ECO-INDUSTRIAL NETWORKING OF THE RICE AND LIVESTOCK SECTOR AT CHACHOENGSAO PROVINCE, THAILAND

C. Visvanathan,

Environmental Engineering and Management Programme,
School of Environment, Resources and Development,
Asian Institute of Technology, P.O. Box 4, Klong Luang,
Pathumthani 12120, Thailand

Email: visu@ait.ac.th

Abstract

Chachoengsao Province located at the east of Bangkok is primarily an agricultural area with vast lands devoted to cultivation and farming. Livestock rearing, especially piggeries and poultries are supplementary sources of income for many families in this region. In the recent years, Thailand has ventured into new markets related to food processing and export, resulting in a corresponding increase of pressure on the agribusinesses to meet market demands. The consequence of this resultant pressure is observed in the form of rapid resource consumption and pollution at various levels and parts of the ecosystem. Agricultural residues and excreta from livestock farms pose severe threats to the region. The potential of these wastes to serve as alternative energy sources remains largely underutilized. This paper attempts to create an eco-industrial network by forming new energy businesses that can both solve the pollution crisis and contribute to improved environmental quality and increased resource efficiency.

1.0 Introduction

Thailand, traditionally an agrarian country, has been a major food exporter and is undergoing rapid economic change along with industrial growth. Exports continued to be Thailand's main growth driver in 2007, amounting to nearly USD 152.5 billion, over 17.5 % from 2006. High overall export growth was underpinned by strong performance in all manufactured product groups, especially labor-intensive and resource-based goods, while agricultural exports slowed down relative to a remarkable expansion in 2006. Agricultural exports grew at 26.7% in 2006 while in 2007 it was only 15%. (World Bank, 2008). This double-digit growth rate was contributed by both higher export volumes and prices. Although agriculture's share in GDP is 10 %, the sector is home to 40 % of the population and also 40 % of the poor in Thailand. Increasing agricultural productivity will not only sustain the growth of agriculture supply in Thailand but also raise the livelihoods of those in the sector.

The rate and pattern of industrialization in Thailand have resulted in many environmental problems which the country is not well-equipped to deal with. For example, heavy concentration of industries in the Bangkok Metropolitan Region and its surrounding provinces have accelerated urbanization and compounded urban problems. Traffic congestion, water shortage, solid waste management, air quality, sewage and wastewater disposal and noise pollution problems have worsened noticeably during the last few years of rapid industrialization. A decade after the financial crisis which devastated Southeast Asia in the

mid-1997, the region, nevertheless is much wealthier; has fewer poor people and a larger global role than ever before (World Bank, 2008).

In essence, Thailand is currently facing the onslaught of industrialization, population explosion, and urbanization. Abundant resources of yesteryears have now become scarce; thanks to the near-exponential rate of consumption. Industrial production processes and domestic consumption patterns have changed in such a way that a considerable portion of resource is discarded as waste.

1.1 Industrial Ecology

Industrial systems aimed at efficient sharing and utilization of resources, technologies focused at alternative use of discarded materials and policies envisaging and enforcing the above are needed to tackle resource and waste crises.

The term "Industrial Ecology" was first introduced in 1989 by two General Motors's researchers Robert Frosch and Nicolas Gallopoulos. The concept spurred out in them as a result of the thought that it should be possible to develop industrial production methods that would have considerably less impact on the environment. This hypothesis led them to introduce the notion of industrial ecosystem (Erkman, 2001). Such an industrial ecosystem would function as an analogue of biological ecosystems.

Garner and Keolaeian (1995) define Industrial Ecology (IE) as the study of the physical, chemical and biological interactions and interrelationships both within the industrial systems and between industrial and natural ecological systems. Industrial symbiosis is a sub-field of industrial ecology and advocates for industries organized along the model of an ecosystem, looking at both environment and economy. As a means of achieving ecologically sustainable industrial activities, it engages industries traditionally separate in a collective approach to gain competitive advantages involving physical exchanges of materials, energy, water, and by-products (Chertow, 2000).

The potential magnitude of the influence on the natural world across the full spectrum of industrial activities has been underappreciated in the business world (Graedel and Allenby, 2004). Usually, companies plan their development within a product-market matrix and all environmental issues are considered secondary to the main goal, resulting in a growth in industrial output accompanied by a more rapid growth in pollution and wastes (Erkman and Ramaswamy, 2003). Traditionally, industries have always given importance to maintaining their market position, income and profits, through high consumption and high outputs, eventually resulting in high pollution. Constraints from adoption of advanced technologies, uneconomical production scales, low production efficiency and severe pollution have challenged their competitiveness.

Involvement of industries is considered crucial if the world is to achieve sustainable development, and responsible corporations may turn out to be among the global leaders in their transition between non-sustainable and sustainable development (Graedel and Allenby, 2004).

1.2 Eco-Industrial Parks

An Eco-industrial Park (EIP), as defined by Lowe (2001) is "a community of manufacturing and service businesses located together on a common property. Members seek enhanced environmental, economic and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize by only optimizing its individual performance.

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impacts. Components of this approach include green design of infrastructure and plants, cleaner production, pollution prevention, energy efficiency, and inter-company collaborations. An EIP also seeks benefits for neighboring communities to assure that the net impact of its development is positive.

1.3 Eco-Industrial Networks

While the concept of Eco-Industrial Parks attempts to reflect the inter-linkages and material flows observed between organisms in natural ecosystems and an industrial system, there are several definitions that could describe EIPs and similar structures, primarily by the level of geographic concentration and fields / complexity of co-operation.

Enhanced cooperation and exchange between companies, park management and local/regional decision makers and the stakeholder striving towards a common vision of industrial activities which are of utmost importance to sustainability in terms of economic, ecological and social aspects is a key characteristic of EIPs. This mandates physical proximity or co-location on a common property to initiate collective action.

Alternatively, a Virtual Eco-Industrial Park, a region, in which industries are not necessarily co-located, but linked through exchange of waste and collaboration at different levels could also exist, still achieving the goals of an EIP (Cohen-Rosenthal, 1996).A community of business, not necessarily co-located but still be able to participate in a network specializing in collection, reuse, recycling, and remanufacturing make a complete Eco-Industrial Network (EIN). This system may be created by an industrial park, a service business or utility, an independent entrepreneur, or possibly by a public industrial development agency. The core services essential for the successful performance of an EIN includes, consulting to support projects, comprehensive audit of materials, energy, and water flows through the entire system to prioritize opportunities for increasing efficiency and lowering pollution, evaluate the feasibility of internal reuse, exchange with neighboring plants, and or resource recovery.

Other supplementary services for the EIN members would include cost reduction through common procurement of goods and services, integrating employee transportation management and resource pooling. In Thailand and other parts of the world, eco-industrial development and networking of businesses have been tried only in the high-tech sector. Networking of manufacturing, chemical, petroleum-based, and pharmaceutical industries have successfully proved themselves in forming eco-industrial networks.

This paper attempts to apply the principles of eco-industrial networking in the agribusiness sector, the often-overlooked ones in development and industrial planning, precisely, the small and medium, rice and livestock industries in the rural provinces of Thailand that form a critical supply chain linked to both national and global markets. Their role in local regional and national economic development is as important as any other sector. Indifferent from other industries, the member businesses of the chain are compounded with wide-ranging issues of market retention, competitiveness, pollution problems and resource threats. Creating an eco-industrial network of the disjointed industries and business in the chain could aid in confronting the issues more comprehensively. In this context, the objectives of this paper are to apply the principles of eco-industrial networking on the rice and livestock sector, identify the technology needs for EIN formation, and comprehend the direct and indirect policy support to EIN formation.

2.0 Study Area

Chachoengsao, a province to the east of Bangkok metropolis is one of the major rice bowls of Thailand with an area of 5,400 km^2. Figure 1 presents the location of Chachoengsao Province.

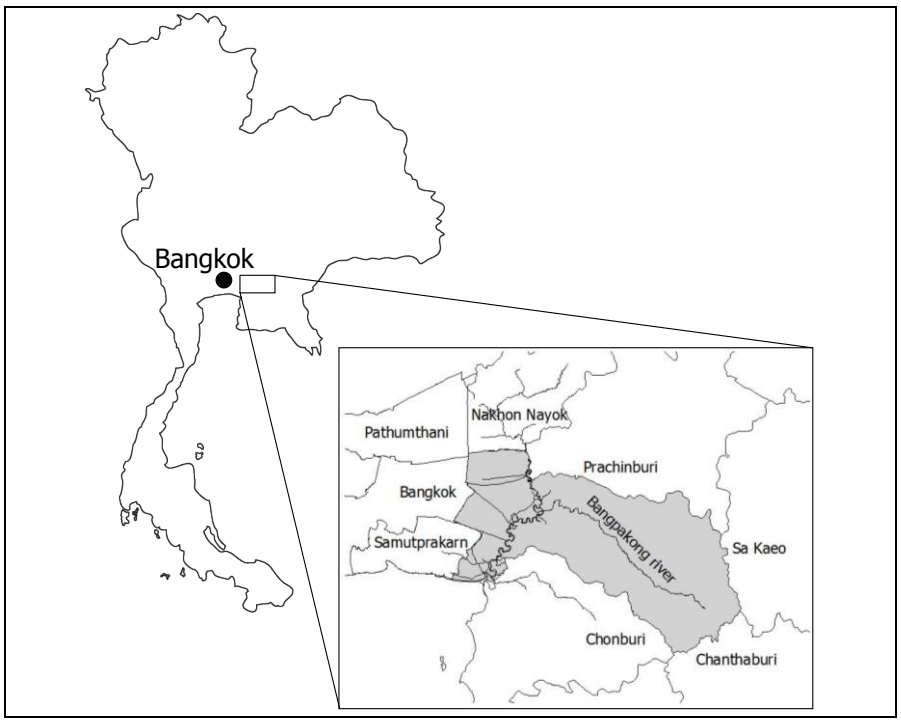


Figure 1 Location Map of Chachoengsao Province

From Figure 2 it could be observed that the population growth in 2003 and 2004 has a negative trend, indicating a population decrease (DoS, 2005). In a developing country like Thailand, especially in rural areas, decreasing population trends are subject to speculation with two possible reasons either the spread of epidemics or population migration. No life-threatening epidemic has been reported in the region during the recent years. Outward migration to nearby urban areas such as Bangkok in search of employment opportunities and other amenities is expected to be the principal cause of population decrease.

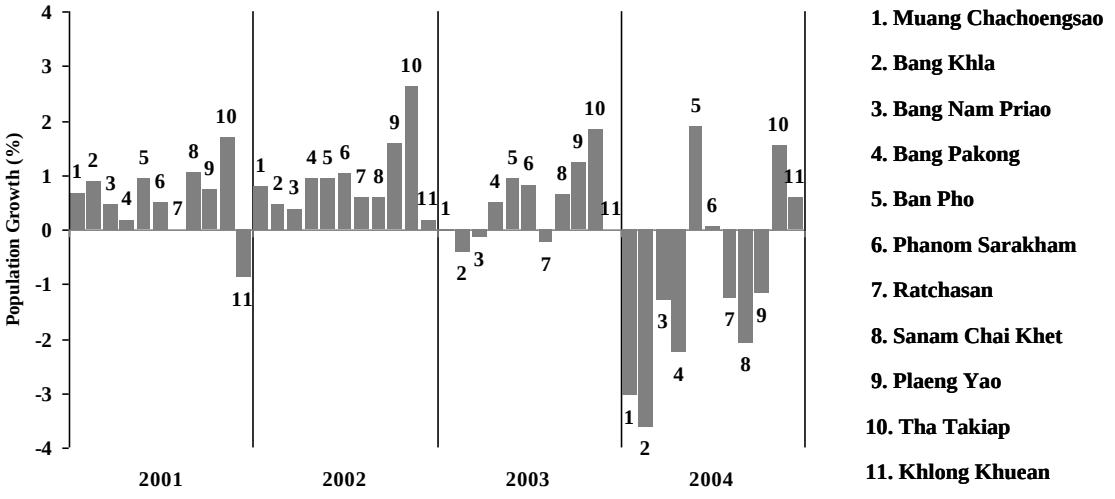


Figure 2 Population Growth Trends in Chachoengsao Province

The topography of the region enables the well-irrigated plains of the Province to practice paddy cultivation and cattle farming. Presently, cultivation lands exceed 60% of the area; half of which is rice, the major economic crop with a yield of about 3.5 tons/ha. Due to efficient irrigation systems, paddy fields of Chachoengsao are highly productive and support up to five harvests in two years. Figure 3 presents the agricultural land use pattern of Chachoengsao (OAE, 2003). From the figure, it is evident that agricultural land use has been declining over the recent years. The Bang Pakong River flowing across a distance of about 120 km is the main water source for about 10 districts of Chachoengsao Province. About 180 million m^3 of water is used for domestic, agricultural and industrial purposes.

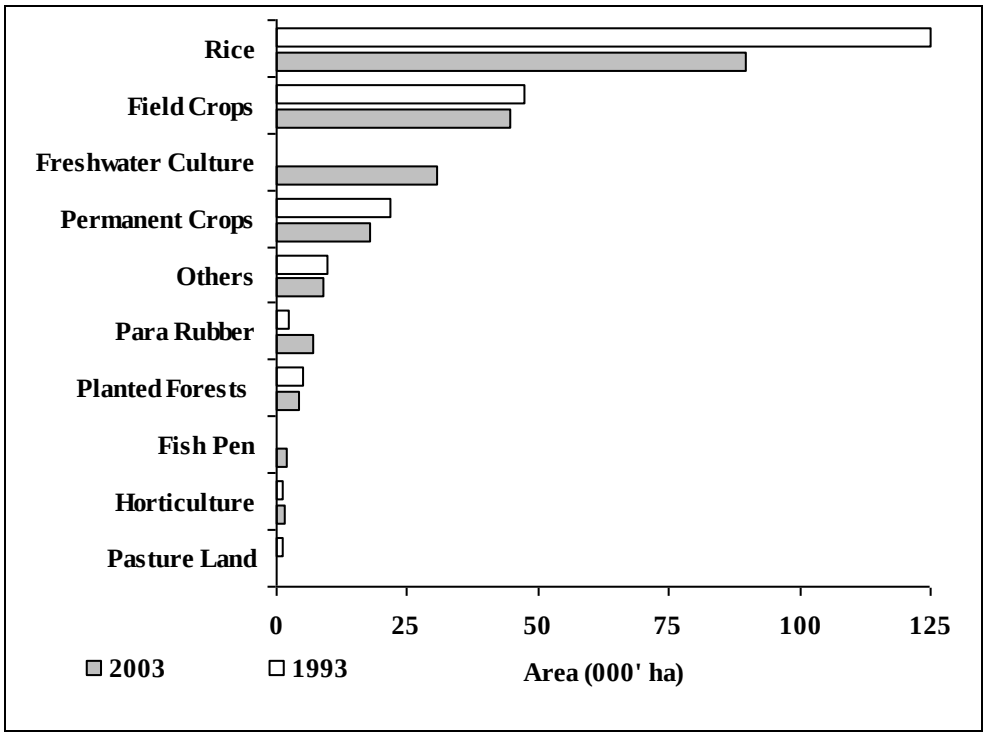
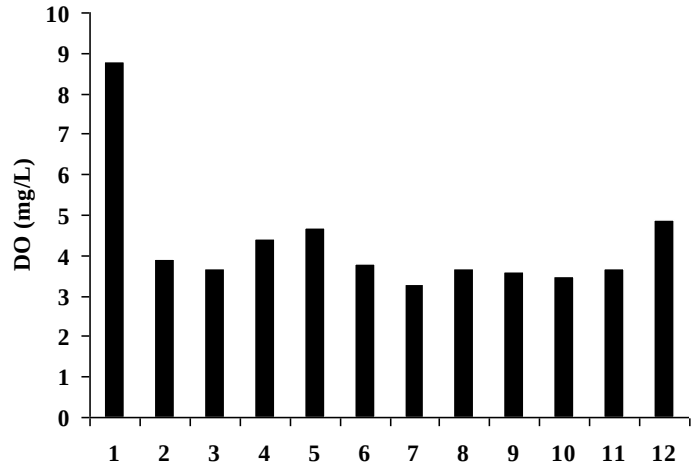


Figure 3 Agricultural Land use in Chachoengsao Province

2.1 Issues in the Rice and Livestock Sector at Chachoengsao

Water Quality Issues

Increasing industrial and agricultural activities have contributed to serious water quality concerns in the Province. Most of the water quality parameters exceed the limits prescribed by the Ministry of Health. While all regulatory measures have been taken to ensure better quality, water pollution remains a major concern for the civic bodies. Figure 4 presents data on Dissolved Oxygen content in Bang Pakong River at various locations, from the origin to its confluence in Gulf of Thailand.



1. **Bangpakong water source**
2. **Bang-ka-nark bridge**
3. **Hor-Sai Temple**
4. **Bangk Khla Pier**
5. **Bangpakong Dam**
6. **Saichon-na-Rungsri**
7. **Chachoengsao bridge**
8. **Baan-bang-pa bridge**
9. **Ban-Po bridge**
10. **Motorway bridge**
11. **Bangpakong bridge**
12. **Bangpakong estuary**

Thai Standards for Water Quality
Class 2 >=6.0; Good
Class 3 >=4.0; Fair
Class 4 >=2.0; Poor

Note: Data for Locations 1- 7 were recorded in 2008, while for 9-12 in 2007. The data is indicative of the water quality and does not represent variations in DO due to flow of the river.

Figure 4 Dissolved Oxygen in Bang Pakong River water

Bang Pakong river water quality is periodically monitored and has been categorized under Class 3 and 4 of the standards. Bang Pakong River water has Dissolved Oxygen (DO) content of around 4mg/L in most places and is categorized as Class 4. Bang Khla and Bang Nam Priao districts are under Class 3 with DO of 1.0-1.9 mg/L and Fecal Coliform bacteria of about 40-2,400 MPN/100 ml (MoPH, 2005).

Agriculture

Rice cultivation is practiced on the banks or near the rivers and canals. Bang Pakong, Ban Pho, Chachoengsao Muang, Bang Nam Priao and Klong Khuen districts are predominantly paddy fields. Water pollution problems are mostly observed in the post-harvesting period. Paddy stubble and agricultural residues left after harvesting are flooded with runoff water and discharged into the local watercourse. Intensive agricultural practices with huge amounts of pesticides and fertilizers have lead to contamination of both ground and surface water sources.

Livestock

Many cattle and livestock farms are present in Chachoengsao Muang, Bang Khla and Phanom Sarakham district. About 900,000 pigs are grown in over 1,750 farms in these districts. On an average, a farm with about 200-2,000 pigs generate wastewater at the rate of about 12.5 L/pig/day with Biochemical Oxygen Demand (BOD) between 1,400 - 4,750 mg/L (PCD, 2005). The average BOD is about 17.65 g/pig/day with a maximum of 58 g/pig/day.

Waste generation from pig farms is about 5 kg/pig/day. About 75% of the pig farms have composting pits, but in reality, the waste is discharged into nearby water sources. Pig farms in Muang Chachoengsao and Bang Khla district cause havoc in water quality, especially in the upstream areas of the Bang Pakong Barrage.

Chachoengsao Province is one of the less urbanized and industrialized regions of the country evidenced by the presence of traditional agro industries. The eastern districts of the Province, also the fringe areas of the Bangkok urban, are well irrigated by the Bang Pakong River and support paddy cultivation largely. Soil conditions favorable for paddy cultivation, abundant water supply through out the year and availability of labor promotes agriculture as a mainstream occupation.

3.0 Components of the Eco-Industrial Network

An analysis of the industrial profile of Chachoengsao Province clearly indicates the role of agriculture and livestock in regional development. Both agriculture and livestock are resource dependent; one is a major resource consumer - the agriculture sector, and the other is a major source of pollution - the livestock.

Agriculture and livestock are traditionally small and medium scale industries with commonalities in their supply chain. The system under consideration is the predominant agriculture sector with rice as the major product, the scattered piggery sector, and the small number of poultry farms. An understanding of these agribusinesses clearly indicates that a reasonable potential exists in their networking.

3.1 Flow of Materials in the Rice and Livestock Sector

The rice and livestock businesses of the region are the lifeline of many communities. The simple, yet significant, linkages in the sector support the economy in more than one way. With no clear starting point, the material flow is rather cyclical than linear. Almost all materials, by-products and wastes or residues find use in one or other component of the entire system. However, the productive use of materials is an issue that remains weakly addressed.
For the purpose of illustration, the material flow starts with paddy cultivation in and proceeds as many steps as possible until all the products and by-products are completely utilized. Similarly, the piggery and poultry sector, which at the first glance do not seem to have a linkage with the agriculture sector are also latently connected through vital material flows. Figure 5 presents the material flow pattern in the region. From the figure, it is evident that though a near-perfect material flow occurs, pollution problems due to unrecognized value of materials still exist, thus creating a weak form of eco-industrial network revolving around the agriculture based industries.

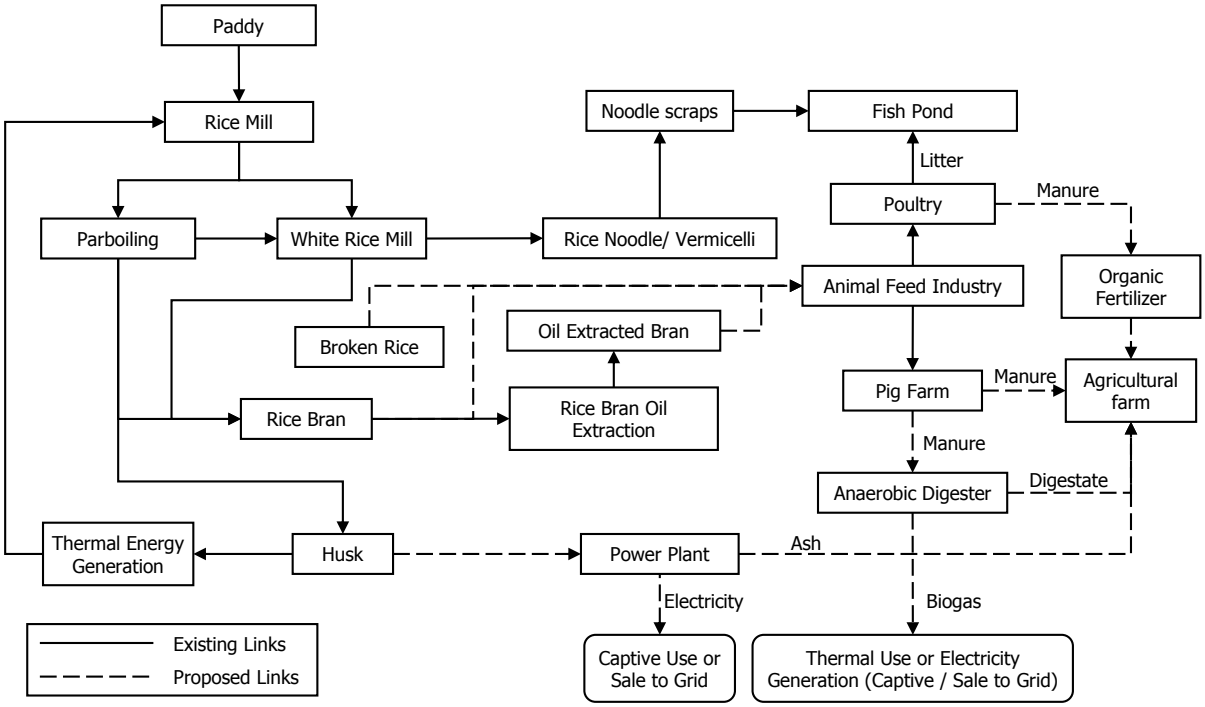


Figure 5 Proposed Eco-Industrial Network in Chachoengsao

The missing or faint part of the eco-industrial network is the lack of productive or best use of the materials presently discarded as waste or those used in a relatively inefficient manner. For example, while the cost of electricity and fossil fuels are shooting up, rice husk, well known for its calorific value and potential for use as a renewable fuel source has not been appropriately realized. In the present situation, rice husk is mostly used for heat generation using primitive technologies resulting in poor thermal efficiency. This also results in lesser eco-efficiency of the material. Another latent drawback of such primitive technologies is reflected in the form of partial combustion of the rice husk. Ash resulting from the combustion is often disposed haphazardly or in some cases used for soil enrichment in agricultural fields. Thus, the productive or best possible use of material is a concern in the region to improve the eco-efficiency of this chain in the system.

The livestock sector poses a different kind of threat. Both piggeries and poultries generate enormous quantities of waste that carry significant value, but are either totally or partially unrecognized in most cases. The reasons for this are many - varying from non-availability of affordable technology to the need for adopting them. Livestock businesses in Chachoengsao have grown over time and their interest in environmental protection and resource conservation is minimal. Farms tend to place the focus only on breeding and rearing, the core purpose of the farms. Thailand is a developing country that has very little stringent regulations on environmental issues arising from the livestock sector. Enforcement of any legislation is another issue that has a totally different perspective. Both environmental awareness and their corresponding legislations (setting of standards) have advanced considerably in recent years, but enforcement is lagging. With no appropriate driver for change, these livestock units have been continuing a business-as-usual scenario, with little care for the environment.

In the present scenario of escalating demand for agricultural products and increasing opportunities for agribusinesses, mitigating the stress on the environment and natural

resources is important to ensure sustainability. In this context, introducing affordable, cost-effective technologies and encouraging policies are essential to transform the present weak and faint eco-industrial network to a more robust one aimed at improving eco-efficiency and driving overall sustainable development.

3.2 Regional Network of Industries

The concept of Eco-Industrial Networking has already been tried and tested in the case of Map Ta Phut Industrial Estate (Chiu and Yong, 2004; Fleig, 2000).The results have shown enormous opportunities for environmental and social development. Proximity or co-location on a common property without any restrictions on physical access has been a major success factor in the case of the Map Ta Phut Industrial Estate. Moreover, the Estate was developed strategically with forethought allowing room for introduction of new concepts and practices. Therefore, introducing the concept of Eco-Industrial Development, with special emphasis on networking was not very tough, with its inherent problems though.

The rice and livestock eco-industrial network has a broader geographical scope, indicating that co-location or physical access is not available and possible. Almost all industries considered in the eco-industrial network are already functional and have been established under various conditions; economic, geographic, resource, labour, raw material and market accessibility, etc. The physical relocation of these industries, therefore, is not possible. The rice and livestock businesses form a regional network consisting of various linkages with product, by product and waste flows, in addition to possible information and knowledge exchanges. Thus, the eco-industrial network has a wider stakeholder group bonded not by geography and physical co-location but by their commonalities in resource dependence. Strengthening the network to make it more robust involves the role of different stakeholder groups.

4.0 Technology Needs for Eco-Industrial Networking

The present level of modernization in the agribusinesses of Chachoengsao could be rated as primitive or in some cases intermediate. Most of the small and micro business units in the region are driven by raw material availability and income generation than capturing business or increasing markets. Therefore, the need to shift to advanced technologies has not yet been felt by the entrepreneurs.

An understanding of the material flow provokes thoughts on the resource efficiency of the processes in the business units. The issues on resource use and waste disposal pattern in the region can be thought of under two different perspectives; lack of awareness on reuse / alternative use of materials and lack of awareness on best possible use of materials. Careless disposal of resources in the form of waste is commonly observed in the region. The latent value of such discarded materials is often unknown or unrealized. In some cases, though materials are reused and recycled, it still does not happen in the best possible way. In other words, materials that could be used for much better are put for ordinary purposes. Whatever be the issue, in both cases lower material/resource efficiency of the business unit affects the whole system and the region in various ways. With this background, the following technologies are essential for the eco-industrial network to become dynamic and robust.

4.1 Rice Industries

Strengthening the eco-industrial network in the sector could be achieved by making the best possible use of the materials. Ideally, these agricultural residues, paddy straw and rice husk could be used to generate electricity for in-house consumption or for exporting to the grid. For example, the 15 MJ/kg of energy potential of rice straw is used for thermal energy generation at lower thermal efficiency. This could be more efficiently used to generate electricity and save costs on power generated from fossil fuels in addition to the environmental benefits.

The energy required for the rice mill can be obtained from the utilisation of the husks. In many rice mills, husk is burned in furnaces with low thermal efficiency leaving black ash of high-unburnt carbon. Assuming that all rice husks are utilized for power generation, and a specific consumption of 2 kg/kWh the theoretical power potential is considerable that it cannot be put to any simple use. Nevertheless, a consistent and stable supply of paddy for milling and rice straw is essential to establish and operate the electricity generation system. The size of the individual mill and its supply chain are key factors in determining the feasibility of generating power, the study of which is beyond the scope of this paper.

4.2 Rice Processing Units

The rice processing units in the region are typically small and medium enterprises with limited funds and relatively intermediate technology. Some industries have been using superior technologies, most of them are limited to improving productivity, reducing energy and raw material consumption, and thereby increasing profits. Very few industries have implemented waste recovery or wastewater treatment systems.

All of the rice products prepared in these industries require extensive water in the process. Wastewater streams arising in the various stages of processing contain large amounts of starch dissolved in it. Almost all industries in the study region, simply discard the starch laden wastewater in their backyards or in nearby water bodies. Starch, typically consists of high amounts of carbohydrates and is organic in nature thus imparting very high BOD. Essential technologies for rice processing industries include recovery of starch from wastewater and (or) anaerobic digestion systems to extract biogas.

4.3 Piggery

The piggery sector in the study region has been following various innovative and modern business models (Tisdell, Murphy and Kehren, 1997). Nevertheless, all these models have been developed, tested and implemented in improving productivity. Very little focus has been made on waste disposal issues and environmental concerns.

The piggeries of the study region are predominantly owned and operated at the family level, giving little room for technological advancements owing to financial constraints. However, the environmental issues rising from these sectors are so serious that they cannot be sidelined under any circumstance.

Technologies have been constantly evolving to provide low-cost and efficient solutions for solving the waste disposal concerns of the piggery sector. Integration of waste handling and

treatment systems in the business models is essential to ensure environmental and economic sustainability.

Anaerobic digestion of piggery waste has been widely tried and tested in many countries across the world. The results are appealing in most of the cases. Piggeries in Chachoengsao need to be familiarized with this technology as a means of reducing cost through parallel businesses of electricity generation from biogas generated in anaerobic digesters. The digestate and residues resulting from the digestion process have a potential to be used as organic fertilizer in agricultural fields.

4.4 Poultry

Unlike the piggeries, environmental issues posed by poultries are confined to the farm. Poultry litter or bird droppings are the feces of the birds - chicken and ducks mainly. The open dumping of this poultry litter releases huge amounts of methane due to uncontrolled decomposition. Technologies for high rate bio-methanation are essential to recover resources out of the so-called waste.

The highly organic nature of the wastes generated from all the major components of the EIN make anaerobic digestion a promising option for its treatment. However, the main constraint lies in the volume of generation and the location of the sources of waste. Evidently, the rice based industries, piggeries and poultries are not co-located, but are distributed over the entire region, yet the issue is the same. Considering the scattered nature of the industries and farms and the difference in the type of wastes they generate, distributed or decentralized small-scale waste treatment systems adopting anaerobic digestion technology for biogas generations is an attractive option to turn problems into opportunities.

Experiences across the world indicate that small scale anaerobic digesters with digester volumes as small as 25-70 m^3 could be successful in their operation (Lansing, Boterob and Martina, 2007). Simple flow-through reactors consisting of a tubular polyethylene bag, PVC piping, and plastic hosing to transport the biogas from the digester have proved to be successful in similar applications (Chará, Pedraza and Conde, 1999). Providing such small scale decentralized anaerobic digestion systems at the local level could help creating additional businesses and employment opportunities apart from solving the waste disposal crises and creating a functional eco-industrial network at a regional level.

Where treatment of a single waste stream through anaerobic digestion becomes impossible or unattractive, co-digestion through mixing of different waste streams could also be attempted. Whatever be the case introducing waste-to-energy systems through biomass or anaerobic digestion could aid the formation of the EIN.
Apart from avoiding/reducing waste disposal crisis, these technological interventions can also aid in getting additional income through sale of a carbon credits under Clean Development Mechanism of Kyoto Protocol. This applies to all technological interventions recommended, such as biomass based power generation from agricultural residues, anaerobic digestion for piggery waste management and high rate bio-methanation for poultry waste.

5.0 Policy Setting for Eco-Industrial Networking

In a country like Thailand where agribusinesses are often taken up to ensure livelihood, environmentally conscious development can be imparted only through policies and State initiated programs. After the 1997 crisis, Thailand has restored its economic position among the Southeast Asian countries through various policy reforms. This demonstrates the role pro-development policies can play in uplifting the nation.

In the present situation, eco-industrial development has been taken up as an initiative of the Industrial Estate Authority of Thailand. No specific policies enforcing or encouraging eco-industrial networking is present. The transformation of isolated industries into an eco-industrial network through resource-efficient linkages or strengthening the weak linkages such as the ones discussed here can be initiated, implemented and accelerated only through well-formulated policies. With this hypothesis, the following sections present an overview of the prevailing policies.

5.1 Thai SME Policy

The agribusinesses in the region fall into the Small and Medium Enterprises category. Realizing the need and potential of its SMEs, the government has made strong policies in accelerating their growth through institutions such as, SME Development Bank of Thailand, Office of Small and Medium Enterprises Promotion and Institute of Small and Medium Enterprises Development etc. These agencies and institutions perform with the objectives of promoting sustainable growth in SMEs by upgrading competency and labor skills, technological aspects, R&D, clustering and integration; developing SMEs in communities, regions, and rural areas, in the context of local resource utilization; financially supporting and SMEs to improve efficiency and capability; promoting R&D including technology transfer and local know-how; promoting linkages and networking among SMEs; supporting the development of the small-scale enterprises and community enterprises in rural and urban areas and setting up networks and clusters of SMEs.

5.2 Incentives by Board of Investment

The study area, Chachoengsao Province is classified under Investment Zone 2 of the Thai Investment Promotion Zones. New industrial activities in these regions qualify for fiscal rebates such as 100% waiver of import duty on machinery for industries in estates, 50% waiver for industries outside the estate, corporate income tax exemption for 7 years for industries within industrial estate and 3 years outside the estate and exemption on import duty for raw material for one year in both cases.

In addition to the Promotion on Investment Zones, agro processing and waste re-processing have been identified as priority activities. Special incentives such as machinery import duty exemption and corporate income tax exemption for a period of 8 years regardless of zone with no limits among other rights and benefits from BoI are granted for agro processing and waste re-processing industries.

New measures by the Board of Investment encourage existing plants investing on environmental protection technology and looking beyond legal minimum standards include

import duty exemptions on machinery and equipment, and corporate tax holiday, designed to cover 70 % of the expense of the investment, over a three-year period. A double tax deduction on the expense for companies that invest in environmental protection activities is also envisaged.

5.3 National Economic and Social Development Plan

The Ninth National Economic and Social Development Plan 2002-2006 was based on the philosophy of "sufficiency economy" bestowed by His Majesty the King. The philosophy intends to overcome the economic crisis brought about by unexpected change under conditions of rapid globalization, and achieve sustainable development. Developing local economies, small and medium scale enterprises, and cooperative systems; marketing and distributing products from local to regional, national and international markets; distributing economic growth and development benefits; developing networks, cluster creation and linking public, private, and civil sectors, decentralizing growth in and to regional areas and emphasizing development of production networks, supply chains and services are some of the salient features of the philosophy.

5.4 Energy Sector

Plans in the energy sector include policies to promote the use of alternative fuels, set up an energy regulatory board, and investments in electricity and natural gas to meet the growing demand. The current efforts on the promotion of biofuels and using renewable sources indicate the Governments strong support in promoting alternative energy.
Regulations on renewable energy sources have been amended to promote their greater use. The original regulation on Very Small Power Producers allowed them to connect to the national grid at commercial rates. The new regulation introduces a subsidy on the commercial rates, ranging from THB 0.3 – 8.0/kWh for seven years. In addition to the subsidy, a generator's net flow to the grid was expanded from 1 MW to 10 MW. This encourages larger generators, or projects that require scales, to connect to the grid easily. The new regulations also extend eligibility to cogeneration as well.

Renewable Portfolio Standards
The Royal Thai Government has an objective of increasing the renewable energy utilization from 0.5% at present, to 8%, by 2011. In reaching this target, biomass-based energy is expected to provide a share in excess of 60%, reflecting the fact that Thailand is a country highly dependent on the agricultural sector and hence has access to large amounts of waste agricultural material. To achieve the 8% goal, the government encourages the power producers to generate 1,900 MW from renewable sources. Independent Power Producers are required to meet the Renewable Portfolio Standard to accelerate renewable energy utilization. Under this, power producers willing to sell power to the national grid are required to generate 5% of their energy from renewable sources.

A thorough analysis and understanding of all the policies relevant to eco-industrial networking clearly indicates excellent support from the government for the development of new industries and businesses. Looking at the policies in a segmented view indicates high possibilities of creating new networks and strengthening existing ones through creation of new businesses aimed at bridging the gap to close the material loop. Looking holistically, the availability and accessibility to adoptable technology is a big challenge. While the prevailing

policies are encouraging, technologies are not. In such a situation, it is essential to develop policies that are not fragmented but are tethered with the goals of eco-industrial networking.

6.0 Conclusion

An analysis of the rice and livestock agribusinesses in Chachoengsao provokes multipoint thoughts. The commendable point here is the role of the agribusinesses in the economic contribution to the Province in terms of providing employment, regional income, livelihood and opportunities for business and trade. However, the agribusinesses are haunted by various issues that need to be resolved in improving their competitiveness and enhancing its sustainability. In this endeavor, an understanding of the sector places importance on three factors that cannot be neglected; material flows, technology status, and policy interventions.
Material flow in the region is remarkable yet offering possibilities for its strengthening. The real value of some important materials has been unrecognized thus leading to its indiscriminate use or pollution. An understanding of the materials disposed as waste clearly indicates a lack of technology to make the best use. Small-scale, decentralized, cost-effective, affordable and replicable technologies are vital to make the best use of the waste materials. Introduction and or transfer of technology are essential to improve the eco-efficiency of the agribusinesses in the region.

Independent of all other benefits, the districts of Chacheongsao province focused in the study fall in the fringe trapped between the rural areas and the urban Bangkok. Eco-industrial networks in this rural-urban fringe provide environmental benefits in terms of reduced pollution to both regions.

In a developing country like Thailand, proactive policies have favored growth largely. The success showcase of positive and visionary policies is wide and needs no illustration. The material flows in the studied agribusinesses show promising results. The role of technology in forming an eco-industrial network is evident. However, the transformation has to be invariably driven by policies. At present, the policies of the Thai government are favorable for the Small and Medium Industries and address specific issues. Policies for SMIs, Investment Promotion and Energy generation, directly relevant to the eco-industrial network are positive and appealing. Precisely, the recent policy of the Board of Investment on environmental protection and pollution control is encouraging. Such policies need to be reformulated or refined to go beyond protection and focus on efficiency improvement through eco-industrial network formation. Eventually, improvements to the policies will foster sustainable development and contribute in achieving the Millennium Development Goals through poverty alleviation by additional income generation and better living conditions from improved local environment.
Given that, the material flow has potentials for improvements in eco-efficiency, the transfer or introduction of appropriate technologies through proactive policies, the eco-industrial network can be a successful model for agribusinesses across the country and the world.

References

Chará, J., Pedraza, G. and Conde, N. (1999) The productive water decontamination system: a tool for protecting water resources in the tropics, *Livestock Research for Rural Development*, Vol.11, No.1, Online Edition

Chertow, R. Marian (2000) Industrial Symbiosis: Literature and Taxonomy, *Annual Review of Energy and the Environment*, Vol 25, pp.313–337

Chiu, S.F.A and Yong, G. (2004) On the industrial ecology potential in Asian Developing Countries, *Journal of Cleaner Production*, Applications of Industrial Ecology, Vol. 12, No. 8-10, pp.1037-1045

Cohen-Rosenthal, E (1996): "Top Myths about Eco-Industrial Parks" Obtained through the Internet: http://www.cee.cornell.edu [accessed 30 September 2008]

DoS, (2005) Provincial Statistical Report, Department of Statistics, Chachoengsao Provincial Government, Thailand

Erkman, S. (2001) Industrial Ecology: A New Perspective on the Future of the Industrial System, *Swiss Medicine Weekly*, Vol. 131, No. 37-38, pp531– 538.

Erkman, S. and Ramaswamy, R. (2003) Applied Industrial Ecology: A New Platform for Planning Sustainable Societies, Bangalore: Aicra Publishers

Fleig, A. (2000) Eco-Industrial Parks: A Strategy towards Industrial Ecology in Developing and Newly Industrialised Countries, Eschborn: GTZ

Garner, A. and Keoleian, A. (1995) Industrial Ecology: An Introduction, Michigan: University of Michigan

Graedel, T. and Allenby, B.R. (2004) Industrial Ecology (2nd ed), Beijing: Tsinghua University

Lansing, S., Boterob, R. B. and Martina, J.F., (2007) Waste treatment and biogas quality in small-scale agricultural digesters, *Bioresource Technology*, Vol. 99, No. 13, pp.5881-5890

Lowe, E. (2001) Eco-industrial Park Handbook for Asian Developing Countries, Manila: Asian Development Bank

MoPH, (2005) Annual Health Report 2005, Ministry of Public Health, Thailand

OAE, (2003) Agricultural Statistics of Chachoengsao - 2003, Office of Agricultural Economics, Thailand

PCD, (2005) Pollution Control Department, Ministry of Natural Resources and Environment, Thailand

Tisdell, C., Murphy, T. and Kehren, T. (1997) Characteristics of Thailand's commercial pig and poultry industries with international comparisons, *World Animal Review*, FAO 1997

World Bank, (2008) Thailand Economic Monitor 2008, World Bank Office, Bangkok, Thailand.