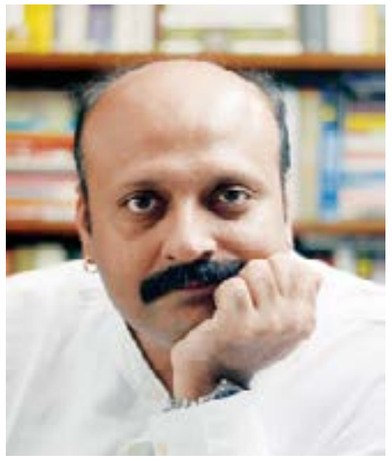
BIOMANUFACTURING: India Must Adopt the 'Triple Helix Model'



Clockwise from the left: Amit Kapoor & Mukul Anand

THE DEFINING challenge of the day is to meet the fundamental human needs for food, medicine, and energy without compromising the environment, all the while fostering innovation and technology-led advancement. In this backdrop, the bioeconomy, which encompasses all economic activities derived from the use of biological resources, including bio manufacturing, is emerging as a critical enabler in addressing this challenge. With projections suggesting that up to 60 per cent of the global economy's physical inputs could be produced biologically, it promises to deliver a transformative impact across sectors.

India's bioeconomy, which contributes 4.25 per cent to the GDP, has surged to an unprecedented $165.7 billion in 2024, marking a sixteen-fold increase from just $10 billion in 2014, highlighting both economic and scientific progress. This success is not accidental but the result of a long-term vision. The foundation was laid in 1982 with the establishment of the National Biotechnology Board, which was upgraded in 1986 to the full-fledged Department of Biotechnology, creating a dedicated body to steer the nation's biotech ambitions. A series of national-level strategies followed, each building on the last. The 2007 strategy opened up opportunities across various sectors; the 2015-2020 plan focussed on creating a world-class manufacturing hub; and the 2021-2025 strategy prioritised a skilled workforce and innovation. Approved by the Union Cabinet in August 2024, the BioE3 Policy is India's most comprehensive initiative to date.

Success in a knowledge-intensive sector like biotechnology is driven by innovation, which requires a highly skilled and productive workforce. While India appears well-positioned on the surface, boasting the world's third-largest number of Science and Engineering PhDs, a deeper analysis reveals a critical paradox that questions the quality and impact of this talent pool. India's rank in the Global Innovation Index 2024 was 39th. Under the pillar 'Business Sophistication', India ranked 58th, with the 88th rank under the sub-pillar 'Knowledge Workers', which measures the percentage of a country's total workforce employed in knowledge-intensive roles. Under the 'Innovation linkages' sub-pillar, which evaluates the strength of collaboration within an innovation ecosystem by measuring the extent of university-industry R&D partnerships, the depth of industry clusters, and the frequency of public-private co-publications and joint ventures, India ranked 61. This signifies that, despite its respectable overall GII rank, India's bio manufacturing ambitions are hindered by the need to develop a high-skilled workforce and foster effective collaboration between academia and industry.

A probable reason for this is that India's R&D expenditure, which accounts for only 0.64 per cent of its GDP, is significantly lower than China's (2.4 per cent) and that of most developed nations (over two per cent). This underinvestment is compounded by its structure; whereas innovation-led economies are driven by private sector R&D (with an over 50 per cent share in GERD), India's spending is dominated by the government (at 59 per cent). A telling indicator of this challenge is the outcome: a minuscule 0.77 per cent share of global biotechnology patents. This disparity strongly suggests that merely producing a large number of PhDs is insufficient. It highlights a systemic gap in translating academic achievement into commercially viable innovations.

Additionally, this challenge of low innovation output is further exacerbated by a persistent "brain drain," which both stems from and contributes to the underperforming R&D ecosystem. The lack of a conducive research environment and competitive career paths driven by low investment compels India's most promising scientific talent to seek better opportunities abroad. This situation has intensified post-pandemic, as awareness and interest in biotechnology have surged, leading more students and professionals to seek better exposure and employment opportunities overseas.

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India is not alone in facing challenges in its push towards bio manufacturing. The US experience, for instance, highlights the sector's long gestation periods, where technical hurdles in industrial biomanufacturing involve immense trial and error, making the journey from lab to market a lengthy and uncertain process. This history of slow progress has consequently eroded the long-term confidence of investors and policymakers, making them hesitant to commit the capital required for such time-consuming ventures. Another hurdle facing the US is a shortage of both the physical bio manufacturing facilities and the trained workforce needed to scale production. This shortage is so critical that it forces some US companies to relocate their manufacturing operations to Europe or Asia, undermining the US's goal of producing bio-products domestically. This highlights that the lack of skilled talent in bio manufacturing can be a self-limiting factor for growth.

The key takeaway is that as much as these bottlenecks affect India, they also impact countries worldwide. Several strategic initiatives are already underway to address these bottlenecks. The Budget 2025-26 set aside Rs 20,000 crore for DST towards research in the private sector. This fund is part of the Rs 1 lakh crore corpus fund first announced in the 2024 budget to boost private sector R&D. Additionally, the 'Bio-RIDE' scheme has been implemented to foster innovation, promote biotechnology entrepreneurship, and strengthen India's position as a global leader in bio manufacturing.

To further accelerate its bioeconomy, India must cultivate a robust 'Triple Helix' model tailored to socio-economic needs, uniting academia, industry, and the government. The foundation will be a strengthened industry-academia link, which requires a dual strategy: first, enhancing STEM education at all levels, and second, implementing policies to retain and attract top talent. To achieve this, academic programmes must be deeply aligned with industry needs through employer partnerships, practical internships, and entrepreneurship training. Furthermore, developing a strong intellectual property (IP) ecosystem is essential, as it provides the commercial incentive for research and innovation, thereby encouraging the long-term investment needed to transform discoveries into market-ready products.

Bioeconomy represents one of the most significant opportunities of this century to transform global industries for the benefit of both people and the planet. Realising this promise requires a concerted, ecosystem-wide effort. If the above imperatives are met, India will not only overcome its current challenges but will also be poised to realise its full potential as a global leader, driving the future of a sustainable and prosperous bio-economy. BW

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