

Role of Knowledge and Innovation-driven Bioeconomy towards Sustainable Development: A Futuristic Perspective

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Abstract

Biotechnology being heart of 'bio-based economy' is the major reason for the present-day bio-based innovations, offering solutions to global challenges ranging from food, feed, energy, medicine thereby, addressing basic requirements of humankind to the worldwide epidemic, relevantly explicated by recent Covid-19 pandemic. Developing biobased economy using eco-efficient and renewable bioresources is strategic challenge for present day. 'Biotechnology' as 'Knowledge and Innovation driven Bioeconomy', mentioned by National mandates for 2025, target the nation to stand as a global biotechnology hub, forecasting 100 bn \$ bio-based economy with over 10 million jobs, requiring defined strategies and implementation action plan. This article emphasizes on current state of biotechnology-based economy, building industry-ready graduates and defining majors to combat key challenges towards achieving circular biobased economy with resource management targeting sustainable development.

Keywords: Biotechnology, Bio-based Economy, Sustainable development, Entrepreneurship, India, SDGs

1. Introduction

The term "Bioeconomy" was coined in a conference of American Scientific Developments Association on "Genomics" by

R. Martinez and J. Enriquez. "Bioeconomy" encompasses all industries/economic sectors dealing with production, management and exploitation of biological resources and related services. Various reports with immense data on global flow towards emergence of bioeconomy for sustainable development have been published. Transition of bioeconomy plays an important role in the development of any economy (1). Global progression through industrialization of developing and underdeveloped countries focusses on advancement of bio-based industries ensuring sustainability with reduction in adverse environmental impact. Industrial biotechnology possesses great potential of new growth and innovation(2, 3, 4). In last few decades various biotechnology-based innovations in agriculture, industrial, medical sectors are reported and is continuing to be major contributor to bioeconomy providing vital support to employment, energy supply, new biotechnology-based products and subsequently to enormous job opportunities. Final potential of biotechnology market certainly depends upon how market scenario, which can be properly monitored tracking progress against future indicators, focussing successful innovation timely. Global initiative has been taken to understand horizon of bio-based market by 2050 with respect to relationship between academia and biotechnology value chain paving the path for intensive applied research (4, 5).

Development of bioeconomy concept as a framework of sustainable advances, is important to address the complex challenges, facing bioeconomy transitions. Green economy is the environmental pillar of sustainable development, and the social pillar is associated with ensuring socio technical challenges (6).

Industrial Biotechnology finds scope in various segments like chemicals, bioenergy, biosimilars differing profoundly in volume requirement, price, type, etc. (7). A forecast on the transitioning path for achieving bio-based economy through developing bio-pharmaceutical, biohydrogen, bioplastics etc has been seen to be achieved by Asian nations with India as a major contributor by 2050. Of all these biopharmaceutical industries is expected to have the largest share, with bio-hydrogen being most sensitive and a sector promising efficient investment. India is expected to provide largest market for GM products and its investment across Asia. Asian countries are expected to pay large prices to achieve 2°C and 4°C targets but can ease the negative impacts by decrease usage of fossil fuel leading to bioeconomy development gradually (8). Agribusiness, Water scarcity, fertilizer degradation and alternatives, increasing calorie consumption per person are all paving towards increasing demand of agri-based products through environmentally friendly process (9). Studies have also focussed on values chains in technological innovation system (TIS) framework to derive adequate policies focussed to take care of high heterogeneity of biotechnological applications. Fundamental differences from innovation to implementation give clearer idea on bottlenecks (10, 11, 12, 13). Biotechnology has potential to hold major contributor along the value chain providing support to the development of bio-based industries that can be a lead factor for growth of both; developing and least developed countries (14, 15, 16).

Identification, analysing and managing bioeconomy, through technological delineation based on IPC codes and

biotechnological inventions are majorly required for development of sustainable activities (17). The role of the biotechnology with revenue of over USD 300 bn, goes much beyond industrial growth providing opportunities for progress towards many of the UN sustainable development goals (SDGs). Growth in biotechnology-based bioeconomy provides ample opportunity for fairly addressing SDGs 3 (good health and well-being); 6 (clean water and sanitation), 7 (affordable and clean energy), 9 (Industry, Innovation and Infrastructure), 12 (responsible consumption and production) precisely (10). Change in climate is a big challenge to all human endeavours, which also is major restriction in development of future techniques in energy generation and consumption, having effect on water supply, agricultural productivity, CO₂ emissions. The United Nations Environment Programme (18)(UNEP) (2010) has observed 80% higher CO₂ emissions to achieve doubling of wealth, thus there is high need to break the link between growth and increasing emissions at the expense of sustainability (19, 20, 21). Harnessing economic dynamism and youthful population, large reservoir of knowledge capital and rich resource base are pillars of India that will help in narrowing the development gaps quickly. It is reported by Organization of Economic cooperation and Development (OECD), that India's growth story is dependent on strong macro-economic fundamentals. As suggested by experts Bio-based economy can also be catalysts for the strategy to mobilize large industry, small and medium-sized enterprises (SMEs).

Reports and analysis on contribution of bioeconomy to overall economy of different countries have suggested that each country differs in terms of level of economic development with different strategies (18). Constraints and opportunities vary with difference in income level and biomass availability (22). Sectors selected by each country for contribution towards bioeconomy strategy is reflection of objectives and priorities identified by the country, with

comparative analysis on advantages like endowment in biomass resources, historical economic specialization and past investments in research and development, to name a few (9). Bioeconomy comprising use renewable biological resources from land and sea-like crops, fish, forests, animals, and microorganisms to produce food, materials, and energy (23, 24).

This article highlights current state of biotechnology-based bioeconomy, building industry-ready graduates and defining majors to combat key challenges for circular biobased economy development with resource management for achieving sustainable development goals bringing ahead India's world-wide participation and position in biotechnology sector based on all global mandates and present an overview of challenges and opportunities towards achieving sustainable bioeconomy system. The article also highlights critical factors pertaining to industrial biotechnology, its contribution to bioeconomy at national and global level. Identifying opportunities for entrepreneurs and their endeavours towards bioindustries, with a comprehensive understanding of bioeconomy at national and international level, knowledge gap, major challenges and initiatives to overcome the same, thus defining the current state of bioeconomy in our country. In the present scenario of Bioeconomy and its role in Sustainable Development in India, attempt is being made in this article, to find answers to the following research questions (RQs)-

Research questions

RQ1. To recognise the government policies for promoting ecosystem for Biotech education, research and entrepreneurship

RQ2.To illustrate the approach of bio-sectors towards sustainable economy

RQ3.To identify gaps in achieving national mandates

RQ4.To abstract the factors detrimental for achievement of SDGs towards sustainable bioeconomy

RQ5.To outline the ways to enhance establishment of Start-ups and strengthen Industry Academia Connect

RQ6.To coordinate the enhancement in innovation translation to business and strong policies to fulfil national mandates

RQ7.To plan towards attainment of SDGs towards strong bioeconomy

2. Research Methodology

2.1. Data Collection

Primary data (interviews and discussions) and secondary data collection was done using various sources mentioned below-

2.1.1. Primary data- Sources were qualitative (interview and informal discussions) and semi-quantitative (predesigned interview questions).

Semi-structured interview was chosen with predesigned questions to provide adequate coverage for the research topic. Major questions were developed in the form of a general statement which was then followed by a sequence of sub-questions for further probing.

2.1.2. Secondary data-Documents and reports were collected from the website resource, annual reports, and other printed materials (e.g. journals, textbooks, newspaper, conference reports, articles) available for the purpose of the research from related government (Department of Biotechnology (DBT), BIRAC, etc.), and private organizations (TiE, ABLE, companies-Biocon, Panacea). Government policies and regulations related to Biotech education, research and entrepreneurship for schools and Higher Education Institutions were collected from websites of related government education bodies for Intermediate and Higher levels (Ministry of skill and entrepreneurship development, UGC, AICTE, Niti-Ayog, MHRD, NCERT, CBSE). Policy points from International organizations like United Nations, European Union have been collated.

2.2. Data analysis

The detailed analysis of the primary and secondary data on Industrial biotechnology and bioeconomy was analysed, discussed, compared and contrasted, and synthesized.

2.2.1. Mixed-method methodology using both qualitative and quantitative methodologies were utilized to integrate perspectives and create a holistic picture.

Quantitative data analysis-Quantitative data was obtained from primary and secondary data obtained as above.

Qualitative data analysis-It used the details of interview, observations, and report records to support the findings.

2. Literature Review

Knowledge based production and utilization of biological resources, related processes and principles to sustainable development across all economic sector, can be best defined by bioeconomy, with its major element being renewable biomass and efficient bioprocesses for sustainable production, enabling and converging technologies, integrating applications such as agriculture, health and industry(25). Biological science is in exponential phase towards broadening array of options to develop incremental and differential innovations across various sectors. A continuous approach on understanding bio-based economy and its growth has suggested a range of 10-25 years for complete development based on research growth and market requirement. This interpretation has been done studying complete scenario of biobased socio-economic system (2, 26, 27, 28, 29, 30)

India stands in top 12 destinations for biotechnology worldwide and second in Asia (after China), with over more than 2700 biotech start-ups and 2500 biotech companies, of which 665 FDA (US Food and Drug Association) approved plants, holding 44% of the global abbreviated new drug applications (ANDA) and over 1400 manufacturing plants in compliance with WHO. With specific examples, India is world's third largest producer of recombinant

Hepatitis B Vaccine and second largest producer of BT cotton. In 2019, Indian biotechnology industry amounted to US\$ 63 bn which is expected to reach US\$ 150 bn by 2025, with a annual growth rate of 16.4%, this ideally account accounts for 19 % contribution of Indian biotechnology industry globally by 2025 (NBDS 2021-2025).

India's Bioeconomy by the end of calendar year 2020 was valued at \$70.2 Bn. India registered 12.3 percent growth in Bioeconomy compared to the previous year's figure of \$ 62.5 bn (31). Of all biotechnology industries, biopharmaceuticals is the largest segment contributing about 58% to the Indian biotechnology market presently, followed by bio-agriculture and bio-services contributing 19% and 15% respectively, being lead destinations for clinical trials, contract research and manufacturing activities (32)(. Bioinformatics and potential producer of transgenic crops are other significant areas. Out of the various initiatives taken by Gol, Biotechnology Industry Partnership Program to develop new technologies and developing of National Rural Healthcare Mission to boost healthcare spending of great importance. As compared to US\$ 1.1 bn in the 11th five-year plan to accelerate the pace of research, innovation and development, Government's 12th five-year plan aims to spend US\$ 3.7 bn. National Biotechnology development strategy (2015) to strengthen Industries Human Resources and infrastructure promoting growth & Trade and allowing 100% Foreign Direct Investment (FDI) through the automatic route for manufacturers of drugs and pharmaceuticals are other initiatives taken by Government of India (Gol) (33).

World has faced a major impediment sue to Covid 19 pandemics leading to wide requirement of vaccine development (34). Few recent developments in chemical sectors with respect to 100% FDI can be highlighted as setting up Fast track lab (in the month of March 2021) by Cytiva, in Telangana in order to accelerate and advance local biopharma scale up needs, Gland Pharma Ltd. (252 million doses Sputnik V), 10 URJIT (University

Research Joint Industry Translation) clusters; National Research Foundation, Biocon Biologics (biosimilar arm of Biocon); Zydus Cadila (); Bharat Biotech (700 millions doses of Covid-19 vaccines) etc [34].

Biotechnology Industry Research Assistance Council (BIRAC) established by DBT, strengthens Indian Biotech Sector through numerous initiatives like 'Innovate India', Biotechnology Parks and Innovators etc. Thus, BIRAC aims at building biotechnology in India that is on the platform of entrepreneurship, innovation, developing domestic talent and demonstrating value-based care. India has immense experience of scientific knowledge to treat diseases, wherein boosting the biotechnology sector under the flagship programmes such as 'Make in India' and 'Start-up India, is need of the hour(35)(Report-Live Mint 13 February 2016). The draft of first biotechnology policy has been released by Odisha, to become one of the top-5 biotech hubs in country, proposing to set up a fund with investment of US\$ 3.73 million and reaching mandates for same.

BIRAC has been able to support 1000+ biotech Start-ups and entrepreneurs, 150+ research institutes, enterprises and industries having filed 200+ patents converting to 110+ products and technologies reaching to the market. BIRAC's BIG programme has become one of the largest early-stage programs and has supported more than 500 start-ups and entrepreneurs (Indian BioEconomy Report 2021).

Global Forum of Biotechnology, non-official body (established, 2010) is one of the 15 global fora created by Organisation for Economic Co-operation and Development (OECD), where broad communities/ networks of stakeholders can interact. This provides platform of peer learning and policy dialogue on next generation global issues, providing multidisciplinary as well as horizontal approach fostering partnership with intergovernmental organizations, bringing together government officials, policy analysts, business leaders, academic experts, researchers, and various stakeholders.

According to recent reports and data, industrial biotechnology market is expected to reach USD 576.89 Bn by 2026, with one of the major shares of biofuels. Increasing use of technologies around numerous industries with its eco-friendly approach of environmental acceptability, competent production methods, minimized waste generation, cost-effective process, new and effective raw material consumption is predicted to boost bioeconomy (36, 37, 38). With this background, following key questions arise in the present scenario that act as challenges for circular biobased economy development for achieving sustainable development goals.

3. Findings and Discussion

4.1. Recognition of government policies for promoting ecosystem for Biotechnology education, research, and entrepreneurship

Encouraging growth in biotechnology sector is due to strong foundation in research and education and thus building and strengthening strong educational research and translation ecosystem is needed. Universities, colleges, educational and training institutions are already offering degrees and diploma in biotechnology. National Biotechnological development strategy by Department of Biotechnology, Government of India ensures that educational curriculum requires to aligned to prepare students as per industry demands and initiation of Biotech IMPRINT Program in collaboration of Ministry of Education (MoE) targets to build research capacities in universities and research Institutes. Ensuring open access policies to entire education and research institutes across nation (NBDS 2021-2025; India-Bio-economy Report, 2020).

4.2. Approach of bio-sectors towards sustainable economy

Regional Bio-clusters is predicted to bring about sustainable production process in Indian bioeconomy. To meet the increasing demand of better health, fuel and feed, it is

important to build essential policies. The vision to see India reach \$100 Billion bio-economy by 2025, requires to work on all aspects of biotechnology sectors like vaccines, novel protein therapeutics, biosimilars, stemcells, synthetic biology, improved hybrids in agriculture, systems biology, renewable energy, clean technologies and sustainable development. Nations approach to develop product and services led 10 million jobs driven BioEconomy, in order to deliver affordable access to global healthcare through cost effective quality products, including components of medicine, therapeutics, enzyme technologies, agriculture, green technology, bioremediation products. In totally an innovation drive to improve life of people in India and abroad (India-Bio-economy Report, 2020).

4.3. Identification of gaps in achieving national mandates

Nations' objectives and bioeconomy priorities to encompass economic growth, employment, energy security, food security etc. needs to focus on major gaps due to lack of consented approach to attain the targets and strategies. Beyond this due to differences in countries constraints, policies and priorities leading to difficulties in following coherent methodologies during the process of evaluation of importance of bioeconomy across countries. It is essential to understand the gaps in achieving national mandates, like production of indigenous components, reducing our dependency on other nations, having stronger base model for research and development with vision of technology transfer. Skilled workers and industry ready students are required for fast growth and development of the sector. Company internship for student aspiring jobs in bio-industries and recognizing entrepreneurship skill are call of the moment, that will certainly lead to boost in bioeconomy.

According to the European Commission Report-2020, bioeconomy can contribute to economic recovery as it can stimulate the European Union (EU) recovery from the COVID-19 crisis by aligning the

economy with the biosphere. In terms of sustainable development, COVID-19 pandemic has impacted not only the EU economy but the global economy as well and has revealed the importance of bioeconomy (39).

4.4. Factors detrimental for achievement of SDGs towards sustainable bioeconomy

To attain SDGs towards strong bioeconomy, building capacities for both human resource and infrastructure development, Strengthening and nurturing of a strong basic research innovation driven ecosystem, promoting the translation and product development, balance between basic and translational research needs to be maintained to ensure that we have a robust pipeline of new knowledge, raise of commercialization ecosystem. strategic partnership are major steps to be looked. The Sustainable Development Goals Report 2020 stated that the progress made since the adoption of the SDGs (2015) was insufficient and SDGs are now facing a regressive impact. Developing nations need to move ahead to address United Nations sustainable development goals specifically 8, 9 and 12.

4.4.1. Major factors for imbalance in job market

Although the bio-pharmaceutical clusters in Indian states have shown major increase in job creation, an imbalance in job market persists and few prominent reasons include high interest rates and funding shortages, layoffs, cost cutting, gaps in skills, preference to experienced person, increased competitions etc. Skills being taught in academic set up and those being required in industries difficult to be at par and thus numerous skill-based courses are required to be incorporated in curriculum. Evolving biotech industries are coming up with interdisciplinary fields like bioinformatics and data sciences, and thus expertise in the area is very much required. Its also seen that higher educational degrees like Ph.D. also fail to provide a promising opportunity to lack in awareness and failure to build professional network in industry.

Biotechnology industry and market dynamics offers rare remote opportunities, is highly competitive and there is high demand of specific expertise. These factors have a great impact on job market.

4.4.2. Factors inhibiting compliance towards national mandates

Major gaps in translation of research and technology work from academia and research sector to industrial sector is challenging inhibitor towards achievement of national mandates. Correct flow of information to individual is another major hindrance. Biotechnology is an expertise driven sector and specialized industry ready candidates are not available as per requirement. These include few major inhibiting factors for compliance towards national mandates (India-Bio-economy Report, 2020).

4.5. Ways to enhance establishment of Start-ups and strengthen Industry Academia Connect

Numerous strategies have been employed by the government of India for encouraging and enhancing start-ups nationwide. This includes 5-year tax holiday for registered biotech start-ups from TDS, GST and tax exemption for investments up to Rs 10 crore in biotech startups. Special incentives for start-ups in biotechnology sectors such as Biodiversity Act, duty free manufacturing zone, loan without collaterals etc. waiving up of import duties in materials and machines etc (Ministry of Finance (2020) Union Budget 2020-2021). Bio-services, accounted for 15% of the biotechnology industry in India, is becoming a leading destination for clinical trials, contract research and manufacturing activities. Table 1 depicts the major opportune areas for start-ups and jobs at national and international level.

4.6. Enhancement in innovation translation to business and strong policies to fulfil national mandates

International and national mandates on bioeconomy, working in hands with

Industry and academia. Robust environmental, health and safety (EHS) policies and procedures are followed by companies to implement global best practices encompassing conservation of natural resources, reduction of carbon footprint, use of renewable energy resources, increasing energy efficiency, reduction in waste generation, sustainable sourcing and contributing to biodiversity. Companies follow dedicated environment management cell having online legal compliance tracking system together to create and ecosystem of effective compliance management (MNRE Report 2014).

Understanding size and structure of bioeconomy in the sectors like bio-agriculture, bio-industries and biopharmaceuticals covering more than 60% of bio-based economy is the logical path maker for moving ahead towards development of sustainable bio-industry growth. Government of India's mandate for need for actual blending of ethanol through second generation bio-ethanol productions, based on crude petroleum requirement of our nation is one of the thrust areas of work as defined by industrialists and business motivators. Under the policy support by our country and need for establishment of biorefineries, vaccine production units, investments in agriculture, health and medicine with support of partners in biotechnology like Biocon, Panacea Biotech, Serum Institute, Bharat Biotech Pvt. Ltd. under guidance of Government of India, Department of Biotechnology, ABLE and other renowned partners are the keyways towards development of bio-industries. Few listed potential molecules that can play major role in overall development are enzymes, recombinant DNA products, biosimilars, antibodies, large molecules etc. There is huge import of materials from foreign nations, that may be taken for indigenous production, thus creating vast opportunity for individuals in India and reducing our dependency on other countries. Integration of life and social sciences in education system through flexible short courses accessible to students from different backgrounds need to be encouraged

for bio-based economy (33). Tools like scenarios and models may also be used to describe the various elements of the bioeconomy system and possible developments in the future and to analyse them in terms of their impact on society, the economy and the environment(47, 48)

4.7. Plans for attaining SDGs towards sustainable bioeconomy

The vision to India has been to become a “Bioeconomy” extending benefits of biotechnology to its citizens during early part of last decade. One of the visions was to see if India can reach \$100 bn Bioeconomy by 2025.

Table 1: Major opportune areas for start-ups and jobs at national and international level				
S. No.	Sector/ Areas	Examples of Products	Examples of Companies	Reference
1	Agricultural Feedstock & Industrial Biosciences	Fertilizers, pesticides, herbicides, fungicides and agricultural microbials • Corn and soybean oil • Ethanol and biodiesel fuels • Organic chemicals made from renewable resources or through biological processes • Polymers, plastics and textiles synthesized from plant-based feedstock or through biological processes • Biocatalysts • Biobased ingredients for cosmetics, personal care products, flavours and fragrances	• Godrej Agrovet • Britannia • Rallis, a Tata Enterprise • Amyris • BASF Enzymes • Bayer CropScience • Corteva Agriscience • Evolva • Genus • Novozymes • Poet • Scotts Miracle-Gro • Simplot Plant Sciences • Syngenta	(31) (40)
2	Bioenergy /Biofuels	• Bioethanol • Biodiesel • Biogas • Development of low-carbon energy technologies and products e.g. solid biofuels and its application • Enzymes for cellulosic ethanol • Biobutanol production enhancement research	• Abellon Clean Energies • Adi Biotech pvt ltd • Advanced enzymes • Advanta Ltd • Agrosys products India Pvt. Ltd. • Ascent industries • Bharat Petroleum • Bharat renewable energy Ltd • Chemcel Biotech Ltd • Enhanced	(41)

			Biofuels and technologies • Novozyme South Asia	
3	Drugs & Pharmaceuticals	• Biopharmaceuticals • Vaccines • Targeted disease therapeutics • Tissue and cell culture media • Dermatological/topical treatments • Diagnostic substances • Animal vaccines and therapeutics	• Bharat Serums and Vaccines Limited, Mumbai • Panacea Biotech • Biocon • Serum Institute of India Limited, Pune • Acorda Therapeutics • Alkermes • Alnylam Pharmaceuticals • Amgen • Bayer • Biogen • Eli Lilly and Company • GlaxoSmithKline • Novo Nordisk • Pfizer • Roche Group-Genentech • Sangamo Therapeutics • Vertex Pharmaceuticals	(42) (31)
4	Medical Devices & Equipment	Bioimaging equipment • Surgical supplies and instruments • Orthopaedic/prosthetic implants and devices • Genomic sequencing equipment • Automated external defibrillators (AEDs) • Vascular stents and other implantable devices • Dental instruments and orthodontics	• Cdr Medical Industries Ltd. Centenial Surgical Suture Ltd. • Cure Specs Lasers Ltd. • Invicta Meditek Ltd. • 3M Health Care • Auris Health • Baxter • Boston Scientific Corp. • Cook Medical • DuPuy Synthes • GE Healthcare • Insightec • Medtronic • Outset Medical • Regenesys Biomedical • Stryker	(43) (31)

			• Zimmer Biomet	
5	Research, Testing, & Medical Laboratories	• Stem cell/regenerative research • Molecular diagnostics and testing • Preclinical drug development • Drug delivery systems • DNA synthesis • Research/laboratory support services	• Dr. Lal PathLabs Ltd • Serum Institute of India Limited, Pune • Biorasi LLC • Clinipace Clinical Research Pvt Ltd • Concept Medical Research Pvt Ltd • Metropolis Healthcare Ltd. • Charles River Laboratories • Covance • IQVIA • Laboratory Corp. of America • PPD • Quest Diagnostics • Rallybio • Sema4 • Virent	(44) (31)
6	Bioscience-Related Distribution	Pharmaceuticals • Vaccines • Plasma/blood • Veterinary medicines • Surgical instruments/appliances • Diagnostic and bioimaging equipment • Plant seeds • Agricultural chemicals	• Serum Institute of India Limited, Pune • Intas Biopharmaceuticals Pvt. Ltd., Ahmedabad • Maharashtra Hybrid Seeds Company Limited, Jalna • AmerisourceBerg en • Apria Healthcare • Cardinal Health • CuraScript SD • McKesson • Omnicare • Owens & Minor • Park Seed • Patterson Companies • PharMerica Corporation • Seminis Vegetable Seeds • Wilbur-Ellis	(43) (45)

7	Bioinformatics & Health IT	• Software applications and services: for pharmaceutical, biotech companies • Solutions in Genomics, proteomics, metabolomics, Image analysis • Pharmacovigilance • Drug designing • R&D in novel therapeutics & molecular diagnostic products via-Genome Analysis, Transcriptome, (Expression) Analysis, Metabolome Analysis and Lead Optimization and Recombinant Protein Expression.	• Accelrys software solutions • Advanced Computer System (ACS) • Agilent India • ArisGlobal Software • Aurigene Discovery Technologies • AvesthaGengrain e Technologies Pvt. Ltd. • Biologene India • Biomed Informatics • BioMakro • Biomed Informatics	(46)
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The key components of this Bioeconomy were to take all aspects of the biotechnology sector like new forms of vaccines, novel protein therapeutics, biosimilar manufacturing, stem cells, systems biology, synthetic biology, improved hybrids in agriculture, renewable energy from biological sources, clean technologies, and sustainable development. National Education Policy 2020 (NEP-20) targets to introduce entrepreneurship at school level for young minds to understand the nuances of independent and innovative thinking making them self-reliant and further help in development of sustainable economy.

4. Implications

4.1 Focussed approach of industrial biotechnology endeavours towards sustainable economy

For more than decades biotechnology has had great impact on various sectors like healthcare, law, regulatory environment, business etc and have also come up with varied products having broad market share. Evolution of biotechnology sector and their profound impact on increase in endeavours by industries towards sustainable economy (49). The European Commission's 2020 Strategic Foresight Report states the immense potential of sustainable

bioeconomy, towards transforming agricultural and industrial base thereby creating new jobs, alongwith enhancement of natural resources and ecosystems.

Public and private sector is continuously fostering policies and providing funds. Focussed approach on development of business models for cost effective research and development through targeted innovation is promising way to step towards sustainable bioeconomy, as it will ensure products at reasonable cost. Leading biotechnology companies of India as Biocon, Panacea biotech, Serum Institute of India, Bharat Serum and Vaccines Institutes etc. are biotechnological base of our country and have defined policies for sustainable business in future (Biocon Fortitude 2019; Biocon Annual Report 2020; Panacea Biotech Annual Report 2019-2020).

Indian Biotech Industry has seen great transformation in last five decades with consistent growth in global market, in which policy initiatives from government has played an important role towards reaching destination of R&D and manufacturing, recognizing \$100 bn to India's ambition to become a \$5 trillion economy. Major sectors followed are agri-biotechnology, bio-manufacturing, biofuels, bio services,

biopharma and biosimilars. All these sectors are vital for India to become the 3rd largest economy in coming years and will contribute to the ambitious aim of a \$5 trillion economy by 2024 (NBDS 2021-2025).

Karnataka's contribution to National bioeconomy was around 22.6 bn dollar in 2019, accounting 10.2 percent gross state domestic products, and stands of immense importance in valuation of national bioeconomy, estimated to be around 62.5 bn dollar. Nationwide bioeconomy targeted is around 100 bn dollars for 2025. Biocon is a major stakeholder for the area and stands from a time at the turn of millennium when this sector was in its infancy.

5.2. Ways to enhance establishment of Start-ups and strengthen Industry Academia Connect

Opportunities from government sectors and collaborations with industries is creating many avenues for start-ups and new opportunities for jobs among youngsters. Start-ups and entrepreneurship opportunities are aligned for overall development of nation. Changes in physical environment and technological advancement has necessitated the requirement of exploring new opportunities and updating learning processes. There has been a total of approximately 2700 start-ups in our country during 2012-2018 and the graph is exponential (India Bioeconomy Report 2020; India Bioeconomy Report 2021).

All India Council for Technical Education (AICTE), Ministry of HRD, Govt. of India, launched Entrepreneurship Development Cell (EDC) to encourage students in polytechnics and degree technical institutions to consider self-employment as a career option. The National Innovation and Start-up Policy launched (2019) by Ministry of Human Resource Development for students and faculty of Higher Education Institutions (HEIs), Secondary Education Boards (CBSE Entrepreneurship 2013 NCERT) and Entrepreneurship Development Institute of India (EDII). The implementation of National

Innovation and Start-up Policy (NISP) has been initiated by The University Grant Commission (UGC) in all the universities and colleges. The policy aims to promote and support innovations and entrepreneurs right from the college level (News 18-Report 2021). Government of India has taken various initiatives like Start-up India, Pradhan Mantri Mudra Yojana, Skill India Mission, state level flagship schemes for encouragement of skill and entrepreneurship development. Skill India campaign was launched 2015 to train over 40 crore people in India in different skills by 2022 (Report-NDTV 2015). Various initiatives under this campaign include: National Skill Development Mission, National Policy for Skill Development and Entrepreneurship, Pradhan Mantri Kaushal Vikas Yojana (PMKVY) (50). National Skill Development Council (NSDC), Gol, provides support to trainees and training partners to facilitate self-employment/ entrepreneurship through various programs and initiatives (Report-Daily News and Analysis, London 2015). The Ministry of skill and entrepreneurship development is implementing many other schemes like Pradhan Mantri Yuva Udyamita Vikas Abhiyan (PM-YUVA), a centrally sponsored scheme related to entrepreneurship education and training. Women Entrepreneurship Platform (WEP) has been set up by jointly by NITI Aayog, Gol (2018), in partnership with the Government of the United States of America to promote and support established as well as aspiring women entrepreneurs in India (Women Entrepreneurship Platform (WEP), Niti-Ayog 2018). Along with Government agencies and NGOs, NSDC extends benefits such as Mudra Loans, Entrepreneurship Support and strengthening placement cells towards entrepreneurship endeavours.

5.2.1. Industry Academia Connect

Industry consultation towards setting of instruction protocol, better placement and obtaining patents is gaining recognition is required for overall development. University Industry linkages (UILs) are taking steps

towards designing Framework of University-Industry Linkages in Research' conducted by the PHD Chamber of Commerce and Industry with support from DSIR, Ministry of Science and Technology. There is need for development of innovation ecosystem in academia and translation of research from academics to industries. Exposure of students is required for strengthening intellectual capabilities benefitting industries with job ready students. Skill enhancement to enhance knowledge through continuous learning is essential for all round student development to make them industry ready. Process to bridge the gap between academia and industry for student development for their eventual success.

Association of Biotechnology Led Enterprises (ABLE), a not-for-profit pan-India forum is working with focus towards accelerating the pace of growth and managing regulatory affairs, encouraging entrepreneurship and investment providing a conducive environment for companies to explore collaboration and partnerships, thereby strengthening links between academia and industry. ABLE is acting as catalyst for tie-ups between the industry, the government, academic and research institutes, and investors at national and international levels (<https://ableindia.in/home>).

The Indus Entrepreneurs (TiE) (51), a global non-profit organization devoted to entrepreneurs in all industries, at all stages, from incubation, throughout the entrepreneurial lifecycle. With a global reach and a local focus, the efforts of TiE targets five programs as mentoring, networking, education, funding, and incubation. Various aspects targeted are understanding opportunities, bringing prior knowledge for student progression, exploring practical knowhow, industry requirement and building a future-ready workforce for Industry 4.0.

5.3. Enhancement in innovation translation to business and strong policies to fulfil national mandates

The key elements required for managing the ecosystem at national and

international level requires-University Bioscience R&D Expenditures, Funding from organization like DBT, Bioscience-related Patents and Venture Capital and Angel Investments in Bioscience Companies. Various innovations have been converted to business and at much faster pace in COVID era mainly towards, vaccines, diagnostics, and medical devices.

Indian National mandates for 2025 have mentioned "Biotechnology" as "Knowledge and Innovation driven Bioeconomy", targeting the nation to stand as a global biotechnology hub, forecasting 100 bn \$ bio-based economy accounting for over 10 million jobs, that includes sectors like biofuels, enzymes, biosimilars, therapeutics including mass vaccine production (~60% of global production), distilleries, genetically modified products to name a few. Next 5 years targets from 2021 to 2025, India targets contributing to a "knowledge and innovation driven Bioeconomy" with global Biomanufacturing Hub by 2025, with exponentially rise to achieve a growth of \$150 Bn.

5.4. Attainment of SDGs towards strong bioeconomy

New India needs to move towards innovation driven bioeconomy, with a complete understanding of basic and higher education, vocational skills, fundamental research, doctorate and patents, prototype for commercial production, innovative products and applied research and industrial collaborations. Development of system by understanding internship, part-time job opportunities, real world case studies and having knowledge to real business problems, with introduction of entrepreneurship in early professional career is required for the system. Bio-incubators have been facilitated by government of India for development of Innovation driven bioeconomy. Government of India with its promising bodies like, Association of Biotechnology Led Enterprise, Technology Business Incubator, Technology Incubation and Development Entrepreneurship, Bio-incubation Nurturing Entrepreneurship Scaling Technologies is full set to provide an

entrepreneurial environment in India with all visionaries to explore these opportunities.

Few of the thrust areas to be explored for development of sustainable bioeconomy in our country are biopesticides (US \$ 1.8 bn), bio-fertilizers, bio-stimulants, tissue culture, biotechnology derived water industries, industrial enzymes (US \$ 7 bn), 1.5 to 7.8 bn tones, fermentation industries (\$ 128 bn), enrichment of food, healthcare, recombinant based technology, insulin, interferon, multiple sclerosis, biosimilars, trade and international development, stem cell therapy and age related issues though biotechnological approach, prebiotic and probiotics etc. Overcoming challenges in preclinical research by working hand in hand with industry (eg. covid vaccine: AstraGeneca with oxford), increased ability of industries to adapt changes and implement new technologies, proper academia-industry connect and solving current issues are judicious measures to be taken ahead.

Thorough need-based analysis and market survey is must before initiation of any start-up. Strengthening of institutions, processes, and policies. Empowering the executive committees of Skill India Mission at Centre and state level for information and knowledge sharing along with policy exchange and development shall give a boost towards creation of sustainable system.

The role played by bioeconomy in their development strategy is an important aspect to reflect in the efforts required for measurement. It could be help in monitoring the progress in reaching the SDGs or environmental targets. Synergy is required between countries' commitments towards the measurement of SDGs and leverage the bioeconomy. Application of decision-making towards sustainable and circular bioeconomy in an impactful manner shall be helpful in creating new bio-based value chains depicting the hand-in-hand journey of prosperity and environmental health.

The Bio-based Industries Consortium (BIC), a non-profit organisation as private sector in a public-private partnership (PPP)

with the EU on Bio-based Industries (BBI) mobilises investment worth €3.7 bn, in innovative facilities and processes that manufacture high-quality bio-based products and other sectors covering agriculture, agro-food, forestry, pulp and paper, chemicals, aquatic, waste, energy and other sectors (EC2018). BIC brings together an authoritative pool of over 200 industry members including large companies, SMEs and SME Clusters spread across Europe, cross sector, and multi-disciplinary expertise in the field of bio-based industries(52), thereby, setting a model at global level SDGs for bioeconomy.

6. Conclusion

From the study it becomes imperative to mention that there are limited biotechnology application areas that are robust and flexible enough to sustain the frequently changing external factors and unfavourable conditions. This leads to partial exploitation of the potential of Industrial Biotechnology to contribute to a bioeconomy surpassing the grand challenges towards achieving circular economy. Awareness programs need to be developed to strengthen implementation and improve access to initiatives such as Start-up India, Pradhan Mantri Mudra Yojana and state level flagship schemes introduced by government of India. Convergence or leveraging of central and state schemes, programmes, projects, or missions along with strengthening cooperation amongst various stakeholders, including through public-private partnerships need to be done for boosting the skill and entrepreneurial initiatives. Also, sustainable and circular bioeconomy need to be helpful in creating new bio-based value chains for both, prosperity and environmental health.

Mobilising adequate investments for financing skills and entrepreneurship in bio-based sectors shall be a great help in sustainable development of bioeconomy. Bioeconomy strategies need to consider intangible aspects, such as policies, institutional set-up, governance, incentives,

regulations, and financial instruments, creating favourable environment for the sustainable development of bioeconomy.

Conflicts of Interest

The authors declare no conflicts of interest in this work.

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