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ECO-Industrial Clusters: Pathways for Evolving New Business Models for ECO-Innovation and Green Growth

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Industrial Clusters development has so far been very successful experience in transforming the economy of many countries and spread of multi-national companies (MNCs) in several parts of the world. Unlike Industrial-clusters per se Eco-Industrial Clusters (EICs), are defined as: "A community of business; geographic concentration of interconnected companies in a specialized field that cooperate with each other and with the local community to efficiently share resources (information, materials, energy, water, infrastructure, finance, etc), leading to improved environmental quality, economic gains, and equitable enhancement of human resources for both the business and local community." Essentially, an Eco-Industrial Cluster (EIC) aims at efficient use local renewable/ recyclable resources while achieving economic development targets and meeting the social demands of the local community. The potential benefits expected from eco-industrial cluster development are multiple, viz. zero emission, employment generation, new product development, branding, eco-labelling and green growth. The paper attempts to put together and highlight some of the recent innovative planning, use of eco-designing approaches and achievement in developing the concept as well as project-based applications of eco-industrial clusters, with focus on eco-innovation, sustainable development and green growth by developing innovative and replicable business models for local and regional development. The paper also highlights the evolution of various types of Eco-clusters, criteria for selection of clusters; and some of the successful eco-industrial cluster-based business models in many parts of the world, including in India, and the learning thereof for future improvement. Impact analysis and business potential of Eco-industrial clusters are also discussed briefly in the paper.

Key words: Eco-industrial Clusters, Eco-innovations, Green Growth, Sustainable Development

Introduction

Current researches in industrial ecology indicate that geographic proximity of economic activities enables higher levels of productivity and innovation. Clusters, i.e. geographically co-located producers, suppliers, service providers, research laboratories, educational institutions, and other institutions in a given economic field, are important drivers of dynamic regional economies. Way back in the late 19th century, the renowned economist Alfred Marshall (Marshal, 1820, 1890) investigated industrial districts. He identified externalities that were caused by the local availability of qualified labour, a growing demand in the location and a high specialization of companies at different levels of the value-chain. He came to the conclusion that the industrial atmosphere contributes to the improvement of social and economic performance of the companies located in the districts.

The geographic agglomeration of firms within industries is a visible fact in many countries and has been recognized many years ago. The auto industries clustered around Detroit in the USA and Turin in Italy are well-known examples. Later, the high-tech industries settled in Silicon Valley at San Francisco and around Boston in the USA whereas Dublin is known as a home for high-tech firms in Europe. Economists have developed a lot of different theories explaining why firms may locate next to each other and which kind of competitive advantages they gain from their location. However, when it comes to the size of these location benefits there are only a limited number of empirical studies mainly due to lack of relevant data, and the studies are mainly case-based and examine the performance of a few selected clusters (Glasser et al, 1992).

Cases of industrial agglomeration or clusters arise in the presence of industry-specific and local externalities, also called Marshallian externalities. The standard argument is that such externalities may justify a policy of infant-industry protection to allow and encourage clusters to emerge (Rodr´ıguez-Clare, 2007). There is abundant evidence that such externalities exist and lead to

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industry-level agglomeration (Rosenthal and Strange, 2004).

The targeting of industrial development programmes at specific industry clusters generally will provide greater economic development benefits than those associated with more unfocused industrialization efforts because of instant availability of local resources and skilled manpower. The concentration of an industry at a particular location may result in significant cost savings to firms in the cluster, as a result of a greater availability of specialized input suppliers and business services; a larger pool of trained, specialized workers; public infrastructure investments geared to the needs of a particular industry; financial markets familiar with the industry; and an enhanced likelihood of inter-firm technology and information transfers. In addition, clustering encourages networking or cooperation among firms in an eco-system and industry clusters facilitate new firm start-ups and futuristic growth.

According to the President's Council on Sustainable Development, Eco-efficiency Task Force Report, Washington (DC), 1997, Eco-Industrial Clusters (EICs), are defined as: "a community of business; geographic concentration of interconnected companies in a specialized field that cooperate with each other and with the local community to efficiently share resources (information, materials, energy, water, infrastructure, finance, etc), leading to improved environmental quality, economic gains, and equitable enhancement of human resources for both the business and local community." Essentially, an Eco-Industrial Cluster (EIC) aims at efficient use local renewable/ recyclable resources while achieving economic development targets and meeting the social demands of the local community. As one of the applications of industrial ecology principles and business competition theories, EICs can become an emergent venture of integrated environmental and economic planning. The driving force of an EIC is inter-firm networks for the optimized use of both direct and derived resources. Recycling, reusing and finding alternate use for discarded waste materials are essential characteristics of such networks for building a competitive advantage. Thus, the emphasis of an eco-industrial cluster is rather a closed-loop material cycle/ recycling than a linear chain of material flow in the identified project sites. Promoting the concept of eco-industrial clusters in potential eco-systems represents a focusing mechanism for eco-restructuring of industrialization at regional or even local level for fostering green growth. This also shows the future pathways of a sustainable development opportunity with job prospects for ecologically degraded, economically distressed and socially isolated local communities.

The objective of the paper is try to build a comprehensive understanding about the principles of eco-clustering of industrial units and their scope of future development to economic advantage on a competitive basis with focus on eco-innovation, sustainable green growth by developing innovative and replicable business models for local and regional development. Impact analysis of eco-clustering initiatives both globally and locally; and looking into the future business potential of Eco-industrial clusters are also the other objective of the paper.

Foundation of Eco-Industrial Clusters

Industrial Clusters development has so far been very successful development in transforming the economy of many countries as well as in the spread of multi-national companies (MNCs) in several parts of the world. However, the concept has not gained adequate attention in the development of micro, small and medium enterprises (SMEs) where there is enormous potential for enhancing 'inclusive growth'. The introduction of clusters; especially the eco-clusters in these enterprises, can offer various advantages compared to a situation where such small businesses are located in geographically scattered areas with limited resources for future expansion. The potential benefits expected from eco-industrial cluster development are multiple, viz. zero emission, employment generation, new product development, branding, eco-labelling, improved efficiency in production and marketing as well as conducive environment for eco-innovation etc. (Anbumozhi, 2008, Chiu and Geng, 2004, IGES, 2007, Fujita, 2008, Michael, 2008, Matsuomoto, 2008, Visvanthan, 2008). Various studies undertaken by several research workers in recent times in selected economic sectors points towards a variety of drivers that propel the process of eco-industrial cluster development which varies from response to climate change impact, environmental regulation and governance, the strategic intent of developmental assistance policy (e.g. green-funding) to economic dislocation (e.g. climate refugee) and spontaneous response to international market opportunities. Regardless of the origin or sector, the following characteristics are identified as key foundations of EICs clusters:

Inter-firm Networks

Successful Eco-Industrial Clusters (EICs) are made up of enterprises that constantly seek inter-firm networks, not only in terms of minimizing recyclable wastes and reduce pollution, but also to look in for all types of eco-innovations (e.g. eco-technology, renewable energy) to improve zero emission processes with eco- standards to develop new eco-products. Agreements among the eco-enterprise players based on mutual trust within a network of community aim to share by-products, wastes and physical and natural resources including labour, technology and financial resources. Such networks can generate new and emerging eco-markets, logistics, supply chains and cluster-related management operations. The environmental, economic and social benefits gained through such inter-firm networks are expected to be quite substantial over a period of time.

In many Asian economies, the industrialization does not happen overnight. It evolved from the backyard family operations, to small and medium enterprises (SMEs) located in un-zoned areas. Furthermore, they developed into linked businesses due to supply chain force, and eventually many of them succeeded to become medium and big multinational companies (MNCs) located in clustered industrial estates. Similarly, the total quality environmental management (TQEM) approach of the eco-industrial clusters also has their four developmental stages. They can be explicitly described as given in Table-1 (Chiu, 2000):

Social Capital

Well-established social networks among project communities and a trusting relationship between cluster firms, academic institutions and community-based organizations greatly facilitate inter-firm collaboration as well as diffusion of new technologies. The creation of social capital through the formation of an eco-industrial cluster generally gives a fillip to the eco-industry to reach its full potential in a given time. There is a good example of a Wood Industrial Cluster in Japan (Box 1) where, high social capital that includes the relationships, attitudes and values governing the interactions among people, businesses and institutions, facilitated the sharing and development of ideas and pertinent market information thus reducing the transaction cost for businesses operating within the EIC. While the concept of mutual trust among competitors is not the norm among businesses, evidences indicate that it has the potential to build through progressive action by community-based cluster players such as the local Non-Government Organizations (NGO) or Self-Help Groups (SHGs).

Table-1: Total Quality Environmental Management (TQEM) approach of Eco-industrial Clusters

Stage of Achievement	Features and Approaches
Stage I. Internally Neutral	Plant / Business Complex Level minimal impact For example, applying strategic Cleaner Production (CP) / Green Productivity (GP) / Eco-efficiency approaches
Stage II. Externally Neutral	Estate with some Locators Level minimal impact For example, using Environmental Management of Industrial Estates (Cote, UNEP Tech Report 39)
Stage III. Internally Supportive	Estate and all Locators Level cumulative minimal impact For example, implementing Programmatic Systems and Approaches in Industrial Estates in one or various aspects such as CP, EIA, EMS, Biodiversity, APELL, etc. (Cote, 2000)
Stage IV. Externally Supportive	Total System Level synchronized minimal impact Optimal harmony of Industrial Ecology into the System (Synergy of resources at holistic approach at the right industry mix achieving economic, environmental, and social impact.

Source: Chiu, 2000

Stage IV is achieved when it envelops all the three key features of industrial ecology.

Box 1: Example of Eco-initiatives within a Wood Industrial Cluster in Japan

Production of wooden boxes for packing is the mainstay of the wood industries in Maniwa City, Okayama Prefecture. This region has a population of 52,000 and is home to 75 wood based SMEs. The production process generates waste such as wood trimmings and shavings. Inter-firm network of various businesses in the supply chain realised the commercial value in such waste products and explored options of wood as a biomass fuel, extraction of ethanol and wood-based concrete. Technologies such as boilers enabled the process to be carried out, and knowledge/information was brought in by the Universities of Tokyo and Okayama University. Taking leadership and participation by business in community based social networks increased the availability of market information and lowered its cost. It also led them to reach collective decisions and implement actions together. Maniwa City promoted a "biomass town" initiative encouraging businesses with several kinds of funds and subsidiaries.

(Source: Nakashima, 2006)

A critical mass of clusters creates demand for availability of natural resources, access to eco-technology, intellectual and financial resources and infrastructure for producing a reinforcing cycle that stimulates a region's future prospects for competitive advantage and sustainable green growth of the eco-industry. Sustainable regional strategies in such cases, among other things, focus on growing clusters of eco-firms, and not just individual firms. All industry clusters are composed of related industry sectors. The interconnections between and among these sectors illustrates the 'clustering effect'.

Types of Eco-Industrial Clusters

Eco-industrial clusters can be broadly divided into three categories; namely established clusters, evolving clusters and emerging clusters depending on the stage of evolution and maturity for full-scale development.

Established clusters are those traded industry clusters in which a region has a potential competitive advantage relative to the nation. They are made up of traded-related industry sectors. The sectors that comprise the cluster are sufficiently concentrated to represent a regional specialization compared to the same sector grouping nationallymaking them "traded." Established clusters are those typically identified by widely accepted quantitative cluster analysis methods.

Evolving clusters are those already established or traded industry clusters that are evolving because of the presence of newly related industry sectors, which hold the promise of transforming the established portion of the cluster over the long term. The newly related industry sectors serve as potential agents of change and diversification. Evolving clusters are composed of both traded-related and newly related industry sectors. The newly related industry sectors are insufficiently concentrated to contribute a traded competitive advantage to the cluster compared to the same industry sectors nationally. However, activity within these new sectors is quantitatively identified as highly related to the established cluster and considered dynamic. Over a period of time, these related sectors could alter the cluster's competitive direction, having an impact on regional economic growth prospects. Impacts of the Evolving clusters are easy to assess, because they have an established base for growth and benefit from all the advantages of eco-clustering.

Emerging clusters are those industry clusters that exhibit the potential for developing a regional competitive advantage but have not yet done so. They are composed solely of newly related industry sectors. These sectors are not considered traded. Sometimes, emerging clusters are clusters in decline. However, they can also represent the presence of technology commercialization from a center of excellence that is gaining economic momentum. The growth of evolving and emerging clusters can signify a positive trend and, in other cases, a negative one depending upon job quality and productivity. The terms evolving and emerging are value neutral. They relate to changes in the data that need to be contextualized regionally for purposes of interpretation. Not all regions have evolving and/or emerging cluster activity. In some instances, industry-clustering activity is limited to established clusters and sometimes is associated with economies experiencing economic stagnation.

In India, Bangalore- the Silicon Valley of Asia, houses the most prominent cluster in India. From a mere 13 software firms in 1991-92, the city now has a pool of over 1,200 software firms working in areas such as computer chip design, systems software and communication software, employing over 100,000 IT professionals. Compared to other locations in India, Bangalore has high-end technology/industry concentration such as VLSI and telecom services and higher degree of MNC presence with over 200 foreign firms in operation. It is now ranked fourth as a global hub of technological innovation, behind San Francisco and Austin of US, and the Taiwanese capital Taipei (Ramachandran & Ray, 2003).

Cluster is considered to be a good example of corporate collaborative action as well as social networking in that it could help develop its members in improving their business competitiveness across eco-industrial enterprises and in gaining thereof their financial benefits well within growing competition of the modern eco-industrial economies. The concept of business cluster is lately being transferred in the field of corporate environmental management and industrial ecology to provide new ways of collaborative ventures for the upcoming firms on facing environmental challenges resulting from the climate change phenomena, which in turn, could allow them to achieve simultaneously the objectives of economic viability (Karaev et al., 2007) of the region.

Corporate environmental management literature presents many terms and concepts to clarify how collaborative actions of firms on environmental issues could contribute to natural resources preservations and scientific utilization to provide livelihood support to mankind. Some recently introduced terms coined for the purpose include: eco-clusters, industrial ecology, industrial symbiosis, corporate environmental network and eco-parks. Although those types of firms' formation focus on solving environmental problems, nevertheless they provide essential conditions for creating innovation and improving competitive advantages. According to Esty and Porter (1998) industrial ecology thinking would assist firms to make productivity improvements by using raw materials drawn from nature and therefore to improve their competitiveness in the process because of limitations imposed by the availability of natural resources. Mirata and Emtairah (2005) were of the view that industrial symbiosis could provide eco-innovations through implementing common activities to eliminate environmental impacts and help develop inter-organizational collaboration and learning strategies. However, the terms that are used so far to describe collaborative efforts of firms in the field of corporate environmental management take different meanings and orientation when attempts are made to go in for eco-design in the potential eco-industrial projects. For example, industrial symbiosis, industrial ecology, eco-parks focus mainly on topics such as environmental performance, resource productivity and geographical proximity, while the terms of eco-clusters and eco-industrial networking seems to face loosely the geographical proximity.

Criteria for Selecting Industry Clusters: The Regional Economic Development Research Laboratory (REDRI), University Clemson, South Carolina, USA uses approach to cluster identification and targeting by following three principal steps:

Step 1: Identify industry concentrations for which the region has experienced recent employment growth.

Step 2: Construct value chains for the industry clusters selected in Step 1. Identify industries in the value chains with the greatest linkages to the local industry concentrations.

Step 3: Rank the selected industries from Steps 1 and 2 by expected economic and fiscal impacts on the local economy.

The REDRL approach to industry targeting focuses on identifying industry clusters for which the study area exhibits promise for attracting and growing. Such a focus on growing industry clusters takes advantage of the roles of historical path dependencies and external economies of scale in determining the attractiveness of a region to manufacturers. The REDRL approach has been applied to local and state industrial development efforts. The interested reader may refer to the following publications for examples of the industry clusters targeting methodology (Barkley et al, 1998, 2002).

Eco-industrial Park: an Innovative way of Clustering Business Enterprise

Eco-industrial Park is one of the emerging forms of Eco-industrial Cluster of new and emerging business enterprise. There are several definitions of the term Eco-industrial Park. In 1995, Coˆte´ and Hall proposed this definition: An eco-industrial park is an industrial system which conserves natural and economic resources; reduces production, material, energy, insurance and treatments costs and liabilities; improves operating efficiency, quality, worker health and public image; and provides opportunities for income generation from use and sale of wasted materials. An industrial park is also defined as "a large tract of land, sub-divided and developed for the use of several firms simultaneously, distinguished by its shareable infrastructure and close proximity of firms". Types and synonyms of industrial parks include: industrial estates, industrial districts, export processing zones, industrial clusters, business parks, office parks, science and research parks, and bio-technology parks. Eco-industrial parks have now been added to this list.

The concept of an eco-industrial park evolves from the emerging discipline of industrial ecology. By collectively managing environmental and energy issues, eco-industrial park members seek to enhance their environmental and economic performance and, as a result, achieve a combined benefit that is greater than the benefits each company would have realized from optimizing only its individual performance. An eco-industrial

park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resources issues including energy, water and materials. By working together in harmony, the community of businesses seeks a collective benefit that is apparently far greater than the sum of the individual benefits each company would have realized if it optimized its individual commercial interests for sustainable economic gains with long-term perspective.

Lowe Warren (1996) observed from their research findings that an Eco-industrial park may include many of these features but the essential feature is the interactions among businesses and between the businesses and the natural environment for green growth in an eco-friendly manner without detriment to the environment and ecology. As is the case with the field of industrial ecology, the definition of an eco-industrial park is still evolving with the passage of time and through developing new eco-industrial models based on eco-innovations.

Current Global Experiences in establishing Eco-industrial Parks

The following examples of eco-parks are based on summaries provided in the PCSD 1997 Report, The Road to Sustainable Development: A Snapshot of Activities in the United States (http://www.calrecycle.ca.gov/LGCentral/Library/innovations/recoverypark/CaseStudies2.htm).

Northampton County, Virginia: An example of the first type of eco-park is the Port of Cape Charles Sustainable Technologies Industrial Park, located in Eastville, Northampton County, Virginia. Cape Charles is in the Chesapeake Bay coastal region. The area serves as a critical flyway for migrating birds, with some of the highest bird counts on the whole eastern shore. In addition to its natural features, the area has a rich cultural and historic heritage, characterized by Native American archeological sites and historic homes. The community, as part of a comprehensive Sustainable Development Action Strategy, is designing the Port of Cape Charles eco-park. If successful, the facility will create local jobs and provide protection for the area's natural and cultural resources. The eco-park will provide for water recycling among the resident companies by means of a used-water collection system, a water recovery facility, and a recycled-water distribution system. In addition, a technical panel will analyze and determine whether other companies within the park can use the by-products of existing and proposed companies. Construction on the eco-park began in October 1996, with funding from local, regional, State, and federal sources. The first tenant will be Solar Building Systems Inc. The Northampton County Department of Sustainable Economic Development/Joint Industrial Development Authority is managing the project. Initial efforts have focused on recruiting compatible companies and on developing effective management for the park as an industrial ecosystem. The local community is enthusiastic and committed to the project, and it will be a key to the park's future success.

Brownsville, Texas: An example of the second type of eco-park (a "virtual" eco-park) is a project in Brownsville, Texas. Brownsville is located on the southern tip of Texas in the Rio Grande Valley and is often referred to as a city "on the border, by the sea." It has a rich natural environment and is considered to be one of the three top bird-watching sites in the United States. At the same time, the city has some of the most serious environmental problems in the northern hemisphere and is struggling to address its high poverty and unemployment rates. Local and state government officials have been the primary drivers behind the development of an eco-park in this border region. Clearly if the region's industrial growth is to continue, the nature of that development must change to protect both human health and the environment.

As a virtual eco-park, the Brownsville project takes a regional approach to exchanging waste materials and by-products. This approach is sometimes referred to as regional "industrial symbiosis." The project could eventually include a group of businesses that are geographically located together, but co-location is not the driving force behind the project at this time. As currently envisioned, the project will include not only industrial facilities but also small businesses and the agricultural sector. Planning for the Brownsville project has focused on identifying firms that could benefit from participating in regional industrial symbiosis. Project planners have developed a database of companies in Brownsville and in the neighboring city of Matamoros, Mexico. They are analyzing it to identify potential materials

exchanges among these industries and/or new companies. The Texas Department of Commerce and the Brownsville community have provided initial funding, and project leaders are working to secure long-term support. State officials will be working closely with project leaders to ensure that permitting procedures do not become a barrier to development. After adding cost-based data to the database, project planners will develop a marketing plan to evaluate and recruit participants. They plan to educate and involve the local residents in implementing the project. The project holds great promise for improving the lives of the people of Brownsville.

Burlington, Vermont: An example of the third type of eco-park (eco-development) is the Riverside Eco-Park in Burlington, Vermont. This project will create an agricultural-industrial park in an urban setting that will:

1. Generate electricity using biomass technologies that use readily available resources (e.g., wood chips).
2. Use the waste heat generated by the power plant to support the greenhouse production of fish and horticultural products.
3. Use biologically-based "living systems" to digest liquid organic wastes (which are common in the food processing industry) to purify water and create high strength fertilizers.
4. Recycle and compost the area's waste foodstuffs and yard debris to replenish local soils, increase agricultural production, and support value-added organic food industries. All of these emerging technologies are being developed with the ultimate goal of transferring them to other industries and communities.

This project is expected to have several positive results, including reducing the waste heat that is released into the air and water, improving soil conditions and water quality, and creating sustainable jobs for the local people. A feasibility study that examined the inputs, outflows, and costs of the biomass energy systems and the living systems led to the conclusion that combining the two systems could be economically and environmentally beneficial. The next steps will be to prepare engineering and cost analyses of the linked systems. A Community Development Block Grant, the Burlington Electric Department, the Department of Public Works, and Cornell University are providing support. Project leaders have applied to the U.S. EPA and the U.S. Department of Energy for funding. The leaders have also recruited a number of organizations and companies to participate in the first demonstration project. They plan to bring in additional partners as the strengths and weaknesses of the project become evident. Project leaders have developed an aggressive five-year plan. They expect to transfer this eco-development model to other sites and to the development of commercially viable spin-off industries.

In the United States, a number of initiatives have been taken pursuant to support from the United States Environmental Protection Agency and the President's Council on Sustainable Development. Similarly, Canada has a few industrial projects underway embodying ecological characteristics embedded with the potential for many more across the country. The "Industrial Park as an Ecosystem" project in 'Burnside industrial Park' for instance, began in 1992 as a multi-disciplinary research initiative, investigating the possible application and interpretation of ecological characteristics and functions to develop into an eco-industrial park. The expected outcome of the research guidance was first, on the transformation of Burnside itself and second, for the establishment of future eco-industrial parks. A similar study has been underway in the Portlands Industrial District in Toronto, Ontario since 1995. This industrial area also involves enterprises in a variety of sectors in manufacturing and services with the potential for waste and energy exchanges. A recent study of the potential for integrated eco-industrial parks with co-generation, energy cascading and recycling across Canada identified 40 sites of which nine were deemed to have excellent possibilities for eco-industrial development. There are a number of sites in Canada where limited industrial ecosystems are in operation. In Sarnia, Ontario, some symbioses exist between oil refineries, a synthetic rubber plant, petrochemical facilities and a steam electrical generating station and more linkages are possible. At the Bruce Energy Centre, also in Ontario, the "eco-park" is organized around Ontario Hydro's nuclear power station to take advantage of its waste heat and steam generation capacity. The following Table 2 shows the current potential of some Eco-industrial Parks in Canada.

Table 2: Eco-industrial Parks' current Potential in Canada

Province	Key industries
Vancouver, British Columbia	Steam generator, paper mills, packaging, industrial park
Fort Saskatchewan, Sask.	Chemicals, power generation, styrene, PVC biofuels
Sault Ste. Marie, Ontario	Power generation, steel, paper mill, flakeboard mill, industrial park
Nanticoke, Ontario	Thermal generating station, oil refinery, steel mill, cement, industrial park
Cornwall, Ontario	Power and steam generation, paper mill, chemical, food, electrical equipment, plastics and concrete products
Becancour, Quebec	Co-generation plant, chemical plants (H2O2, HCL, Cl, NaOH, Alkylbenzene)
Montreal East, Quebec	Co-generation plant, petrochemicals, refineries, compressed air, gypsum board, metal refinery, asphalt
Saint John, New Brunswick	Power plant, paper mill, oil refinery, brewery, sugar refinery industrial parks
Point Tupper, Nova Scotia	Generating station, pulp and paper, building board, oil refinery

Source: Report prepared for Environment Canada, Industry Canada and Natural Resources Canada, Ottawa, 1997.

Fig. 1: Aerial View of an Eco-industrial Park at Rantasalmi, ETELÄ-SAVO, Finland

A brief description of some of the Eco-industrial Park Models set up in other parts of the world is given below as illustrations for better understading on the subject.

The Finnish Ecological Parks: Located at Rantasalmi, the Finnish Ecological Parks usually consist of forest industry businesses which use their wood-derived wastes for energy, selling electricity to the community, utilizing residual heat from electricity generation for industrial process steam and district heat for residential areas. The Rantasalmi eco-industrial park project can, however, be considered the first attempt to plan and organize an eco-industrial park in Finland. Real Estate (Fig.1). Rantasalmen Silva Oy also acts as a development company in the region and one of the aims is to generate a strong knowledge and business concentration in the area. It is owned by Rantasalmi municipality (49%), Rantasalmi Oy (49%) and Spikera Oy (2%).

The evolution of eco-industrial parks into ecosystems is still at a nascent stage of development. Although some research and design projects have attempted to identify the essential characteristics as well as uniqueness of eco-industrial parks, there is, apparently, no agreement as yet. All the same, there does appear to be some general consensus emerging from the learnings of the French, Japanese, American and Canadian eco-project initiatives; as also from the UNEP technical report on Eco-industrial parks development as a new economic development proposition.

Landskrona, Sweden: The Landskrona Industrial Symbiosis Project was introduced in 2002 by the International Institute for Industrial Environmental Economics, IIIEE, at the University of Lund, Sweden. A team of IIIEE researchers coordinated the application of a systematic approach for assisting the development of symbiotic connections. The project is supported by

the Swedish Business Development Agency (NUTEK). The companies contribute to the project financially, even though the sums contributed are relatively small.

National Industrial Symbiosis Program, NISP, Great Britain: The National Industrial Symbiosis Programme, NISP, is the first industrial symbiosis initiative in the world on a national scale. NISP is a business-led initiative and it is supported by the UK Government and industrial organizations. The program serves as a link between industries and various sectors.

The Luxembourg Eco-Innovation Cluster: Luxembourg hosts a thriving eco-innovation sector. There are numerous eco-companies in the country, working mainly in the field of eco-construction, renewable energy, waste management, water and electro- mobility, supported by numerous public agencies and research organizations. The goal of eco-innovation is to reduce the environmental impact of processes, products and services. Whether it is by finding a more energy-efficient process, a way to address environmental problems or a replacement for an excessively polluting production method, the scope is very wide. Luxembourg's research activities in environmental technologies focus on environmental management, life-cycle assessment, clean technologies and process engineering, environmental modelling as well as the sustainable management of aquatic and terrestrial ecosystems.

The take-up of green technologies is empowered by an ambitious Government action plan, which has recently been adopted in order to stimulate the production of eco-technology products, the management of natural resources and changes in the design and development of production and consumption systems, in order to make them cleaner and more resource efficient (eco-construction, eco-design, environmental regulations of processes, recycling materials, etc.). Another priority is to support research and development in the environmental technologies field, thereby leading to greater sustainability and economic diversification.

The Luxembourg Eco-Innovation Cluster is a network that supports the various actors of the eco-innovation sector in Luxembourg with the goal of creating and developing new and sustainable business opportunities through collaborative R&D and innovation projects. The Luxembourg Eco-Innovation Cluster comprises companies, research institutes and public organizations involved in the field of eco-technologies. Due to this unique mix of competences, the Luxembourg Eco-Innovation Cluster provides support for the development of collaborative project ideas, the identification of potential business partners and the search for suitable funding in order to empower the development of the eco-technologies sector in Luxembourg and to increase the uptake of "green technologies". Its activities also include the organization of regular networking events, visits, themed conferences and workshops. The Luxembourg Eco-Innovation Cluster comprises companies, research institutes and public organizations involved in the field of eco-technologies. Due to this unique mix of competences, the Luxembourg Eco-Innovation Cluster provides support for the development of collaborative project ideas, the identification of potential business partners and the search for suitable funding in order to empower the development of the eco-technologies sector in Luxembourg and to increase the uptake of "green technologies". Its activities also include the organization of regular networking events, visits, themed conferences and workshops.

Eco-Industrial parks in China: In China the environmental management of industrial parks has been enhanced with the help of EMS's, usually ISO14001. Comprehensive environmental management systems (CEMS) have also been implemented in the industrial areas. EMS's are established for individual firms as well as for the industrial estate management. The aim is to enhance cooperation based on different EMS's. CEMS tries to find similarities between different EMS's and integrates them into common policies, activities and management strategies. Chinese industrial parks have governing administrative bodies that take care of various activities, services, products and the park as a whole. The estate administration is responsible for implementing legislation and regulations, planning and designing the park's supply services (e.g. energy), infrastructure and economic development. These activities can be managed and improved meet the ISO 14001 standard and so the estate administration or government receives the standard. The idea is that the standard can improve the environmental management of governmental institutions. The next step from the CEMS-system is to implement an eco-industrial park on the estate.

There are few studies of eco-industrial parks in the world. There are probably numerous self-evolved parks that have not been identified and studied yet. However, some research on self-evolved systems has been conducted and in many cases synergies have been developed further. New eco-industrial parks have been designed and engineered by researchers, companies and developers in different parts of the world, e.g. in the Netherlands, Austria, Spain, Costa Rica, Namibia, South Africa, Australia and several Asian countries, on the inspiration provided by the research.

Asian Initiatives: Philippines and India have both started doing the EIN earlier than the neighboring economies. Thailand, on the other hand, has shown strong enthusiasm and the infrastructure is very strong. While some countries have already been practicing some EIN components unofficially, there are also other nations like Vietnam and Nepal conducting initial feasibility studies (Sathasivan and Hoang Hai, 2001).In Malaysia, earlier publication on website by USAEP revealed environmental activities in the industrial estates, but similar to Japan, they were rarely referred to as EIN or Eco-industrial Park (EIP). More and more EIN or Environmental Management Projects are in different stages of developments; the Table 3 browses through some of the EIP related activities in the Asian economies:

Eco-Town Projects in Japan: The Ministry of Economy, Trade and Industry and the Ministry of Environment, Japan are presently promoting an Eco-Town project, aiming for the construction of a resources-recycling economic society through the development of industrial industries by utilizing local industrial accumulations, the prevention, and the promotion of recycling of wastes based on the uniqueness of local districts. The Eco-Town projects are operated by local authorities to support advanced environment-conscious town building through cooperation with local residents and industries (Eco-Town Projects/Environmental Industries in Progress, Ministry of International Trade and Industry (MITI) in 1997: Environment-Conscious Type of Town-Building Models of Eco-Town Municipalities/Business Firms: Case Introduction: http://www.meti.go.jp/policy/recycle/main/3r_policy/policy/pdf/ecotown/ecotown_casebook/english.pdf). The details of the Eco-Town Project are given below in Figure 2:

In Japan, Eco-town projects can be promoted and funded by a government program started by the Ministry of International Trade and Industry (MITI) in 1997. The main objective of the programme is to encourage community development throughout the environmental industry and development of environmentally sound community systems involving industrial and public sectors. The programme was initiated as the result of a waste management crisis. As discussed above, Japan has been facing a serious problem with its waste management. Waste treatment facilities and landfills are almost exhausted. Yet, the environmental and recycling industries are considered "venous industry" (receptive, secondary) and have yet to develop a viable eco-market with high business potential. By promoting

Table 3: Eco-industrial Parks in Asia

China	Dalian, Tianjin, Suzhou, Yantai, Guidang, Nanhai
Philippines	Laguna International Industrial Park, Light Industry & Science Park, Carmelray Industrial Park, LIMA, Laguna Technopark, Philippine National Oil Company Petrochem Industrial Park; Clean City Center project (USAID)
Indonesia	Lingkungan (LIK), Tangerang; Semarang; Industri Sona Maris
India	Naroda; Tirupur Textile sector; Tamil Nadu tanneries; Calcutta foundries; Tamil Nadu Paper / Sugar; Bagelore Water project; Ankleshwari, Nandeseri, Thane-Belapur
Malaysia	LHT Resources Linkage
Japan	12 ecotowns (e.g. Kitakyushu, Itabashi), Fujisawa, Toyota City
Taiwan	Tainan Technology & Industrial Park, Changhua Coastal Industrial Park; Corporate Synergy System (CSS II) projects
Vietnam	Amata (envi mgt), Hanoi Sai Dong II (feasibility study)
Thailand	Industrial Estate Authority of Thailand plans (Map Ta Phut, Northern Region, Amata Nakorn, Eastern Sea Board, Bang Poo); Samut Prakarn Province CPIE project (ADB funded); Bangkok (Panapanaan)
Sri Lanka	Ministry of Economic and Industrial Development plans

Source: Lowe (2001)

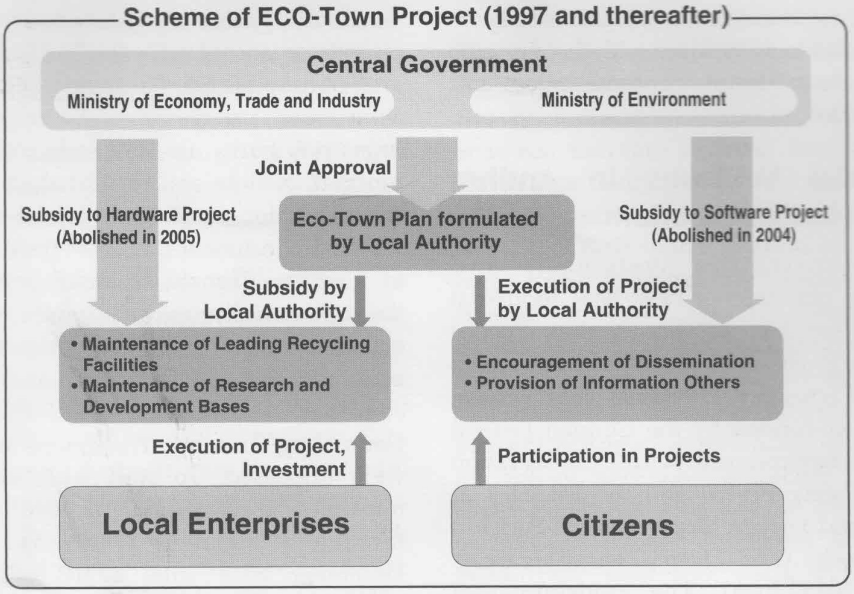

Fig. 2: Schematic Project Plan of Eco-Town Project in Japan

the environmental industry, the program attempts to involve both community and industry in waste management, which, in turn, promotes local economy and community. The central government provides both technical and financial support to local governments that wish to establish eco-towns as areas where regional zero emissions are promoted through various recycling and industrial symbiosis efforts. Once a development plan is submitted by a local government and approved by MITI, they are eligible for federal financing to promote and encourage ecologically sound industrial activity (Eco-Town Prohramme:http://www.meti.go.jp/policy/recycle/main/english/3r_policy/ecotown.html; METI, 2000).

Local governments of Japan can use MITI funds to develop and implement comprehensive plans for the area, attract companies that will actively facilitate recycling and waste and energy use reduction programs. The area may also serve to attract businesses developing environmental technology, and may contain research and development facilities. The most unique feature of this program is that funds are made available to private businesses and projects located in the region that develop new environmental technologies to promote regional zero emissions (Fujimura, 1999). This public-private partnership is noted as an important factor in the success of this program as it can facilitate local economic development. Up to 50% of the project cost, both for managerial activities, such as planning or promotion, and for technical costs, such as recycling facilities or new environmental technologies, can be financed by the funds.

Under this arrangement, local governments and communities benefit by having an opportunity to reduce and repair environmental degradation and improve human health and safety. In addition, local governments are given a way to promote economic development by attracting new business. Many businesses also perceive improved public relations benefits from being members of an eco-town. The central government benefits by promoting environmentally friendly business and development, and easing the burdens associated with waste disposal, scarcity of virgin resources, and environmental damage in Japan. Moreover, these projects promote the development of high-tech environmental products that can benefit Japan's economy and trade. There are 10 projects currently approved as Eco-Town Projects in Japan. Each of these projects takes a different form in carrying out eco-town plans. Some involve eco-industrial parks or regional by-product exchange, while others focus on recycling technologies. The bottom line is that each area develops its plan in the context of region specific characteristics and advantages. For instance, Omuta, Akita, and Uguisuzawa will develop the area abandoned after the closing of mines and utilize the technologies in pollution prevention and resource extraction for the development of eco-industrial projects and the encouragement of local economy. The flexibility of

the eco-town projects allows local government to develop their plan in accordance with their specific geo-climatic distribution characteristics and business situations.

Eco-industrial Ventures in Andhra Pradesh: An Indian Experience

For demonstrating systematic and comprehensive planning of new Eco- industrial parks, a Multi-product Andhra Pradesh Special Economic Zone Project at Visakhapatnam, covering an area of 5,683 acres (2,300 hectares) was taken up. The Project is co-funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Ministry of Environment and Forests (Eco-Industrial Parks in Andhra Pradesh: GTZ- http://www.giz.de / Themen/en/30432.htm). The environmental impact assessment (EIA) taken up on the Eco-industrial Project included study of baseline environmental conditions, meteorology, ambient air quality, inland water quality, ground water quality, surface water quality, soil quality, flora and fauna, marine environment, socio-economic conditions, risk analysis and disaster management planning, traffic studies and transportation management. Based on the EIA studies, Site Master Planning was taken up comprehensively. The plan includes special elements such as transport network, storm water drainage system, cogeneration plant, common waste water treatment and disposal, treatment of sewage and reuse, waste management, green belt and provisions for disaster risk management. Based on impact assessment findings, there is now a spurt of fresh demands coming up on larger application of the concepts for establishing new eco-parks with added elements of energy efficiency, renewable energy, and addressing environment and climate change issues. With the increased environmental/energy personnel at APIIC Project Centre of Andhra Pradesh and propagation of eco-industry park concepts, a number of activities have been initiated for reduction of negative environmental impacts from industrial parks including stopping of illegal discharge of industrial effluents and wastes, initiation of actions against defaulting industries, plantation activities, identification of infrastructure requirements their augmentation, construction of a Common Effluent Treatment Plant (CETP) in one of the industrial parks (Vijayawada) Also, significantly visible is the plantation taken up by APIIC for 40 eco-industrial parks and planning to set up CETPs in various industrial parks.

Round Tables on "Eco Industrial Parks" were recently organized in Hyderabad (Andhra Pradesh) and Ahmedabad (Gujarat). Environmental awareness programmes were organized in industrial parks in Kakinada, Visakhapatnam, Tirupati, Nellore and Shamshabad, coupled with tree plantation. Particularly on the occasion of the World Environment Day 2009, the theme of "Unite to Combat Climate Change" was propagated through a massive rally in Hyderabad and parallel events in several industrial parks. For promoting eco industry park concepts and sustainability concepts, a number of activities related to Counseling, Training, Workshops and Exhibitions were organised. To start with, activities to be implemented during 2009 to 2010 were identified through a Planning Workshop organized in December 2008 with APIIC officials (Project implementation partner). Support was provided to the workshop on "Eco Industrial Areas" organized by the Andhra Pradesh Pollution Control Board which had over 150 participants from industry, experts from the field of environment. The workshop helped promoting the eco industrial park initiatives. An Awareness Workshop on "ECO-PROFIT Programme" was held at Hyderabad on April 16, 2010 in cooperation with the Federation of Andhra Pradesh Chamber of Commerce & Industry (FAPCCI) for the member industries of FAPCCI. A 'Tool Box on Eco-Industrial Development' was developed by GTZ the German International Funding Agency, drawing on experiences of eco-cluster projects from India, Thailand, China, the Philippines and Tunisia.

Multiple impacts : Replication of Eco-Industrial Park concepts started in Andhra Pradesh and other parts of India: The Project succeeded in replication of the Eco-Industrial Park concepts within Andhra Pradesh and beyond in several parts of the country with multiplier effects. APIIC had scaled up the application of the concepts from the two ecio-industrial parks that were taken up initially to 32 eco-industrial parks. The results are forthcoming in 15 industrial parks with more convincing results. In the state of Gujarat, the activities were initiated for transformation process of two existing industrial parks at Naroda and Vatva near Gandhinagar. Activities for promoting eco- industry park concepts in pharmaceuticals sector have also been initiated in cooperation with the Department of Pharmaceuticals (DoP) of the Indian Ministry of Chemicals and Fertilizers. The focus is in five states having significant presence of pharma industries and these include: Andhra Pradesh, Gujarat,

Maharashtra, West Bengal and Tamil Nadu. Further, for the Government of Orissa, a proposal was developed for planning and development of 450 acre 'Solar Technology Park' through the Industrial Promotion and Infrastructure Corporation Ltd. (IPICOL). A cooperation agreement was made with the Engineering Staff College of India (ESCI) in Hyderabad, with the Centre for Climate Change taking lead in implementing Eco-profit and other training measures for pharmaceuticals industries.

Eco Industrial Park concepts were expanded with climate-relevance. The relevant tools viz. Eco-profit, Environmental Audit and Energy Audit, were demonstrated in industries with content-inclusion of climate-relevant measures, which specifically aim at energy and resource efficiency. Also, the originally conceived concepts of Eco Industrial Parks were expanded while targeting expansion of the concepts to other parts of India. For example, for expansion to the pharmaceuticals sector in India and for eco industrial development in the state of Gujarat, the focus had been provide for infrastructure strengthening including on renewable energy and on resource/energy efficiency in individual industries.

Eco-industrial Cluster Analysis and its Economic Significance

Industrial cluster analysis is a tool to better understand our regional economy. The purpose of cluster analysis is to identify those areas of the economy in which a region has comparative advantages and to develop short and long-term strategies for growing the regional economy. Increased regional prosperity is achieved by creating a positive environment to nurture these clusters. An industry cluster is considered to have a comparative advantage if the output, productivity and growth of a cluster are high relative to other regions. In addition, local infrastructure and collaborative efforts afford cluster industries other advantages that are a result of their shared geographic location and common goals. While the total number of jobs in comparative-advantage industries in a region may not represent the majority of the region's employment, these industries are the economic engines of the rest of the economy. Workers, inventors, community, institutions such as government and education, and others need to support the cluster industries and affect a broad range of industry cluster groupings.

The Standard Industrial Classification (SIC) system has been used on a selective basis in some of the eco-project sites in different parts of the globe to classify employment sectors by the type of activity in which they are engaged throughout the late 1900's. This traditional method can, at times, have difficulty defining the driving industries in a region in terms of their spatial location, employment size, wage rates, infrastructure needs, suppliers and competitors. The SIC system is based on a four-digit industry coding system and groups industries by sectors such as Wholesale Trade, Services, and Manufacturing. Today, new driving industries like biotechnology, software, environmental technology, and communications do not fit into classic SIC sector definitions of the Manufacturing or Service sectors.2 Industries broadly labeled. Within the next few years a new industrial classification system will be implemented in the NAFTA countries. The North American Industry Classification System (NAICS) in the NAFTA region will be a more detailed one and will allow for multi-national comparisons across the borders. While some definitional problems may be solved, the grouping of "biotech" straddle sector definitions, somehow does not fall neatly into the categories outlined by the SIC system. The use of clusters, particularly the eco-industrial clusters as a descriptive tool for regional economic relationships provides a richer and more meaningful representation of local industry drivers and regional dynamics than the one provided by the traditional Standard Industrial Classification (SIC) system.

Firms within an eco-cluster by and large exhibit strong inter-relationships and connectivity for maintaini9ng resilience in the project eco-system. The flow of goods, information and services between geographically concentrated industries in a cluster is stronger than the flow linking them to the rest of the economy. An eco-industry cluster is different from the classic definition of industry sectors (e.g., construction, manufacturing services, etc.) because it represents the entire value-chain of a broadly defined industry from suppliers to end producers and consumers, including supporting services and specialized infrastructure. By locating the eco-clusters close to one another, businesses are able to acquire information, communicate and share inputs in such a way as to add to a "collective" advantage that could not otherwise be achieved alone. Clustering facilitates collaboration to overcome shared problems and obstacles. This can be done directly by the formation of industry

associations, or indirectly through regional legislation. Even though some firms may be competing, certain collaborations, such as providing industry-relevant training, transfer of eco-technology, access to renewable resources etc are extremely beneficial for setting up eco-clusters more effectively. Common goals and geographic concentration of eco-clusters leads to the development of specialized skills, institutions, and alliances within the cluster agglomeration because of the spin-off and multiplier effects more synergistically.

Focusing on clusters does not mean that economic prosperity will be limited only to those employed in cluster industries nor does it suggest that other industry sectors are unimportant. It must be emphasized that high technology employment sectors include many non-high technology jobs. Thus, cluster focus is not an attempt to pick winners nor does it focus solely on very high skilled, elite jobs. Clusters are a way to track employment trends underlying structural shifts in our economy. Cluster analysis is an attempt to maximize the efficiency of public policy and investment by focusing efforts primarily on the economic drivers of the region. More importantly, positive benefits are gained by non-cluster sectors as a result of the inter-industry relationships that exist in a manufacturing and service-based industries will likely remain an important issue that will require cluster analysis for clarification. In India, there is currently a strong emphasis to develop industrial clusters in identified Special Economic Zones (SEZ) with distinct competitive advantage.

Because industries in an economy are linked and inter-related, positive investment in one sector is also felt by numerous other sectors of the economy. Focusing on the economic drivers of an economy is not a new approach. The manufacturing sector used to be the primary driver of a regional economy and was the recipient of past economic investments. Since today's driving industries are no longer solely located in manufacturing, economic policy has adapted to incorporate broader industriesmade possible with industrial cluster analysis. Cluster analysis is therefore perceived to be an evolving analytical tool, and over time cluster definitions and the statistics used to track them will need to be revised with newer experiences in the field of industrial ecology in general eco-industry in particular.

Integrating Economic Development through Environmental Linkages

Developing countries, particularly in Asia, are struggling to cope with the negative impacts of concentrated industrial activities. Inspired by the theory of industrial ecology, eco-towns or eco-industrial parks are frequently promoted in many localities as a strategy for reducing the environmental burden of industry in a way that is consistent with economic development. Yet the reach of those eco-approaches are limited to traditional manufacturing industries concentrated in urban areas. However, for countries looking beyond simple manufacturing and which are turning to the adoption of new kinds of industries, it is the inner regions, the zones of transitions which begins with the edge of residual green space and the fringe areas making up the hinterlands between urban and rural areas that offer an opportunity for equitable growth. These areas are already used as sites for clusters of new industries that want equal access to raw materials as well as to urban markets. However, rather than just co-existing, these companies could become interconnected, sharing resources and achieving economic, social and environmental success. The solution is to create an Eco-Industrial Cluster (EIC). The key foundations of EICs, as can be learned from these four prototype cases in India, Japan, Thailand and Viet Nam are: inter-firm networks, enabling technologies, social capital and public policy support. It is important that these infrastructures should be created simultaneously with new industries, and not after environmental problems have already developed, as has been done in the past (http://enviroscope.iges.or.jp/modules/envirolib/upload/1593/attach/policy%20brief%20no.8-e.pdf). Changes in policy orientation are essential to promote the EIC as a new model for sustainable regional development. Joint efforts that cut across three main policy streams of industrial policy, environmental policy and regional development policy that favour co-operative, multi-stakeholder and often location specific approaches are needed to unleash the sustainability potentials of the future eco-industrial clusters in any part of the world.

Sensing the Eco-Industry's Business Potential

The green industry focuses on making a profit while having a negligible (or even a beneficial) impact on the environment. Leaders make sustainability a key consideration in decision-

making throughout the organization as they work to minimize both use and production of harmful chemicals, excess materials, and waste byproducts in the delivery of their goods and services. Recognizing the importance of our planet's dwindling natural resources, the green industry seeks to meet the demands of today without compromising the needs of tomorrow.

More businesses than ever are taking strides to build an eco-conscious business model. In fact, consumers are behind the push, looking for and even demanding that companies turn to an environmentally friendly focus. Manufacturers are doing so even when the immediate financial rewards are non-existent. What are businesses doing to meet these demands? Manufacturing companies can make changes in plenty of ways and in the long-term, the financial rewards will pay off. The use of biodegradable packing or minimalist packaging is another example of how manufacturers can make significant changes. It is difficult exactly to define the "eco-industry", and therefore also its growth and export potential.The environmental industry comprises firms which provide goods and services for both environmental protection and resources management (e.g. waste recycling, renewable energy supply and water supply). Eco-industries have been defined according to the definition contained in "The Environmental Goods and Services Industry Manual for Data Collection and Analysis" (OECD/Eurostat, 1999, 2005). This defines eco-industries as: "Activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use".

A recent EU study has made estimation on the situation in the EU-15 and the Candidate Countries (ECOTEC, 2010a &b). The eco-industry is broadly defined as "activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use". This means that pollution management, resources management, clean technologies and renewable energies are included, while areas such as nature protection and organic farming are not included. The report says that EU eco-industries is a strong and diverse export sector, and is major global player alongside the USA and Japan. The global eco-industry market is estimated at around 550 Bn euros in 1999. This means the EU has approximately one third of the overall market (183 Bn euros), equal to the USA. The Japanese market is estimated to be worth about 84 Bn euros. The Canadian market is the next most significant at 36 Bn Euros. The overall turn-over (Million Euros) of the Eco-Industries in EU Region during 1999 is given in Table 4.

Table 4: Turn-Over (Million Euros) of Eco-Industries in EU Region, 1999 Scenario

Country	Pollution Management	%	Resources Management	%	Total Turnover	%
Austria	8,270	7	620	1	8,900	5
Belgium	2,400	2	2,380	4	4,770	3
Denmark	5,400	4	1220	2	6630	4
Finland	1,790	1	310	1	2100	1
France	22330	18	15660	28	37990	21
Germany	41190	32	15510	28	56710	31
Greece	1040	1	850	2	1900	1
Ireland	530	0.4	250	0.5	790	0.4
Italy	10700	8	5280	9	15980	9
Luxembourg	160	0.1	110	0.2	280	0.2
Netherlands	7,170	6	2,440	4	9,610	5
Portugal	920	1	830	1	1,750	1
Spain	5,530	4	2,510	4	8,030	4
Sweden	2,620	2	690	1	3,310	2
UK	17,090	13	7,390	13	24,470	13
EU-15	**127,140**	**100**	**56,070**	**100**	**183,220**	**100**

Source: ECOTEC (2002a)

North America remains the EU's biggest export market and has shown significant growth, while the Candidate Countries are becoming increasingly important export markets, in particular for EU Member States with close historical trading relationships to that region. The favoured method of EU company penetration into this market is through setting up a joint venture with domestic companies. EU companies are amongst the world leaders in developing new renewable energy technologies, both for domestic markets and worldwide. The strong and expanding domestic markets provide the basis for many EU companies to be active in worldwide markets. For example, the EU is the largest market for wind energy developments, with 75% of the total world installed capacity of 18.5 GW. The EU operates a trade surplus in environmental products with the rest of the world of around 5 Bn euros in 1999 which is less high than the surplus in 1997 and 1998 as a result of increased imports and a levelling out in exports. The balance of trade with respect to environmental services is unknown. The economic perspective for setting up of eco-industry can be gauged from the following statistical summary (ECOTEC, 2002a &b):

- The total EU eco-industries supply some 183 Bn euros of goods and service a year, of which 54 Bn euros are investment goods and 129 Bn euros are services, including 'in-house' non-market services.
- Total Pollution Management and Cleaner Technologies eco-industry supplies are around 127 Bn euros of goods and services a year.
- Total Resources Management eco-industries (excluding renewable energy plant) supply around 56 Bn euro of goods and services a year.
- The current size of the renewable energy plant market in the EU is around 5 Bn euros a year.
- In real terms, total pollution management expenditure has risen by 5% per annum since 1994. The proportion of expenditure spent on operating costs has increased in real terms by 8% per annum to a level of 69% in 1999.
- There has been an increase in waste management activities during the period (of 11% per annum) and waste water (by 3% per annum) while air pollution control expenditure has fallen by 5% per annum. This is likely to be a result of substantial investments having already been made during the past 10 years. Contaminated land remediation and noise and vibration control expenditure have both risen.
- The private sector is increasingly important in driving pollution management expenditure rising from 45% of total expenditure in 1994 to 59% by 1999. Household expenditure remains around 5% of total expenditure.
- From 1994, the number of direct investment related jobs in the EU in 1999 has increased by around 75% to 550,000 jobs.
- The estimated value added provided by eco-industries, based on direct labour costs, in 1999 is 98 Bn euros, which has gone up from 35 Bn in 1994.

According to the ECOTEC study, direct employment in the EU in eco-industries amounts to over 2 million (FTE) jobs in 1999. Employment levels for the wider environmental industry sector are significantly larger than the core eco-industry (i.e. pollution management) definitions used in the past. A high-end estimate of environmental employment is around 4 million jobs, using various procedures to give more realistic coverage and including the use of 'multipliers', which try to build in the indirect effects of environmental expenditure (ECOTEC, 2002a). Environmental sector employment accounts for on average 1.3% of total paid employment in the EU-15, although it is higher in some countries (e.g. Austria, Denmark, and France). For every 1 Bn euro of investment in environmental goods and services there is another 1.6 Bn euro generated in operating expenditure and the generation of 30,000 direct jobs (ECOTEC, 2002b).

A detailed estimate of environmental jobs is offered in a study for London, making a distinction between core environmental jobs and non-core ones. The non-core environmental jobs are the environmental goods and services activities in the non-environment sectors. They consist of environmental accounting, book-keeping, green finance provision, environment sector organizations (NGOs), environmental lawyers, researchers and the like. Employment in the core is estimated at 35,000 in 2001 (1% of London employment) whereas total employment in environmental activities is estimated at 140,000 in 2001 (3.4% of total employment in London), considerably higher than software development and consultancy (68,000). This suggests that environmental employment in the broadest sense (comprising all work activities that are concerned with dealing with environmental issues) is important.

According to a study by the Swiss Federal Statistical Office, Switzerland employed approximately 50'000 people in the eco-industrial sector in 1998, equivalent to approximately 1, 3% of all employees that year (SFO, 2003). This figure comprises 15'000 employees in fully eco-industrial activities and 35'000 employees in partially eco-industrial activities. In biological agriculture, which uses few environmentally harmful processes and therefore on the edge of the eco-industrial sector, had 12'500 employees in 1998? In the fully eco-industrial sector, 77% of the employees were active in sewage purification, waste disposal and other disposal and 20% and 3% respectively in the areas of recovery and preparation for recycling and wholesale of scrap and waste material. Of the employees in the fully eco-industrial sectors, 6% were women and 94% men, of which only 53% of the women and 92% of the men were employed on a full-time basis.

Rennings and Ziegler (2006) offered estimates about employment effects of environmental innovations in the adopting company, which are found to be small. Overall 88 % of the eco-innovating firms said that the adoption of the most important eco-innovation had no notable effect on employment. In 9 % of the cases the number of long-term employees increased due to the innovation, in 3% of the cases it decreased. This shows that there is a weak but positive relation between the introduction of eco-innovations and employment at the company level, with product innovations and service innovations having an above-average positive employment effect (18 % and 20 %). A number of studies have shown the positive link between environmental performance and job creation. The research shows how 'greening the economy' can boost job creation in areas directly connected to the environment such as conservation, waste, water and air quality. These are often referred to as eco-industries and are covered in studies such as:

- Analysis of the EU eco-industries, their employment, and export potential (Ecotec, 2002);
- Eco-industry, its size, employment, perspectives and barriers to growth in an enlarged EU and;
- Study on the competitiveness of the EU eco-industry (Ecorys and IDEA, 2009)

These studies use a statistically delineated definition which relies heavily on Environmental Protection Expenditures (EPE). However, this definition focuses on money spent to protect the environment, and is much weaker on jobs that depend on a good environment, or depend on natural resources. A study by GHK, IEEP and Cambridge Econometrics (IEFP, 2007) on 'Links between the environment, economy and jobs', looked not just at the direct jobs captured in the eco-industry concept, but also used multiplier effects to calculate the 'indirect' jobs created and jobs dependent on a good environment within for example eco-tourism and organic farming.

According to the above mentioned studies, the eco-industry "produces" goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources". The sectors fall into two general categories, pollution management and resource management.Estimating the number of jobs starts with estimating the turnover of the sector, and then requires the number of jobs associated with that employment to be estimated. Both of these steps are subject to uncertainty, although the data and methodologies are improving. Therefore, for preparing the update of the number of jobs dependent on the environment and resource efficiency improvements the Ecorys and IDEA (2009) study has been conducted in two ways. Firstly, only the EPEs were updated, secondly, the methodology was updated and applied. Based on updated Environmental Protection Expenditures (EPEs), new methodology and updated labour compensation levels, the following key figures were derived:

- Around 2, 2 million people worked in the EU-27 eco-industry in 2000.
- About 2, 7 million people worked in the EU-27 eco-industry in 2008 which represented 0, 81% of the total workforce (people age 15 - 64).
- For 2012, with extrapolation from reported figures, the total number of people working in eco-industries is around 3, 4 million.
- The average annual growth (2000 - 2008) in eco-industry jobs is approximately 2, 72 % corrected for inflation.
- The EPE levels in 2000 amounted to EUR 223 - 243 million, depending on methods for

calculation and representing 2, 95% of EU-27 average GDP.

- In 2012, the estimated EPE of EU-27 is EUR 557 million.
- The average growth rate for EPE (2000 2008) was 2, 8%.
- The annual growth rate over 2004 2008 for employment in eco-industries was 0, 7%.

The update of the GHK study shows how a broader definition of jobs related to the environment increases the numbers. If one uses the broader definition, some 19 million jobs in Europe are related to the environment which represents some 5% of the total working population (2010 figures). This study explored how 'greening the economy' can boost job creation in areas directly connected to the environment such as conservation, waste, water and air quality. In 2012, it is estimated that the total number of people working in eco-industries is around 3, 4 million which represents around 1% of the total workforce, and that the eco-industries have a turnover of around EUR 550 million. The general trend is of a growing number of 'green jobs' and case studies show, not surprisingly, that improving resource efficiency leads to job creation. The global market for eco-industries is estimated at roughly EUR 1.15 trillion a year in 2010. There is broad consensus that the global market could almost double, with the average estimate for 2020 being around EUR 2 trillion a year. The EU-27 has a strong export position vis-à-vis nearly all of the world's largest economies. Estimates on the growth potential vary among European companies working in environmental and resource efficiency related sectors. Generally speaking, the European companies are performing well on the global market. In three out of seven sectors photo-voltaic, air pollution control, and waste disposal - the EU has a revealed comparative advantage. Hydropower and other environmental equipment are more middle performing sector with growing competition coming from Brazil and Russia in the former sector and the US in the latter.

From a global perspective, resource efficiency has gained strategic importance. Globalization and rapid economic growth in emerging economies has led to increased global competition for natural resources and recyclable materials. It has led to resource shortages on the global market, which results in higher prices, which is significant when, as is the case for the EU, there is a dependence on imports. This has further implications for the EU economy as non-EU companies with easy and cheap access to resources may gain a competitive advantage relative to their European counterparts. As such, there is a positive correlation between the resource efficiency of countries and their competitiveness. There is also some evidence that higher levels of resource productivity go hand in hand with the competitiveness of a sector or even individual companies (Ecorys and IDEA, 2009). Resource scarcity and dependency on resource imports into the EU-27 present a clear threat to the international competitiveness of the EU, making resource efficiency a strategic factor in the European economy and as such implicitly in the European employment market.

Green eco-industries currently account for a 15% share (approx. USD 430 billion) of the world's economic stimulus packages. According to calculations made by the International Monetary Fund, every "dollar used for green purposes" attracts another dollar. Europe alone is plowing EUR 7 billion into energy efficiency to make cars more economical and buildings and factories more energy-efficient. EUR 6 billion is being channeled into development of renewable energies, while EUR 3.5 billion has been earmarked for energy infrastructure. A further half a billion euros will be spent on offshore wind farms. In the midst of the crisis, Germany has injected some EUR 80 billion into the economy, about 13% of which is set aside for climate and environmental protection activities. Compared to the international community, that is a fairly modest sum. South Korea, for example, plans to pump around USD 36 billion fully 80% of its overall stimulus package into energy efficiency, renewable energy and water pollution control over the next four years. In absolute terms, China is spending most (in the context of economic stimulus) to protect the environment and the climate: more than USD 220 billion twice as much as the USA. As early as 2013, the market for environmental technologies including renewable energy should be worth USD 1 trillion in the People's Republic.

According to study made by Lifestyles of Health & Sustainability (LOHAS-Green Business), three trends appear to be shaping the face of the green industry (Green Business - eco-industry worldwide: http://www.lohas.de/content /view/1279/195/). The first is fierce predatory competition as the first movers are accompanied by smart followers companies that intelligently plug

into other companies' technological developments. A willingness to invest heavily in research and development will be critical to the success of today's market leaders. Green technology is an extremely innovative industry characterized by short innovation cycles, so most growth happens when good ideas are quickly turned into marketable products. Patents are a good indicator of growth. Recent surveys of the environmental technology industry show that their number rose by about 19% per annum to 1,044 in the period from 2004 through 2007. German companies lead the field around the world. Of all new environment-related patents granted by the European Patent Office in 2007, 23% came from Germany. The USA (22%) and Japan (19%) followed close behind. It is important to use patents to protect good ideas.

In the past, German companies have not always been good enough at transforming R&D into market success. This because the road from basic research to marketable application is often too long one of the biggest challenges is for science and industry to work closely together including strategic alliances with the public sector. An outstanding example of such cooperation is the Fraunhofer Centre for Sustainable Energy Systems in Masdar (Abu Dhabi), the world's first carbon-neutral city. Such approaches ensure that theoretical research finds its way directly into practical applications (Green Business - eco-industry worldwide: http://www.lohas.de/content/view/1279/195/).

Second, many environmental technology markets are only now reaching the critical mass they need to accommodate production on an industrial scale. Fragmentation remains a conspicuous feature of the environmental technology industry. Roland Berger Strategy Consultants believes that waves of consolidation will sweep over the industry in the years ahead. This will be the case especially in areas where off-the-peg products enable ever greater economies of scale. A series of well-resourced companies is already exploiting growth opportunities by means of acquisition strategies.

Third, even price-conscious target groups nowadays consider ecological aspects of consumption when making product purchase decisions. In the USA, 30% of consumers already see themselves as belonging to the "lifestyle of health and sustainability" group, or LOHAS. LOHAS like to enjoy life, but only with a good conscience, for which they are more than happy to pay a dollar or two more. Marketing experts distinguish between a hard core of environmentally aware consumers and a wider circle of consumers who vacillate between buying ecological and non-ecological products depending on the situation. The hard core really does want to make the world a better place by shopping green and creating a "demand pull" for more environmentally friendly products. Though not very big in absolute terms, they form a well-networked community that has a seminal influence on the image of green products.

The current estimates of the current global market for environmental goods and services range between 330 and 410 billion EURO. OECD countries currently account for approximately 90% of the total global market. Approximately 50% of the global market value relates to the provision of environmental services. Equipment and resource management activities (including water utilities) each account for approximately a quarter of world environmental markets. Split by environmental media, the two largest sub-sectors of the global environmental industry are waste management and wastewater treatment, which together account for approximately 80% of the market value. Until the late 1970s the environmental industry was mainly located in and focused towards markets in developed countries, particularly Western Europe and North America.

The challenge of reconciling economic and ecological interests demands a new concept of progress. In this context, the environmental technology industry is emerging as an extremely dynamic factor. Companies in Germany can tap vast potential not only in their domestic market but also in the USA, Japan, Brazil, Russia, India and China. The true extent of this potential is revealed by a study commissioned by the US chambers of foreign trade. In collaboration with Roland Berger Strategy Consultants, they asked 300 companies in the US green-tech industry including the US subsidiaries of a number of German firms about their expectations for the future. Some 34% of the US companies said that they expect their revenues to grow by more than 10% within the next year and by a further 51% in the next five years. The mood among the subsidiaries of German firms in the USA was even more upbeat: 38% expect at least 10% higher revenues in the next year and a further 60% increase over the next five years. The labor market will also benefit: fully 87% of companies in the study plan to quickly create new jobs.

Conclusion

The present study on Eco-industrial clusters indicates that these clusters are unique in terms of creation of eco-innovation opportunities and in developing new business models that are eco-friendly, replicable, economically viable, environmentally sustainable and have huge potential to provide local jobs with multiplier effects. It was also observed that eco-clusters provides for local resources mobilization, waste minimization, energy conservation, low-cost technology testing and scaling, experience & information sharing, eco-market development, community actions, effective business communication and networking involving the community at large. Future eco-cluster models should focus on evolving new frontier of eco-innovations with system-based eco-designs that should not only be eco-friendly and commercially competitive; they should be so located and designed that they can offset the adverse impact of global climate change and bring in reduction of green-house gas emissions and thereby progressive reduction of carbon footprints in carbon space to help promote ecological and economic revival.

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