



## Review

## The biotechnology and bioeconomy landscape in Malaysia

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## ABSTRACT

Since 1990s Malaysia aspired to make biotechnology and bioeconomy as her engines of economic growth to utilise the abundance of natural resources and biodiversity. The public sector plays an integral role in developing the sector and various incentives are in place for the private sector to be actively involved and to forge collaboration with the public sector. The country launched its National Biotechnology Policy in 2005 and later launched its National Bioeconomy Programme in 2010 to become the first country in South East Asia and second in Asia after China to have such an initiative. Malaysia is also very proactive in its biosafety law and regulations and has most of the related legal instrument in place. A lot of success has been recorded since the inception of the National Biotechnology Policy in terms of job creation, contribution to GDP through biobusinesses and investment from foreign companies, but the sector is not spared from challenges too. Due to the nature of the discipline that is multidisciplinary and that requires huge amount of investment, expertise and political will, there are a lot of barriers before the country emerges as a bioeconomy player. This paper discusses the public policies, initiatives and funding mechanisms in place in Malaysia that drive its research, development and commercialisation in the area of biotechnology and bioeconomy. The authors also discuss the challenges faced in Malaysia in implementing the policies.

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## The government's biotechnology agenda: a historical background

The biotechnology initiatives in Malaysia commenced in mid 1990s where the government committed significant amount of investment, time and energy to make the country an international biotechnology hub. The biotechnology agenda was developed to capitalise Malaysia's rich natural resources and biodiversity and turn them into biobusiness and wealth.

Historically, Malaysia has been actively pursuing agricultural research through a number of world recognised research institutes to promote higher yield and better quality of rubber, oil palm and agricultural commodities [1]. The country also boasts a strong manufacturing sector with the presence of multinational companies. These were seen as a pre-requisite to build the biotechnology sector.

The *modus operandi* to make the country a biotechnology hub might have changed due to change in leadership in early 2000, but the commitments remained strong which is seeing various initiatives being rolled out by the government to strengthened biotechnology and bioeconomy to make these the pillars of economic engine. In Malaysia, government institutes and agencies continue to play a central role in accelerating the biotechnology and bioeconomy agenda.

## Biotechnology related policies, regulations and initiatives in Malaysia

The government realised from the beginning that there is a need to provide a strong policy direction to invigorate this economic sector. Since 2005 the government has shown its commitments through the development of a number of policies, regulations, programmes and initiatives that are aimed to support the biotechnology and bioeconomy development.

### The National Biotechnology Policy (NBP)

The strongest boost for the biotechnology sector in the country was the launch of the National Biotechnology Policy (NBP) in 2005. The main aim of NBP is to develop biotechnology sector into one of the key economic drivers for the nation, contributing 5% of the nation's GDP by 2020. NBP was designed to provide a

comprehensive roadmap that would foster a conducive ecosystem for accelerated growth in the biotechnology industry.

The policy identified three main biotechnology areas (agricultural biotechnology, healthcare biotechnology and industrial biotechnology) and the peripheral areas that are critical for the development of biobusiness such as R&D and technology acquisition; human capital development; financial infrastructure development; legislative and regulatory framework development; strategic positioning; and government commitments as shown in Table 1 [2].

The implementation of the policy is divided into three phases: Phase 1 for Capacity Building (2005–2010), Phase II on Science to Business (2011–2015), and Phase III to develop Global Business (2016–2020). The key national development goals for implementation of the NBP over the three phases are shown in Table 2 [3].

Upon launching the NBP, the Malaysian Biotechnology Corporation (now renamed Malaysian Bioeconomy Corporation) was established to serve as a one-stop agency to facilitate the involvement of companies in biotechnology industry, implement government policies and initiatives, encourage research, development and commercialisation and create a robust investor ecosystem.

### BioNexus companies

In order to encourage bioentrepreneurship among locals and to attract foreign companies, BioNexus status was introduced. BioNexus is a special status awarded to qualified foreign and Malaysian biotechnology companies. The status bestows fiscal incentives, grants, capacity building programmes and other guarantees to assist growth. This status is awarded to qualified companies undertaking value-added biotechnology and/or life sciences activities. Apart from the overall benefits and support, BioNexus companies are assured a list of privileges as stipulated in the BioNexus Bill of Guarantees [4].

To date, there are 268 BioNexus companies, out of which 141 are involved in agriculture, 82 in healthcare, and 45 in industrial biotechnology [4].

There is a set of criteria a company should fulfill to be eligible for the BioNexus status. The main criteria are the company's business should be based on life sciences or substantially utilise biotechnology processes; the company should be involved in continuous research works and has access to the required infrastructure and

**Table 1**  
Malaysian National Biotechnology Policy and its nine thrusts (2005).

No.	Policy thrust	Aim
1	Agriculture Biotechnology Development	Transform and enhance the value creation of the agricultural sector through biotechnology.
2	Healthcare Biotechnology Development	Capitalize on the strengths of biodiversity to commercialize discoveries in natural products as well as position Malaysia in the bio-generics market
3	Industrial Biotechnology Development	Ensure growth opportunities in the application of advanced bio-processing and bio-manufacturing technologies
4	R&D and Technology Acquisition	Establish Centres of Excellence, in existing or new institutions, to bring together multidisciplinary research teams in coordinated research and commercialization initiatives. Accelerate technology development via strategic acquisitions
5	Human Capital Development	Build the nation's biotech human resource capability in line with market needs through special schemes, programs and training
6	Financial Infrastructure Development	Apply competitive 'lab-to-market' funding and incentives to promote committed participation by academia, the private sector as well as government-linked companies. Implement sufficient exit mechanisms for investments in biotech
7	Legislative and Regulatory Framework Development	Create an enabling environment through continuous reviews of the country's regulatory framework and procedures in line with global standards and best practices. Develop a strong intellectual property protection regime to support R&D and commercialization efforts
8	Strategic Positioning	Establish a global marketing strategy to build brand recognition for Malaysian biotech and benchmark progress. Establish Malaysia as a center for contract research organizations and contract manufacturing organizations
9	Government Commitment	Establish a dedicated and professional implementation agency overseeing the development of Malaysia's biotech industry, under the aegis of the Prime Minister and relevant government ministries

**Table 2**  
Malaysian Biotechnology Policy and its Phases.

Phase 1: Capacity Building (2005–2010) Setting up the building blocks	Phase 2: Science to Business (2011–2015) Potential for the industry	Phase 3: Global Business (2016–2020) Attaining world class status
<ol style="list-style-type: none"> <li>1. Adoption of policies, plans and strategies</li> <li>2. Establishment of advisory and implementation councils</li> <li>3. Establishment of Malaysia Biotechnology Corporation Sdn Bhd (BiotechCorp)</li> <li>4. Capacity building in research and development</li> <li>5. Industrial technology development</li> <li>6. Develop agricultural, healthcare and industrial biotechnologies</li> <li>7. Develop legal and intellectual property framework</li> <li>8. Incentives</li> <li>9. Business and corporate development through accelerator programmes</li> <li>10. Bioinformatics</li> <li>11. Skills development</li> <li>12. Job creation</li> <li>13. Regional biotechnology hubs</li> <li>14. Develop BioNexus Malaysia as a brand</li> </ol>	<ol style="list-style-type: none"> <li>1. Develop expertise in drug discovery and development based on biodiversity and natural resources</li> <li>2. New product development</li> <li>3. Technology acquisition</li> <li>4. Promote Foreign Direct Investment (FDI) participation</li> <li>5. Intensify spin-off companies</li> <li>6. Strengthen local and global brands</li> <li>7. Develop capability in technology licensing</li> <li>8. Job creation</li> </ol>	<ol style="list-style-type: none"> <li>1. Consolidate strengths and capabilities in technology development</li> <li>2. Further develop expertise and strength in drug discovery and development</li> <li>3. Leading edge technology business</li> <li>4. Maintain leadership in innovation and technology licensing</li> <li>5. Create greater value through global Malaysian companies</li> <li>6. Rebranding Malaysia as a global biotechnology hub</li> </ol>

capability to carry out such work; the company should have a significant percentage of knowledge workers; and the company should compile to laws and regulations related to the business among others. The complete criteria are available in “Guidelines on BioNexus Qualifying Criteria” [5].

#### *The Biosafety Act*

Malaysia may not be a country that grows biotech or GM crops but it is a country that is fully dependent on imported grains for the use as feed in the poultry and livestock industry. The country also has a number of research projects at public institutes that aim to develop biotech crops such as disease resistant banana, rice, rubber, oil palm, papaya, teak, pineapple, chilly, and orchid. For all these purposes a legal instrument that regulates living modified organisms (LMOs) became important. Malaysia is also a signatory to the Cartagena Protocol on Biosafety that requires Parties to have a national legislation framework in place. So, the Biosafety Law was passed in 2007 after years of negotiation and consultation among various stakeholders and came into force in 2009. Its aim to establish the National Biosafety Board (NBB) to regulate the release, importation, exportation and contained use of living modified organisms, and the release of products of such organisms, with the objectives of protecting human, plant and animal health, the environment and biological diversity [6].

The Ministry of Natural Resources and Environment is the National Focal Point for the Cartagena Protocol on Biosafety. A committee by the name of the Genetic Modification Advisory Committee (GMAC) was established in May 2010 to make decisions on LMOs use in Malaysia and to provide scientific, technical and other relevant advice to the NBB.

The Department of Biosafety was also established to carry out the following tasks [7]:

- To implement and enforce the Biosafety Act;
- To be the secretariat and the operational arm of the National Biosafety Board (NBB);
- To be the secretariat of the Genetic Modification Advisory Committee (GMAC) and committees/sub-committees established under the NBB and GMAC;
- To monitor all activities relating to living modified organism (LMO) and products of such organism;

- To provide a platform for consultation with various parties in order to formulate and update policies, laws and guidelines related to biosafety;
- Coordinate and integrate the efforts taken by Federal Government agencies and State and Non-Government Organizations and the Modern Biotechnology Industries related to biosafety issues;
- Build strategic partnerships with relevant agencies within and outside the country in the field of biosafety;
- Establish mechanisms to facilitate the collection, storage and dissemination of data related to biosafety;
- Help the Government to formulate the country’s stand on the issues of biosafety at international forums; and
- Increasing public awareness on biosafety.

Malaysia is one of the few Asian countries that has most of its regulations and guidelines in place namely, Guidelines for Institutional Biosafety Committees; Guidelines for Contained Use Activity of Living Modified Organisms; Guidelines for Environmental Risk Assessment of Genetically Modified Plants in Malaysia; Guidelines for Confined Field Trial of Living Modified Organisms in Malaysia; Guidelines for Risk Assessment of Genetically Modified Microorganisms; and Guidelines for Public Announcements.

#### *The Bioeconomy Transformation Programme (BTP)*

To complement the National Biotechnology Policy, the Bioeconomy Transformation Programme (BTP) was launched in 2012 to further accelerate the country’s bioeconomy development. Malaysia’s Bioeconomy agenda is spearheaded by the Ministry of Science, Technology and Innovation (MOSTI). The priority shift towards bioeconomy was necessary as the country moves into the third phase of the National Biotechnology Policy that aimed at Malaysian biobusinesses going global. The Programme’s core strategies focus on the complete value chain approach to increase multiplier effects for a sustainable economy and create a positive impact on the income and welfare of the people. The abundance of renewable biological resources in the country provides the opportunity for the growth of the bioeconomy through research and innovation [8].

The BTP is expected to be one of the strategies to transform Malaysia into a high income nation with activities focusing on agriculture productivity, discoveries in healthcare and the adoption of sustainable industrial processes. BTP targets to secure RM48 billion (USD10.9) of Gross National Income (GNI), create 170,000 new job opportunities and capture an investment of RM50 billion (USD11.4) by the year 2020 [9].

As of Dec 2015, there were 48 trigger projects under BTP that have taken off and contributed RM5.97 billion (USD1.4) to the GNI, created 23,355 job opportunities, and RM18.21 billion (USD4.1) in terms of investment [10].

With the emphasis given to bioeconomy, the Malaysian Biotechnology Corporation was renamed to Malaysian Bioeconomy Corporation in 2016.

### Biotechnology-related agencies under the Ministry of Science, Technology and Innovation

There are over 20 agencies and research institutes under the Ministry of Science, Technology and Innovation (MOSTI) that deals with biotechnology. The National Institute of Biotechnology (NIBM) was inaugurated to lead, coordinate and implement the national biotechnology agenda through research, development, innovation and commercialisation activities. There are three institutes under NIBM: Malaysia Agro-Biotechnology Institute (ABI)

Malaysia Institute of Pharmaceuticals and Nutraceuticals (IPHARM), and Malaysia Genome Institute (MGI) [11]. Some of the other agencies are Malaysian Bioeconomy Corporation, Nuclear Agency, Nano Malaysia, SIRIM, Standards Malaysia, Malaysian Technology Development Corporation, Malaysian Debt Ventures and Technology Park Malaysia.

These institutes and agencies undertake a wide range of activities such as research and development, commercialisation, facilitation of biobusiness, project financing, development of industry standards, and provide incubation services related to biotechnology among others.

### Other players in the biotechnology space

Besides MOSTI, there are a number of research institutes and universities that actively carry out biotechnology activities, especially research. The Malaysian Agricultural Research and Development Institute (MARDI) which is under the Ministry of Agriculture and Agro-based Industries (MOA) is involved in livestock, crop biotechnology, horticulture, food technology, genomics, and bioinformatics. Research on rubber, palm oil, cocoa, pepper is conducted by Malaysian Rubber Board, Malaysian Palm Oil Board, Malaysian Cocoa Board and Malaysian Pepper Board respectively. The Forest Research Malaysia (FRIM) is dedicated to research on forestry biotechnology, forest and environment, forest products, forest biodiversity, and natural products.

There are about 44 universities (20 public and 22 private) that offer bio-based degree programmes ranging from basic sciences in related to biology to biotechnology, biomedical science, food technology, bioprocess engineering, biochemical engineering,

molecular biology, agriculture technology and marine biology among others. These universities also carry out research in these areas. Five public universities are branded as research universities, namely University of Malaya, Universiti Sains Malaysia, Universiti Putra Malaysia, Universiti Teknologi Malaysia and Universiti Kebangsaan Malaysia. All these universities are involved in commercialisation of their research activities as well.

### The achievements

The country has seen significant progress since the inception of biotechnology policies and initiatives. To date there are 268 BioNexus companies, 70% locally owned and 30% by foreign entities. Table 3 shows the achievements in Phase 1 of National Biotechnology Policy [12].

The total investment by BioNexus status companies as of 2011 was USD678.2 million [13]. The USA, Singapore, India, UK, Australia, China, Germany, British Virgin Island, Taiwan, Japan, Italy, South Korea, Brunei, Canada, France, Hong Kong and Belgium are among the countries that own some of the BioNexus status companies in Malaysia.

### The missing links

While Malaysia has created its initial footprints in bioeconomy, it remains a tall order to be a significant global player and to achieve its targets in 2020. Malaysia has all the right policies and initiatives in place but the missing link is in its implementation. Biotechnology is a complex field where multiple factors intertwine and there is a need for deep understanding of these factors and balancing it correctly. In the excitement of developing biotechnology, the country is now suffering from a loose definition of biotechnology. There is a rush to grab the low-hanging fruits and many companies are not strictly involved in the real biobusinesses.

Universities and research institutes too have not been an effective feeder to the industry in providing tangible research that could be commercialised. In the pursuit of getting products too soon into the market, the appetite for basic research is lost. Research priorities follow the trend of funding mechanism and priorities shift to where funding is available. It is known fact that biotechnology has a long gestation period and continuous funding is required till the research attains maturity and is ready to be commercialised. There is a need for public-private sector collaboration to enable biotech firms to efficiently obtain international investment and alliances to ensure sustainability, as well as to develop bold and creative approaches for developing and recruiting talent both at home and abroad [14]. These areas need to be strengthened to see the real biotechnology areas flourishing in Malaysia.

As mentioned in the earlier section, Malaysia is one of the few countries in Asia with all the biosafety regulations in place and it has a science-based approach towards GMOs. However, research in this area is too slow where commercialisation of biotech crops is not expected to be seen anytime soon. This is not because Malaysia will not benefit from biotech crops. Farmers are struggling with Shigatoka and Panama diseases in banana; rice farmers face

**Table 3**  
National Biotechnology Policy Phase 1 Achievements.

Indicators	Phase 1 (2006–2010) Target	Phase 1 (2006–2010) Achievement
New Investment	USD 1.98 billion	USD 1.79 billion
Employment	40,000	54,776
Annual revenue	USD6.61 billion	USD 4.46 billion
Contribution to GDP	2.5%	2.2%

serious problems with weedy rice and pests like golden apple snail and rice diseases like sheath blight; our local fruits are highly perishable; and harvesting pepper is extremely labour intensive due to non-synchronised ripening. These are some of the challenges in agriculture that could be addressed through genetic modification if research is prioritised to meet the needs of the farmers and key stakeholders.

A strong research culture with the country's priority as the end point needs to be envisaged. Biotechnology innovation is a different ballgame and what works in other fields might not give the same results and this has to be understood by the policymakers and politicians. There is an urgent need for public-private collaboration, funding mechanism and research priorities need to be strengthened.

### Why is biotechnology innovation so critical and yet challenging in Malaysia?

Innovation is critical because of the need, potential and impact of affordable biotechnologies on a society like Malaysia. Besides the core technology aspects, we need to examine the nature and pathways of biotechnology R&D and innovations in Malaysia, propose evidence based policy measures to overcome the bottlenecks and barriers, and to enable positive and healthy growth of the biotechnology industry, eventually leading to strengthening the R&D of the country.

The system suffers from the following weaknesses:

1. A mismatch between talent development and market needs
2. Insufficient funding for biotechnology R&D is a serious problem

3. Minimising duplication and maximising collaboration between all research institutes and universities. There is a strong need to streamline the activities of all the agencies under MOSTI and other biotechnology-related ministries, agencies and research institutes
4. Appointment should be based on merit, experience and skills in the area of biotechnology instead of political appointment for the top positions at government agencies and research institutes.
5. The chase for university ranking through publications that dilutes industry engagement

Biotechnology might further suffer due to the current economic situation in Malaysia and reduction in budget.

### Key ingredients to transform a biotechnology idea to a product

Converting an idea into a commercial model is not an easy task. The person who gives birth to the idea must take ownership as there will be no one else capable of understanding the concepts and depth of the idea as the person who conceptualised the idea. For an idea to be commercially successful it has to continue growing and evolving so that it can adapt to current circumstances. Failure to evolve will result in obsolescence of the idea.

To transform the idea into a commercially viable model it needs a list of key ingredients as show in Fig. 1.

Idea alone is not enough to make biotechnology research success as we need a set of other ingredients as well. First a prototype must be built based on a technology with a team working on this. Before getting into the prototype it is important



Fig. 1. Key Ingredients to transform an idea to a product (published with permission from Vibazone Private Limited) [15].

for the team to have a target customer and understand the market before investing further into the research. The team should look at how it can automate some of the work so it is scalable when the product is ready. The team should also understand the risks involved and how they would fund it to completion. It is important to ensure that the team is motivated in its work and there is a unique selling point with clear defined commercial goals.

Malaysian researchers need more exposure, understanding and training in these areas.

### Jobs and careers

Malaysia is not short of talents produced in this field. There are dozens of public and private universities that offer a wide range programmes in life sciences. While the government is advocating for more students to pursue Science, Technology, Engineering and Mathematics (STEM) areas and is forecasting that the country will require more talents in this area, the industry is not growing in tandem with the projection.

Graduates who aspire to stay in research careers are struggling to find a job as companies do not carry out extensive research work. They are also very few companies that are involved in high-end biotechnology business and research activities.

However, the government has been positive and is undertaking initiatives to link graduates to industry. Bioeconomy Academy under the Malaysian Bioeconomy Corporation plays a vital role in this area. Bientrepreneurship is also encouraged among graduates to create their own job and to become a job creator. Trainings are conducted by the Malaysian Technology Development Corporation (MTDC) and other agencies and universities and positive outcome has been seen through these efforts.

### Funding options for commercialisation of biotechnology in Malaysia

There are several ways to fund biotechnology research in Malaysia some of the main ways are as follows: –

1. Fund from revenue: A company could be funded from the organisation's operations income which is generated from its operations. Some organisation allocates a percentage to be used for this activity. An example of this would be a university using its income generated via fees and other means to fund research or a company would fix a percentage of its income for research.
2. Interested partners: This a be a third party who do not have the capability of doing research and hence might want to be a partner of an organisation which is carrying out work in an area of business attractive to them. A typical way is how many organisations would work with a university to produce new research.
3. Fund it yourself: This is how generally one gets started but as biotechnology research requires deep pockets this might often not be the best route to follow. Initial funding by the founders or bootstrapping for the first few months is a common practice as a biotech start-up shows the credibility and proves the commitment of the founder, but in the long term a biotechnology company would require other sources of funding.
4. Debt financing: This can be secured or unsecured loans which need to be repaid. The organisation can use existing patents and other collateral as security for debt financing.
5. Friends, family and angels: This is generally a safe form of fund which can be taken in any form as gifts, debt or equity.
6. Incubators: Incubators are a good source of fund that is given as a debt, grant or equity.
7. Financial Assistance from Government Grants: This is the best form and in Malaysia there are lots of different grants available and hence an organisation can access these. These grants are usually reimbursable or matching grants. Government bodies and agencies encourage R&D by providing financial assistance to the researchers.
8. Venture Capital and Private Equity: This is provided by fund managers for an exchange of equity, the benefit of this type of fund is that the funder generally plays an active role and this can be of enormous benefit to the organisation. However, venture capital is usually suitable for business that has the potential to grow rapidly.
9. Public Investment (Equity Funding): These are usually large funding groups which generally acquire a company to add great value to them. This type of fund is of great value to the company as these funding agencies have a wealth of experience in making companies succeed.
10. Business Loans from Banks: These are just loans from the banks which need to be repaid and generally for biotechnology these would be difficult to acquire.
11. Mergers and Acquisitions: This primarily happens when a bigger company or competitor merge or acquire smaller companies to consolidate the market. However, this decision is based on the vision and nature of the business.
12. Corporate Partnering: This is when a research partner is a corporate figure who would fund the research and possibly in return acquire the license for the research.

**Table 4** shows various agencies and types of funding available in Malaysia, that are supported by the government. Besides all major banks offer loans at attractive rates for SMEs. There are also several venture capitalists but however this industry is still at nascent stage.

From **Table 4** it is clearly visible that the government is very proactive in providing financial support to both companies and universities for commercial activities. While the funding is available, the quantum and its criteria need be further improved to suit the nature of biotechnology research and commercialisation process.

### Challenges for bioeconomy in Malaysia

The biotechnology sector is naturally multi-layered, multidisciplinary and complex, which makes it difficult to unlock its true potential and provide quality services in a short span of time. It extends to information gathering, interactions across disciplines, and understanding of wider disciplines that might go beyond the realm of sciences.

The complexity that arises from the unique nature of biotechnology research and commercialisation may lead to unclear policies, goals and strategies. Many researchers are not aware of funding mechanism and business models. It is common for research projects to run into financial problems and the research is abandoned mid-way as the planning was not done well at its conception stage.

There is also a mismatch between industry's needs and research priorities at the universities. The value chain of commercialisation has not been truly understood by the research community. Many are not aware of technology transfer procedures, market validation, IP issues and fund raising mechanisms. This is increasingly being addressed by Technology Transfer Offices and most universities now have them. Universiti Putra Malaysia has one of the best commercial arm, Putra Science Park that provides excellent training to their researchers. Universiti Sains Malaysia is also another leading university with a strong technology transfer and commercialisation initiatives.

**Table 4**  
Funding Agencies in Malaysia.

Agency	Type of Funding
1. Amanah Ikhtiar Malaysia (AIM)	Micro-Credit
2. Bank Kerjasama Rakyat Malaysia Berhad (BKRM)	Loans
3. Bank Pembangunan Malaysia Berhad (BPMB)	Loans
4. Agrobank Malaysia	Loans
5. Bank Perusahaan Kecil & Sederhana Berhad (SME Bank)	Loans
6. Commerce Asset Ventures Sdn. Bhd.	Private Equity
7. Credit Guarantee Corporation Malaysia Berhad (CGC)	Loans
8. Export-Import Bank Malaysia Berhad (EXIM Bank)	Loans
9. Majlis Amanah Rakyat (MARA)	Grants and Loans
10. Malaysian Bioeconomy Development Corporation (Bioeconomy Corporation, formerly known as BiotechCorp)	Grants
11. Malaysia Debt Ventures Berhad (MDV)	Debt
12. Malaysia External Trade Development Corporation (MATRADE)	Support export activities
13. Malaysian Industrial Development Authority (MIDA)	Support foreign companies to setup in Malaysia
14. Malaysian Technology Development Corporation Sdn Bhd (MTDC)	Grants
15. Malaysian Venture Capital Management Berhad (MAVCAP)	Venture Capital
16. Malaysian Industrial Development Finance Berhad (MIDF)	Loans
17. Maybank Ventures Sdn. Bhd.	Venture Capital
18. MIMOS Berhad (MIMOS)	Grants
19. Malaysia Digital Economy Corporation Sdn Bhd formerly known as Multimedia Development Corporation (MDeC)	Grants
20. Perbadanan Nasional Berhad (PNS)	Equity
21. Perbadanan Usahawan Nasional Berhad (PUNB)	Bumiputera Loans
22. Small and Medium Industries Development Corporation (SMIDEC)	Grants
23. Yayasan Tekun Nasional (YTN)	Loans
24. Ministry of Science, Technology and Innovation	Grants
25. Cradle Fund Sdn Bhd (Cradle)	Grants
26. Cradle Seed Ventures	Venture capital

Incubation challenge can also be a hindrance as biotechnology requires highly skillful incubation staff which is also a shortage. Researchers often overvalue their research and technology. What must be noted is that development and commercialisation takes many folds cost of research.

One of the critical challenges in funding is efficiently deploying the capital. There is lack of discipline and experience in managing the fund. Excessive amounts are spent on non-critical infrastructure, hiring a team too fast, renting out too much space and over compensations. These are weaknesses among local entrepreneurs. Thoughtful and disciplined spending of funds will help a start-up in biotechnology last longer and scale faster. Fortunately, most funding agencies are now vigilant in this area and they monitor closely on how the funds are managed.

### Opportunities for bioeconomy in Malaysia

In spite of the stated missing links and challenges, the government is driving the sector in full force. This is a huge impetus for those involved in this area. There are tremendous potential in areas of industrial biotechnology with the use of biomass; herbal, cosmetics and wellness products; aquaculture; transforming agriculture through molecular and conventional breeding; ingredients for *halal* food and pharmaceuticals; stem cell research and therapies; bioinformatics and in providing next generation sequencing services.

Another area that should be prioritised is plant-made pharmaceuticals and compounds of high industrial value. As Malaysia has all the biosafety regulations in place, excellent projects with high commercial value could be identified and brought to Malaysia for contained commercial production. There are excellent facilities in most universities to carry out such commercial activities that comply with the national biosafety law and regulations. These universities also have the expertise that is required to commercialise such research.

The existing BioNexus companies may be involved in low-end biotechnology activities but they have the potential to climb up the

value chain given the country's commitments and fiscal incentives offered to these companies.

Malaysia is still a great destination for foreign companies to expand their business and manufacturing activities as the cost of operation is competitive and the government offers a wide range of incentives. There are currently a number of companies that have their businesses in Malaysia such as Biocon from India, Verdezyne and Glycos from the USA, Arkema and Metabolic Explorer from France, CJ Bio from Korea, Mitsui from Japan and AJ Pharma from Saudi Arabia.

Malaysia has five economic corridors (Northern Corridor Economic Region, East Cost Economic Region, Sabah Development Corridor, Sarawak Corridor of Renewable Energy, and Iskandar Region), all of which offer excellent infrastructure and logistics support for industry players. A number of foreign companies are already operating at these corridors.

### Conclusion

Malaysia has a strong potential to develop the biotechnology sector, but there is a need to evaluate the current system and practices to set the right priorities and enhance the country's capabilities and competitiveness in this area. Biotechnology innovation should be focused for future needs and not today's needs. Market needs are changing at a rapid rate with Malaysia's rapid growth and modernisation and this has to be understood by the research community.

Malaysia has done well in developing the policies and now the effort should go into implementing it with a strong political will. There is a need to change the funding mechanism, research culture and the mindset about commercialisation. Policymakers should understand that the gestation period for biotechnology innovation is longer than other industry. They need the stamina to see the fruition of research, otherwise researchers will be pushed into producing low-hanging fruits and this will only delay or stifle the country's goal to go global.

In order for biotechnology and bioeconomy to be sustainable in Malaysia, it should be not just be government or researcher-centric. A weak sustainability model is primarily based on one attribute like the public sector but we need a strong model which is based on multiple attributes so we need to focus on accessibility for funding, talent development, government policies, market needs, industry collaboration and other relevant attributes. These areas have been the focus but more should be done to strengthened them through better implementation.

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