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Bio-Innovations for Philippine Competitiveness

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BIO-INNOVATIONS FOR PHILIPPINE COMPETITIVENESS

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The Philippines has the 39th largest economy in the world in terms of nominal Gross Domestic Product (GDP), standing only a few places behind neighbouring countries Malaysia (34th), Singapore (35th) and Hongkong (36th).[1] The country's transformation from a sluggish economy to a dynamic, newly industrializing economy has been so striking that it managed to land a spot in the International Monetary Fund's list of emerging markets.[2] In East Asia alone, its GDP growth has been one of the fastest and most consistent (Fig. 1 and 2). Though growth dropped in the first quarter of 2014 due to the effects on agriculture of Typhoon Yolanda (also known as Haiyan), an optimistic scenario of high growth continuing over the next two years in the Philippines remains convincing (World Bank, 2014).

[1] Based on data compiled by the United Nations Statistics Division, 2012

[2] The IMF classifies the Philippines as an emerging economy under "Developing Asia."

The term "emerging markets" refers to nations going through rapid economic growth and industrialization. It is also used interchangeably with "emerging and developing economies." (Source: Economy Watch)

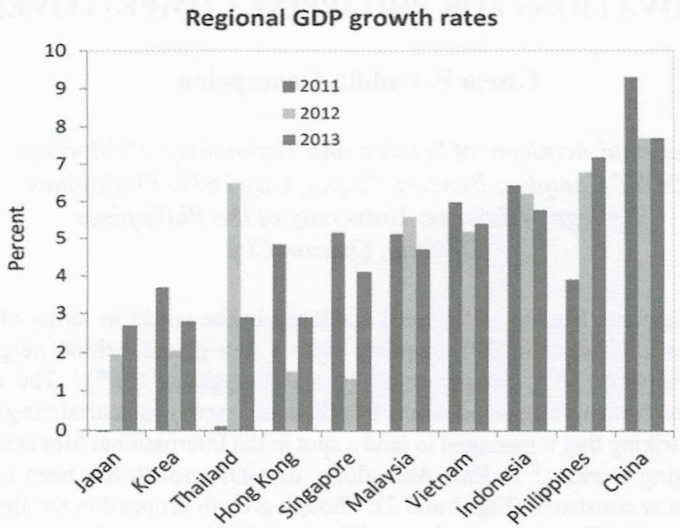


Figure 1. GDP growth rates of selected Asian countries, 2011 to 2013
Source: CEIC via World Bank, 2014

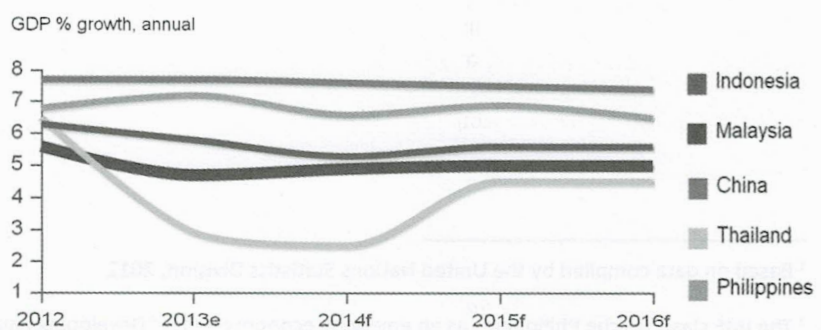


Figure 2. Actual, expected and projected GDP percentage growth of selected Asian countries, 2012 to 2016
Source: World Bank, 2014

Production, alongside factors such as high private consumption, accounted for the growth of our economy. Figure 3 shows how the services sector mainly drove local production, with the strongly expanding manufacturing sector providing considerable boost (Aldaba and Pasadilla 2010).

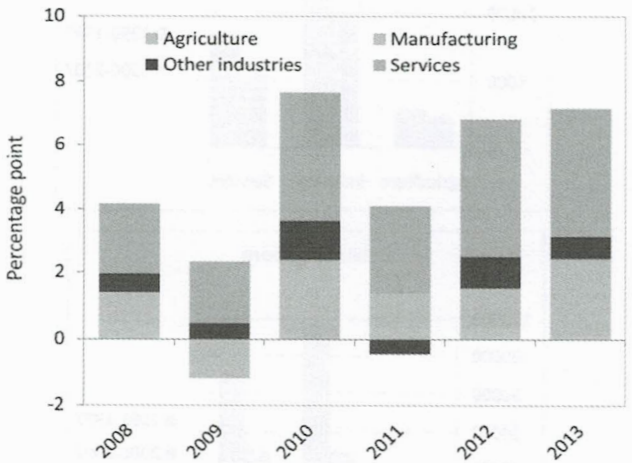
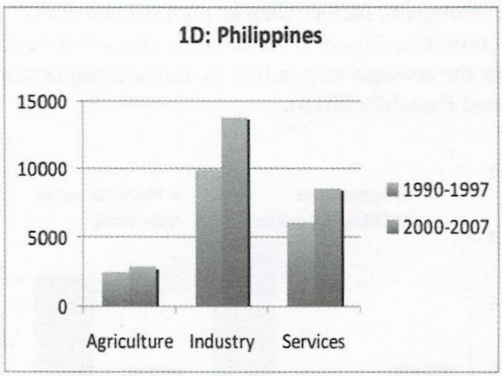
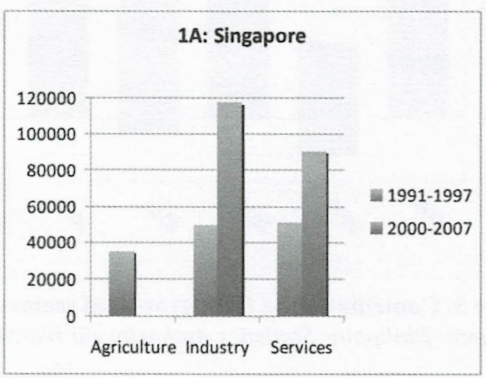


Figure 3. Contribution to GDP growth of sectors, 2008 to 2013
Source: Philippine Statistics Authority via World Bank, 2014

In the Philippines, manufacturing and services increased more than the agriculture sector (Fig. 4a). The services sector has quickly caught up with the manufacturing sector in developed countries as well. In Singapore, the economic structure has shifted drastically from agriculture, manufacturing and services to solely manufacturing and services, with the services sector almost doubling in labor productivity (Fig. 4b). Aldaba and Pasadilla (2010) concluded that a productive services sector is vital to enhance economic growth.





Figures 4a (left) and 4b (right): Average labor productivity level by sector 9purchasing power parity in US$ per worker), Philippines and Singapore, 1991 to 2007

Source: Aldaba and Pasadilla, 2010

Unharnessed Potential for Growth

While the Philippine's reliance on its services and manufacturing sectors has generated exceptional results, the country's great potential in tourism and the bioeconomy[3] still cannot be discounted. Unfortunately, local efforts have yet to successfully match the growing demand in these sectors.

[3] The bioeconomy, as defined by the European Commission in February 2012, is the "sustainable production of renewable biological resources and their conversion into food, feed, bio-based products and bio-energy via innovative and efficient technologies provided by Industrial Biotechnology."

For instance, in 2000, the Philippines was in a tight race with Vietnam in the number of visitor arrivals in the ASEAN (Fig. 5). Eleven years after, Vietnam managed to completely leave us behind. Just as disheartening is the fact that, despite the country's world-class heritage sites, our tourism industry never came close to what Malaysia, Singapore and Thailand achieved in the last decade.

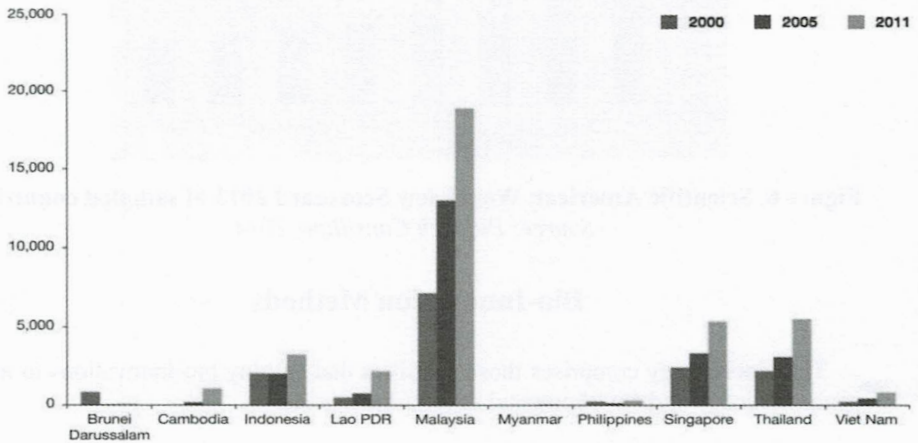


Figure 5. Number of visitor arrivals in the ASEAN, 2000 to 2011
Source: Asian Economic Chartbook, 2012

Furthermore, whereas developed and other emerging economies have already drawn on the bioeconomy to penetrate global markets (Fig. 6), the Philippines, with its rich biological resources, is yet to energize its bioeconomy on a large scale. It does not help that the growth of our young and underdeveloped bioeconomy is hampered by intertwined social, environmental and economic problems: urban sprawl, food and water supply shortage, threatened biodiversity, loss of productive lands, fisheries, forests and coral reefs, and overall decline in agricultural productivity.

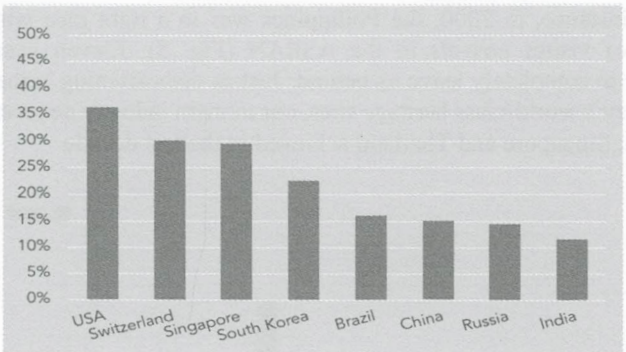


Figure 6. Scientific American Worldview Scorecard 2013 of sampled countries
Source: Pugatch Consilium, 2014

Bio-Innovation Methods

The bioeconomy comprises those activities that employ bio-innovations to meet economic, social and environmental development goals.[4]

Bio-innovation is the development and production of novel, high-value products, services, processes and systems from biological materials (microorganisms, plants, animals and humans) and from information obtained from these materials. The methods used in bio-innovation are the following:

1. Biotechnology which deals with the application of science and technology to living organisms to alter living or non-living organisms such as yeasts, bacteria, algae, plant and fungi to produce knowledge, goods and services (Organization for Economic Cooperation and Development, 2005). Some examples of products created through biotechnology are biofuels, therapeutic molecules, bionanomaterials, high-value chemicals, industrial enzymes, and food and cosmetic ingredients.
2. Bioengineering which develops biology-based technologies for integrative applications such as the diagnosis, treatment and prevention of disease,

[4] The scorecard is an assessment of countries' relative innovative capabilities and successes as they relate to biotechnology. The graph shows only the sample of eight countries. The country sample is "geographically and economically diverse with a mix of high-income mature OECD economies and middle income and emerging markets" (Pugatch Consilium 2014).

[5] Based on the definition of the Department of Science and Technology of the Republic of South Africa

design of novel materials, devices and processes; and enhancing of environmental health (Cuello, 2006).

3. Bioinformatics which applies computational tools and approaches to expand the use of biological, medical, behavioral or health data. It involves storage, organization, curation and visualization of such data (US National Institutes of Health, 2000)
4. Biprocessing which utilizes living cells, either completely or partially, to obtain biological, chemical or other products for commercial use. For example, Cell Therapy Bioprocessing, which brings together cell therapy and bioprocessing, is engaged with the production of cell-based therapeutics.

Bio-innovations could address basic human needs such as food, nutrition, health, hygiene, clothing, shelter, education, safety, security and environment protection. Bio-innovations can also be used to enhance the quality of life of individuals and communities, and contribute to the socio-economic growth and global competitiveness of a country. Specific examples of bio-innovation are discussed in the succeeding sections.

Bio-Innovation in Strong ASEAN Economies

Because research and development (R&D) steers innovation, it is not surprising to see that countries actively involved in bio-innovations are those that are research-intensive (Fig. 7). This is especially true in the ASEAN where countries like Singapore and Malaysia are in the lead (Fig. 8).

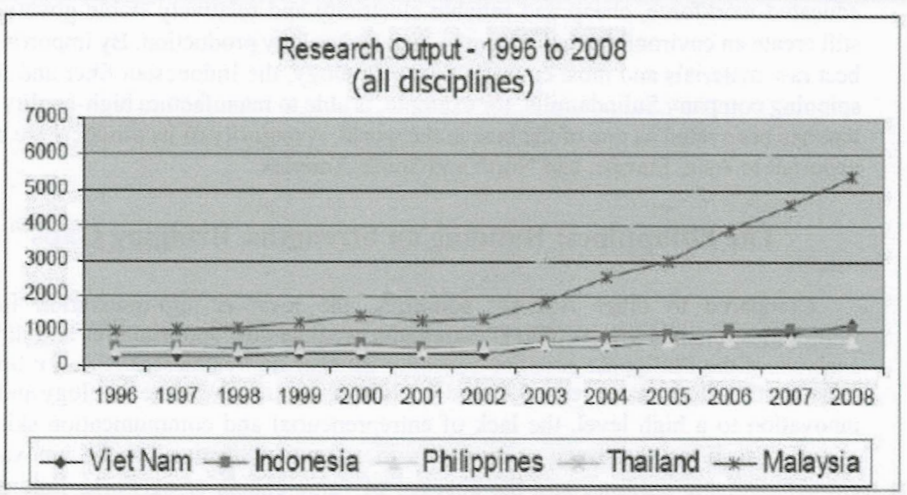


Figure 7. Research output of selected Southeast Asian countries, 1996 to 2008
Source: Lagro, 2011

Figure 8. Innovation ranking of ASEAN member countries
Source: World Economic Forum via Business Mirror, 2013

Singapore attracts several leading biopharmaceutical companies with its first-rate physical and regulatory infrastructure, global connectivity and skilled manpower (Singapore Economic Development Board, 2014). Aside from operating global manufacturing bases that produce a wide range of active pharmaceutical ingredients, biologics and nutritionals, these companies also engage in public-private partnerships with some of Singapore's scientific, medical and academic institutions.

Bio-innovation is likewise in full force in Malaysia as evidenced by the breeding, micropropagation and cultivation of important crops, the application of oil palm fiber as sound-deadening components in cars, and the use of epoxidised natural rubber in eco-friendly green tires, to name a few.

Although Indonesia did not fare as well as its neighbours in R&D (Figure 8), its educated workforce, cheap and reliable electricity and relatively stable government still create an environment conducive to high technology production. By importing the best raw materials and most cutting-edge technology, the Indonesian fiber and fabric spinning company Sulindamills, for example, is able to manufacture high-quality yarn that has been rated as one of the best in the world. A majority of its products are being exported to Asia, Europe, and North and South America.

The Philippines: Building on Strengths, Bridging Gaps

Compared to other ASEAN countries, the level of bio-innovation in the Philippines remains low. A SWOT (strengths, weaknesses, opportunities and threats) analysis of the Philippine situation reveals a number of weaknesses (Fig. 9): limited expert and skilled human resources and facilities that can drive biotechnology and bio-innovation to a high level, the lack of entrepreneurial and communication skills of scientists to bring discovery or invention to commercialization (or the innovation-entrepreneurship culture), and the absence of value chains or networks linking the market with investors and inventors. Low investments in research and development, manifested in the lower research output and innovation ranking of the country, also

undermine the sustainability of biotechnology efforts while the risk-aversion for biotechnology of investors reflects the low science literacy of the general public.

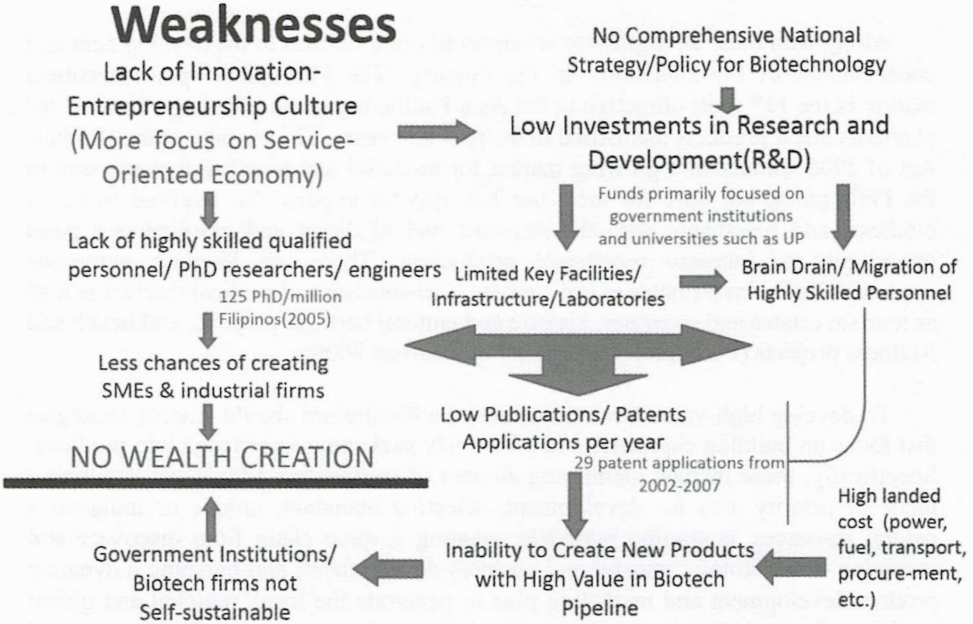


Figure 9. Diagram showing the issues that weaken Philippine bio-innovation

Climate change, with its economic and social costs, poses a serious threat to the Philippines, too.[5] In addition, our biodiversity is on the brink of collapse, e.g., with serious reduction in forest cover and extremely high rate of species extinction (Posa and others 2008).

However, even with these weaknesses and threats, the Philippines could still capitalize on its strengths such as relatively abundant (although also rapidly diminishing) mineral reserves[6] and increased government awareness to address human development. To strengthen global competitiveness of Filipino graduates, the educational system has been restructured and greater emphasis has been placed on

[6] In the World Bank list of top 12 countries most at risk of flooding, the Philippines ranked first.

[7] The Philippines is 5th in the world in minerals, 3rd in gold reserves, 4th in copper, and 5th in nickel. It is also the largest chromite source in the world.

vocational/technical training (such as that offered by TESDA). Government is also committed to spend on S&T R&D infrastructure and create innovative policies that will strengthen public-private partnerships and advance bio-innovation.

Along with these strengths are windows of opportunities in the development and enhancement of bio-innovation in the country. The Philippines' pharmaceutical market is the 11th most attractive in the Asia Pacific region and the huge demand for pharmaceutical products intensified in the past few years. The passage of the Biofuels Act of 2006 stimulated a growing market for biodiesel and bioethanol production in the Philippines, not only for local use but also for export. The required blend of biodiesel and bioethanol with the standard fuel of diesel and gasoline is a good opportunity to increase bioethanol production. There are likewise numerous opportunities for investments in eco-tourism, agri-tourism and medical tourism as well as tourism estates and ecozones, historic and cultural heritage projects, and health and wellness projects (Philippine Department of Tourism 2009).

To develop high-value bio-innovations, the Philippines should employ strategies that focus on building capacities and effectively packaging knowledge into products. Specifically, these include identifying an area of competitive advantage; targeting a niche or priority area for development; selecting abundant, unique or indigenous natural resources as starting materials; creating a value chain from discovery and invention to technology transfer and business development; and pursuing a dynamic product development and marketing plan to penetrate the local, regional and global markets. Promoting science literacy and generating modern information-based decision-making tools should also help vitalize bio-innovation in the country.

Political, economic, social and technological (PEST) analysis helps integrate and manage the different elements of strengths and opportunities alongside threads to achieve higher bio-innovation success (Fig. 10). The extent by which government contributes to the economy specifically in areas of tax policy, labor law and environmental law has great impact. Governments also exert influence on a nation's state of health, education and infrastructure. The parameters of economic factors including economic growth and interest rates have an impact on how businesses operate and make decisions. Similarly, social factors like cultural features, population growth rate, age distribution and career attitudes affect the demand for a company's products. Lastly, technological factors such as technology incentives and the rate of technological change determine the minimum efficient scale of production.

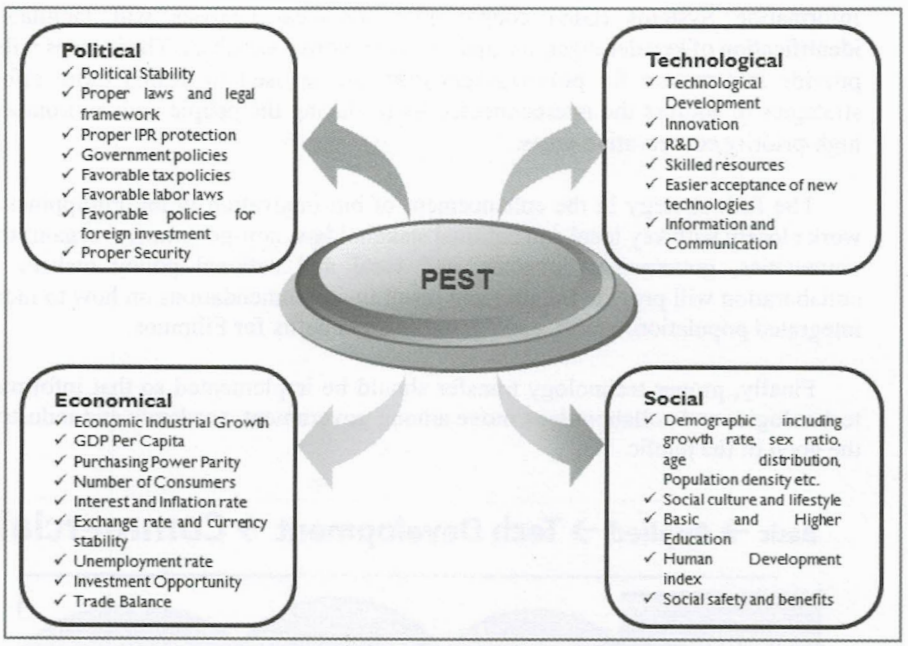


Figure 10. Political, economic, technological and social factors used in PEST analysis

Source: crackmba.com

Six strategies can be adopted to advance bio-innovations in the Philippines considering its political, economic, social and technological conditions (Fig. 11).

First, the diverse flora and fauna, presence of mineral reserves, the archipelagic nation and rich indigenous culture are niche areas in which we have a competitive advantage, and therefore must be prioritized and developed.

Second, public education through media involvement will enhance science literacy. This awareness will attract investors in bio-innovation projects and also encourage the youth to join the scientific community and subsequently provide marketing support.

Third, the transfer of funded research from the laboratory to the market will allow the scientific community to properly address public needs and meet global standards while enabling the scientists to have promising and dynamic product development.

The fourth strategy for increased bio-innovation achievements is the creation of information-based decision-making tools. Digitized maps using Geographic

Information Systems (GIS) couple with statistical analysis will facilitate the identification of key demographic and socio-economic variables. These maps will also provide information for policymakers that can be used to design more effective strategies to address the interconnected issues facing the people and environment in high-priority conservation areas.

The fifth strategy in the enhancement of bio-innovation in the Philippines is to work closely with key local and national stakeholders, non-government organizations, universities, government agencies, and local and national policy makers. This collaboration will provide training and result in recommendations on how to increase integrated population, health, and environment benefits for Filipinos.

Finally, proper technology transfer should be implemented so that information, technologies and collaborations move among government, academia and industry for the good of the public.

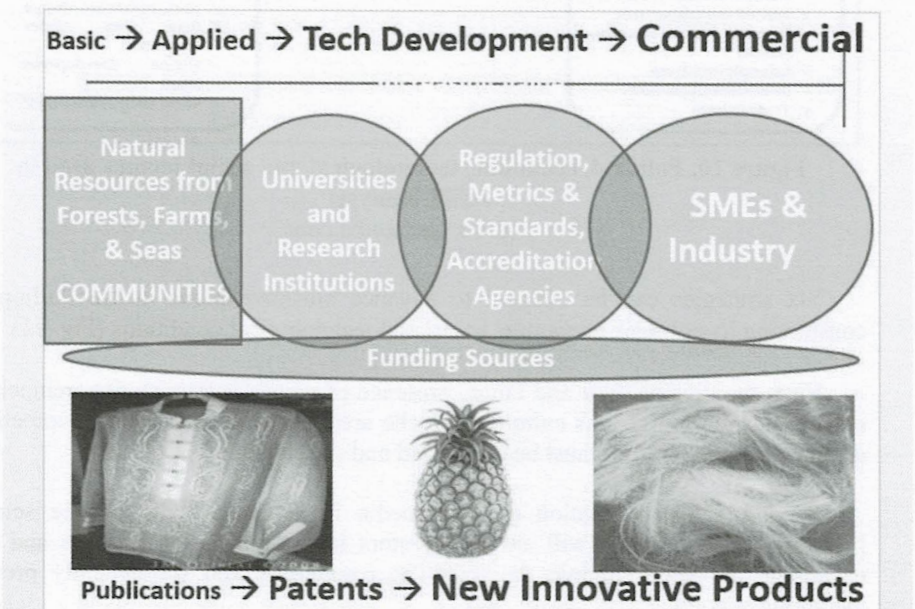


Figure 11. Bio-innovation landscape

Bio-Innovation Research and Applications in the Philippines

Bio-innovation is already being pursued with enthusiasm by the academic community, in hopes of addressing major problems of society. Some examples were presented at the NAST RTD (Round Table Discussion) on Bio-innovations held before the NAST ASM (Annual Scientific Meeting).

For instance, the "Ridge to Reef to Community" complex system network analysis of a biodiversity hotspot in Abra de Ilog, Occidental Mindoro is a good illustration of how bio-innovation can solve eco-tourism and environment protection issues. Dr. Maria Helena Yap, principal investigator from the University of the

Philippines Marine Science Institute (UP-MSI), is exploring a tie-up with ABS-CBN Foundation to develop a sustainable ecotourism plan for the area (Fig. 12).

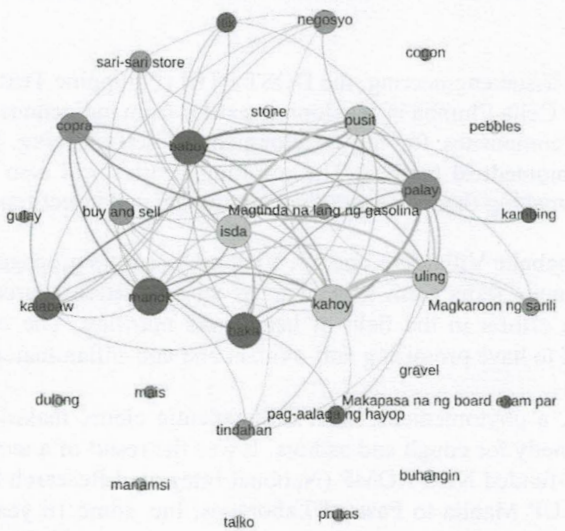


Figure 12. Part of the livelihood network analysis generated from the project
Source: M.H.T. Yap

On the other hand, using agricultural biotechnology, Dr. Beningo Peczon of the Biotechnology Coalition of the Philippines studied the need to modernize Philippine agriculture and the positive impact of Genetically Modified Organisms (GMOs) on food and agriculture. He has been advocating the release of the coconut levy fund to advance R&D and infrastructure development in the coconut industry. His group's

efforts have demonstrated the use of bio-innovation for food, nutraceuticals, energy, biomaterials, shelter and clothing.

Also along the lines of bio-innovation in agriculture are products such as vitamins for forest and commercial trees, soil- and microbial-based fertilizers, and growth hormone from coconut water for vegetables and ornamentals, produced at UP Los Baños BIOTECH headed by Dr. Reynaldo Ebora.

At the PNRI (Philippine National Research Institute) of the DOST (Department of Science and Technology), there have been efforts to apply nuclear techniques, materials and processes to increase agricultural and industrial productivity, such as induced mutation breeding to improve grain quality in rice.

Through biomedical engineering, Dr. Gonzalo Serafica of Xylos Corporation was able to utilize the modest *nata de coco* microbial cellulose as a drug delivery system for antimicrobials and analgesics. As an outstanding example of bio-innovations for health, his creations reached clinical trials in the US and are now available in the market.

Using tissue engineering, the DOST PTRI (Philippine Textile Research Institute) led by Dir. Celia Elumba is developing textiles from indigenous resources as bio-nano fiber and composites for the development of self-cleaning, UV-protected, flame-retardant biomedical textiles. The resulting textiles will also incorporate bioactive materials, making them antimicrobial, antifungal and insect repellent.

Dr. Anabelle Villalobos and Dr. Victor Amoroso's propagation and promotion of ten indigenous ferns from Mindanao as an alternative source of food shows bio-innovation efforts in the field of health and nutrition. The edible ferns were also discovered to have promising anti-oxidant and anti-inflammatory properties.

Ascof, a phytomedicine with a therapeutic claim, makes use of *Lagundi* as a natural remedy for cough and asthma. It was the result of a technology transfer from the DOST-funded NIRPROMP (National Integrated Research Program of Medicinal Plants) of UP Manila to Pascual Laboraties, Inc. some 16 years ago. Today, Ascof holds 10 percent of the total over-the-counter market, translating to roughly one billion pesos in earnings annually.

Still in the area of bio-innovations for health and disease are drug leads from our diverse flora and fauna. A project of the Philippine Mollusk Symbiont International Cooperative Biodiversity Group, led by this author, and based at UP MSI (Marine Science Institute), for example, focuses on bacteria associated with marine mollusks to enhance conservation, research capability and economic development while pursuing high-value pharmaceutical and bioenergy-related discoveries. Similarly, the

PharmaSeas Marine Drug Discovery Program led by UP MSI, funded by the DOST PCAMRD/PCHRD, is uncovering potential anti-infective and anti-pain agents from marine sources.

UP MSI's Dr. Rhodora V. Azanza's research examined toxins and other substrates from HAB (Harmful Algal Blooms) causative organisms and bacteria for standards and tools, an important example of applying bio-innovation to food safety and environment protection.

But bio-innovation efforts in the country are not limited to universities; the private sector has its own share of successful stories as well.

The Palawan Aquaculture Corporation is a globally competitive player in the full cycle breeding and culture of high-value marine species like the king crab and sea cucumber. D.M. Consunji, Inc. (DMCI) has made impressive achievements in cacao plantation, fruit processing and fruit marketing. In Davao del Sur, Dacon Corporation operates a mixed plantation devoted to coffee, cacao, Thai durian and pomelo, while Seirawan Fruits Corporation makes refrigerated coconut milk for export. Finally, EcoSystem Technologies, Inc. has pioneered Sequencing Batch Reactor (SBR) technology using more sophisticated biotechnology and molecular tools for microbial applications in wastewater treatment.

Summary and Conclusion

The Philippines has enjoyed continued economic growth in recent years, due to its performing services and manufacturing sectors. Aside from these sectors though, the Philippines could also benefit greatly from the bioeconomy because of its rich natural resources. Bio-innovations not only help solve a range of problems, as shown by the diverse applications made by academic and private groups, but also provide excellent opportunities for wealth creation. To develop bio-innovations that can compete globally, the country must first be able to address basic issues in infrastructure, personnel and value chains as well as be prepared to deal with climate- and biodiversity-related threats. Strategies that target capacity building, technology transfer and business development are especially crucial.

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