OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Eco-Industrial Parks

in Emerging and Developing Countries

Achievements, good practices and lessons learned

A comparative assessment of thirty three cases in twelve emerging and developing countries

UNIDO

Version V02 - 04 August 2014

Table of contents

Abbreviations

AC: Administrative Commission
APIIC: Andhra Pradesh Industrial Infrastructure Corporation
APSEZ: Andhra Pradesh Special Economic Zone
BEAP: Bizerte Economic Activities Park
CIP: Cartago Industrial Park
CP: Cleaner Production
DDA: Dalian Development Area
EID: Eco-Industrial Development
EIP: Eco-Industrial Park
GCPC: Gujarat Cleaner Production Center
GIDC: Gujarat Industrial Development Corporation
GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit
IP: Industrial Park
IS: Industrial Symbiosis
MLD: million liters per day
MWC: Mahindra World City
NEPL: Naroda Enviro Projects Ltd.
PIEAG: Eco-efficient Industrial Park of Graphic Arts
PIESB: Eco-Efficient Industrial Park of San Benito
PPP Private Public Partnership
PPSEZ: Phnom Penh Special Economic Zone
RECP: Resource Efficient and Cleaner Production
SCIP: Shanghai Chemical Industry Economic and Technology Development Park
SDA: Shenyang Development Area
SEZ: Special Economic Zone
SME Small and medium enterprises
SSEZ : Sihanoukville Special Economic Zone
TEDA: Tianjin Economic Development Area
TLIP: Thang Long industrial park Corporation
TSDF: Treatment, Storage and Disposal Facility
VSIP I: Vietnam Singapore Industrial Park I
WISP: Western Cape Industrial Symbiosis Programme
ZNEIP: Zhenjiang New Energy Industrial Park

Acknowledgements

Foreword

Chapter 1 Introduction

This Global Comparative Assessment, carried out in twelve countries, is undertaken within the framework of the joint global Resource Efficient and Cleaner Production (RECP) program of the United Nations Industrial Development Organization (UNIDO) and United Nations Environment Programme (UNEP). The programme is aimed at scaling-up and mainstreaming the application of RECP policies, practices and techniques with a view to improve resource productivity and environmental performance of industries, in particular Small and Medium Enterprises (SMEs).

Industrial parks (IP) in emerging and developing countries provide an institutional framework, modern services and a physical and often social infrastructure, which might not be available in the rest of the country. The concentration of companies can foster innovation, technological learning and company growth. Economies of scale of the supply of services and facilities reduce the costs for companies. When IPs are successful, they contribute to high growth regions and national economic development. However the economic gains often come at a loss of environmental quality within and around industrial estates. Environmental issues have often not been fully considered and integrated into the planning and construction of IPs (UNEP/SEPA, 2001). For example in China, problems have arisen due to the rapid growth of IPs, despite regulations and awareness of environmental management (UNEP/SEPA, 2002). Important environmental issues are water, waste water and waste management. Water shortages are becoming increasingly serious and could threaten the development of IPs. Similarly with growing production and consumption there is an increase in waste which needs to be handled properly.

There is a difference between creating green industries and the global process of the greening industries. The creation of green industries implies the achievement of the industrial supply of a diversified set of environmental goods and services, such as clusters of renewable energy developers or recycling and safe disposal of waste streams. The second category, the greening of industries, refers to all industrial activities. It entails the waste and emission reduction in individual plants, through a high level of coordination of their individual environmental initiatives. Another example is through waste (solid, liquid, gaseous) treatment in collective facilities for reuse by other enterprises. For RECP implementation the second category of greening industries is most important. IPs are very suitable because of their scale which leads to large scale achievement of plant level resource efficiency resulting in waste streams that can then further be collectively recovered.

An industrial park in which companies cooperate with each other and with the local community trying to reduce waste and pollution, efficiently share resources and help to achieve sustainable development, with the intention to augment economic gains and improving environmental quality, can be called an *Eco-Industrial Park (EIP)*.

Advantages of such environmental management (UNEP/SEPA, 2001a):

- IPs are export oriented and therefore environmental management practices of IP companies become gradually in line with international standards
- Environmental management should rely on measurements to achieve high efficiency
- Environment affects investment, eco-industrial parks put more effort in controlling environmental quality than normal areas
- EIPs can serve as special designated area to test new environmental management practices and advanced instruments

A positive net economic effect is made by many environmental investments and services because they make manufacturing more efficient, i.e. decrease in waste, energy efficiency and loss of materials. They also lower the costs of environmental compliance. Where benefits are properly shared between the park management and its tenant companies, all parties can benefit. The park manager can recover some of the costs made for environmental management services by charging fees to tenant companies. Some environmental services can also be provided by private contractors which can charge a fee which is lower than the costs saving (Europe and Central Asia Regional Conference on industrial parks, 2012).

An overall challenge for the global RECP programme is to develop, trial and promote approaches to scale-up and mainstream the application of RECP: through reaching out to many individual enterprises in a region or sector, collective application of RECP e.g. in resource conservation facilities through economies of scale and finally through *industrial ecology* or *industrial symbiosis*. Industrial symbiosis is the exchange of byproducts of one company (or sector) by other companies (or sectors) in close geographic proximity. More broadly, industrial ecology can be described as the design of industrial infrastructures as if they were a series of interlocking ecosystems with interfaces with the natural global ecosystem.

An industrial zone, sector or park can turn into an eco-industrial park through the combination of two factors:

1. Plant level efficiency: resulting in minimization of waste and emission generation from individual enterprises
2. Collective synergies: resulting in optimized resource exchanges between companies.
3. Environmental and utility systems
4. Proper zoning and planning
5. Environmental management of park operations

The ultimate aim is to almost zero the net generation of waste, effluents and emissions. The term Eco-Industrial Park (EIP) has become the umbrella term for parks that practice such collective environmental initiatives in their design, construction and/or ongoing operation and management (UNIDO, 2014). Environmental and utility systems and the impact of zoning are discussed in the following chapter.

Stakeholders involved in establishment of or conversion into an eco-industrial park are

- Developers and investors, private or governmental, who are often mainly concerned with economic benefit and may be concerned that good environmental practices are costly
- Government decision makers and managers
- Company decision makers – future and present tenants
- Environmental managers
- Consultants for environmental planning of EIP
- Involved public
- International community, including bilateral and multilateral aid agencies and international financial institutions

Their impact depends on their environmental awareness and scope of their responsibility.

Eco-Industrial Parks have been assessed in various comparative studies, mostly in developed countries. So far the following drivers for EIPs in developing and emerging countries have been promoted: environmental and resource conservation benefits; operational costs saving; and technology learning and adaptation. However insight in these drivers behind the development of EIPs specifically in developing and emerging economics is lacking. UNIDO therefore set out to document in comparable manner 33 examples of EIPs in 12 developing and emerging economies, including their policy context (Cambodia, China, Colombia, Costa Rica, Egypt, El Salvador, India, Morocco, Peru, South Africa, Tunisia and Viet Nam). The goal of this report is to carry out an in-depth comparative analysis of the results of the country level case studies, to understand the environmental, social and economic benefits, extract good practices and success factors and to formulate policy suggestions. This should contribute to the scaling-up of the environmental and economic benefits to a larger number of industrial parks and their occupant companies. Summaries of the EIP cases are included as annex II to this report. The full details of each case can be found in separate on-line publications on www.recpnet.org.

Chapter 2 Characteristics of the cases

In this chapter there is a presentation of the basic findings for all of the cases. The results show a high variety among the cases, related to the country of origin, location, industry mix, ownership and various other factors. This variety reflects the boundary conditions in which eco-industrial development takes place. Thirty three cases in total have been analyzed, spread over twelve countries. The countries are: China, India, Vietnam, Cambodia, Egypt, Morocco, Costa Rica, Colombia, El Salvador, Peru, South Africa, Tunisia (see Table 2.1). These countries all have developing or emerging economies with GDP per capita ranging from $2600 (Cambodia) to $12900 (Costa Rica). Members of the RECP*net* in the study countries reviewed several cases of eco-industrial park developments in their home country. For each case the following information was collected: history or eco-industrial story; achievements and practices implemented; economic, environmental and social benefits; monitoring and evaluation; best practices,

drivers and success factors; needs, difficulties and lessons learned, and perspectives and outlook. The reviewers collected information from various sources, including planning and policy documents, technical reports and through direct data collection from park managers and tenant companies. In Annex II the summaries of all cases are presented. This chapter describes some of the cases and discusses briefly the stage of development, characteristics, sectors, EIP located in ecological areas, ownership, number of SMEs in IPs and physical infrastructure.

Stage of development

Annex I shows the development state of the IPs and EIPs and whether each is in full operation or not. The stage of development is indicated by the parks themselves. Some IPs are going to implement EIP applications (the two Egyptian IPs and SSEZ Cambodia), some are pilots (IP Nacharam and IP Mallapur India and CIP, Costa Rica) and others are demonstration parks (TEDA and SCIP, China). APSEZ, in India, is a greenfield project, still under development.

Other industrial parks call themselves EIP or "Eco-park" but are still rather premature with respect to eco-industrial development. It appears that governments have different approaches for EIP and different standards. For not all IPs designated as EIP indeed display EIP features. For example the three Peruvian IPs are all called "EcoPark", but are not EIP yet, according to considerations of plant level and collective resource efficiency mentioned in chapter 1.

Some IPs like the two Cambodian cases are not yet fully operational. In some countries the creation of an IP is risky because of the investments needed and the uncertainty of companies coming to actually establish themselves in the IP. On the list several IPs are not fully operational, meaning that some land or even factory units are not utilized, giving rise to inefficiencies in land use. This is a serious issue for planners of EIP and IP, see example below of APSEZ.

Box 2.1 APSEZ (India) a greenfield eco-industrial development project

In 2004 Andhra Pradesh Government started to foster Eco-Industrial Development (EID) in IPs. The case of Nacharam and Mallapur was the first pilot. The results were used for conversion of other IPs and for establishment of new IPs. APSEZ was identified as ideal case for a planned EIP. The measures included Green SEZ (policy level) guidelines, Environmental Management Cell (park level), Eco-club and Eco-Profit (unit level) and Skill Development Centre and Eco-Drive (society level).

EID at APSEZ included site selection, environmental impact assessment, site and land use planning, green belts creation, establishing management structure for environmental management, monitoring of performance of the zone and industries, improving waste and water handling, supporting industries in RECP measures, strengthening the environment, utility and related industrial infrastructures and more.

Resettlement of villagers took place in a considered way on mutually agreed terms and their living conditions improved at the new site.

Because APSEZ was newly planned, Site Master Planning was important. It helps a park to attract investment and create a competitive industrial environment. Zoning of the site was done to explore synergies between the units and reducing the stress on environment. Industries with significant environmental impact were restricted from the park. APSEZ contains a one stop service center of $2.2 million to ease administrative difficulties. So overall APSEZ is attractive as it is relatively new, the location was carefully selected, Andra Pradesh Industrial Infrastructure Corporation (APIIC) is an experienced planner and there was land use planning. However because the park is new it is not fully operational and many facilities have not been installed yet, for example hotels and restaurants and technical facilities as wastewater plants. It is the first planned EIP in India. The state has invested heavily as it saw potential to reduce environmental and social impacts of industrialization while increasing the economic benefits. There are currently only 13 units operating at APSEZ.

Case characteristics

Table 1 shows the area (ha), number of companies and number of employees in all the cases. The cases show large variation in numbers. There are a few very large parks: Chinese TEDA with 10000 companies, Chinese DDA with 4000 companies and Peruvian Industrial Park «EcoPark Callao» with 3180 companies. Further more there are a few IPs with 1000 to 1700 companies: Chinese SDA, Egyptian 6th of October City and 10th of Ramadan City and Indian Vapi and Naroda industrial estates. Very small number of companies in the IPs are the mine Rustenbrug (1 company), Guangxi Xianggui Sugar Group (4), El Salvadorian El Pedegral (12) and Miramar (11) and Indian APSEZ (13). Concerning the number of employees, some IPs offer space to a few companies, but consisting of very large companies, and other IPs locate numerous companies yet very small ones. IPs with a particularly high employment (more than 100,000) are: the Chinese DDA, TEDA and SDA, Indian Vapi, the two Egyptian IPs and Vietnamese VISP I. These high numbers show the economic and social importance of the IP.

Many of the parks have a relatively high number of people living in the vicinity of the park. Almost 4 million near MWC (and within MWC 100.000 see box 4.2), more than a million inhabitants for DDA, TEDA and SDA and more than 100.000 for SCIP, the Egyptian cases, El Pedregal, Sidi Bernoussi, Eco PYMES and Callao.

Table 1 Characteristics of the cases

Country	Case	Area (ha)	No. of companies	No. of employees
Cambodia	PPSEZ	360	38	10000
	SSEZ	528	27	11000
China	SCIP	2940	71	17000
	Guangxi Xianggui Sugar Group	266	4	1350
	ZNEIP	900	30	2000
	DDA	104000	4000	256000
	TEDA	34000	10000	484800
	SDA	44800	1300	300000
Colombia	PIEAG	0.4	88	400
	PIESB	Not available	78	Not available

Costa Rica	CIP	45	33	9000
Egypt	6th of October City	3600	1400	140000
	10th of Ramadan City	5847	1300	129000
El Salvador	El Pedegral	10.4	12	6500
	Miramar	8000	11	493
India	IP Nacharam and IP Mallapur	364.2	681	17000
	APSEZ	2264	13	2738
	Mahindra World City	630	62	35000
	Vapi Industrial Estate	1140	1696	247000
	Naroda Industrial Estate	363	1100	30000
	Satchin Industrial Estate	749	600	45000
Morocco	Sidi Bernoussi Industrial Park, Casablanca	1000	600	50000
	Tangier Industrial Park	138	107	25000
Peru	Industrial Park «EcoPYMES Pantanos de Villa»	13.7	300	3670
	Industrial Park «EcoPark Callao»	4600	3180	25000
	Industrial Park «EcoPark Pucallapa»	44	80	0
South Africa	Western Cape Industrial Symbiosis Programme	virtual	virtual	virtual
	Capricorn Park	70	180	Not available
	Rustenburg Platinum Mines Limited (Ltd)	16000	1	20706
Tunisia	Bizerte Economic Activities Park	81	62	5470
	Industrial Area of Djebel Oust and Bir M'Cherga	228	105	23000
Vietnam	Thang Long industrial park Corporation	274	78	63600
	The Vietnam Singapore Industrial Park I	500	240	96367

The year of establishment (see also Annex I) varies greatly. Some Indian, Moroccan, Egyptian and Chinese parks are rather old. The mine Rustenburg even originates from 1931. The IPs that are older are more likely to have polluting infrastructure, use of old technologies and poor zoning. All the industrial parks have started with eco-industrial development (EID) from the year 2000 or later.

Sectors

Most IPs contain multiple sectors of industry. Most common are (petro) chemicals, manufacturing, textile, pharmaceutics, (agro)food, dyes and automotive. A few IPs consist of only one sector: ZNEIP China (photovoltaic), PIEAG Colombia (graphic arts industry), PIESB Colombia (tannery), and Peruvian EcoPark Pucallapa (especially wood based industry). Mahindra World City contains only non and little polluting industry as it is also a green city. The same holds for Capricorn see Box 2.2.

EIP located in ecological areas

One observation is that some IPs have been purposely created to locate several companies close to a natural reserve. For example EcoPYMES Pantanos de Villa is located adjacent to a wildlife refuge wetland, and EcoPark Pucallapa is in the Amazone forest. Capricorn Park (Box 2.2) in South Africa is located on environmentally sensitive land with high biodiversity. The Chinese Dalian Development Area (DDA) is located in the Dalian Municipality. Dalian is a famous tourist city on an ecologically sensitive peninsula. Planning an industrial zone next to a natural reserve is a matter of discussion.

Box 2.2 Capricorn Park

Capricorn Park South Africa is located at an environmentally sensitive land with high biodiversity. All tenant companies are subjected to a strict environmental screening process. The fact that the development site was located within such a biodiverse landscape meant that Capricorn Park was required to sign an Environmental Agreement with the Cape Town City Council. Only commercial and light manufacturing companies are allowed.

Ownership

There is a difference in ownership of land, companies and park (its collective infrastructures and built environment, e.g. roads, water and energy supply and waste and effluent treatment). In addition there is a difference between involvement of public or private sector in the development phase of the EIP and the operation of the EIP. Most common is public or PPP for development of an IP and private ownership for companies. However in many IP there are state-owned companies. In addition some parks have more foreign investment than others.

For example SSEZ is a Private Public Partnership (PPP) founded by a Cambodian company and a Chinese company. Another example is the Vietnamese IP VISP I (see Box 2.3). Another IP with foreign investment is TLIP, which is jointly established between Sumitomo Corporation, a world's leading integrated trading house of Japan and Dong Anh Mechanical Company, one of the most successful Vietnamese companies under the Vietnam Ministry of Construction. The companies are Japanese or Vietnam/Japanese joint stock.

The land in many cases is owned by the government (like all Chinese IPs except Guangxi Xianggui Sugar Group). Privately owned land is the case in CIP, Costa Rica, PIEAG Colombia, El Pedegral, El Salvador, two cases in South Africa and the two Moroccan IPs.

Box 2.3 Business model of VISP I

Vietnam-Singapore Industrial Park I is a symbol of Vietnam-Singapore cooperation, and has been considered one of, if not, the most successful industrial parks in Vietnam from a sustainable development perspective. VSIP I has contributed to the socio-economic growth of the region and the country with a total investment capital of US$ 2.62 billion from 240 projects of 22 countries all over the world,

VSIP is developed as a joint venture between Becamex IDC Corporation, Vietnam and Sembcorp Development Ltd (SDL), Singapore. Becamex IDC Corporation, one of the most successful state-owned enterprises in Vietnam belonging to the Binh Duong Province People's Committee, holds

49% of the legal capital. The remaining 51% is held by Sembcorp Development Ltd, a 100% owned subsidiary of Sembcorp Industries which is a trusted provider of essential energy and water solutions as well as developer of integrated townships and industrial parks in the region.

Number of SMEs in IP

Another key factor is the number of small and medium enterprises (SMEs) within the IPs. SMEs are often labour intensive and can play an important role in providing jobs and incomes at the regional level around the IP. Some IPs mention a high number of SMEs as a cause for the higher level of pollution, as is the situation with Vapi Industrial Estate, India (Box 2.4). SMEs at DDA, TEDA and SDA do not receive adequate support for their EIP efforts. Under Chinese legislation, medium- and small-scale projects, unlike larger companies, can easily bypass the compulsory cleaner production audit requirements. Managers of SMEs have relatively lower environmental awareness and often regard environmental protection as a burden. SMEs have been growing rapidly in number in these and other IPs. Their production has caused significant negative environmental impacts. TEDA decided to support SMEs in obtaining the ISO 14001 certification, which is costly in China. The Administration Commission (AC) at TEDA provided a subsidy of 30.000 RMB consulting and certification fees. 240 companies at TEDA passed the certification. At DDA the AC compensated up to 50% of the consulting and certification fees, resulting in 119 companies passing the certification. SDA does not provide any financial subsidy to its tenant companies for ISO 14001 certification due to its lower public budget. Until August 2013, only 55 tenant companies had passed the ISO 14001 certifications.

Box 2.4 VAPI: This particular cluster was chosen for a case study within the perspective of RECP because Vapi is a core industrial cluster of Gujarat. According to the Indian Institute of Foreign Trade, SMEs contribute about 6% of the country's GDP. The Vapi SMEs are facing rising energy cost, poor effluent treatment plant performance, sludge generation, potential pollution load, use of old technologies and lack of proven technologies. SMEs have been facing the problem of compliance with environmental standards and are facing challenges in operation & maintenance. Poor performance of the CETP was one of the factors for the Industrial Estate Vapi being categorized as critically polluting in the year 2009.

Physical infrastructure

Below is a table listing the physical infrastructure possibilities as mentioned by the cases. The infrastructure is either provided by the local, provincial or national authorities, by private companies (subcontracted by the IP) or by the IP as collective service. Companies of an IP may have to pay for some of these products and services. For example Mahindra

World City has contractors for security, waste management, water supply and sewage treatment.

Table 2 Physical infrastructure as mentioned in the case studies

Physical infrastructure			
Collective road network	External power supply	Railway	Sanitation
Collective solid waste	Telecommunication	Port	Private well water
Collective water supply	Security	Airport	Rain water harvesting
Water supply from outside IP	Health clinic	Greening landscape	Storm water drainage
Power supply from IP cogeneration	Bank	Recycling	Lights
	Bus station		

For some IPs the creation of physical infrastructure is essential as there is a lack of infrastructure in the rest of the country. An IP with good infrastructure will attract more companies. This is a major issue in developing and emerging countries. The infrastructure is not taken for granted.

Chapter 3 Importance of EIP

In this chapter and the next chapter it is shown that given the EIP is planned and developed in a proper way, it can bring major environmental, economic and social benefits. It is illustrated that eco-industrial development can foster economic and social growth whilst safeguarding the environment.

3.1 Environmental benefits

As can be expected, the environment can benefit greatly from EIP development. The main types of environmental benefits are listed in Table 3. These include reduction in air emissions, reduced energy and water consumption and reduced waste water. The types and relative importance of environmental benefits vary largely between EIPs and to a large extent reflect differences in industrial structure of the EIPs, such as composition of tenant enterprises by sector, size and level of technology and management. Equally important for the reduction of environmental impacts are the development of relevant indicators and their monitoring (chapter 4) and the enforcement of environmental regulations (chapter 5).

Table 3 Environmental benefits

Less air pollution
Less soil pollution
Less water pollution
Lower CO_2 emissions, lower contributions to climate change
Cleaner waste water or reduction in waste water
Less water consumption
Energy saving through energy efficiency, energy recovery and use of renewable energy
Biodiversity preservation
Reduction in solid and hazardous waste
Reduction of product losses
Creation of green space in EIP
Reuse, recycling
Planting drought resistant plants
Reduction in space needed for waste storage

The most commonly mentioned achievements in environmental management are treatment of waste water (e.g. VSIP I is the first industrial park in Vietnam to have a common wastewater treatment facility which is a complete and modern system), treatment of emissions and odour (companies have to install their own systems), treatment of solid and hazardous waste, and management of trees and plants (e.g. 30% of area cover).
As mentioned in chapter 2, some IPs are located in ecologically sensitive areas. The management of these parks maintains very strict environmental standards in order to limit the impact on the natural reserve. These parks also consider preservation of biodiversity as a priority, for example EcoPYMES and Pucallapa in Peru.

Several IPs that were included in this comparative assessment, caused very severe pollution in the past, and despite praiseworthy improvements, still remain significant pollution sources. Some parks have decided to close down the most polluting companies. At DDA almost 100 industrial plants have been closed because of inefficiency. Also at Naroda Industrial Estate many companies had to close down in the 1990s because of pollution in the villages nearby. Vapi Industrial Estate is an industrial park dating back from the 1960s. They have initiated several environmental initiatives, including industrial symbiosis (table 3). However, much more is needed in particular to deal with sewage. Vapi is listed as a critically polluted area, no expansion of production activities have therefore been allowed for the last four years, creating a significant driver for companies to become more resource efficient as a means to still grow and improve competitiveness.

Box 3.1 Rustenburg Platinum Mines

The Rustenburg Platinum Mines is spread-out integrated mining, minerals processing and metallurgical complex with severe environmental impacts. The Rustenburg Waterval smelter is the world's largest platinum smelter. Through modernisation, the SO_2 emissions dropped significantly. Operations are very energy intensive. Mining operations remain the largest user of energy through compressors, winders, pumps, ventilation and cooling systems. Smelting and concentrating are the second largest users of energy through the furnaces and flash driers, followed by refineries which use the least energy. In an effort to enhance energy efficiency at their mining operations, Rustenburg have replaced conventional boilers with heat pumps at all mining change-houses. All operations have environmental management systems that are ISO 14001 certified.

Box 3.2 Climate change and environmental benefits at Naroda Industrial Estate

At Naroda (and Vapi) climate change studies were carried out by the Gujarat Cleaner Production Center (GCPC) to assess the vulnerability of industries to climate change because of severe drought in Gujarat. In the past forty years, Gujarat has experienced 12 years of drought and the return period of major drought events has decreased substantially in the last couple of decades. Also there are expected to be more severe rainfall events

Naroda Enviro Projects Ltd. (NEPL) has set up two main projects at Naroda: a Common Effluent Treatment Plant (CETP) of 3 million liter per day (MLD) capacity, which is giving services to the polluting industries located on the Naroda Gujarat Industrial Development Corporation (GIDC) Estate, and the first Hazardous Treatment, Storage and Disposal Facility (TSDF) to which over 1400 enterprises dispose their hazardous waste. The German International Development Agency (GIZ) has supported the development of EIPs in Gujarat since 2010, and pilot projects and capacity building (2012) took place together with GIDC and GCPC.

Industrial Symbiosis

As mentioned earlier, the concept of Industrial symbiosis (IS) is attracting more and more interest as a way to foster environmental benefits at a large scale as companies start to use each other's waste steams as alternative inputs. The benefits from industrial symbiosis can be very significant, as is illustrated by the various cases that have applied industrial symbiosis. Table 4 lists the various forms of IS.

Box 3.3 TEDA

TEDA is a success story in China, because it has had strong leadership, international support and well-developed industrial symbiosis. Unlike other national EIP projects in China, TEDA received the technical support from international experts in its earlier EIP stage. The regional industrial symbiosis network covers infrastructure sharing, integrated water, solid waste, land and information management. Various environmental benefits, such as conserving natural resources, reducing solid waste volume, and reducing the burden of the local landfills, have been obtained. 248 companies have joined the local industrial symbiosis activities, resulting in 42 industrial symbiosis partnerships. However, the net outreach of industrial symbiosis in TEDA remains modest, considering the size of this very large IP with more than 10,000 companies.

Table 4 Overview of industrial symbiosis in the different case studies

Case	Industrial symbiosis
SCIP	Processing of by-products is done by various units or the same company
Guangxi Xianggui Sugar Group	Yes
ZNEIP	Yes
DDA	A circular economy promotion center, established in 2009, coordinates industrial symbiosis
TEDA	Special funds have been prepared by the administration commission to support industrial symbiosis related R&D activities so that more by-products exchange opportunities can be identified among different tenant companies.
SDA	Yes
CIP	ITCR staff found a way to implement a new model whereby waste was to become a raw material for other enterprises
IP Nacharam and IP Mallapur	Not explored
Vapi Industrial Estate	Industrial symbiosis: plastic waste recycling by the cement industry, consumption of gypsum by cement industry, secondary sludge for composting and more.
Naroda Industrial Estate	Currently, the industries do not access new innovative technologies or techniques for industrial symbiosis. A research project was done by the University of Kaiserslautern (Germany) to utilize synergies of industrial ecology networking among the companies. The four recycling projects are recycling of spent acid, chemical gypsum, chemical iron sludge, and biodegradable waste.
Industrial Park «EcoPYMES Pantanos de Villa»	Recommended to identify industrial symbiosis
Industrial Park «EcoPark Callao»	No symbiosis yet
Industrial Park «EcoPark Pucallapa»	Symbiosis expected for waste management of wood
Western Cape Industrial Symbiosis Programme (WISP)	Although outlined in its Environmental Management System (EMS), very little actual industrial symbiosis is evident at Capricorn Park. No sharing of

	services, utility and by-product resources is apparent.
Capricorn Park	Industrial symbiosis is largely untapped and could be implemented in an effort to attract more business and investment.
Bizerte Economic Activities Park (BEAP)	Industrial Ecology as part of UNIDO project and CITET options that have been identified, not implemented yet
Industrial Area of Djebel Oust and Bir M'Cherga	IP has identified an option for industrial symbiosis: Recovery of the industrial waste building materials by the cement industry as raw materials.
TLIP	Industrial symbiosis (sharing of resources, raw materials exchange) - needs to be explored and encouraged through advocacy and policy intervention.

The application of IS though remains fairly new and many IPs are just starting to explore the possibilities of IS. It is a typical component of an EIP. One way to increase IS is through the application of a facilitated industrial symbiosis programme as was done in TEDA and Western Cape (WISP, see Box 3.4).

An example of an IP with little IS is Capricorn Park in South Africa. Although outlined in its Environmental Management System (EMS), very little actual industrial symbiosis is evident at Capricorn Park, South Africa. As such, the Park appears to be more 'environmentally friendly' than 'eco-industrial'. Strict policies regarding waste water, air pollution and biodiversity management apply. However, no sharing of services, utility and by-product resources is apparent. If any material or energy exchange does occur at Capricorn Park then it occurs at the individual, private firm level, as such practices are not actively enforced by the park management.

Box 3.4 WISP

The Western Cape Industrial Symbiosis Programme (WISP) is a 'virtual' eco-industrial park which seeks to build networks of businesses by identifying mutually profitable links or "synergies", so that under-utilized and under-valued resources from one business (materials, energy, water, logistics, assets and expert knowledge) are used by another. WISP is a free facilitation service which uses an Industrial Symbiosis approach to enhance business profitability and sustainability. In its inception phase, this pilot project has been initiated by the Western Cape Government (under its green economy programme) and is being delivered by the GreenCape Initiative, a sector development agency.

The benefits of the programme are not yet possible to gauge (as it is still in inception phase, and thus lacking sufficient data to track progress). WISP is based on the successful UK National Industrial Symbiosis Programme (NISP) and supported by International Synergies Limited (ISL). WISP is a novel approach to resource efficiency, and provides a potentially realisable alternative to eco-industrial parks, especially within the South African context where such parks are not promoted nor prioritised in national industrial policy.

Overall we can conclude that all cases have reported environmental benefits. The active pursuit of EIP clearly has a positive environmental impact.

3.2 Economic benefits

In this section, examples of the economic benefits are presented. Primarily it is shown that the economic benefits of EIP and IP in development can be very large. The economic benefits of several cases are listed in Table 5. The main economic benefits are direct and indirect employment creation, cost savings because of reduction in waste and resource and energy efficiency and increased competitiveness. Some IPs also report higher foreign direct investment in their parks.
In absolute terms the scale of economic advantages varies largely between smaller IP and larger IP, similarly the benefits for a large EIP tend to be greater than for a small EIP.

Table 5 Direct economic benefits

Direct employment creation and income generation	Foreign direct investment	Reduced resource costs	Avoidance of regulatory penalties due to waste charges
Export growth and export diversification	Government revenues	More efficient material use	Increase in income per capita
Foreign exchange earnings	Increased competitiveness of companies	Increased sales through green marketing and image	Meeting customers requirements
Reduced costs for waste management	Reduced energy costs	Reduced costs of water consumption	Reduced costs for transportation
Benefits for industrial and residential infrastructure	Integration with regional, national and international markets	Mixed land use planning	Improvement of the business/investment climate
Access to investment capital	Access to environmental credit lines	Access to environmental certification	

The indirect benefits are more difficult to measure but are very important for long term economic development: indirect employment creation, skills upgrading and training; technology transfer; improved image; demonstration effect arising from application of best practices; and regional development.

Important for many IPs are the price of energy (power, fuels, heat) and other utility costs (water, waste water, waste management etc). TEDA and SDA (Box 3.5) show that sound investment in infrastructure increases the competitiveness of companies within the IP and reduces resource costs.

Moreover, some of the cases mention the economic benefits of industrial symbiosis. The value of by-products exchanges among different companies at TEDA reached $3.36 million in 2012. The by-products exchanges at SDA reached over $1.6 billion.

Economic benefits of best practices

Many of the best practices listed in the cases bring economic benefits. Whilst some listed benefits are exclusively linked to specific eco-industrial initiatives others cannot be disentangled from traditional industrial park development:

- For example in the case of SSEZ, Cambodia, best practices include use of solar water heating on the factory roof and use of energy-efficient lights and sky lights, which all reduce energy costs.
- Companies located in SCIP China saw an increase in profit from 2008 to 2011 with 141.2 % while total investment in environment protection was $123,7 million (2011) or 17% of total fixed asset.
- The Guanxi IP in China reports a doubling of income from the sales of molasses and 35% increase in income out of bagasse (used for packaging material). Filter mud was processed into organic fertilizer, increasing income with $47.6 per ton. Waste water was reused, saving $95000. Sales revenue reached $37 million through improved resource efficiency, new product sales and cost savings.
- At DDA the total gross domestic production increased by 11.5% to 147.2 billion RMB.
- At TEDA the GDP increased by 4.5% in 2012 to 200 billion RMB.
- SDA's GDP in 2012 reached 110.5 billion RMB, increased by 9.41 %.
- Costa Rican CIP listed the following yearly savings: more efficient illumination: $166.000, compressed air: $86.000 and water saving: $31.000.
- Similarly El Pedegral natural lighting project: cost $45.000 and annual saving $7.200. Water saving investment of $38.000 resulted in annual savings of $4.200 and improvements irrigation costed $20.000 for annual saving of $2.400. A common waste water treatment plant costed $75.000 and no saving has been made. All these measures have reportedly attracted foreign companies to the park.
- Sidi Bernoussi IP had a project called Corporate Citizenship, with an investment of $6 Million. The gains were: electricity: $3.3 Million, fuel: $3.3 Million, water: $0.8 Million. Another initiative had an investment of $642.000 and an annual gain of $638.000.
- The EcoPYMES case reports economic benefits from reduction of waste, energy and water consumption, a biodigester and use of saw dust for boiler instead of freon.
- The case EcoPark Callao describes for a few enterprises the costs savings in water consumption, energy consumption.
- The Tunisian park BEAP mentions cost reduction of fuel consumption by cement through the use of by-product; improved profitability of operating a still in the park; reduced management costs of waste, recovery of waste and reduced space needed for storage of waste. Various cost saving projects are under study.
- The Tunisian IP Industrial Area of Djebel Oust and Bir M'Cherga also mentions recovery of concrete waste by the cement industry as raw materials, recovery of brick waste by the cement industry (both not implemented yet) and maintenance of public lights.
- In IP TLIP Canon has achieved energy saving, reduced water consumption, reduction of solid waste and reduction of chemical use per production unit

- The Rustenburg Base Metals Refiners (RBMR) utilises a lot of water and generates a liquid waste containing sodium sulphate. The operation attempted to reuse this waste water by returning it into their processes. However, this was not possible due to the high levels of sodium sulphate. In the early 1990s, Rustenburg decided to begin recovering this sodium sulphate by-product in its solid form. This by-product is sold to Unilever for use in their shampoo and soap products.

Several parks are not fully operational (Annex I) and still have empty lots and in some cases unutilized or under-utilized buildings and infrastructures. Several IPs (e.g Indian APSEZ (Box 2.2) and Cambodian PPSEZ) reported difficulties to attract companies, a phenomenon common to any IP development. Unfortunately such situation increases the costs for the companies already established in the IP as the costs of for example a CETP have to be divided among a smaller number of companies.
Only one case mentioned direct negative economic impacts. Some of the PIEAG companies in Colombia experienced a decline in competitiveness, because of the additional costs of investing in and running more technologically advanced equipment. Some of these companies have left the park. Other companies in the same park have gained benefits, due to subsidies provided by the environmental authority and academy as listed in table 5.

Interestingly, Indian MWC introduced two different indicators: Investment made per hectare of land ($0.9 Million/ha) and Exports per hectare of land ($1.8 Million/ha). Since some parks reported economic output and export the ratio based on those indicators can be calculated. Table 5 lists the economic output and export divided by the size of the area. El Pedegral shows the highest export per area ratio followed by TLIP and BEAP. The other IPs did not report on these data. The GDP ratios are highest for DDA and TEDA.

Table 6 Economic output and export ($ Millions)/ ha ratio

Case	Economic output $ Million /ha	Export $ Million /ha
DDA	1.42	
TEDA	0.92	0.58
SDA	0.40	0.17
6th of October City	0.17	
10th of Ramadan City	0.33	
El Pedegral		20.58
Miramar		0.01
Mahindra World City		1.76
Vapi Industrial Estate	0.08(VAT)	1.06
Naroda Industrial Estate	2.75(turnover)	0.33
Sidi Bernoussi Industrial Park, Casablanca		
Bizerte Economic Activities Park (BEAP)		3.46
Thang Long industrial park (TLIP) Corporation		8.25

Box 3.5 SDA (China) and industrial symbiosis

At SDA, with careful planning, a regional industrial symbiosis network has been Established that covers infrastructure sharing, integrated water, solid waste, and energy management. A key industrial symbiosis effort at SDA is energy saving and application of
renewable and sustainable energy application at the whole park level, including the reduction of energy consumption through the application of ground source heat pumps, district heating and de-sulphurization and de-NOx technologies in the local coal-burning power plants and reduction of energy consumption for the promotion of service sectors. Also through symbiosis water consumption and pollution of many substances have been reduced. From economic incentives point of view, the administrative committee of SDA established a circular economy promotion fund (with a total value of $4.8 million) to support key industrial symbiosis projects. A large amount of investment is dedicated to supporting public infrastructure at SDA for water pipelines, CNG pipeline and heat pumps. This and industrial symbiosis led to increased competitiveness of companies, reduced resource costs, less dependence on coal, increased sales due to 'green' and niche marketing, and other. Notably back in the late 1990s Shenyang was listed as one of “ten dirty cities” in the world.

3.3 Social benefits

Though not always planned in an EIP development, the creation of a more environmental IP often involves the creation of a social infrastructure as well. The poorer the country or region is, the more important is the social infrastructure. The social infrastructure activities consist of facilities and services. Examples of facilities are schools, clinics, pharmacies. Examples of services are: creation of more awareness, training of women and young people or community services. The social infrastructure provided by the cases is listed in Table 7. Some companies have social benefits as part of a deliberate strategy for Corporate Social Responsibility (CSR). In Morocco at IP Sidi Bernoussi there was a project for slum dwellers. In developed countries these social products and services are often provided by the government and thus taken for granted.

Table 7 Social benefits of EIP

Social infrastructure	
School	Financial institutions
Training	Recreational space
Hospital	Personnel transport
Cultural facility	Pharmacy
Occupational health and safety	Residential units
Breastfeeding program	Providing furniture
Reforestation	Providing play equipment
Awareness	Roads to surrounding area

Cleaner environment	Training women
Creation of green communities	Project for slum dwellers
Community networks	Environmental education
Customer services to clients	Increase value natural area
Administrative assistance	Transition to more sustainable land forms
Abundant water supply	Police
Low cost energy	Postoffice
General maintenance	Restaurants
Kindergarten	Vocational center
Containers for waste	Preservation of nature

The Rustenburg example is dominated by one company (Anglo American Platinum) having several large operations. Environmental management at Anglo American Platinum is characterised by an increased focus on conducting mining and its related activities in a sustainable manner, integrating social, economic and environmental factors so as to secure their licence to operate, minimize harm and deliver long-term benefits to all of their stakeholders. The need to restructure the company – to restore profitability and align production with market demand –is required for the long-term sustainability of Anglo American Platinum. The loss of jobs has large consequences for the local community.

Tunesian Industrial Area of Djebel Oust and Bir M'Cherga: is constructing a centre of life with the aim to improve the quality of life and hygiene and strengthen infrastructure like banks. EIPs can also be beneficial for the treatment of resettled inhabitants, which is a very important issue in India.

In 2010, VSIP I was awarded the Award for Green Technology by the Vietnam Environmental Protection Association for its contribution to environmental conservation. A number of companies in VSIP I have ISO 14001 certification such as Procter & Gamble Indochina, Uchiyama, Yakult, Esquel Garment, MHE Demag Vietnam,Takako and Estec. As a result, these companies are continuously seeking to improve their environmental and social performance through cleaner production and resource efficiency solutions.

Chapter 4 Role of governance and monitoring

This chapter highlights the role of governance, management and monitoring in development, implementation and ongoing operations of EIPs.

4.1 Governance and management

A distinction can be made between governance and management of each park. Governance is about who sets the rules and standards, and monitors implementation (with an option for sanctions in case of non compliance). Management is more narrowly concerned with planning, implementing and operating an industrial estate. The cases did

not report much about who sets the rules and standards. However they did report on monitoring (see section 4.2).
For example governance at TLIP is done by the government while TLIP's management is done by TLIP Corporation.
In addition, some cases have separate bodies for management of the industrial estate as a whole and the management of specific environment or utility projects in the respective industrial estate, e.g. its CETP and/or TSDF.

All forms of business model of the IPs are represented in the various case studies:

- Private: Guangxi, CIP, PIEAG, Rustenburg and PPSEZ
- Not for profit association: two cases from El Salvador and Sidi Bernoussi, Pucallapa, Djebel Oust
- Private Public Partnership: SSEZ, PIESB, MWC, VISP
- State owned: SCIP, ZNEIP, DDA, TEDA, SDA, Nacharan, APSEZ, Vapi, Naroda, Sachin, WISP, Eco PYMES, Callao
- Mix of all for the two Egyptian cases

The largest cases, which come from India (except MWC), China (except Guangxi) and Peruvian Callao are all state-owned.
Currently in Egypt there are no regulations that support the development of industrial zones according to Eco-Industrial Development principles. The two Egyptian cases concern two very large IPs. The implementation of EIP has not taken place yet, although the concept is gaining increased attention.

Awareness
Several cases mention the lack of environmental awareness of economic, environmental and social benefits among government agencies, administrators and companies, as is reported in the case PIESB, Colombia.
Within China, per capita incomes vary largely. The cases show that compared with both DDA and TEDA, the public environmental awareness at SDA is still lower. This reflects the fact that people in coastal regions in China usually care more for their environmental quality due to their advanced economic development and increasing health concerns. However, people in inland areas or western part still struggle for economic development and higher income, therefore, paying less heed to environmental issues.

Training of people
Various IPs give training and teach capacity building to local people, youth and employees. To date, over 200 training workshops have been hosted by TEDA. VSIP I is the first industrial park in Vietnam which has a technical school, the Vietnam Singapore Technical School (VSTS), aiming to improve the technical skills of the Vietnamese workforce in the area. Vapi Industries Association and Indian Chemical Council have organized many seminars and awareness programs in the past for the benefit of the member industries and their staff members. Management and worker training can help them incorporate cleaner technologies and environmental planning into work patterns. Governments should encourage
cooperative efforts for smaller firms with joint research and development on environmental issues, for example, for joint use of pollution control or waste treatment

facilities. And finally at Sidi Bernoussi, IZDIHAR created the "Energy and Environment Upgrade" (MNEE) Committee in the year 2000. Raising awareness towards industrial pollution; training industrial owners and employees on environmental protection; communicating on various existing grants and projects funding. IZDIHAR held several trainings together with GIZ

Box 4.1 Influence of foreign investment on awareness

TLIP in Vietnam is a Japanese-Vietnamese undertaking. TLIP Corporation has a policy to only serve those companies with investment projects that use modern and high-end technologies which are for manufacturing ,and which are environmentally-friendly, clean technologies or/and energy-efficient. Achievements in environmental management are treatment of waste water, treatment of emissions and odour (companies have to install own systems), treatment of solid and hazardous waste, and management of trees and plants (23% of area cover). Since all the companies in TLIP are Japanese or Japan-Vietnam joint stock, the average environmental awareness level is considerably high. This understanding of environmental responsibility, together with the requirement of the TLIP Corporation, has resulted in the tenant companies adhering to high targets for environmental management of the cluster. The best examples of these companies include leading Japanese electronics companies such as Panasonic and Canon. These companies are pursuing policies guided by an eco-efficiency perspective especially energy and material efficiency. For example Panasonic is creating model factories not only developing eco-products with sustainable industry practices but also taking a lead role in promoting greater eco-awareness in the community through outreach activities. Canon has an energy saving program. TLIP has had a high coverage ratio (close to 100%) contrary to many IPs in Vietnam.

Land use planning has many advantages. It greatly facilitates the development of a new EIP, as is explained in Box 4.2. On the contrary, SDA planners physically separated its five main industrial pillars into five independent industrial clusters. This impeded the potential linkages among different industrial clusters.

Box 4.2 Mahindra World City and Site Master Planning

Mahindra World City is a PPP, between TIDCO (Tamil Nadu Development Corporation, government of Tamil Nadu) which invested $64 Million and Mahindra Group, an Indian multinational Group. These two promoters brought different skills, experience and sector specific knowledge. The developers included sectors in which the region has competitive advantage and could be sustained in the long run. MWC aims to be the first Green Integrated Township in India. The approach of development was two phased: creating new jobs through world class infrastructure, and once that was achieved expanding the area with a body of residential, social and leisure developments. MWC is the source of livelihood for more than 100,000 people. Best practices include Site Master Planning, which is a building block of EID. It determines the success of an EIP as it reduces the stress on environmental infrastructure, with the possibility of exploring synergies among different industries, disaster management, emergency preparedness etc. A flexible site

master plan was designed taking into account: industries, optimal land use planning, resource use planning, provision for logistics, type and quantity of generated waste water, preserving natural features (like ponds) provision of common facilities and more. Most important for the development of the plan was the consideration of future conditions and expansion. Moreover the development of MWC is an answer to conventional chaotic urban development models, and prevents decline in competitiveness of the IP over time. After ten years MWC is still an attractive business destination for world players. During the conception of MWC, the site master planning was a very new concept to India. Site Master Planning was also used for APSEZ. However this has been less successful as at the time of the survey only 13 units were operating at APSEZ.

Foreign development support

In Tunisia both cases are pilots of UNIDO project. Together with UNIDO (Integrated Technical Cooperation Program), the Group of Maintenance and Management (GMG) with CITET (Tunisian Cleaner Production Centre) and Sofies (Swiss expert), identified options for industrial symbiosis. These two cases were selected as pilot area. The establishment of industrial ecology strategies in both parks has the following objectives:

- Create a dynamic collaboration between private economic actors and bodies of land management;
- Identify and implement industrial symbiosis (materials, water, energy, etc.) between existing economic actors in the industrial area. A workshop was organized around the themes:
- Services (Human Resources, Risk and industrial safety, Transport and infrastructure of the industrial zone)
- Water and Energy (Recovery of waste heat, waste water management, renewable energies)
- Resources and waste.

Currently there is no proper wastewater treatment in the two Tunisian cases, so this is seen as an urgent matter.

Several other cases received support from GIZ, such as IP Nacharam and IP Mallapur, APSEZ and Vapi. Also the Moroccan parks worked together with international partners, as did TEDA, DDA, SDA and WISP. The three Peruvian cases receive support from SECO.

4.2 Monitoring

About half of the IP are currently monitoring their performance. The other half will monitor in future, subject to new regulations coming in place or will not monitor. The Indian cases all do monitoring. Clearly, monitoring is a condition to be able to track progress against identified goals and set standards and hence demonstrate environmental, economic and social outcomes in efficient, transparent and accountable manner. Monitoring is a prerequisite for good environmental management. A successful EIP must have monitoring to be able to assess the differences in indicators before and after the measures. For example SCIP monitors its achievements every year according to the National Standard for Sector-based Eco-industrial Park, and reports to the Ministry of Environmental Protection (MEP). A voluntary yearly environmental report addressed to

the residents surrounding the park and the employees, improves the transparency, the involvement and supervision of the public.

Table 8 Monitoring activities in each case

Case	Description
PPSEZ	CETP monitoring
SSEZ	Only monitoring waste water
SCIP	Monitoring
Guangxi Xianggui Sugar Group	No monitoring
ZNEIP	No monitoring
DDA	Not clear, double set of indicators
TEDA	Not clear, double set of indicators
SDA	Not clear, double set of indicators
PIEAG	Environmental management
PIESB	No monitoring but environmental management
CIP	Regulations in place
6th of October City	In future monitoring
10th of Ramadan City	In future monitoring
El Pedegral	No monitoring
Miramar	Monitoring
IP Nacharam and IP Mallapur	Monitoring
APSEZ	Monitoring
MWC	Monitoring
Vapi Industrial Estate	Monitoring
Naroda Industrial Estate	Monitoring
Satchin Industrial Estate	Monitoring
Sidi Bernoussi Industrial Park, Casablanca	No IP monitoring only company level
Tangier Industrial Park	Not reported
Industrial Park «EcoPYMES Pantanos de Villa»	Not clear
Industrial Park «EcoPark Callao»	Monitoring
Industrial Park «EcoPark Pucallapa»	In future monitoring
Western Cape Industrial Symbiosis Programme (WISP)	Developing key indicators
Capricorn Park	Monitoring
Rustenburg Platinum Mines Limited (Ltd)	Monitoring
Bizerte Economic Activities Park (BEAP)	Not clear
Industrial Area of Djebel Oust and Bir M'Cherga	Monitoring
TLIP	Monitoring
VSIP I	Monitoring

The three Chinese cases DDA, TEDA and SDA all follow EIP guidelines as set under both environmental policy and circular economy policy, with part overlapping and part competing sets of indicators and hence do not know which goals to attain. Due to their dual position, two sets of indicators have been applied and regularly used for monitoring: (a) the standards for EIP, issued by the MEP in 2006, and (b) the set of circular economy industrial park indicators, issued by the NDRC. This situation is discouraging for both the

administrative commission and the tenant industries, as they do not know what goals they should attain. The responsible agencies have not yet coordinated and aligned their frameworks and indicators.

Chapter 5 Drivers and barriers

Many of the drivers and barriers that are being mentioned in the cases are to a high degree specific to the respective case. However drivers such as access to finance and technical support, role of government agencies, policies and importance of RECP were mentioned by most of the cases (table 9).

5.1 Drivers

Table 9 Drivers of EIPs

Driver	Explanation
Financial support for eco-oriented technology	Can be in line with government policies, or through banking
Role of government agencies, corporations, institutions and associations	Including changes in institutional structure Chapter 4
Policies	Policy driven EIP, related to renewable energy, incentives, tax exemption, industrial symbiosis, green building, CP (or RECP), CETP, energy saving
Follow-up on implementation of CP	Including voluntary applications of CP and carrying out CP assessment
Industrial symbiosis	Can be policy, network or other, including seed funds Chapter 3
Enhanced infrastructure	Like collective management waste water, or near urban area with good infrastructure Chapter 2
Resource efficiency and resource saving	Energy, water, materials
Economic benefits	Cost savings, in many countries energy prices have been increasing Chapter 3
Need for companies to comply with legal standards	
Foreign investment in EIP	
Support of international organizations	At present, UNIDO, GIZ, EU, Japan, UK and Switzerland
Growing awareness	Spread to public, higher awareness in some foreign companies
Receiving an award	For being a good EIP
Opportunity to improve green image	
Technology support and support from universities	International experts, symposia
Local manpower and material availability	
Positive impacts on local community	Poverty reduction, voluntary participation, infrastructure for resettled villagers
Site Master Planning	See also Box 4.2

The policy review shows a large variety in approaches. Most countries have no special policies for EIPs. Some have no department or ministry for Environment or Natural Resources. But all are aware that they are facing growing issues of environmental pollution on one hand and access to natural resources needed to foster economic development on the other hand.

The policies can be centralized or decentralized and focus on specific environmental indicators, such as energy efficiency. Environmental development and industrial development can be contradictory or complementary in structure. More coherence is

needed among agencies for environmental and economic development. When establishing a new IP environmental concepts are not always taken into consideration. Inclusive policies also (besides industrial growth) look at human development and social responsible industrial growth,

Example of policies

A set of policies were raised and released by considering the local realities. For instance, a green recruitment policy was stipulated by the Administrative Committee for SDA in 2011: all the new tenant companies have to encourage the use of renewable/cleaner energy sources, consider filling the niche of current industrial symbiosis, construct their new buildings by referring to national green building standards, prepare their eco-design, cleaner production and waste treatment plans before the new projects start. Other policies include energy saving and emission reduction regulation at SDA. In order to promote industrial symbiosis, the AC at TEDA has also tested economic incentives (both from AC at TEDA and external). Policies for industrial symbiosis include e-waste management, energy saving and emission reduction regulation, green infrastructure development guidelines, cleaner production promotion guidelines, water pollution prevention and control regulation, regulation and promotion of ISO 14001 certification

---

Box 5.1 Instruments and policies used by DDA

Instruments which promoted industrial symbiosis

- Economic incentives: Seed funds are available to support "synergy linkages", i.e. the infrastructure necessary to build up industrial symbiosis, such as a pipeline. The AC has a mechanism to seek larger financial support through channels such as low interest loans, investors,
- A large set of green policies for the park were released, particularly more demanding for new tenants. Policy enforcement officials are supported by a certain budget and by capacity-building activities.
- Technology support: DDA has taken a leading role in exchanging experience and knowledge on EID locally and internationally, by hosting 50 symposia and workshops. The AC funds R&D activities to identify more industrial symbiosis opportunities.
- Voluntary public participation is encouraged by information (EIP newsletters, television programmes, training courses), coordinated by the environmental protection bureau of the AC at DDA.

Other drivers are: experience of the developer of an EIP, and inclusion of sectors in which the region of an EIP has comparative advantage. Also, environmental regulations of EIP attract certain companies. There is an advantage if an EIP has attracted foreign investment. VSIP I has a strict selection and only serves the companies with investments that use modern, environmentally-friendly technologies or/and energy-efficient technologies. Some of the foreign companies that have entered have gone beyond

meeting the requirements and actively implement various initiatives aimed at environmental and social sustainability.

5.2 Barriers

Four parks mentioned more barriers than drivers: El Pedegral, Miramar, PIEAG and Capricorn.
In developing and emerging countries there are many difficulties arising from lack of experience, lack of awareness and lack of regulations and its enforcement. Below are some examples of difficult situations that some of the EIP cases reported:

- In many cases there is a trade-off between Industrial Development and the Environment. (MWC is a concrete example of development where there is no such "trade-off" and where there is harmony between the two.) It is important to address issues at an early stage of the project, for example with respect to freshwater use
- APSEZ can be considered as the first planned eco-industrial park in India. With no similar large industrial development area initiated/implemented until then in the country, it was a risky proposition for the government to invest a huge amount of capital in such a project. Investment attracted by APSEZ has been below expectations. Many units proposed their plans for establishing the units in APSEZ, but withdrew due to various reasons. Currently only 13 units of land are operational.
- Being one of old industrial estates, most of the small scale industries are using old technologies (Vapi). As mentioned before Vapi is critically polluting.

As Sidi Bernoussi shows, companies in countries that have a less well developed infrastructure may have other priorities than companies in countries with well developed infrastructure. For example, at the project beginning, the national context was less favourable to energy efficiency actions and inertia was observed in industrial mobilization. The slow transmission of information by industries and also by decision-makers was also underestimated. Before the rehabilitation of the industrial park, several companies were more concerned by the lack of infrastructure than the protection of the environment.

Box 5.2 The case of Djebel Oust and Bir M'Cherga
Industrial Area of Djebel Oust and Bir M'Cherga is managed by the group of maintenance and management (GMG). It is a non-profit association with public interest having legal personality bringing together all the operators, owners and occupants of buildings in the industrial area.

- Companies that were located in the area before the law on GMG came into force argue rightly that in their decision-making process of purchasing a lot in an industrial area, it was implied that maintenance of the areas

outside their own land is not their responsibility but instead it is the responsibility of the developer or the local community;
- The financial resources available to GMG are generally very poor.
- GMG has a lack of accountability that led to a lack of visibility and recognition by the industry of the area

Other barriers are:

- Excessive dependence on policies (unreliable when policy changes)
- Lack of proper organization among companies
- Lack of management resources
- Loss of competitiveness
- Lack of reference and guidelines of what exactly is an EIP
- Lack of awareness of government, community (e.g. in western part of China)
- Hazardous waste management, CETP and other facilities may not work properly, leading to high environmental pollution
- Lack of support for industrial symbiosis and other environmental measures
- High proportion of SMEs, SMEs comply less to environmental standards, which leads to more pollution
- High price of fuels and natural gas may lead to switch to coal
- Multiple sources of water supply hamper control of water consumption
- Lack of enforcement environmental regulations
- Demand for environmental superior techniques is weak in China
- Lack of proper indicators
- Problem to attract skilled workers (many IP train workers nearby)
- Many parks are not fully operational

Clearly even if the government supports the creation of an EIP financially and institutionally, some problems may arise due to the lack of awareness among government officials, among company managers and park operators. Also, there may be a lack of indicators and enforcement. In less developed countries managers of companies are more sensitive to fluctuations in price of energy and materials. There might also be a need to train people from the nearby communities.

Chapter 6 Conclusion

6.1 Suggestions from the cases

In emerging and developing economies, the benefits of an IP can be very large. The mere clustering of companies fosters collaboration and innovation and brings economic benefits such as cost savings. In countries where a solid basic infrastructure is often missing, IPs are providing or improving the infrastructure. However only looking at economic gains hampers sound development and leads to inefficient production. EIPs go

one step further. This comparative assessment of various case studies proves that IPs in developing and emerging economies can be directed to EIPs and that doing so is genuinely beneficial for the environment, economy and society. Table 10 lists the suggestions made by the cases.

Table 10 Main suggestions from the cases

Policies	Government should promote CP, energy efficiency, low carbon development by setting policy and regulatory framework
	Promotion of foreign investment
	More research efforts on innovative solutions for waste management, waste water treatment, energy and water efficiency, and industrial synergies between industrial sectors
	Raise awareness about the benefits of EID, promote EIP globally through national and international policies
SMEs	SMEs should also play a role in CP and eco-construction of park
Industrial symbiosis	Ensure good planning, make sure companies can exchange by-products and close industrial loops, identify new eco-innovative potential
	Green infrastructure is necessary for industrial symbiosis
	Results of IS and EIP should be spread to other (E)IP projects
Organisational structure	Management in unified manner, establish information network system, strong leadership is essential, foster exchange between stakeholders, need strong company network
	Combination of planned and facilitated EIP model most successful in China
EIP	Need for better understanding that without sustaining ecological services, the sustainable social and economic dimensions of an EIP development will not be achieved
	Implement pilot projects (in countries where there are no EIP yet)
	Use planning like Site Master Planning
	When you have an old IP remove old infrastructure facilities, recover improper land use planning and deteriorated ground water
Training	Organize capacity building activities and workshops for employees and consumers
IS facilitation and networking	Keep facilitation as a free service and expand its outreach
Audits	Perform baseline audits to assess the current state of the industrial system & surveys of water, energy and material flows, establish indicators based on records with development over years
Monitoring	Monitoring (in EIP where it is currently not done) especially at CETP and TSDF sites, and strict enforcement of pollution control

6.2 Recommendations

It becomes clear when looking at the drivers and barriers in chapter 5, that it can be complicated to create an EIP in emerging and developing countries. Industrialized countries can avail good practices that could be adapted and adopted by developing and emerging economies with regard to policy making or institutional support and foreign investment. A long term involvement in EIP by international organizations may be desirable. Companies' policies and codes of conduct determine how far they can go in implementing RECP initiatives beyond legal requirements.

As an in between step it is important to green the infrastructure: to create good facilities for solid waste management, waste water treatment and hazardous waste at the company and collective level and to ensure good management of these facilities. The next step would be industrial symbiosis. However, when planning a new EIP it is important to plan industrial symbiosis directly from the beginning to optimize the location of companies to stimulate by-product exchange.

The main recommendations formulated by the various case studies are:

1. EIPs are valuable especially in developing and emerging countries as they are beneficial in the form of local infrastructure and environmental, economic and social benefits. Therefore governments and international organizations should promote the development of EIPs
2. Many IPs struggle with waste management (including hazardous waste) and waste water treatment. Even though solutions might be in place they may not work optimally. However waste and waste water management are crucial for the environment and the IP surrounding populations. Governments need to ensure through regulations that waste and waste water management take place already at an early stage of the development of an EIP.
3. Countries importing from emerging and developing countries should inquire about the sustainability and social impacts of imported goods and services.
4. There is a need for a clear definition of an EIP. As mentioned some IPs use the word EIP or Eco-Park while not really being eco-industrial. Also an IP like Vapi applies industrial symbiosis but is still very polluting. This is confusing.
5. Planning by institutions, like Site Master Planning should be stimulated, as it is very helpful for the development of EIPs. EIPs should not be planned close to a natural reserve.
6. Two cases included climate change reduction in their analysis, climate change will affect especially less developed countries. The creation of EIP worldwide will diminish climate change. It should be investigated whether CDM could work.
7. Monitoring needs to be regulated and enforced to be able to assess the successful transition to an EIP. Some IPs need help with the selection of indicators.
8. The cases show that industrial symbiosis is economically beneficial and needs to be promoted by policy makers
9. It is important that the EIPs are fully operational and attractive for companies so they stay in the park and are attracted by the favourable conditions. It may be beneficial for some EIPs to host foreign companies. This may require government, PPP or private investment.
10. The role of the government in development and management of an IP needs to be studied. For example in the forthcoming policy document.
11. Some IP that are less well developed, have their focus more on developing the industrial sector and companies than on integrating environmental and social aspects in their park. A less developed park has more need for communication, administration and management bodies and exchange between stakeholders. It is very important that institutions investigate the impact of the use of old technologies.

12. There is a need for a better understanding that without sustaining ecological services, the sustainable social and economic dimensions of EIP development will not be achieved.
13. It is essential that policy makers in emerging and developing countries assist companies to create more awareness among managers, employees and citizens nearby EIPs.

6.3 General recommendations

In this final section some more general recommendations are being proposed:

- Follow up possibly through monitoring on development of EIP/IP/technological parks
- Especially in less developed economies, inclusive policies that include human development and social responsible industrial growth should be considered.
- It is challenging to make rules for new EIPs or IPs that are to be developed. The cases indicate there is high heterogeneity. They vary in size, type of industries, physical and social infrastructure, making comparisons difficult. There is no ready made single solution of RECP, IS, etc., that fits all. Each situation has to be considered individually.
- EIP strategies should be comprehensive: in countries with little infrastructure environment comes secondary for companies. However EIP development should include infrastructure development as well.
- More in-depth analysis is needed, e.g. to learn about the impact of EID on SMEs and large companies.
- Also an analysis is needed about the suitable policies for greening IPs or starting new EIPs. Governments need to now whether it is more urgent to green existing IPs or to try to create new EIPs. Where possible create new EIPs from the beginning.
- Large economies face more challenges because of the large number of IPs that are being created at a fast pace (e.g. 6900 until 2010 in China).
- Planning an EIP in a natural reserve or adjacent to it, is not straightforward
- Even when an IP applies industrial symbiosis and has environmentally friendly policies, it still may occur that other companies in the park cause heavy pollution. It is therefore important to look at the overall picture of an IP or EIP.
- More information is needed concerning policies and governance, related to who sets the rules and standards. EIPs need consistent policy and good governance to ensure economic, social and environmental benefits flow to country;
- There is need for clear guidelines and description what is an EIP
- More research is needed to assess how economic benefits from reducing environmental impacts, can be maximized.
- More experts in industrial ecology need to be trained. There should be training courses for stakeholders in the field of industrial ecology and exchange of

experiences, for example through study visits. Policy makers should be included as well.

- There should be a strong link between EIPs and agriculture in developing and emerging economies. If possible show the benefits from EIP for farmers.
- International support is needed for waste water treatment and waste management facilities in IPs where they are currently not present. This is an urgent matter. Since it pollutes common water it affects other richer countries as well.
- Environmental economists can fabricate models to assess parameters relevant in EIP development to support decision making.
- Stakeholders in EIP and IP development need to (be made) aware of the large responsibility they have to care for the environment for future generations and of the gratitude of the global society of tackling transboundary pollution.
- An interactive database with best practices (e.g. for recycling and IS) needs to be developed and be freely available online. Stakeholders anywhere should have access to low cost options for greening IPs or developing EIPs
- ISO certification should be made cheaper so SMEs in less developed economies can afford it as well.

Glossary

Eco-industrial park	an industrial park in which companies cooperate with each other and with the local community trying to reduce waste and pollution, efficiently share resources and help to achieve sustainable development, with the intention to augment economic gains and improving environmental quality.
Greenfield project	a project that lacks any constraints imposed by prior work.
Industrial ecology	the design of industrial infrastructures as if they were a series of interlocking ecosystems interface with the natural global ecosystem.
Industrial park	an area zoned and planned for the purpose of industrial development.
Industrial symbiosis	the exchange of byproducts of one company (or sector) by other companies (or sectors) in close geographic proximity.
One stop shop	assistance in case of complex regulations, e.g. help with bank loans.

References

Europe and Central Asia Regional Conference on industrial parks, as a tool to foster local industrial development (2012). UNIDO, Governments of Azerbaijan and Slovenia, Conference Report, 17-18 April, 2012, Azerbaijan.

Environmental management of industrial estates in China (2001a). Environmental Planning Institute for UNEP and SEPA, China.

Environmental management of industrial estates and zones (2002). Workshop report, UNEP/ SEPA, May 11-13 2002, China

Environmental management for industrial estates (2001). UNEP and ICAST, chapter three.

Eco-Industrial Parks: A powerful tool for Inclusive and Sustainable Industrial Development (2014), UNIDO.

Annex I Development stage of the IP, starting year IP and start eco-industrial development (EID)

Country	Case	Development stage	Year of establishment
Cambodia	PPSEZ	Not fully operational	2008
	SSEZ	Not fully operational	2008
China	SCIP	SCIP became a National Demonstrative Eco-industrial Park in 2012	1996 (start EID 2008)
	Guangxi Xianggui Sugar Group	In development	planned, construction period is 2010-2025 in two phases.
	ZNEIP	Fully operational	2009
	DDA	Fully operational	1984 (start EID 2000)
	TEDA	Fully operational	1984 (start EID 2000)
	SDA	Fully operational	1988 (start EID 2009)
Colombia	PIEAG	Being in the park more costly than outside, reduces competitiveness	2003
	PIESB	Planned, not realised	1990 (start EID 2007)
Costa Rica	CIP	Pilot with GIZ	1985 (start EID 2012)
Egypt	6th of October City	Fully operation IP, EIP not implemented yet	1979
	10th of Ramadan City	Fully operation IP, EIP not implemented yet	1977
El Salvador	El Pedegral	Operational, unclear what is EIP exactly	1994
	Miramar	Not fully operational	2001
India	IP Nacharam and IP Mallapur	Pilot	1967 (start EID 2004)
	APSEZ	Greenfield project, still under development	2007
	Mahindra World City	Fully operational	inaugurated in 2002
	Vapi Industrial Estate	Fully operational	1967-1968
	Naroda Industrial Estate	Fully operational	1964
	Satchin Industrial Estate	Fully operational	1984
Morocco	Sidi Bernoussi	Fully operational	1960s
	Tangier Industrial Park	data missing	1975
Peru	EcoPYMES Pantanos de Villa	Fully operational	1989
	EcoPark Callao	Fully operational	2008
	EcoPark Pucallapa	In development	2009
South Africa	Western Cape Industrial Symbiosis Programme (WISP)	Virtual, inception phase	virtual
	Capricorn Park	Not fully operational	1998
	Rustenburg Platinum Mines Limited (Ltd)	Fully operational	1931/restructuring in 1994
Tunisia	Bizerte Economic Activities Park (BEAP)	Fully operational IP, but not implemented EIP yet	1993 in operation since 1996
	Industrial Area of Djebel Oust and Bir M'Cherga	Pilot	1981

Vietnam	Thang Long industrial park (TLIP) Corporation	Fully operational	1997
	The Vietnam Singapore Industrial Park I (VSIP I)	Fully operational	1996

Annex II Summaries of all the cases