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Towards the Development of Eco-Industrial Estates in Bhutan

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Abstract

This research investigates the potential of applying industrial ecology in the development of eco-industrial estates in Bhutan. It presents the factors contributing to the success or failure of eco-industrial estates along with the benefits arising from the set-up of such facilities to industry, environment, and local communities. The development strategies, policies, practices, laws, rules and regulations, market conditions, and private sector initiatives undertaken in Kalundborg Eco-Industrial Park, Burnside Eco-Industrial Park, and Map Ta Phut Industrial Estate in Denmark, Canada, and Thailand respectively are used to analyse the eco-industrial development in Bhutan. The existence of supportive legislation, close working relationship between the government and private sectors, enabling environment for information sharing, and diverse mix of industries in Bhutan are identified as the key opportunities and supportive conditions as well as the challenges for eco-industrial developments in Bhutan and realising the government's vision for a 'cleaner' industrial sector.

Keywords

Eco-industrial estates; Sustainability, Bhutan; Developing countries

1. Introduction

Bhutan, a least developed country, faces its fair share of issues and challenges in the development of various sectors; major factors for this often being cited as shortage of resources, inefficient systems and procedures, and limited technical capacity. Additionally, the negative environmental impacts associated with the development of certain economic sectors, particularly the industrial sector have raised concerns amongst the general populace and relevant authorities. Issues regarding negative environmental impacts experienced and observed by the community residing in the vicinity of Pasakha Industrial Estate and the National Environment Commission (NEC) of Bhutan have raised concerns on the industrial processes and technologies employed by the industries within the industrial estate.

Industrial ecology is "the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources" (White quoted in Allenby and Richards, 1994). This concept was made popular by Frosch and Gallopoulos (1989) who stated that "the traditional model of industrial activity in which individual manufacturing processes take in raw materials and generate products to be sold plus waste to be disposed of should be transformed into a more integrated model: an industrial ecosystem." Closely linked with resource efficiency and cleaner production, industrial ecology places an emphasis on manufacturing processes and product design, studying the flow of energy and

materials through industrial systems from 'cradle-to-grave'. It also concerns itself with the examination of the interaction of economic activities and industrial systems with natural ecosystems, and the subsequent effects (UNEP n.d., para. 5; Lifset and Thomas 2002; Schramm 2012).

The possibility of more viable and sustainable developments through the adoption of industrial ecology has been established by pioneers of eco-industrial parks. These pioneers have proved that such development models would not only help reduce negative environmental impacts of industrial activities but would also address the constraints of limited resources with additional financial benefits. With an expected growth in the industrial sector and plans to develop more industrial estates in Bhutan, addressing the afore-mentioned issues and challenges beforehand would allow for more effective industrial development in Bhutan.

This paper presents the analysis of adopting eco-industrial development models in Bhutan similar to the established eco-industrial parks in Denmark, Canada, and Thailand. The cases were selected with a view to present some of the best practices and examples and what could be learned from them and applied to Bhutan's current scenario and its quest for rapid economic transformation and growth in alignment with the country's development philosophy of Gross National Happiness (GNH). The study aims to assess the feasibility and viability of adopting eco-industrial estate development models in Bhutan based on the current policies, practices, laws, rules and regulations, and market conditions. The better understanding of the eco-industrial development models could assist in their applicability in order for countries like Bhutan to consider the rich possibilities of setting up eco-industrial estates in tandem with economic productivity, the natural environment or the social well-being of the people, whilst actively assisting in the promotion of the private sector.

The findings contribute towards achieving sustainability in Bhutan's industrial sector as per the national development plans and goals. They also contribute significantly towards Bhutan's efforts of creating and promoting 'Brand Bhutan' as its Unique Selling Proposition (USP) (Royal Government of Bhutan, 2010, p. 2).

2. Industrial Development in Bhutan

Bhutan has been blessed by an abundance of fast flowing rivers and streams allowing it to harness these clean and renewable resources into hydroelectricity. Almost 70% of the country's internal electricity consumption is attributed to its industrial sector. The supply of this relatively inexpensive and reliable energy source is one of the key drivers of the growth of Bhutan's industrial sector (Druk Green Bhutan, 2013). An overview of the types of industries in Bhutan is presented in Figure 1.

Please insert Figure <1> here

The Department of Industry (DoI) under the Ministry of Economic Affairs (MoEA) broadly classifies industries into processing & manufacturing industries, service industries, and contract industries. Of these three broad categories they are further divided into large, medium and cottage scale industries depending on the size of financial investment. Within the processing and manufacturing industries, the wood and paper processing and food processing industries are the most dominant ones (IMF, 2010)

There has been a significant growth in various licensed production and manufacturing industries in Bhutan from 2009 to 2011 (National Statistics Bureau Bhutan, 2012). Although steadily increasing, constraints such as weak entrepreneurial orientation, high transport cost, small domestic markets, underdeveloped infrastructure, and lack of resource inventory have prohibited the industrial sector from developing at a faster rate (Department of Information Technology and Telecom, Ministry of Information and Communications Bhutan, 2008). With the development of more hydropower projects underway, totalling a supply of 10,000 MW by 2020, it is expected that the industrial sector will see a significant growth spurt in the coming years owing to the increased supply of inexpensive and reliable hydroelectricity as an energy source.

Bhutan 2020: A Vision for Peace, Prosperity and Happiness is a “twenty year perspective strategy document which sets the preferred direction for where Bhutan wants to be in the year 2020 starting from the base year of 2000” (The Permanent Mission of the Kingdom of Bhutan to the United Nations in New York, n.d., para. 1). The document envisions an industrial sector composed of clean manufacturing industries, high-technology enterprises, and high-value Bhutanese niche and eco-based products; one that is expected to make significant contributions to the growth of the economy and employment generation. It also endeavours to preserve the natural environment, the importance of which is highlighted in the country’s development philosophy of GNH.

Bhutan’s Planning Commission, which was established in 1971, was reconstituted as the GNH Commission in 2008. Functioning as a central government agency, the commission oversees the planning, policy making, and review of all national and sectoral policies, plans and programmes to ensure that the GNH concept and values are instilled fully in policy development and implementation processes. Sectoral development policies, plans, and programmes are formulated and implemented by the government ministries and various agencies. The importance of GNH has been further reinforced by sections 1 and 4 of Article 5 of the Constitution of Bhutan with an emphasis on adopting and supporting environment friendly practices and policies (The Constitution of the Kingdom of Bhutan, 2008).

In line with the above priorities, the MoEA was tasked with the planning, developing, and operating of industrial estates, which are “specific areas zoned for industrial activity in which infrastructure such as roads, power, and other utility services is provided to facilitate the growth

of industries and to minimize impacts on the environment” (World Bank Group, 1998, p. 324). These developments are usually located away from residential and densely populated areas to minimise the potential negative impacts and hazards on the general populace.

Through the provision of shared facilities, industrial estates facilitate and nurture the establishment of small and medium scale industries. This is mainly due to the reduced service costs associated with the provision of shared facilities in lieu of having to set up their own individual basic amenities (Price Waterhouse Coopers, n.d., Chapter.VI, p. 3). The industrial sector in Bhutan, being largely comprised of small and cottage industries and a few emerging and established medium and large scale ventures, has benefited to some degree from the establishment of industrial estates. The provision of common facilities and infrastructure networks also addresses the constraint of limited land available for development in a small country like Bhutan.

The MoEA currently manages two industrial estates: the Pasakha Industrial Estate (272 acres) located in *Chhukha* district (southern Bhutan) and Bjemina Industrial Estate (34.4 acres) located in *Thimphu* district (western Bhutan) (MoEA, n.d., p. 25-26). As of September 2013, the Industrial Infrastructure Development Division (IIDD), DoI, MoEA recorded a total of 35 and 33 industries respectively in these industrial estates in various stages of establishment and operation.

The larger of the two industrial estates, Pasakha Industrial Estate comprises a mixture of mostly medium scale manufacturing and processing industries ranging from the manufacturing of bitumen, steel ingots, ferro silicon, nails and wires, etc. to the processing of animal feed, refined palmolein oil, etc. Pasakha is especially ideal for mineral based industries with mineral sources close by. An added advantage is the location’s proximity to the Indian border enabling (i) access to and ease of import of raw materials; (ii) marketing, transportation, and access to markets for products, and (iii) ready supply of cheap labour. Unlike the Pasakha Industrial Estate, the Bjemina Industrial Estate consists of mostly cottage and small industries like automobile workshops, steel and wood fabrication units, and brick and tile manufacturing units. Additional industrial estates are planned to be established in Bhutan. Figure 2 indicates the locations of the existing and the proposed industrial estates.

Please insert Figure <2> here

A number of factors were considered in the feasibility studies to find the favourable location of the industrial estates for balanced regional development and enhance growth of the rural economy. The development of industrial estates is aimed at clustering industries in a particular region or locality to promote private sector development, environment friendly industrial development, and enhance socio-economic activity in a particular region through increased employment generation and opportunities. It creates a favourable environment and cost-

effective infrastructure to encourage the establishment of SMEs and increase the potential for industrial development through the provision of land, civil and power infrastructure, and waste management system, thereby reducing the initial cost of land development (GNHC, 2009).

With plans for more industrial estates and an expected growth spurt in the overall industrial sector due to increased hydroelectricity supply, it is likely that unsustainable industrial development will be experienced if business-as-usual developments are allowed to take place. Therefore, to avoid escalation and compounding of existing negative environmental impacts such as lack of proper waste management facilities and/or practices, pollution and inefficient use of resources associated with the industrial sector, the government needs to find ways in which these issues can be addressed or avoided.

Eco-industrial parks are a vehicle to reduce waste and pollution and efficiently share natural and man-made resources for sustainable development and growth. Kalundborg Eco-Industrial Park in Denmark, Burnside Eco-Industrial Park in Canada, and Map Ta Phut Industrial Estate in Thailand are some of the most commonly referred examples of transformation of existing industrial parks into eco-industrial parks. However, it should be pointed out that the areas and scale of operations of these parks are much larger than that of the existing and planned ones in Bhutan. Therefore, the development, management, and operation of these parks are definitely more complex and complicated in all aspects in comparison to that needed for the Bhutanese context. The motivations behind the initiatives, the initiators and stakeholders, types of businesses involved, the development strategies, regulatory and implementation tools, challenges and opportunities presented, and the consequent benefits experienced in the mentioned three parks provide valuable information in order to identify similar underlying factors conducive for such transformations to be realised in Bhutan as well as provide justifications for their adoption. The next section briefly introduces the case studies of Kalundborg Eco-Industrial Park, Burnside Eco-Industrial Park, and Map Ta Phut Industrial Estate. They will then be used to examine the drivers, barriers, opportunities, and applicability of eco-industrial estates in Bhutan in the subsequent section.

3. Case Studies

3.1 Kalundborg Eco-Industrial Park, Denmark

The most commonly referred to example of a successful eco-industrial park is the Kalundborg Eco-Industrial Park in Denmark. This model aims to optimise by-product (materials and energy) exchange and use as well as reduce the total waste generated by the participating ventures. It was informally initiated in 1962, and subsequently set up in 1972 by private companies as personal voluntary symbiotic exchange initiatives through collaborative agreements (Schubert, 2007).

3.1.1 Need for change and subsequent benefits

The collaborative, symbiotic efforts were originally aimed at cost reductions and profit generation in a business environment where raw materials were expensive and waste disposal costs were rising due to stringent environmental regulations. The initiatives have clearly achieved these objectives with annual savings of more than 15 million USD and total accumulated savings of 160 million USD for an initial 75 million USD investment in the 19 cooperating projects (Schubert, 2007).

Additionally, environmental benefits such as greater resource efficiency, decreased dependency on non-renewable resources, and decreased negative environmental impacts have also been observed. The benefits aren't just limited to the key participants but also extend to about 20,000 people within the district, though the provision of utilities such as electricity, water, and heat provided by the Municipal Government, and some farmers and small businesses from other districts (Schubert, 2007). It was estimated that approximately 3,500 oil-burning systems employed for residential heating were replaced as a result of effective utilisation of Denmark's largest coal-fired power plant Asnaes' extra heat (International Institute for Sustainable Development (IISD), 2013).

3.1.2 Development and operational strategies

The development of the Kalundborg Eco-Industrial Park can be characterised by (Schubert, 2007):

- i. Private stakeholder initiatives in the form of voluntary collaborative efforts and agreements, and symbiotic relationships driven by economic incentives such as cost reductions, profit enhancement, and market forces;
- ii. Success in spite of an absence of "deliberate institutional mechanisms" or government funding;
- iii. Elimination of counterproductive aspects of competition between businesses involved by ensuring their by-products differed. It was also vital that the products and by-products of the firms be closely linked and the firms were of more or less the same scale of operation;
- iv. Cost effectiveness in by-product exchanges by ensuring close proximity of cooperating firms; and
- v. Acceptance of new business ventures into the symbiotic system based on suitability to be incorporated with existing systems as well as the relative proximity to these systems, so as to ensure cost effectiveness in by-product exchanges.

3.1.3 Development and operation: Strengths and weaknesses

The absence of the direct involvement of the government has been viewed by some critics as a shortcoming of this particular model. Some critics appear to be of the opinion that planning new

eco-industrial developments rather than transforming existing developments along with greater government involvement through intentional strategies, regulations, and subsidies would promote a more environmentally friendly development (Reed and Desrochers, 2008, p. 9-10).

“Potentially lower levels of technical compliance” and “high transaction costs incurred in extensive consultations around permitting” have been identified as some of the limitations of the Danish regulatory framework. In contrast, the strict technology standards set by the United State of America (USA) ensure a certain minimum level of pollution control (Ehrenfeld and Gertler, 1997, p. 76). Although acknowledging these limitations, Ehrenfeld and Gertler (1997, p. 75) are of the opinion that the development of the current system at Kalundborg has been stimulated by this framework, which they state is “consultative, open, and flexible” in comparison to that of the USA.

The transformation of this eco-industrial park appears to have taken place as a result of being presented with the freedom of turning to more economical alternatives than technological measures in addressing constraints. It can be argued that a similar approach in allowing the degree of flexibility provided by the Danish government to its private sector would be one suitable for a country like Bhutan where it will not always be possible to turn to technology standards like the USA, due to the limited financial and technical capacities. However, there is also the possibility that because of the insufficient funding and technical skills and knowledge, such an approach would in fact create a situation where symbiotic relationships are created inefficiently, uneconomically, or wrongly leading to the failure of initiatives in transforming to eco-industrial estates.

3.1.4 Collaborative projects and activities

The key cooperating industries within the eco-industrial park are (Schubert, 2007; IISD, 2013):

- i. Denmark’s largest coal-fired power plant, Asnaes;
- ii. An oil refinery owned by Statoil;
- iii. A pharmaceutical and enzymes maker plant owned by Novo Nordisk;
- iv. A soil remediation company owned by A/S Bioteknisk Jordrens/Soilrem;
- v. Scandinavia’s largest plasterboard manufacturer, Gyproc; and
- vi. The Municipal Government of Kalundborg.

3.2 Burnside Eco-Industrial Park, Canada

Another successful model of an industrial park being converted into an eco-industrial park is that of the Burnside Industrial Park in Dartmouth, Nova Scotia. Considered one of the biggest industrial parks in Canada spanning about 1400 hectares in area, it was established in the early 1970s. The eco-industrial system approach adopted by this park aims to create a balance between economic growth and not disrupting the natural environment (Schubert, 2007).

3.2.1 Need for change and subsequent benefits

The development of this network system was originally initiated by the Municipal Government to improve the environmental management of the park as a result of its experiences with the municipal's solid waste management, particularly landfills and greenhouse gas emissions. The success of this model can be surmised by the following observations regarding yearly reductions (Schubert, 2007):

- i. Solid waste diversion was assessed to be about 1,569 tonnes;
- ii. Liquid waste diversion was assessed to be about 99,413 litres; and
- iii. Water usage decreased by more than 11 million litres.

Additionally, the Halifax Regional Municipality also set up the Eco-Efficiency Centre (EEC), as a joint effort with the School for Resource and Environmental Studies (Dalhousie University), Nova Scotia Department of the Environment, and Nova Scotia Power, Inc. This organisation has been vital and indispensable in its role as a facilitator for materials and information exchange and providing various others supportive awareness raising and environmental functions (The Cardinal Group Inc., n.d).

3.2.2 Development and operational strategies

The development of the Burnside Eco-Industrial Park can be characterised by:

- Greater public influence on network interactions of private companies owing to public planning initiated by the Municipal Government and Dalhousie University (Schubert, 2007);
- Private stakeholder initiatives in setting their own specific conservation and reduction targets (Schubert, 2007);
- Emergence of numerous new firms as a result of raising awareness as to the benefits and necessity of recycling, remanufacturing, and reuse activities in the park (The Cardinal Group Inc., n.d.);
- The establishment of the EEC that acts as the main point of contact as well as a facilitator between the private and public sectors (Schubert, 2007). The EEC's free service Eco-Business Program promotes environmental efforts by setting various preservation and reduction targets for the participating businesses, which include but are not limited to: water conservation, solid waste diversion, toxic chemical reduction, GHG reduction, and energy conservation (Schubert, 2007; The Cardinal Group Inc., n.d);
- The provision of feedback and recommendations by the EEC, in the form of reports on improving operational efficiency by participating businesses based on environmental reviews carried out by the EEC (Schubert, 2007); and

- A highly flexible approach allowing businesses to voluntarily partake in the Eco-Business Program and to some degree, allowing them to make decisions on investments that are in line with or may impact upon the objectives of the park and the collaborative activities (Schubert, 2007).

3.2.3 Development and operation: Strengths and weaknesses

The development of this park involved the transformation of an existing industrial park into an eco-industrial park, mainly through awareness campaigns and knowledge sharing and transfer. The establishment of the EEC has also significantly contributed to stimulating symbiotic linkages for material exchanges. Moreover, Peck (1996) refers to the setup of the ECC as “an example of a very practical, 'on the ground' approach to promoting industrial ecology at an existing industrial park.”

Similar to the Kalundborg case, there are no preventive or compliance related institutional mechanisms in place. This is due to cooperative efforts being encouraged on a voluntary basis and flexibility in allowing firms to set their own targets and commitments regarding savings and efficiency. However, the presence of the ECC and its many initiatives and responsibilities, particularly the recognition and awards for environment related activities provides the participating companies with the necessary incentives. Another incentive is provided in the form of public reports generated from reviewing the participating companies' financial and environmental performances in achieving savings and reductions in both costs and materials usage (Schubert, 2007, Adaptation Flexibility).

A similar approach of setting up a similar centre and eco-business programme would be suitable and achievable to be set up in the existing industrial estates in Bhutan. Funding could be obtained through annual member fees from participating companies. However, the issue of human resource in the form of experts and skills may still be an issue at this point in time owing to the limited number of highly skilled environmental experts in the country. A temporary solution would be hiring experts from international companies to train the existing in-house human resources.

3.2.4 Collaborative projects and activities

The park currently has more than 1,300 small and medium scales enterprises (The Cardinal Group Inc., n.d.). Essentially a mixed-use development, in addition to conventional manufacturing and industrial units, some of the other developments and facilities are (Greater Burnside Business Association, n.d.):

- Retail outlets;
- Hotels and restaurants;
- Meeting spaces and class-A office developments; and

- Natural parks including sport amenities and walking trails.

It is also considered to be the “transportation and warehousing centre of the Greater Halifax economy” (Greater Burnside Business Association, n.d.).

3.3 Map Ta Phut Industrial Estate, Thailand

The Map Ta Phut Industrial Estate in Rayong Province was established by the Industrial Estate Authority of Thailand (IEAT) in 1989, primarily for production of raw materials for domestic consumption so as to replace imported goods (IEAT, 2004). It spans over an area of approximately 1440 hectares. The development of this industrial estate was part of an initiative undertaken by the IEAT in applying industrial ecology for future industrial development in Thailand.

3.3.1 Need for change and subsequent benefits

The development of Map Ta Phut Industrial Estate into an eco-industrial estate was undertaken in a way very different from that of the Kalundborg and Burnside Eco-Industrial Parks; it was part of strategic initiative undertaken by a government body i.e. the IEAT and not a result of private individual collaborations. The management of this industrial estate was planned to effectively encapsulate five core equilibriums in keeping with the Thai culture: economy, equitability, environment, education, and ethics (IEAT, 2004).

Enhanced profitability of the companies and socio-economic benefits for the community owing to numerous corporate social responsibility activities undertaken by the IEAT and the companies within the industrial estate have been observed in recent years. However, unlike in the case of the former case studies, data regarding annual reductions related to waste and emissions were not readily available. In trying to obtain this vital information, a quantitative assessment of industrial waste generated by different industry groups in the industrial estate was found in a study undertaken by Khwankue and Charmondusit (2009). The study identified industrial waste management as one of the industrial estate’s environmental issues and found that industrial ecology management tools were effective in addressing this issue.

3.3.2 Development and operational strategies

In 1999, the IEAT committed to “apply the principles of eco-industrial development as the main strategy for future industrial development in Thailand” (Chiu, 2001). Four existing industrial estates, including Map Ta Phut, were identified as pilot projects for the IEAT’s initiative, with the German Technical Cooperation’s assistance, to transform its 28 existing industrial estates into eco-industrial estates. Material exchange networks, not just within an industrial estate, but also with businesses outside the estates were to be promoted as part of this initiative along with the adoption and integration of environmental protection and conservation tools like cleaner production, resource recovery, community programs, and by-product exchange. The

experiences and knowledge gained from these projects were to be applied to the remaining as well as future industrial estates (Lowe, 2001, Chapter 11, p. 1).

Unlike with the former case studies, environmental targets have been formally set and made mandatory so as to attain certification of International Standard Operation of Environment i.e. ISO 14001 (IEAT, 2004). The industrial estate office also has an organisation for environment management and technological measures and tools to monitor and ensure strict compliance of environmental standards through regular checks and inspections of industrial emissions. Proper land use zoning in the form of commercial, industrial, residential, recreational, and government supported areas was planned right from the initial stages of development so as to ensure safety, health, and environment (IEAT, 2004).

3.3.3 Development and operation: Strengths and weaknesses

Recent years have seen health and environment related issues being raised by the community residing in the vicinity of the Map Ta Phut Industrial Estate. Pollution from the activities within the industrial estate has been blamed for genetic defects and cancer occurring amongst the residents of the region. The Thai News Service Group (2010) reported that a health study revealed the occurrence of genetic defects. Another study showed that residents of the region suffering from leukaemia and other forms of cancer were five times higher than the national rate. The industrial estate was consequently declared a pollution control zone along with the surrounding region with stricter enforcement of environmental regulations and compliance monitoring. As a result of the above, a number of projects were suspended, which in turn impacted on the transformation efforts of the industrial estate into an eco-industrial estate. The fear of loss of interest by future investors in the industrial estate was suggested to have been one of the factors behind the previous lenient environmental regulations imposed by the state.

In 2010, the Ministry of Industry, having declared the above issues as resolved, initiated efforts to draw in more investments by updating foreign investors on the above through road shows. The ministry also planned on formulating plans on dealing with the pollution issues in case new investments in the industrial estate were made. For better environmental management, the ministry also decided to relaunch the initiatives as an “Eco-Town” project (i.e. transformation to eco-industrial estate) (Thai News Service Group, 2010). Individual companies were seen taking initiatives in implementing industrial ecology. An example of this being the PTT Gas Separation Company’s plans to set up “environmentally and socially friendly” small and medium scale firms on a portion of their land. The firms will utilise sugar cane (biodegradable) in the production of bioplastics (Bangkok Post, 2012). Contrary to the above, environmental pollution issues regarding the industrial estate were still being reported in the media.

An apparent lack of efficient environmental monitoring of pollution levels by relevant authorities is clearly evident from all the above observations, as is the lack of motive of the private sector to

ensure minimal negative environmental impacts. Therefore, this case study has established that greater government involvement does not necessarily amount to success in transformations to eco-industrial estates; the other two case studies showed minimal involvement from the government but still resulted in successful transformations. Other factors, including but not limited to, stakeholder influence, involvement, and acceptance have a huge impact on the development and operation of industrial estates.

3.3.4 Collaborative projects and activities

The industrial estate has about 58 factories, which consists of 30 petrochemical factories, 8 steel factories, 2 oil refineries, 6 gas or steam power plants, and 12 chemical fertiliser factories (Vivatpanich, 2012, p. 33).

4. Drivers, Barriers, Opportunities and Applicability of Eco-industrial Estates in Bhutan

4.1 Drivers for Development of Eco-Industrial Estates

The main sources of drivers for the development of an eco-industrial estate can be categorised as (Panyathanakun et al. 2012, p. 259):

- i. Internal drivers: These include influential factors such as new market prospects, improvement of quality of products, and innovation opportunities; and
- ii. External drivers: These include government regulations, customer demands, and industrial initiatives.

While largely dependent on environmental considerations and technological abilities, the review of extant literature and media sources indicate that the major driving force for the successful application of industrial ecology is the willingness of stakeholders to cooperate. The mentioned three eco-industrial parks in Denmark, Canada, and Thailand have shown that financial and environmental considerations are often a major driving force for businesses in implementing symbiotic linkages; the former of which is the key driver for eco-industrial parks (Roberts, 2004).

Stakeholder involvement, usually in the form of either voluntary collaborative initiatives between business owners in establishing symbiotic linkages or communities in the vicinity being informed and made aware of the development activities and the consequent socio-economic benefits as well as efforts being made to avoid negative environmental, safety, and health related impacts on the surrounding community, is often the key for eco-industrial development. The necessity and importance of due consideration towards location-specific factors, government regulations and policies, and financial capacity of the country and the private sector are also required in its application to industrial estates.

Profit generation, cost reductions, and savings are often the main reasons for business owners turning to new innovations and concepts as possible means of achieving this at minimum associated start-up costs. In the case of Kalundborg Eco-Industrial Park, strict environmental regulations and market conditions were the main driving force for businesses in the region to turn to industrial ecology to ensure the possibility of enhancing profitability, cost reductions and savings. This example clearly establishes the effectiveness of market conditions, government regulations, industrial initiatives, and innovation opportunities in the successful transformation of existing industrial parks into eco-industrial parks. It also shows having a master plan and a set development strategy for such a development is not mandatory for its success, the key to success is having proper knowledge and data on the operations of the businesses and information sharing. It also exhibits the superiority of flexible regulatory and legislative frameworks in fostering innovative ideas and systems over conventional command and control regulations (Schubert, 2007).

The sole motivation behind the development of the Burnside Eco-Industrial Park on the other hand was improvement of its environmental management. The involvement of the public sector was more apparent here what with the planning being initiated by the Municipal Government and the Dalhousie University. However, collaborations were still encouraged on a voluntary basis as in the case of Kalundborg Eco-Industrial Park.

The establishment of supportive organisations, the Kalundborg Centre for Industrial Symbiosis (KCIS) and the EEC within the Kalundborg and Burnside Eco-Industrial Parks, have simplified the process of creating and forming new collaborative projects for materials exchange by gathering and sharing relevant information. Although the government had no direct involvement in the initial development of the eco-industrial park, the Industrial Development Council sponsored KCIS assists in the formation of new collaborations as well as in information gathering and sharing on the park. The cooperating companies within the park provide the basic funding for its operations (Schubert, 2007). The benefits arising from the establishment of the EEC aren't just limited to the businesses within the industrial park; although the exchange of wastes and by-products only take place within the industrial park, the EEC also provides similar supportive functions to the business sectors beyond the confines of the industrial park within the Halifax regional municipality and all over Nova Scotia (Schubert, 2007). The provision of other supportive awareness raising and environmental functions carried out by the EEC has encouraged friendly competition between firms within the Burnside Eco-Industrial Park, thus effectively promoting the propagation of industrial ecology through the park.

The case study of Map Ta Phut Industrial Estate illustrates how sometimes even the best laid plans go awry. Despite the government being the main initiator of the transformation project with a set goal of incorporating industrial ecology in all future developments in Thailand and having formal mandatory environmental targets (IEAT, 2004) the transformation still appears to be

facing a lot of issues. This does not appear to be an issue related to the planning and incorporation but rather the weak environmental management of some of the individual industries. It also indicates the possibility of poor management and monitoring of compliance by the government and the IEAT. The fear of future investors losing interest in setting up their businesses in the industrial estate could have been a reason for the lenient environmental regulations imposed by the state.

Originally intended as a pilot project to set the precedence for applying industrial ecology to other existing and new industrial estates, the experience and knowledge gained from this project may be referred to in order to avoid similar issues. The Thai News Service Group (2010) has aptly described the Map Ta Phut experience as a "valuable lesson to the government and the private sector where it has been learned that coexistence must be sought between businesses and communities to achieve sustainable industrial development." Time and time again, it has been proven that stakeholder involvement, participation, and acceptance are necessary and extremely vital for the successful implementation of most projects. In this case, to obtain community acceptance, it was recommended to adopt guidelines for 'green industry' and 'eco-industrial estates' (The Thai News Service Group, 2010).

Therefore, it can be assessed from the Map Ta Phut Industrial Estate that the commitment of individual businesses to achieving environmental conservation or reduction targets and the government and businesses working together are crucial in successfully implementing eco-industrial estates. It also shows sometimes that providing incentives and rewards, in the form of recognition and awards, often go a longer way in encouraging and motivating stakeholders than penalising and placing impositions on them. A fine balance between government support and private sector initiatives is also required.

4.2 Barriers to Development of Eco-industrial Estates

Panyathanakun et al. (2012, p. 259) acknowledge the existence of barriers that need to be overcome in order to successfully carry out these development projects. The most common barriers faced in forming symbiotic relationships for the success of an eco-industrial park are often grouped as: legal or regulatory barriers, organisational barriers, economic barriers, informational barriers, and technical barriers (Heeres, Vermeulen and Walle, 2004).

Observations made in section 4.1 have been found to be supported by those made by Panyathanakun et al. (2012, p. 259) who also found that often times, stakeholders in the form of businesses may not recognise the role they play in contributing to environmental issues or the required capabilities in addressing these issues. They also stress the importance of environmental legislations and that of effective networking amongst the various collaborators.

4.3 Opportunities for and the Applicability of Eco-Industrial Estates in Bhutan

To circumvent the many issues that developed countries faced with the advent of industrialisation and rapid economic growth, Chiu and Yong (2004) recommend adopting industrial ecology as a basic strategic principle in the economic development of developing countries in Asia to effectively achieve sustainable development rather than implementing it in the conventional way as a technical tool. The ever-increasing importance being placed on attaining sustainability across all sectors of development and the equally arising awareness of the constraints of limited natural resources could be effectively addressed through the uptake of industrial ecology in developing countries, including Bhutan.

Stakeholder involvement and awareness will play a major role in convincing the government in adopting industrial ecology as a strategy, at least within the industrial sector. Economic, social, and environmental benefits and advantages that eco-industrial estates present to collaborating industries and to the local communities should provide impetus for both private and public sectors to embrace industrial ecology initiatives. The impending barriers in successfully adopting industrial ecology need to be addressed; necessary plans will need to put in place to create an enabling environment before developments of eco-industrial estates are initiated. A review of the organisational structures and operations of companies would be advisable, along with assessments of existing financial and technical capability of all involved organisations.

In determining the actual possibility of applying industrial ecology to the development of eco-industrial estates in Bhutan, the following opportunities and supportive conditions have been identified:

4.3.1 Supportive legislation

In a small country like Bhutan, with limited resources where development is still fairly new, extra care is taken with respect to the environmental and socio-economic aspects of planning and management; sustainable socio-economic development and environmental conservation being two of the four pillars of Bhutan's development philosophy, GNH. The visions and objectives of Bhutan 2020 and the Constitution of the Kingdom of Bhutan could both be effectively achieved through the adoption of industrial ecology. In addition, Article 5 of the constitution also allows for actions that will be conducive to the adoption of industrial ecology as a strategy for sustainable economic development in Bhutan's industrial sector.

An excerpt from the Fourth Annual Report of the former Prime Minister of Bhutan on the state of the nation presents an inkling of the dedication to maintaining and ensuring environmental sustainability (Cabinet Secretariat Bhutan, 2012, p. 67):

“The pride of Bhutan is the good health of its natural environment. We cannot be greener than at the present time with a forest cover of over 81% much of it in pristine condition, rich biodiversity, clean air and sparkling water. This is the result

of translating a deep reverence for our natural environment into deliberate policies that place conservation at the centre of our development strategy.”

Additionally, being a member of at least twelve environmental conventions and committed to the achievement of the Millennium Development Goals and the South Asian Association for Regional Cooperation (SAARC) Development Goals, which both place an importance on the environment amongst many other goals would also ensure such a strategy could possibly be accepted and supported by the government.

The NEC, the authority responsible for the environmental management and compliance monitoring of all activities across the country, already performs a number of awareness raising and capacity building activities in the environmental field. These activities include informing the private industrial sector and relevant authorities on international environmental mechanisms and tools like Clean Development Mechanism, Cleaner Production, Life Cycle Assessments, 3R concepts, etc. and encouraging the adoption of the same in their operations. Being closely linked with industrial ecology, these tools and mechanisms could very well have already laid the path for its acceptance and successful incorporation in the existing industrial estates. A number of environmental regulations, including the Environmental Impact Assessments (EIA) of proposed projects, especially those of large and medium scales, have been set in place effectively.

According to Bhutan's Economic Development Policy (Royal Government of Bhutan, 2010, p. 12), industries are to be “developed with a cluster approach in order to benefit from the close geographical proximity among industries that are linked by commonalities and complementarities...” Such a development strategy would be conducive to the implementation of symbiotic relationships, not just within industries in industrial estates but other industries as well.

4.3.2 Close working relationship between government and private sectors

The developments of most eco-industrial parks have had technical and/or governmental support (Schubert, 2007, Relevance). As with most developing countries in Asia, Bhutan faces constraints in most of its development activities due to the limited availability of funds, and technical skills and expertise. However, the private sector in Bhutan supported by the government has been working towards capacity building and acquiring funding for major projects through Foreign Direct Investment (FDI) and Public-Private Partnerships (PPP) in recent years. Investment opportunities are also appealing due to the many fiscal incentives including tax holidays and investment programs provided by the government.

Furthermore, a close working relationship already exists between the private industrial sector and the government with the MoEA, the Ministry of Finance, the DHI, the Bhutan Chamber of

Commerce and Industry (BCCI), and the Association of Bhutanese Industries (ABI) all working in collaboration towards the improvement and enhanced development of the industrial sector in Bhutan in line with the principles of GNH. Therefore, MoEA is in the best position to embrace the concept of industrial ecology as a strategy in the development of eco-industrial estates in Bhutan.

4.3.3 Enabling environment for information sharing

As the owner of the existing industrial estates, the government of Bhutan in the form of the MoEA is in the ideal position to initiate the process and practice of information sharing. Since the MoEA and the NEC both already perform the functions of collecting and storing of certain information of all industries within Bhutan, it would not be a very difficult task to improve the existing system. As the developers of the future industrial estates, the MoEA could take similar steps and ensure the development of these industrial estates incorporate industrial ecology to the maximum extent possible.

4.3.4 Diverse mix of industries

Having a wide mix of industries is encouraged for establishing symbiotic relationships as by-products generated are diverse. There exist a wide range of industries in Pasakha and Bjemina Industrial Estates. As of 2013, there are 35 and 33 different companies engaged in the operation of various types of industries (e.g., manufacturing, engineering, fabrication, food processing, service provider) in Pasakha and Bjemina industrial estates respectively. Therefore, the possibility for the formation of a number of symbiotic relationships exists within the existing industrial estates. With the introduction of industrial ecology, studies into viable symbiotic supportive projects would also give rise to new industries being proposed by the private sector, not just for within the existing and proposed industrial estates, but also in other areas. Moreover, these industrial estates currently face a lack of waste management facilities and suitable land for setup of the same. The transformation to eco-industrial estates will assist in reducing the need for these facilities to a significant level due to the increase in resource efficiency and reduction of waste generation that are part and parcel of an eco-industrial system.

4.3.4 Supportive policy measures and incentives

Various government policies and support mechanisms have facilitated in creating a conducive business environment for the establishment and/or development of industrial estates in Bhutan. Comprehensive land use policy and the creation of special economic zones are the major policy reforms in regards to the industrial development. One of the biggest constraints often cited by the business community is the lengthy licensing and other approval processes, which need to be streamlined and simplified by using the ICT tools and through better coordination of government departments (GNHC, 2015). The Economic Development Policy (EDP) 2010 aims to ensure the creation of an enabling environment for a green, stronger and sustainable

economy. On the macro-economic front, the emphasis is on the revision of the FDI policy to make Bhutan more attractive to foreign investors as well as enabling private sector development (GNHC, 2015). Various notable incentive measures such as sales tax and custom duties exemption on manufacturing and service industries for import of plant and machinery, sales tax exemption for permissible raw materials and primary packaging materials used by all manufacturing industries, income tax exemption on earnings in convertible currency of business enterprises, tax holidays for industries operating in in the sub urban and remote areas, and tax rebates for technological upgrade beyond the minimum standard required by law have been introduced. Industries that maintain higher environment standards than legislated are provided additional incentives. There is, however a need for strengthening institutional capacity in key agencies, an assurance of all-time energy availability and adoption of energy efficient technology, and more specific focus on the growth of cottage and small industries (GNHC, 2015).

5. Conclusions

The review of literature on industrial ecology and the case studies of Kalundborg Eco-Industrial Park, Burnside Eco-Industrial Park, and Map Ta Phut Industrial Estate suggest that there is a potential for developing eco-industrial estates in Bhutan. Industrial ecology, as a development strategy, would be an effective tool in addressing the issues and challenges currently being faced in the development of the industrial sector in Bhutan as well as to assist in realising the government's vision of a 'cleaner' industrial sector.

The many benefits identified by the IEAT to industry, environment, and local communities from the creation of eco-industrial estates have been demonstrated by those experienced and recorded by the Kalundborg and Burnside Eco-Industrial Parks. These examples have demonstrated that effective individual cooperative relationships could be formed if the desire to overcome challenges were present amongst stakeholders, without necessarily being guided and instructed by government authorities. Although the study of the Map Ta Phut Industrial Estate also revealed similar benefits, concerns raised by the residents of the region regarding the environmental impacts of the Map Ta Phut Industrial Estate, have shown the possibility of failure of such initiatives, despite having adopted eco-industrial development as a strategy in its development and formal mandatory environmental targets. Although not formally established, factors contributing to this could quite possibly be linked to the lack of monitoring by relevant authorities, lack of commitment of the industrialists within the industrial estate in achieving the mandatory environmental targets, or the lack of stakeholder awareness and involvement.

Review of the three case studies has shown the very importance of government initiatives, incentives, regulations and enforcement, stakeholder commitment and participation, and strong environmental management to the success of eco-industrial developments. If stakeholder commitment and participation are lacking, initiatives by the government may be futile. Benefits

established by the case studies have presented the possibilities of convincing and garnering support from stakeholders in promoting the development of eco-industrial estates in Bhutan. Similarly, the lessons learnt from the case studies, particularly from that of the Map Ta Phut Industrial Estate would be of considerable advantage in avoiding circumstances not conducive to the development. This example clearly establishes the effectiveness of market conditions, government regulations, industrial initiatives, and innovation opportunities in the successful transformation of existing industrial parks into eco-industrial parks.

It has been recommended by Chiu and Yong (2004) to adopt industrial ecology as a strategy for the economic development of developing countries in Asia. To this effect, the existence of supportive legislation, close working relationship between the government and private sectors, enabling environment for information sharing, and diverse mix of industries in Bhutan provide opportunities and supportive conditions that could serve as drivers for eco-industrial developments to take place as well as address the challenges to developmental efforts. Consequently, it is expected that the application of industrial ecology in the development of industrial estates in Bhutan will contribute significantly towards achieving sustainability in the industrial sector. Furthermore, it may be pointed out that the necessary symbiotic relationships between industries need not be limited to just within the confines of a particular eco-industrial estate, but can in fact be applied over a much broader area, thus not only contributing to the industrial sector development but also to the development of the national economy as a whole.

In conclusion, this paper has presented the possibility of applying industrial ecology in the development of eco-industrial estates in Bhutan. The development of the eco-industrial estates in Bhutan may be carried out through an approach consisting of a mix of the strategies employed by the Kalundborg, Burnside, and Map Ta Phut case studies. While the possible strategies have been detailed in the paper, the technological systems and innovations set up by the case studies did not form a part of this research and still need to be investigated in order to have a comprehensive understanding and necessary information in fully determining the viability and feasibility of eco-industrial estates in Bhutan. To fully ascertain the viability and feasibility of applying industrial ecology in the development of eco-industrial estates and quite possibly adopt it as a development strategy for Bhutan, the need for further research is required in the following aspects:

1. A study of the various existing symbiotic relationships between collaborating industries within the established eco-industrial estates needs to be carried out. Particular focus on the types of industries existing and being set up in Bhutan need to be made and accordingly a detailed study of these industries, the operational processes involved, the raw materials required for each industry, the by-products and wastes being generated and used by each industry, the methodologies employed for the exchange of by-products and waste as

resources, and the technological systems and innovations being used need to be carried out.

2. To aid the above research, a detailed study into the operations and waste generation of the industries existing and being proposed in Bhutan needs to be carried out. A study into the possible collaborative symbiotic relationships and the measurable benefits to the environment and economy as well as to the community needs to be assessed.

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