

Sustainability in a dynamic world: Strategic and operational imperatives for the chemicals industry

October 2025



Foreword



The Indian Chemical Council has, over the years, evolved far beyond its role as an industry body – it has become a strategic force shaping the future of Indian industry. Through its commitment to sustainability, innovation, and responsible growth, ICC is helping lay the foundation for a more self-reliant, competitive, and environmentally conscious India.

From advancing safety standards and circular economy practices to enabling green chemistry and sustainable supply chains, ICC's initiatives are deeply aligned with national goals such as "Make in India," "Zero Effect, Zero Defect," and the broader vision of a Viksit Bharat. Its efforts are not limited to policy advocacy – ICC is actively building ecosystems where industries can thrive while remaining accountable to people and the planet.

The Sustainability Conclave reflects this very ethos. It is not just a gathering – it is a call to action, a space where leadership meets responsibility, and where global aspirations are grounded in local action. By fostering dialogue, collaboration, and innovation, ICC is helping transform the Indian chemical industry into a global model for sustainable development.

I commend the Indian Chemical Council for its visionary leadership and the credibility it brings to the sustainability agenda. I am confident that its continued efforts will be instrumental in driving India's transition toward a greener, more inclusive industrial future.


(Anupriya Patel)

October 7, 2025
New Delhi

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Secretary
Government of India
Ministry of Chemicals & Fertilizers
Department of Chemicals & Petrochemicals



24th October, 2025

MESSAGE

As India charts its path to becoming a global manufacturing and innovation hub, the role of the chemical and petrochemical industry is both foundational and transformative. The ICC Sustainability Conclave reflects a timely pivot — from incremental improvement to systemic change — where sustainability is not viewed as a constraint, but as a catalyst for long-term industrial leadership.

Today, the challenge before us is clear: to decouple growth from resource intensity, to scale without compromising safety or environmental integrity, and to build global competitiveness through green technologies and circular practices. Achieving this requires more than compliance — it demands a strategic redesign of how the sector thinks, invests, and collaborates.

This Conclave serves as a platform not only for knowledge exchange but for co-creating the next-generation blueprint for the Indian chemical industry — one that is deeply aligned with global ESG standards, leverages digital and green innovation, and anticipates the regulatory and market shifts of the future.

I appreciate Indian Chemical Council's continued leadership in steering this transition. I am confident that the deliberations and actions emerging from this platform will help position India not just as a participant, but as a frontrunner in defining the global sustainability agenda for the chemical sector.


(Nivedita Shukla Verma)



Message from ICC

Ramya Bharathram

President, ICC & Managing Director & CFO,
Thirumalai Chemicals Ltd

Sustainability now serves as the foundation upon which the chemical industry builds its future—championing innovation, reducing environmental impact, and strengthening community ties. This shift signals a deeper commitment to responsible growth that transcends traditional business goals.

Aligned with the Government of India's LiFE (Lifestyle for Environment) initiative, the chemical industry is uniquely positioned to catalyze behavioral and systemic shifts toward sustainable production and consumption. Its contributions reinforce the nation's broader developmental priorities—ranging from green growth and industrial resilience to environmental preservation. The current dependence on imports for a range of advanced chemical segments points to the untapped potential of India's manufacturing ecosystem. Strengthening local production not only enhances industrial self-reliance but also aligns with broader national goals of green growth, competitiveness, and reduced external vulnerabilities. As global markets seek table and sustainable suppliers, India's positioning becomes increasingly strategic.

I commend ICC and its members for their continued commitment to sustainability-led growth. May this Conclave spark transformative dialogue, forge impactful partnerships, and inspire forward-looking initiatives that strengthen the chemical industry.



Message from ICC

D Sothi Selvam

Director General
ICC

As the global economy navigates the dual imperatives of growth and resilience, sustainability has emerged not just as a guiding principle—but as a competitive differentiator for industries worldwide. Nowhere is this more evident than in the chemical sector, where innovation, efficiency, and environmental responsibility intersect in complex and meaningful ways. India, with its dynamic industrial landscape and growing technological capacity, has the potential to lead this transformation. The country's chemical industry is not only central to its own developmental goals, but also to broader global efforts aimed at securing cleaner, safer, and more sustainable value chains. This leadership, however, demands more than ambition—it calls for systemic change, long-term thinking, and inclusive action.

ICC remains committed to driving sustainable transformation, promoting knowledge exchange, and facilitating partnerships that strengthen the sector's global competitiveness. This conclave is a reaffirmation of ICC's enduring commitment to progress that is mindful, measured, and meaningful. I trust the insights shared here will contribute to a stronger foundation for sustainable industrial practices and reinforce the sector's role in delivering long-term value to the economy, the environment, and society at large.

I convey my best wishes to ICC, its partners, and all participants for a successful and impactful conclave.

Foreword from PwC

India is on its path to achieve the government's vision of Viksit@2047 and the chemicals sector could play a crucial part in the industrial reform and growth due to the sector's linkages across –sectors such as agriculture, food and beverages, textiles, rubber and petroleum refining. This sector already contributes ~7% of GDP and covers a market of 80,000 downstream products which is projected to expand from \$220 billion (2024) to \$2 trillion in 2047.¹

The Indian chemicals industry aims to establish itself as a trusted manufacturer and supplier to the world. However challenges such as emerging tariff orders, import dependence on some raw materials, technology transfer barriers, infrastructure enhancement, regulatory reforms and incentives and sustainable R&D ecosystem. To navigate these challenges, this report aims to bring out the strategic and operational imperatives to make India a resilient chemicals manufacturing hub.

Broadly the report outlines imperatives across the following:

Innovation and operational excellence: Focus on innovation through platform-molecule strategies, process optimisation, green chemistry and collaborative R&D ecosystem. Operating equipment effectiveness and R&D and planning capabilities need to be enhanced further through leverage of AI tools and digital transformation.

Supply chain and infrastructure configuration: It is imperative to have secure supply chains and indigenised to the extent possible. This can be achieved by strategic investment in plastic parks, logistics improvements and strong focus on specialty chemical capability development to improve cost competitiveness and effectiveness.

Sustainable finance and markets transition: There is a shift from sustainability compliance to building sustainable growth enablers which align across global standards, leverage green capital sources and incorporate carbon market economics. Additionally, there is an increased focus towards bio-based and recycled product inputs as well as transition towards low-carbon, circular product portfolios

Together, these can provide a strategic framework for growth and help the Indian chemical industry become a significant and sustainable contributor not just for the domestic economic growth but also for enhancing the global chemicals sector.

PwC India and ICC have developed this knowledge paper to explore these key imperatives which can make India a growth hub for chemicals. We hope that you find the report to be informative and insightful.

Manas Majumdar

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¹<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

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Executive summary

India's chemical industry is undergoing a profound transformation. The industry has the potential to become a strategic pillar of national growth and establish itself as a strong contender in global sustainable manufacturing. Chapter 1 highlights the sector's foundational role in supporting over 80,000 downstream products across pharmaceuticals, agriculture, energy, and consumer goods. Contributing approximately 7% to India's GDP, the industry is projected to grow from \$220 billion in 2024 to \$2 trillion by 2047². This expansion is driven by rising domestic consumption, increasing demand for specialty chemicals, and a supportive policy landscape.

In Chapter 2, we see that securing and localising the chemical supply chain is critical to sustaining India's industrial momentum. With chemical imports valued at \$85.41 billion in 2023³, India faces both a challenge and an opportunity to build self-reliance. Strategic infrastructure investments—such as Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs), Plastic Parks, and logistics reforms under the National Logistics Policy and Maritime India Vision 2030—are enhancing connectivity, reducing costs, and boosting export competitiveness. The private sector's robust base in refineries, petrochemicals, and specialty chemicals positions India well to scale domestic production and reduce import dependency.

Chapter 3 underscores the importance of innovation and R&D in driving sustainable chemical solutions. Indian companies are increasingly adopting platform molecule strategies, process optimisation, and customer-centric R&D to develop high-margin specialty derivatives. Green chemistry and bio-based feedstocks are gaining traction as alternatives to crude-based inputs, supported by India's abundant biomass resources. Collaborative R&D ecosystems—anchored by institutions like the Council of Scientific and Industrial Research (CSIR), the Department of Science and Technology (DST) and the the Department of Biotechnology (DBT), and NITI Aayog—are fostering innovation through regional hubs and digital tools such as AI-enabled platforms and TRL-based funding models.

Chapter 4 focuses on operational excellence through technology adoption and circular economy models. Digital transformation is improving equipment effectiveness by 20–30%⁴, while AI is enabling predictive maintenance, quality control, and mass customisation. Certified inputs like ISCC Plus and RSPO are helping companies meet global sustainability standards. Workforce transformation is underway, with academia–industry–policy collaboration preparing India's talent for AI-era manufacturing. Plug-and-play green infrastructure is accelerating industrial setup and enabling SMEs to adopt sustainable practices.

Chapter 5 explores the integration of ESG principles and the rise of green finance. ESG has evolved from a compliance obligation to a strategic enabler of growth, resilience, and capital access. India's alignment with global standards—the International Sustainability Standards Board (ISSB), the Global Reporting Initiative (GRI), the Corporate Sustainability Reporting Directive (CSRD), and the Securities and Exchange Board of India's (SEBI) Business Responsibility and Sustainability Reporting (BRSR)—enhances transparency and investor confidence. Green finance instruments, including green bonds, loans, deposits, and ESG mutual funds, are mobilising capital for sustainability. The PLI scheme complements these efforts by incentivising domestic production. Government interventions, such as the National Green Hydrogen Mission and Bioethanol Programme, further de-risk investments and stimulate market demand.

The transition to sustainable product portfolios is accelerating, with global demand for bio-based feedstocks, recycled polymers, and low-carbon specialty chemicals projected to grow 70% by 2028⁵. Regulatory pressures, investor mandates, circular economy principles, and consumer awareness are converging to reshape portfolio strategies. Many companies are investing in green technologies, advanced recycling, and bio-based innovations. Start-ups are driving breakthroughs in recycling, biodegradable packaging, biohydrogen, etc. As companies scale operations through access to green finance, their ability to invest in innovation and circular models increases proportionally. This creates a virtuous cycle: robust sustainability reporting enhances capital access; capital investment drives sustainable growth; and growth results in high-value, environmentally responsible products that establish long-term competitive advantage. India's chemical industry is no longer just a manufacturing powerhouse—becoming a major global player.

²<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

³<https://www.ibef.org/industry/chemical-industry-india>

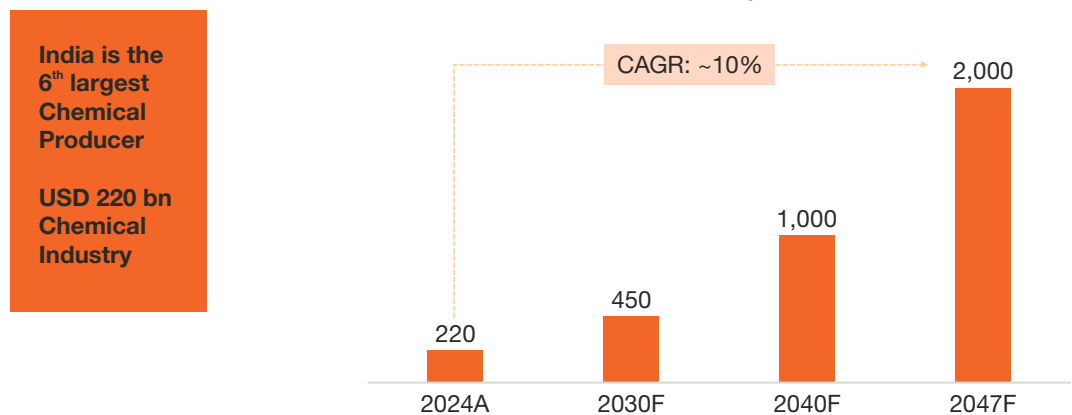
⁴PwC Analysis

⁵PwC Sustainable chemicals pathways: <https://www.pwc.com/gx/en/issues/business-model-reinvention/how-we-fuel-and-power/net-zero-chemicals-industry-transformation.html>

01 Introduction: India's chemical industry

As a cornerstone of India's manufacturing ecosystem, India's chemical industry contributes approximately 7% to the nation's gross domestic product (GDP) and supplies nearly 80,000 products to diverse sectors such as agriculture, manufacturing, pharmaceuticals, textiles, automotive, construction and personal care. Ranked as the world's sixth largest chemical producer, India's chemical market was valued at USD 220 billion in 2024. The market is projected to reach USD 400–450 billion by 2030, USD 850–1,000 billion by 2040 and potentially the USD 2 trillion mark by 2047. These projections are underpinned by key growth drivers such as rising domestic consumption, favourable geopolitical shifts, a growing focus on specialty chemicals, sustainability initiatives, strong innovation capabilities and robust government support. At this pivotal juncture, India is well-positioned to leverage its chemicals ecosystem and global market realignments to enhance its competitiveness, with the potential to increase its share in the global chemicals value chain from 3–3.5% in 2023 to approximately 5–6% by 2030.⁶

Indian chemical industry market size \$ bn



Source: <https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

⁶<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

1.1 Global chemical industry landscape: Challenges and opportunities

The global chemical industry has experienced significant fluctuations since the onset of the COVID-19 pandemic. Following a period of weak demand, reduced production and declining revenues in 2020, the sector witnessed a rapid rebound driven by strong demand and heightened inventory accumulation. This surge was largely motivated by concerns that the supply chain disruptions experienced in 2020 might recur. Subsequently, excess inventory led to widespread destocking, resulting in a temporary decline in global chemical demand. Market conditions have since stabilised, and the global chemical industry recorded modest single-digit growth in 2024. China accounted for the majority of this expansion, while the European Union (EU), the United Kingdom (UK), Asia and the Middle East also demonstrated strong recovery in chemical manufacturing. According to the American Chemistry Council, this positive momentum is expected to continue, with the global chemical market projected to grow by approximately 3.4% in 2025.⁷

Amidst these signs of recovery and growth, certain challenges continue to confront global chemical players as illustrated in Figure 2.

Figure 3: Global challenges



Ongoing geopolitical and economic volatility: Ongoing geopolitical conflicts and trade tensions on a global level are impacting the availability of raw materials, increasing costs and disrupting supply chains. Uncertainties like trade tariffs increase prices across a wide range of products are forcing global players to realign their raw material strategies, revise pricing strategies and restructure their supply chain strategies.



Stringent regulatory norms: As the world puts more focus on sustainability and green-chemistry, governments worldwide are implementing strict regulatory norms with respect to production, transport, storage and usage of chemicals. The push for zero-carbon innovations and strong sustainability requirements influence the selection of suppliers and also play a vital role in determining product specifications. Compliance to sustainability norms increases procurement and production cost, thus necessitating strong R&D and innovation.



Regional market dynamics: Ongoing geopolitical conflicts and trade tensions on a global level are impacting the availability of raw material and increasing costs and disrupting supply chains. Uncertainties like trade tariffs increase prices across a wide range of products are forcing global players to realign their raw material strategies, revise pricing strategies and restructure their supply chain strategies.



Slow innovation and fast commoditisation: Chemical products are getting commoditized faster than before and fundamental innovation seems to have plateaued, with higher focus on incremental innovation. Although chemical companies have gotten closer to their customers, much of the innovation has been focused on incremental value-add to immediate customers, rather than building transformative solutions that address complex, unmet needs of end consumers. The commoditization of products creates margin challenges, whereas the flow of cutting-edge technologies that can command better margins seems to have stalled.

Source: PwC analysis

⁷<https://www.americanchemistry.com/chemistry-in-america/news-trends/blog-post/2024/solid-economy-provides-boost-to-chemical-production>

Collectively, these factors have contributed to heightened market volatility, exerting sustained margin pressures on chemical manufacturers. Consequently, industry players must develop a clear understanding of their strategic positioning within the evolving global chemical landscape and proactively capitalise on emerging growth trends and opportunities. The key growth opportunities that the chemical industry should seek to leverage are outlined below.

- **Growth of specialty chemicals:** Specialty chemicals, developed to perform specific functions across target industries, are witnessing sustained growth in global demand. The industry is undergoing a structural shift from high-volume, low-margin commodity chemicals to high-value, high-margin specialty segments. This surge in demand is largely driven by the need for advanced, next-generation chemical solutions in sectors such as electronics, surfactants, industrial cleaners, flavours and fragrances, agrochemicals, pharmaceuticals and construction. To capitalise on this trend, chemical manufacturers should prioritise innovation and product development aimed at delivering high-performance, application-specific solutions that meet the evolving requirements of end-user industries.
- **Green chemistry:** Stringent regulatory frameworks and growing environmental concerns are accelerating the global shift towards safer, eco-friendly and more sustainable chemical products. Demand for less hazardous and bio-based chemicals derived from renewable feedstocks continue to rise, supported by efforts to reduce dependence on fossil fuels and petrochemicals. High growth has been recorded in segments such as bioplastics, biofuels, bio-based materials and specialty intermediates for pharmaceuticals and personal care. Government initiatives, including bans on single-use plastics and ethanol blending mandates, alongside evolving consumer preferences and a greater willingness to pay a premium for bio-based products, serve as strong drivers of green chemistry adoption.
- **Circular economy:** Another major structural trend in the global chemistry industry is the transition from a linear 'take-make-dispose' production model to a circular economy framework. This model emphasises resource efficiency through reuse, recycling and waste valorisation (converting industrial by-products and waste streams into valuable feedstocks). Governments and chemical manufacturers alike are investing in advanced technologies, such as pyrolysis and depolymerisation, to enhance circularity and reduce dependence on high-priced virgin raw materials. As natural resources continue to deplete and the global emphasis on reuse-reduce-recycle intensifies, circular economy practices present chemical firms with opportunities to lower raw material dependence and improve operational margins through efficient waste utilisation.

- **Continuous innovation:** Continuous innovation has emerged as a critical driver of competitiveness in the global chemical landscape. The growing demand for specialty and green chemicals necessitates substantial investment in research and development (R&D). Innovation enables firms to differentiate themselves, develop high-margin specialty products, optimise production processes and align with the United Nations Sustainable Development Goals (SDGs). A strong R&D orientation also enhances market share, profitability and operational efficiency, while building long-term resilience. Moreover, increasing collaboration between manufacturers and customers in emerging domains, such as recycled materials, nutrition, personal care, carbon removal and water purification, underscores innovation as the defining factor that distinguishes industry leaders from followers.
- **Focus on high-growth areas:** Although global chemical demand continues to expand, certain end-use sectors offer disproportionately higher growth potential. Specialty chemicals for semiconductors, battery materials and bio-based recyclable products, such as bioplastics, have shown rapid expansion, alongside clean energy solutions like green hydrogen and water treatment chemicals. Additional high-growth opportunities exist in agriculture, pharmaceuticals, construction, high-performance materials and industrial chemicals. To capture these opportunities, manufacturers must strategically invest in R&D and innovation, targeting high-value, high-growth customer segments that promise superior margins and long-term competitiveness.

1.2. India's emergence as a resilient chemical hub

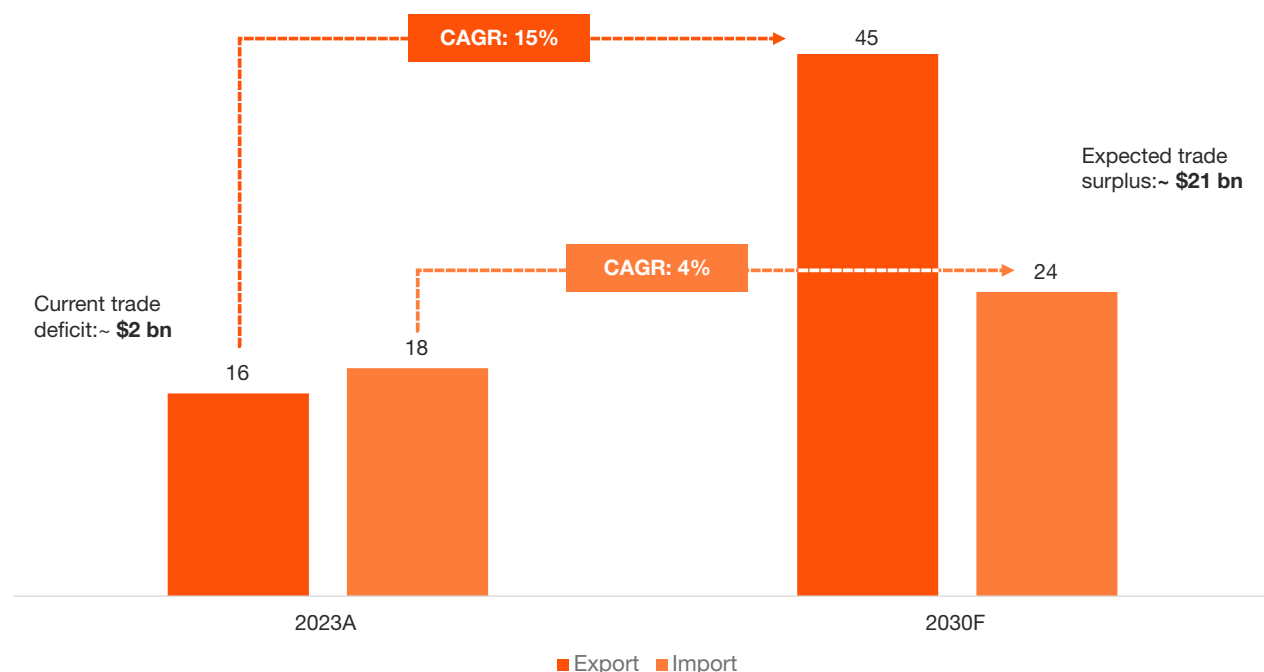
As the global chemical industry stands at a critical inflection point, India is strategically positioned to capitalise on the expanding global chemical market supported by strong domestic demand, enabling government policies and a robust industrial ecosystem.

Ranked as the world's sixth largest chemical manufacturer and the 14th largest exporter, India's chemical industry was valued at approximately \$220 billion in 2024. It is projected to grow to \$400–450 billion by 2030, reach \$1 trillion by 2040, and expand further to \$2 trillion by 2047. The country also aims to increase its current share of 3%–3.5% in global chemical manufacturing to between 5% and 6% by 2030. Employing more than two million people and exporting to over 175 countries,⁵ India's chemical sector possesses the scale and capabilities necessary to leverage the evolving global chemical landscape. However, achieving this potential will require sustained government support, advanced manufacturing and logistics infrastructure and continuous innovation in product development, process optimisation, cost efficiency and sustainability.

Several growth drivers provide India with the opportunity to establish itself as the next global hub for chemical manufacturing:

- **Rising domestic consumption:** India's chemical industry produces approximately 80,000 distinct chemical products serving diverse sectors such as agriculture, electronics and automotive manufacturing. Despite being the 14th largest global exporter, India remains a net importer owing to its substantial domestic demand, with around 70% of chemical production consumed domestically. The combination of a growing population, rapid urbanisation and evolving consumer preferences is expected to play a major role in the growth of the Indian chemical industry.⁸
- **India's focus on specialty chemicals:** India is well-positioned to benefit from the global shift towards specialty chemicals and bio-based chemicals. The domestic industry is increasingly prioritising high-value, high-margin segments such as specialty chemicals, intermediates and advanced materials. Specialty chemicals currently account for roughly 47% of India's domestic chemical consumption and are expected to grow at an annual rate of 11% through 2030.⁹ Within this segment, agrochemicals are anticipated to play a pivotal role, representing nearly 40% of India's chemical exports by 2040.¹⁰ The ability to manufacture and export specialty chemicals, supported by a strong R&D base, will be the defining pillar of growth for India's chemical industry.

Figure 4: Trade balance in India's specialty chemicals industry (actual and forecasted in \$ billion for 2023–2030)



Source: <https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

⁸ <https://www.investindia.gov.in/team-india-blogs/chemical-industry-growth-drivers-and-investment-opportunities-india>

⁹ <https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

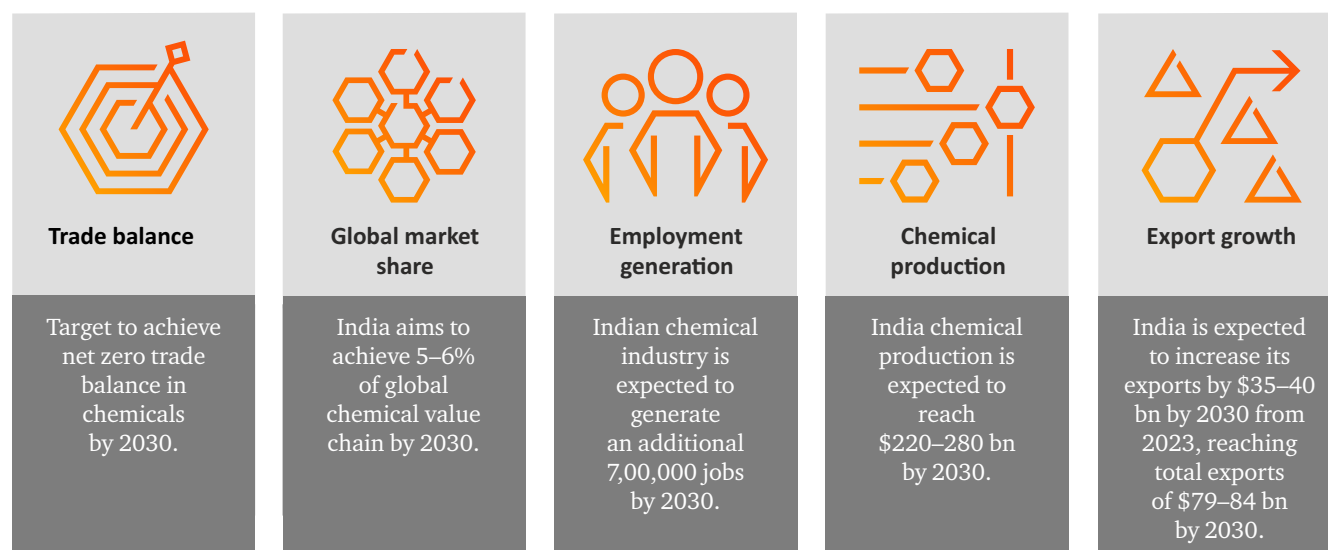
¹⁰ <https://www.investindia.gov.in/team-india-blogs/chemical-industry-growth-drivers-and-investment-opportunities-india>

- **Growing domestic petrochemicals market:** With rising population levels and increasing industrialisation, global petrochemical demand continues to expand, and India is well-positioned to capitalise on this trend. The country already exhibits substantial petrochemical consumption, estimated at 25–30 million tonnes annually. However, India's per capita consumption remains significantly lower than that of developed economies, presenting considerable room for future growth. The Government of India, in collaboration with public sector undertakings and private enterprises, is investing heavily in petrochemicals, with projects worth \$45 billion, complemented by an additional investment of around \$100 billion. These investments are expected to increase domestic capacity, enable import substitution and support India's transition into a lower-carbon economy. With petrochemical capacity projected to increase from 29.62 million tons in 2024 to 46 million tons by 2030, India is poised to emerge as a major player in the global petrochemicals market.¹¹
- **Aligning with the increasing need for sustainability in the global chemical market:** As global environmental regulations tighten and consumers demonstrate a greater willingness to pay premium prices for sustainable products, India can strengthen its position as a major hub for green chemical manufacturing. The Indian Chemical Council's Responsible Care Initiative provides a robust regulatory framework that promotes adherence to environmental, health and safety standards, and is increasingly being adopted across the industry. To align with global sustainability initiatives, India must accelerate innovation and the development of bio-based chemicals, curb carbon emissions and provide greener alternatives to the global chemical market.
- **Global supply chain diversification strategy:** Another significant driver for India's chemical sector is the global diversification strategy aimed at reducing dependence on a few manufacturing destinations. Amidst ongoing geopolitical uncertainties, rising labour costs and increasingly stringent environmental regulations, many multinational companies are looking at diversifying their manufacturing destinations. In this context, India emerges as a viable alternative for establishing manufacturing hubs and strategic partnerships with its competitive production costs, strong focus on specialty chemicals, skilled workforce, expanding domestic market and supportive government policies.

¹¹ <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2066135>

- Government policy support:** The Government of India has demonstrated a strong commitment to accelerating the growth of the chemical industry. A key initiative is the Production Linked Incentive scheme, designed to promote domestic manufacturing by offering financial incentives. The Union Budget FY2024 allocated \$20.93 million to the Department of Chemicals and Petrochemicals to enhance domestic production capacity. Additionally, the establishment of Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs), which are special economic zones, underscores the government's focus on cluster-based industrial development. With investments amounting to ₹10 lakh crore (approximately \$142 billion), the PCPIR programme reflects a long-term vision for sustainable industry expansion. Complementary initiatives, such as Plastic Park scheme and textile parks, coupled with the facilitation of 100% foreign direct investment (FDI) through the automatic route, further reinforce this growth trajectory. Other initiatives, such as the Chemical Promotion Development Scheme, implemented through grants, workshops, and industry partnerships, aim to foster innovation and collaboration. The petrochemical segment alone is expected to attract investments of around \$87 billion over the next decade, representing nearly 10% of projected global petrochemical capacity expansion.¹²
- Strong vision and future aspirations:** India's chemical industry has articulated ambitious growth aspirations for the coming decades. By 2030, it aims to generate approximately 7,00,000 additional employment opportunities, increase exports by \$35–40 billion (beyond the \$44 billion recorded in 2023) and expand its share of global chemical production to 5–6%, representing a net output of \$220–280 billion. Moreover, the industry aims to achieve a net-zero trade balance by 2030. Realising these aspirations will require coordinated efforts across the industry and government. However, if successfully implemented, they will firmly position India as a leading global hub in the chemical industry.¹³

Figure 5: Growth aspirations of India's specialty chemicals industry



Source: <https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

¹²<https://www.investindia.gov.in/team-india-blogs/chemical-industry-growth-drivers-and-investment-opportunities-india>.

¹³<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

India has articulated a strong and forward-looking vision to accelerate the growth of its chemical industry at an exponential rate in the coming years. The targets sets by the government are designed to position India as one of the major players in the global chemical landscape, achieving a significant share in the global chemical value chain by strategically leveraging multiple growth drivers. However, realising this ambition will require a robust and well-coordinated implementation plan that effectively capitalises on India's inherent strengths. Central to this effort must be the integration of sustainability as a core strategic differentiator. As global markets increasingly transition towards sustainable products and solutions, India must harness the principles of sustainability (not only as an environmental commitment but also as a competitive advantage) to distinguish itself on the global stage and fulfil its long-term growth aspirations.

1.3. Sustainability as a strategic differentiator

The chemical industry, which produces an extensive range of products fundamental to modern life, stands at a pivotal inflection point where sustainability has evolved from a regulatory obligation into the most decisive strategic differentiator shaping the sector's future

As an energy-intensive industry responsible for high greenhouse gas emissions, and heavily dependent on fossil fuels as raw materials and energy sources, the global chemical sector is under unprecedented pressure from the worldwide decarbonisation agenda and the commitments of the Paris Agreement. This unique positioning has transformed sustainability from an optional corporate initiative into an existential strategic imperative. With increasingly stringent regulatory frameworks taking hold across jurisdictions, and growing transparency and demonstrable reductions in environmental impact, chemical companies can no longer regard sustainability as merely a cost centre or compliance obligation. Instead, firms with well-established sustainability credentials are realising significant market advantages across multiple strategic dimensions. These advantages include improved access to capital, operational efficiency gains, the ability to command price premiums, strengthened brand reputation and enhanced resilience in navigating a volatile global market landscape.

Sustainability becomes a strategic differentiator due to the following aspects:

Figure 6: Strategic differentiators for sustainability



Source: PwC analysis

Capital expenses optimisation

Investments in digitally enabled machinery, green buildings and sustainable project infrastructure create long-term value, while advancing environmental, social and governance (ESG) objectives. These initiatives enable cost reductions, improved resource efficiency and the adoption of circular economy principles.

Access to capital

To further facilitate companies' sustainability transitions, a diverse array of financing options has emerged, including green finance instruments, social impact funds, climate and transition financing, ESG-focused private equity and venture capital investments

Enhanced brand image and market access

Sustainability-driven organisations derive considerable benefits through brand enhancement, market repositioning, and stakeholder engagement. The advantages manifest across several dimensions:

- Strengthened investor confidence
- Improved brand perception and market optics
- Higher employee engagement and retention
- Increased appeal to socially conscious consumers guided by sustainability values.

Fostering talent

Companies that proactively enhance diversity, equity and inclusion metrics across organisational levels unlock untapped innovation potential and realise financial and non-financial benefits.

Risk responsiveness and resilience

Enterprises with mature ESG frameworks are better equipped to anticipate, identify and respond to long-term risks, thereby enhancing overall resilience. Such companies are less exposed to reputational and financial setbacks arising from environmental or social controversies. Empirical evidence also indicates that sustainability focused organisations experience fewer ESG related controversies, translating into reduced reputational and legal risk.

Strategic premium

Companies with robust ESG credentials increasingly command valuation premiums in financial and consumer markets. Meanwhile, customers demonstrate a clear willingness to pay for both products that align with ethical, environmental and social values, reflecting performance expectations and emotional affinity.

Thus, sustainability provides significant strategic and financial benefits to companies by enabling long-term value creation through the optimal utilisation of capital and resources. It also facilitates access to sustainability-focused financing, enhances stakeholder engagement and brand reputation, expands market share and fosters innovation through a diverse and

inclusive talent base. Moreover, it strengthens organisational responsiveness to regulatory pressures and unlocks premium value through the development of sustainable products and solutions.

The subsequent chapters in this report examine the core dimensions of the chemical industry's sustainability journey:

- **Chapter 2** focuses on supply chain security, emphasising localisation strategies and the creation of sustainable ecosystems.
- **Chapter 3** explores innovation and R&D in the chemical industry, focusing on how green chemistry applications, advancements in materials and specialty chemicals and collaborative R&D frameworks are driving sustainable transformation.
- **Chapter 4** examines operational excellence, highlighting opportunities for manufacturing process optimisation, energy efficiency enhancement, circular economy integration and Artificial Intelligence (AI)-driven digital transformation.
- **Chapter 5** discusses business integration of sustainability, outlining global alignment with sustainability standards, the rise of green and sustainable finance and the strategic evolution of sustainable product portfolios.





02 Securing the supply chain

The chemical manufacturing industry plays a pivotal role in driving the growth and sustainability of a nation's economy. The chemicals value chain also serves as foundational pillar for numerous industries by providing essential raw materials and intermediates for critical sectors such as pharmaceuticals, energy, agriculture and food processing and a wide range of consumer goods. For a rapidly developing country like India, characterised by a burgeoning population and a strong growth trajectory, securing and localising the chemical manufacturing value chain is imperative. Without a resilient and well-integrated chemical supply chain, India may find it challenging to sustain its projected economic growth and industrial expansion. To achieve this, a multi-pronged strategy must be implemented in which it promotes the localisation of critical raw materials, advances digital transformation, strengthens risk management frameworks, attracts investments from established manufacturers and increases focus on R&D capabilities.

2.1 Localisation strategy

The chemical sector constitutes the backbone of the entire manufacturing ecosystem, underscoring the critical need to establish robust and resilient supply chains for the industry. Recent global disruptions, ranging from the COVID-19 pandemic and ongoing regional conflicts to shipping congestion and heightened geopolitical risks, have exposed the inherent fragility of global supply networks. Disruptions within the chemical supply chain can trigger cascading effects across multiple downstream industries, constraining industrial output and impeding overall economic growth.

In 2023, India imported chemicals valued at approximately \$85.41 billion, representing around 4.6% of the global chemical trade.¹⁵ The Indian chemical industry is projected to expand significantly from an estimated \$220 billion in 2024 to almost \$2 trillion by 2047¹⁶ This robust growth outlook presents a multi-billion dollar opportunity for import substitution and the development of a localised, self-reliant chemical supply chain.

The Government of India, through its flagship initiatives such as 'Make in India' and Production Linked Incentive scheme, is actively promoting broad-based industrial development and supply chain localisation. These programmes aim to strengthen domestic manufacturing capacity, attract strategic investments and enhance India's competitiveness in the global chemical landscape.

India's chemicals supply chain

India is the world's sixth-largest producer of chemicals, with the sector contributing approximately 7%[#] to the country's GDP. This highlights the presence of a strong industrial foundation upon which India can further build to localise its entire chemical value chain. Strengthening domestic production capabilities and reducing import dependencies will be critical to realising the country's aspiration of transforming the chemical industry into a \$1 trillion sector.

Table 1: India's chemical imports

Category	Key chemicals	Application
Organic	Methanol, phenol, Aniline	Serve as feedstock for a wide range of intermediates and end products, including plastics, dyes and pigments.
Inorganic	Soda ash, High-Density Polyethylene, polypropylene, Purified Terephthalic Acid, styrene	Used in the production of detergents and various plastic-based finished products.
Others	Specialty chemicals, dyes and pigments, agrochemicals, fertilisers	Applied across multiple industries such as paints and coatings, crop protection and adhesives manufacturing.

Source: PwC analysis; Ministry of Chemicals and Fertilizers

¹⁵<https://chemindia.chemicals.gov.in/Publicationspdf/Statistics-at-a-Glance-2024.pdf>

¹⁶<https://www.ibef.org/industry/chemical-industry-india>

[#]<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

In 2023, the top five chemicals imported into India were high-density polyethylene, polypropylene, purified terephthalic acid, styrene and methanol.¹⁷ These chemicals serve as critical inputs across various stages of polymer and plastic product manufacturing, supporting a wide range of industrial and consumer applications. The country's expanding population, coupled with rising disposable incomes, has led to increasing demand for polymer-based products and specialty chemicals, a demand that continues to outpace current domestic production capacities.

However, the outlook for India's chemical production remains positive. Over the years, the private sector has developed a robust industrial base encompassing world-class refineries, petrochemical complexes and manufacturing facilities for agrochemicals, polymer feedstock, adhesives and dyes. This strong domestic production capacity has enabled India to emerge as a net exporter of key chemicals, including herbicides, benzene and reactive dyes. These achievements underscore the sector's resilience and provide a solid platform for further expansion and localisation of chemical manufacturing in the country.

Challenges

Despite the overall positive outlook and strong performance of the chemical industry, several challenges persist in achieving full localisation of the supply chain, especially within the specialty chemicals segment.

Figure 7: Challenges

Quality assurance The industry needs to focus on institutionalising stringent quality checks which can enhance the industry's reputation and increase demand for locally made products.
High logistics cost Despite significant investments in logistics infrastructure, local bottlenecks continue to drive up costs and slow freight movement. Examples include congestion at ports , fragmented warehousing across states, and limited multimodal connectivity between industrial hubs. These inefficiencies are particularly critical for the chemical sector, where timely and safe transport is essential.
Regulatory challenges Speed of regulatory approvals is slower than international benchmarks which increases the duration of investment. cycle.
Low availability of skilled workforce Strengthening workforce training in chemical manufacturing is essential to ensure operational safety and build public trust. Incidents such as the 1984 Bhopal gas tragedy and the 2020 Visakhapatnam styrene leak have left a lasting impact on regulatory and societal expectations. These events underscore the need for rigorous safety protocols, continuous upskilling, and proactive risk management to support long-term growth and responsible industrialization.

Source: PwC analysis

¹⁷<https://chemindia.chemicals.gov.in/Publicationspdf/Statistics-at-a-Glance-2024.pdf>.

Way forward

Localisation of the chemical industry supply chain is critical to building a holistic and resilient manufacturing ecosystem in India. Leading industry players and the government are actively collaborating to address existing challenges. Additionally, several initiatives are directly targeting the bottlenecks impeding localisation, with the aim to strengthen domestic production capabilities.

Development of clusters

The Government of India has introduced the PCPIRs policy to attract capital and skilled labour for developing mega-clusters that support supply chain localisation. The four designated PCPIRs—Dahej, Pradeep, Cuddalore, and Visakhapatnam—are strategically located near deep-water ports, offering excellent connectivity and access to skilled manpower. These locational advantages enable operational efficiency and facilitate rapid scaling from inception.

Complementing the PCPIRs is the Plastic Park Scheme, which promotes the growth of downstream plastic processing industries. As of October 2025, the government has approved 10 plastic parks,¹⁹ underscoring the strategic intent and the strong domestic demand for an integrated and competitive chemicals manufacturing ecosystem in India.

Ports and logistics

Effective localisation of the chemical supply chain requires a robust logistics infrastructure that ensures efficient, cost-effective and timely transportation. The National Logistics Policy (NLP) seeks to reduce logistics costs and enhance end-to-end supply chain efficiency by strengthening factory-to-consumer transport infrastructure.²⁰ Supported by the PM Gati Shakti framework, the NLP promotes a multimodal logistics approach that leverages advanced geospatial technologies to enhance connectivity across industrial clusters and improve supply chain competitiveness.²¹

Moreover, the Maritime India Vision 2030 outlines 150 strategic initiatives aimed at expanding port cargo-handling capacity, including the development of dedicated terminals for chemical handling to reduce shipping costs. Enhanced port capacity and improved logistics efficiency are expected to significantly boost export competitiveness, thereby encouraging greater localisation and investment across India's chemical sector.²²

Regulatory incentives

Traditionally, the chemical manufacturing industry has faced high entry barriers owing to extensive regulatory requirements related to environmental and social compliance. Recognising these challenges, the Government of India has introduced a series of policy measures to ease compliance burdens, reduce entry barriers and stimulate sectoral expansion.

The government now permits 100% FDI in chemical manufacturing under the automatic route and has de-licensed several key segments such as organic and inorganic chemicals, dyestuffs and pesticides manufacturing.²³ These policy reforms are expected to boost investment in specialty chemicals manufacturing and foster the development of intellectual capital essential for the industry's long-term growth and innovation.

¹⁹https://sansad.in/getFile/loksabhaquestions/annex/184/AU798_ONfhSF.pdf?source=pqals

²⁰<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2167224>

²¹<https://www.india.gov.in/spotlight/pm-gati-shakti-national-master-plan-multi-modal-connectivity>

²²<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

²³<https://www.investindia.gov.in/sector/chemicals>

Additionally, international trade agreements are opening new avenues for market access. For example, the India–United Kingdom Free Trade Agreement (FTA) provides tariff-free access for Indian chemical products to the UK market. In parallel, ongoing negotiations for the India–EU FTA aim to extend similar benefits across major European markets, including Germany and France.²⁴ Such agreements will facilitate the creation of a self-sustaining ecosystem, integrating the chemical value chain from feedstocks to end products, while strengthening India's global trade competitiveness.

Environmental and social compliance requirements, which are traditionally viewed as constraints, are increasingly being reframed as enablers of sustainable growth in the next phase of chemical industry evolution. In this regard, the Securities and Exchange Board of India (SEBI) has mandated Business Responsibility and Sustainability (BRSR) for the top 1,000 listed companies,²⁵ including value chain disclosures starting from FY 2026. This initiative encourages companies to minimise ecological footprints, enhance social impact and align with international reporting frameworks, such as the EU's Corporate Sustainability Reporting Directive (CSRD) and Carbon Border Adjustment Mechanism, thereby maintaining export competitiveness.

However, disparities in environmental clearance timelines across states and industrial clusters continue to delay project execution and undermine investment efficiency. The absence of a centralised chemical substance database, similar to the EU's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) framework,²⁶ further constrains regulatory harmonisation and transparency. Hence, establishing a unified national database and streamlining the environmental clearance process would significantly enhance India's regulatory efficiency, bolster investor confidence and attract high-value investments into advanced and sustainable segments of the chemical industry.²²

Talent development and research

Over the past two decades, manufacturing technologies have undergone significant transformation, with the Internet of Things, digitalisation, advanced technologies (ATs) and sustainability emerging as central pillars of modern manufacturing. Despite India's considerable engineering talent, the chemicals industry continues to face a talent gap, as academic curricula have not kept pace with the ATs being adopted in the sector. To address this gap, the Department of Chemicals and Petrochemicals under the Ministry of Chemicals and Fertilizers has developed targeted skill development programmes in collaboration with the Ministry of Skill Development and Entrepreneurship. The Institute of Pesticide Formulation Technology delivers these programmes, encompassing various stages of the manufacturing process.²⁷

However, R&D remains a critical area of concern owing to the shortage of skilled talent and insufficient investment. In 2023, Indian companies allocated only 0.7% of their total revenues to R&D, which is significantly below the global average of 2.3%.²² Strategic investment in R&D is essential to maintain a competitive edge, meet evolving customer

²²<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

²⁴<https://www.thehindu.com/news/national/india-eu-working-on-series-of-transformative-initiatives-besides-eyeing-to-seal-fta-by-december/article70024581.ece>

²⁵https://www.sebi.gov.in/legal/circulars/jul-2023/brsr-core-framework-for-assurance-and-esg-disclosures-for-value-chain_73854.html

²⁶<https://www.pwc.in/assets/pdfs/indian-chemical-industry-enablers-to-make-india-a-growth-hub-for-chemicals.pdf>

²⁷<https://www.indianchemicalnews.com/opinion/resilience-to-rise-indias-chemical-sector-poised-for-strong-rebound-amid-global-realignment-27364>

demands and reduce reliance on imports. Recognising the potential of India's growing talent pool, several global chemical manufacturers have established Global Capability Centres aimed at fostering a robust culture of innovation and research. Furthermore, sustainability and decarbonisation initiatives are attracting additional R&D investment, offering the potential for domestic industry to leapfrog directly to global sustainability standards, bypassing traditional growth phases.

2.2 Building integrated sustainable/circular manufacturing ecosystems

To facilitate the transition of the Indian chemical industry towards an integrated, sustainable and circular manufacturing ecosystem, it is important to identify the existing challenges and the potential opportunities for planning and implementation. While the shift towards circularity offers promising benefits, there are also distinct challenges that should be addressed through coordinated efforts by industry stakeholders and policymakers.

According to industry reports, the majority of industrial waste in India remains untreated, highlighting gaps in recycling infrastructure and waste management systems. Meanwhile, the sector faces increasing compliance requirements owing to a fragmented regulatory framework, characterised by overlapping legislation governing environmental protection, waste management and chemical handling. Notably, A large section of small and medium-sized enterprises (SMEs) in the chemical sector have reported regulatory complexity as a significant obstacle. Moreover, the high initial capital expenditure associated with green technologies, which tend to be substantially higher than that of conventional systems, continues to constrain such adoption among smaller firms. A PwC India survey revealed that only a limited number of chemical companies²⁸ had formally adopted circular economy strategies, underscoring a broader trend of resistance or slow adoption towards new and sustainable business models.

Integrated sustainable/circular manufacturing ecosystems represent a transformation-centred approach to industrial production, aimed at fundamentally reimagining how chemical manufacturing can operate in alignment with environmental and social priorities. Such ecosystems encompass strategically clustered industrial zones, integration of ATs, cross-industry collaborations and bio-based material flows. Collectively, these elements foster manufacturing models capable of delivering net-positive environmental outcomes.

²⁸PwC, 2021: <https://www.pwc.in/assets/pdfs/publications/2021/india-a-global-manufacturing-hub-for-chemicals-and-petrochemicals.pdf>.

Overall, the chemical industry is characterised by complex, multi-step production processes, a diverse range of products and high resource intensity. Within this context, an integrated circular ecosystem presents transformative potential, not only to address the sector's sustainability challenges but also to unlock new business opportunities. Given that chemical manufacturing involves intermediate products, co-products and various waste streams, and that the sector traditionally clusters around petroleum refining and petrochemical complexes, it is well-positioned to benefit from circular approaches that transform environmental liabilities into economic assets. Furthermore, the increasing availability of ATs, modular infrastructure solutions and digital integration can serve as critical enablers, allowing companies to implement and scale circular manufacturing models more effectively.

Some of the critical aspects involved in developing integrated, sustainable and circular manufacturing ecosystems within the chemical sector include:

Industrial symbiosis and co-location strategies:

This dimension includes models, such as PCPIRs, along with other clustering strategies designed to promote waste-to-feedstock integration across multiple facilities and industries.

PCPIRs are designated large-scale industrial zones intended to cluster petroleum refining, chemical and petrochemical industries. India has identified several PCPIRs in states such as Andhra Pradesh, Odisha and Gujarat to boost investment, generate employment and increase export potential in these strategically important sectors. However, these industries have traditionally been resource- and energy-intensive, often contributing to pollution, resource depletion and associated social challenges. Consequently, transitioning to sustainable PCPIRs is essential.

Sustainable PCPIRs: India's industrial growth engine

Policy framework and vision

The key objectives of PCPIR Policy 2020–2035 are to:

- develop world-class industrial clusters dedicated to petroleum, chemical and petrochemical production
- attract an estimated investment of ₹10 lakh crore²⁹ (approximately \$142 billion) by 2025
- expand petrochemical production capacity from 29.62 million tons to 46 million tons by 2030³⁰
- facilitate 100%³¹ FDI via automatic routes
- align sectoral development with India's low-carbon transition and clean energy goals.

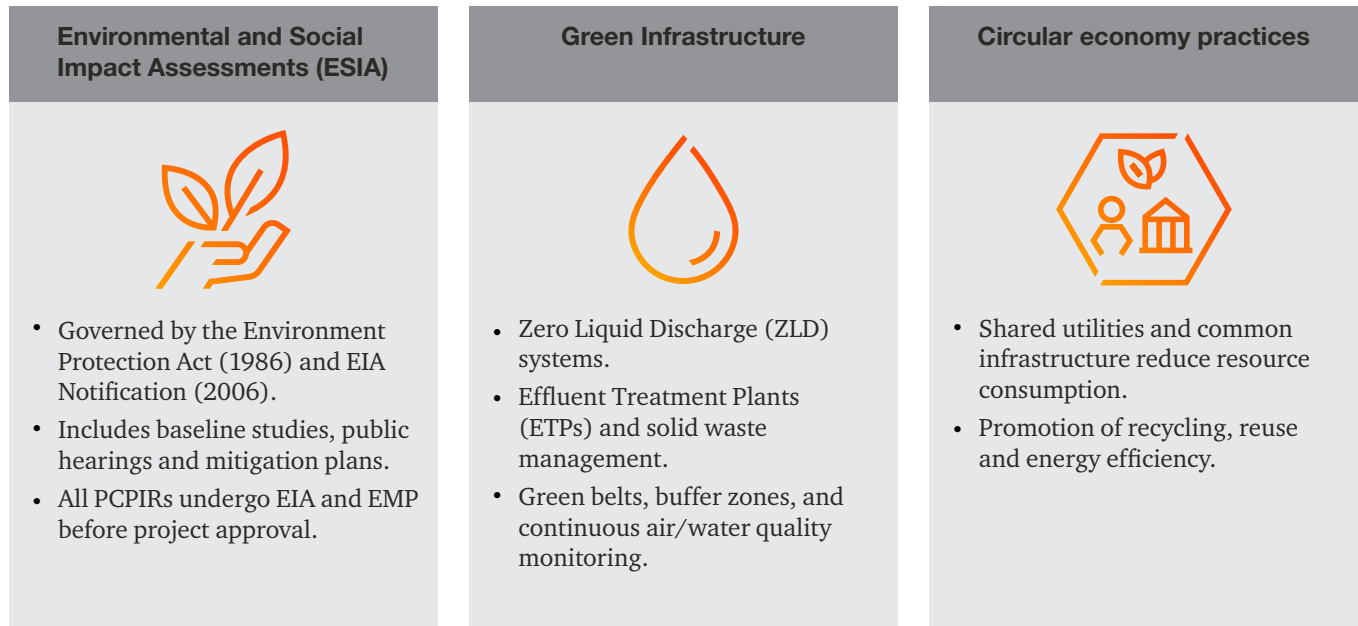
²⁹PIB: <https://pib.gov.in/PressReleaselframePage.aspx?PRID=2066135>

³⁰PIB: <https://pib.gov.in/PressReleaselframePage.aspx?PRID=2066135>

³¹Dept of Chemicals and Petrochemicals: <https://chemicals.gov.in/faq>

Integrated environmental management system: PCPIRs are designed with robust, integrated environmental management systems that incorporate ATs and safeguards for pollution control and resource efficiency. These include state-of-the-art facilities for effluent treatment, air emission management and solid waste collection and disposal. These systems are also supported by real-time monitoring mechanisms that enhance regulatory compliance and ensure adherence to environmental standards.

Figure 8: Sustainable PCPIRs: India's industrial growth engine



Source: PwC analysis

Circular economy and resource efficiency: PCPIRs actively promote industrial symbiosis as a means to advance circular economy principles and enhance resource efficiency. Within these industrial clusters, enterprises collaborate to exchange materials, energy and by-products, thereby reducing waste and optimising resource utilisation. For example, waste gases generated by one facility can be harnessed as fuel by another, while spent catalysts may be repurposed in alternative production processes or used for the recovery of rare earth metals.

Energy transition and emission reduction: PCPIRs incorporate renewable energy sources, such as solar, wind and bioenergy, into their operational frameworks to advance India's clean energy objectives. The adoption of energy-efficient technologies, including best available technologies, heat integration systems, and combined heat and power units, further enhances process efficiency and reduces energy intensity across industrial operations. In addition, emissions reduction strategies are embedded within the design and operation of PCPIRs. These include the implementation of carbon capture, utilisation and storage (CCUS) technologies, alongside comprehensive methane leak detection and control systems aimed at mitigating fugitive greenhouse gas emissions.

Stakeholder engagement and social development: Sustainable PCPIRs promote inclusive and equitable development through active stakeholder engagement initiated in the planning stage. This participatory approach ensures that community perspectives are integrated into decision-making processes, thereby enhancing social acceptance and long-term sustainability. Occupational safety and health standards are upheld through the establishment of comprehensive safety protocols, emergency response systems and welfare programmes designed to protect and support workers. PCPIRs also invest in the development of social infrastructure, including education, healthcare and housing facilities, with the objective of improving the overall quality of life for workers and the broader community.

Innovation, skills development and governance: Sustainable PCPIRs place a strong focus on R&D, as a driver of technological advancement and competitiveness. This includes the adoption and diffusion of cutting-edge technologies such as green chemistry and biotechnology. Skills development is promoted through training centres aimed at equipping the workforce with the technical competencies and knowledge required to implement sustainable manufacturing practices and adapt to emerging technologies.



Advanced recycling/upcycling technologies:

India has witnessed rapid progress in recycling and upcycling technologies aimed at addressing plastic and chemical waste streams. These innovations go beyond conventional mechanical recycling and encompass advanced methods such as pyrolysis, depolymerisation, catalytic conversion and AI-assisted sorting. Advanced recycling processes like pyrolysis and thermo-catalytic are being employed by various companies, to convert mixed plastic waste into fuel and syngas.

AI-based sorting systems, are transforming waste segregation through the application of computer vision and machine learning. Additionally, some organisations are employing data-driven cleaning and sorting processes to produce high-quality recycled plastics, or upcycle multi-layer plastics into usable raw materials.

Bio-based feedstock integration: The integration of bio-based feedstocks involves replacing petrochemical-derived inputs with biomass-derived materials, including agricultural residues, used cooking oil, sugarcane, starch and lignocellulosic biomass. These renewable inputs are utilised in the production of bio-based chemicals, bioplastics, enzymes and green solvents. India's BioE3 Policy (Biotechnology for Economy, Environment and Employment)³² serves as a major driver of this transition, promoting high-performance biomanufacturing through R&D hubs, bio-foundries and bio-AI platforms.

As for renewable sourcing, it emphasises the use of sustainably grown biomass and waste-derived inputs for chemical production. Key materials include vegetable oils, fats, grains and wood, which are employed in the manufacture of surfactants, polymers and pharmaceutical ingredients.

The Government of India is supporting this transition through multiple initiatives:

- **BioE3 Policy:** Focusing on bio-based chemicals, biopolymers and enzymes.
- **Technology Development Board:** Funding eco-friendly chemical technologies, with over ₹94 crore disbursed to date.
- **National Bio-Energy Mission:** Incentivising biofuel and biomass-based energy production.
- **Green Public Procurement:** Promoting the adoption of bio-based products in government contracts.

India's bio-based chemicals market is expected to grow substantially over the next few years. Growth is expected to be driven by demand from the packaging, automotive, agriculture and personal care sectors.

³²https://www.pmindia.gov.in/en/news_updates/cabinet-approves-bioe3-biotechnology-for-economy-environment-and-employment-policy-for-fostering-high-performance-biomanufacturing/

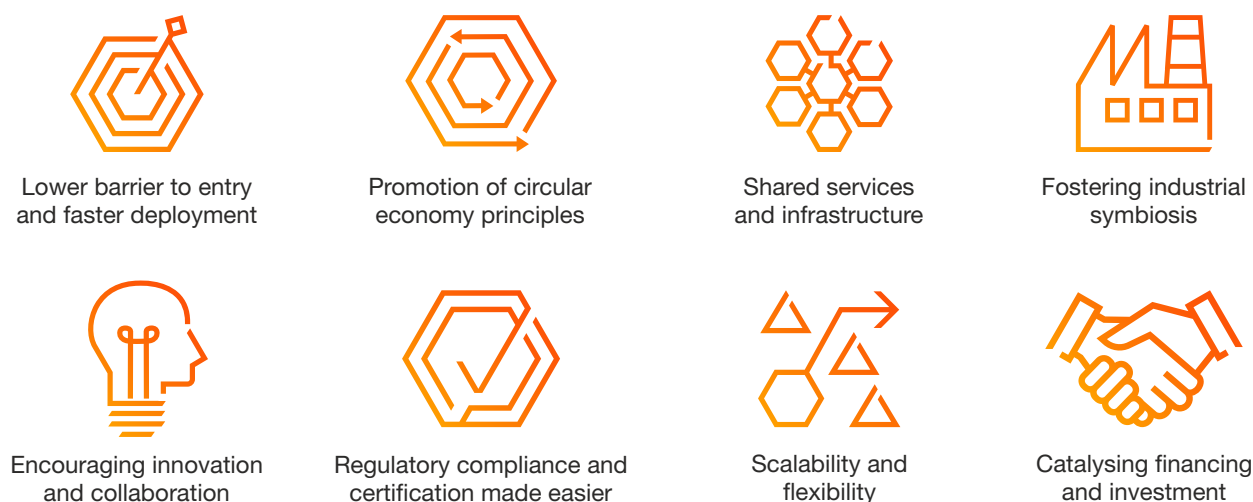
Energy system optimisation: Waste heat recovery is a key strategy for improving energy efficiency in chemical plants, which rank among the most energy-intensive industrial operations. Technologies, such as recuperators, waste heat boilers and cascade recovery systems, are employed to capture heat from furnaces, kilns and reactors.

Chemical manufacturers are increasingly integrating renewable energy sources, including solar, wind, biomass and green hydrogen into their energy mix. This transition is supported by national initiatives such as the National Green Hydrogen Mission and Renewable Purchase Obligations. Additionally, solar energy is being deployed for process heating and power generation, while biomass and biogas are replacing fossil fuels in boilers and dryers. Meanwhile, companies are exploring the production of green ammonia and methanol by using renewable inputs.

Plug-and-play green infrastructure and modular facilities: Plug-and-play green facilities are pre-configured industrial infrastructures designed to enable rapid deployment of sustainable manufacturing operations. These facilities are equipped with sustainable technologies, resource-efficient utilities and systems designed to minimise environmental impact. Their modular, flexible and scalable design supports green manufacturing and circular economy practices, allowing businesses to commence operations quickly without substantial upfront capital expenditures in infrastructure development.

For India, plug-and-play green facilities address critical infrastructure gaps that constrain sustainable chemical manufacturing, especially for SMEs. By providing access to advanced green technologies and shared resource-efficient utilities, these facilities enable micro, small and medium enterprises (MSMEs) to adopt environmentally sustainable practices more effectively. They also support government initiatives, such as 'Make in India' and 'Startup India' by promoting entrepreneurship, innovation and the development of eco-friendly chemicals. In addition, plug-and-play facilities contribute to regional economic development, job creation and simplified regulatory compliance.

Figure 9: Advantages of plug-and-play green facilities



Digital integration and process optimisation: Companies are increasingly adopting smart manufacturing systems that integrate sensors, actuators and cyber-physical systems to monitor and control production processes in real time. These systems facilitate predictive maintenance, optimise energy consumption and ensure consistent product quality. For instance, various firms, have adopted cloud-based platforms and digital ISO systems to centralise operational data, manage crises and benchmark performance across multiple production units.

Digital transformation also enables ecosystem-wide coordination by linking supply chains, logistics and procurement functions. Emerging platforms connect suppliers, buyers, consultants and academic laboratories, fostering collaboration across the chemical value chain, from molecule development to market access. These platforms particularly benefit SMEs and start-ups by facilitating seamless sourcing, co-development and commercialisation, thereby accelerating the adoption of advanced manufacturing and sustainable practices.

Cross-industry partnerships: Industrial symbiosis leverages waste or by-products from one industry as inputs for another. For example, the Naroda Industrial Estate in Gujarat, comprising over 65 companies, participated in a study examining shared waste management and recycling systems.

Government bodies, such as the Department of Chemicals and Petrochemicals (DCPC) and NITI Aayog, actively promote and enable circular economy models. The DCPC has developed action plans³³ to repurpose toxic and hazardous industrial waste through partnerships with academic institutions and industry clusters. These plans involve geographic mapping of waste-generating industries and the development of commercially viable recycling technologies.

The National Circular Economy Framework (NCEF), led by the Confederation of Indian Industry (CII),³⁴ is another major initiative. It encourages cross-sector collaboration across 16 industries, including chemicals, textiles, construction and agriculture. This framework also promotes resource conservation, waste reduction and climate resilience, aligning with India's broader sustainability goals under MoEFCC's Mission LiFE and the United Nations SDGs.

Emerging models of industrial symbiosis and energy pooling enable cross-facility energy sharing, especially within chemical clusters and industrial parks. Excess energy or recovered heat from one facility can be used by another, improving overall system efficiency. Although still in nascent stages, initiatives supported by the Bureau of Energy Efficiency and The Energy and Resources Institute (TERI) are mapping MSME clusters to identify opportunities for shared energy infrastructure and collaborative optimisation.

³³<https://chemicals.gov.in/circular-chemistry>

³⁴<https://ciiblog.in/indias-circular-economy-journey-the-national-circular-economy-framework-ncef-2024/>

Future of Indian chemicals industry

The Indian chemicals industry is optimistic about sectoral expansion and the localisation of supply chains. Comprehensive government policies are attracting significant foreign and domestic investment, creating favourable conditions for exponential growth. A key enabler of this transition is the development of sustainable PCPIRs, which aim to attract ₹10 lakh crore (approximately \$142 billion) in investments by 2025. The sector's emphasis on bio-based feedstocks is expected to reach \$21 billion by 2031, with a CAGR of 5.5%. This transition is supported by national initiatives, including the BioE3 Policy, the National Bio-Energy Mission and Green Public Procurement.

India is also advancing in its capabilities in recycling and upcycling technologies, such as pyrolysis, depolymerisation and AI-powered sorting, to convert plastic and chemical waste into valuable feedstocks and end products.

Access to sustainable manufacturing is further facilitated through plug-and-play green infrastructure. Concurrently, digital transformation is enabling real-time resource management and ecosystem-wide coordination. Meanwhile, companies are adopting smart manufacturing systems, predictive maintenance and cloud-based platforms to optimise operations and enhance efficiency. In addition, cross-industry partnerships are fostering industrial symbiosis, in which waste from one facility serves as inputs for another. National frameworks, such as the NCEF and action plans from the DCPC and NITI Aayog, are institutionalising these models across sectors.

Leading specialty chemical manufacturers have already established operations in the country, with FDI inflows reaching approximately \$22.87 billion in 2024.³⁵ Domestic manufacturers view supply chain localisation as a \$25–30 billion opportunity.³⁶

Despite certain challenges, such as high capital costs (20–30% above conventional systems) and regulatory complexities, India's policy landscape is evolving to support sustainable growth. Various measures, including 100% FDI, the SEBI's BRSR framework and ongoing FTA negotiations with the EU and UK are improving market access and investor confidence. With the convergence of supportive policy, ATs and growing market demand, India is well-positioned to become a global hub for sustainable chemical manufacturing, with the sector projected to reach \$1 trillion by 2040.³⁷

³⁵<https://www.indianchemicalnews.com/opinion/indian-chemical-sector-welcomes-us-2287-billion-fdi-during-april-2000-sept-2024-24780>

³⁶<https://economictimes.indiatimes.com/industry/indl-goods/svs/chem-/fertilisers/india-has-a-big-import-substitution-opportunity-in-chemicals-sector-srf/articleshow/123664201.cms?from=mdr>

³⁷<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>



03 Innovation and R&D: Driving sustainable chemical solutions

India's specialty chemicals sector is currently experiencing a period of significant innovation and technological advancement, driven by increased private sector participation in R&D and supported by government-backed research agencies/departments such as the Council of Scientific and Industrial Research (CSIR), the Department of Science and Technology (DST), the Department of Biotechnology (DBT) and Indian Oil Bioenergy Centres. Sustained R&D efforts have led to the development of new generations of advanced materials that offer enhanced performance, greater durability and improved ecological safety. This innovation manifests in the creation of novel formulations and product molecules, customisation of solutions, diversification of applications and co-development of applications in collaboration with customers. Initiatives in green chemistry, coupled with technology readiness level (TRL)-based funding for decentralised research at central and state levels, have accelerated commercialisation and the mass adoption of specialty chemicals. The availability of skilled human capital, strong research institutions and an ecosystem that protects innovation through robust intellectual property rights frameworks and regulatory measures have further enabled the growth of sustainable innovation in the specialty chemicals sectors. The following sections examine the various dimensions of innovation in sustainable chemicals in greater detail.

3.1 Advanced materials and specialty chemicals innovation

Innovation in the chemical industry is inherently multidimensional, encompassing several interrelated domains:

- **Process innovation:** Enhancing production yield, reducing energy consumption and minimising waste.
- **Product innovation:** Developing new derivatives, formulations or performance-enhancing additives.
- **Sustainability innovation:** Incorporating renewable feedstocks, implementing closed-loop systems and applying principles of green chemistry.
- **Application innovation:** Creating novel use-cases across sectors such as pharmaceuticals, agriculture, coatings and electronics.

Indian chemical manufacturers are increasingly prioritising process optimisation and application-driven innovation through the development of diverse derivatives and formulations. These companies have demonstrated expertise in process scale-up, while leveraging closed-loop, systems to enhance operational efficiency, reduce emissions and maintain consistent product quality. Such approaches not only improve cost competitiveness but also facilitate alignment with global sustainability standards.

Key enablers of innovation in India's advanced materials and specialty chemicals

Figure 11: Innovation levers



Platform molecule

01

Identifying a platform molecule and developing processes to produce multiple downstream products from it.



Customisation

02

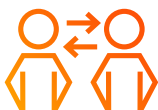
Tailoring chemical formulations to meet specific performance, regulatory, or environmental requirements of end-use applications.



Application diversification

03

Adapting core chemistries to serve multiple industries or application areas beyond their original scope.



Collaborating with customers

04

Collaborating directly with customers to co-develop customised chemical solutions that meet specific technical or regulatory needs.

Source: PwC analysis

Innovation journey of a leading Indian specialty chemical player: An Indian specialty chemicals company has successfully achieved higher EBITDA margins by transforming a single molecule into a versatile platform chemical. Through a strategic combination of process innovation, application development and R&D, the company has established a scalable, sustainable and globally competitive business model within a niche segment.

Platform molecule strategy: The company identified a high-potential intermediate and adopted a platform approach to maximise its value. Key strategic initiatives included:

- Investing in safe and scalable production technologies
- Establishing backward integration to secure feedstock availability and maintain cost control
- Strengthening R&D capabilities to develop a broad portfolio of downstream derivatives.

Process innovation: To enable efficient and sustainable production, the company developed a closed-loop pyrolysis process to convert the key starting material into a high-value platform chemical. This process is designed to operate with zero emissions, ensuring high product stability and purity. Moreover, the company has successfully optimised its scale-up techniques to achieve cost efficiency, allowing for scalable expansion while maintaining operational excellence and adherence to environmental compliance standards.

Application innovation: The company leveraged its chemistry platform to develop tailored derivatives for multiple end-use industries: Pharmaceuticals, Agrochemicals and Pigments. This strategic approach enabled the company to diversify its customer base, broaden its market reach and enhance the relevance of its products across multiple industrial sectors.

Customer-centric R&D: The company initially pursued co-development programmes, including contact development and manufacturing organisation partnerships with several pharmaceutical and agrochemical firms. Over time, it scaled these capabilities to serve a broader customer base. By providing custom synthesis and formulation support, the company delivered solutions tailored to specific client requirements, thereby strengthening long-term partnerships and fostering innovation at the application level.

3.2 Green chemistry and bio-based feedstock development

Green chemistry focuses on designing chemical processes that are inherently safer and environmentally sustainable from inception. Rather than managing pollution post-production, it focuses on the prevention of environmental and health impacts at the source. This paradigm shift is driven by several factors:

- **Regulatory compliance:** Stringent regulations, such as REACH, Toxic Substances Control Act (TSCA), Halal and Kosher certifications, are incentivising cleaner chemical processes.

- **Consumer demand:** Increasing preferences for eco-friendly products are shaping industry practices.
- **Corporate sustainability goals:** ESG objectives are prompting companies to prioritise sustainable process design and production methods.

Figure 10: Green chemistry drivers

Green chemistry		
Regulations	ESG goals	Consumer/end use industries' demand
Environmental compliance pressure: The Central Pollution Control Board (CPCB) and State Pollution Control Boards are enforcing stricter norms on hazardous waste, effluent discharge, and emissions	Environmental goals: Companies are setting measurable targets to reduce carbon emissions, water usage, and hazardous waste generation.	Preference for natural and safe products: From personal care to home cleaning, buyers are actively seeking products free from harsh chemicals and synthetic additives.
Global trade alignment: Export-oriented chemical companies must comply with international standards like REACH (EU) and EPA Safer Choice (US) , prompting upstream changes in formulation and process design.	Investor and partner pressure: Global investors and MNCs are prioritising suppliers with strong ESG credentials, influencing procurement and innovation decisions.	Transparency and labelling: Brands that disclose ingredients and sustainability practices are gaining trust and loyalty, especially among urban and millennial consumers.
Incentives for cleaner technologies: Schemes like the Technology Development Board (TDB) funding and Green Rating Projects encourage adoption of sustainable innovations.	Governance and reporting: ESG disclosures are now part of annual reports, with third-party audits and certifications gaining prominence.	Impact of social media: Eco-conscious narratives are amplified online, creating pressure on brands to go green and back claims with credible action.
		Premium willingness: A growing segment of end use industries are willing to pay more for products that are ethically sourced, biodegradable, and environmentally friendly.

Source: PwC analysis

Challenges with synthetic/crude oil-based feedstock and opportunities for bio-based alternatives: Indian chemical industries benefit from integrated facilities located near oil-based feedstock sources, providing a degree of feedstock security and supporting operational efficiency. The strategic placement of refineries and petrochemical complexes along the coastline facilitates streamlined access to raw materials and key demand centres via port infrastructure. However, this supply structure also imposes significant constraints. For instance, a substantial portion of petrochemical building blocks is dedicated to bulk polymer production, limiting the availability of feedstocks for other downstream chemical segments. Consequently, these segments often face feedstock shortages and must rely on imports, introducing complexity and volatility into the synthetic chemical manufacturing value chain. This challenge, in turn, presents an opportunity to expand the adoption of bio-based feedstocks, which can enhance supply security, promote sustainability and reduce dependence on imported materials.

Bio-based chemical production—a strategic alternative: In contrast, bio-based chemical production presents a compelling alternative to conventional petrochemical feedstocks. In this regard, India possesses abundant biomass resources, including sugar crops, starch and lignocellulosic materials. The domestic availability of these feedstocks positions the country as a favourable market for bio-based chemical manufacturing, offering long-term feedstock security and potential cost advantages. This also creates opportunities for product diversification, import substitution and sustainable growth across specialty chemicals and biochemical segments.

Table 2: Application of bio-based feedstocks

Chemical products	Fossil-based source	Bio-based alternative	End-use industries
Acetic Acid	Methanol from natural gas	Bioethanol from sugarcane and corn	Food, adhesives, textiles, and pharma
Ethylene Oxide (EO)	Cracked from naphtha	Bioethanol from sugarcane	Surfactants, pharma, textiles, and detergents
Bio-Glycols (MEG/DEG)	Ethylene from fossil fuels	Molasses-based ethanol	PET bottles, antifreeze, and cosmetics
Polylactic Acid (PLA)	Polypropylene/ Polyethylene	Corn and sugarcane	Packaging, textiles, and disposables
Acetaldehyde	Ethylene oxidation	Oxidation of bioethanol	Pharmaceuticals, agro-chemicals, paint binders, plasticisers, and cosmetics

Source: PwC analysis

3.3 Collaborative R&D ecosystems

Ecosystem design for collaborative R&D across India:

1. Establish institutional anchors

A robust institutional foundation is essential for driving mission-oriented research and aligning national priorities with industrial innovation. Key institutional anchors include:

- **The CSIR:** The CSIR has been instrumental in leading mission-mode projects in areas such as green chemistry, plastic upcycling and carbon capture. For instance, the CSIR–NCL has developed bio-based polymers in partnership with industry partners.
- **The DST:** The DST supports bilateral and multilateral R&D initiatives, including the India–Sweden Green Transition Partnership, and funds innovation through programmes such as the Global Innovation and Technology Alliance (GITA).
- **NITI Aayog:** NITI Aayog plays a strategic role by integrating sustainability into the national chemical sector roadmap, ensuring that R&D initiatives align with India's Net Zero 2070 commitments.

These institutions form the backbone of India's innovation ecosystem, enabling long-term, high-impact research and fostering collaboration between academia, industry and government.

2. Develop collaborative platforms across regions

To foster innovation at scale, India must establish structured platforms that integrate academia, industry and government stakeholders.

- **Global Innovation and Technology Alliance (GITA):** This public–private partnership between the DST and the CII funds industry–academia R&D projects with strong commercialisation potential.
- **The India–Sweden Green Transition Programme:** This initiative focuses on sustainable materials, AI-enabled process optimisation and societal impact tools across sectors such as cement and chemicals.

These collaborative platforms also facilitate co-development, intellectual property sharing and knowledge transfer while simultaneously de-risking innovation through shared funding, governance and strategic oversight.

3. Build regional innovation hubs

Localised innovation hubs can serve as engines of industrial growth while linking to global knowledge networks.

- **CSIR laboratories and IIT research parks:** These institutions act as regional anchors by providing infrastructure, talent and industry linkages. For example, the CSIR–IICT in Hyderabad supports pharmaceutical and specialty chemical R&D.

- **State-level clusters:** Regions in Gujarat, Maharashtra and Tamil Nadu are emerging as innovation hotspots, characterised by strong industry–academia–government collaboration and specialisation in areas such as specialty chemicals and green manufacturing.

Such hubs facilitate accelerated prototyping, localised problem-solving and the scaling of innovative solutions, thereby strengthening regional competitiveness and integration into global innovation ecosystems.

4. Integrate digital and deep-tech capabilities

Digital transformation is a critical enabler of next-generation R&D ecosystems in the chemical sector.

- **AI and automation:** AI and automation are being incorporated into chemical R&D through initiatives such as the CSIR's AI-enabled platforms and the DST's Research, Design and Innovation Scheme, which supports digital laboratories and predictive modelling.
- **TRL-based funding models:** TRL frameworks, particularly levels 4–8, ensure that innovations are not only technically robust but also commercially viable.

By embedding digital and deep-tech capabilities, India can reduce time-to-market, enhance process precision and scale sustainable solutions more effectively. Several examples of industry-academia collaboration have led to significant reductions in emissions, conversion of plastic waste to re-usable materials, achieving manufacturing targets and capitalise bio-based feedback in place of synthetic raw materials, among others.

Institutional anchors play a pivotal role in leading publicly funded research initiatives. Whether through standalone projects or collaborations with foreign technology partners, these institutions foster ecosystems that enable the development of novel chemical applications, ensuring they are safe, functional and suitable for commercial use.





04 Operational excellence: Technology and implementation

Operational excellence is attained through the establishment of robust processes and systems that facilitate change management without disrupting day-to-day operations. However, well-intentioned initiatives, such as the adoption of new technologies, redesign of circular economy models or efficiency improvements involving substantial alterations to business processes, do not automatically guarantee measurable benefits. Such measures may fail to achieve their intended outcomes. Organisations that have developed operational excellence are better equipped to manage and adapt to change. Additionally, renewed interest of chemicals industry for green-product certifications, such as REACH, Roundtable on Sustainable Palm Oil (RSPO) and RedCert, is a strong indication that organisations are ready to embrace eco-friendly products.

4.1 Manufacturing process optimisation and technology adoption

Process optimisation serves as a critical driver of operational efficiency, innovation and sustainable growth in the chemical industry. It also entails a systematic and continuous improvement approach designed to enhance process performance, ensure consistent product quality and minimise waste across the value chain.

Technology-enabled process optimisation

As the Indian chemical sector continues to expand in response to global demand and sustainability imperatives, the integration of automation and control technologies has become essential. These digital enablers not only enhance productivity and safety but also support organisations in meeting increasingly stringent environmental and quality regulations.

Digital transformation has demonstrated substantial potential to improve overall equipment effectiveness by 20–30% in chemical manufacturing environments.³⁸ For batch-process chemical manufacturers, the adoption of a structured digital roadmap can generate significant value by:

- Reducing operational costs
- Enhancing asset utilisation
- Improving EBITDA margins
- Enabling data-driven decision-making.

When appropriately tailored to the scale and maturity of an organisation, a proven digital transformation framework can facilitate the transition of chemical manufacturers from reactive operations to predictive, optimised and ultimately autonomous systems.

Figure 12: Transformation roadmap



³⁸PwC analysis

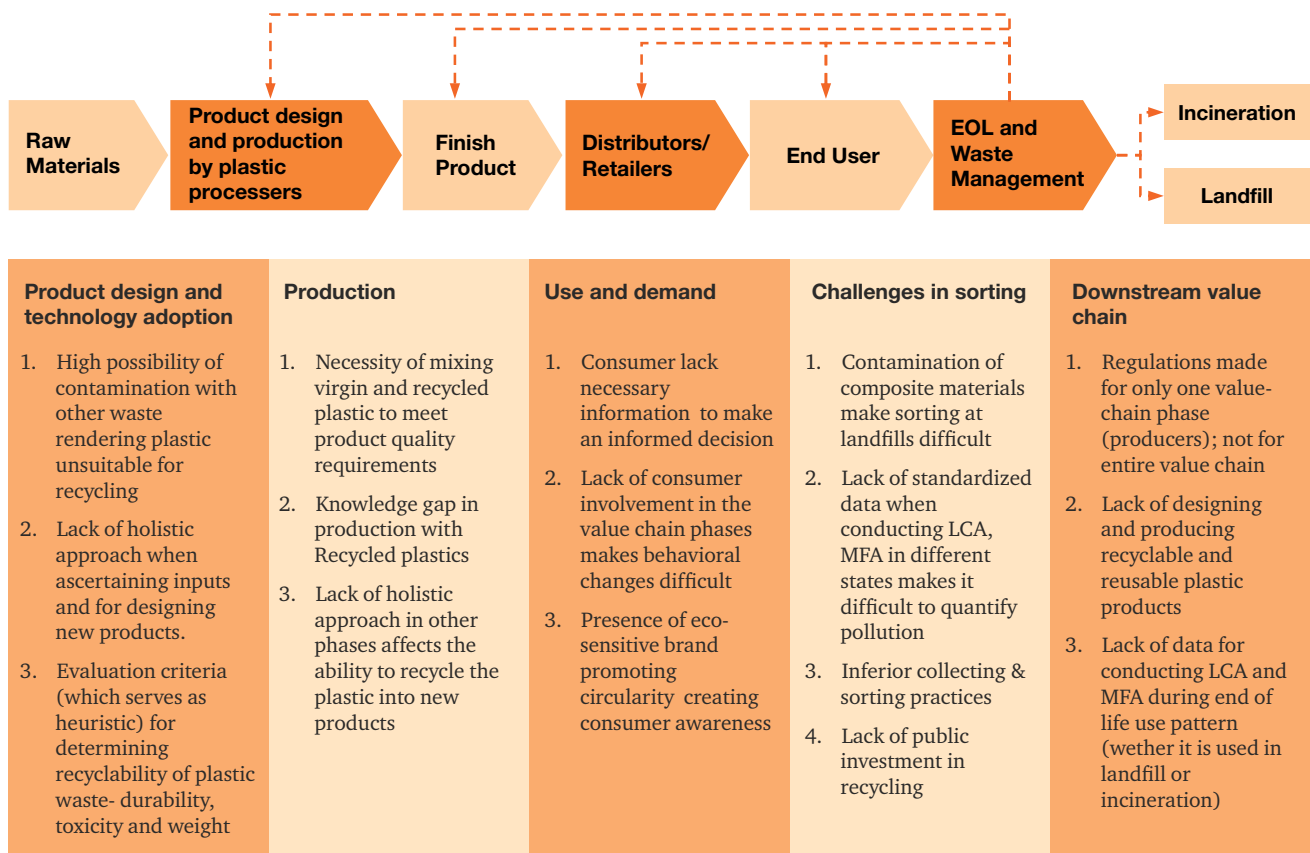


Circular economy in plastics industry:

The three Ps of sustainability: Profit, People and Planet has gained significant traction in the polymer and specialty chemicals manufacturing sectors. There is also growing industry-wide recognition of the importance of incorporating recyclable chemicals into manufacturing processes. Notably, 54% of chemical industry CEOs believe that resource substitution will form the foundation of a circular economy. Meanwhile, decarbonisation of the economy is being pursued through two primary approaches: transitioning to green fuels or implementing point-source emission control systems to mitigate fugitive emissions. Moreover, 46% of chemical company CEOs contend that decarbonisation of economy will have a significant impact on advancing a circular economy.³⁹

Decarbonising the economy is achieved through a four-step process: circular procurement, customer value chain integration, the development of circular products and end-product recycling. To fully grasp the complexity of the cradle-to-grave journey of plastics, it is essential to first map the role of each stakeholder within the entire value chain.

Figure 14: Challenges in implementing circular economy for plastic



Source: Description of value chain phases from plastic production to plastic waste with major challenges in each phase.
Reprinted from (Johansen et al., 2022) & licensed under CC BY 4.0

³⁹PwC analysis

Redesigning manufacturing processes and enabling manufacturers to adopt sustainable practices is comparatively easier than enforcing Extended Producer Responsibility. Ideally, a redesigned process should yield a green-certified product or by-product that is either biodegradable or easily recyclable. This transformation is increasingly being driven by stringent compliance requirements such as the EU's REACH regulation, growing demand for food product traceability and heightened awareness of environmental pollution, particularly from plastic microbeads in aquatic ecosystems. In response, a new generation of environmental certifications has emerged. These certifications set benchmarks for ecologically safe chemicals that serve as sustainable alternatives to traditional raw materials, aligning with circular economy principles. The following section presents select case studies that demonstrate how the adoption of certified inputs is enabling innovative, commercially scalable product designs.

An example of cross-industry collaboration involves a large oil and gas company and a plastics processor working together to improve access to recycled materials across end markets. The polymer manufacturing division of a global oil and gas firm has developed an innovating recycling technology, which is now being leveraged by a US-based producer of packaging films. This collaboration enables the integration of recycled content into advanced packaging solutions.

An Indian chemicals organisation has successfully commercialised ISCC Plus-certified products, validating the facility's capability to produce end products via chemical recycling and ensuring compliance with strict traceability protocols and sustainability standards across the value chain. These certified products are derived from chemical recycling involving the conversion of waste materials like plastics, old tires, etc. The refinery has a massive waste recycling facility, generating reusable materials that are subsequently synthesised into end-use products.

Moreover, some of the Indian chemicals manufacturers have developed RSPO-certified chemicals covering the entire value chain, from feedstock growers and downstream traders to processors, consumer packaged goods (CPG), manufacturers, retailers, and social and environmental auditors. Extending RSPO certification across the entire value chain enhances the credibility of internal sustainability commitments and strengthens the environmental credentials of partnering FMCG brands. As direct-to-consumer brands increasingly challenge legacy FMCG players by offering healthier and more ecologically responsible products, such re-engineering of supply chains is expected to accelerate in the coming years.⁴⁰

⁴⁰PwC analysis

4.3 AI-driven digital transformation



Projected GDP boost by 2035 \$85–100 billion

Through AI-driven productivity and efficiency gains in manufacturing

Source: <https://economictimes.indiatimes.com/news/india/ai-can-lead-to-8-plus-economic-growth-to-realise-the-vision-of-viksit-bharat-niti-aayog-report/articleshow/123893937.cms?from=mdr>

AI is emerging as a transformative lever in manufacturing operations through its integration across the entire value chain. When effectively employed, AI has the potential to:

- reduce operational costs
- achieve superior product quality
- strengthen supply chain resilience
- attain global competitiveness.

AI-driven digital transformation is reshaping the manufacturing landscape by fostering demand for technologically augmented workforces, driving automation, enhancing data-informed decision-making and enabling smarter, more efficient production systems.

Key applications include:



Predictive maintenance

Real-time monitoring of equipment to prevent downtime, reducing losses and maximizing asset utilisation



Process optimisation

AI algorithms optimise variables to improve throughput, yields and energy efficiency.



Quality control

Computer vision and anomaly detection ensure defects are caught early, lowering rejection rates.



Mass customisation

Intelligent design tools enable customer-specific products at near mass production costs.



Workforce enablement

Upskilling through a tiered 'AI for advanced manufacturing' programme prepares engineers for Industry 5.0 environments.

Five pillars of manufacturing mission

The government's manufacturing mission is built on five foundational pillars. Among these, AI exerts the most significant influence on three aspects: ensuring the availability of ATs, developing a future-ready workforce and strengthening MSMEs. These areas are where digital transformation will make the deepest impact.

Table 3: Foundational pillars for government's manufacturing mission

Pillar	Objective	AI Impact	Examples of AI Use cases
Ease and cost of doing business	Simplify regulations, reduce costs, attract investments	Indirect	AI-driven compliance tools, digital regulatory filing, automated documentation
Future-ready workforce	Equip workers with skills for high-tech manufacturing	High impact	AI training platforms for upskilling
			Digital twins for experiential learning
			Certification in AI/robotics
Vibrant and dynamic MSME sector	Empower SMEs with finance, tech, market access	High impact	AI-enabled supply chain and demand forecasting
			Affordable SaaS AI tools for MSMEs
			Digital B2B platforms
Availability of technology	Drive innovation and adoption of advanced tech	High impact	Predictive maintenance and robotics
			AI-driven scheduling and process optimisation
			Advanced analytics for R&D
Quality Products	Ensure Indian goods meet global standards	Indirect/ Supportive	AI-enabled quality inspection, defect detection and compliance monitoring

Source: <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2098392>; <https://niti.gov.in/sites/default/files/2025-09/AI-for-Viksit-Bharat-the-opportunity-for-accelerated-economic-growth.pdf>

AI-driven digital transformation is a powerful catalyst for achieving operational excellence in the Indian chemical industry. It also enables companies to balance economic competitiveness with critical sustainability and safety imperatives. However, realising its full potential requires a deliberate and structured approach, encompassing careful planning, piloting, securing, governing and scaling of AI initiatives. While the journey presents several challenges, current developments already demonstrate promising returns and strong alignment with India's regulatory and sustainability objectives.

4.4 Workforce development and transformation

India is uniquely positioned to lead workforce transformation through technological integration, leveraging its scale and adaptability. This transformation is underpinned by a large, digitally skilled workforce that plays an integral role in global delivery systems. With a robust foundation in engineering, systems thinking and data proficiency, India possesses the capability to swiftly adapt to emerging technologies. The growing prevalence of cross-functional skill sets further enhances workforce adaptability and versatility across a wide range of roles.

Successfully transitioning to a technology-augmented workforce in India requires coordinated efforts across four interconnected stakeholder groups:

- Individuals: Proactively develop AI-aligned skills within their domain and function.
- Academia: Embed AI-era competencies, tools and applied project work into mainstream curricula.
- Industry: Redesign job roles and delivery models to integrate AI workflows and foster continuous reskilling.
- Policy and public institutions: Enable scalable skilling infrastructure, co-funding models and academic–industry collaboration platforms.

Over the next five years, the primary focus will be on facilitating a significant transition in the workforce, from performing routine process tasks to engaging in intelligent orchestration. This transformation will be driven by close collaboration between humans and ATs, in which human expertise is augmented by intelligent systems to optimise decision-making and streamline complex workflows. Achieving this evolution will require upskilling of employees, redesigning roles to effectively incorporate technology and fostering a culture that embraces innovation and partnership between humans and machines for enhanced productivity and value creation.

India's workforce transformation in the AI era presents a unique and timely opportunity to harness ATs to foster inclusive economic growth, enhance skill development and position the country as a global leader in technology-driven services and innovation. By adopting AI and digital transformation, India can unlock new avenues for job creation, increase productivity across multiple sectors and cultivate a resilient workforce equipped to meet emerging challenges of Industry 5.0, which emphasises human-centric designs.

Applications, such as digital twin solutions for condition-based monitoring of high-value assets and AI-driven predictive maintenance, illustrate the complementary relationship between human judgement AI technologies. Concurrently, the development of recyclable polyethylene and polypropylene has generated renewed optimism within the circular economy framework. Meanwhile, AI, having accelerated drug discovery processes for some chronic diseases, also holds significant potential to design optimised molecular structures for recyclable materials, thereby advancing the pursuit of a fully circular economy in the near future.



05 Sustainable transformation: Leveraging standards, finance and market opportunities

Global ESG frameworks have evolved from voluntary guidelines into essential mechanisms that investors, regulators and communities depend on for ensuring transparency and accountability. For the chemical industry, characterised by significant resource consumption and subject to intense scrutiny regarding its environmental and social impacts, this shift marks a critical turning point—what was once regarded as a compliance obligation is being increasingly recognised as a strategic lever that fosters long-term growth and competitiveness.

Currently, chemical companies are positioned to leverage three interrelated drivers: standardised ESG reporting requirements, expanded opportunities in green finance and rising consumer demand for sustainable products. This section explores how these dynamics are reshaping the sector, enabling companies to address environmental and social challenges more effectively through adherence to established standards and the strategic utilisation of sustainable finance.

5.1 Integrating sustainability into business operations

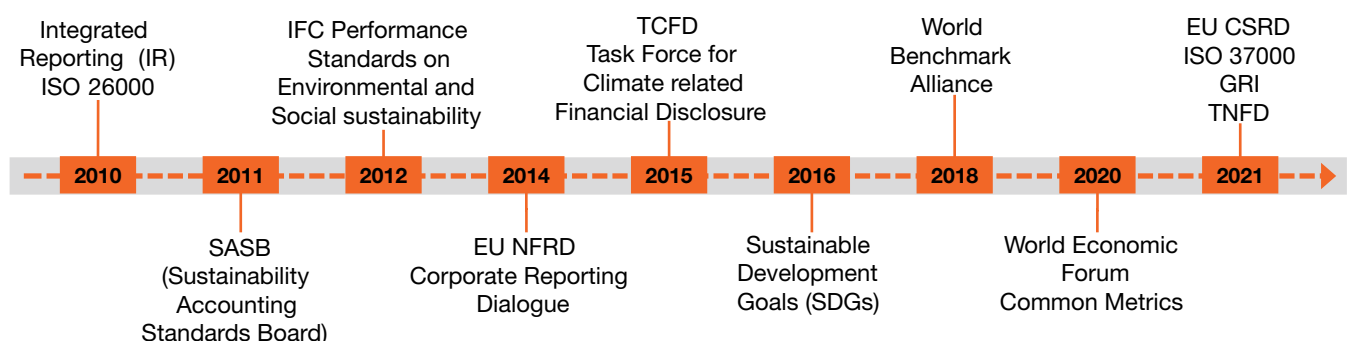
Integrating sustainability within organisations or businesses requires the establishment of a common language. Sustainability standards and frameworks serve as foundational platforms and structured methodologies for embedding sustainability principles into corporate practices. The evolution of these standards reflect a growing demand for consistent, transparent approaches to evaluating corporate environmental and social impacts. By providing a standardised language for disclosure, these frameworks facilitate comparability and accountability across diverse sectors and markets. Meanwhile, enhanced interoperability among sustainability standards has further advanced global alignment, while the incorporation of ESG factors into financial investments underscores the increasing recognition among investors as a critical component of risk management and long-term value creation.

Evolution of ESG standards

ESG reporting has evolved from a voluntary exercise into a globally recognised baseline for investors, regulators and communities. Understanding this convergence requires tracing the development of key ESG frameworks that have shaped the landscape over time.

- **The Global Reporting Initiative (GRI):** Established in 1997, GRI laid the foundation for ESG reporting by emphasising transparency and accountability in how organisations impact the environment, economy and society. It is still the most widely adopted sustainability reporting framework globally.⁴¹
- **The Sustainability Accounting Standards Board (SASB):** SASB was introduced a set of sector-specific, investor-oriented metrics designed to meet the needs of investors. Its standards have enabled comparability of ESG performance across industries.
- **Task Force on Climate-related Financial Disclosures (TCFD):** Launched in 2015, TCFD brought climate-related financial risks to the forefront of corporate reporting. By embedding climate considerations into governance, strategy, risk management and metrics, TCFD significantly influenced global investor expectations and catalysed the integration of climate risk into mainstream financial decision-making.

Figure 15: Evolution of sustainability standards



Source: PwC analysis

Convergence to interoperability

2021 marked a pivotal moment in the convergence of sustainability reporting standards, driven by a growing demand for alignment, consistency, comparability, integration and interoperability of ESG considerations into reporting practices and investment decisions. A key milestone in this process was the establishment of the International Sustainability Standards Board (ISSB) by the International Financial Reporting Standards (IFRS) Foundation. The publication of IFRS S1 (General Requirements for Disclosure of Sustainability-related Financial Information) and S2 (Climate-related Disclosures) in 2023 further solidified this shift. These standards, which significantly incorporated the foundational principles of the TCFD, represent a major step towards creating a globally harmonised baseline for sustainability disclosures.⁴⁰

Figure 15: Evolution of sustainability standards



Connecting Global Standards

Source: PwC analysis

To advance this objective, GRI and ISSB entered a cooperation agreement to develop a building-blocks approach. Under this framework, ISSB focuses on financial materiality, while GRI addresses broader environmental and societal impacts. This collaboration also enables organisations to utilise a single dataset for multiple reporting purposes. This marks a significant transition from complex, disparate ESG frameworks to a more practical and aligned disclosure system which allows companies to streamline reporting while meeting the needs of investors and stakeholders.⁴²

Meanwhile, regulatory bodies are adopting similar strategies. For instance, the EU's CSRD has mapped each European Sustainability Reporting Standard (ESRS) disclosure against ISSB and GRI to minimise redundancy, demonstrating that global standards can complement rather than compete with one another. Similarly, Canada has introduced its own sustainability disclosure standards (CSDS 1 and 2), which are directly aligned with ISSB, but retain flexibility for local context. Across jurisdictions, the message is clear: interoperability is becoming the new norm.

⁴²<https://www.pwc.com/gx/en/asia-pacific/esg/sustainability-counts/sustainability-counts-2024>

Various frameworks, such as GRI, SASB and TCFD, have laid the groundwork, while ISSB seeks to unify these standards. This unification is particularly significant for India, where SEBI mandates the Business Responsibility and Sustainability Report (BRSR) for the top 1,000 listed entities. In this regard, the question is no longer whether to align with international frameworks but how to navigate interoperability in a way that preserves local relevance, while satisfying the expectations of global capital markets.⁴³

Interoperability is not merely a technical convenience; it is crucial for preventing ESG reporting from becoming fragmented and burdensome. In the absence of alignment, multinational companies face a complex regulatory landscape: ISSB in one jurisdiction, CSRD in another, BRSR in India and the GRI globally. This lack of cohesion leads to duplication, increased compliance costs and reporting fatigue. Conversely, alignment enables a single dataset to serve multiple audiences, investors, regulators and communities. This approach of reporting once and using many times is transforming ESG reporting from an administrative obligation into a strategic asset.

Momentum for this alignment is already building. For example, ISSB's global baseline is gaining traction, with 36 jurisdictions either having adopted or in the process of adopting its standards, including 17 that have already finalised their approach.⁴⁴ GRI has also updated its climate standards to ensure interoperability with IFRS S2, incorporating critical themes such as just transition and energy impacts, which resonate with broader societal concerns.⁴⁵

Moreover, global ESG reporting is evolving into a network of interconnected standards. In this case, the ISSB provides the financial backbone, the GRI brings in the societal and environmental dimensions and regional frameworks, such as the CSRD and BRSR, align with these global norms. The SASB is also being subsumed under the ISSB to ensure greater consistency.

This evolution is of particular significance because sustainability challenges transcend borders, while capital markets demand comparability. Companies cannot afford to produce multiple reports for different audiences, and regulators cannot tolerate fragmentation that enables greenwashing. Thus, interoperability offers a pragmatic middle path, creating a shared language for ESG reporting that can be universally understood.

ESG integration in the chemical sector

Amidst evolving geo-economic dynamics, ESG integration has emerged as one of the strategic instruments for the chemical sector. Such integration provides a robust framework for enhancing operational resilience, improving resource efficiency and driving product stewardship across the value chain. Given the sector's resource-intensive nature, stringent regulatory landscape and heightened environmental and social scrutiny, ESG considerations are central to the sustainable operationalisation of chemical businesses. Additionally, ESG integration enhances a company's reputation as a sustainable and responsible business, facilitates access to sustainable finance and opens up emerging opportunities in areas such as clean energy, circular economy models and low-carbon technologies.

Key aspects and associated risks for the chemical sector included the following:

⁴³<https://www.pwc.com/us/en/services/esg/library/sustainability-reporting-interoperability.html>

⁴⁴<https://www.ifrs.org/news-and-events/news/2025/06/ifrs-foundation-publishes-jurisdictional-profiles-issb-standards/>.

⁴⁵<https://www.globalreporting.org/news/news-center/new-climate-standards-can-unlock-actionable-and-streamlined-reporting-on-impacts/>.

Materiality assessment

- A comprehensive materiality assessment is essential for identifying the most significant ESG issues that affect an organisation's operations. This process has evolved into what is now referred to as a double materiality assessment, which provides a more holistic perspective. Double materiality captures two dimensions: financial materiality (outside-in) and impact materiality (inside-out), expanding the traditional notion of materiality.
- The chemical sector has a relatively high environmental and social (E&S) footprint, along with associated sustainability risks. In this context, materiality assessment enables companies in the chemical sector to comprehensively assess and prioritise their material issues across the value chain. This process enhances organisational integrity and transparency, fosters stakeholder trust and supports the creation of long-term value.

Table 4: ESG materiality assessment

Environment	Social	Governance
Decarbonisation and energy efficiency	Occupational health and safety (OHS)	Board oversight of ESG
Water and resource management	Diversity and workforce development	Risk management
Green chemistry	Community engagement	Transparency and reporting
Climate risk	Product stewardship	Ethics and compliance
Biodiversity		Supply chain

Climate risks

- The breach of the 1.5°C global warming threshold⁴⁶ has heightened the urgency of addressing climate-related risks, which increasingly affect corporate operations, compress financial valuations and disrupt supply chains.
- Climate risks, categorised as physical risks and transition risks (arising from policy, market, technological and societal shifts), affect businesses dynamically, varying in intensity and frequency across different time horizons.
- For the chemical sector, climate risk is particularly significant owing to its resource-intensive nature and carbon-intensive operations. Climate-related impacts can interact to amplify existing business risks, influencing credit and liquidity profiles, market competitiveness and operational continuity. In extreme cases, unmanaged climate risks may lead to stranded assets and increased liability exposure.

⁴⁶<https://www.un.org/en/climatechange/science/climate-issues/degrees-matter>

- Thus, integrating climate risk assessment into enterprise risk management (ERM) and business continuity planning is essential. This integration not only enhances strategic planning and organisational resilience but also improves corporate reputation, strengthens stakeholder trust, drives innovation, and offers a competitive advantage and builds resilience across the supply chain.

Biodiversity and nature risks

- The relationship between biodiversity and the chemical industry is complex, presenting challenges and opportunities.
- The chemical industry has a dependence on ecological goods and services for sourcing key raw materials while simultaneously contributing to biodiversity loss through environmental degradation (manifested in bioaccumulation, biomagnification, heavy metals pollution, etc.).
- Assessing and integrating biodiversity-related and/or nature-related risks into ERM and business strategies enhances strategic planning and assists green chemistry and bioprospecting initiatives. It also contributes to improved corporate reputation, strengthened stakeholder trust, increased innovation capacity and enhanced competitive advantage. Moreover, it fosters supply chain resilience through sustainable sourcing practices and responsible waste management.

Decarbonisation and net zero plan

- Decarbonisation is a crucial initiative for driving operational efficiency, strengthening business resilience and building stakeholder trust, as the chemical sector remains highly energy-intensive and heavily dependent on fossil-based feedstocks.
- Given the chemical sector's significant contribution to global industrial greenhouse gas emissions, advancing decarbonisation and transitioning to net-zero operations has become imperative. This can be achieved through a combination of process optimisation, the adoption of energy-efficient technologies and the shift towards low-carbon and renewable energy sources. In addition, promoting circular economy principles, such as reducing dependence on virgin fossil-based feedstocks and investing in emerging solutions (including CCUS) is also a critical pathway.

Water risk assessment

- Water is a critical input throughout all stages of operations in the chemical sector, and water-related risks are expected to worsen in the context of climate change.
- Thus, water management becomes a cornerstone for enhancing the resilience of business operations. This also presents an opportunity for chemical companies to embed water stewardship at the core of their sustainability strategies by implementing practices such as water recycling and reuse, adopting zero liquid discharge systems, reducing water footprints through process optimisation and adopting water-efficient technologies.

Supply chain assessment

- The supply chains of companies in the chemical industry are typically complex, global, and often multi-tiered and opaque. This complexity increases exposure to ESG risks, including environmental degradation, violations of human rights and labour standards and non-compliance with responsible governance practices.
- Hence, comprehensive assessment across the ESG pillars in a supply chain is pivotal for effectively managing and mitigating ESG-related risks.

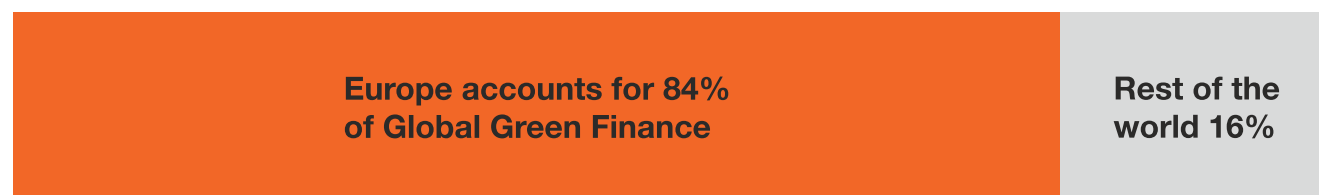
ESG integration in the chemical sector is not only pivotal from a compliance perspective but also as a strategic enabler that facilitates the balance between profitability and corporate responsibility. This is achieved by embedding sustainability into core business strategies, developing sustainable products and ensuring safety and transparency throughout operations.

5.2 Green finance and sustainable investment opportunities

ESG considerations have evolved from a compliance exercise to a critical determinant of capital allocation in India's chemical industry. Private equity investors, in particular, are increasingly incorporating ESG diligence to underwrite risk, identify operational value creation and inform exit strategies. Strong ESG performance is now associated with improved risk management, greater cost efficiency and enhanced enterprise value. This, in turn, contributes to premium valuations, access to broader investor pools and greater engagement from responsible investors across strategic planning, supply chain management and decarbonisation initiatives.

This shift is further reinforced by institutional investors and Development Finance Institutions (DFIs), which are integrating ESG metrics into capital deployment frameworks. ESG data and ratings providers play a pivotal role in this process by offering tools to quantify risk exposure and performance. These assessments create comparable baselines that inform investment mandates, pricing mechanisms and eligibility criteria for funding. In parallel, DFIs and climate-focused funds are offering patient, concessional or blended capital to support projects aligned with national and international climate objectives. Such financing mechanisms help bridge viability gaps for emerging technologies and enable upgrades in energy efficiency, process optimisation, waste management and clean feedstocks across chemical value chains.

Globally, green finance is expanding at a rapid pace. For example, in 2024, the global green finance market reached an estimated \$3.2 trillion, representing an 8% increase over 2023,⁴⁷ with Europe accounting for the largest share.⁴⁸ This momentum presents a timely opportunity for India's chemical sector to access sustainable capital that can enhance competitiveness and long-term growth. According to the International Finance Corporation (IFC), there is mounting pressure to reduce supply chain emissions and develop greener products. In response, financial flows are increasingly directed towards projects that demonstrate measurable environmental outcomes. For Indian chemical producers, green finance, when paired with operational modernisation, is becoming essential for remaining competitive, complying with evolving standards and safeguarding access to export markets.⁴⁹

Figure 17: Green finance market: Europe vs the world

Source: PwC analysis based on UNCTAD report: UNCTAD report on sustainable finance trends 2025:
https://unctad.org/system/files/official-document/wir2024_ch03_en.pdf

Table 5: Instruments for green finance integration

Instruments	Type	Definition and relevance in green finance
Climate funds and DFIs	Development finance mechanism	Specialised pools and institutions offering concessional or blended finance for mitigation and adaptation, including process electrification, heat recovery, effluent treatment upgrades and clean logistics. They also provide knowledge transfer, technical assistance and access to new markets.
ESG mutual funds and ESG equity funds	SEBI-regulated pooled vehicles	They channel domestic savings into listed equities and debt instruments of green leaders and transitional businesses, thereby signalling market demand and potentially improving liquidity, valuations and cost of equity for ESG-aligned chemical companies.
Green credits and Carbon Credit Trading Scheme (CCTS)	Market-based mechanism	Market-based instruments enable the monetisation of verified emission reductions or carbon sequestration, helping firms offset residual emissions and achieve climate targets while also improving project bankability.
Green deposits and loans	Banking product	Fixed-term deposits and loans are increasingly being earmarked for the financing of environmentally friendly projects.
Green bonds	Capital market instrument	Green bonds, i.e. debt securities in which proceeds are exclusively allocated to projects with environmental benefits, are guided by the International Capital Market Association's (ICMA) Green Bond Principles.
Production Linked Incentive (PLI) Scheme	Government Incentive Scheme	The PLI scheme, while not a green finance instrument per se, incentivises increased domestic manufacturing output. However, it can serve as a catalyst for scaling and efficiency improvements that align with ESG objectives and enhance readiness for green capital.

⁴⁷ IBEF Org: State of market report 2025 (Chemicals): https://www.ibef.org/download/1754896488_Chemicals-May-2025.pdf.

⁴⁸ UNCTAD report on sustainable finance trends 2025: https://unctad.org/system/files/official-document/wir2024_ch03_en.pdf.

⁴⁹ IFC Report on Outlook for Chemical market: <https://www.ifc.org/content/dam/ifc/doc/mgrt/ifc-sectornote-outlookforchemicals-final.pdf>.

Climate funds and DFIs

DFIs and climate funds are playing an increasingly pivotal role in supporting the transition towards sustainable industrial practices by providing targeted capital for climate mitigation and adaptation initiatives. Climate funds are specialised investment vehicles that focus exclusively on financing projects and companies that address climate change through low-carbon and climate-resilient solutions. These funds typically mobilise capital from a diverse range of sources, including governments, development banks, pension funds and institutional investors, with the aim of directing financial resources towards high-impact, sustainable outcomes. As for the chemical industry, climate funds serve as a critical mechanism to bridge the financing gaps between conventional funding and the higher costs associated with novel green technologies and infrastructure upgrades.

Transactions supported by DFIs and climate funds have enabled various financial institutions and commercial banks to finance clean manufacturing and supply chain decarbonisation initiatives.

Green credits and Carbon Credit Trading Schemes

Market-based mechanisms, such as green credits and carbon credit trading schemes, serve as tools to internalise the environmental cost of pollution by placing a price on carbon emissions. These instruments incentivise companies to adopt cleaner technologies and practices, as emitting greenhouse gases becomes financially burdensome. However, such mechanisms are most effective when used in conjunction with direct emissions reduction, rather than as a substitute for them. As for India's chemical industry, carbon and green credits offer significant potential to co-finance high-impact decarbonisation projects, de-risk the deployment of emerging low-carbon technologies and monetise sustainability interventions across supply chains. As compliance markets mature, they are expected to play an increasingly influential role in determining the cost of capital and shaping export competitiveness, especially in jurisdictions with stringent carbon border adjustment mechanisms and sustainability requirements.



Table 6: Two distinct carbon markets

Voluntary carbon markets	Regulatory/compliance carbon markets
Companies purchase carbon credits to meet their corporate sustainability goals and net-zero commitments, typically after undertaking direct emissions reductions. Credits are issued for verified emissions reductions/removals in accordance with recognised standards, and subsequently registered, purchased and retired to offset residual emissions. Emerging economies account for more than 75% of voluntary credit supply,⁵⁰ underscoring the scale of the opportunity and the need of ensuring robust project quality, monitoring, reporting and verification, as well as market integrity. In 2024, nature-based removal credits attracted premium prices and strong forward demand, reflecting the growing willingness among voluntary buyers to pay more for high-integrity removals, compared with other credit types.	Regulatory frameworks mandate emission reductions and employ tradable allowances and credits to achieve them. Programmes, such as the European Union's Emissions Trading System (EU ETS), California's cap-and-trade system and China's National ETS establish caps, issue allowances and enable trading to minimise abatement costs, while driving decarbonisation. In 2024, over half of global carbon revenues were earmarked for environmental, infrastructure and development projects (which is a slight increase compared with previous years), underscoring growing policy alignment and the reinvestment of carbon revenues to support the low-carbon transition.⁵¹

Source: World bank report: <https://openknowledge.worldbank.org/bitstreams/152de0c2-e2be-49d6-aec1-3be8ebad4f74/download>

India's carbon market landscape

Voluntary Market Green Credit Programme (GCP): India's GCP is a government-led, market-based initiative administered by the Ministry of Environment, Forest and Climate Change (MoEFCC). It aims to issue tradable green credits for verified environmental services that extend beyond carbon mitigation. While the GCP can be linked to carbon offsets when aligned with approved methodologies, its scope is not limited to carbon-related activities. Instead, it is designed to quantify and incentivise a broader range for ecological services. The programme currently emphasises afforestation and reforestation activities, with credit issuance based on measurable outcomes such as canopy density and tree survival rates. Although initially envisioned to reward diverse eco-friendly activities, such as water conservation, waste management and sustainable agriculture, the methodologies for other green activities are intended to be developed over time.

Carbon Credit Trading Scheme (CCTS): The CCTS is India's national framework for a compliance carbon market. It is intended to facilitate the issuance and trading of carbon credits linked to mandated emissions reduction obligations. It is also designed to enable cost-efficient abatement by enabling obligated entities to participate in a regulated, tradable market. Additionally, the CCTS aims to support the development of market infrastructure necessary for scaled decarbonisation across sectors.⁵² The following case study illustrates how global chemical companies are leveraging the GCP and CCTS to achieve environmental compliance, while meeting financial and strategic sustainability objectives.

⁵⁰UNCTAD: least developed countries report: <https://unctad.org/publication/least-developed-countries-report-2024>.

⁵¹World bank report: <https://openknowledge.worldbank.org/bitstreams/152de0c2-e2be-49d6-aec1-3be8ebad4f74/download>.

⁵²Ministry of Energy and Environment (Govt. of India): Carbon pricing mechanism [https://www.pib.gov.in/PressNoteDetails.aspx?NotelD=154721&ModuleId=3#:~:text=The%20Carbon%20Credit%20Trading%20Scheme%20\(CCTS\)%20in%20India%20is%20a,by%20establishing%20the%20institutional%20framework](https://www.pib.gov.in/PressNoteDetails.aspx?NotelD=154721&ModuleId=3#:~:text=The%20Carbon%20Credit%20Trading%20Scheme%20(CCTS)%20in%20India%20is%20a,by%20establishing%20the%20institutional%20framework).

Voluntary Carbon Credit Scheme

A global provider of crop inputs demonstrates how manufacturing companies can diversify revenue streams by engaging in carbon credit trading beyond their traditional product sales. Through its digital platform the company enables farmers to earn tradable carbon credits by adopting verified agricultural practices such as reduced tillage and cover cropping. The company's strategic partnerships creates robust demand for these carbon credits, leveraging extensive global networks to connect with entities seeking verified emission offsets. This integrated approach not only enhances the company's cash flow through participation in voluntary carbon markets but also provides farmers with technical support and additional revenue streams.

For India's chemical manufacturers, particularly those in the fertilisers and agricultural inputs sectors, this model offers a valuable framework. It also illustrates how companies can transform supply chain relationships into carbon credit generation opportunities while cultivating strategic partnerships that secure consistent market demand.

Green deposits and loans

While voluntary carbon credit schemes constitute market-driven instruments within green finance, green deposits and green loans (including sustainability-linked loans [SLLs]) represent institutional mechanisms that directly channel capital towards sustainable manufacturing. Globally, the issuance of green loans has increased by 31% year-on-year,⁵³ driven by growing demand for financing projects in sectors such as chemicals and energy. Although still at a nascent stage, green deposits are gaining traction in regions, such as Asia and Europe, with financial institutions in Hong Kong, Japan and Germany offering structured products designed to support renewable energy, clean transportation and pollution control. These instruments are governed by stringent exclusion criteria to prevent the financing of carbon-intensive activities.

In India, the Reserve Bank of India's Green Deposit Framework (June 2023)⁵⁴ enables banks and non-banking financial companies (NBFCs) to mobilise funds exclusively for environmentally friendly projects, while promoting transparency and mitigating the risk of greenwashing. Leading banks now offer green deposits, which are fixed-term instruments specifically for projects related to renewable energy, energy efficiency and pollution mitigation. These deposits generate a dedicated capital pool that supports the issuance of green loans, which constitute approximately 39% of India's green finance transactions.⁵⁵ For chemical manufacturers, this financial linkage is significant: green loans provide cost-effective financing for energy-efficient upgrades, effluent treatment and waste management initiatives, thereby accelerating the transition to cleaner production processes. AA European energy company and its subsidiary finalised sustainability-linked revolving credit facility, where borrowing costs are directly linked

⁵³UNCTAD: World Investment Report 2024: World Investment Report 2024: Chapter III - Sustainable finance trends

⁵⁴RBI notification (Framework for acceptance of Green Deposits): <https://rbi.org.in/Scripts/NotificationUser.aspx?Id=12487&Mode=0>.

⁵⁵Climate Bonds led India Initiative: State of Market (sustainable debt): https://www.climatebonds.net/files/documents/publications/Climate-Bonds_India_Sustainable_Debt_SotM_2024_Jun-2025.pdf.

to the company's ESG performance. The flexible capital will support the expansion of renewable energy, grid modernisation and broader decarbonisation efforts, with interest margins varying based on progress towards targets such as lowering emissions intensity and increasing renewable energy capacity. Similarly, a downstream manufacturer in India has signed sustainability-linked loan (SLL) with a major foreign bank. The proceeds will fund capital expenditure to increase capacity, with an enhanced focus on sustainability. The SLL is linked to a sustainability performance target measured via a single key performance indicator (KPI) aimed at reducing net CO2 emissions intensity.

Key benefits for the chemical sector:

01

Green loans funded by green deposits provide cost-effective financing for sustainability projects, reducing the financial burden.

02

Enables investment in energy efficiency, effluent treatment and pollution control technologies, supporting chemical manufacturers in meeting stringent environmental regulations.

03

Creates a reliable funding pipeline and supports the adoption of cleaner and circular economy practices.

Source: PwC analysis

Figure 18: Four core components of green bond principles

The GBP outlines four core components:⁵⁶



Source: PwC based on ICMA principles

Green bonds

As banks and NBFCs utilise green deposits to support the issuance of green loans, capital markets play a complementary role through the deployment of green bonds, which are critical for financing in high-emissions sectors such as chemicals. Green bonds have also become a cornerstone of global sustainable finance, facilitating large-scale capital mobilisation for projects that deliver measurable environmental benefits. To ensure transparency, integrity and credibility within this market, the International Capital Market Association (ICMA) has established Green Bond Principles (GBP), which serve as the leading voluntary framework guiding the issuance and management of green bonds.

⁵⁶ICMA Green Bond principles: <https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/>.

Globally, green bond issuance is surging, driven by increasing investor demand for ESG-aligned assets and regulatory support for low-carbon transitions. These instruments are particularly well-suited for capital-intensive sectors, such as chemicals, where decarbonisation efforts require significant upfront investment. In India, green bonds dominate the green finance landscape, accounting for approximately 83% of the market. By December 2024,⁵⁷ cumulative green debt issuance reached \$55.9 billion (marking a 186%⁵⁸ increase since 2021), with \$6.4 billion issued in 2024 alone. Typical issuance sizes range from \$100 million to \$500 million, attracting institutional investors to finance renewable energy, clean technology and industrial decarbonisation projects. For the chemical sector, green bonds provide access to large-scale capital for investments in cleaner feedstocks, energy efficiency and advanced pollution control technologies, aligning with global sustainability standards and the ICMA's GBP.

ESG mutual funds

ESG mutual funds are emerging as a credible domestic instrument of green finance, channelling household and institutional savings into Indian companies that demonstrate verifiable sustainability performance and credible transition strategies. SEBI's regulatory framework for mutual fund schemes⁵⁹ has enhanced market integrity by mandating that ESG schemes allocate at least 65% of their assets under management⁶⁰ to listed entities with BRSR Core assurance. This requirement improves data quality, comparability and accountability while mitigating risks of greenwashing. For chemical manufacturers, this development presents an incentive and a pathway: improving BRSR Core assurance, setting science-based targets and demonstrating capital expenditure-linked emissions abatement can increase eligibility for inclusion in ESG fund inclusion, deepen market liquidity and potentially reduce the cost of equity. Benchmarked investment vehicles, and ESG Sector Leaders ETF, reflect growing index-base demand, while active strategies apply integration and positive screening approaches to reward credible decarbonisation, safety, circularity and governance.⁶¹ As stewardship and proxy voting by ESG funds become more assertive, these mechanisms can further accelerate sectoral transition by prioritising verifiable emissions reductions (e.g. improvements in process heat efficiency and nitrous oxide abatement), resilient supply chains and transparent disclosures aligned with the SEBI's evolving ESG framework.

While market-based instruments, such as green bonds, green loans and ESG mutual funds, provide external capital for sustainability initiatives, government-led programmes, such as the PLI scheme, complement these efforts by incentivising domestic manufacturing and operational efficiency.

⁵⁷ Climate Bonds led India Initiative: State of Market (sustainable debt): https://www.climatebonds.net/files/documents/publications/Climate-Bonds_India_Sustainable_Debt_SotM_2024_Jun-2025.pdf.

⁵⁸ Climate Bonds led India Initiative: State of Market (sustainable debt): https://www.climatebonds.net/files/documents/publications/Climate-Bonds_India_Sustainable_Debt_SotM_2024_Jun-2025.pdf.

⁵⁹ https://www.sebi.gov.in/legal/circulars/jul-2023/new-category-of-mutual-fund-schemes-for-environmental-social-and-governance-esg-investing-and-related-disclosures-by-mutual-funds_74186.html

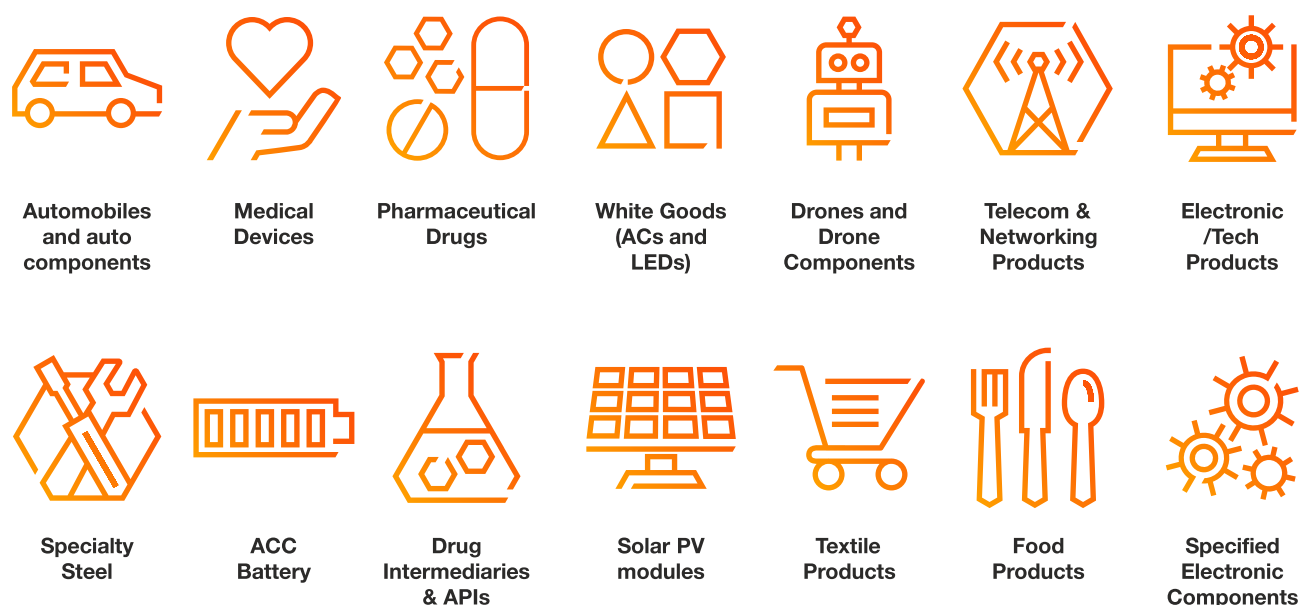
⁶⁰ SEBI Circular Mutual fund ESG: https://www.sebi.gov.in/legal/circulars/jul-2023/new-category-of-mutual-fund-schemes-for-environmental-social-and-governance-esg-investing-and-related-disclosures-by-mutual-funds_74186.html.

⁶¹ Crisil research article on ESG Mutual Funds: <https://www.crisil.com/content/dam/crisil/our-analysis/esg-research/esg-readings/how-indias-nine-esg-mutual-funds-stack-up.pdf>.

Production linked incentive (PLI) scheme

The PLI scheme is an initiative by the Government of India designed to promote domestic manufacturing and reduce import dependency by offering financial incentives to companies based on incremental sales of products manufactured within the country. Under this scheme, eligible companies receive a percentage of their increased sales for a defined period, contingent upon meeting domestic production criteria.

Figure 19: PLI scheme sectors



The PLI scheme currently spans 14 strategic sectors,⁶² with chemical companies particularly well-positioned to benefit through targeted segments such as advanced chemistry cell (ACC) batteries, pharmaceutical precursor chemicals and APIs manufacturing.

Globally, PLI mechanisms have emerged as critical policy tools for driving industrial transformation towards sustainable manufacturing. Various countries, such as China, South Korea and Germany, have implemented similar schemes that link local financial incentives to domestic production performance, creating competitive advantages for companies that adopt energy-efficient technologies and sustainable practices within core operations.

Although the PLI scheme is not explicitly a green finance instrument, companies in sectors, such as specialty chemicals, ACC batteries and APIs, can strategically align their participation by integrating sustainability measures into their operations. The scheme's emphasis on production scale and efficiency inherently complements sustainable manufacturing practices, because firms that adopt energy optimisation, waste reduction and circular economy principles often achieve higher operational efficiency and lower production costs.

⁶²Ministry of Commerce & Industry (Govt. of India): <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1945155>.

By embedding sustainability at the core of operations, chemical companies can maximise the benefits offered under the PLI scheme and enhance their preparedness for green finance. Firms demonstrating strong ESG performance also become more attractive to green investors and lenders, thereby creating a multiplier effect in which the PLI scheme supports sustainability improvements that, in turn, unlock further access to green finance. In this way, the PLI scheme not only functions as a production stimulus but also as a strategic enabler for integration into the broader green finance ecosystem.

Leveraging the PLI scheme for specialty chemical and pharmaceutical companies

The PLI scheme serves as a significant catalyst for specialty chemical and API manufacturers, providing targeted financial support to enhance domestic production capabilities.

To complement government initiatives (such as the PLI scheme) and market-based instruments (such as green bonds and green loans), DFIs and climate-focused funds offer catalytic capital. This blended finance approach enables chemical companies to scale sustainable manufacturing practices and overcome traditional barriers to green financing.

Other government incentives

Building on the momentum of green finance, government policy interventions have emerged as essential enablers within the Indian context. Strategic budgetary allocations to missions, such as the National Green Hydrogen Mission and the Bioethanol Programme, serve dual functions: stimulating market demand and mitigating investments risks, especially in capital-intensive sectors such as chemicals.

Under the National Green Hydrogen Mission, the Government of India has allocated ₹4,440 crore for domestic manufacturing of electrolyzers and an additional ₹13,050 crore to support green hydrogen production.⁶³ To further ease implementation, the MoEFCC has exempted Green Hydrogen/Ammonia production facilities from compulsory environmental clearance requirements. Meanwhile, Interstate Transmission System (ISTS) charges have been waived for a 25-year period for renewable energy-based production units. These integrated policy measures act as financial and regulatory enablers, significantly lowering compliance costs and operational risks while enhancing the investment appeal of green projects within the chemical sector. As a result, these interventions facilitate improved access to green finance for industry players.

Despite these advances, India's green finance flows remain insufficient for meeting its climate commitments. Current funding for mitigation accounts for only a small proportion of actual financing needs, while investor confidence continues to be constrained by concerns over transparency, risks of greenwashing and broader geopolitical uncertainties. Although recent regulatory frameworks have strengthened, the scaling of green finance will depend on sustained efforts to build stakeholder trust and reduce perceived investment risks.

Encouragingly, the discourse on sustainability in India is shifting beyond conventional compliance metrics such as emissions tracking. Increasingly, the focus encompasses resource efficiency, value creation resilience and circular economy principles. Even amidst global volatility and the emerging trend of 'green hushing', the urgency of climate action is reshaping business priorities. Notably, India's announcement of a climate finance taxonomy in the Union Budget 2024–25 reflects a strong policy commitment to unlocking capital for climate adaptation and mitigation.

⁶³<https://nghm.mnre.gov.in/supply-incentives?language=en>.

Moreover, accelerating these measures can foster a more predictable and credible green finance ecosystem, enabling high-emissions sectors, such as chemicals, to secure the investment required for a low-carbon, competitive future.

5.3 Sustainable product portfolios

The global chemical industry is undergoing a rapid transformation, driven by rising demand for energy-transition materials, such as battery chemicals, lightweight composites and renewable feedstocks, as well as by increasingly stringent regulatory frameworks, heightened investor expectations and a growing public emphasis on sustainability. Currently, sustainability-led growth is outpacing that of conventional product markets. Recent estimates project that global demand for sustainability-related chemical products will rise approximately 70% by 2028, reaching a market value of \$570 billion, i.e. a CAGR of 11%. This rate is nearly 4.5 times higher than the 2.4% CAGR projected for traditional chemical products.⁶⁴ For forward-looking companies, the ability to capture this growth opportunity will depend on strategically shifting product portfolios towards sustainable alternatives. This transition must be managed alongside short-term challenges, including cost competitiveness and the availability of sustainable feedstocks.

Multidimensional push towards sustainability:

The transition towards sustainable portfolios in the chemical industry is not driven by a single factor but by the convergence of multiple interrelated factors.

- 1. Regulatory pressure:** The transition towards sustainable product portfolios in the chemical industry is significantly influenced by evolving regulatory frameworks. Various instruments, such as the EU's REACH and the United States Environmental Protection Agency's (US EPA) TSCA, are pushing companies to reduce the manufacture and use of hazardous substances, while promoting the development of safer and more environmentally friendly alternatives. These increasingly stringent and dynamic global regulatory environments are forcing chemical companies to adopt more sustainable practices and rethink their product strategies.

Under the tightening of REACH regulations, several companies have restructured their portfolios. For instance, an European chemical producer has phased out certain substances of very high concern and reoriented its offerings to ensure compliance, introducing a new range of polymer additives and environmentally safe coatings. Similarly, other chemical companies have discontinued select high-risk chemicals and launched alternative product lines.

Comparable shifts have also occurred under the US TSCA framework. Various companies have made significant portfolio changes, notably through the complete phase-out of per- and polyfluoroalkyl substances. Several leading fertiliser manufacturers in India, were required to reformulate or withdraw certain agrochemical products owing to concerns related to toxicity and residue levels.

In certain cases, regulatory constraints have prompted strategic divestments. Such examples underscore the imperative for chemical companies to embrace sustainability by leveraging advanced chemistry and technology to design safer, more eco-friendly products that align with global compliance and market expectations.

⁶⁴PwC Sustainable chemicals pathways: <https://www.pwc.com/gx/en/issues/business-model-reinvention/how-we-fuel-and-power/net-zero-chemicals-industry-transformation.html>

2. **Investor demands:** With the growing prominence of ESG mandates, investors and regulators increasingly expect companies to monitor and disclose their E&S impacts. Meanwhile, financial institutions and investors are demonstrating a greater willingness to provide capital or offer more favourable borrowing terms to chemical companies that follow strong ESG practices. In several jurisdictions, including the UK and members of the EU, ESG disclosures have become mandatory for large chemical companies, making it essential for firms to measure and report these effects to strengthen investor confidence.

The direct link between ESG initiatives and capital access can also enhance a company's market value and support long-term growth by signalling lower investment risk and responsible corporate governance. In this regard, financial instruments, such as green bonds, green equity funds and green securitisation, are emerging as effective green finance mechanisms, incentivising companies to integrate sustainability into their core business strategies.

Aligning product innovation and portfolio decisions with ESG objectives has resulted in a major portfolio transformation, marked by divestment from carbon-intensive business segments and increased investment in low-carbon technologies such as green hydrogen and circular plastics. Other leading chemical companies have similarly committed to ambitious sustainability goals such as achieving carbon neutrality. To meet these targets, companies have restructured their portfolios and introduced more sustainable product lines.

In the case of a leading American chemical and polymer producer, pressure from shareholder resolutions and ESG-focused investment funds catalysed corporate action on plastic waste management. In response, the company set a target to produce and market a significant amount of recycled and renewable-based polymers. This commitment has significantly influenced its portfolio strategy, resulting in a greater focus on chemical recycling and bio-based polymers.

3. **Circular economy:** Driven by the urgency of climate initiatives and limited natural resources, the chemical sector is transitioning towards sustainable practices, emphasising the use of biobased inputs, advanced recycling technologies, and circular (closed-loop) models. The emergence of the circular economy represents a structural transformation, rather than a temporary trend. Currently, innovations in bio-based feedstocks, advanced recycling technologies and closed-loop product designs are central to material innovation and are increasingly informing strategic portfolio decisions.
4. **Consumer demands:** As consumer-facing industries and end-users become increasingly aware of their environmental impact, the demand for sustainable raw materials is rising rapidly. This heightened awareness is driving a broader shift towards responsible sourcing and sustainable production practices across the value chain, thereby increasing the demand for environmentally friendly and low-impact chemicals.

In response to these evolving market expectations, many chemical companies have committed to sustainability-driven transformations. Several companies have divested from technologies and businesses with high environmental impact while simultaneously investing in the development of new product lines aligned with sustainability goals. Notably, a new generation of companies has emerged with sustainability as their core business strategy.

In practice, these driving forces (i.e. regulatory pressure, investor demands, circular economy principles and consumer demands) rarely act in isolation. Instead, they converge to shape strategic decision-making across the chemical industry. In India, this convergence is increasingly reflected in the growing focus on sustainable chemicals, driven by shifting market sentiments. For example, a leading Indian chemical manufacturer is investing in the development of specialty silica derived from rice husk and bio-based prebiotics while also conducting research into the recycling of lithium-ion batteries. Similarly, a major Indian agrochemical firm is actively developing biopesticides and organic farming solutions aimed at improving agricultural productivity with minimal environmental impact.

Overall, sustainability has evolved from a regulatory obligation or investor expectation to a powerful driver of innovation, growth and long-term resilience. As global demand for sustainable products accelerates, and as regulatory frameworks, capital markets, circular economy principles and consumer awareness increasingly converge, companies that embrace this transformation are best positioned to lead in a competitive landscape. Evidence from India and global markets demonstrates that sustainability is no longer a peripheral or niche strategy. Instead, it is becoming central to competitive advantage. By reimagining portfolios, investing in green technologies and aligning operations with ESG imperatives, chemical companies can unlock new sources of value, build stakeholder trust and contribute to shaping a future that is not only profitable but also environmentally responsible and socially regenerative. Although the journey ahead presents significant challenges, it is equally abundant with opportunity for firms willing to lead with purpose and innovate for impact.

The chemical industry's growing alignment with global sustainability reporting standards, such as the ISSB, GRI, CSRD, and BRSR, has further enabled India's chemical sector to communicate material risks, climate vulnerabilities, biodiversity impacts, supply chain integrity and decarbonisation strategies with greater transparency and consistency. This convergence enhances communication with investors, regulators and stakeholders while unlocking operational resilience and long-term competitiveness through standardised frameworks and credible assurance mechanisms.

Enhanced transparency and improved risk management through credible, standards-based sustainability reporting directly facilitates access to green finance. With verified and comparable data, investors and financial institutions are better equipped to assess a company's sustainability performance and allocate capital with greater confidence. This alignment between disclosure and capital allocation opens up pathways to a wide range of green financial instruments, including green bonds, sustainability-linked loans, ESG mutual funds and climate-focused capital, allowing chemical companies to secure preferential financing terms and reduce their overall cost of capital.

As companies scale operations through access to green finance, their ability to invest in innovation and circular economy models increases proportionally. This enables the expansion of sustainable product portfolios (ranging from bio-based feedstocks and recycled polymers to low-carbon specialty chemicals) that are increasingly aligned with evolving market demand. In turn, this dynamic increases a virtuous cycle in which robust, standards-based sustainability enhances capital access, capital investment drives sustainable growth and such growth results in the development of high-value, environmentally responsible products that establish long-term competitive advantage in a transitioning global economy.



06 Conclusion

India's chemical industry is currently at a critical reflection point. As the sixth-largest chemical producer in the world, India is poised for substantial growth, with projections estimating the domestic chemical market to expand from \$220 billion in 2024 to \$2 trillion by 2047.⁶⁵ In a global context where the chemical industry is seeking diversification, resilience and sustainability, India is increasingly viewed as a key beneficiary of the global manufacturing diversification strategy and a potential global chemical hub. To fully capitalise on this momentum, the industry must strategically leverage its growth drivers, including supply chain development, research and innovation, operational excellence and access to sustainable finance while aligning with market expectations.

Despite a high dependence on imports, India has begun to take decisive steps towards establishing resilient and localised supply chains. Central to this effort is the development of PCPIRs, which aim to attract capital investment, advanced technology and skilled labour to established integrated chemical manufacturing hubs. Complementary efforts include the implementation of robust regulatory policies, the modernisation of port and logistics infrastructure, and targeted talent development initiatives. To address persistent challenges in recycling infrastructure and waste management, government-led initiatives such as sustainable PCPIRs and national bio-energy missions are attracting large-scale investments. Additionally, the scaling of advanced recycling technologies, the adoption of digital transformation and smart manufacturing systems and the promotion of cross-industry collaborations will be essential for India to achieve growth in sustainable chemical manufacturing.

⁶⁵<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>

In the pursuit to become a major chemical player and the development of a sustainable chemical ecosystem, innovation emerges as one of the most important success factors. The Indian chemical industry has already demonstrated a strong emphasis on R&D, with private players increasingly supported by government-backed research institutions. These collaborations are fostering the development of sustainable alternatives that are not only ecologically safe but have also demonstrated superior performance compared with their conventional synthetic counterparts.

Operational excellence is a fundamental pillar of the chemical industry's sustainable growth journey. It is increasingly being redefined through the adoption of advanced technology such as AI-driven manufacturing, predictive maintenance systems and circular economy models. To remain competitive and environmentally compliant, companies must redesign production processes to generate certified biodegradable and recyclable outputs, guided by defined frameworks. Moreover, sustainability is being integrated into core business operations through the adoption of global reporting and assurance standards. These enhance transparency and accountability while facilitating access to green finance. Such access enables preferential capital allocation for capacity expansion, process modernisation and innovation. This financial agility is critical for scaling sustainable product portfolios and strengthening India's position in the global chemical industry.

Finally, it is imperative that India cultivates a workforce that is not only equipped with strong technical expertise but also with digital skills. Together, these strategic and operational imperatives will be instrumental in enabling India's chemical industry to realise its ambitious targets: achieving a market size of \$1 trillion by 2040 and \$2 trillion by 2047.⁶⁶ This growth trajectory envisions innovation-led, environmentally responsible growth at scale, positioning India as a globally competitive and sustainable chemical manufacturing hub.

⁶⁶<https://www.niti.gov.in/sites/default/files/2025-07/NITI-Aayog-Chemical-industry-report.pdf>



About ICC

The Indian Chemical Council (ICC) is the apex national body representing all segments of the chemical industry in India, encompassing sectors such as organic and inorganic chemicals, plastics and petrochemicals, petroleum refineries, dyestuffs and dye-intermediates, fertilisers and pesticides, specialty chemicals, paints, etc. Originally established in 1938 as the Indian Chemical Manufacturers Association by visionaries Acharya P. C. Ray and Rajmitra B. D. Amin, along with a group of pioneering industrialists, the organisation was created to promote the interests of India's nascent chemical sector.

Over the decades, the ICC has grown into a dynamic institution that embodies the aspirations, achievements and ongoing concerns of the Indian chemical industry. The ICC is led by senior executives from global and domestic chemical companies, with its executive committee comprising industry veterans who bring deep expertise and strategic insight. Under their stewardship, the ICC continues to advance the sector's growth and sustainability objectives.

In response to the sector's rapid expansion in recent decades, the ICC has actively promoted initiatives that align with the evolving needs of the industry. Recognising the critical role of information and knowledge sharing, the ICC has positioned itself as a key facilitator and bridge, uniting diverse stakeholders across India's chemical landscape to foster collaboration, innovation and responsible growth.

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Notes



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