K4D | Knowledge, evidence and learning for development

Evidence of India's Biotechnology Innovation Experience

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Question

What evidence tells about key lessons learned of India's experience with innovation?

Contents

1. Overview

India has engaged on a national level effort to increase the country's capacity to innovate in biotechnology. They have marked biotechnology as a national priority for sectoral development. At the policy level there is a national development strategy to develop biotechnology. They also developed a dedicated organization to serve as an innovation ecosystem enabler- the Biotechnology Industry Research Association Council (Department of Biotechnology, 2019).

In 2012, India developed the Biotechnology Industry Research Association Council - a special purpose organization aimed at bridging a gap in the biotechnology innovation ecosystem. This was the first of its kind in the country developed to promote and mentor innovation research for affordable product development. The organization was created by the GOI to promote research industry academia partnerships in response to an existing gap in the innovation system where there was a need for connecting research to commercial product development (BIRAC, 2019).

Support by the Indian government for innovation in biotechnology is largely focused on start-ups and entrepreneurs to promote the translation of research ideas to commercial products. Several targeted initiatives are created to promote entrepreneurship in biotechnology. National investment schemes and venture capital provide necessary financing and opportunities to support collaboration across public sector researchers and 1st generation entrepreneurs. Early start ups and SMEs are encouraged to innovate and develop products in key social sectors to address national needs (Nogrady, 2018).

Support for innovation in biotechnology is occurring through technology transfer through strategic alliances with other countries focused on innovation as well. There is increasing evidence that these collaborations are no longer concentrated between developed countries and developing countries as there is an increase in partnerships taking place between developing countries (Konde, 2009).

This rapid literature review has found that evidence on India's experience and achievements in biotechnology is largely generated by government reports and state agency websites. A review of academic studies, government publications and Government of Indian websites, as well as reports issued by different development agencies was conducted to gather evidence on achievements in the Indian experience of innovation in biotechnology. Much of the evidence gathered is based on Government of India reports.

The report particularly focuses on the evidence from India's innovation experience on the health, agriculture, clean energy and waste to value sectors. The literature on these sectors mainly focuses on what has been achieved with sector specific evidence on how innovation was supported in specific programmes and projects. Some of the key examples gathered address varying levels of innovation development. These include national level sectoral strategies, policy development, incubation, international collaborations and support for commercialization of ideas. Examples include:

- The Access to Clean Energy Programme jointly implemented by the government and the UNDP piloted community level vericompost biodigesters in Karnataka provides a case of both clean energy access and waste to value. The programme aimed to provide access to clean energy in rural areas while enabling households to earn income by making saleable fertilizer from biogas (UNDP, 2010).

- The Village Energy Security Programme (VESP) in 2005 - a large country wide pilot programme in biomass was executed to test models for supplying biomass power generation in rural areas. However, was stopped because it was unsuccessful due to operational issues and lack of coordination among stakeholders (Palit et. al 2013).
- India has emerged as one of the leading countries in the world in promoting local R&D in agricultural biotechnology in general and genetically modified GM-crops in particular. However, policies especially between central and state level, to tackle the many complex problems that face product development, testing and commercialisation of transgenic crops in India are in need of improvement to facilitate further development (Ananth, 2015)
- The National Biopharma Mission is a national level sectoral strategy that supports innovation through an industry- academia collaborative mission of Department of Biotechnology in collaboration with the World Bank for accelerating discovery research to early development of Biopharmaceuticals and to be implemented by Biotechnology Industry Research Assistance Council (BIRAC). Innovation support includes: product development that aims to meet public health needs; infrastructure development and incubation of new ideas; accelerating research; developing human capital and technology transfer (National Biopharma Mission, 2019)
- The UK Research and Innovation (UKRI) consortium, and the Department for Biotechnology (DBT) India, supports innovation through multidisciplinary research collaborations between the academic and industrial communities based in the UK and India. Support for innovation focuses on multidisciplinary research collaborations between the academic and industrial communities based in the UK and India (UK Research and Innovation, 2018).

The report is structured as follows. Section 2 briefly discusses the Indian approach to innovation specifically on its efforts to enable the innovation ecosystem through the BIRAC. Section 3 provides evidence on India's innovation experience with biotechnology with a sectoral focus on health, agriculture, waste to value and clean energy; and section 4 provides examples of biotechnology innovation programmes and highlights findings on how innovation was supported in these.

2. Indian Approach to Innovation in Biotechnology

India's biotechnology development strategy aims to establish the country as a world-class bio-manufacturing hub. The development process of biotechnology is currently guided by its national policy titled, "National Biotechnology Development Strategy 2015-2020". It intends to launch a major mission, backed with significant investments, for the creation of new biotech products, create a strong infrastructure for R&D and commercialization, and empower India's human resources scientifically and technologically (Department of Biotechnology, 2019). Key priorities include:

- Making India ready to meet the challenge of achieving a US$100bn bioeconomy by 2025 (India BioEconomy Report, 2019 p.7)
- Creating a Technology Development and Translation Network across the country with global partnerships 5 new clusters, 40 Biotech incubators and 20 Bio-connect centres
- Launch four major missions in healthcare, food and nutrition, clean energy and education

India developed a special purpose organization in 2012 (i.e. Biotechnology Industry Research Assistance Council (BIRAC)), which is aimed at bridging a gap in the biotechnology innovation ecosystem. The organization was the first of its kind in the country and was developed to promote and mentor innovation research for affordable product development. BIRAC was created by the Government of India (GOI) in response to an existing gap in the innovation system in India where there was a need for promoting partnerships between industry and academia – so that research could be taken through the translational phase to product development. To translate scientific research into commercially viable products, BIRAC provides funding, mentoring, capacity building, and infrastructure in their programming. It acts as an enabler of the Indian biotechnology innovation ecosystem (BIRAC, 2019).

BIRAC identifies gaps and challenges facing biotechnology entrepreneurs and responds by creating targeted programming to address the needs of these start-ups/entrepreneurs. It supports projects at each stage of the 'innovation cycle' – starting from ideation, to testing for proof of concept (POC), to late stage product development, and finally its commercialisation in the marketplace (BIRAC,2019).

2.1 The BIRAC model

BIRAC's support to the development of Indian bioeconomy focuses on biotech start-ups and small and medium-sized enterprises (SMEs) as well as on raising their capabilities. BIRAC notes that a current issue in the Indian biotechnology industry is the lack of mentorship of biotechnology entrepreneurs on how to take ideas to proof of concept. As a result, targeted programs were created to allow for handholding, financing and mentorship to bridge the gap from ideation to proof of concept (BIRAC, 2019). This literature review has noted that there is an absence of independent assessments on the results produced by BIRAC. However, achievements documented to date by BIRAC included (BIRAC, 2019):

- Generating 180 Intellectual Property Rights (IPs);
- Supporting 45 bio-incubators across India – that have developed 133 products and technologies to the market;
- Supporting 682 start-ups, which have generated 125 million USD;
- Creating 767 jobs through incubators; and
- Supporting 973 beneficiaries through funding, mentorship, capacity building.

BIRAC has been a pioneer in funding and nurturing innovative ideas through its Biotech Ignition Grant Programme (BIG). The grant was launched in 2012 and was aimed at creating and seeding viable biotech start-ups. The programme has been instrumental in encouraging innovation among young entrepreneurs to test their ideas and bring them to the Proof of Concept stage. The program offered (BIRAC, 2019):

- 18-month business incubation with seed funding of approximately 70,000 USD[1];

1 BIRAC (2019) Biotech Ignition Grant Programme: https://birac.nic.in/big.php

- Collaboration with international research institutions, such as the Judge Business School – University of Cambridge for knowledge and learning;
- Creation of 25 biotechnology incubator hubs across the country that will focus on medical devices, bio-pharma, vaccines & diagnostics and Industrial biotechnology. The bio-incubators provide the incubation space and other required services for entrepreneurs and start-up companies for their initial growth;
- Handholding support to start-ups to: foster generation of ideas with commercialization potential, upscale and validate proof of concept, encourage researchers to take technology closer to market through a start-up and stimulate enterprise formation.

3. General Evidence on India's Innovation Experience with Biotechnology

Rose (2004) noted that most studies on biotechnology are descriptive (i.e. primarily qualitative in nature) and, therefore, fail to provide firm specific data and analysis. Further, while these studies depict biotechnology as an enabling factor, they do not give a full picture of its dynamics. Also, in the case of India, clear indicators that can capture the nature and complexity of innovation being imbibed by biotechnology firms are unavailable (Chaturvedi, 2005).

The following sections synthesizes information on the Indian experience of biotechnology in biomass energy (clean energy), agricultural biotechnology, health technology and waste-to-value.

3.1 Clean Energy

India is committed to enhancing innovation toward a clean energy transition. The country has signed a Memorandum of Understanding (MoU) with the International Energy Agency (IEA) on 'Enhancing Innovation for the Clean Energy Transition' on August 30, 2018. This MOU is a joint program under 'Mission Innovation' which is a global initiative of 24 countries and the European Commission (on behalf of the European Union).These 25 members have committed to seek to double public investment in clean energy R&D and are engaging with the private sector, fostering international collaboration and celebrating innovators (Mission Innovation, 2019 a).

As part of Mission Innovation, India was able to advance research on indigenous technology to convert biomass to ethanol along with speed and efficiency by converting agricultural waste into ethyl alcohol or bio-ethanol. Its first Second-Generation (2G) Ethanol plant to build commercial scale biomass ethanol plants based on the home-grown technology and was developed under a project of the Ministry of Science and Technology. To do this, the government supported and incentivised research into technologies, resource assessment and system modelling of the biomass energy sector (Department of Biotechnology, 2019).

Additionally, a large country wide pilot programme in biomass was executed to test models for supplying biomass power generation in rural areas. The Village Energy Security Programme (VESP) in 2005 was rolled out to go beyond electrification alone, and address the total energy needs (i.e. cooking, lighting, and productive use) of remote villages by using local biomass resources. At the end of the project, about 700 kW of electricity generation equipment was installed of which nearly 90% was biomass-based gasifier technology (World Bank, 2011).

India's experience in renewable energy ranges in technologies and devices, such as improved cook stoves, biogas plants for various applications, biomass gasifiers using different feedstock's, solar photovoltaic lighting, solar thermal water heating systems and water mill from different parts of the country, appropriate to rural areas and capable of providing access to clean energy in rural areas. According to a UNDP report on access to energy in India, the innovativeness is not only in the technology application for various end uses but also in developing and implementing a sustainable delivery and revenue model. An example is SKG Sangha (SKGS) – a non-profit organization based in Kolar district of Karnataka. The organisation is setting up hybrid vermicompost biodigesters in rural Karnataka and in other states of India. This has the twin objectives of i) providing clean cooking gas generated through biogas to these rural areas and ii) to enable the rural households to earn additional income by making saleable fertilizer from biogas residue and other unmanaged agricultural and domestic organic wastes (UNDP, 2010).

Biomass is a good example of Indian advancement in industrial biotechnology and it has been prioritized for sectoral support from the government – both at the national and state level. As per the Ministry of New and Renewable Energy (MNRE) of GOI, a total of 288 biomass power and cogeneration projects aggregating to 2665 MW capacity have been installed in the country for feeding power to the grid (UNDP, 2010)

Balachandra (2011) has listed several points in favour of adopting modern biomass energy, especially for rural India. The author noted that: (i) biomass resources potential in India is high to produce adequate amount of modern energy, (ii) advanced biomass energy technologies for decentralized utilization in rural areas have reached near commercialization, (iii) India has local expertise in developing and deploying biomass gasifier technologies for power generation and bio-methanation technologies for biogas production, (iv) scopes for medium, small and micro scale rural enterprises are large – which would help to promote rural income generation and employment.

However, even with decades of experience in managing biomass power in India, gaps still exist in the supply chain. The main scope for interventions conducted in India are in collection and mobilization of the raw material to the plant, technical upliftment of the processing units (including both bio as well as thermo plants), improving design and engineering aspects, promoting performance monitoring and management systems, conducting feasibility studies and carrying out focused research and development (Denmark in India, 2019).

Central to the development of the sector is the Biotechnology Industry Research Association Council, where businesses are supported from research and testing of ideas to commercial products. An example of a recent achievement in the commercialization of biomass has been India's 1st Second-Generation (2G) Ethanol plant which was inaugurated in 2018 (Make in India, 2019).

Biomass has now become an important energy source for the country. Currently, about 32% of total primary energy used in India is derived from Biomass. More than 70% of the country's population depends upon biomass for its energy needs (Denmark in India, 2019). Biomass projects throughout India address issues of lack of access to conventional electricity in rural areas, affordability, dependence on diesel fuel, and generation of employment. Government policy incentives along with R&D support are central to the development of the sector although there have been several pilot projects for testing biomass and other rural renewable energy projects led by NGO's and international development programs (UNDP, 2010).

3.2 Agriculture Biotechnology

India has emerged as one of the leading countries in the world in promoting local R&D in agricultural biotechnology in general and GM-crops in particular. Further, it has experience in the functioning of comprehensive biotechnology and biosafety regimes that regulate the introduction and commercialisation of GM-crops and GM-products (Ananth, 2015). this is important since India is an agriculture-based country, where more than 50% of population is dependent on agriculture (Madhusudan, 2015).

The country's agricultural biotechnology sector made strides in the 1990s in Ribosomal DNA, transgenics and molecular marker assisted plant breeding processes. The Government of India responded with a matching policy support and regulatory framework that was designed to render the path of progress in R&D to be sustainable and bio-safe. To a large extent, developments in the policy front have been induced by a vibrant non-governmental sector that intensely intervened on the sensitivities of modern biotechnology (Damodaran, 2004)

The concept of 'agricultural biotechnology' covers two main categories of activities, one of which is characterised by genetic modification using recombinant DNA techniques (GM-technology), while the other involves no GM-technology (Ananth, 2015).

The need to improve the translation of research to product development was stressed by Ananth (2005) – in his study on the successes and failures of public R&D efforts in transgenic crop development. The author stated that indigenous transgenes are beginning to become available as a result of past decisions of public funded research institutions and funding agencies to invest in molecular biology. Additionally, policies to tackle the many complex problems that face product development, testing and commercialisation of transgenic crops in India are in the process of evolution, presenting an opportunity for improving the policy environment (Ananth, 2005).

3.3 Health Biotechnology

India launched the National Biopharma Mission in 2017. It is the first ever Industry-Academia mission to accelerate biopharmaceutical development in India. In this context, the Innovate in India (i3) programme is part of India's efforts to support an enabling ecosystem to promote entrepreneurship and indigenous manufacturing in the biopharmaceutical sector. This is a government initiative to focus on consolidated efforts to promote product discovery, translational research and early stage manufacturing in the country to ensure inclusive innovation. I3 is considered and inclusive innovation programme because it aims to fill the gaps in making affordable biopharmaceutical products available (National Biopharma Mission, 2019)

The following is a list of initiatives of the BIRAC - National Biopharma Mission[2]:

Part of the National Biopharma Mission is the Vaccine Programme. This has helped to realize the lowest cost Rotavirus vaccine which became part of the India's universal immunization programme. Indian medical biotechnology also took major strides towards vaccine for diseases like malaria and dengue. One out of every 6 children over the world receive vaccines manufactured in India (Department of Biotechnology, 2019). This first indigenous low cost Rotavirus Vaccine

[2] Celebrating Biotechnology: Building India as an Innovation Nation (2019)

(which is efficacious in preventing severe rotavirus diarrhoea in low-resource settings) has been introduced in 9 Indian states, namely; Odisha, Andhra Pradesh, Haryana, Himachal Pradesh, Assam, Tripura, Tamil Nadu, Madhya Pradesh and Rajasthan. The ROTAVAC® has been granted WHO prequalification in 2018 (National Biopharma Mission, 2019)

A technology for rapid diagnosis of celiac disease (CD) in humans was developed in India. Celiac Micolisa & Celiac Card kits have been developed **through a collaborative, multi-institutional, inter-disciplinary approach** funded by DBT. The kits have been made commercially available by a distributor in New Delhi. These indigenous kits are cheaper than imported kits (Celebrating Biotechnology: Building India as an Innovation Nation, 2019)

A programme to address Pre-Term Birth (that is multi-institutional and interdisciplinary in scale) was also launched in 2014. It is a research effort to predict and diagnose pre-term birth by enhancing the knowledge of the underlying pathophysiological mechanisms. This programme is aimed at addressing a social need as India accounts for 25% of neonatal death globally. Early findings from research done on 1000 mothers indicates indoor pollution is associated with early birth (Celebrating Biotechnology: Building India as an Innovation Nation, 2019).

3.4 Waste to Value

The Department of Biotechnology is contributing towards new technology development through several initiatives under 'Swachh Bharat' (also known as the Clean India Mission). It is a national campaign to improve the sanitation conditions in India. Realizing clean energy and waste to value are its priority mission areas (Make in India, 2019)

Innovation has been supported through international collaborations. Such partnerships have been leveraged to develop technologies to provide clean water for various end uses like drinking and agriculture. DBT has recently achieved significant milestones in bio-energy research and scale up from fundamental research to applications to ensure nimbleness and constant access to the best technologies. It has developed cost effective and efficient ways to convert waste to energy and has set up plants for scaling up the production of energy in different forms (Celebrating Biotechnology: Building India as an Innovation Nation Report, 2019).

Current achievements listed in the report include:

- First Biomass Ethanol Plant (and Commercialization) which transforms biomass to ethanol (along with speed and efficiency) by converting agricultural waste into ethyl alcohol or bio-ethanol.
- Five reactors running 24/7 for wastewater treatment and 4 pilots that are operational for anaerobic pre-treatment and energy recovery.
- Novel Bio-Toilet Technologies that provide innovative solutions for less water usage, pathogen free and odour free discharge, and bio digestion of the waste.
- Green Remediation Technology for Wastewater Treatment which is being used in the textile industry.

A complete list of achievements documented by the Department of Biotechnology from the Celebrating Biotechnology: Building India as an Innovation Nation Report can be accessed at: http://dbtindia.gov.in/sites/default/files/DBT_Report_R2V6_250219%20%281%29.pdf

4. Specific Programmes on Biotechnology Innovation

Some of the key biotechnology innovation programmes in India and their experiences have been highlighted to show how innovation was supported.

4.1 Clean Energy

Several clean energy initiatives (that incorporate biotechnology into renewable energy development) have been started in India. The following is a brief list of developments in this area:

India-Sweden Innovations Accelerator

The India-Sweden Innovations Accelerator (ISIA) is an initiative with the purpose to bridge innovations and entrepreneurship between India and Sweden**. ISIA has developed several new clean energy technologies, including solar powered water pumps to bring water and energy to rural India, and the repurposing of the material used to make airbags to create fabric-based biogas reactors** (Mission Innovation, 2019 b)

These developments were supported under 'Mission Innovation' (see Section 3.1). The support for innovation development was done by (Mission Innovation, 2019 b):

- Promoting India-centric innovation for clean energy proliferation;
- National, bilateral, and multilateral joint virtual centres on clean energy themes;
- Setting up of technology platforms led by industry for clean energy technologies;
- Scaled-up funding to academic and R&D institutions as well as R&D units in industry for research on identified topics relevant to clean energy;
- National, bilateral, and multilateral capacity building programs in clean energy;
- Demand-oriented mission programs on clean energy technologies; and
- Setting up demonstration models/pilot plants for developed technologies.

String Integrated Methane Platform

The String Integrated Methane Platform project exploits advances in synthetic biology, fermentation technology, chemistry and process engineering to convert methane to protein. The project received support from BIRAC and is also currently being supported under Mission Innovation. The project has been carrying out product development and testing to create a protein product for animal feed. Innovation was supported through research grants both from BIRAC (for waste to value funding) and an award from Future Food Asia (as an agri-technology product) (Mission Innovation, 2019 c).

The project is currently being validated at pilot scale and is seeking finance, manufacturing capacity and land to scale the technology to commercial production. The project scope can be further widened when adapted for other geographies as well as alternate sources of methane. Converting methane into protein creates a sustainable protein source that is cost effective and can address the growing worldwide protein demand by using a vented or flared resource as the input carbon.

4.2 Agricultural Technology

Marker-Assisted Selection of Pearl Millet

The use of marker-assisted selection (MAS) to improve a locally adapted pearl millet variety and the dissemination of a new disease and drought resistant variety is one of India's efforts in agricultural biotechnology. The collaboration of several institutions, scientists and funding partners, from tools development to the release of the new variety, spanned over twenty years (1989 to 2010). The objective of the collaboration was to develop genetic maps based on molecular markers and use them for better understanding of breeding of traits, such as disease resistance and drought tolerance, for the benefit of smallholder pearl millet farmers in India (FAO, 2013).

A key lesson learned from this programme was that the research into improvements in breeding and molecular biology are not enough to achieve success in making impact on development needs. Critical to success is the adoption of products of the technology by consumers at the farm level. As such, bridging the research to product gap was a critical success factor (FAO, 2013).

ABF Biotech-KISAN Hub

ABF Biotech-KISAN Hub is a programme funded by Department of Biotechnology (DBT), Government of India (GOI). **The programme empowers farmers through science and provides solutions to challenges of small and marginal farmers** (Celebrating Biotechnology: Building India as an Innovation Nation, 2019).

To support innovation, the programme has done the following:

- Thematic (Mahila Kisan Biotech) Fellowships have been instituted
- Strong Scientists-Farmers Interaction Platform created;
- Demonstrations and scale-up of programmes conducted to address water, soil, seed and marketing issues of local farmers with validated technologies;
- Biotech hubs have been established in 9 Agro-Climatic zones; and
- An estimated 5300 farmers have benefitted and trained by the programme.

Further, the Biotechnology and Biological Sciences Research Council (BBSRC), the Engineering and Physical Sciences Research Council (EPSRC), and Innovate UK, all part of UK Research and Innovation (UKRI), and the Department for Biotechnology (DBT) India **are co-investing (in the Newton-Babha Fund) to support collaborative research projects between UK and Indian scientists to increase sustainable production of pulses or oilseeds in India**. Production of both crops currently falls short of demand in India. However, the outcomes of these joint projects will help to enhance food security, reduce the need for imports and meet the demands of a growing population in India. The research will improve pulse and oilseed crop varieties by understanding and exploiting traits to enhance yield potential, increase tolerance to climatic stresses or poor-quality soils, or counter pests or diseases. The programme is supported by a joint BBSRC and DBT India investment of £5.3 million (BBSRC, 2019)

4.3 Health Technology:

National Biopharma Mission

The Ministry of Science and Technology launched the National Biopharma Mission (NBM) in June 2017 **to accelerate biopharmaceutical development** (National Biopharma Mission Report, 2017). It is an industry- academia collaborative mission of DBT – in collaboration with the World Bank for accelerating discovery research to early development of Biopharmaceuticals. The programme is being implemented by Biotechnology Industry Research Assistance Council (BIRAC, 2019).

The aim is to enable and nurture an ecosystem for preparing India's technological and product development capabilities in biopharmaceutical to a level that will be globally competitive over the next decade. It also aims to transform the health standards of India's population through affordable product development. The Mission is implemented by BIRAC (National Biopharma Mission Report, 2017).

Support for Innovation is done by:

- **Product development:** Development of product leads that are at an advanced stages of the product development lifecycle and relevant to the public health needs in vaccine, biosimilar, medical devices and diagnostics.
- **Infrastructure development:** Establishing and strengthening shared infrastructure facilities for product development and validation. These would be for all product being developed.
- **Accelerating research:** Developing human capital by providing specific trainings to address the critical skills gap across the product development value chain.
- **Technology transfer:** Creating and enhancing technology transfer and intellectual property management capacities and capabilities.

Innovate in India for Inclusiveness Programme (I3)[3]

The Innovate in India for Inclusiveness Programme (I3) was launched in 2017 in collaboration with the World Bank. **The aim of the programme is to boost the growth of domestic biopharma industry by accelerating the translation of research concepts into viable products and supporting clinical validation** (Haththotuwa, 2016).

It aims to increase indigenous private sector innovation in quality-assured, low-cost biopharmaceuticals, medical devices, and diagnostics which address public health priorities. Additionally, through BIRAC, it is intended to enable sustainable networks for collaboration between industry and academia, and support entrepreneurial ecosystem (Haththotuwa, 2016).

The programme facilitates innovation in biopharmaceutical products and medical devices by:

[3] Innovate in India for Inclusiveness is an active programme currently being implemented by the BIRAC in association with the World Bank. The mid-term evaluation is due for May 2020 as such immediate outcomes were not available.

- Expanding the firms' capabilities to innovate;
- Upgrading and expanding technology centres in India;
- Promoting collaboration through Product Development Partnerships (PDPs) targeting biopharmaceuticals, diagnostics, and devices addressing public health priorities;
- Strengthening infrastructure and technology for shared production and validation facilities;
- Developing skills and strengthening training facilities and tools in key areas of need;
- Developing Technology Transfer Offices (TTOs) in facilities across the country; and
- Raising awareness within Government of India on global regulatory processes in the sector.

4.4 Waste to Value

Regarding waste to value, the UK Research and Innovation (UKRI), and the Department for Biotechnology (DBT) India, also support multidisciplinary research collaborations between the academic and industrial communities based in the UK and India. **Research and development projects in the area focus on using cutting-edge bioscience, chemistry and engineering solutions to reduce industrial waste and pollution in India** (BBSRC, 2019).

The conversion of industrial waste into multiple useful products (a biorefinery approach) have been carried out in India to allow for improved value recovery from waste, reducing the amounts needing disposal or being released into water courses (BBSRC, 2019). Projects funded through this programme provide an opportunity for collaborative learning around biorefining technologies. The projects also focus on the reduction and valorisation of Indian waste streams – linked to the sugar cane sector, the paper and pulp sectors, and municipal solid waste (BBSRC, 2019).

This programme has supported innovation by enabling academic researchers to work with their industrial counterparts – both in India and the UK. This is intended to help translate research into waste management solutions for India, with the potential for application in other developing countries worldwide (BBSRC, 2019).

The following projects have been initiated through the UK-India collaboration:

- Biorefining Value from Industrial Waste;
- Economic non-food sugar from variable mixed solid waste for high value chemical products;
- Integrated biorefinery for converting paper mill waste into chemical wealth (waste-2-wealth);
- Reducing industrial waste from sugarcane processing; and
- Valorising Waste from Sugar Cane and Associated Industries – via Innovations in Pre-treatment, Biotransformation and Process Intensification.

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- Biotechnology and Biological Sciences Research Council (BBSRC): https://bbsrc.ukri.org/news/industrial-biotechnology/2018/180730-pr-joint-investment-uk-india-takes-aim-at-global-challenges/
- Department of Biotechnology, Ministry of Science and Technology, Government of India: http://dbtindia.gov.in/
- Biotechnology Industry Research Assistance Council (BIRAC): https://birac.nic.in/desc_new.php?id=89
- Ministry of New Renewable Energy, Government of India: https://biomasspower.gov.in/About-us-3-Biomass%20Energy%20scenario-4.php

- Denmark in India, Ministry of Foreign Affairs in Denmark: https://indien.um.dk/en/innovation/sector-updates/renewable-energy/biomass-energy-in-india/
- Biomass Portal, Department of Biotechnology: https://biomasspower.gov.in/About-us-3-Biomass%20Energy%20scenario-4.php
- Mission Innovation: http://mission-innovation.net/our-work/mission-innovation-breakthroughs/string-integrated-methane-platform/

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About this report

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