ISSN 2664-4002 (Print) & ISSN 2664-6714 (Online)
South Asian Research Journal of Humanities and Social Sciences
Abbreviated Key Title: South Asian Res J Human Soc Sci

| Volume-4 | Issue-2 | Mar-Apr -2022 | **DOI: 10.36346/sarjhss.2022.v04i02.008**

Review Article

Tackling Natural Resource Depletion and Revenue Decline through Diversification: The Case of Brunei Darussalam

S. Radzuan[1], Christopher Chatwin[1], Rumy Hasan[1*]

[1]University of Sussex, Falmer, Brighton BN1 9RH, United Kingdom

***Corresponding Author:** Rumy Hasan
University of Sussex, Falmer, Brighton BN1 9RH, United Kingdom

Article History
Received: 07.03.2022
Accepted: 12.04.2022
Published: 17.04.2022

Abstract: Exports of hydrocarbons have been a great boon to the small state of Brunei Darussalam and, as such, this paper argues that it provides an example of a country that has not been overly afflicted by the "resource curse" or "Dutch disease". But it has been adversely affected by oil and gas price volatility that inevitably has a profound impact on hydrocarbon exporters, despite resorting to futures markets. Given Brunei's minimal non-hydrocarbon tradable sectors, and like all other countries that are heavily reliant on the export of hydrocarbons, it is confronted by the iron law of resource depletion, compounded by the volatility of the oil market. This reality has prompted the government of Brunei to embark on industrial diversification. This paper provides 3 hi-tech sectors which can be deemed as comprising the basis for an industrial policy: semi-conductors and fibre optics, hi-tech farming, and advanced manufacturing.

Keywords: Brunei, resource curse, Dutch disease, industrial diversification, semi-conductors and fibre optics, hi-tech farming, and advanced manufacturing.

INTRODUCTION

Brunei and the Resource Curse and Dutch Disease

The small state of Brunei Darussalam (or Brunei for short) has long been – and remains – highly reliant on the export of hydrocarbons. A question of profound importance is whether like many other exporters of primary products, it has been afflicted by the "resource curse", a term first coined by Richard Auty who garnered evidence to suggest that:

[N]not only may resource-rich countries fail to benefit from a favourable endowment, they may actually perform worse than less well-endowed countries. [Moreover], mineral economies' [that is, hydrocarbon and hard mineral exporters] economic growth and their social welfare are inferior to those of non-mineral economies at similar of development … The frequent existence of substantial rents [from these natural sources] can, however, when captured by the government through taxation, destabilize the economy. In particular, the imprudent domestic absorption of mining sector rents is capable of rendering much agricultural and manufacturing activity internationally uncompetitive. This occurs through a process known as "Dutch disease". It results from a strengthening (appreciation) of the exchange rate as a consequence of the over-rapid inflow of mineral rents into the domestic economy (Auty, 1993, pp. 1-5).

There is, however, no agreement as to the precise mechanism of the resource curse [[1]] but we can summarise the main hypotheses and ascertain whether any apply to Brunei. Building on Auty's insights, Sachs and Warner argue that natural resources generate 'positive wealth shocks' thereby creating excess demand for non-traded products in a country which, in turn, drives up non-traded prices, especially inputs and wages. Hence these higher input costs impact upon tradables, above all of manufacturing products, driving up their prices on the international market with attendant loss of competitiveness. Ipso facto, manufacturing and overall growth of the economy suffers – evidence shows that natural

[1]A detailed survey of the resource curse literature is provided in Frankel, 2012.

resource-rich economies tend to have small contributions from export growth in manufactures and, accordingly, do not successfully pursue export-led growth that has been the hallmark of a number of successful East Asian economies which have been characterised by the development of strong industrialisation across various sectors (Sachs and Warner, 2001, pp. 833, 835; also see Sachs and Warner (1995) for their survey across several nations; and Papyrakis and Gerlagh (2004) on transmission channels of the resource curse).

An alternative explanation is provided by Thorvaldur Gylfason who stresses the neglect of education that can emanate from resource abundance. He provides evidence to show that 'public expenditure on education relative to national income, expected years of schooling for girls, and gross secondary-school enrolment are all … inversely related to the share of natural capital in national wealth across countries. Natural capital appears to crowd out human capital, thereby slowing down the pace of economic development' (Gylfason, 2001, p. 847).

The 'crowding out' effect also appears to manifest itself in regard to entrepreneurial activity and innovation as wages in the natural resource sector are relatively high and thereby pull in some of the best talent and, accordingly, this acts as a disincentive to would-be entrepreneurs and innovators in other sectors of the economy (Sachs and Warner, 2001, pp. 835, 836). More generally, there is also a preference to work in the state sector which also offers relatively high wages that flow from rents from the natural resource sector, combined with job stability and low risk of failure which is an inevitable encumbrance to the development of the private sector. Other mechanisms that have been posited include the secular decline of prices of primary products on world markets – this hypothesis, however, has not been borne out by facts (Frankel, 2012, p. 24); rather it is the *volatility* of such prices that is problematic given that this can engender excessive macroeconomic instability via the real exchange and government spending. There is the risk, owing to poor management, of natural resources depleting too quickly with insufficient time and commitment to diversify the economy. This is discussed below in regard to Brunei and hydrocarbons.

The natural resource state versus the developmental state

We can think of a 'natural resource state' as preventing the nurturing of a 'developmental state' that has arisen in several resource-poor countries and, if so, is this necessarily problematic? We make the claim that this has, hitherto, not been the case for Brunei. The natural resource export strategy aims at channelling export earnings from natural resource exploitation into downstream processing and thence into broader industrialisation. It is clearly limited to developing countries with substantial natural resources, and is often constrained by the inability of the economy to 'absorb' the funds generated because of labour or skill shortages and inadequate physical and human infrastructure (as was the case with the oil-exporting Gulf states in the 1970s which channelled enormous sums into Western banks as 'petrodollars'). Governments bargain with multinationals over access to resources, the rate of exploitation, the location of processing and the share-out of rents and profits.

By contrast, the 'developmental state' is seen (e.g. by Amsden, 2003; Jenkins, 1991) as the main reason for the much faster growth of resource-poor East Asian countries as compared to Latin American countries. The state is not only highly interventionist in economic affairs as the term implies, but gives paramount importance to economic development via a strong regulatory framework, incentive regimes, and the co-ordination of investment through an industrial policy. The concept was first developed by Chalmers Johnson (1982) in regard to Japan and he thought it significantly different to the 'plan ideological state' of the communist command economies and the 'regulatory orientation' of the advanced market economies.

Adrien Leftwich (1995, pp. 405-420) develops Johnson's path-breaking insight to helpfully posit six major components of the developmental state model:

(i) A determined developmental elite whereby a 'core elite has been associated with a small cadre of developmentally-determined senior politicians and bureaucrats, usually close *to* the executive head of government who was instrumental in establishing the developmental regime and its culture'.
(ii) Relative autonomy, meaning that 'the state has been able to achieve relative independence (or insulation) from the demanding clamour of special interests (whether class, regional or sectoral) and that it both can and does override these interests in the putative national interest'.
(iii) A powerful, competent and insulated economic bureaucracy so that 'economic co-ordination and development in these states has been managed by specific institutions, whose task has been to organise the critical interactions between state and economy'.
(iv) A weak and subordinated civil society. Leftwich argues that 'developmental states have generally operated in social contexts where civil society has been crushed or was weak to start with. By "civil society" is meant 'all privately-organised interests and groups, above the family level but below that of the state'.
(v) The effective management of non-state economic interests. The above factors 'all strengthened the capacities of developmental states *vis-d-vis* their dealings with private economic interests, internal and foreign. The key point here

is that in the developmental states under review, state power and autonomy was consolidated *before* national or foreign capital became influential'.

(vi) Repression, legitimacy and performance. Leftwich makes the claim that 'a grim feature shared by developmental states is the combination of their sometimes brutal suppression of civil rights, their apparently wide measure of legitimacy and their generally sustained performance in delivering developmental goods'.

The question arises as to whether Brunei could have opted for the developmental state model instead of pursuing a strategy focused on export of natural resources. There is no compelling reason for this. Rather, as Laura El-Katiri (2014) argues, the oil rich 'guardian state' model is a viable alternative to the developmental state model that is espoused by small oil-exporting states, including Brunei – though it has drawbacks. Its key distinguishing feature from other economies that are also well-endowed with natural resources, including hydrocarbons, 'consists in its *strong economic welfare objective function*, which in line with its exceptional oil wealth renders its population amongst the wealthiest nations in the world'. But El-Katiri goes on to highlight the fact that 'the guardian state also illustrates some of the negative externalities associated with resource wealth, namely the policy dilemma of directing seemingly abundant financial resources into the economy. The state faces a high propensity for waste, and for the systemic dilution of market incentives, thereby rendering sustained and self-generating economic growth more difficult than in less resource-rich economies' (El-Katiri, 2014, p. 22).

Evidence suggests that Brunei has not been unduly affected by the resource curse. First, prior to the discovery of oil and gas, it was an entirely agrarian economy with practically no manufacturing sector (Cleary and Wong, 1994). Hence, the deleterious impact of the positive wealth shock on manufacturing tradables was of little relevance as these did not exist, though Brunei has struggled to nurture such a sector in an attempt to diversify. In regard to the crowding out of human capital from the extensive reliance on hydrocarbons, in the early years at least, this appears not to have been the case; indeed, education provision improved significantly with wealth generation from exports of oil and gas. But there has certainly been the crowding out of innovative and entrepreneurial activity as the attraction of the hydrocarbon and state sectors has been so overwhelming that the private sector has been suppressed thereby curtailing the flourishing of these activities; furthermore, there has been great reliance on foreign skilled workers (Cleary and Wong, *op. cit.*).

In regard to the "Dutch disease", Humphreys, Sachs and Stiglitz elucidate upon the consequences:

This [revenues generated from natural resources lead to the appreciation of the real exchange rate of the domestic currency], in turn, makes exporting non-natural resource commodities more difficult and competing with imports across a wide range of commodities almost impossible (called the "spending effect"). Foreign exchange earned from the natural resource meanwhile may be used to purchase internationally traded goods, at the expense of domestic manufacturers of the goods. Simultaneously, domestic resources such as labour and materials are shifted to the natural resource sector (called the "resource pull effect"). Consequently, the price of these resources rises on the domestic market thereby increasing the costs to producers in other sectors (Humphreys, Sachs and Stiglitz, 2007, p. 5).

Owing to the priority given to macroeconomic and exchange rate stability, Brunei has pegged its currency to the Singaporean dollar at parity – Singapore has a just reputation for a well-run, stable economy – thereby obviating the problem of currency appreciation that is characterised by the Dutch disease. It is, however, likely that owing to the peg, over the long run, the Brunei dollar has been over-valued with current budget deficits larger than they would have been under a free-floating currency. That said, estimating with precision the costs and benefits of this trade-off is difficult, but our judgement is that recourse to the peg has proved a reasonably effective policy.

It has been large economies such as Mexico, Nigeria, and Venezuela that have been particularly afflicted by the resource curse; by contrast, Brunei has fared well with its plentiful endowments of oil and gas. Living standards have, for decades, been very high, second only to Singapore in the ASEAN region and at the level of advanced economies. With respect to the Human Development Index – a broader index of development than the simple income per capita [2] – that is produced by the United Nations Development Programme (UNDP), for its *Human Development Report 2021*, Brunei was ranked 47 which is within the Very High Human Development category; the key component of this is its extraordinarily high Gross National Income (GNI) per capita of $64,000 in 2021 (2017 PPP$) (UNDP, 2021).

The main counterfactual is whether Brunei's economy would have performed better or at least on a par without hydrocarbons. Our hypothesis is in the negative – indeed this is by no means unique as precisely the same reasoning applies to the oil-exporting Gulf States. As Patrick Clawson (2012) forcefully points out in a provocative paper, prior to the discovery of oil, the Gulf States were desperately poor, registering very low levels on every socio-economic

[2]The Human Development Index is a composite of Gross National Income per capita, life expectancy at birth, and mean and expected years of schooling.

indicator: the massive revenues from oil exports transformed their economies and societies in a relatively short period of time. This was in direct contradiction to the striking metaphor provided in 1976 by Juan Pablo Perez, former Venezuelan Minister of Mines and Hydrocarbons: "Ten years from now, twenty years from now, you will see: oil will bring us ruin … it is the devil's excrement" (cited in Useem, 2003; also see Moss *et al.*, 2015, ch. 3). For Brunei, oil has certainly not been the devil's excrement, an alternative description of the resource curse.

Moss *et al*., (*ibid.*) point out that since the early 1990s, oil-producing countries have been 50% more likely than non-oil-producing countries to experience civil war, but Brunei has had no civil strife whatsoever; indeed, it is a remarkably stable society, a crucial determinant of economic growth and development. That said, it has been adversely affected by oil and gas price volatility noted above that inevitably has a profound impact on hydrocarbon exporters, despite resorting to futures markets. However, this has been cushioned by reserves (including gold) of $4 billion (figure for 2020; Trading Economics.com, 2022) that obviate the need for loans on the international financial markets or from global agencies such as the IMF, World Bank, or Asian Development Bank, as is typically the case for larger oil-exporting countries.

Even if we acknowledge that the resource curse has not been of significant importance to Brunei, like all other countries that are heavily reliant on the export of hydrocarbons, it is confronted by the iron law of resource depletion: reserves of oil and gas are estimated at 27 years (AMRO, 2022) and 22 years respectively (derived from the production to reserves ratio, BP Statistical Review of World Energy 2018, pp. 6, 20) [[3]]. Brunei's government has long been cognisant of this and has attempted to diversify the economy. In this undertaking, however, it has not been particularly successful as is attested by the fact that over 90% of export revenues and over 70% of government revenues stem from oil and gas (BDSYB, 2020). Clem Tisdall (1998, p. 395) points out that diversification was, in fact, an objective of the First National Development Plan (1954-58) though given the rapid inflows of oil revenues, it was not diligently pursued. But that goal remained in place in subsequent decades: Mark Cleary and Shuang Yann Wong (1995) stress the limited success that Brunei had had in diversifying the economy during the Fourth (1980-84), Fifth (1986-1990), and Sixth (1991-95) National Development Plans.

Given the small domestic market and strong gravitational pull of the government sector amply fuelled by export revenues from hydrocarbons, a burgeoning private sector that is vital for diversification and the production of internationally competitive goods and services did not materialise to the desired and requisite level. The difficulty of diversification is compounded by the fact that the hydrocarbon industry is "almost hermetically sealed" (*ibid.*, p. 100) from the rest of the economy – little more than an enclave – and, for small countries, almost entirely dependent on foreign companies and workers. Hence, there are few linkages and spillover effects on domestic sectors, though multiplier effects are obtained especially in service sectors from the demand generated by these foreign companies and workers

We assume that Brunei will not rely inordinately on its financial reserves plus returns from overseas investments, and we further assume that it will continue to be a trading nation rather than retreat into an autarkic framework. Given its small size, Brunei is constrained by limited factor endowments, though in relative terms, it is land rich, as some 90 per cent is not inhabited. Thus, according to Hecksher-Ohlin trade theory (see, for example, Jones, 1987), Brunei has effectively utilised its comparative advantage in natural resource commodities but ought to shift gradually to intensively producing land-based products (that is, agricultural, and related) for domestic and export markets and import capital-rich products. In terms of labour, the country is not-so well-endowed as the population is small (417,000) [[4]] and, owing to the large percentage that works in the government sector, there are significant skills shortages, particularly with respect to industrial sectors. Therefore, at least for the short term, there will continue to be – as indeed there has long been – the need for migrant labour but this runs counter to the government's policy of reducing immigration levels and utilising more indigenous labour as made clear by the Sultan (OBG, 2013) so the only means by which this square can be circled is by the granting of limited period work permits. Hence, diversification requires the creation of land-centred capital-intensive industries and attendant technology transfer so that in the long run local labour is sufficiently skilled to produce internationally competitive products.

An ongoing peg to the Singaporean dollar will inevitably have a deleterious impact on the creation of a comparative advantage in other tradable sectors. Accordingly, the starting point of diversification remains at a low base so without the requisite skills, recourse to foreign direct investment and attendant technology transfer is a *sine qua non*. It is with respect to these considerations that the following three hi-tech industries have been identified as a viable, and

[3]If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate (*loc. cit.).*

[4]Figure for 2015 – 301,000 are Brunei citizens (72% of the total), 29,000 are permanent residents, and 87,000 are temporary residents (BDSYB, 2016). Hence Brunei relies greatly on foreign workers

indeed necessary path, for Brunei to pursue: semi-conductors and fibre optics, hi-tech farming, and advanced manufacturing with the aim of providing sustained dynamic comparative advantage in these sectors. Taken together, they can be considered the fulcrum of an industrial policy and come within the ambit of the BIMP-EAGA [Brunei-Darussalam-Indonesia-Malaysia-Philippines East Asian Growth Area] *Vision 2025* initiative formulated in 2017, in particular the first two of the three main outcomes to be achieved:

(i) A competitive and green manufacturing sector aiming to transition from resource extraction into higher levels of processing and value-added production;
(ii) Sustainable, competitive and climate-resilient agro-industry and fisheries to ensure food security, export development and livelihoods; and
(iii) BIMP-EAGA as a sustainable, well-developed and connected multi-country tourism destination, to benefit less developed areas (BIMP-EAGA Vision 2025, p. xi).

Semiconductors and industrial fibre-optics

Silica, a core element in the production of semi-conductors and fibre optics, is abundantly available in Brunei and the Brunei Economic Development Board (BEDB) is looking at the potential of developing silica sand industry. The Sultanate has an estimated reserve of 16.25 million metric tonnes of the silica material commonly used to make glass. Two types of sand are present: 1) an upper, fine white sand of excellent glass making quality, with variation in thickness between 0.6 to 4.6 meters, and; 2) an underlying, humus stained fine sand. Sieve analyses on the sands indicate that more than 90% consists of the ideal grains (36 + 100 mesh sieve sizes). The white sands are rather pure (BSP, 1996) as confirmed by sample analysis conducted by the Leerdam Glasfabrieken in the Netherlands in 1987 (Fe_2O_3 0.015 weight %). The sand is suitable for manufacturing quality glass but the Fe_2O_3 level is too high for optical glass manufacturing.

The silica sand deposits at Muara cover a total area of about 7.8 km^2 – with an average thickness of 1.8 meters, the reserves are roughly 15 million m^3 for the upper good quality sand and approximately the same amount for the poorer quality sands. A quartz sand deposit is located at Meragang, to the northwest of Muara Town. As in the Tutong area, the sand also forms a terrace, at a height of 18-21 meters above sea level. Sample analyses indicate that the sand is of poor quality and less uniform than that at Tutong. Most of the sand has already been excavated for the Muara Deepwater Port and the Muara Road projects (BSP, *op. cit.*). This suggests that Brunei has a potential to develop its raw silica into a semiconductor industry that involves pre-fabrication, fabrication and post-fabrication verticals.

The success of the semiconductor sector in India for example is a case that Brunei can learn from. According to the India Electronics & Semiconductor Association, the Indian Electronic System Design and Manufacturing (ESDM) market will grow from US$ 76 billion in 2013 to US$ 400 billion by 2020. Consumption of semiconductors, in the meantime, has also steadily climbed. According to a report by NOVONOUS, the semiconductor industry is estimated to grow from US$ 10.02 billion in 2013 to US$ 52.58 billion in 2020 at a Compound Annual Growth Rate (CAGR) of 26.72 per cent (IBEF, 2017).

The electronics and the semiconductor sectors are complementary hence growth in one sector parallels growth in the other. The major semiconductor end-user segments have been communications, IT, and consumer electronics. Semiconductors are poised to impact human life far more as they open up new possibilities in nano-sciences, biotechnology, medical sciences, electro-mechanical devices, photonics, and remote sensing. The semiconductor design requirements of such verticals provide an opportunity for multinational companies to invest in Brunei as this small state possesses potential to become a regional hub. The reasons for the growth in the semiconductor industry is mainly due to the growth in the chip design industry and unprecedented growth in the domestic consumption of electronic goods; hence, there is significant export potential for semiconductors.

Brunei possesses the resources to develop this industry but it has nevertheless languished in regard to industrial technology and automation to foster the development of high-value-added manufacturing and production sectors. Owing to extensive skills shortages, there is the necessity of permitting FDI and attendant workers from overseas in the silica-related and downstream industries. The government needs to implement an R & D strategy to encourage the development of raw white silica into semiconductor end-products. The feasibility of the development of the semiconductor industry is attractive as this coincides with the government's avowed goal of diversifying into hi-tech industries. There are significant market opportunities within the ASEAN and the Asia-Pacific regions to supply producing countries with semiconductor-based products for the manufacture of hi-tech accessories. Brunei's central location in South-east Asia means that it can position itself as a small-scale semiconductor manufacturer to balance trade among countries in ASEAN. The primary product of the semiconductor industry is Integrated Circuits (IC) – a set of electronic circuits composed of multiple transistors connected by wires on a plate of semiconductor material, usually silicon – which is an intermediary product composed of numerous smaller parts used in several consumer and industrial electronics.

The value chains of semiconductor manufacturers start with Integrated Circuits design, and extend to wafer fabrication and assembly and testing. Most of the manufactures concentrate on assembly and testing process in Malaysia (Abad *et al*., 2015). Collaborative efforts with other ASEAN governments can facilitate the development of the semiconductor industry and will continue to play essential roles in addressing crucial factors in human resource development and technological expertise. The semiconductor industry is seen as sustainable as there is continuous demand of high quality devices and fibre optics from manufacturing nations in the Asia-Pacific region especially Korea, Taiwan and Japan for which Brunei can set up joint-venture project in this field, which enable technology transfer.

There is, however, concern that silica dust potentially causes health defects, notably obstructive pulmonary disease. But, evidence suggests that state-of-the art silica sand mining has minimal environmental impact and virtually no public health risk (Orr and Krumenacher, 2015) but the unregulated and over-exploitation of silica mining does risk causing serious environmental damage. Hence, an environmental conservation strategy and compliance with international standards are of vital necessity.

Hi-tech farming

Hi-tech farming or agro-technology mainly refers to agricultural methods using the latest technology. There are minimal physical inputs to the system, but it is capital intensive since a large capital outlay is required to buy specialised equipment, maintenance, and training of labour. It is also a commercial farming system for which the investment services both local and export markets; technical know-how is a must, for example, for hydroponics, computers are used for monitoring purposes. It is also labour-intensive requiring lab technicians, scientists, chemists and farm-hands; it uses farming technology to boost yields and the pesticide-free method appeals to health-conscious consumers. The sector is heavily dependent on continuing research and development hence the need for very highly-skilled workers.

High-tech farming can potentially yield fruit and vegetables, and poultry products more cost-effectively; and the space requirement for farming is less. Singapore has, in recent years, become a test-bed for hi-tech farming as the government encourages farms to explore innovative methods to overcome the chronic shortage of land and to reduce reliance on imports. The farm grows vegetables vertically in towers several metres high by means of a hi-tech system that uses the movement of irrigation water to slowly rotate the plants, grown in trays of earth, so they get the right doses of sunlight and water. Singapore imports more than 90 percent of its food and has only a tiny farming industry that occupies about 200 hectares, less than 1% of its land area of 71,000 hectares. The farms focus on producing leafy vegetables, fish and eggs for local consumption. Hi-tech farming is the key to food sustainability for Singapore (Krishnamurthy, 2014). Since 1986 AVA Singapore (Agri-Food Veterinary Authority) has started hi-tech farming because of limited agricultural land. It has utilised modern technology since 1986; presently it has over 200 agricultural firms in various Agro-technology Parks that manufacture milk, vegetables, fish, eggs and fruit. Singapore's success in hi-tech farming can be a worthwhile lesson to Brunei in developing its hi-tech farming industry with a focus on high-price crops or plants that have export markets. Agriculture, along with forestry and fisheries, contributes only 1% to the Brunei's total GDP (BDSYB, 2015). The primary agricultural products include rice, vegetables, fruit, chickens, water buffalo, cattle, goats and eggs.

Since the discovery of hydrocarbons, agriculture has been of marginal importance to Brunei's economy. It employs only 0.1% of the workforce, accounts for 0.69 percent of GDP and agriculture land is just 2.1% of the total land mass (BDSYB, 2016). Some 55 percent of the cultivated land is under ruminant livestock production with the rest being horticulture, mixed cropping and poultry farming. Crop production is dominated by horticulture, which includes the cultivation of vegetables, production of fruit, floriculture and ornamental plants.

Vegetable growing is mainly concentrated on the urban fringes while fruit orchards are scattered across the country. Owing to high temperatures and rainfall, humidity is high throughout the year with an average of 82 percent. This tropical climate is an essential pulling factor for the plantations of high value crops, tree plants or fruiting trees both for food and medical purposes. Through better management of agricultural farms, much greater yields can be produced. The adoption of robotic technology in hi-tech farming could help improve crop yields. A robotic system has been developed that utilises an agricultural monitoring device for testing the quality of soil. It has the potential to reduce the environmental impact of farming. Increasing efficiency to 100% is not entirely feasible but implementing hi-tech farming techniques would conserve resources and improve crop performance (Gomiero *et al*., 2011). The ineffective technical infrastructure geared for conventional farming is a potential risk factor. Despite the government's incentive in promoting agricultural industry to meet both domestic demand and exports, high-tech farming has been neglected. This is mainly because farmers are not familiar with the concept of hi-tech farming, and have poor knowledge of agricultural technology adoption. Investment in hi-tech farming with proper selection of high value crops, tree plants or fruiting trees can attract foreign investors. The robotic technology is already firmly entrenched as part of the modern farming industry and is likely to become more ubiquitous in the future. Strong global demand for certain high value crops, tree plants or fruiting trees will not only yield more agricultural products but also will attract agri-tech innovation activities.

An important example is agar wood which grows wildly in Brunei's deep equatorial jungle. The agar wood industry has the potential to be fully developed and commercialised in high volume production for raw materials and downstream industries through hi-tech farming approaches. Agar wood is one of the most expensive non-timber wood products in the world and can be used in the production of cosmetics, incense, medicines, and perfumes. First-grade agar wood is an expensive natural raw material for which superior pure material can cost as much as US$100,000/kg., although in practice adulteration of the wood and oil is common, allowing for prices as low as US$100/kg (Naef, 2011). Oudh oil is distilled from agar wood and fetches high prices depending on the oil's purity. The current global market for agar wood is estimated to be in the range of US$6 - 8 billion and is growing rapidly (Akter *et al*., 2013). One of the main reasons for the relative rarity and high cost of agar wood is the depletion of this wild resource (Broad, 1995). There are, however, important considerations that need to be taken into account. Climate change is a primary problem and an un-controllable factor to certain crops, tree plants and fruiting trees that require a certain effective technical strategy to ensure that the harvesting period is not affected. Thus, commercially developing the agar wood industry is seen advantageously in regard to these issues. Use of chemical fertilizers, pesticide sprays, invisible pesticide and artificial growth hormones are issues to both human health and environment. Despite these caveats, rigorously developing the agar wood industry nevertheless offers a compelling sector for development as part of a diversification strategy.

Advanced Manufacturing Technology

The third suggested high-tech industry is Advanced Manufacturing Technology (AMT) which entails the innovative integration of new technology, production processes and management techniques, organisation and culture of the enterprise to form a total system of enhanced production (Barua and Islam, 2008). Indeed, the advanced manufacturing movement, in tandem with the information technology revolution, is transcending the traditional parameters of mass production, giving rise to a new era in manufacturing in which manufacturers are increasing the speed and flexibility of production while improving product quality and customisation.

The benefits of AMT are increased productivity, improved flexibility, higher quality products, and reduced production costs. Advanced technological instruments include the utilisation of industrial robots. The factors affecting the rate of success in the implementation of AMT include level of investment, context of organisation (organisation culture and organisation structure), strategic orientation, entrepreneurial environment (type of ownership, experience and education), external factors (government, supplier, customer and technology trend), manufacturing strategy, management information systems, justifying, planning and installation (Raymond and Pierre, 2005). The spin-offs from labour-intensive conventional manufacturing to industrial automation and robotic control can enhance the ability to introduce new products faster, more frequently and of higher quality.

Creation and inculcation of necessary education and training for AMT is of paramount importance and requires sufficient numbers of institutions of a high calibre; a resource that Brunei needs to expand. The country has two universities, the University of Brunei and the University Technology Brunei; there is also Brunei Polytechnic, a technical college set up in 2008 and the Brunei Institute of Technical Education, which is an autonomous post-secondary educational institution. To augment these domestic institutions, the government provides generous funding for overseas education. While these are valuable, a successful transition to non-hydrocarbon high tech industries will require their upgrading and additional new institutions to be established.

The Brunei government through the Ministry of Industry and Primary Resources has introduced industrial development plans to attract foreign multinationals to invest in high technology industries. The Authority for Info-communications Technology Industry (AITI), established in 2003, functions as telecommunications regulator, national radio-frequency spectrum manager and developer of Brunei's ICT industry. Intensive use of information technology is the basis to improve not only business operations but also enhance the entire manufacturing process and reduce development time of new products. However, the low level of understanding in the implementation of strategies for the development of the hi-tech manufacturing sector and utilisation of industrial automation is a prime issue. The challenge for government policy is to develop research links between industry, academia and government authorities. The nature of Brunei's small economy results in a lack of supply-chain articulation and low level industrial design creativity. The demand for industrial robots has accelerated considerably due to the ongoing trend towards automation: 'In 2017, robot sales increased by 30% to 381,335 units, a new peak for the fifth year in a row' (International Federation of Robotics, 2018, p. 13) that reflects the significant importance of industrial automation for which there is growing demand. Implementation of AMT in Brunei's industrial sector can not only stimulate economic growth rate but also promote the development of environmentally efficient technologies to overcome problems associated with traditional manufacturing systems. Various subgroups of technologies lie within AMT which can be classified as systems, devices, stations and integrated and managerial systems. More specifically, these include automated identification stations, automated inspection stations, automated material handling devices, computer aided design work-stations, computerised numerical controlled machine tools, programmable production controllers, robots and shop floor control systems. The integrated and managerial systems mainly include computer-aided manufacturing, computer aided engineering, statistical process

control, production planning/inventory management software, engineering data management, computer-aided process planning, local area networks and group technology. The key to survival and prosperity of small businesses in this decade and beyond will likely rest on their ability to successfully exploit and benefit from the rapidly developing field of information processing in manufacturing.

CONCLUSION

The above three cases provide a rational approach for Brunei's present economic predicament and desire to diversify. They provide a core basis for an industrial strategy. Government policies can aid private companies in developing their new products with the stress on technology transfer – and lack of such support will indubitably act as a disincentive to foreign investment. Hence, it is imperative that government policies provide an enabling incentive regime including supportive regulations and legislation. Investment in the education and training of researchers and other highly skilled workers is a *sine qua non* in ensuring the successful adoption of high-tech industries. Moreover, human capital is a key factor in the adoption of new technologies and the introduction of innovative practices. Creating, developing and diffusing new products and processes requires strong science and technology skills as well as many non-research soft and entrepreneurial skills. There is an increasing emphasis on policy issues related to the availability of highly skilled labour. Strong science and technology skills facilitate the uptake and use of new technologies, which drives innovation throughout the economy. This places a premium on both the quantity as well as the quality of highly skilled labour in the economy. The development of a well-educated, adaptable and technologically capable population can guide Brunei's aspirations towards a technology-based industrial nation that is no longer highly reliant on hydrocarbons.

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