

## Unlocking the global potential of vetiver: Integrating digital technologies for economic growth in India

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### Abstract

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**Background:** Agriculture serves as a critical driver of economic growth in developing countries like India. India's tropical climate is highly suitable for vetiver cultivation, a crop with significant global demand. However, despite its potential, the vetiver industry in India faces challenges in marketing and commercialization, limiting its ability to tap into lucrative domestic and international demand. This study investigates the economic potential of vetiver grass across three key sectors: root sales, handicrafts, and essential oil in domestic (India) and global markets and analyses use of digital technologies like blockchain, e-commerce platforms and social media to address the marketing and commercialisation issues.

**Method:** This descriptive study uses secondary data to assess economic potential of vetiver across value chain- roots, handicraft and essential oils. It also uses articles, literature, reports and secondary data to analyse how digital technologies can help vetiver producers to market their products and to sell their products not only in the domestic market, but also in global markets.

**Results:** The study found that the integration of digital tools, including e-commerce platforms, blockchain, and digital marketing, offers a working solution to these challenges. These technologies have the potential to address bottlenecks in marketing and distribution, ensuring the increased profitability of vetiver products in developing countries like India. The study provides actionable insights for stakeholders, to integrate the digital economy tools in marketing and consumer outreach of the vetiver products to improve the economic conditions of agricultural communities in India.

*Keywords:* vetiver; essential oils; handicrafts; economic development; digital economy

*Abbreviations:* Compound Annual Growth Rate – CAGR; Virtual reality – VR

### Introduction

In pursuing sustainable agricultural practices and rural economic development, vetiver grass (*Chrysopogon zizanioides*) has appeared as a crop with immense untapped potential. Commonly known in India as „khus,“ vetiver is a perennial, clump-forming grass native to tropical regions, particularly South Asia, where it has been valued for centuries for its medicinal and aromatic properties. Vetiver be-

longs to the family Poaceae and is known for its extensive, fibrous root system that grows vertically into the soil, reaching depths of up to three meters (10 feet). This unique root network protects the plant against soil erosion, (Bariteau et al., 2013) drought, and other harsh environmental conditions (Lavania, 2019). It also contributes to the grass's various environmental and economic benefits, making it a promising candidate for environmentally friendly farming practices (Truong, 2000).

Vetiver's roots have long been used in Ayurvedic and traditional medicines to treat ailments such as fever, inflammation, and digestive issues (). Beyond its medicinal uses, vetiver root oil is prized in the fragrance industry for its rich, earthy aroma and has proved itself as a valuable part of luxury perfumes and cosmetics (Shabbir et al., 2019). More recently, vetiver has gained attention for its effectiveness in soil conservation, water management, and phytoremediation – offering natural solutions to challenges like erosion and land degradation (Kumar and Kumari, 2023; Cindik and Demirel, 2013). Additionally, vetiver roots can be crafted into eco-friendly handicrafts such as mats, baskets, and blinds, meeting a growing demand for sustainable products. As global markets for essential oils and eco-friendly handicrafts expand, vetiver presents a unique opportunity for economic growth in rural India, where small-scale farmers and artisans could benefit from increased cultivation and commercialization of this versatile crop (Gupta and Narain, 1996). Vetiver's environmental benefits are matched by its economic potential, especially in rural India, where sustainable farming practices are increasingly encouraged. As the demand for natural products like essential oils and handmade crafts grows globally, vetiver has become a valuable economic crop for three main sectors: raw root sales, handicraft production, and essential oil extraction. Each of these sectors presents distinct commercialization opportunities, which, if properly developed, could contribute to rural income generation and economic diversification in India (Shabbir et al., 2019).

The digital economy has become a transformative force across various industries, including agriculture and handicrafts, offering unprecedented opportunities for market expansion Yao and Sun, 2023; Ghosal and Prasad, 2019). E-commerce platforms like Amazon, Etsy, and India MART provide vetiver producers and artisans with direct access to domestic and international markets, eliminating intermediaries and increasing profit margins (Bhatnagar, 2020). These platforms also cater to the growing global demand for eco-friendly and sustainable products, particularly among urban and international consumers (Gao et al., 2022).

Blockchain technology is another innovation that can transform the vetiver industry by ensuring supply chain transparency and product authenticity. For example, blockchain can verify the organic production of vetiver essential oil, trace the origins of raw materials, and certify fair trade practices, thus building trust among international buyers (Patel and Sharma, 2022). This is especially critical in the fragrance and aromatherapy industries, where product integrity is a significant concern.

Additionally, digital marketing through social media platforms such as Instagram, Facebook, and YouTube has emerged as a cost-effective way to promote vetiver-based

products. Creative campaigns highlighting the sustainability and artisanal value of vetiver handicrafts can attract eco-conscious consumers globally, creating new avenues for rural artisans. Virtual reality (VR) showrooms and immersive online experiences are also emerging as tools to highlight high-quality vetiver products, further enhancing global consumer engagement (Xue, 2022).

This study investigates the demand potential for vetiver, while identifying the challenges farmers face in marketing their products and reaching customers. It also examines the role of the digital economy in enabling producers to connect with potential customers globally. The findings offer actionable solutions to address the marketability and accessibility challenges faced by vetiver producers, leveraging key drivers of the digital economy to enhance reach and profitability.

This study is organized into key sections, beginning with an introduction that analyses the economic potential of vetiver and the role of digital economy tools in enhancing product awareness and marketability. The second section presents a comprehensive literature review, followed by the method section, analysis of market trends, revenue potential, and opportunities for leveraging digital platforms such as e-commerce and social media to promote the sale of vetiver roots and handicrafts. The results section highlights the findings on the profitability and marketability of vetiver products, emphasizing the impact of digital economy drivers. The study concludes by synthesizing key insights and offering actionable strategies to address challenges, enhance market access, and improve the profitability of vetiver products.

## Literature review

Vetiver (*Chrysopogon zizanioides*) has gained recognition as a valuable economic crop with diverse applications, particularly in rural development. Studies underscore its utility in multiple industries, such as essential oils, handicrafts, and eco-friendly products, making it a significant contributor to income generation in rural areas (Shabbir et al., 2019). Extracted from the roots, vetiver essential oil is highly valued in the fragrance industry for its deep, woody aroma. Due to its complex chemical composition, vetiver oil is used not only in perfumery, but also in aromatherapy and cosmetics. The global essential oils market, with vetiver oil as a critical part, is expanding rapidly and was valued at over USD 5 billion in 2020, with projections showing consistent growth as consumer preferences increasingly shift toward natural and organic products (Shrivastava et al., 2024). Research by Irshad et al. (2019) highlights the critical role of vetiver oil in the fragrance industry due to its distinct woody aroma and fixative properties, making it indispensable in luxury per-

fumes. However, small-scale producers face barriers such as high initial costs for essential oil distillation and a lack of access to global markets. Vetiver oil has a robust presence in the global essential oils market, driven by demand from the fragrance, cosmetics, and aromatherapy sectors. While countries like Haiti, Indonesia, and Brazil dominate production, India's tropical climate and large agricultural workforce offer untapped potential (Sharma and Mehta, 2020). Increasing consumer preference for organic and sustainable products underscores the need for scalable production models that align with international standards. Vetiver roots have long been used to craft artisanal products such as mats, baskets, and fans, which align with the growing global demand for sustainable, eco-friendly products (Chomchalow, 2001). In rural India, vetiver roots are woven into baskets, mats, and fans, a practice that has existed for centuries (Chomchalow, 2001). Gupta and Narain (1996) document the traditional use of vetiver in Indian handicrafts, emphasizing its cultural and economic significance. In recent years, the resurgence of interest in handmade, natural products, particularly in Western markets, has created new opportunities for rural artisans, especially women, who dominate this sector.

○ RQ 1: How can the economic potential of Vetiver be assessed across key sectors such as root sales, handicrafts, and essential oil extraction?

Research by Babu et al. (2021) highlight the export potential of vetiver handicrafts. Despite this burgeoning demand, the economic potential of vetiver in India remains untapped due to inadequate commercialization infrastructure. Market access is another major barrier; while there is significant demand for vetiver products both domestically and internationally, farmers struggle to connect with buyers due to poor market linkages and the absence of organized distribution channels (Dhawan et al., 2021). A significant advancement in product commercialization can be achieved by using digital economy tools. Platforms such as India MART, Amazon, and Etsy enable rural producers to directly market and sell their products to consumers, bypassing intermediaries and increasing profit margins (Bhatnagar, 2020). Furthermore, blockchain technology authenticates the origin and originality of the products, building trust with international buyers (Patil and Sharma, 2022). Digital marketing, through platforms like Instagram, Facebook, and YouTube, can amplify the reach of any product by targeting urban and international eco-conscious consumers. These innovations offer a transformative pathway for any industry to capitalize on its untapped potential (Kumar and Gupta, 2021).

○ RQ 2: How can digital economy tools, such as e-commerce platforms, blockchain, and digital marketing, be integrated to expand the market reach and commercialization of Vetiver products?

## Methodology

This descriptive study uses secondary data to assess the economic potential of vetiver (*Chrysopogon zizanioides*), focusing on root sales, handicrafts, and essential oil extraction and examines the use of digital tools to enhance the global marketability and customer reach of vetiver products. Credible sources, including government publications, industry reports, and international databases, provide insights into policies, market trends, and trade data. Reports from the Ministry of Agriculture, National Bank for Agriculture and Rural Development, and state agricultural bodies of India provide information on national support and the role of vetiver in rural development. Industry reports from organizations like the International Fragrance Association and the Essential Oils Association highlight market opportunities, particularly in the global essential oils and handicraft markets. International databases from the FAO, UN COMTRADE, and the World Bank offer data on crop production, export values, and trade trends, positioning India within the global vetiver market. This structured review helps identify strategies for leveraging Vetiver as a sustainable economic asset for rural communities

## Data analysis

Vetiver can become a valuable economic crop for three main sectors: raw root sales, handicraft production, and essential oil extraction. Each of these sectors presents distinct commercialization opportunities, which, if properly developed, could contribute to rural income generation and economic diversification in India (Shabbir et al., 2019).

### ○ RQ 1 – Economic relevance of vetiver in India

The data in Table 1 provides a comparative overview of the pricing and market dynamics for vetiver-derived products, focusing on essential oil, handicrafts, and raw roots. The analysis highlights significant differences between domestic and international markets, emphasizing the economic potential of vetiver products across different value chains.

**1. Vetiver essential oil:** Essential oil derived from vetiver roots is the most valuable product in Indian and international markets. In India, the price ranges between ₹18 000 and ₹20 000 per kilogram, reflecting its premium status in

**Table 1. Market dynamics and price ranges of vetiver products (in ₹)**

Product category	India (price range)	International (price range)	Market dynamics
Vetiver essential oil	₹213-₹236 per litter ₹415(Avg. price per kg)	\$250 – \$350	High demand in the fragrance, cosmetics, and aromatherapy sectors. Major exports to the U.S., Europe, and Gulf nations.
Vetiver handicrafts	₹2.36 – ₹11.84 per item	\$10 – \$50 per item	Niche demand for eco-friendly and handmade products. Popular in domestic craft fairs and select export markets.
Vetiver roots (raw)	₹100 – ₹200 per kg	\$2 – \$5 per kg	Used domestically for cooling mats and perfumery. Internationally valued for essential oil production.
Vetiver-based products (value-added products)	₹500 – ₹3,000	\$15 – \$100	The growing popularity of high-value derivatives such as perfumes, soaps, and wellness products in urban and export markets.

Source: Author's compilation (Danh, L. T., Truong, P., Mammucari, R., Tran, T., & Foster, N. (2009). Vetiver grass, *Vetiveria zizanioides*: A choice plant for phytoremediation and bioenergy. *Bioresource Technology*, 100(6), 1717–1721. <https://www.alibaba.com>, <https://www.exportersindia.com/indian-suppliers/vetiver-root.htm>, etc.)

the fragrance and wellness sectors. Internationally, the prices are even higher, ranging from \$250 to \$350 per kilogram, driven by robust demand in the U.S., Europe, and Gulf nations. This price premium is attributed to the oil's unique aromatic profile and limited supply, positioning it as a highly lucrative commodity for export markets.

**2. Vetiver handicrafts:** Vetiver-based handicrafts, such as mats, baskets, and fans, are popular in eco-friendly product niches. In India, prices range from ₹200 to ₹1 000 per item, depending on the artisanship and product type. Internationally, these products fetch higher prices, typically ranging from \$10 to \$50 per item, driven by growing demand for sustainable, handmade goods. However, the market remains niche, with limited scalability due to artisanal production processes and a lack of market linkages.

**3. Vetiver roots (raw):** Raw vetiver roots, primarily used domestically for cooling mats and aromatic applications, are priced between ₹80 and ₹150 per kilogram in India. On the global market, these roots are valued at \$2 to \$5 per kilogram, primarily for use in essential oil production. While the demand for raw roots is steady, it is less profitable than processed products like essential oils or handicrafts.

### Market dynamics

**Domestic trends:** In India, the vetiver market is fragmented, with production largely concentrated in small-scale operations (Silva et al., 2024). While essential oil production is the most profitable segment, limited access to global markets and a lack of technical ability hinders broader commercialization. Handicrafts have moderate demand but remain constrained by the artisanal nature of production.

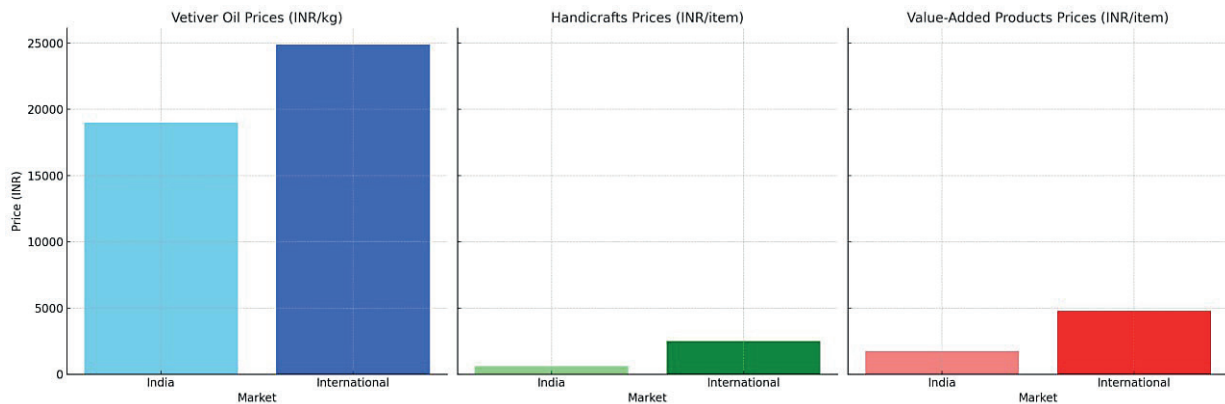
**International trends:** Globally, vetiver essential oil is highly sought after in the fragrance and cosmetics industries, with countries like Haiti and Indonesia dominating the market (Singh and Yadav, 2022). India has the potential to capture a larger share of this market through improved cultivation practices, processing facilities, and market linkages (Saha and Patel, 2020). The growing demand for eco-friendly and sustainable products presents added opportunities for expanding the market for vetiver handicrafts and value-added products (Gupta and Sharma, 2019; Kumar and Gupta, 2021).

Figure 1 provides a comparative analysis of the prices of vetiver-based products across domestic and international markets, highlighting their economic potential. Here are the three bar graphs representing the pricing data for Vetiver products:

**1. Vetiver essential oil:** Domestic prices are ₹18 000 – ₹20000 per kilogram, reflecting its premium value in the Indian market. International prices average ₹24 900 per kilogram (converted from \$300), highlighting its export potential due to high demand in aromatherapy, perfumery, and cosmetics industries.

**2. Vetiver handicrafts:** Domestic prices range from ₹200 – ₹1000 per item, depending on the intricacy and size of the product. International prices average ₹2490 per item (converted from \$30), highlighting the appeal of eco-friendly, handmade products in global markets.

**3. Value-added products:** Domestic prices for items like perfumes and soaps range between ₹500 – ₹3000, showing a robust market for premium products. International prices average ₹4772 per product (converted from \$57.5), reflecting the demand for high-quality derivatives of vetiver in export markets.



**Fig. 1. Prices of vetiver products in India vis-à-vis the international market**

Source: Author's compilation (<https://www.exportersindia.com/indian-suppliers/vetiver-root.htm>, <https://dir.indiamart.com/search.mp?ss=vetiver+oil>, <https://dir.indiamart.com/search.mp?ss=vetiver+root>, etc)

These graphs visually illustrate the differences in pricing between the domestic and international markets for vetiver-derived products. It emphasizes the economic viability of vetiver products and their potential to boost rural livelihoods in India through targeted market interventions and value addition.

It focuses on understanding the economic potential of vetiver products by examining pricing trends and market dynamics across three key categories: essential oil, handicrafts, and value-added products. The analysis provides a comparative overview of domestic and international markets using secondary data from government publications, industry reports, and international trade statistics. The findings reveal significant price point variations, highlighting essential oils' profitability and the growing niche for handicrafts and eco-friendly products. The analysis shed light on opportunities for scaling vetiver production and improving market access for Indian farmers and artisans.

### **RQ 2 – Digital technology and vetiver's products**

The digital economy is revolutionizing industries like agriculture and handicrafts, providing significant opportunities for market growth. For Vetiver, digital tools such as e-commerce platforms, blockchain, and digital marketing are essential for connecting rural producers with global consumers. Platforms like Amazon, Etsy, and IndiaMART enable direct access to both domestic and international markets, eliminating intermediaries and increasing profits (Bhatnagar, 2020). These tools also meet the growing global demand for eco-friendly and sustainable products, especially among urban and international buyers.

Blockchain technology is another innovation that can transform the vetiver industry by ensuring supply chain transparency and product authenticity. For example, block-

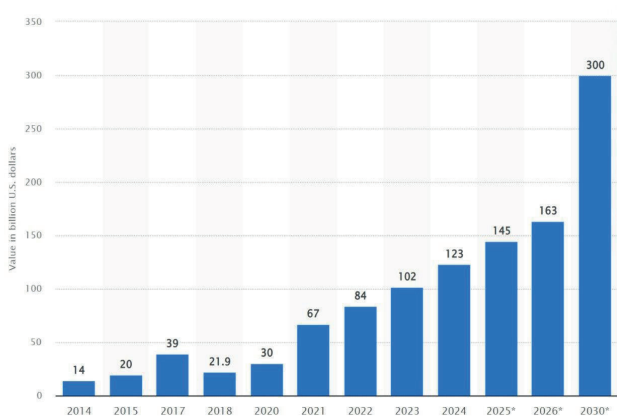
chain can verify the organic production of vetiver essential oil, trace the origins of raw materials, and certify fair trade practices, thus building trust among international buyers (Patel and Sharma, 2022). This is especially critical in the fragrance and aromatherapy industries, where product integrity is a significant concern.

Additionally, digital marketing through social media platforms such as Instagram, Facebook, and YouTube has appeared as a cost-effective way to promote vetiver-based products. Creative campaigns highlighting the sustainability and artisanal value of vetiver handicrafts can attract eco-conscious consumers globally, creating new avenues for rural artisans (Kumar and Gupta, 2021). Virtual reality (VR) showrooms and immersive online experiences are also appearing as tools to showcase high-quality vetiver products, further enhancing global consumer engagement.

### **Digital potential**

The analysis highlights that Vetiver products have immense sales potential when marketed digitally. Domestic platforms such as Flipkart and IndiaMART enable producers to target eco-conscious Indian consumers, while international platforms like Alibaba and Etsy cater to a global audience willing to pay premium prices for natural and sustainable products. The use of digital marketing tools, including social media campaigns, can further enhance visibility and drive consumer engagement.

Figure 2 illustrates the exponential growth in the value of a particular market from 2014 to 2030, starting at \$14 billion in 2014 and projected to reach \$300 billion by 2030. This suggests a growth trajectory, where industries or products within this market could experience significant returns as they scale.

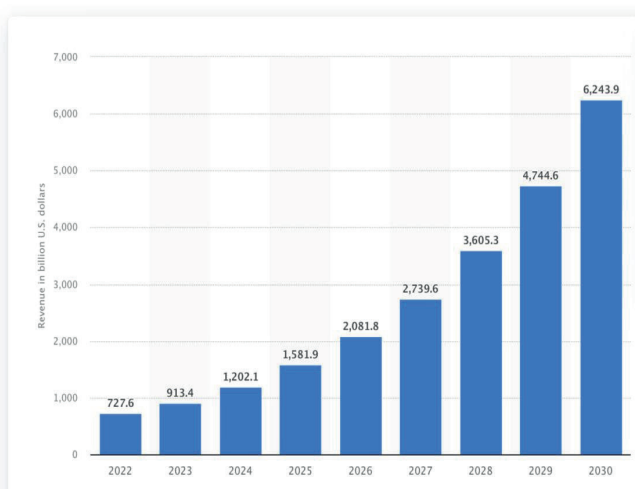


**Fig. 2. Market size of the e-commerce industry across India**

Source: [https://www.statista.com/statistics/792047/india-e-commerce-market-size/?srsltid=AfmBOoqDLfkAa3auNOngk2Af5\\_E0ghXG50f10Lu0YAFDthKWgn8fCF9](https://www.statista.com/statistics/792047/india-e-commerce-market-size/?srsltid=AfmBOoqDLfkAa3auNOngk2Af5_E0ghXG50f10Lu0YAFDthKWgn8fCF9)

If vetiver farming is positioned to be marketed via various platforms, it could potentially mirror this growth trend. By tapping into the increasing demand for natural and sustainable products, vetiver-based goods (such as essential oils, handicrafts, and roots) could benefit from this expanding market, positioning it as a profitable venture in line with future growth projections.

This growth trend indicates that vetiver could see a similar rise in demand, contributing to both economic development in rural areas and profitability for farmers involved in vetiver cultivation.



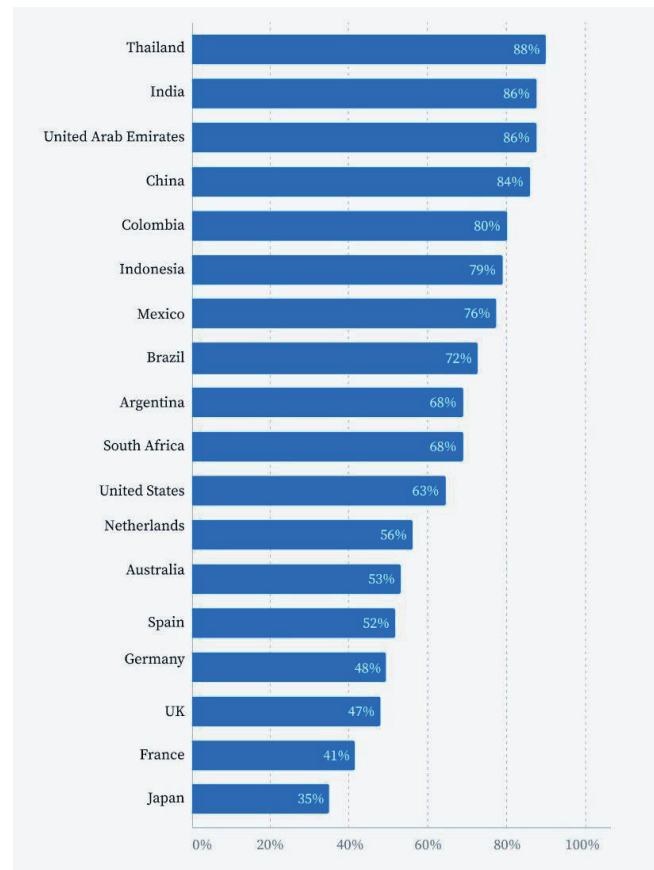
**Fig. 3. Social commerce revenue worldwide (2022–2030)**

Source: <https://www.statista.com>

Figure 3 presents a strong upward trajectory in the revenue of a specific market, starting from \$727.6 billion in 2022 and projected to reach \$6,243.9 billion by 2030. This rapid growth indicates a significant expansion, reflecting the increasing demand and the potential profitability of the sector.

Given the growth of the e-commerce industry, which has seen substantial increases in revenue in recent years, it can be inferred that online sales channels are a key driver of this upward trend. This is crucial for vetiver farming, as it presents an opportunity for the sale of vetiver-based products through e-commerce platforms. As the e-commerce sector continues to grow, the accessibility and reach for vetiver products, such as essential oils, handicrafts, and roots, are also likely to increase.

The revenue projections for 2030 suggest a substantial market expansion, which offers significant potential for vetiver farmers to tap into this growing demand by leveraging online sales platforms. By aligning with the rise of e-commerce, vetiver-based products could see increased market



**Fig. 4. Percentage of online buying from social networks in selected countries (2022)**

Source: <https://www.tidio.com/blog/social-commerce-statistics/>

penetration and profitability, following the general market growth indicated in the graph.

Figure 4 illustrates the percentage of online consumers purchasing products via social networks in various countries in 2022. Thailand leads with 88% of consumers buying through social platforms, followed closely by India (86%) and the United Arab Emirates (86%). These high percentages highlight the significant role social media plays in e-commerce, particularly in Asia.

Countries such as the United States (63%) and the Netherlands (56%) show lower adoption rates, while European countries like Spain (52%), Germany (48%), and France (41%) exhibit moderate engagement. Japan shows the lowest percentage at 35%, indicating a slower adoption of social commerce in the country.

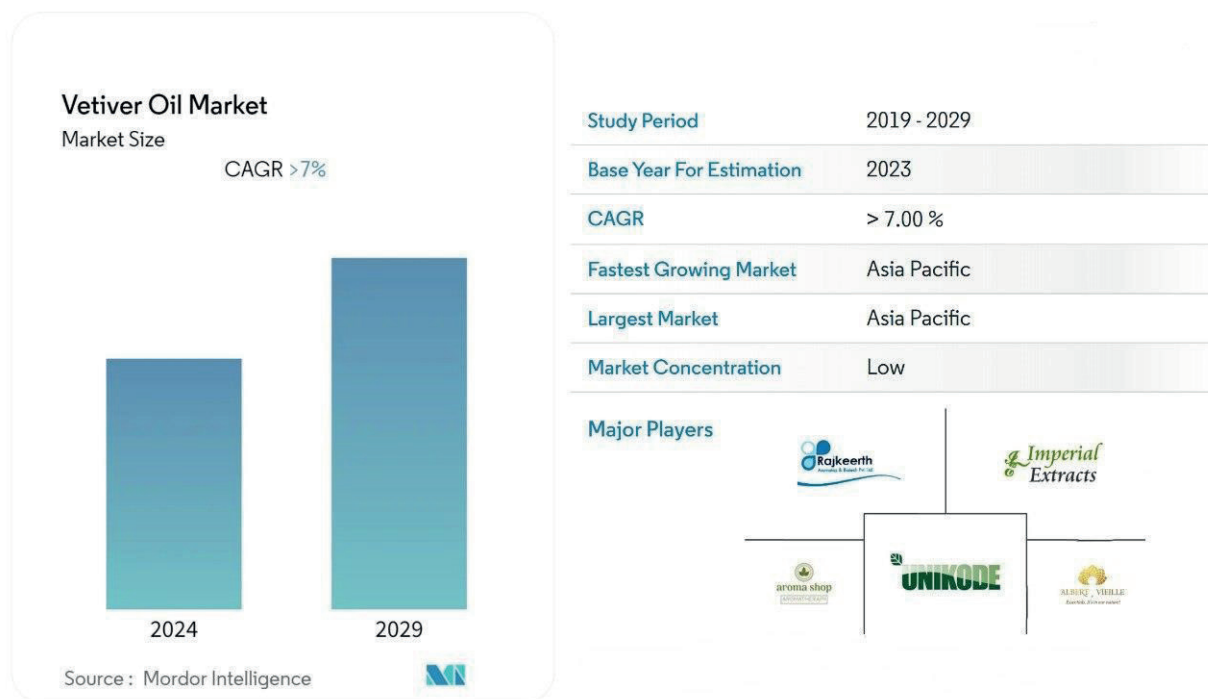
This data demonstrates the growing trend of social commerce, with a particularly strong presence in Asian markets. It emphasizes the importance of leveraging social media for marketing and selling products, especially in countries with higher consumer engagement like India. For vetiver-based products, tapping into social commerce in such regions could significantly increase visibility and sales.

Figure 5 shows the market size and projected growth of the vetiver oil industry, with a Compound Annual Growth Rate (CAGR) of over 7% from 2019 to 2029. Asia Pacific is

identified as both the fastest growing and the largest market, indicating significant demand for vetiver oil in this region. The market concentration is low, suggesting opportunities for new players and innovation within the industry.

India, being part of the Asia Pacific region, stands to benefit greatly from this expanding market. As the global demand for natural and sustainable products like vetiver oil increases, India's established expertise in vetiver cultivation and production positions it well to grow both locally and internationally. With the right market penetration strategies, India could capitalize on this trend, boosting exports and increasing market share in the global vetiver oil industry.

Table 2 highlights the estimated revenue potential of vetiver-based products – roots, handicrafts, and essential oils, through digital platforms in domestic and international markets. Vetiver roots offer significant revenue opportunities, particularly in international markets, where bulk sales can generate ₹16.6 – ₹41.5 lakh annually on platforms like Alibaba. Handicrafts, while catering to niche eco-conscious buyers, provide premium pricing opportunities, with international sales ranging from ₹8.3 – ₹20.7 lakh on platforms like Etsy and Amazon Handmade, although scalability remains a challenge. Essential oils emerge as the most lucrative product per unit, with potential international revenues of ₹10.3 – ₹14.5 lakh annually, driven by high demand in



**Fig. 5. Market size of vetiver oil market**

Source: <https://www.mordorintelligence.com/industry-reports/vetiver-oil-market>

**Table 2. Estimated revenue potential for vetiver products through digital platforms**

Product	Domestic Sales Estimate (₹)	International Sales estimate (₹)	Digital platforms
Vetiver roots	1.6 – 4.5 lakh	16.6 – 41.5 lakh	IndiaMART, Flipkart, Alibaba
Vetiver handicrafts	2 – 10 lakh	8.3 – 20.7 lakh	Etsy, Instagram Shops, Amazon Handmade
Vetiver essential oils	1.8 – 4 lakh	10.3 – 14.5 lakh	Amazon Global, Alibaba, Nykaa

Source: Author's Compilation (<https://dir.indiamart.com/search.mp?ss=vetiver+root>, [https://www.amazon.com/s?k=Vetiver+oil&bbn=230659011&crd=2Z0WW4G8W5PKY&srefix=vetiver+oi%2Caps%2C419&ref=nb\\_sb\\_noss\\_2](https://www.amazon.com/s?k=Vetiver+oil&bbn=230659011&crd=2Z0WW4G8W5PKY&srefix=vetiver+oi%2Caps%2C419&ref=nb_sb_noss_2), etc.)

luxury fragrance and aromatherapy markets. Digital tools such as ecommerce platforms, blockchain for supply chain transparency, and social media marketing play a crucial role in eliminating intermediaries, increasing market reach, and enhancing profitability for rural producers. By addressing challenges like logistical support, training, and certifications, the integration of digital technologies can unlock substantial growth for vetiver products in global markets.

Additionally, blockchain technology can strengthen international sales by ensuring traceability and quality certification, ensuring transparency and trust by authenticating product origins (Vazquez Melendez et al., 2024). This is crucial for high-value products like vetiver oil, catering to premium markets in fragrances and aromatherapy. By adopting a digital-first approach, producers can scale their operations, increase revenues, and significantly improve their market reach. This transformation benefits rural farmers and artisans and aligns with global trends toward sustainable and transparent product sourcing.

Platforms like Alibaba and IndiaMART connect Indian producers directly with global buyers, bypassing intermediaries and increase profitability. These tools not only expand market access but also enhance credibility, enabling Indian vetiver producers to capitalize on rising global demand, while fostering trust and sustainable trade practices.

Handicrafts can benefit from digital marketing and sales through platforms like Etsy and social media campaigns targeting eco-conscious consumers. Virtual reality (VR) tools can create immersive online showrooms, highlighting artisan artisanship to global audiences.

Online marketplaces like Amazon and Flipkart enable D2C sales, making high-quality perfumes, soaps, and wellness products derived from Vetiver accessible to urban and international customers. Crowdfunding platforms such as Kickstarters can help fund innovative vetiver-based products, attracting global investment and consumer interest.

## Results and Findings

The analysis of vetiver's economic potential reveals key opportunities in its commercialization, particularly in root

sales, handicraft production, and essential oil extraction. Despite its environmental and financial benefits, vetiver cultivation in India remains limited. Market analysis indicates a growing demand for vetiver products, particularly essential oils, in both domestic and international markets. Despite this trend, India's share in the global essential oils market remains modest. In the fiscal year 2024, India's export value of essential oils was approximately \$323 million (STATISTA). While India is among the top exporters of vetiver oil, with significant shipments to countries like the United States, United Kingdom, and Taiwan (VOLZA), the global vetiver oil market is projected to reach \$91.9 million by 2032, growing at a CAGR of 6.5% (IMARC GROUP). This suggests that there is substantial room for India to expand its presence in this growing market, presenting a significant opportunity for expansion. Countries like Indonesia and Haiti currently dominate, but India's favourable climate offers the potential for scaling production and capturing a larger market share (Kikon and Angami, 2018). Similarly, the vetiver handicraft sector offers significant potential for rural economic development but faces challenges such as limited market access and the need for targeted awareness campaigns to enhance its visibility and reach.

The integration of digital tools significantly enhances Vetiver's marketability. Platforms like Instagram and Facebook expand the reach of vetiver products, particularly handicrafts and essential oils, while blockchain technology ensures supply chain transparency, which is crucial for high-value exports. E-commerce platforms, such as Amazon and IndiaMART, reduce reliance on intermediaries, increasing profit margins for producers. Blockchain integration can address these challenges by certifying the quality and origin of the essential oil, enhancing its appeal in export markets (Lavania, 2019).

## Discussion and Conclusion

This study examines the economic potential of vetiver (*Chrysopogon zizanioides*) as a sustainable cash crop for rural communities in India, focusing on three key sectors: root sales, handicraft production, and essential oil extrac-

tion. While global demand for vetiver, particularly in the fragrance, cosmetics, and aromatherapy industries, continues to rise, India's share in the market remains limited. This presents significant opportunities for expanding production, especially of vetiver oil, which is highly valued for its scarcity and unique properties. The integration of digital tools, such as e-commerce platforms like IndiaMART and Amazon, along with blockchain technology, can help rural farmers and artisans connect directly with global markets, bypassing intermediaries and increasing profit margins. Blockchain can also ensure supply chain transparency, critical for high-value exports like vetiver oil. With the right policies and use of digital tools, vetiver can become a key driver of rural economic growth and a prominent player in the global essential oils market.

Digital technologies offer solutions to these challenges. Mobile applications tailored for vetiver farmers can give critical information on best practices, market trends, and buyer networks, empowering them to adopt vetiver cultivation (Kumar and Gupta, 2021). Blockchain technology can ensure fair trade practices and transparent pricing, enabling small-scale producers to compete effectively in global markets (Patel and Sharma, 2022). Cooperative models, supported by digital financing tools such as micro-loans and crowdfunding, can address resource and infrastructure gaps, fostering broader adoption of vetiver farming (Sharma et al., 2021). E-commerce platforms such as Alibaba and IndiaMART offer direct access to international buyers, facilitating the export of vetiver oil and handicrafts. Blockchain technology adds value by ensuring product authenticity and quality, which is particularly important for high-end markets like luxury perfumes and aromatherapy (Patel and Sharma, 2022). As the global demand for essential oils continues to grow, leveraging these digital tools can position India as a key player in the international vetiver market, expanding its reach and boosting its economic potential. Crowdfunding platforms like Kickstarter and digital trade platforms like Alibaba could address these barriers by connecting rural producers with international investors and buyers, facilitating resource acquisition and market expansion (Sharma et al., 2021). With the integration of e-commerce platforms, these handicrafts can now reach global markets, enabling rural artisans to cater to a broader audience and achieve greater financial independence.

## Future scope

The future of vetiver cultivation in India holds significant potential, particularly in terms of economic growth. While this study provides insights into the commercializa-

tion of vetiver through root sales, handicrafts, and essential oils, several areas require further investigation. Key areas for future research include optimizing cultivation practices by exploring agroecological zones, improving soil and water management, and adopting precision farming techniques using digital tools like IoT sensors to increase yield and reduce resource wastage. Additionally, developing a more structured supply chain is crucial for connecting farmers directly with markets. E-commerce platforms and blockchain technology can improve market access, ensure fair pricing, and guarantee product authenticity. Expanding the production of value-added vetiver products such as health and wellness items, textiles, and bio-based chemicals is another promising avenue. Digital marketing and crowdfunding platforms can support the growth of these products, targeting eco-conscious consumers. The discussion further emphasizes the need for continued research to address challenges within the handicraft sector and set up a robust, tech-enabled supply chain for essential oil marketing. With these advancements, vetiver could become a practical alternative to traditional crops, contributing to long-term sustainable development and economic diversification in rural India. Government policies, financial support, and mobile apps for real-time market insights can also help scale up vetiver farming and commercialization. Eco-certification programs through digital platforms can incentivize farmers to adopt sustainable practices while opening new markets for certified products.

In summary, vetiver cultivation in India has vast potential for economic and sustainable growth. By addressing barriers and leveraging digital economy tools, vetiver can become a key driver of rural development, contributing to both farmer livelihoods and India's presence in the global natural products market.

## Conflict of interest

There is no conflict of interest.

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