu, 2021). Other benefits include hemp being twice as recyclable as wood-based paper and resistant to yellowing over time (Ahmed et al., 2022). The morphological structure of hemp fibres also enables a faster pulping process that requires less water and fewer chemicals (including sulfur and chlorine bleach) (Ahmed et al., 2022).

Despite these benefits, industrial-scale production of industrial hemp paper faces challenges such as higher costs and industrial limitations in current paper-making technologies (Ahmed et al., 2022; Dhondt & Muthu, 2021; Karche & Singh, 2019). The adoption of dual-purpose hemp crops, which utilise both seeds and fibres, could help lower agricultural costs and make hemp paper more economically competitive (Dhondt & Muthu, 2021). Increased investment in hemp processing technologies could allow the plant

hemp to balance production and consumption, reduce deforestation, and significantly lessen the ecological footprint of the paper industry (Karche & Singh, 2019). Today, hemp paper is primarily used for specialty products such as banknotes, archival paper, security paper, filter paper, insulating paper, greaseproof paper, coffee filter, tea bags, handmade paper, biblical paper, and specialty art paper (Dhondt & Muthu, 2021; Karche & Singh, 2019).

Hemp Textiles

Historically cultivated for textile use, hemp is now gaining renewed attention for its potential to revolutionise the fashion and textile industries (Ahmed et al., 2022). The textile industry's use of cotton and polyester exacerbates the climate crisis, which highlights hemp alternatives (Dhondt, 2020). When synthetic fibres in textiles are washed, tiny microfibres are released into the ocean, harming marine life and can take up to 300 years to break down in landfills, and can find their way into the ocean, harming marine life (Karche & Singh, 2019). Compared to cotton, hemp decomposes easily, has a natural dye-ability, and can be processed almost chemically-free (Karche & Singh, 2019). Further, hemp is known to have strong fibres that hold shape better and stretch less than other natural fibres, improving durability (Ahmed et al., 2022; Dhondt & Muthu, 2021). Hemp fabric also offers comfort and versatility with its ability to retain warmth, while remaining breathable, making it suitable for various climates (Dhondt, 2020). Additionally, hemp's high-water absorbency ensures vibrant, long-lasting colours when dyed (Dhondt, 2020). Recent technological advancements have also improved the texture of hemp textiles, making them softer and lighter, which has expanded their applications to include apparel such as jeans, sportswear, underwear, socks, shoes, bags, hats, accessories, as well as fabric for furniture, home furnishings, lamp shades, pillowcases, sheets, duvet covers, rugs, and carpets (Dhondt, 2020). Fabrics made from hemp further highlight diverse applicability through air permeability, anti-mould, antibacterial, and anti-static properties, making them suitable for protective clothing and healthcare environments where they can help reduce infection transmission (Ahmed et al., 2022). For hemp to fully integrate into the textile industry as a widely accepted fibre alternative, challenges must be addressed (Dhondt, 2020). These challenges include governance, fibre processing and trends in the fashion industry (Dhondt, 2020). Further, it is estimated that it may take up to 20 years for the hemp supply and demand to develop sufficiently (Dhondt, 2020). Hemp therefore provides numerous benefits, with slight limitations in making it a large-scale adaptation in the textile industry.

Hemp-Reinforced Composites

The use of hemp-reinforced composites, particularly in the automotive and mechanical industries, is gaining traction as a sustainable alternative to synthetic fibres such as fibreglass and carbon fibre (Karche & Singh, 2019). Composites generally are materials extracted from biological origins (also

known as biocomposites) with phases of reinforcement of natural fibres with organic matrix or biopolymers (Karche & Singh, 2019). These materials are created by embedding hemp fibre with thermosets, thermoplastic and biodegradable matrices (Ahmed et al., 2022). Chemical and physical modifications of hemp fibres have significantly improved their tensile strength, strength-to-weight ratio, flexural strength, and rebound properties, making them highly desirable for applications in automotive and aerospace industries (Dhondt & Muthu, 2021; Government of Alberta - Agriculture and Forestry, 2020; Karche & Singh, 2019; R. B. Malabadi et al., 2023).

In automotive applications, hemp-reinforced composites are increasingly used for interior parts such as door panels, trunk liners, spare wheel covers, headliners, and insulation mats (Dhondt & Muthu, 2021; Karche & Singh, 2019). Compared to glass fibre, hemp fibres offer advantages such as lower production costs, reduced weight, and a smaller environmental footprint (Dhondt & Muthu, 2021; Karche & Singh, 2019). Further, the ability of hemp-based composites to naturally decompose at the end of their life cycle makes them a compelling solution for reducing waste (Karche & Singh, 2019). However, drawbacks include thermal degradation at elevated temperatures and poor moisture resistance, which may limit outdoor applications (Ahmed et al., 2022). While the use of hemp fibres in car parts is still emerging, several countries are increasingly supporting its integration into the automotive industry (Karche & Singh, 2019). Other possible applications of hemp-reinforced composites include film membranes (which are good for water and wastewater treatment (Saleh et al., 2025)), moulding coating particle fibres (which is coating for biocomposites that provide a durable surface finish, applicable in transportation chemical plants, renewable energy systems or pipelines for example (Rogers et al., 2014)), and foams (e.g. expanded starch foams in the food packaging sector) (Karche & Singh, 2019).

Hemp Plastics

Petroleum-based plastics currently dominate global markets and contribute to widespread environmental harm (Ahmed et al., 2022; Modi et al., 2018). Plastics derived from fossil fuels are non-biodegradable, and 79% of them end up in landfills or natural environments, with projections of over 12 billion metric tons of plastic pollution by 2050 if current trends persist (Ahmed et al., 2022; Karche & Singh, 2019). In contrast, plastics produced from cellulose extracted from hemp, are 100% biodegradable, recyclable, and free from toxic derivatives (Ahmed et al., 2022; Modi et al., 2018). Hemp plastics are increasingly being used in packaging, construction, and automotive industries as they are found to be five times stiffer, more than twice as strong two point five times stronger and require 22-45% less energy to produce than other non-renewable based plastics (Modi et al., 2018). Further research and development are needed to address production costs of hemp plastics, to compete with inexpensive conventional petroleum-based plastics (Karche & Singh, 2019; Modi et al., 2018).

Agricultural Uses of Hemp

Incorporating hemp into agricultural practices can improve and further alleviate climate change in this industry. Hemp can be grown with few chemicals and risk of disease in this crop remains relatively low when grown in Western Canada using management practices such as rotation with non-susceptible crops and managing hosts (e.g. volunteer canola) (Government of Alberta - Agriculture and Forestry, 2020). Hemp has been noted to be a good crop rotation option (Herrera, 2023; Kaur & Kander, 2023; Muhit et al., 2024), breaking up disease cycles and pests and helping manage hosts (Government of Alberta - Agriculture and Forestry, 2020). In addition, the hemp cropping system is suitable for cover cropping and livestock integration because hemp significantly improves the health of the soil (Herrera, 2023). Due to the root system of the hemp plant, it provides excellent soil oxygenation, which will decrease fertiliser use, chemical use, (Kaur & Kander, 2023) and contribute to soil health overall (Government of Alberta - Agriculture and Forestry, 2020; Herrera, 2023). Phytoremediation is the process where contaminated soils are restored through absorption of heavy metals and eliminating and displacing tiny crops or weeds, which hemp facilitates well (Ahmed et al., 2022). Through the use of hemp, this process benefits vulnerable, dry (Herrera, 2023), and even polluted land (from heavy metals) (Linger et al., 2002). If grown in a clean field where the growing conditions are ideal, hemp can typically germinate before weeds and out-compete them, benefiting other crops (Government of Alberta - Agriculture and Forestry, 2020).

Building Materials

The construction sector is a major energy consumer, responsible for close to 32% of the global energy demand and creating 30% of energy-based carbon emissions (Ahmed et al., 2022). As such, eco-friendly, sustainable, carbon-negative building and construction and building materials are in demand, with hempcrete (also called hemp-lime composite, canobiote, canosmose, isocharge) (Karche & Singh, 2019), becoming more popular (Ahmed et al., 2022). Hempcrete is made from the woody core of the hemp plant, along with plant-based aggregates and mineral binders (Ahmed et al., 2022). Hempcrete started being used significantly in 1980, and is now an acceptable material for roof insulation, floors, non-load bearing in walls (Ahmed et al., 2022), slabs, panels, wallboards, and fibreboards (Dhondt & Muthu, 2021) - though it is primarily used for walling (Jami et al., 2019). The material was designed to sustainably replace insulation materials including glass wool, fibreglass, and dense-packed cellulose, but has expanded to where entire buildings have been constructed with hempcrete and timber frames (Jami et al., 2019).

Hempcrete has numerous advantages over conventional materials, including having which can withstand time as it has around a 100-year lifespan (Herrera, 2023). As a moisture buffering material, hempcrete has better extreme humidity control, decreases vapor condensation, limits micro-organism development, and provides indoor comfort (Ahmed et al., 2022). The material is a good insulator, due to its highly porous structure (Ahmed et al., 2022), which lowers overall energy consumption costs (Karche & Singh, 2019). This structure also lends to better sound insulation and thus is a good building material to reduce unwanted noise (Ahmed et al., 2022).

Compared to conventional concrete and filling materials, hempcrete can delay fire spreading, is lighter, has excellent hygrothermal properties, requires less energy to make, and acts as a natural carbon sink (rather than releasing carbon dioxide emissions, as cement does) (Ahmed et al., 2022). At the end of its life, the breakdown of hempcrete is facilitated by micro-organisms (making it biodegradable) and it can be recycled into nutrient-rich compost (Muhit et al., 2024). Despite its growing use, incorporating hemp materials into the building and construction industry has its challenges. Hempcrete has low mechanical performance and strength and will degrade with long-term exposure to rain or extreme humidity (Ahmed et al., 2022), which can make it sensitive to mould, meaning its durability cannot be guaranteed (Dhondt & Muthu, 2021). The latter could be mitigated, however, by using coating or breathable finishing (Ahmed et al., 2022). With humidity, the material will become sensitive to mould, and durability cannot be guaranteed (Dhondt & Muthu, 2021). Further research is necessary on hempcrete's strength, durability, and fire resistance, before full implementation (Dhondt & Muthu, 2021).

Biofuel and Bioenergy

A key contributor to climate change and global warming are the manufacturing and use of fossil fuels which pollute the air, environment and deplete the ozone layer (Ahmed et al., 2022). Biofuels and bioenergy are alternatives to fossil fuels for the purposes of generating heat and, power, vehicles, and they can mitigate greenhouse gas emissions (Dhondt & Muthu, 2021). The demand for biofuels is expected to triple by 2035 (Parvez et al., 2021), so it is also a growing and improving market. Biofuel production is encouraged through ethanol blend mandates in British Columbia, Saskatchewan, Alberta, Manitoba, and Ontario (Parvez et al., 2021).

A variety of energy and fuel products can be made from hemp (Ahmed et al., 2022; Dhondt & Muthu, 2021; Karche & Singh, 2019; Parvez et al., 2021). This includes solid biofuels such as briquettes and pellets for heating purposes (Ahmed et al., 2022; Parvez et al., 2021), biomass for electricity, and biofuel through anaerobic digestion methods (Ahmed et al., 2022). The oil of pressed hemp seeds and fermenting of the hemp stalks can make biofuels (Karche & Singh, 2019) including bioethanol, biodiesel, biogas, and

biohydrogen (Dhondt & Muthu, 2021). Hemp dust resulting as a by-product of manufacturing hemp can also be used to create products like biofuels (Parvez et al., 2021). Biochar is made from burning organic material at high temperatures under limited oxygen to create a carbon rich product, and it can provide direct nutrients to soil and mitigate greenhouse gas emissions (R. Malabadi et al., 2023). Finally, biochar made of hemp can be used as fuel, fertiliser, or an additive to concrete for example, to sequester carbon (Parvez et al., 2021).

There are many benefits and advantages of hemp bioenergy compared to fossil fuels or other bioenergy sources. Biomass sources can be regularly produced in substantial amounts, are carbon neutral, sustainable, and because they are often waste products, it is inexpensive (Parvez et al., 2021). Compared to other crops, hemp has the highest digestible concentration of cellulose and hemicellulose, making it ideal for biofuel (Ahmed et al., 2022). It is also more profitable in producing ethanol than crops such as switchgrass and kenaf (Parvez et al., 2021). Hemp also has good output-to-input energy values, yields more energy per hectare (Dhondt & Muthu, 2021), and hemp biofuel has excellent oil quality with high kinetic viscosity (Ahmed et al., 2022).

On a broader scale, there is also economic benefit for hemp energy as it can supplement and increase the use of other renewable resources such as wind and solar power (Parvez et al., 2021). As previously mentioned, Canada is one of the largest hempseed producers globally, the country has a surplus of hemp straw that could go into bioenergy uses (Parvez et al., 2021). Wood as a heat source is a large Canadian market but burning wood produces particulate matter and carbon monoxide (Parvez et al., 2021). Solid hemp fuel could replace this and reduce the health risks (Parvez et al., 2021). A potential challenge is that fossil fuels like coal have a higher energy density and may be the preferred energy source when biomass is not inexpensively available (Parvez et al., 2021).

One particularly important application for hemp bioenergy is co-firing with conventional energy sources like coal. In a co-firing system, coal and hemp biochar would be used together in a fuel blend to improve the efficiency of the process, reduce the volatilization of potentially toxic elements, and reduce greenhouse gas emissions while using existing infrastructure. A high proportion of Canada's energy production comes from coal – in 2016, 210 petajoules (PJ – a measure of energy) was produced from coal, which resulted in 52.5 metric tonnes (Mt – a measure of carbon dioxide) of carbon dioxide (CO₂) emissions. If a co-firing process were used with 20% industrial hemp biochar, emissions would be reduced by 10%, meaning 5.25 Mt less of CO₂ emissions (Parvez et al., 2021).

Pharmaceuticals and Medicine

For millennia, hemp has been used medicinally across the globe (Ahmed et al., 2022; Amaducci et al., 2015; Karche & Singh, 2019), and the plant is now re-entering and slowly growing in the modern market (Dhondt, 2020; Kaur & Kander, 2023; Leonard et al., 2020). Certain medicines that contain hemp are now FDA approved and sold in pharmacies, and it is likely they will become more easily accessible in the near future soon (Karche & Singh, 2019). Historical medicinal uses include clearing phlegm; easing childbirth; stimulating appetite in patients with cancer and AIDS; as a cure for rabies, epilepsy, anxiety, rheumatism, gonorrhea, dysmenorrhea, and respiratory conditions; and for its anaesthetic, analgesic, anti-inflammatory, anti-biotic, anti-parasitic, digestive, diuretic and expectorant properties (Karche & Singh, 2019).

The use of hemp in pharmaceuticals and medicine is still growing, and this industry is a key area of hemp research, including its potential to treat chronic diseases like diabetes (Kaur & Kander, 2023). The cannabinoid CBD has been used in various pharmacological products, but more scientific research is needed on the claims of health benefits (Kaur & Kander, 2023). The most promising situation for the North American hemp industry is to continue focusing on oilseed and CBD production for pharmaceuticals (Cherney & Small, 2016), especially as recent regulations in Canada now allow for bioactive components from flowers, leaves and roots to be used (Government of Alberta - Agriculture and Forestry, 2020).

Cosmetics

Among many other uses, hemp – particularly the seed - is known to be useful for cosmetics and skincare (Ahmed et al., 2022; Amaducci et al., 2015; Dhondt & Muthu, 2021; Government of Alberta – Agriculture and Forestry, 2020; Karche & Singh, 2019; Kaur & Kander, 2023; R. B. Malabadi et al., 2023). Existing hemp products in this industry include makeup, moisturizing creams, hair products, shampoos, facial oils, conditioners, (Dhondt & Muthu, 2021), essential oils (Kaur & Kander, 2023) and as additives in soap, deodorant, and hair spray (Karche & Singh, 2019). The oil from hemp seeds contains beneficial factors for dry skin, including many minerals, vitamins, and fatty acids (Dhondt & Muthu, 2021). The plant has been found to help treat acne, heal skin inflammation, soothe skin, regulate natural oils, and act as a pollution barrier, which make it suitable for skincare (Karche & Singh, 2019).

Discussion - Feasibility and Sustainability

The large-scale adoption of hemp-based materials and processing technologies presents significant opportunities for Canada but considerable challenges in terms of feasibility and sustainability also exist. While Canada has a strong agricultural sector and an existing hemp industry, scaling up production

to meet industrial demand requires addressing technological, economic, and social barriers (Kaur & Kander, 2023; Parvez et al., 2021). Technological advancements in processing facilities can improve efficiency and environmental outcomes, making hemp a more viable commercial material (Kaur & Kander, 2023; Parvez et al., 2021). Decortication (a harvesting practice that involves the removal of fibres), for instance, enhances fibre extraction while reducing waste and energy consumption (Parvez et al., 2021). Most processing facilities in Canada remain small-scale and scattered, limiting supply chain efficiency (Parvez et al., 2021). Significant investments in infrastructure and research are needed to ensure they can meet industry demands (Kaur & Kander, 2023). Additionally, scaling up requires coordination between policymakers, industry stakeholders, and researchers to establish large-scaled hemp production (Kaur & Kander, 2023).

One of the primary barriers to expanding Canada's hemp industry is economic feasibility. Competing with well-established markets in China, Europe, and the United States requires strategic financial support from federal and provincial governments (Kaur & Kander, 2023). Currently, production costs in Canada remain high due to labour expenses, regulatory hurdles, and a lack of large-scale processing infrastructure (Parvez et al., 2021). To address these challenges, targeted subsidies and incentives such as tax breaks for farmers and processors, grants for research and innovation, and financial support for new processing facilities could help offset initial costs and encourage industry expansion (Cherney & Small, 2016; Government of Alberta - Agriculture and Forestry, 2020; Kaur & Kander, 2023; Parvez et al., 2021).

Public perception also remains a significant challenge in scaling up the hemp industry in Canada. The historical stigmatisation of hemp, primarily due to its association with recreational cannabis, has limited public and governmental support for its expansion (Parvez et al., 2021). Even though industrial hemp contains negligible levels of THC and has numerous sustainable applications, misconceptions persist, slowing regulatory advancements and consumer adoption (Government of Alberta - Agriculture and Forestry, 2020; Parvez et al., 2021). Consumer awareness initiatives can enhance acceptance and promote broader adoption across various industries, including bio-composites, biofuel, and renewable building materials.

Opportunities and Implications for Indigenous Peoples

For Indigenous youth and communities, hemp aligns with cultural knowledge and practices, offering pathways to sovereignty, environmental stewardship, and land-based learning. For example, housing is a foundational determinant of health that profoundly shapes the physical, mental, emotional, and spiritual well-being of Indigenous Peoples of Turtle Island.

Indigenous communities continue to lead housing advocacy, advance land stewardship, and design culturally rooted housing models that foster healing and connection to land and community (Bowra & Mashford-Pringle, 2021; Thistle & Smylie, 2020). Of note, Gitxsan communities on the Pacific Northwest Coast of Canada are currently aiming to address homelessness, overcrowding and toxic homes with self-sourced building materials and ancient building techniques including hemp through a project called Xsan Hemp Homes (Sutherland-Wilson, 2023). Communally building homes for people in need and increasing Gitxsan presence on their lands will lead to healing for the people and the land – including through growing hemp to rehabilitate the land (Sutherland-Wilson, 2023). Ultimately this project will strengthen sustainable energy sovereignty, and support climate resilience initiatives by and for Indigenous peoples (Sutherland-Wilson, 2023).

Another example that demonstrates the versatility and potential significance of hemp is the Indigenous Hemp and Cannabis Farmers Cooperative (IHCFC) made to support developing Indigenous standards, cultivation, value added processing, appropriate technologies, and fair-trade markets which ultimately ensures tribal participation in the hemp and cannabis market benefit the plant and the community (IHCFC, n.d.). IHCFC looks to hemp to mitigate ecological, economic and quality of life issues, in the context of Tribal Hemp and Cannabis Policies that protect farmers, growers, land, and all resources sustainably (IHCFC, n.d.). Hemp and cannabis have the potential restore healthy lands, protect water, reduce carbon and create wellbeing in tribal nations through restorative economics (IHCFC, n.d.).

Potential risks may include challenges in implementing hemp sustainable solutions, due to ongoing colonialism, anti-Indigenous racism and discrimination. More specifically, Indigenous people are more likely to be subjected to marijuana charges and face unfair legal repercussions as a result of using hemp for any purpose (IHCFC, n.d.). This can be alleviated through equity work similar to the IHCF, including securing dispensary licences for Indigenous folks, creating jobs in farming hemp, and having people previously incarcerated for hemp being able to benefit from cannabis justice and economic efforts now (IHCFC, n.d.).

Conclusion

Looking ahead, hemp's role in mitigating the climate crisis must be taken seriously. By embracing hemp as a key part of climate action strategies, we can move towards a future that prioritises ecological balance, economic resilience, Indigenous self-determination, and a renewed relationship between us humans and Mother Earth. Collaboration with Indigenous communities who have traditional knowledge of sustainable land use could provide valuable insights for ecological and culturally safe hemp production practices. Hemp's diverse applications in sustainable construction, biofuel, regenerative agriculture, textile, and food industries among others, highlight its potential

as a powerful tool in mitigating the climate crisis (Ahmed et al., 2022; Dhondt & Muthu, 2021). The urgency of the climate crisis demands immediate and innovative solutions, and hemp presents an opportunity to integrate ecological approaches and transition away from environmentally destructive practices and use of resources (Dhondt & Muthu, 2021). Its biodegradable properties, rapid growth rate and excelled performance in various industries demonstrate enormous potential for a shift towards hemp being adopted as a more common raw material (Ahmed et al., 2022; Kaur & Kander, 2023). Despite these advantages, large-scale adoption of hemp requires further Indigenous-led research.

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