

**DEVELOPMENT OF AN INDUSTRIAL ECOLOGY MODEL FOR THE ATHI RIVER
SPECIAL ECONOMIC ZONE: POLICY IMPLICATIONS FOR GREEN GROWTH IN
KENYA**

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degree of Doctor of Philosophy (Environmental Policy) of the University of Nairobi.**

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DECLARATION

I declare that this PhD thesis is my original work and sources of information other than my own have been duly acknowledged.

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DEDICATION

To all my three children Celine, Michelle, and Paul for their unfailing and constant encouragement that I have to become a PhD holder and set a shining example for them. To all those who believe that climate change is real and the challenge it poses to mankind will shape his production and consumption behavior for a long time to come.

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ABSTRACT

Kenya Vision 2030 currently guides the country's development agenda. It recognizes industrialization as one of the key pillars of economic growth and wealth creation. As a result, there has been a marked increase in the development of special economic zones (SEZs) across the country. Through inter-company exchange of wastes and by-products, SEZs can reduce negative environmental impacts that emanate from industrial consumption of raw materials, energy and water, hence decoupling accelerated growth from environmental degradation. There is need to transform the country's SEZs into low-carbon, resource efficient, climate resilient, and socially inclusive units that are competitive in attracting green foreign direct investments (FDI). The overall objective of the study was to assess the efficacy of Industrial Ecology (IE) model in enhancing the environmental governance of the Athi River SEZ. The study characterized production clusters of the SEZ; analyzed material flows; assessed environmental performance; and using the IE approach, proposed a governance model for the zone. A mixed methods approach was used with both qualitative and quantitative data being generated from primary and secondary sources. Primary data was obtained through Key informant interviews of factories and zone management personnel; factory production volume baseline analysis; inspection of the factory's procedures and practices; and identification of waste and by-products. Resource Flow Analysis was used to quantify material and energy flows in different clusters. Secondary data was obtained through the review of utility records and production reports. The study revealed an unregulated evolution of industrial symbiosis (IS) at the zone in four clusters. These comprised use of (i) 240 tons/year of seed cake by-product as raw material for animal feed manufacturing leading to 80% secondary transport energy savings and 86,427 kg CO_{2e}/year of reduced emissions; (ii) 108 tons/year of tarpaulin waste as raw material for making plastic water tanks leading to the creation of five on-site plastic reprocessing green jobs; (iii) 255 tons/year of textile fabric off cuts for making sofa sets and on-site steam generation leading to the creation of fifteen green jobs and 9% avoided emissions (1,142 kg CO_{2e}) and (iv) 204 tons/year of chipboard saw dust waste used as steam boiler fuel replacing fuel oil with 11% avoided emissions (4,448 kg CO_{2e}). Inter-company use of wastes and by-products as raw material inputs reduced the raw material transport costs by over 80% resulting in a lower carbon footprint. Waste reuse diverted the potential solid wastes from the landfill, created new products and jobs, hence contributing to the country's green growth agenda. However, most of the zone's material flows were largely linear due to lack of policy and weak infrastructure for waste recovery and reuse. There was no evidence of genuine partnerships with communities; no strategic co-locating of industries that exchange wastes; no functional infrastructure for IE promotion; no IE enabling policies/incentives; and limited commitment to a resource efficient zone. A governance model was developed that (i) creates a multi-stakeholder Green Cell within the Zone Authority with the sole mandate of promoting resource use efficiency through Cleaner Production and IS; and (ii) seeks to strengthen partnerships between industry, government and academic institutions in eco-innovation. The findings of this study forms the basis of the country's switch from the inefficient linear production approach to an integrated and resource efficient circular economy.

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ACRONYMS

ACE	Answers to the Carbon Economy
CE	Circular Economy
CP	Cleaner Production
CSR	Corporate Social Responsibility
EC	European Commission
EEA	European Environment Agency
EICs	Eco-Industrial Clusters
EIP	Eco-Industrial Park
EMS	Environmental Management System
EPZ	Export Processing Zone
EPZA	Export Processing Zones Authority
EZ	Economic Zone
GESIP	Green Economy Strategy and Implementation Plan for Kenya
GEC	Green Economy Coalition
GHG	Greenhouse Gases
GIZ	Germany Technical Corporation
GOK	Government of Kenya
IE	Industrial Ecology
IGBC	Indian Green Building Council
IS	Industrial Symbiosis
KIRDI	Kenya Industrial Research and Development Institute
KNCPC	Kenya National Cleaner Production Center
KPI	Key Performance Indicators
LAPSSET	Lamu Port South Sudan Ethiopia Transport Corridor
LCA	Life Cycle Assessment
LCZ	Low Carbon Zone
LCZG	Low Carbon Zone Guidelines
LE	Linear Economy
MEPS	Mandatory Energy Performance Standard
MoIED	Ministry of Industry and Enterprise Development
NCCAP	National Climate Change Action Plan
NCCRS	National Climate Change Response Strategy
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NISP	National Industrial Symbiosis Program
OECD	Organization for Economic Corporation and Development
PPP	Public Private Partnerships
PSDS	Private Sector Development Strategy
RECP	Resource Efficiency and Cleaner Production
RFA	Resource Flow Analysis
3Rs	Reduce, Reuse, and Recycle
SCU	Science Communication Unit
SD	Sustainable Development
SEZ	Special Economic Zone
SGR	Standard Gauge Railway

SMC	Sustainable Materials Cycle
SMM	Sustainable Materials Management
SUDS	Sustainable Urban Drainage System
UNEP	United Nations Environment Program
WEF	World Economic Forum

CHAPTER ONE: INTRODUCTION

1.1 Background

Industrial Ecology is an emerging field in environmental science that seeks to develop an ecological model of industrial systems that operate within the Earth's carrying capacity (Mirovitskaya & Ascher, 2001; Ashton, 2008; UNEP, 2011; Anbumozhi et al. 2013). Such an industrial system under this approach should be seen as a web of interconnected production units, linked by the flow of materials and energy determined by physical and ecological principles (Benyus, 1997; Chertow, 2006; Bermejo, 2014). The proven stability of ecosystems relies on their interaction and interdependence while industrial systems emphasize independence and competition (World Economic Forum, 2014). What is needed is a system of running industry in a manner that enables materials and energy to be retained within it, and also ensure that production systems are fully integrated with natural ecosystems and functional material cycles (UNEP, 2011; World Bank, 2014). Applied industrial ecology involves the evolution of industrial systems from linear systems, where resources are consumed and damaging wastes dissipated into the environment to a more closed loop system similar to what happens in ecological systems (Bermejo, 2014). In a linear process, materials and energy enter one part of the system and then leave either as products or by-products/wastes (Ashton, 2008; Mirata and Emtairah, 2005). Unless the supply of materials and energy is infinite and the carrying capacity of the natural systems can assimilate the wastes and emissions, the linear production system is unsustainable (UNEP, 2011). In most of our national industrial manufacturing systems, some wastes are recycled or reused within the system while others leave it (World Bank, 2014). In a more evolved and integrated industrial ecosystem, there is a dynamic equilibrium with ecological systems, where energy and wastes are constantly recycled and reused in closed loops by other processes within the system (Mirovitskaya and Ascher, 2001; Ashton, 2008; UNEP, 2011; & Anbumozhi et al. 2013). The principles of waste

and by-product exchange should be applied at different spatial levels: within and between companies, within special economic zones, and at regional or national levels (Mirovitskaya and Ascher, 2001; Chertow and Lombardi, 2005).

As the need for proactive environmental management becomes clear, the search for innovative approaches to pollution prevention is moving beyond individual firms to incorporate networks and strategic alliances (Chertow, 2004; Ashton, 2008; and UNEP, 2011). Just as there is ecological succession in natural ecosystems, industrial establishments also evolve through technological upgrading (Kibert et al. 2002, Chertow, 2008). The concept of industrial ecology provides firms with new frameworks for working together to solve environmental problems (Lowe, 1997; Mirovitskaya & Ascher, 2001; UNEP, 2011). Industrial ecology models industries like living organisms where the by-product of every metabolic process is food for another organism (Mirovitskaya & Ascher, 2001; Ashton, 2008; UNEP, 2011). Industrial ecology makes it easier for industries located in close physical proximity to design facilities that can help them exchange energy and materials to their mutual environmental and economic benefit (Graedel and Allenby, 1995; Lowe, 1997; Lombardi and Laybourn, 2012; Bermejo, 2014). Doing this not only lowers pressure on the use of virgin materials but also diverts waste from the land fill with accompanying environmental benefits.

Special Economic Zones (SEZs) that offer duty-free importing and streamlined custom procedures do play an important role in advancing industrial development, attracting foreign direct investments (FDIs), creating jobs, strengthening export capabilities and serving as experimental subjects for the testing, refinement and application of emerging and promising tools of environmental management (World Bank, 2014). They do concentrate industries in fenced

geographical locations (Farole, 2011). Zone based companies therefore share infrastructure in form of roads, railway, waste management as well as effluent treatment (World Bank, 1992; 2008). The close proximity of zone based industries and the diversity of actors creates an enabling environment for industrial ecology as it becomes easier to match exchanges of materials and energy (Lowe, 1997; Bermejo, 2014). As we continue to gather evidence that climate change is real, environmental advocates have started pressurizing governments, private sector developers, and managers of SEZs to start incorporating elements of sustainability in their master plans by seeking innovative ways of incorporating from the very beginning resource use efficiency, cleaner production and industrial symbiosis (UNEP, 2011; World Bank, 2014). The Kalundborg experience affirms that this sustainability challenge can be overcome by embracing industrial ecology (Jacobsen, 2006; Huber, 2012).

The Kenyan Government has in place a draft SEZ policy and the SEZ Act that both do not incorporate the desired sustainability elements of industrial ecology and green growth. The country's special economic zone (SEZ) Act No. 16 of 2015 was assented to on September 11, 2015 and came into force on December 15, 2015. Unfortunately, both the draft SEZ policy and Act do not prioritize the need to develop low carbon, green and resource efficient SEZs. This is against the global trend that is being advocated for by UNEP and the World Bank Group that seeks to promote environmentally friendly eco-industrial economic zones that are powered by resource use efficiency, cleaner production and industrial symbiosis (UNEP, 2011; World Bank, 2014). Although Kenya's industrialization policy mentions cleaner production as an approach to waste minimization at source, it is silent on how to deal with the inevitable residual waste that is the target of industrial ecology. As is expected, the Green Growth agenda that came into being in 2012 (Rio + 20) as an innovative approach to achieving sustainable development goals (SDGs) is not

directly mentioned in Government policy documents that were published earlier than 2012. This category includes the Kenyan Constitution, industrialization policy, and Kenya Vision 2030. Interestingly, due to limited stakeholder consultations, even the Government publications that were published after 2012 such as the amended EMCA, 2015, the SEZ Act of 2015, and the draft SEZ regulations still have no mention of the green growth agenda.

Recent developments in the global economy are pushing firms to develop new strategies of competition and new processes for managing their environmental impacts (Massard et al. 2014). These trends include (i) a growing awareness of the relationships between economic and environmental sustainability; (ii) a better understanding of the business opportunities – both potential cost reductions and higher profits – in adopting quality environmental management practices; (iii) a growing realization in government and the private sector that regulatory controls, while necessary, are not sufficient to achieve pollution prevention; and (iv) growing international pressures on corporations to adopt voluntary standards for environmental management that go well beyond regulatory compliance as a precondition for participation in global trade and investment (Mirovitskaya & Ascher, 2001; GIZ, 2015b). The management of SEZs should develop zone use regulations that seek to promote low-carbon, resource efficient and social inclusive industrialization processes (GIZ, 2015b).

The Constitution of Kenya (2010) provides ground for the formulation of adaptation and mitigation legislation, policies and strategies by guaranteeing the right to a clean and healthy environment under the Bill of Rights. Every person has the right to a clean and healthy environment (Articles 42, 69 and 70), which is a fundamental freedom under the Bill of Rights. This right cannot be fully provided for unless action is taken to address environmental pollution, which can be supported

through a low carbon climate resilient development pathway. The Constitution recognizes a clean and healthy environment as a basic human right and provides for sustainable exploitation, utilization, management and conservation of the environment and its natural resources¹. Vision 2030, the national development blue print encapsulates flagship programs and projects with aspects of adaptation and mitigation. It aims to achieve an annual growth of 10 percent per annum and transform Kenya into “a globally competitive and prosperous country with a high quality of life by 2030”². In an effort to promote green growth, the Kenyan Government has developed a green economy strategy that will support its development efforts towards addressing key challenges of poverty, unemployment, inequality, environmental degradation, climate change and variability³, infrastructural gaps and food security. The policy framework for green economy in Kenya is spelled out in the constitution of Kenya 2010, Kenya Vision 2030, Green Economy Strategy and Implementation Plan (GESIP), National Climate Change Response Strategy (NCCRS)⁴, National Climate Change Action Plan (NCCAP)⁵, the draft Environmental Policy, the draft Kenyan Climate Change Policy of 2014 and the Climate Change Act, Number 11 of 2016.

The Athi River SEZ was not planned for waste and by-product exchange among companies. Its master plan did not incorporate elements of sustainability. In other words, there was no deliberate effort of zoning the park in such a way that those companies that can exchange wastes and by-products are located in close proximity. However, due to the prevailing market forces, there is emerging exchange of wastes and by-products among companies, a development that should be

¹ GOK, 2010. The New Constitution of Kenya, Printed by the Government Printers on 27 August 2010.

² GOK, 2008. Kenya Vision 2030, Printed by the Ministry of Planning and National Development

³ GOK, 2015. Green Economy Strategy and Implementation Plan (GESIP) for Kenya.

⁴ GOK, 2010. National Climate Change Response Strategy (NCCRS), Ministry of Environment, Water, and Natural Resources

⁵ GOK, 2013. National Climate Change Action Plan (NCCAP) for 2013-2017, Ministry of Environment, Water, and Natural Resources

investigated to guide future zone planning and management. In order for the zone to be classified as low carbon and green, it should deliberately start embracing resource use efficiency through cleaner production and industrial symbiosis. This sequential approach to materials management is not currently being fully embraced by the tenant companies of the zone. This study sought to establish the environmental limitations of the current linear development model of the Athi River SEZ. It investigated how industrial ecology could be engaged to transform this wasteful linear model into a greener and sustainable closed loop supply chain. Specifically, the study sought to determine the potential industrial clusters of the Athi River special economic zone (SEZ); establish their material flow patterns and symbiotic relationships among the zone clusters; apply the principles of industrial ecology in mitigating the environmental challenges of the zone and development of a governance model that can help transform the current SEZ into a low-carbon and resource efficient green zone.

1.2 Statement of the Research Problem

Kenya's current industrial development model is largely linear. It is based on the wasteful linear development economic model of extracting raw materials, converting them into consumable products and discarding the resultant wastes into the landfill. This traditional linear development model is characterized by linear flows of matter, where raw material inputs are mined, value added into desired products, made use of, and discarded with a trail of waste at every stage of the supply chain (Bermejo, 2014). Such an approach to economic development can only be sustainable in a situation where the country is endowed with endless resources for its increasing demand. This is certainly not the case. As a result of this realization, there is a strong international consensus that over-reliance on wasteful linear economic development models is no longer sustainable. A much more promising economic development model is one that seeks to promote a circular economy

that is powered by enhanced resource use efficiency, the adoption of the 3R philosophy of reducing, reusing, and recycling wastes, before engaging industrial symbiosis to deal with the inevitable residual waste. Doing this will help divert waste streams from the landfill and also reduce pressure on the use of virgin raw materials. Given the great danger posed by a changing climate regime, promoting resource use efficiency, diverting wastes from the landfill, and re-circulating materials again and again in closed loop manufacturing value addition cycles will definitely reduce the amount of climate damaging greenhouse gasses (GHG). The climate change and environmental shortcomings associated with un-regulated economic zones can easily over ride their proven socio-economic advantages if environmentally friendly interventions such as industrial symbiosis are not incorporated.

This research project sought to assess what needs to be done at the Athi River SEZ so that the zone can be enabled to abandon the wasteful and environmentally polluting linear economic development model and instead embrace the much more promising circular economy. Switching to a zero waste circular economy as it has sustainably happened in natural ecosystems not only advances prudent and sustainable use of scarce resources but also opens a window for industrial spin-offs that generate green jobs. Successful adoption of a circular economy using industrial symbiosis at the Athi River SEZ will require enhanced institutional capacity in green growth promotion, demonstrated awareness that investing in industrial symbiosis makes good economic and environmental sense, and a functional infrastructure for waste recovery and recycling that are all being addressed by this research project. In an industrial ecosystem, production is organized in such a synergistic manner that mimics natural systems so that waste from one company becomes a resource for another company (UNEP, 2011; UNIDO, 2015)

Kenya Vision 2030 currently guides the country's development agenda (GOK, 2013). The vision recognizes industrialization as one of the key pillars of economic growth and wealth creation (GOK, 2013; 2015). As a result, there has been a marked proliferation of un-regulated special economic zones (SEZs) across the country. Kenya currently boasts of 57-gazetted public and private SEZs and this number is rapidly increasing (Export Processing Zones Program Annual Performance Report, 2013). Plans are underway to establish a total of 10 industrial parks/ special economic zones (SEZs) along the country's major infrastructure corridors⁶. SEZs do concentrate industrial plants in a designated geographical area with increased levels of pollution in form of climate changing emissions and solid wastes (World Bank, 2014). There is need therefore for cluster wise planning and zonation of the economic zone, a practice that is yet to be embraced by the Zone Authority. This has resulted in inefficient use of raw materials, energy and water with significant generation of wastes and emissions. Stockpiles of solid wastes are visible within the economic zone.

The initial zone master plan was not designed with the ideals of sustainability in mind. This means that there was no deliberate attempt to zone and cluster together industrial plants that could exchange wastes and by-products. Therefore zone resident companies are not in a position of fully benefiting from economic and environmental savings that could result from embracing resource use efficiency at company level and industrial symbiosis comprising of closed material, energy and/or water cycles within the clusters of co-located industries (UNIDO, 2015). Without this deliberate move, the Athi River SEZ will not be in a position of attracting green foreign direct investments (FDIs) (GIZ, 2015a). Absence of a clear industrial policy that prioritizes Industrial

⁶ GOK, 2015. Kenya's Industrial Transformation Program, Ministry of Industry, Investment and Trade.

Ecology is to blame for the country's over reliance on this wasteful linear development economic model. This study targets policy makers, industrialists, managers of SEZs/ IPs, consultants, and researchers with the message that investing in a circular economy that seeks to divert wastes from the landfill makes good business and environmental sense.

1.3 Research Questions

The main research question was to find out how the environmental limitations of the linear development model at the Athi River SEZ could be improved by embracing Industrial Ecology that seeks to transform this wasteful linear model into a greener and sustainable closed loop supply chain.

The sub-questions were:

1. Which industrial clusters have evolved at the Athi River special economic zone (SEZ)?
2. What material flow patterns and symbiotic relationships exist in the identified clusters?
3. How can the principles of industrial ecology be applied in helping to mitigate the environmental challenges of the zone?
4. What governance model can help transform the zone's wasteful linear economic model into a circular economy?

1.4 Research Objectives

The general objective of this study was to assess the efficacy of Industrial Ecology as an environmental governance model for transforming the wasteful Athi River SEZ's linear development model into a green and sustainable closed loop supply chain. Specific objectives were:

1. To determine the evolution of industrial clusters at the Athi River SEZ;
2. To establish the material flow patterns and symbiotic relationships within the clusters;
3. To assess the application of industrial ecology principles in mitigating the environmental challenges of the zone;
4. To propose a governance model that can help to transform the zone's wasteful linear economic development model into a circular economy.

1.5 Justification of the Study

Promising smart economies of the future are those that are continuously striving to minimize the production of waste and reusing wastes as resources in other production lines (EC, 2014). This reduces the pressure on the country's finite virgin resources and also diverts waste from the landfill (UNEP, 2015). At the moment, the country's linear industrial system is driven by inputs of virgin materials with waste continually being generated and disposed of outside the production systems. This is unsustainable and a circular economic development model is preferred. Nowhere can this be done with ease than in a special economic zone (SEZ) where industries are located in close proximity with shared infrastructure. Moving towards a zero waste society not only makes environmental sense but is also increasingly becoming a factor of improved competitiveness. Kenya as a country needs to move away from the traditional linear development model that is characterized by linear flows of matter, where raw materials are mined, value added into a wide range of products that are utilized by consumers and discarded with a trail of waste at each unit operation of the value addition chain to an efficient closed loop supply chain (Mirovitskaya and Ascher, 2001; Ashton, 2008). It's hoped that Kenya's resource constraints and environmental pressures will accelerate its transformation from a linear extraction-use-throw-away model of economic growth into a closed loop supply chain as has been ably demonstrated in Asia and Europe (EC Decision, 2014). These noble intentions are already spelled out in the country's National Climate Change Action Plan (NCCAP) and its Green Economy Strategy and implementation Plan (GESIP), but not in the SEZ Act, draft SEZ policy and SEZ regulations.

In order to achieve this, the country's SEZs should seek to organize and sequence their industrial production lines in a manner that mimics the circular flow of matter in natural ecosystems so that waste from one production line becomes feed stock for another production line (Wolf et al. 2012).

Deliberate construction of green eco-industrial parks as is happening in South Korea and China is promising as it presents an enabling environment for improved resource use efficiency, enhanced eco-innovation, and a workable industrial symbiosis. There is however, growing awareness by governments, businesses and society in most developing countries that continuous discarding, burying and incineration of waste is no longer sustainable (Roberts, 2004). This is informed by the fact that the natural resources that provide the energy and materials for production are finite and are becoming scarce and more expensive to access. Despite a significant increase in waste materials recovery in Kenya, the end of life cycle for most of the country's products is unfortunately still the land fill. Industrial symbiosis provides a simple but cost-effective solution to resource use efficiency and waste minimization in an Economic Zone (EZ) through an exchange of energy, waste and material resources between firms, so that the waste or excess material of one enterprise becomes a raw material input for another enterprise (World Bank, 2014). This allows significant optimization and savings of energy and resources and vastly cuts down on the resource losses and environmental impact of the zone as a whole (World Bank, 2014). There is need for the development of infrastructural mechanisms for diverting waste from the landfill. Kenya is making advances in trying to address the country's ever increasing waste problems. The economic zone should put in place effective waste management regulations that seek to reduce the volume of wastes at source and encourage recovery and recycling of the inevitable wastes.

1.6 Thesis Structure

This thesis is divided into five chapters. Chapter One presents the background and states the statement of the research problem. The Chapter states the research questions, research objectives, and presents the justification of the study.

Chapter Two introduces the concept of Industrial Ecology and reviewed the evolution of Kenya's industrial policy framework starting from the National Industrialization Policy of 1996; Kenya Vision 2030; the National Industrialization Policy Framework for 2012-2013; the Kenya Industrial Sector Strategic Plan 2013- 2017; the Kenya Industrial Transformation Program for 2015; the Amended Environmental Management and Coordination Act (EMCA, 2015), the National Climate Change Action Plan 2013-2017; Kenya's Intended Nationally Determined Contributions (INDC); and best practice policy reviews for the European Union, China, Japan, South Korea, South Africa and the lessons that Kenya can learn from their past experiences.

Chapter three describes in detail the study area; data collection methods and instruments; data needs, types and sources; the sampling procedure as well as the methodological approach of the research.

Chapter four presents the study's results and their discussion in terms of the zone's inputs and outputs as well as the evolving industrial symbiosis networks. It also proposes a governance model based on expanded triple helix collaboration for green growth.

Chapter five details the conclusions and recommendations of the study.

CHAPTER TWO: LITREATURE REVIEW

2.1 Introduction

This chapter outlines the Industrial Ecology (IE) concept and explains its evolution over time. This review focused on past research, underlying theories and proven implementation outcomes. It reviewed policy interventions for IE application in the European Union, China, Japan, South Korea and South Africa and concluded that the best approach for Kenya will be one that adopts resource use efficiency and waste minimization at tenant company level first before engaging Industrial symbiosis to deal with the inevitable residual waste. Evidence from the ground revealed no systematic evidence of zone tenant companies engaging themselves in resource efficient cleaner production (RECP), the 3Rs of seeking to reduce, reuse and recycle wastes and adoption of industrial symbiosis (IS) to deal with the inevitable residual waste. A speedy adoption of RECP, the 3Rs and IS will require Government funded demonstrations. The review drew lessons from the Indian Government that has already developed green rating systems and standards that advocate for energy efficiency, water use efficiency, waste minimization and management as well as the application of renewable energy solutions in form of solar, wind and biomass. It was observed that the greening of SEZs helped boost the country's ability to attract green Foreign Direct Investments (FDIs).

2.2 Overview of Industrial Ecology

The forward thinking of Frosch and Gallopoulos way back in 1989 gave birth to the first definition of Industrial Ecology whose relevance seems to be increasing as a result of dwindling natural resources as well as the dangers being posed by a changing climate regime. Through a seminal paper, Frosch and Gallopoulos recommended that...

The traditional model of industrial activity ... should be transformed into a more integrated model: an industrial ecosystem. In such a system, the consumption of energy and materials

is optimized, waste generation minimized, and the effluents of one process serves as a raw material for the other..... (Cliff & Druckman, 2016)

Industrial Ecology operates on the premise that the design of sustainable industrial systems should as much as possible copy from the cyclic flows of materials in natural ecosystems (Graedel et al. 1995). There is emerging international consensus that the way we are using our resources is unsustainable and interventions such as industrial ecology should be encouraged so that wastes are diverted from the landfill and reused again and again so as to reduce pressure on the country's use of virgin materials. This is what is popularly referred to as a "Circular Economy). Unfortunately, company manufacturing operations within the Athi River SEZ are largely linear in the sense that raw materials are extracted from the environment, value added into final products that are consumed with resultant wastes destined for the landfill. This can only be sustainable if the country's resources are infinite which is not the case. Therefore there is need to think of innovative ways of conserving our finite resources. Adoption of RECP will help reduce waste generation at source before engaging industrial symbiosis (IS) to deal with the inevitable residual waste with the aim of seeking to divert it from the landfill.

Subscribing to a circular economy powered by resource efficient cleaner production (RECP) and industrial symbiosis will improve resource security of the economic zone, reduce associated environmental impacts associated with waste disposal, and offer new opportunities for economic growth and wealth creation. However, accelerated adoption of industrial symbiosis in Kenya is likely to be hampered by factors such as inadequate awareness of the economic and environmental benefits of embracing industrial ecology especially by Kenyan policy makers, insufficient and inaccurate production data that cannot be relied upon to make informed decisions, over reliance

on out dated policies that do not prioritize industrial ecology and resource use efficiency in general, absence of operational demonstrations to serve as convincing learning points, limited research in the emerging area of industrial ecology, and non-defined Government role in promoting the IS culture (Clift & Druckman, 2016). It has been demonstrated in Europe and Asia that a speedy adoption of industrial ecology requires an incentive scheme. The incentive will enable the participating companies to close their material and energy loops as opposed to letting wastes and by-products be disposed of in a landfill.

The Kalundborg symbiosis developed slowly on its own over the last 40 years without an form of design (Ehrenfeld & Gertler, 1997). This industrial symbiosis never received public subsidies and each linkage between firms was negotiated as an independent business deal (Ehrenfeld and Gertler, 1997). In other words, the Kalundborg symbiosis has always been driven by market forces and the actual physical linkages and their economic viability were the subject of bilateral talks between industrial actors without external prompting (Jacobsen & Anderberg, 2004). These factors must be explicitly stated when using the Kalundborg as a standard model for the establishment of eco-industrial development (Ehrenfeld and Gertler, 1997). Without the knowledge gained from the Kalundborg case, it is doubtful that the recycling networks across the world have been identified or developed (Starlander, 2003). In fact, it is hardly imaginable that eco-industrial development would have flourished so strongly in the last 30 years without the identification, intensive study and well documented material and monetary savings surrounding the spontaneous innovation at Kalundborg (Jacobsen, 2006).

There two main reasons responsible for explaining the past and continuing success of the Kalundborg industrial symbiosis are; that the industrial partnerships are commercially viable, and, the networked partners are located in close proximity to each other, which easily facilitates any form of material or energy exchange (Jacobsen & Anderberg, 2004).

The approaches to promoting a circular economy have to be designed to fit the local context. Some of the key concepts related to this approach are:

Cleaner Production: The continuous application of an integrated preventive environmental strategy to processes, goods, and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to goods themselves, and to various services provided in society (UNEP, 2011);

Circular economy: is one that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. In practical terms Circular economy promotes re-using, repairing, refurbishing and recycling of existing materials and products, as well as better eco-design of products that will allow their durability, repairability, recyclability and waste prevention. Circular economy is becoming one of the key strategies in the EU supporting its resource efficiency and competitiveness goals. The circular economy was adopted by the Chinese Government in 2001 as its official economic development model (UNEP, 2011).

Industrial ecology: Industrial ecology is a science focusing on the shifting of traditional waste-producing industrial processes to closed-loop systems, where wastes become inputs for new processes. Industrial ecology searches more effective use of internal resources, or clustering with other industrial processes. It studies the redesign of manufacturing processes and business

relationships to use less energy, reject less waste, and substitute non-polluting inputs instead of using more traditional chemical processes (UNEP, 2011).

The key gaps that will hamper an accelerated uptake of industrial ecology (IE) by Kenyan SEZs will include weak waste recovery and recycling infrastructure; a non-supportive policy and regulatory framework; limited awareness about the economic and environmental benefits of investing in industrial ecology.

2.3 Policy Framework for Kenya's Industrialization

2.3.1 Kenya Constitution 2010

The Constitution of Kenya (2010) which provides ground for the formulation of adaptation and mitigation legislation, policies and strategies by guaranteeing the right to a clean and healthy environment under the Bill of Rights (GOK, 2013). A clean and healthy environment (Articles 42, 69 and 70) is a fundamental right under the Bill of Rights (GOK, 2013). This right cannot be fully provided for unless action is taken to address environmental pollution, which can be supported through a low carbon climate resilient development trajectory (GOK, 2010).

2.3.2 Kenya Vision 2030

It is a twenty four year long-term development blue print for Kenya that is implemented through five year development plans. The vision is inspired by the principles of sustainable development that prioritize the decoupling of economic growth from environmental degradation. The vision advocates for reasonable and equitable access to the benefits presented by a clean and safe environment prioritizing sustainable exploitation of natural resources, proactive management of pollution and waste, improving capacity for climate change adaptation, and strengthening institutional capacity for environmental governance⁷. The Kenya Vision 2030 aims at achieving

⁷ Ministry of Environment and Natural Resources – Kenya, 2015. Nationally Appropriate Mitigation Action on a Circular Economy Solid Waste Management Approach for Urban Areas in Kenya.

an annual growth of 10 percent per annum and transforming Kenya into “a globally competitive and prosperous country with a high quality of life by 2030 (Kenya Vision 2030).

Under this vision, the Government is implementing a number of policies and initiatives that include increased investment in renewable energy, promotion of resource use efficiency and sustainable consumption and production of scarce natural resources and prudent waste management in anticipation of a newly industrializing status and middle income capability that is capable of providing high quality of life to all citizens within a secure and healthy environment. Manufacturing is one of the key sectors within the economic pillar of the Vision 2030 that is expected to generate 10 per cent economic growth per annum⁸. This plan aims to develop and promote Micro, Small and Medium Industries (MSMIs) earmarked as critical in propelling industrialization process and recognizes the establishment of Industrial parks (IPs) and Special Economic Zones (SEZs) as flagship projects to support industrial growth. Development of master plans and structural designs are in progress for SME industrial parks in Nairobi, Nakuru, Mombasa, Eldoret and Kisumu while 135 and 20 acres of land were identified in Eldoret and Taita Taveta respectively (GOK, 2013). This will enhance productivity, attract foreign and local investments, create jobs, generate wealth, tackle extreme poverty and integrate environmental sustainability into the country’s socio-economic development. The main activity under this Vision was the construction and equipping of Constituency Industrial Development Centres (CIDCs) in all the 210 constituencies to provide worksites, stations, and tools for the youth to pursue gainful employment. A total of 188 constituencies out of the 210 identified land for the construction of CIDCs. The Ministry of Industrialization and Enterprise Development completed construction of

⁸ Kenya Vision 2030

139 Constituency Industrial Development Centres in various constituencies while construction works for the remaining 49 centres are at various stages of implementation (MTP II). Out of these, 47 CIDCs have been identified for upgrading into industrial parks in each of the counties (MTP II).

2.3.3 National Industrialization Policy Framework for Kenya 2012 - 2030

In order to realize the desired Vision 2030 GDP growth rate of 10 percent per annum, and to enhance Foreign Direct Investments (FDIs), a number of flagship projects and other programs were identified in every sector to be implemented over the Vision period. During the 1st medium term plan (MTP), the flagship projects under the manufacturing sub-sector included the following: Development of SME Parks, development of Special Economic Zones (SEZs), Industrial Parks, Industrial and Manufacturing clusters, inputs cost reduction, value addition and market access development, financial services deepening and development of livestock Disease Free Zones for production of premium quality beef and other livestock products. Progress in this area has been slow but promising. During this 1st MTP (2008-2012), at least five (5) Small and Medium-Enterprise (SME) Industrial parks were to be developed in key urban centres in Nairobi, Nakuru, Mombasa, Eldoret and Kisumu. To align the implementation of Vision 2030 and the Kenya Constitution 2010, the approach has been reviewed to develop the SME Parks in the 47 counties. Land has been identified and acquired for 2 SME parks in Taveta and Eldoret .

Currently 135 and 20 acres of land was identified in Eldoret and Taita Taveta respectively (MTP II). Development of master plans, structural designs and feasibility studies for Eldoret and Taveta SME Parks was initiated Other outstanding activities include feasibility studies, development of Master plans and Architectural Designs initiated. Governance and Management structures of the SME Parks will be put in place through the PPP approach. Funds mobilization for both horizontal

and vertical development of the parks will be initiated. Special Economic Zones (SEZs) are designated geographical areas with liberal economic laws, and developed infrastructure. They play an important role in catalyzing economic and social development and increasing competitiveness. During the plan period, three (3) SEZs were planned to be implemented in Mombasa, Lamu and Kisumu. Land was identified in Dongo Kundu and Lamu. The SEZ concept paper was approved by Cabinet and plans for the development of the Master Plan are underway.

Further a SEZ policy and bill have been developed and approved by cabinet and a Sessional paper on the same has been prepared in readiness for tabling in parliament. During the first MTP, two (2) industrial parks were to be developed in Mombasa and Kisumu within the Special Economic Zones (SEZ). In Mombasa and Kisumu, 3000 and 1000 acres of land were identified respectively for development of industrial parks. Master plans and basic infrastructure for the industrial parks will be developed within the second MTP. Resources to support development of the parks will be mobilized through a Public, Private sector Partnership (PPP) approach. Furthermore during the implementation period, land for development of a third industrial and technology park was identified at Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Juja. The university allocated 32 acres of land for development of the park and a Memorandum of Understanding (MoU) has been signed between the Ministry and the University. The development of master plans and structural designs for the park are in progress. During the second MTP, resources will be mobilized to develop basic infrastructure and a project management structure will be put in place. Though well intentioned and in line with the aspirations of Kenya Vision 2030, the implementation process has been rather slow largely due to lack of funds and the ideals

of green growth have not been given the attention that they deserve in the already developed master plans.

2.3.4 Kenya Industrial Sector Strategic Plan 2013 – 2017

The mission of the country's National Industrialization policy is to enhance a sustained growth of the industrial sector, by at least 15 per cent per annum by 2017, by creating an enabling environment for a robust, diversified, fair competition field, cost and time conscious, and innovative industrial sector; that offers targeted incentive packages in priority sectors; and desires to have a country wide dispersal of industrial activities leading to regional economic empowerment. The specific goals to be achieved in the short term (5 years) are: (i) strengthening local production capacity to increase domestically-manufactured goods by focusing on improving the sectors productivity and value addition by 20 per cent; (ii) raising the share of Kenyan products in the regional market from 7 to 15 per cent; (iii) developing niche products through which Kenya can achieve a global competitive advantage; (iv) increase the share of Foreign Direct Investment in the industrial sector by 10 per cent; (v) increase by 25 per cent the share of locally produced industrial components and spare parts; (vi) developing at least 2 Special Economic Zones and 5 SME Industrial Parks; (vii) creation of an Industrial Development Fund with a minimum of Kshs. 10 billion for long term financing; (viii) increase by 20 per cent the share of manufacturing in total MSME Output; (ix) increase the local content of locally manufactured goods for export to at least 60 per cent; and (x) increase the share of industries located outside major urban centres (Nairobi, Mombasa, Kisumu, Nakuru, Eldoret) to 50 per cent. Majority of these specific goals can be achieved through the construction of well managed SEZs/IPs.

The policy recognizes the need for the Government to plan, demarcate, zone and acquire land for industrial development in every county. Additionally, the policy seeks to develop a framework for commercializing of research findings; formulate mechanism to facilitate collaboration with the private sector in research, technology and development; strengthen capacity for technology certification and adoption; establish a funding mechanism for Research and Development to facilitate innovation, acquisition of strategic and relevant technology for industrial development; and establish an industrial information database. The concepts of green growth as interpreted from the point of view of being low-carbon, resource efficient, and climate resilient are not captured in the plan to mainstream green growth ideals in the establishment of Special Economic Zones and Industrial Parks to support the promising circular economy.

2.3.5 Kenya Industrial Transformation Program 2015

This is a strategic document to guide industrial development in Kenya towards transforming the country into an industrial hub in the region and beyond. In order to achieve this goal, the program recognizes the need to overcome challenges such as infrastructure and land availability, skills and capabilities in priority sectors, quality of inputs, cost of operation, access to markets and investor friendly policies. The strategy acknowledges creation of green industry as a priority to drive a low-carbon green economy. This will provide the much needed niche while marketing domestic products overseas where consumers are increasingly emphasizing on environmentally manufactured products. However, the strategy lacks adequate SCP considerations and integration into its five pillars thereby requiring the need to subject the program to a Strategic Environmental Assessment to identify and strengthen strategic greener implementation pathways.

Though the program prioritizes sub-sectors such as special economic zones and industrial parks along the country's major infrastructure corridors, the concept of a circular economy through Eco-industrial parks, Industrial symbiosis; Resource Efficiency and leaner Production (RECP), Eco-innovation, Eco-labels in line with the SCP paradigm were not considered. The 10 YFP framework on Programs on Sustainable Consumption and Production (10 YFP) was adopted at RIO+20. The program recommends that industrial transformation should be underpinned on Sustainable Consumption and Production practices such as resource efficiency and cleaner production, eco-industrial parks, industrial symbiosis, extended producer responsibility, EMSs and Eco-labels.

Though the country has continuously developed progressive and enabling policies for industrialization, its ability to fully implement them has been wanting. The end result is that the good policy intentions that are ably put on paper are not translated into implementable actions on the ground. Kenya Vision 2030 is currently guiding the country's development agenda (GOK, 2013). This vision recognizes industrialization as one of the key pillars of economic growth and wealth creation (GOK, 2013; 2015). As a result, there has been a marked increase in the proliferation of manufacturing value added special economic zones (SEZs) across the country. Kenya currently boasts of 50 gazetted public and private SEZs and this number is rapidly increasing (Export Processing Zones Program Annual Performance Report, 2013).

Plans are underway to establish a total of 10 more industrial parks/ special economic zones (SEZs) along the country's major infrastructure corridors⁹. The planned industrial parks are Mombasa Industrial Park (Dongo Kundu), Miritini Garment Industrial Park, Voi Industrial Park, Sultan Hamud Industrial Park, Athi River special economic Zone (SEZ), Naivasha Industrial Park,

⁹ GOK, 2015. Kenya's Industrial Transformation Program, Ministry of Industry, Investment and Trade.

Nakuru Industrial Park, and Kisumu industrial park along the SGR and Lamu Industrial Park and Baringo-Silali Industrial Park on the Lamu Port South Sudan Ethiopia Transport (LAPSSET) corridor as shown in the map below. The culture of industrialization through special economic zones (SEZs) and industrial parks (IPs) is gathering momentum in Kenya. Increasingly, the Kenyan private sector is recognizing that SEZs/ IPs do provide an enabling environment for manufacturing through well managed solid, liquid, transport, energy and waste management infrastructure that is non-existent in the rest of the country. Because SEZs/ IPs concentrate industries in delimited areas, their strict adherence to the ideals of resource use efficiency and cleaner production (RECP) and industrial symbiosis (IS) will enable them lower their carbon footprints and remain competitive.

2.3.6 National Climate Change Action Plan 2013 - 2017

Kenya has an elaborate five year climate change action plan that runs from 2013 to 2017. Its main aim is to help minimize waste related greenhouse gas emissions and fundamentally improve on the country's approach to waste management. It was developed in 2013 to help implement the mitigation and adaptation provisions of the country's 2010 National Climate Change Response Strategy (NCCRS). The Action Plan recognizes waste management for green job creation, advocates for improved collection and recovery of wastes as well as use of waste for energy generation. Fuel switch from the use of fossils to the use of biomass based energy sources whenever feasible is recommended for economic and environmental reasons.

2.3.7 Kenya's Intended Nationally Determined Contributions (INDC)

As part of its UNFCCC obligations, Kenya has committed herself to abating its greenhouse gas (GHG) emissions by up to 30% by 2030 relative to the business as usual (BAU) scenario of 143 MtCO₂eq. The country affirms that this will be subject to continued internal support in form of financing, investments, technology development and transfer support, as well as the accompanying capacity building support. In order to realize this goal, Kenya will continue implementing its climate change action plan for 2013 – 2017, and subsequent action plans. The implementation plan will include the promotion and implementation of enhanced energy and resource use efficiency across different sectors of the economy; adoption of environmentally friendly and clean energy technologies for purposes of reducing over-reliance on fuel wood; adoption of low-emission and efficient urban transport systems and a switch to sustainable waste management systems. The emission reduction levels registered in this study through fuel switch from the use of furnace oil to the use of biomass is one business model that can help the country realize its 30% reduction levels by 2030.

Industrial Symbiosis contributes directly to the achievement of sustainable development goal (SDG) 8 on promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; goal 9 on building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation; goal 12 on ensuring sustainable consumption and production patterns; goal 13 on taking urgent action to combat climate change and its impacts; and goal 17 on strengthening the means of implementation and revitalization of the global partnership for sustainable development (Lombardi, 2015). Resource use efficiency and cleaner production (RECP), adoption of the 3R philosophy of reducing, reusing and recycling and industrial symbiosis investigated in this study will enable the country promote

energy efficiency, water use efficiency, minimize waste at source, adopt renewable energy solutions, and adoption of a circular economy through industrial symbiosis will go a long way in enabling the country meet its emission targets by 2030.

In order to facilitate the widespread adoption of RECP and IS within Kenyan SEZs, there will be need to make provision for monitoring, reporting, and review mechanisms. The Zone Authority will need to install and operate a zone wide information management system that will (i) support inter-enterprise communications (ii) provide a centralized data acquisition and analysis system to monitor energy, GHG, and water flow data; and (iii) inform enterprises on local and national developments related to energy and environmental management (UNEP, 2014). Of fundamental importance is the need for zone based enterprises to embrace energy efficient technologies, processes and practices (World Bank, 2014). The Zone Authority with the assistance of the “Green Cell” should be organizing workshops, training and learning sessions to help enterprises conduct energy audits and adopt best practices in energy efficiency (UNEP, 2014).

2.3.8 Green Economy in the Kenyan Context

There is growing recognition that transitioning to an ‘inclusive green economy for Kenya’ can provide the means to address some of the systemic problems of the current economic system, and can generate more inclusive and sustainable growth by increasing the economic and social returns from investing in environmental improvement and low-carbon, climate-resilient development trajectories (JPA, 2012; GOK, 2013; Hu, 2014). UNEP defines a green economy as one that results in *improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities* (UNEP, 2011). For the SEZ’s, this transition means supporting resource-efficient, low-carbon and climate-resilient growth; creating and sustaining decent green jobs, and

expanding other economic opportunities that benefit the poor, including the informal economy; stimulating innovation and adopting green technologies that can benefit the poor; and diversifying and enhancing the resilience of the regional economies (JPA, 2012). Further, the social pillar means improving the health and well-being, especially among the poor; Promoting equity, including gender equality; building social capital and enhancing the resilience of local communities, especially among the poor; while the environmental pillar advocates for increased productivity and efficiency of natural resource use, reduced pollution and impact of natural hazards, improved management of environmental risks, and making investments in restoring and sustaining ecosystem health and resilience (JPA, 2012). All these tenets are well explained in the country's draft Green Economy Strategy Implementation Plan (GESIP). The governance pillar entails empowering citizens/ employees through access to information and justice and participation in decision making, particularly among marginalized groups, improving transparency and accountability in the public and private sectors and insisting on better regulation of markets (UNEP, 2011).

In the Kenyan context, Green Economy is seen as a smart way of delivering an equitable society that resides in a sustainable environment (GOK, 2015). The definitions of Green Economy by four international organizations OECD, UNDP, UNEP and the World Bank are broadly characterized by three objectives: improving resource-use efficiency (a green economy is one that is efficient in its use of energy, water and other material inputs); ensures ecosystem resilience (protects the natural environment, its ecosystems' structures and flows of ecosystem services); and enhances social equity (it promotes human well-being and fair burden sharing across societies) (NCCAP, 2013; EEA, 2014; GOK, 2015). The concept of Green Economy does not replace that of

sustainable development, but can instead be understood as an innovative way to achieving sustainable development (UNEP, 2011). Low-carbon green growth is a development pathway that decouples economic growth from carbon emissions, pollution and resource use, and promotes development through the creation of new and environmentally friendly products, industries and business models that seek to improve people's quality of life (ADB, 2012; NCCAP, 2013). The United Nations Industrial Development Organization (UNIDO) defines green industry as: "the potential for industries to decouple economic growth and revenues from excessive and increased resource use and pollution (UNIDO, 2011; UNEP 2011). This vision foresees a world where the industrial sector minimizes waste in every form, utilizes renewable resources as input materials and fuel, and takes every possible precaution to avoid harming workers, communities, climate or the environment (UNIDO, 2011; UNIDO 2015). Green industries will be creative and innovative, constantly developing new ways of improving their economic, environmental and social performance (UNIDO, 2011; UNIDO 2015). This involves both the greening of existing products and the creation of green industries that deliver environmental goods and services (UNEP, 2011; UNIDO 2015).

2.3.9 Challenges of Promoting Green Growth in Kenya

Although there is unanimous national support for a green economy, Kenya as a country has to overcome key challenges that might derail its grand march to the green economy status (GOK, 2015). The first challenge is attributed to the country's inability to enforce its sustainability enabling laws and regulations. The weak enforcement fate that has characterised the implementation of the amended Environmental Management and Coordination Act (EMCA, 2015) and its subsequent regulations is likely to be the same fate that will face will characterise the implementation of the climate change act, its implementation regulations as well as the already

published green economy strategy and implementation plan (GESIP) (GOK, 2015). Secondly, the country does not boast of any existing standards for green technologies, green manufactured goods and environmentally benign services. Progress is underway as evidenced by the Government's efforts to set minimum energy efficiency standards for certain appliances across the country (GOK, 2015). Use of voluntary rating schemes for SEZs has proved to be successful in promoting good manufacturing behavior in India and China (GIZ, 2015a; 2015b). The country has a weak technology transfer infrastructure that will tend to complicate its ability to bring into its economy environmentally sound technologies (ESTs) (UNEP, 2015). Companies operating within the SEZs will therefore experience difficulties in transferring ESTs into their domain as well as acquiring techno-managerial capability to transfer, adopt, and adapt these technologies to the Kenyan setting (GOK, 2015). Successful adoption environmental standards not only benefits the environment but also boosts the country's ability to trade with the international community. Eco-labels should be embraced as a way of enabling consumers make easy informed choices as regards their consumption habits.

Third, the current economic policy framework for Kenya needs to account for the intrinsic value of its natural capital and support sustainable development (GOK, 2015). Like most countries, Kenyan prices and policy regimes do not fully account for the external costs associated with technologies, products and practices that are not environmentally friendly (GOK, 2015). This also tends to diminish any emerging demand for greener alternatives (GOK, 2015). There is potential though to use fiscal policy instruments to correct this, such as environmental taxes, subsidies, pollution charges, public expenditure on green infrastructure, green public procurement, feed in tariffs and grants (GOK, 2014). Kenya already has a feed-in tariff intended to promote green

energy but it excludes some resources such as wave, tidal and ocean thermal energy conversion (GOK, 2013). These tariffs help to level the playing field with fossil fuel energy sources (GOK, 2015). Fourth, additional funding will be needed to effect a transition to a green economy due to its high up front capital costs, particularly in areas like energy where up-front costs for clean technologies can be prohibitively high (GOK, 2015) although they enjoy attractive payback periods. These funds will need to originate from both the private and the public sector (GOK, 2014). At the international level, Kenya may be underutilizing international donor funds available for low-carbon development (GOK, 2015). At the domestic level, enhancing its ability to mobilize domestic funds for investment in new renewable technologies will require addressing current disincentives (GOK, 2015).

Fifth, there is insufficient knowledge regarding the costs and performance characteristics of available green technologies (UNIDO, 2015). There is also entrenched policy, market and financial barriers that prevent the transition from fossil fuel-based technology to greener alternatives (GOK, 2015). Efforts to increase awareness of energy efficiency and renewable energy technologies can improve knowledge of best practices, promote the concept of a green economy and provide needed education and outreach (GOK, 2015). Kenya needs to emulate the successful Chinese experience in promoting a circular economy. The Circular Economy (CE) Promotion Law passed in China in 2008 is a working example of a Resource Efficiency and Cleaner Production (RECP) policy in action. A CE puts emphasis on the most efficient use of resources and promotes reducing, reusing and recycling (UNEP, 2015). It supports resource efficiency by integrating cleaner production and industrial ecology in a broader system that includes industrial firms, networks or chains of firms and eco-industrial parks (UNEP, 2015). The CE initiative targets resource efficiency at three

levels: at the firm level, the Manager must seek much higher efficiency through cleaner production (primarily reducing, reusing and recycling); reuse and recycle resources in industrial parks and clustered or chained industries so that resources will circulate fully in the local production system; and integrating different production and consumption systems in a region so that resources circulate among industries and urban systems (UNEP, 2015).

2.3.9 Legal Framework

Table: 1 Summary of Relevant Legal Framework for SEZs

Table 1 below shows a summary of how the relevant legal provisions apply to SEZs.

Act	Sections of the Act Relevant to the Study	Sections of the Regulations relevant to the study
Amended EMCA, 2015	<ul style="list-style-type: none"> -The Act requires that new industrial parks be subjected to a Strategic Environmental Assessment (SEA) study -Licenses all waste management practitioners in the country 	<ul style="list-style-type: none"> - Guidelines on how to handle, store, transport, and treat for disposal a wide range of waste streams - Regulations prioritize waste minimization (reducing, reusing, recycling and recovering wastes); cleaner production technologies, techniques and practices; - Source segregation of wastes that is key for promoting industrial symbiosis at the economic zone level. - These same regulations provide an opportunity for private sector investment in waste management that will be key in helping to establish spin off companies for the creation of decent green jobs.
SEZ Act 2015	The Act does not address any elements relevant to green growth and the need for low-carbon, resource efficient, and socially inclusive development trajectories	The draft regulations do not give priority to the country's green growth agenda
Climate Change Act, 2016	Act calls for adoption of a green growth development trajectory that is low carbon, resource efficient and	The Act Regulations are yet to be drafted

	socially inclusive in terms of creation of decent green jobs	
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2.4 Promotion of RECP and IS at the Athi River SEZ

The Kenyan Athi River SEZ was planned, designed, built and run with little concern for its impact on the environment and that explains why there has been a marked accumulation of wastes and by-products within its zone boundaries over time. The economic zone operates a wide range of industrial establishments that leads to a cumulative effect of the environmental impacts of individual companies within the zone with each company attempting to fix its challenges single handedly. This should not be the case. The proximity of companies within the economic zone should be exploited economically by exploring ways and means of enabling these companies to exchange wastes and by-products through industrial symbiosis. By working together, the community of businesses within the economic zone will achieve a collective benefit that will be greater than the sum of individual benefits each company would realize by only optimizing and making efficient its individual performance (Lowe, 2001).

The environmental dimension of the economic zone has been overlooked for a long time. A cooperative, collaborative and inclusive approach in addressing specific enterprises' environmental challenges will not only reduce the impacts of the enterprises but also contribute to the overall reduction of the zone's environmental impacts through exploitation of synergies between companies. This approach is much more cost effective when compared to industrial enterprise engagement. The green growth agenda of the economic zone must be played by both the zone and its tenant companies. This is due to the fact that, there are some environmental issues that are not important at company level while they are extremely important when the overall activities of the economic zone are considered. Examples in this regard will include water or

energy consumption, and greenhouse gas (GHG) emissions. This requires the Zone Authority to work closely with its tenant companies in developing for example GHG inventories and other collective green growth objectives. There is therefore need for a mechanism that allows both tenant companies and the Zone Authority to speak the same environmental language and similarly work towards the mutually reinforcing goals of the economic zone. Unfortunately, there is no inbuilt enabling infrastructure that is designed to fully tap into these potential synergies on a wide scale. With proper planning, Kenyan economic zones can provide unrivalled leadership in environmental performance due to the existence of shared infrastructure. UNEP points out that environmental impacts associated with economic zones can be easily divided into two types: impacts that occur as a legacy from when the industrial park was planned and impacts that arise from the day-to-day operations of the industrial park (UNEP, 2015). It is easier and cost effective to improve on the day-to-day operations of industrial parks.

The Athi River SEZ does not have a controlled landfill. There is therefore no incentive for tenant companies to seek innovative ways of diverting wastes from the landfill. As a result, there has been a marked accumulation of solid wastes in the zone over the years. This can rapidly change if the zone's waste streams can be integrated back into the value addition cycle. The Athi River SEZ has the requisite threshold number of companies to permit cooperative and collaborative approaches to synergies such as waste and by-product exchange. It should be the cardinal duty of the Zone Authority to encourage this. Lack of this intervention means that materials within the economic zone are continuously flowing from the economy into the environment with disastrous impacts. In order for the economic zone to fully embrace the ideals of sustainability, it has to drift away from over reliance on end-of-pipe approaches and instead embrace pollution prevention at

source. The end-of-pipe is a reactive approach that creates a problem and then seeks a solution to it. There is urgent need for a more proactive approach that seeks to avoid the problem of waste generation in the first place. The tenant companies of the economic zone are at different levels of environmental stewardship. There are a few front runners that are already embracing IS while a great majority of the zone enterprises are yet to embrace IS, leave alone resource use efficiency and cleaner production. Ideally, the economic zone enterprises should be actively engaged in on-site activities that seek to minimize waste generation at source through avoided leakages, spillages and over flows. These waste streams are the pollutants that lower the quality of the surrounding environment. The economic zone should strive to make the maximum use of its by-products as a way of reducing the need for virgin materials; close material loops through recycling; de-materialize its products and economic activities by reducing the mass of material required for production; and de-carbonization of its energy supply by progressively shifting to greater energy efficiency and sources of energy that are richer in hydrogen and poorer in carbon (UNEP, 2015). By strictly analyzing material and energy flows, it is possible to identify waste and by-product synergies that can be actualized.

The Zone Authority should work towards establishing a zone wide environmental policy that should give a sense of direction as to the zone should minimize its waste at source and exchange the residual wastes through synergies. Some of the key issues that the zone wide environmental policy should address include: (i) the zone's vision with regard to environmental sustainability, (ii) the zone's willingness to adhere to the principles of continual improvement and pollution prevention, (iii) a willingness to comply with the threshold requirements of environmental laws, standards and regulations, and (iv) the desire to maintain an open and interactive communication

with all key stakeholders and interested parties (UNEP, 2015). At the moment, there is no such zone wide policy at the Athi River SEZ. It should be clearly understood that good environmental practices will benefit both the tenant companies and the economic zone as well. An environmental program powered by resource use efficiency and cleaner production (RECP) and industrial symbiosis (IS) will enable tenant companies to locate wastage and inefficiencies in their operations and have them fixed at process level. Subscription to good environmental practices enhances the image of the economic zone and by extension that of the tenant companies. Doing this will make the economic zone more attractive to prospective investors and the value of setting base within the economic zone increases.

According to UNEP, the fact that the economic zone demonstrates reasonable and responsible care by giving priority to prevention over remediation, helps to improve relations with Government and the surrounding communities (UNEP, 2015). The economic zone together with its tenant companies should be perceived to be willing to go beyond mere compliance with environmental regulations. The best way of assuring this is to promote the use of cluster based voluntary codes of practice that are promoted by business associations within the sector-wise clusters of the economic zone. Such voluntary codes of practice should be anchored on the principles of RECP, the 3Rs (reduce, reuse, recycle), and industrial symbiosis (IS). Voluntary green rating schemes can also be promoted as a way of encouraging tenant companies to meet and even exceed the set environmental standards. The Zone Authority can help to develop common training programs for the economic zone tenant companies. The aim of such training programs will be to improve the general awareness of all staff on RECP, the 3Rs, and IS; create specialized green skills needed to promote the Zone's green growth agenda; and promotion of general techno-managerial skills. The

Zone Authority should constantly monitor the environmental parameters of the economic zone in form of ambient environmental quality; emissions to water and air; solid waste generation, storage of goods and wastes on-site; accidental spillages, and procedures for emergency preparedness and response.

Data derived from this monitoring program exercise should be stored in a data base. This data should be routinely analyzed and trended so as to inform good decision making. It will therefore be the duty of the Zone Authority to aggressively promote RECP, the 3Rs, and IS within the zone's tenant companies. Investing in RECP has an assured pay back for the tenant companies. Good knowledge of material flows within the production lines is a mandatory requirement for process optimization and industrial symbiosis. The Zone Authority should accurately map out material and energy flows of all companies operating within the zone. Data accruing from this mapping exercise should be entered into a data base managed by the Zone Authority through an established information clearing house. When wastes and by-products are produced within the economic zone, this information should be relayed to a zone wide information platform that should ideally connect all the tenant companies of the zone. With the help of a waste exchange clearing house, it can be possible to match those who generate wastes with those who need those wastes as feed stock raw material input. This matching of the "haves" and "wants" will facilitate negotiated payments for wastes and by-products that could otherwise have been landfilled. A data base of generated wastes and by-products will help develop synergies for waste and by-product exchange through industrial symbiosis opportunity workshops. UNIDO states that there are three elements that affect the stable operation of an industrial symbiosis system: (i) communal facilities that support the development of enterprises within the economic zone, such as an information centre, a technological centre, an

environmental centre, good road network, a solid waste disposal and recovery site and an energy centre; (ii) relational networks of industrial symbiosis; and (iii) a supportive service which contains the factors that will affect and regulate enterprises within parks in terms of policy, the regulatory regime, park administrators, laws and financing priorities (UNIDO, 2016).

Introduction of industrial symbiosis (IS) at the Athi River SEZ should follow a step wise approach. The initial step should be an exploration of potential networks, to be followed with a feasibility study before final commercialization of the IS with the active participation of the private sector (UNIDO, 2016). Potential IS networks should be identified using a bottom up approach. This will entail company in-put/ output data collection for purposes of exploring the existence of new synergy networks. This production data from companies will be reviewed with the sole aim of determining possible waste and by-product exchanges. Tenant companies with potential for waste and by-product exchange will be encouraged by the Zone Authority to participate in the IS network through waste exchange opportunity network seminars and business meetings. For IS to become a cultural practice within the economic zone, there is need for continuous collection of on-site information from zone tenant companies through various forums so that synergy building becomes a continuous exercise that is constantly being refined and improved upon.

The Zone Authority with the help of the Government should then proceed and fund the feasibility studies of the most promising IS synergy networks. Best feasibility results will be derived from team effort with contributions from multi-disciplinary teams. Promising IS proposals should then be developed further into bankable business models with stakeholder input. These proposals should be piloted first within the economic zone so as to be able to establish the best approaches

of full scale roll out. The piloting exercise should be strictly monitored so that meaningful feedback is derived to inform future implementation road map. Ideally, the business model should be co-authored with stakeholders as a way of trying to cement their buy-in. Commercialization of the technically and financially feasible business models will have to overcome a wide range of barriers that will include financial, technical and attitudinal. There is need for detailed negotiations that seek to protect the interests of all players, those who generate wastes and those who receive the wastes for use. In fact trust is the foundation of any successful synergy building network. The financial barrier will be overcome by seeking to tap into the emerging green funds at national, bilateral and international levels. Technical barriers will largely be attributed to lack of cleaner and environmentally sound technologies that can be transferred into the country if there is an enabling technology transfer infrastructure and policy that assures value for the investments. Attitudinal barriers will be overcome through training and retraining, awareness raising and organization of study tours to places where IS has worked successfully to demonstrate its environmental and economic benefits.

Firms that will enter this IS network should know that they can compete and cooperate at the same time within the expansive network. There must be a constant flow of waste and by-products in a reliable manner. This underscores the need for up to date waste recovery and recycling infrastructure. When these waste materials are produced constantly and reliably, the transaction costs will generally come down. It will be important for this synergy seeking approach to build on those networks that have developed organically or spontaneously on their own due to the prevailing forces of supply and demand. This underscores the fact that for IS to succeed, it must make good business sense and should also be used to create additional efficiencies in terms of

lowering the operational cost of doing business. A successful IS network entails a multi connected waste recovery system; a robust training program on waste and by-product exchange as well as the related synergy building; an infrastructure for waste and by-product recovery and re use; a system for managing the network and its players; a community liaison and outreach office for managing joint projects with the surrounding community; and a vibrant triple helix collaboration for eco-innovation (World Bank, 2014). The main aim is to create a system of recovering and trading by-products and wastes among zone companies. The noble intention is to divert wastes from the landfill, lower production costs, generate extra revenue from the waste streams, create more decent green jobs, reduce pollution levels, lower disposal costs, and reduce pressure on the use of virgin raw materials (Kechichian & Jeong, 2016).

This in essence seeks to connect individual firms into industrial ecosystems by closing loops through waste and by-product reuse and recycling; maximizing efficiency of materials and energy use; minimizing waste generation at source; and defining all wastes as potential products and seeking markets for them (UNIDO, 2016). It is important to determine which waste streams are already being re-used and recycled on-site and which ones need to be further recovered and diverted from the landfill. The resources that no company is currently using within the economic zone should be identified and appropriate technologies and business models developed to put these resources back to economic use through manufacturing value addition. This will extend the value of the recovered wastes along the production supply chain. There is need for proper planning and analysis if the art of waste and by-product exchange networks has to be expanded within the economic zone. According to UNIDO, this should entail characterizing energy, water, and material flows so as to highlight and map existing and promising exchanges of by-products; providing

training, tools, and support for the development process, data gathering and analysis; gathering further data on resource flows of companies that have committed to the by-product exchange; identifying companies which could process selected materials, provide collection services for specific by-products, or otherwise support the operation of the by-product exchange; identifying for fixing potential barriers in regulations, business practices, and environmental management; and developing a strategic plan for expanding from a by-product exchange to a full scale eco-industrial network (UNIDO, 2016).

The four clusters at the Athi River SEZ have just self-organized as a result of the prevailing market forces of supply and demand. A comprehensive materials flow investigative study is required for the economic zone so that an up to date inventory of wastes and materials is developed. It will also be important to establish waste and by-product exchanges that are spontaneously on-going and those that are currently being discarded into the economic zone but could be otherwise be exchanged and the burden this business as usual practice is having on common infrastructure in form of landfills and centralized effluent treatment plants. The goal should be to help establish innovative new businesses that turn waste and by-product streams into feed stocks inputs for other companies. Sustainable waste and by-product exchange should only come after the participating companies have already adopted other environmental management strategies like waste reduction at source, pollution prevention and energy efficiency. It is critically important to assure the synergy participating companies that their trade secrets will not be revealed to third parties. This underscores the need to code the data as a way of preventing unauthorized disclosures.

On-site investigations revealed that at times, there is need for pre-processing of discarded wastes before they are made ready for use by other production lines. The off cuts from plastic tarpaulins manufacture will need to be palletized before being used for plastic water tanks and chairs. This initiative can best be promoted through incubation. Adoption of an incubation framework to fill this gap within the economic zone will enable it not only create more green jobs but also fulfill the wider goal of embracing a closed loop system, that relies on optimized reuse and recycling of wastes and by-products. Once company managers are made aware of the opportunities to cut costs and possibly gain new income through exchange of by-products, they may start negotiating with potential trading partners without need for any encouragement (UNIDO, 2016). However, lessons learnt from Europe and Asia justify the need for waste exchange opportunity seminars, a privately owned by-product exchange website, and newsletters may be required to open up a more active network of interactive exchanges. There is also need to construct within the economic zone infrastructure in form of conveyor systems and bulk storage facilities to facilitate a smooth exchange. The developed world has developed software to help facilitate waste and by-product exchange synergies. By matching residual by-products from zone businesses with a generic data base, the software can be used to determine potential synergies. This software is yet to be tested at the Athi River SEZ. The ultimate goal is to close the energy and material flow cycles, engage multi stage energy cascading and waste minimization at source, enable waste and by-product exchange through industrial symbiosis for improved productivity, resource use efficiency and competitiveness. At the Athi River SEZ, most tenant companies operate as silos with no formalized communication among them. The economic zone also lacks a platform through which economic zone tenant companies can meet and deliberate on issues of mutual interest such as resource use efficiency, cleaner production and waste and by-products exchange through industrial symbiosis.

Kenya's efforts of promoting green growth is at its infancy. As such, there is no policy that currently prioritizes the promotion of industrial symbiosis in the country. For policy makers, industrial symbiosis presents an opportunity to value add on waste streams for improved profitability while at the same time expanding the waste and by-product exchange networks beyond the boundaries of the firm to incorporate external clusters (OECD, 2010).

Industrial ecosystems also tend to evolve over time. According to Graedel and Allenby 1995, Type I industrial ecosystems are the typical industrial processes of today, linear systems with little or no recovery of materials from the waste stream. Type II are emerging industrial ecosystems that include reuse and recycling in their processes but also require significant primary material inputs for their functioning. Closed loop Type III industrial ecosystems with full materials recovery do not exist in Kenya at the moment, partly because of a lack of appropriate technologies and partly because of limited awareness of such possibilities. According to Chertow, 2007, a planned EIP model entails a conscious effort of identifying potential companies from different industrial sectors and locating them together so that they can exchange wastes and by-products as well as share common utility infrastructure (Chertow, 2007; Nardin, 2012). A self-organizing EIP model is one where an intricate industrial ecosystem spontaneously emerges from decisions of the private sector actors that are motivated by a strong desire to cut down on operational costs, increase the company's revenue base, and expand the businesses' product range (Chertow, 2007; Meneghetti and Nardin, 2012). This spontaneous evolution is what is already happening at the Athi River Special Economic Zone (SEZ). However, the Zone's accelerated uptake of industrial symbiosis will be determined by the quality of waste recovery and recycling infrastructure as well as the existence of an enabling and supportive policy framework.

In an ideal system, both renewable and non-renewable materials would be utilized in a closed loop to minimize the input of virgin resources (Kibert et al. 2002). The Athi River SEZ does not have any functional management information system (MIS) to help accelerate Zone Company networking. Zone wide meetings on matters of mutual interest such as waste management were not common. There should be a management information system (MIS) to facilitate information and knowledge transfer between and among network partners. This justifies the need for a waste matching software that will enable companies to know who can use their wastes and by-products and from whom can they get wastes and by-products for use as raw material inputs. The success of an industrial symbiosis network relies on active participation of its members and their commitment to continual improvement.

Traditional EPZs are exclusively export oriented; depend heavily on fiscal incentives; have limited linkages with the local market; focus on labor intensive industries with little value addition; focus on production and assembly and have primarily foreign investors (EPZ Program Annual Performance Report, 2013). On the other hand, SEZs are a broad concept that includes Free Trade Zones, informational Technology (IT) Parks, Free Ports, Foreign Trade Zones and allow for sales both in the local and foreign markets (Farole, 2011). The Governance structure of the country's SEZs is too centralized to be effective in delivering effective technical advisory support to all its gazetted zones across the country. According to Benyus, 1997, engineers and environmentalists can learn from Nature's design parameters as it runs only on sunlight; uses only the energy it needs; fits its form to function; recycles everything; rewards co-operations; banks on diversity; demands local expertise; curbs excesses from within; and taps into the power of limits. The cardinal

requirements for industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity” (Chertow, 2000). In a typical industrial symbiosis network, there are normally three types of symbiotic transactions that manifest, (i) utilizing waste derived from the activities of another plant as a raw material input; (ii) sharing common utility infrastructure; and (iii) partnering on issues of mutual interest such as emergency preparedness and response; training and capacity building, and promotion of integrated sustainability planning of economic zones (Chertow et al., 2008).

A linear production system is illustrated in the Figure 1 below.

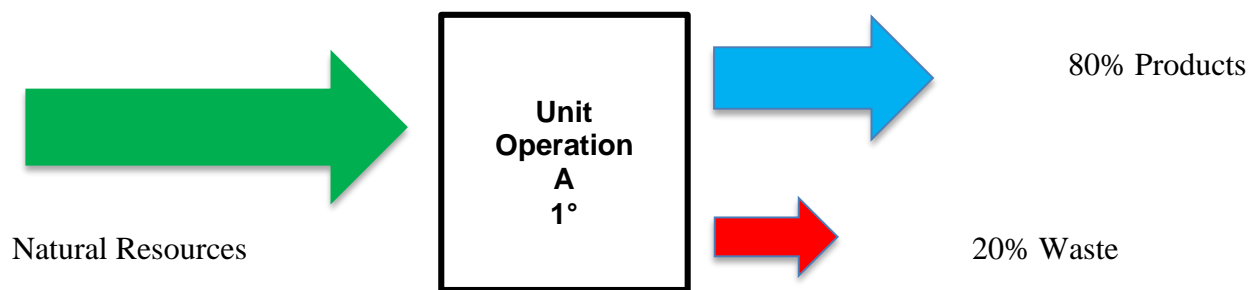
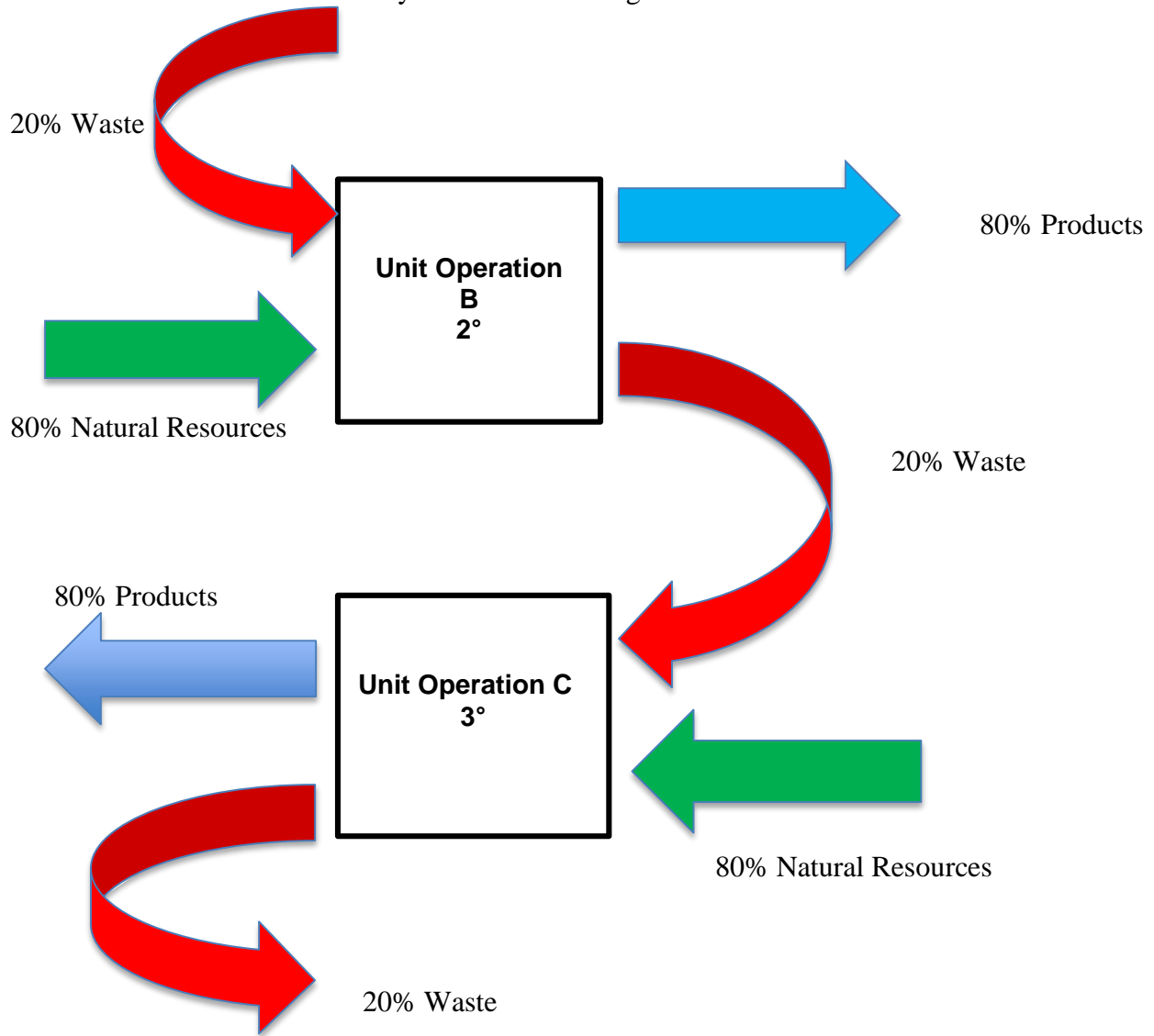


Figure 1: Linear Production System

A transition to a circular economy is illustrated in Figure 2 below.



Source: International Synergies Limited, 2013: National Industrial Symbiosis Program (NISP) of the UK

Figure 2: Circular Economy

The Kenyan Government ascended to its Special Economic Zone (SEZ) Act No. 16 of 2015 on September 11, 2015. This Act came into force on December 15, 2015. Although the SEZ Act together with the draft SEZ policy do not put priority on the need to transform our current SEZs into those that emit less emissions, utilize resources much more efficiently and make them more

resistant to the vagaries of a changing climate regime, this research project seeks to establish how this transition can be fruitfully realized. The ultimate goal is to help build a roadmap that can enable the country's current SEZs transform into green zones through the adoption of resource use efficiency, cleaner production and industrial symbiosis (UNIDO, 2015).

2.5 Emerging Industrial Ecology Models of the World

Europe's development is promoted by a resource efficiency initiative that is anchored within a roadmap for a resource efficient Europe. The flagship initiative compels member states to prioritize resource efficiency gains through industrial symbiosis (Laybourn and Lombardi, 2012). Kenya is yet to develop its own industrial symbiosis flagship initiative based on a solid roadmap. The continent's keen interest in promoting industrial symbiosis is informed by the remarkable success of the UK's National Industrial Symbiosis Program (NISP) (Laybourn and Lombardi, 2012). Likewise, Kenya with the help of the East African Community (EAC) should set up demonstrations that aim to show that investing in industrial symbiosis enhances the productivity and competitiveness of participating companies. Europe's 2020 Agenda prioritizes development trajectories that are smart, sustainable, and socially inclusive (SCU, 2013). Adoption of a circular economy will make European economies competitive, inclusive in terms of green job creation and offer a high standard of living with a comparatively much lower carbon footprint (EC, 2011). Within the framework of the country's GESIP, Kenya should develop a green vision for its sustainable development agenda powered by resource use efficiency and industrial symbiosis.

The ultimate aim is to treat waste as a resource and be constantly be looking for innovative ways of minimizing its generation at source and engaging in waste recovery and reuse for the inevitable waste streams that cannot be minimized at source (EC, 2011). Recycling in all its forms diverts

waste from the land fill and contributes to more efficient use of resources (EEA, 2011). The ultimate goal is to decouple economic growth from increased resource use, support innovative ways of advancing development that is associated with lower greenhouse gas emissions, expand the use of renewable energy solutions, modernize the transport sector by making it efficient and effective, and promote energy efficiency in both manufacturing and service sectors of the economy (EC, 2011; OECD, 2012; SCU, 2013).

Just as is happening in Europe, Kenya's virgin resource availability constraints and accompanying environmental pressures should accelerate the country's transformation from a linear extraction-use-and-throw-away economic model of production and consumption to a closed loop supply chain (EC Decision, 2014). The country's ultimate goal should also be to create a smart economy that seeks to minimize the production of waste and reuses wastes as a resource in other production lines (EC Decision, 2014). This is happening at a time when the marketing proposition of SEZs has shifted from a mere provision of shared infrastructure to one that is driven by the need to make SEZs generate less greenhouse gas emissions, make optimal and efficient use of resources, and implement climate resilient innovative actions (World Bank, 2014).

Through a combination of cheap labor and the construction of well managed special economic zones (SEZs)/ industrial parks (IPs), China became the industrial park of the world (UNDP&IPRCC, 2015). Although this rapid industrialization process created jobs and helped lift millions of people above the poverty line, it came at a huge environmental cost that is proving to be difficult and expensive to restore. The Chinese Government responded to this development environmental challenge by adopting the circular economy approach powered by resource efficient cleaner production, the 3Rs of reducing, reusing and recycling waste as well as waste and by-

product exchange through industrial symbiosis. The adoption of SEZs/ IPs for industrialization is gathering momentum in Kenya and it will be important that Kenya learns from the Chinese experience so that it adopts a proactive approach rather than a reactive one.

To tackle this problem, policy makers in China have chosen to embrace the circular economy (CE) as their official policy for promoting sustainable development (Geng et al. 2012). Consequently, the country has enacted enabling national laws and regulations to facilitate the successful implementation of its circular economy and also initiated circular economy demonstration projects that aim to demonstrate the economic and environmental benefits of a circular economy (SCU, 2013). Kenya should similarly develop appropriate laws, regulations, and incentives that can help facilitate a speedy implementation of its emerging circular economy. Demonstrations will be key in securing investor buy-in. As of 2006, the country had established 16 national pilot EIPs. The country also embraces the concept of industrial clusters that seek to promote resource efficiency, environmental performance and economic competitiveness (Lei, 2006). Since the early part of this century, China has been a global leader in the development of national eco-industrial park (EIP) networks. This great achievement includes the establishment of 15 national demonstration projects and an additional 45 trials that actively involve hundreds of researchers and professionals operating in the green growth development space for purposes of promoting eco-innovation (Shi et al. 2012). In order to generate credible information on the status of circular economy (CE) implementation, China became the first country in the world to publish nationally focused CE indicators (Geng et al. 2012).

Likewise, Kenya should develop indicators that will help it monitor accurately the progress it makes in promoting its green growth agenda. These indicators have so far attracted interest from

both developed and developing countries that are seeking to promote and regulate sustainable development measures within their green growth and circular economy endeavors (SCU, 2013). The country's current indicator system is voluntary and its promotion is hinged on individual company benefit of subscribing to the ideals of a circular economy (Geng et al. 2012). The Circular Economy Promotion Law passed in China in 2008 is a classic example of resource efficient and cleaner production (RECP) policy in action (UNEP, 2015). It puts emphasis on the most efficient use of resources and promotes reduction, reuse and recycling (UNEP, 2015). Kenya should similarly develop enabling laws for its emerging circular economy.

The Japanese eco-towns project seeks to achieve a low carbon and zero-emissions society as a way of domesticating the ideals of sustainable production and consumption (UNEP, 2011; SCU, 2013). The project advocates for a zero-emissions approach to industrial development in which participating companies and industries were required to keep the amounts of wastes associated with their operations to the greatest practical minimum, and establish systems for recovering and recycling wastes, in partnership with other industries thereby setting up a sound materials recycling society (SCU, 2013). Kenya should also adopt the eco-towns initiative as a way of trying to tackle its worsening urban waste management problems. Establishment of a link between the SEZ and the surrounding urban centres will help create a win-win framework as regards waste recovery for recycling.

The model prioritizes interventions at national, local government, business, and citizenry levels through improved governance, education and awareness, as well as technology development and demonstration (UNEP, 2011). Strict enforcement of these laws in Japan have not only promoted waste diversion from the landfill but also led to the mushrooming of 3R based value addition spin

off companies. The Kenyan laws and regulations are not comprehensive enough to fully address the emerging challenges of dealing with a waste stream whose composition keeps on changing. It can be observed that Japan's ability to understand fully how materials flow in its economy has been central to its ability to advance the ideals of a sound materials cycle society (SCU, 2011). On the contrary, Kenya does not have a thorough understanding of material flows within its economy.

Mapping and inventorization of materials within SEZs will help develop a data base that could be relied upon while building synergies for waste and by-product exchange. This is an exercise that can be promoted by the zone authority. The Asian Development Bank (ADB) Green City's publication lists important eco-towns features as being (i) legislation that encourages a material-recycling society, (ii) cooperation between national and local governments in bringing clusters of industry to the site, (iii) product research and development, (iv) large and rapidly expanding eco-business market, both domestically and internationally, (v) a heavy focus on environmental technologies and innovative solutions in addressing environmental challenges, and (vi) a focus on energy conservation, material development, and integrated waste management¹⁰. Kenya will need to adopt these features if it has to successfully embrace its own eco-towns initiative.

South Korea has a national plan for eco-industrial Park (EIP) development (Kim, 2006). This national plan is being jointly implemented by the Korean National Cleaner Production Center with the assistance of Ministry of Commerce, Industries and Resources (Kim, 2006). Similarly, a national EIP promotion plan for Kenya should be developed and jointly promoted by the Ministry of Industry, Investment, and cooperatives in collaboration with the Kenya Industrial Research and

¹⁰ ADB, 2012. Green Cities

Development Institute (KIRDI) and its host the Kenya National Cleaner Production Center (KNCPC). The South Korean plan was rolled out through demonstration projects, that sought to convert all conventional industrial parks into EIPs; use of the triple helix collaboration to promote eco-innovation; development of accurate baseline information on raw material inputs and outputs; and dissemination of best practice lessons derived from pilot studies (KIM, 2006). This enabled them to develop their home grown EIP with the aim of maximizing material and energy re-use within the park and seeking to achieve a zero-emissions EIP (Kim, 2006). The Kenyan Ministry of Industry should similarly seek to convert its existing SEZs/ IPs into EIPs starting with research based pilots before upscaling to cover the entire country.

Professor Kim of Pusan University proposed to establish a Centre in the industrial park (IP) to be analyzing energy, by-product, and water flow networks through a process diagram and management technique, with the goal of making the Pusan industrial park an eco-industrial park, and eventually convert it into a symbiocity (Kim, 2006). Similarly, Kenya should establish a one-stop-shop at KIRDI to serve as a Knowledge Repository and Advisory Service Facility to guide the country's SEZs and IPs enterprises in their green growth transition and also promote eco-innovation based on demand driven research. In order to realize a "low-carbon, zero-waste society", the South Korean Government developed a comprehensive waste management strategy that emphasized the switching to a material recycling social structure, the realization of waste upcycling, the creation of a unified waste processing infrastructure, and the promotion of a resource circulation industry and technological development (PCGG, 2014). Kenya is yet to develop landfill management rules that are designed to encourage waste exchange for recycling so that useful materials are diverted from the landfill.

In South Africa, industrial symbiosis is at its infancy but with very promising prospects. The Western Cape Industrial Symbiosis Program (WISP) follows the methodological approach developed, tested and perfected by the International Synergies Limited (ISL) of the United Kingdom (WCG, 2013; Laybourn & Morrissey, 2009). The Kenyan Government through its Ministry of Industry, Trade and Cooperatives should similarly follow suit and initiate a nation-wide industrial symbiosis program for the country, starting with the piloting phase that will help inform the actual roll out and upscaling. The initiative is one of the leading green economy initiatives of the Western Cape Government (WCP) that is fully funded by the South African Department of Economic Development and Tourism (SADED, 2011). The WCG is motivated by a strong desire of seeking to become the greatest green economy hub not only in South Africa but also across the whole African continent (SADED, 2011; WCG, 2013). All these noble intentions are contained in the Province's Green Economy Strategic Framework and Implementation plan of 2013. The implementation roll out of Kenya's Green Economy Strategy and Implementation Plan (GESIP) of 2015 should adopt the same national approach and be supported jointly by the Kenyan Ministries of Environment and Trade. Promoting green growth in Kenya will have to start from scratch due to the country's inadequate infrastructure for waste recovery and recycling. This scenario will be compounded further by the limited awareness and appreciation of the Kenyan population about the importance of living in a clean and safe environment that happens to be also their constitutional right (Kenya Constitution, 2010). In the Kenyan context, the Green Economy is proudly seen as a sustainable approach to the delivery of an equitable society that caters for the needs and aspirations of everyone including the marginalized groups (GOK, 2015). It makes a lot of sense for Kenya to also aggressively work towards diverting useful materials from the landfill through waste exchange and recycling. The wisdom is that industrial establishments that engage

in industrial symbiosis should first embrace resource use efficiency through cleaner production so that the inevitable residual waste that remains is what is subjected to industrial symbiosis (UNEP, 2015). The United National Environment Program (UNEP) defines a Green Economy as one that is low-carbon, resource efficient and socially inclusive in terms of the creation of green collar jobs (UNEP, 2011; World Bank, 2014).

Ideally, SEZs/ IPs do provide a fertile ground for new innovations/ demonstrations that can successfully be carried out in partnership with knowledge institutions for enhanced economic prosperity, social inclusion and improved environmental stewardship (World Bank, 2014). In these circumstances, SEZs/ IPs are important in providing a conducive environment for experimenting and testing how eco-innovation can promote the country's sustainable development agenda (UNEP, 2011). SEZs/ IPs should be able to develop sustainable development action plans that can enable them to lower their overall carbon footprint through improved energy efficiency, water use efficiency and harvesting, waste minimization and management as well as the adoption of renewable energy solutions (World Bank, 2014; UNIDO, 2015). The planning, design and construction of SEZs/ IPs should be guided by green master plans that have incorporated all the relevant elements of sustainability (UNEP, 2011). Some of the notable and promising interventions for GHG reduction include the upgrading of the economic zone's energy efficiency, adhering to building codes that support the design and construction of green buildings, and the construction of infrastructure for waste recovery and recycling (UNEP, 2011).

2.6 Types of Special Economic Zones (SEZs)

SEZs/ IPs are defined as geographically delimited areas that are centrally administered by a single authority (in the Kenyan case the EPZA) and offers duty-free importing and streamlined custom

procedures to businesses that physically locate and operate within the economic zone (Akinci & Crittle, 2008; World Bank, 2008). The World Bank identifies 6 categories of special economic zones (SEZs) that cover different geographical configurations and functions as shown in Table 2 (World Bank 1992; World Bank, 2008).

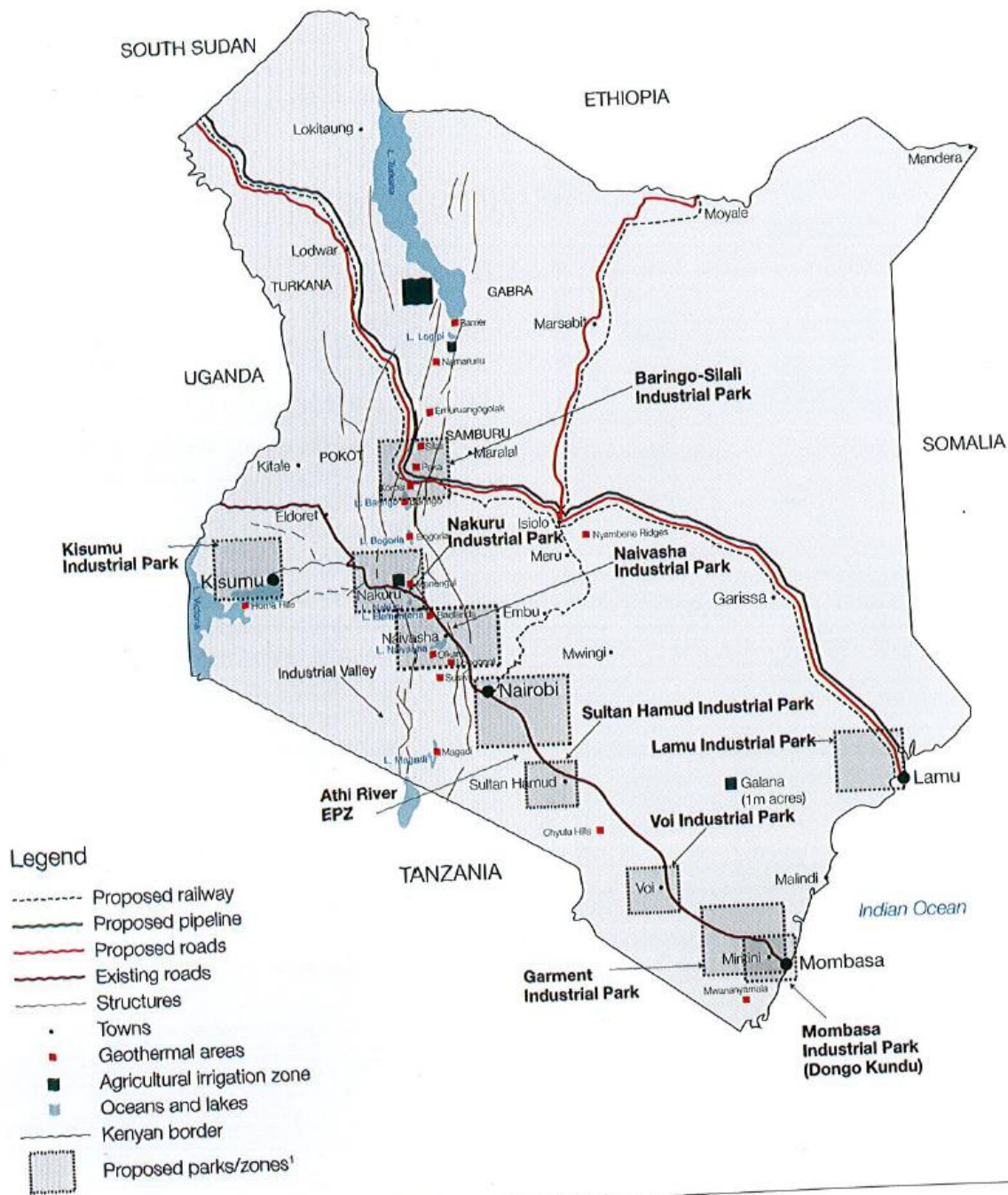
Table 2: Taxonomy of Zone Types (World Bank, 2008)

Type of Zone	Physical Configuration	Description
Free trade zone (FTZ) / commercial free zones	Size normally less than 50 hectares (Size < 50 Hectares)	Fenced-in units, duty-free areas, offering warehousing, storage, and distribution facilities infrastructure for trade, transshipment, and re-export operations.
Traditional Export Processing Zones	Size < 100 Hectares; total area is designated as an EPZ	Industrial estates aimed primarily at foreign markets. Hybrid EPZs are typically sub-divided into a general zone open to all industries and a separate EPZ area reserved for export-oriented, EPZ-registered enterprises.
Enterprise Zones	Size < 50 Hectares	Intended to revitalize distressed urban or rural areas through the provision of tax incentives and financial grants.
Free Ports	Size >100 km ²	Typically encompass much larger areas. They accommodate all types of activities, including tourism and retail sales, permit on-site residence, and provide a broader set of incentives and benefits.
Single factory EPZ	Designation for individual enterprises	Provide incentives to individual enterprises regardless of location; factories do not have to locate within a designated zone to receive incentives and privileges.
Specialized Zones	Size < 100 Hectares	Include science/technology parks, petrochemical zones, logistics parks, airport-based zones, etc.

The Kenyan Government is working hard to create an enabling environment to accelerate industrial development through the establishment of industrial parks/ special economic zones

along its major infrastructural corridors¹¹ (Figure 3). As shown on the map, the Kenyan Government plans to set up eight industrial parks along the Standard Gauge Railway (SGR) and two along the Lamu Port/ South Sudan/ Ethiopia Transport Corridor Program (LAPSSET). The aim is to build a network of competitive industrial parks/ zones with sector appropriate incentives and supporting infrastructure¹². Creation of green industry within the planned industrial parks is not only a key priority of the Government but also the right thing to do. The Ministry of Industry, Investment and Trade seeks to drive a sustainable industrial development process that emits less emissions, utilizes resources much more efficiently and is socially inclusive through the creation of decent green jobs¹².

¹¹ Government of Kenya (GOK), 2015. Kenya's Industrial Transformation Framework, Ministry of Industry, Investment and Trade.



¹ Zones proposed by the government overall, not exclusively by this programme.
 SOURCE: Geothermal Development Company

Figure 3: Potential Industrial Parks/ Special Economic Zones (SEZs)

2.7 Framework for Low-Carbon Green Zones

The framework for low-carbon green zones comprises of five core components that entail the setting of GHG mitigation targets, provision of sustainable infrastructure, promotion of climate friendly investments, development of low-carbon policy incentives and regulations, as well as making arrangements to tap into the opportunities presented by carbon finance (World Bank, 2011; UNIDO, 2015). The World Bank recommends that all the economic activities of tenant companies of the economic zone have to be governed by concrete mitigation action plans (World Bank, 2011). Green strategies should be developed by the Zone Authority to guide tenant companies in establishing realistic low-carbon goals and committing themselves to set GHG reduction targets (World Bank, 2011). The starting point will be to develop a GHG emission baseline for the zone using known GHG accounting rules and inventory development systems, that will make it possible for the management to monitor progress and also establish which sector generates which amount of emissions so as to be in a position of setting up realistic improvement targets for each of the functional sectors operating within the economic zone (World Bank, 2011; UNEP, 2011). Some of the opportunities for GHG emissions mitigation within an economic zone setting will include making investments in the use of renewable energy, aggressively promoting energy efficiency and conservation, adoption of green building codes, embracing sustainable and rapid transportation system, promoting water reuse, recycling, and harvesting (World Bank, 2011). Although material, waste and water recycling can be promoted at individual company level, its widespread adoption across the entire economic zone is recommended as it maximizes overall benefits (World Bank, 2011).

Economic zones in Kenya are licensed and regulated by the Export Processing Zones Authority (EPZA). The Kenyan EPZA as is currently constituted does not have the capacity to promote green growth activities among all the tenant companies of the program country wide. In order to strengthen the zone authority's capability to promote green growth investments, this research project recommends the establishment of a "Green Growth Advisory Centre" to be hosted at KIRDI and work closely with the EPZA's "Green Cell" in advancing the country's green growth agenda. Within this "Green Growth Advisory Centre" support, tenant companies, local universities, and research institutes will collaborate with the sole purpose of developing, transferring, and deploying clean technologies and technical advisory through a functional public-private-partnership (PPP) model (World Bank, 2011; UNIDO, 2015).

Such a Green Growth Advisory Centre will become a centre of excellence for promoting innovation, knowledge and techno-managerial skills sharing and training for local companies and consulting institutions in emerging tools of environmental management (World Bank, 2011; UNEP, 2011). According to the World Bank, sustainable infrastructure for a SEZ/ IPs means planning, designing, and building the entire economic zone using systems that are energy efficient, resource conserving, and low emission generation methods that provide ample opportunities to reduce the zone's overall carbon footprint (World Bank, 2011). Incorporation of energy saving measures within buildings at the design and planning stage inform of using natural ventilation and efficient lighting will sustainably reduce emissions (World Bank, 2011; UNIDO, 2015).

2.8 Low-Carbon Green Special Economic Zones

The climate change agenda has emerged as the greatest development challenge of our time signaling the need for countries not to continue with their business-as-usual development activities that are characterized with high consumption of fossil fuels and instead embrace a green growth development pathway that will help reduce the negative impacts (World Bank, 2011; UNEP, 2011). To developing countries such as Kenya, development and climate change are two intertwined challenges that the country cannot afford to sacrifice (World Bank, 2011). The challenge is that these developing countries have to work hard and push 1.4 billion people out of poverty by building green factories, low-emission plants, climate proof roads, green buildings, and environmentally friendly transport systems using technologies that are currently not in their possession (World Bank, 2011). This underscores the need for the strengthening of the country's technology transfer infrastructure. Kenya as a country should work hard to promote sustainability, significantly reduce its carbon footprint while aspiring to develop and create the much needed job openings (World Bank, 2011).

This new development trajectory should be designed with the sole purpose of seeking to decouple the country's economic growth from further increases in GHG emissions and massive consumption of resources in a typical "making more from less scenario" (World Bank, 2011; UNEP, 2011). By leveraging on clean and environmentally friendly technologies, this development pathway will create green jobs and generally improve livelihoods (World Bank, 2011). The shift to a low-carbon, green economy should be carefully executed so as not to sacrifice the country's economic growth and competitiveness (World Bank, 2011; UNEP, 2011). Due to the realization that SEZs/ IPs concentrate pollution, Governments, developers, planners, and regulators around the world are increasingly demanding that SEZs/ IPs are made to promote

environmental sustainability by innovatively seeking to improve energy and material use efficiencies and recoveries (World Bank, 2011). Asian economic giants China and India have already developed functional policies and guidelines for the green design and construction of green SEZs/ IPs while South Korea has gone ahead to focus on the systematic development of eco-industrial parks (EIPs) (World Bank, 2011). This simplifies matters for Kenya that simply needs to domesticate the already developed Asian policies and guidelines to fit its own local circumstances. It is worth noting that the more than 3,000 SEZs across the world present one of the best opportunities for tackling climate change by seeking to reduce GHG emissions in a systematic and easily verifiable manner (World Bank, 2011; UNIDO, 2015).

2.9 Spectrum of Environmentally Sustainable Zones

Due to increased stakeholder environmental awareness and the need to promote environmental sustainability within SEZs/ IPs as a way of helping to mitigate the climate change challenges, there has been mounting pressure on SEZs/ IPs to design and construct environmentally friendly SEZs/ IPs across the country (World Bank, 2011; UNEP, 2011). Shared vision action plans should be put in place in form of a road map to ensure that the SEZs/ IPs are enabled to graduate from just being pollution control zones to eco-industrial parks (EIPs) and then eventually being low-carbon and green SEZs/ IPs (World Bank, 2014). The pollution control zone level is the most basic of them all and focuses largely on the implementation of effective measures for pollution control and environmental compliance in form of a centralized waste water treatment system, air pollution control, toxic and hazardous waste collection and disposal, and environmental training programs for zone managers, company operators, and administrators (World Bank, 2014). This is the operational level where the Athi River SEZ is. The pollution control approach is largely reactive in the sense that it responds to already generated waste that makes it expensive and unsustainable

in the long-run. A more pro-active approach is recommended so that attempts are made to minimize waste generation at source before dealing with the inevitable residual waste stream whose composition, volume, and characteristics will have been drastically altered hence making it easy and cost-effective to handle and manage (UNIDO, 2011).

The next level is that of eco-industrial parks that goes beyond simple environmental management to minimize waste generation at source through RECP for the sole purpose of reducing the overall negative impact of the entire zone's pollution levels on the surroundings, before integrating the 3Rs and waste and by-product exchange (World Bank, 2014). Ideally eco-industrial parks are expected to recover, reuse, and recycle wastes and resources within individual companies and also within the wider cluster networks for the sole purpose of ensuring continuous re-circulation of wastes and by-products (World Bank, 2011; UNEP, 2011). The establishment of synergies networks between and among participating tenant companies on a mutual benefit basis is the cornerstone of a successful industrial symbiosis engagement exercise (World Bank, 2011; UNEP, 2011).

Low-carbon and green SEZs/ IPs are the most comprehensive and sophisticated in terms of embracing the key elements of environmental sustainability (World Bank, 2011; GEC, 2012; ADB, 2012). In general terms, low-carbon, green SEZs are defined as those that are designed, developed, and operated in a low-carbon, green and sustainable fashion while seeking to reduce the zone's overall carbon footprint as a way of helping to mitigate against the challenges posed by a changing climate regime (World Bank, 2011; ADB, 2012).

2.10 Enabling Policy and Institutional Framework for a LCZ

The government should introduce a mix of policy instruments that include fiscal incentives and mandates that provide the signals for change (World Bank, 2014; UNIDO, 2015). At the same time, the government should develop good practice guidelines for zone enterprises and establish or strengthen institutions to promote and facilitate the implementation of projects and monitor results (World Bank, 2014; UNIDO, 2015). The goal for government policy making should be to develop a comprehensive policy framework that is conducive to low-carbon investment (Falcke, 1999; World Bank, 2014). This overall policy framework should include regulations that facilitate the admission, treatment, settlement, and support for foreign investment in low-carbon areas, as well as sector-specific low-carbon related regulations that benefit industries both inside and outside the zones (World Bank, 2014; UNIDO, 2015). Successful development of LCZs requires strong market drivers for low-carbon products, services and technologies in the industrial sector (World Bank, 2014; UNIDO, 2015). Policy instruments such as feed-in tariffs, renewable portfolio standards, blending mandates, mandatory energy performance standards (MEPS), and green public procurement guidelines can be used to build new business opportunities and create markets for low-carbon products and technologies (UNEP, 2011; World Bank, 2014).

Government policy should also encourage the sharing of technology and best practices between the foreign investment entities and the domestic firms to maximize the value of foreign Direct Investment (FDI) in low-carbon development (UNEP, 2011; World Bank, 2014). LCZs can also serve as testing grounds for new policy interventions to promote low-carbon development or improve the general investment climate (World Bank, 2014). Low-carbon policies should be evidence-based and have clear and measurable objectives (World Bank, 2014).

2.11 Institutional Framework for a Low-Carbon Zone

The drive towards a low-carbon green zone has to be championed by either an institution or a respected business player (World Bank, 2014). The Country's EPZA does not have capacity to champion for the adoption of low-carbon green zones. Similarly there are no respected Kenyan business players in this space yet. Generally, an institutional champion is required for purposes of helping to coordinate multiple stakeholders while also lobbying for the adoption of enabling policies (EC, 2011; World Bank, 2014). Ideally, within a low-carbon green SEZ, a dedicated department in charge of low-carbon and green growth initiatives needs to be established within the SEZ Authority (World Bank, 2011).

The World Bank popularly refers to such a department as a "Green Cell" (World Bank, 2011). Its main goal will be to help in the development of low-carbon master plans, lead its implementation process, and coordinate between and among different ministries and departments since climate change issues are cross-cutting (EC, 2011; World Bank, 2011). An individual champion comes in handy when it comes to securing top management commitment buy-in that is essential for successful adoption of low-carbon green growth. This presents a governance and enforcement challenge that needs to be addressed through comprehensive institutional strengthening, development, and reform (World Bank, 2014). Figure 4 below represents an ideal institutional framework for supporting low-carbon zone development.

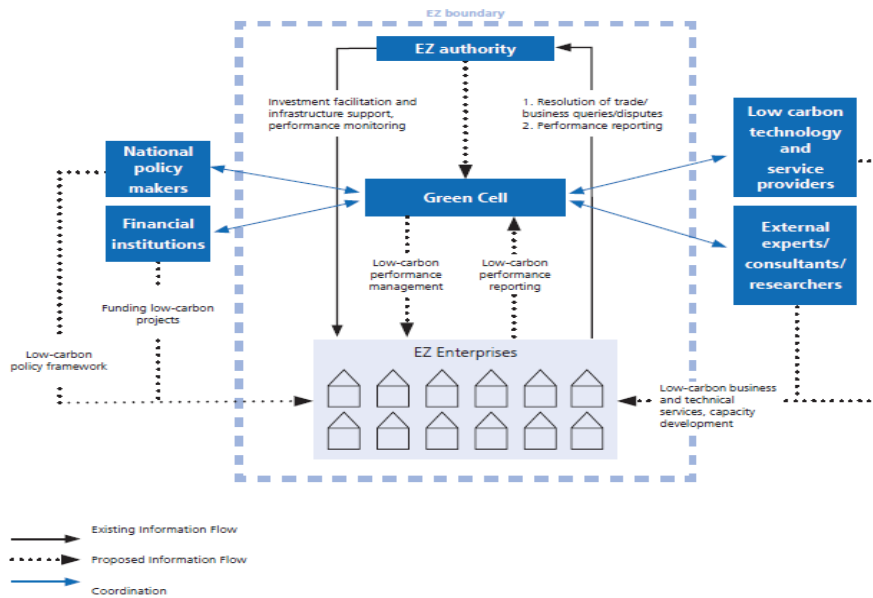


Figure 4: Institutional Framework to Support LCZ Development

Source: World Bank, 2014

Successful development of LCZs will depend on the presence of a strong institutional ecosystem that not only includes the enterprises, zone developers, government departments, and ministerial departments, but also the business service providers, engineers, environmentalists, consultants, operations and maintenance professionals, equipment suppliers, financiers, academic institutes, research institutes and vocational training centers (ADB, 2012; World Bank, 2014). One way that the zone authority can designate dedicated resources for overseeing low-carbon development is by setting up a specialized body or “green cell” within itself to champion low-carbon initiatives (World Bank, 2014). The green cell, made up of technological experts, engineers and consultants, will be charged with establishing the zone’s strategy for low-carbon transformation, including major actions and initiatives (World Bank, 2014; UNEP, 2015). A green cell formalized in legislation may strengthen its mandate to affect changes in the zone and lend credence to the coordination, governance and communication structures necessary to promote LCZs (World Bank, 2014). The green cell provides a platform for collaboration among zone enterprises and donors,

equipment suppliers, NGOs, and civil society (World Bank, 2014). It can evolve to become a one stop service center that will coordinate with external and internal agencies to drive implementation of low-carbon activities in the zone and help to ensure continuous national dialogue and coordination on low-carbon growth (World Bank, 2014).

2.12 Important Considerations in SEZ Development and Implementation

Upgrading and retrofitting of special economic zones/ industrial parks is achieved through the incorporation of resource efficiency aspects, integration of environmental monitoring and management structures for ecologically friendly production and promotion of gender sensitive infrastructural designs (GIZ, 2015b). India established a Green Building Council (GBC) in 2001 for purposes of establishing SEZs/ IPs that strive to reduce their environmental impacts (GIZ, 2015b). The green factory building rating system is a voluntary and consensus based system based on materials and technologies that are currently available in India (GIZ, 2015a). The system seeks to promote energy efficiency, water use efficiency, creation of healthy and more productive work places, and help establish environmentally friendly factories (GIZ, 2015a). Kenya should also develop such a voluntary green rating scheme to serve zone tenant companies that want to go green on a voluntary basis.

The rating system is based on the awarding of credit points based on prescribed requirements and general performance (GIZ, 2015b). The scheme is designed to address national priorities and also improve the quality of life for Indian factory employees (GIZ, 2015b). It is designed to cater for new and existing factory buildings (GIZ, 2015b). Before filing an application for certification, it is mandatory that existing factory buildings first addresses issues such as soil erosion control, making changes the design to accommodate the requirements of disabled people, adoption of low-

flow water fixtures, starting harvesting rainwater harvesting, embracing minimum fresh air ventilation requirements, assuring comfortable working conditions, and using eco-friendly housekeeping materials (GIZ, 2015b).

This Indian rating system is valid for 3 years (GIZ, 2015b). Upon the expiry of the 3 year period, certified projects are re-assessed, validated and renewed based on the prevailing latest version of the rating scheme (GIZ, 2015b). The guidelines spelled out under each credit are capable of enabling the design and construction of green factory buildings of all sizes and types (GIZ, 2015b). The Indian Green SEZ guidelines were developed by the Indian Green Building Council and the Ministry of Commerce and Industry. These green SEZ guidelines are voluntary and consensus based (GIZ, 2015b). The guidelines' main objective is to facilitate the establishment of energy efficient, water efficient, healthy working environments, comfortable work places, and environmentally friendly SEZs/ IPs (GIZ, 2015b). Table 3 below summarizes the sustainability elements of the Indian Green SEZ rating system.

Table 3: Indian Green SEZ Guidelines

Criterion	Basis
Site Preservation and Restoration	
Soil Erosion	Soil erosion control measures should adhere to the best management practices prioritized by the Kenyan National Building Code; and Reuse top soil for landscaping
Nurseries	Developers will be required to set up their own tree nurseries for plantation of seedlings
Reduce site disturbance	
Landscape open areas	Landscape open areas to an extent of at least 50% of the zone area
Reduce impact on microclimate	Install at least 50% of the roof area with green roof or high reflective materials
Site Planning and Design	
Tobacco smoke control	Smoking should be prohibited in all common/ public areas
Basic amenities	Provide at least ten amenities within the zone; Provide optical fiber communications (OFC) for efficient internet connectivity to the industrial units
Vicinity to public transport	Provide access to public transportation such as public bus station or railway station, within a radius distance of 1 km of any access point to the zone
Bicycle Lanes	Provide bicycle lanes (in all primary and secondary streets) to encourage occupants to commute by bicycles to and from the work place
Footpaths and pathways	Provide exclusive foot paths in primary streets for comfortable pedestrian street access; and Provide pedestrian pathways across various blocks in the zone
Eco-friendly transportation	Provide internal transportation facilities in the zone to cater to at least 10% of the permanent occupants through low emission vehicles; and Provide alternate fuel stations
Parking facilities	Provide parking facilities to meet but not exceed the local parking regulations; and allocate at least 10% of the parking capacity for carpool vehicles
Design for differently abled	Design for easy access to all the common spaces
Green buildings within the SEZ	Design individual buildings within the SEZ in accordance with the appropriate rating system
Water use Efficiency	
Rainwater harvesting, 25%	Provide rainwater harvesting or a storage system to capture at least 25%
Waste water treatment, 100%	Provide an on-site waste water treatment system to treat 100% of waste water generated for on-site re-use
Lawn design	Limit the use of lawn to an extent of 20 % (minimum) of the landscaped area

Drought tolerant species	Design landscape with plant species which consume less water
Efficient irrigation systems	Provide highly efficient irrigation systems
Rain water filtration	
Treated waste water reuse	Reduce at least 50% of water requirement by using treated waste water for landscaping
Energy Efficiency	
Energy efficiency	Optimize energy use efficiency of the building and systems to reduce environmental impacts associated with excessive energy use
Onsite renewable energy	Install renewable energy systems to generate power through solar, wind, biomass/ biogas, or any other forms of renewable energy for at least 5% of the annual consumption
Energy monitoring system	Develop and implement, a measurement & verification (M&V) plan to monitor building performance
	Avoid the use of HCFC based refrigerants and ozone depleting substances which negatively impact the environment
Materials and Resources	
Segregation of waste	Develop a waste management plan and identify methods to Segregate, recover and dispose of the waste efficiently
Waste reduction – during construction	Avoid at least 50% of the waste generated during construction from being sent to landfills and incinerators
Organic waste management	Install on-site treatment plant to treat at least 50% of organic waste generated in the zone
Materials with recycled content	Select materials having recycled content such that the total recycled content constitutes at least 10% of the material
Local Materials	Ensure at least 50% of the building materials (by cost; civil and interior materials only) are sourced locally within a radius of 500km
Innovation and Design Process	
Innovation and Design Process	Provide design teams and projects the opportunity to be awarded points for innovative performance in Green Building categories

Source: Indian Green Building Council and the Ministry of Commerce and Industry

2.13 Resource Efficiency and Cleaner Production (RECP)

Resource Efficient Cleaner Production (RECP) relies on cleaner production in accelerating the application of preventive environmental strategies at company level with a focus on processes, products and services (UNEP, 2015). The term Cleaner Production (CP) was defined by UNEP in 1990 as: ‘the continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment’ (UNEP, 1990). CP as a tool addresses problems at source, using a product lifecycle approach that also considers best environmental practices and techniques that go beyond manufacturing to include the service sector (UNIDO, 2015; UNEP, 2015).

Over the years, as the economic and environmental crises intensified, UNEP and UNIDO responded by introducing resource efficiency alongside cleaner production (RECP) for purposes of advancing production efficiency, environmental management and human capacity development (UNIDO, 2015; UNEP, 2015). This strategy integrates the strengthened lifecycle perspective that looks at the point of extraction all along the supply chain to the point of final disposal, including the critical issue of resource scarcity (UNEP, 2015). Resource efficiency achieves environmental management through the minimization of waste and pollution at source (UNEP, 2015). Production efficiency makes economic and business sense as it foregoes the use of unnecessary materials and reduces energy and material use in producing goods and services (UNEP, 2015). Humans automatically benefit from the efficient and cleaner processes as this effort promotes judicious use of global resources (UNEP, 2015). Kenya National Cleaner Production Center (KNCPC) spearheads the promotion of RECP activities in Kenya with the support of like-minded institutions like KIRDI and Universities as well as private sector business associations who together are

constantly lobbying policy makers and other stakeholders at the national level to promote a more resource efficient and green economy (UNIDO, 2015; UNEP, 2015).

2.13 Theoretical Framework

The theoretical basis for this study was arrived at after reviewing the ecological transition theory, the life cycle thinking, the shared value approach, and the industrial ecology mechanism. The ecological transition theory advocates for living within our ecological limits¹². Applied to the SEZ/ IP set up, this means that all operational zones/ industrial parks should strive to operate within their boundary limits as defined by the perimeter fence that runs around them. In other words, the theory calls for their self-reliance in their capability to deal with all the negative effects associated with zone operations such as solid waste management, effluent treatment and disposal as well as management of gaseous emissions. The theory calls for societal transformation into a a more ecologically sound model that is characterized with system level and incremental changes (UNEP, 2011; CIRAG, 2015). Life cycle thinking aims at going beyond the traditional focus on the production site and manufacturing processes to include environmental, social, and economic impacts of manufactured products over their entire life cycle¹³.

In the context of a SEZ/ IP this means that the country's economic zones will be held responsible for the negative impacts posed by their products throughout their entire life cycle (CIRAG, 2015). This requirement should help the country's SEZ/ IP to seek for innovative partnerships that target the collection of wastes associated with zone companies for reuse and recycling in partnership with the surrounding communities. This leads us to the shared value theory advanced by Porter and

¹² CIRAG, 2015. Circular Economy. A Practical Literature Review of Concepts, International Reference Centre for the Life Cycle of Products, Processes, and Services.

¹³ Life Cycle Initiative (LCI), 2013.

Kramer that advances the belief that, “what is good for society is good for business”. According to the two, shared value is a management strategy focused on companies creating measurable business value by identifying and addressing social problems that intersect with their businesses (Porter and Kramer, 2011). Therefore, in order for a SEZ/ IP to be granted a license to operate, it has to address itself to the social challenges of the surrounding communities. Community engagement is the way to go as regards the need to secure a permanent license to operate. The Industrial Ecology approach that is the focus of this study advocates for companies to work together as one organism (CIRAIG, 2015). The theory seeks to reduce the environmental stress caused by industry whilst encouraging innovation, resource use efficiency and sustained growth (Chertow, 2000). In this theory, industries are seen as man-made ecosystems that operate in a similar way as natural ecosystems, where waste or by-products of one process is used as an input for another process (UNEP, 2011). Looking at the operational requirements of all the theories described above, it was easy to see that a sustainable materials theory kind of integrates all their environmental sustainability requirements.

The theoretical basis of this study is the sustainable materials management (SMM) theory that originated at the Earth Summit in 1992. This theory was used to determine how the Athi River SEZ could preserve its natural capital through the adoption of the most appropriate science and engineering skills know-how, the development and actualization of business models and management practices that seek to divert wastes from the landfill and reduce pressure on the use of virgin raw materials while also helping to lower the zone’s carbon foot print as was successfully demonstrated in the US (US EPA, 2009). The Sustainable Materials Management theory advocates for a total shift from waste management to materials management in total support of the ideals of

sustainable management (OECD, 2012). By modelling industrial production systems in a zone as a system of material flows similar to what happens in natural ecosystems, it was possible to see how waste from one production line could be used as raw material for the other (OECD, 2012). The theory seeks (i) the most productive use of raw materials; (ii) to broadly focus on positive and negative impacts and policies relating to all supply chain stages of a material or product that includes upstream considerations of using less material, using environmental friendly materials, or making products more durable as well as downstream solutions such as material recovery, reuse and recycling; (iii) concerns itself with input and output materials to and from the environment in relation to the zone's operations of advancing efficient use of materials, energy and water for the sole purpose of promoting sustainability within the economic zone (EEA, 2011; UNEP, 2015b).

This mode of thinking helped to justify the need for more accurate mapping of the zone's material flows and their associate impacts; the need for increased resource productivity and resource use efficiency; the need to reduce the zone's material throughput; the need to increase on-site recovery, reuse and recycling of zone materials as a way of preserving its natural capital and the need to advance process technologies that seek to eliminate wastes and toxins while preserving the zone's long-term health through research driven eco-innovation (OECD, 2011a; EC, 2011; EEA, 2011; UNEP, 2015b). This calls on SEZs to start embracing proactive approaches such as resource use efficiency, cleaner production and industrial symbiosis. Integration of these contemporary tools ensures that process wastes are minimized at source through cleaner production while the inevitable residual waste is handled through industrial symbiosis that advocates for waste and by-product exchange between and among production lines. According to the OECD, sustainable materials management (SMM) is defined as “...*an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural*

capital throughout the life-cycle of materials, taking into account economic efficiency and social equity”(OECD, 2011a; OECD, 2012).

In this context, it is crucial for SEZs to advance policies that prioritize sustainable materials management that build on the 4R philosophy of reducing, reusing, recovering, and recycling wastes and by-products (OECD, 2011b). The theory seeks to maximize positive impacts to the environment while minimizing negative ones with the sole purpose of promoting human health and well-being (OECD, 2012). Through management styles that prioritize safety and sustainability at each stage of the supply chain, efforts should be made to ensure that zone operational risks are not shifted from one section of the supply chain to the other (OECD, 2012). The ultimate goal was to ensure that the zone’s economic and social outcomes were optimized while natural capital was preserved and materials sustainability properly managed. This approach calls for intense cooperation between waste exchange actors across the entire supply chain (life cycle) so that all the key actors are made aware of the impacts of their actions on the environment. This will ultimately help to boost the zone’s prospects for industrial symbiosis. The adopted theoretical basis guided the study in putting more emphasis on innovative environmental approaches such as detoxification, dematerialization and design for value recovery (OECD, 2012).

In this theoretical context, dematerialization means doing more with less and underscores the need for more efficient use of raw materials (resource use efficiency) without decreasing the quality of the service being rendered (*OECD, 2011a*). The theory recommends further the engagement of all zone stakeholders to take active, ethically correct responsibility for achieved sustainability outcomes. Implementation of SMM supportive policies and practices at SEZ level is a promising strategy for helping to decouple the zone’s economic growth from natural resource consumption

and pollution (OECD, 2011c). Therefore SMM constitutes an important component of any green growth strategy for the SEZs. SMM policies will also indirectly reduce demand pressures on natural resources and contribute to better resource security (OECD, 2011c; OECD, 2012). Natural resources and healthy ecosystems are essential to all life and provide the natural capital on which humans depend (OECD, 2012). In other words, materials management therefore casts a far broader net than waste and chemicals management has traditionally done (US EPA, 2009) and was used in the theoretical design of this study. The basis of SMM is to ensure that the consumption of resources and their associated wastes do not exceed the carrying capacity of the planet hence justifying the need to decouple economic growth from massive resource use (OECD, 2012).

2.14 Conceptual Framework

The conceptual framework below shows the linear production system as the business as usual scenario; and the proposed intervention that seeks to lead to a circular economic development model (Figure 5). It also shows how industrial ecology can be used to divert waste destined for the landfill and have it used as feed stock for another production line. Doing this will reduce pressure on the use of virgin raw materials and also lower the economic zone's carbon footprint since wastes from one production line will be channeled to the other through an industrial symbiosis network. Additionally, the diversion of wastes from the landfill also prevents the generation of methane that has a higher global warming potential than carbon dioxide. In established industrial systems, individual companies continuously exploit synergies in the supply chains of energy, material, water and services in order to enhance economic performance while reducing environmental impacts (Roberts, 2004). In this economic development model, waste products of one company serves as a raw material for the other (ACE, 2014).

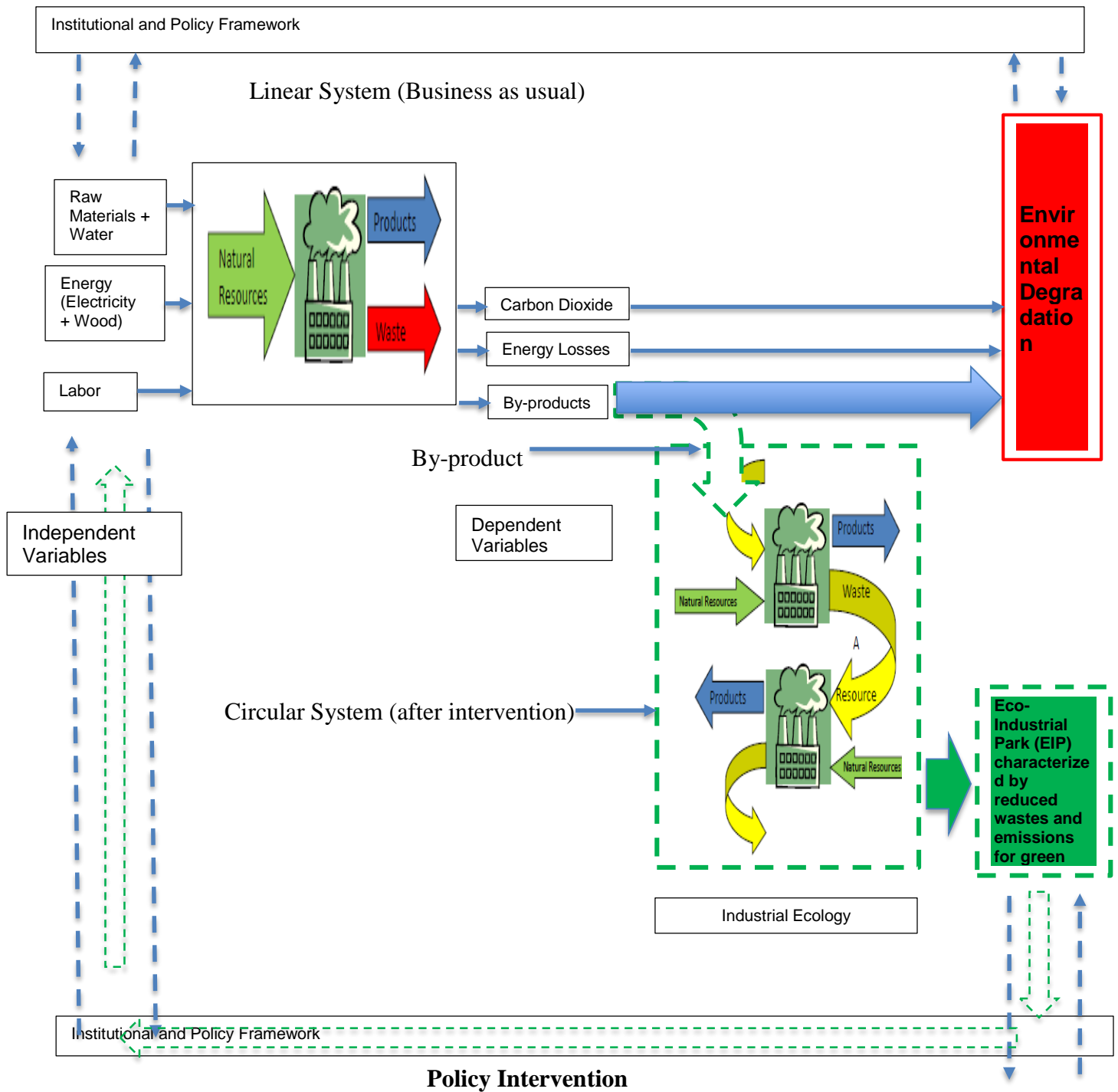
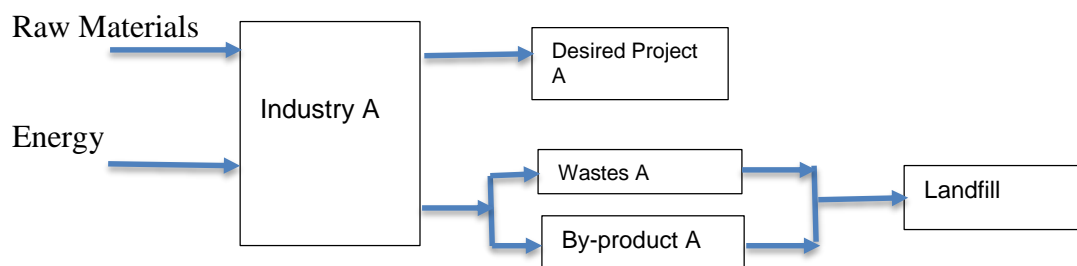


Figure 5: (i) Conceptual Framework

Source: Modified from the UK National Industrial Symbiosis Program (NISP) of 2009.

This conceptual framework puts priority on diverting wastes from the landfill. It underscores the need for zone companies to switch from a wasteful linear economy into a resource efficient circular economy where companies are constantly promoting waste and by-product exchange. Doing this will enable our existing SEZs to adopt a green growth development pathway. The intervention only targets wastes and cascaded energy with implications on emissions. The conceptual framework shows the switch from a wasteful linear development model at the Athi River SEZ to a closed loop circular economy that diverts waste from the landfill¹⁴. In this context, circularity implies a break with the linear, “take, make, dispose” model that characterizes consumer behavior in society today, relying on large quantities of easily accessible cheap resources and energy¹⁵. Circularity, or circular economy, is an industrial development economic model that has restorative intentions, aims to be powered by renewable energy, minimizes, traces, and potentially eliminates the use of toxic and hazardous chemicals, increases competitiveness while reducing operational costs and waste generation through the design for the environment approach (DfE)¹⁶.

Expressed simply, the linear production model as Figure 5 (ii).

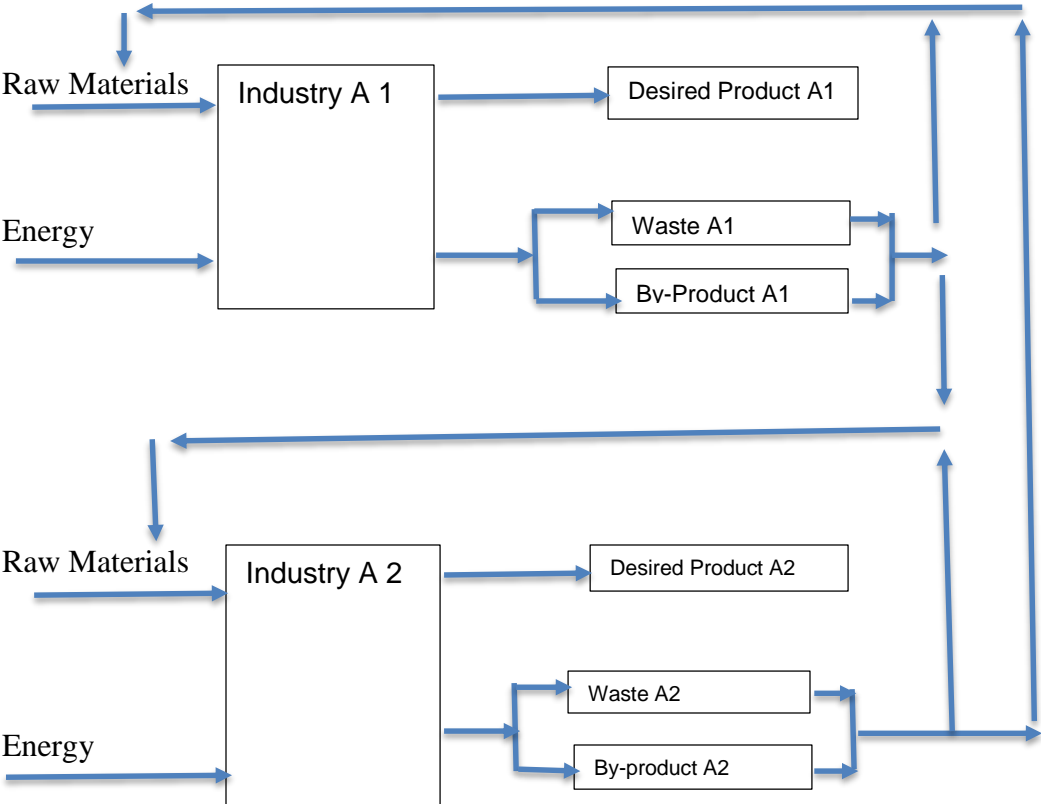


¹⁴ Modified from the UK’s National Industrial Symbiosis Program: The Pathway to a low-Carbon Sustainable Economy by Peter Laybourn and Maggie Morrissen – International Synergies, 2009

¹⁵ Kechichian, E. & Jeong, M. H. 2016. Mainstreaming Eco-Industrial Parks: Conclusions from the Eco-Industrial Park 2015 event in Seoul, South Korea.

¹⁶ McKinsey and MacArthur (McKinsey Global Institute and Ellen MacArthur Foundation). 2013. *Towards the Circular Economy*. Vol. 2.

Illustration of the circular economy as Figure 5 (iii)



CHAPTER THREE: STUDY AREA AND METHODS

3.1 Study Area

The Athi River SEZ is the oldest and biggest in Kenya having been established on 23 November 1990 by the EPZ Act Cap 517 of the Laws of Kenya. It is the most advanced in terms of road, air, rail and telecommunications infrastructure. It is a public SEZ that commands over 50% of the EPZ business in the country. The zone that has a perimeter fence possesses a diverse range of industrial establishments with requisite information essential for the realization of my intended study objectives. The Athi River SEZ covers a total gazette land area of 634ha (Athi River LR No. 18474), out of which 182ha (30%) has already been developed with an additional 454ha (70%) equivalent to 235 plots of approximate area of 2ha each awaiting to be developed in the future (EPZ Program Annual Performance Report, 2013). There is therefore enough room for the restructuring and transformation of the zone into an eco-industrial park (EIP). These findings will not only be applicable to the Athi River SEZ but also to all others around the country.

3.2 Methods

This research was undertaken at the Athi River SEZ with a view to establishing what needs to be done so as to transform the zone into a low-carbon and resource efficient industrial production system as a way of improving its environmental stewardship. A mixed methods approach was used. The following sequential steps were used to address the four study research questions:

- (i) Determination of the evolving clusters of the Athi River special economic zone (SEZ);
- (ii) Scientific analysis of the material flow patterns and how they lead to symbiotic relationships within the identified clusters;
- (iii) A baseline assessment of the application of the principles of industrial ecology to the mitigation of the environmental challenges of the zone; and

(iv) Aiding the development of a governance model that strengthens the capability of the Zone Authority in technically assisting and guiding the transformation of the zone into a low-emission economic zone that is resource efficient and socially inclusive. An assessment of the development and status of green growth policy issues was undertaken.

In order to assure validity and credibility, different sources of information were used including interviews, direct observations, at the sites, websites, annual performance reports, statistical abstracts, economic surveys, etc.

3.2.1 Types and Sources of Data

The approach entailed the collection of both qualitative and quantitative data sets. Primary data was obtained through questionnaire interviews, zone and process inspections, analysis of utility bills and company records. Secondary data was derived from statistical abstracts, official government industrial survey reports, sessional papers, private sector development strategies (PSDSs), Kenya Vision 2030 blueprint, development plans, zone master plans, operational process manuals, Acts of Parliament, and environmental audit/ impact assessment reports. The focus of this research was to establish the quantities of solid and liquid wastes generated by zone companies and how much of this is exchanged through industrial symbiosis and diverted from the landfill. The approach involved the use of key informant interviews and check lists. During the planning phase of the research, background information about the zone was collected, research objectives and general goal of the research explained to the zone management and modalities of engaging zone companies agreed upon. Background information about the site was obtained from the zone's environmental policy, financial policies relating to the environment, relevant rules and regulations governing the zone, and annual environmental audit reports. Additional zone information specifics included the general zone lay out, site history, land area, on-going manufacturing activities, shared

waste management infrastructure, organizational structure as well as its internal environmental policies, procedures and guidelines.

3.2.2 Development of Study Tools and Piloting

A comprehensive questionnaire covering all aspects of resource use optimization, cleaner production, and industrial symbiosis and targeting a wide range of stakeholders was developed. A zone visit during normal operation hours was arranged with an intention of meeting with the officer in charge of the zone to explain and justify the purpose of the study, assess the extent to which the gathered baseline information was accurate and up to date, make a follow up on the list of preliminary best practice waste management practices, identify and request for additional zone information and arrange for visits to selected zone enterprises. The feedback from this initial site visit was used to finalize the research questionnaire, designed to contain an evaluation criteria for purposes of assessing compliance with relevant legislative and regulatory standards, conformance to internal environmental policies, procedures and guidelines, status of current environmental stewardship, and staff awareness of the economic zone's internal environmental policies, procedures, techniques and guidelines. The questions also sought to establish whether the companies received by-products or waste products from other companies that are then used as inputs for their production processes or whether their by-products and wastes were used by other companies.

3.2.3 Field Work and Literature Review

Field work sought to establish how the tenant companies of the zone managed their wastes as regards the existence of waste generation data bases, their interpretation of the threats to health and the environment posed by waste accumulation within the economic zone, whether the economic zone had functional waste management policies, by-laws and rules, establish already

attempted strategies within the economic zone for reducing, reusing, recovering and recycling wastes, whether the economic zone already derives energy from waste, presence of adequate waste recovery infrastructure, waste accounting systems and mechanisms, level of tenant company compliance to set waste management policies, by-laws and rules as well as general adequacy of the infrastructure for waste management within the economic zone. The key research issues relating to water, soil, and air pollution and management within the economic zone included the existence of zone based policies, by-laws, rules, and standards for the control of zone water, soil, and air pollution, adherence to a set water, soil, and air quality criteria, roof top and storm water rain harvesting, recovery of sludge from the effluent stream, existence of programs/ strategies for reducing water usage and pollution and adequacy of infrastructure for managing and controlling water pollution. Staff interviews were undertaken with selected tenant companies of the zone to obtain information on current and past operational practices, deviations from statutory and zone requirements, and awareness of best practice approaches. This was followed with an intensive literature review on the efficacy of industrial ecology as a tool for promoting sustainable industrial development and what legal, policy, technological and institutional frameworks are required for its survival. Additional interviews were held with relevant key informants drawn from Development Agencies, Government Ministries, State Corporations, Academia, Research Institutes, County Leaders and Business Associations on the potential for industrial ecology as a tool for greening Kenya's SEZ and what needs to be done to accelerate its uptake.

3.2.4 Identification of Clusters

In order to ascertain the total number of clusters at the Athi River SEZ, an up to date inventory of all the operational companies in the zone was developed. The firms were then classified on a sector-wise basis and on the basis of integration of activities and collaboration of members for mutual benefit and investigated for waste and by-product exchange. The concept of clustering

referred to in this thesis means local concentrations of horizontally or vertically linked companies which specialize in related lines of business together with supporting organizations (Porter, 1990). Four clusters out of the zone's total were selected for detailed investigation. This involved assigning numbers to each of the identified clusters. These numbers were written on small papers, folded and haphazardly mixed in a container before being picked. The identified clusters were benchmarked against a World Business Council for Sustainable Development (WBCSD) standard guidelines on assessment of the Industrial Symbiosis (IS) potential with a view to identifying gaps that need to be addressed if the clusters are to be sustainably grown while fully embracing resource efficiency and industrial symbiosis. In this thesis, a cluster is defined as a territory comprising of a high concentration of small and medium scale enterprises with highly specialized production, generally greatly interdependent in their production cycles and strongly integrated with the local socio-economic environment (Porter, 1990; Klimova et al. 2016).

3.2.5 Sampling Size

The sampling size was 11 based on the sector wise clusters developed for all the 22 companies that were operating within the economic zone. Out of the 11 clusters, 4 were randomly selected for detailed investigation. The selected 4 clusters had a total of 11 operational companies whose symbiotic relationships were investigated.

3.2.6 Material Flows

Process inspection of the selected clusters was undertaken with a view to understanding their material and energy flows and potential synergies within and outside the cluster were inspected. An understanding of the material flows in the clusters was to enable the classification of by-product and waste lines within and outside the cluster; map the value chain of materials and by-products, group users of identical resources together, analyze possibilities for raw material cascading and waste/by-product exchange; assess possibilities for physical infrastructure sharing; evaluate

sustainability of waste sources; explore options for on-site waste reuse and recycling; and determine the potential for the creation of a network for raw material, energy and waste exchange within the participating clusters. Waste and by-product streams in the selected cluster firms were quantified and analyzed further for possibilities of linking them with other businesses that use similar materials. Resource Flow Analysis (RFA) was used to track and quantify energy and material flows through the respective cluster companies. This was undertaken on a weekly basis for a period of two weeks so as to gather adequate data for the annual projection. Literature search based on Life-Cycle Materials Management and Efficiency inspired by Cleaner Production, Industrial Ecology, and Industrial Symbiosis was undertaken. According to UNEP, (2015), Material Flow Analysis (MFA) is the reliable accounting framework that has emerged to aid the calculation of these material flows. The approach makes it possible to accurately quantify resource material flows, the total amounts extracted, the total amounts used, and the total amounts extracted but not used within the value addition chain.

3.2.7 Benchmarking of Industrial Ecology Principles

In order to establish the extent to which the zone operations have incorporated the principles of industrial ecology in mitigating its environmental challenges, the zone's operations were benchmarked against the seven principles of industrial ecology. This was executed through individual interviews, focus group meetings, and zone/ site inspections. The Governance Model of the zone was assessed on the basis of its ability to network and create synergies for waste and by-product exchange, engage academia in eco-innovation promotion and general commitment to the ideals of a green economy.

3.2.8 Data Analysis and Presentation

In order to demonstrate the efficacy of industrial ecology as an effective tool for helping to convert the wasteful linear economic development model at the Athi River SEZ into a sustainable and resource efficient circular economic development model, material flow analysis and tracking was undertaken among the evolving symbiotic relationships of the four identified clusters for detailed investigation. The aim was to track, measure, and quantify wastes and by-product material flows within the emerging symbiotic relationships weekly for a period of two months and then use the established waste and by-product generation averages to project annual symbiotic exchanges. In the agro-processing cluster, it was demonstrated that the reuse of the residual seed cake for animal feeds manufacture led to energy savings in production, reduced transportation costs, and avoided emissions. For the garment cluster, the recovery of the garment offcuts for use as boiler fuel and in sofa set manufacture led to avoided climate damaging emissions and creation of 15 decent green jobs. The reuse of tarpaulin plastic off cuts for the manufacture of plastic water tanks and chairs after on-site reprocessing led to the creation of 5 decent green jobs. The established waste and by-product generation trends were presented using bar graphs while percentages were used to represent avoided emissions and cost savings. The established waste and by-product generation trends were presented using bar graphs.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter presents results and discusses the findings of the study. The results reveal a spontaneously emerging cluster network within the economic zone that is largely driven by the prevailing forces of supply and demand; an existing intercompany material flow system that is being hampered by a weak waste recovery and recycling infrastructure; a limited application of the principles of industrial ecology in mitigating the environmental challenges of the economic zone; and a weak governance structure that is incapable of enabling the economic zone to become low-carbon, resource efficient and climate resilient. For the economic zone to fully adopt low-carbon and resource efficient status, its tenant companies must unanimously shift their production lines from linear to closed loop systems where wastes from one production line become inputs for the other. Doing this will reduce pressure on the use of virgin materials and also lower the carbon footprint of the economic zone by diverting vast amounts of waste from the landfill.

In other words, there should be no such a thing as waste within the economic zone – since one industry’s waste or by-product should become the raw material for the another production line. This is the foundation of Industrial Ecology that seeks to enable industry mimic the cyclic operations of natural ecosystems. The economic zone had 22 operational firms that were grouped into 11 clusters. Four clusters out of the identified 11 were randomly picked for detailed investigation to determine the material flow patterns. The industrial practices of the four clusters were benchmarked against the seven principles of industrial ecology and improvement measures proposed. A governance model capable of transforming the SEZ into a low-carbon and resource efficient zone was proposed. This governance model justifies the need to strengthen the triple helix and community collaboration for improved eco-innovation and adoption of environmentally sound technologies (ESTs) by the zone for improved competitiveness.

4.1 Determination of the Industrial Clusters of Athi River SEZ

This study found that the cluster zonation approach was not part of the initial master plan that created the Athi River SEZ since the master plan was developed in the 1980s long before the cluster concept took root globally (Porter, 1990). This means that adoption of the cluster initiative for increased competitiveness of the economic zone has to be treated as a new development project. As a result, the tenant company's readiness to engage in active pooling of sustainability knowledge and know-how was low. It was therefore difficult to establish mutual trust between companies that have for a long time operated independently from each other and are now being persuaded to cooperate and compete at the same time. Participating companies must be assured that their trade secrets will not be misused. A cluster champion will be to help develop joint internal and external communication networks that will aid the coordination of zone wide cluster activities.

The study also found that the zone clusters had evolved spontaneously due to the prevailing market forces of supply and demand. The 22 industrial plants operating within the zone were classified into 11 clusters on a sector wise basis. The composition of the firms in each of the clusters keeps on changing as some firms opt to leave the zone at the expiry of the 10 year tax holiday. The eleven identified clusters were agro-processing, pharmaceuticals, cement, electricals, garments, beverages/ spirits, organic fertilizer manufacturing, plastics, food processing, clean stoves assembly and darts board manufacturing (Table 4).

Table 4: Industrial Clusters of the Athi River SEZ

Cluster	Number of firms	Production Type
1. Agro-Processing	3	Oil Extraction; Manufacture of ready to eat Unimix food ration; Artemisinin plant extraction
2. Pharmaceuticals	1	Pharmaceutical products processing
3. Cement	1	Cement Manufacturing
4. Electricals	3	Electrical Fittings and Assembly
5. Garments	5	Garments Manufacture
6. Beverages/ Spirit	1	Beverages/ Spirit manufacture
7. Organic Fertilizer Manufacturing	1	Manufacture of organic fertilizer from human waste
8. Plastics	2	Plastic Tarpaulins manufacture and PET bottle re-processing
9. Food Processing	3	Food processing
10. Clean Stoves Assembly	1	Energy Efficient clean biomass stoves manufacture and assembly
11. Darts and Darts Board	1	Darts and Darts Board Manufacture and Assembly
Total - 11	Total - 22	

Out of these eleven identified clusters, four clusters namely agro-processing, garments, plastics and darts/darts board manufacturing were selected for in-depth investigation as regards what they were exchanging with respect to the management of their wastes and by-products. Four clusters were then randomly selected for detailed investigation. The selected four clusters comprised of a total of 11 firms. Their accompanying waste/by-product types are as shown below (Table 5).

Table 5: Clusters for In-depth investigation

Cluster	Number of Enterprises	Production Type	Waste/ by-product stream
Agro-processing	3	Oil Extraction; manufacture of ready to eat “Unimix” food ration; Artemisia botanical products extraction	Seed cake, waste grains, boiler ash, spent leaf and wax
Garment	5	Garments Manufacture.	Textile off cuts
Plastic	2	Plastic Tarpaulins manufacture and PET bottle re-processing	Plastic waste, Returned used PET Bottles
Darts/ Darts Board Manufacture	1	Darts and Darts Board Manufacture and Assembly	Chip board saw dust, sisal waste, steel wire off cuts

The study findings established that the embryonic clusters that have evolved spontaneously on their own due to the prevailing market forces of supply and demand might not grow into maturity due to lack of an enabling policy and regulatory environment. This is backed up by a response from the Special Economic Zone (SEZ) Environmental Manager Mr. Mathew Were (pers. Comm.) who stated:

....This economic zone is not planned for Industrial Ecology, however, aspects of waste and by-product exchange among companies have evolved on their own due to the prevailing market forces of supply and demand. This spontaneous development of Industrial Ecology is pushing us to re-think our future expansion plans with a view to incorporating this important aspect.....

This finding concurs with similar findings on the spontaneous evolution of industrial clusters in Asia and Europe (Chertow & Ehrenfeld, 2012; Ghali et al. 2014; Anbumozhi et al. 2013; and Mossard et al. 2014). Their mode of evolution is similar to how other clusters similarly evolved in the EU, China, Japan, South Korea and South Africa as was pointed out by Chertow & Ehrenfeld, 2012; Ghali et al. 2014; Anbumozhi et al. 2013; and Mossard et al. 2014. These countries recognized the organic evolution of their clusters and then created enabling conditions for their further growth and expansion. The Kenyan Government needs to similarly do more in terms of

creating an enabling legal, institutional and regulatory framework if it has to harness fully the power of clusters and clustering as an economic and regional development tool for its special economic zones (SEZs) (World Bank, 2009).

The study established that there were no voluntary SEZ green rating schemes that could encourage zone based companies to meet and even exceed the set environmental standards. The culture of voluntarism where zone based companies subscribe to a voluntary code of practice that advances resource use efficiency and waste exchange creates an incentive scheme that makes private sector players meet and even exceed the set environmental standards at the persuasion of nobody except the economic interest. Such a green rating system will encourage companies resident in the economic zone to not only meet their environmental standards but voluntarily exceed them for the sake of the competitiveness of their businesses. This model has been applied successfully in India ((GIZ, 2015a; 2015b).

The study found out that there was no evidence of triple helix collaboration between Universities/ Research Institutes-Industry-Government within the SEZ that creates an innovation ecosystem that is key in promoting eco-innovation through research, development and demonstration (RD&D). An in-depth examination of the economic zone activities revealed no evidence of the triple helix collaboration. As a result, the Kenyan economic zone companies cannot therefore benefit fully from research driven eco-innovation for their increased productivity and competitiveness as was pointed out by Zeng in 2006. A functional triple helix collaboration will augment internal research and development capabilities of zone based companies. The triple helix collaboration creates a functional innovation ecosystem in which the operational needs of zone companies constitute the

research agenda of participating academia. These Athi River SEZ findings conform to Porter's and Zeng's observations that clusters do add economic, social and environmental value to the development of the economy by creating groups of networked businesses in specific sectors while improving their business capabilities through tailored research support (Porter, 1990; Zeng, 2006). The private sector alone cannot drive research as their core business is to make profits. Academia through Universities and Research Institutes should partner with the private sector within the economic zones so that their research programs are demand driven and targeted at solving the operational challenges of the private sector. Such meaningful partnerships will help raise the much needed research funds that are essential for break through research. Through pilot level demonstrations, academia and research institutes can show the private sector that investing in energy efficiency, water use efficiency, and waste minimization and management makes good environmental and economic sense. Although the Government has committed to be allocating 2% of its GDP to the National Research Fund (NRF) established by the Science Technology and Innovation (STI) Act of 2013, there has been little progress towards the fulfilment of this goal.

The study established that the economic zone's infrastructure for waste and by-product recovery and exchange was inadequate. The spontaneous evolution of waste and by-product exchange among the tenant companies of the zone is likely to be affected by the absence of non-enabling infrastructure at the Athi River SEZ. Consequently, progress towards the zone's full uptake of RECP, 3Rs, and IS will be slowed down due to its weak waste recovery and recycling infrastructure. The exchange of wastes and by-products among the clusters not only lowers pressure on the use of virgin materials but also diverts waste from the land fill with demonstrated benefits (UNIDO, 2011). A lot more can be realized if the economic zone invested in state-of-the-

art waste recovery and recycling infrastructure. These findings are similar to those of (Costa & Ferraro, 2010) in which they observed that this noble practice spontaneously manifests itself through the use of waste streams and by-products as alternatives to the use of virgin raw materials. The findings are also consistent with Chertow's observations that synergies are generally driven by economic advantages offered by prevailing market conditions with companies acting for their own benefit instead of responding to Government intervention (Lowe, 2001; Chertow, 2007)

The study also found out that there were no Government sponsored cluster based waste and by-product exchange demonstrations that seek to show that investments in waste and by-product exchange makes good environmental and business sense while helping to convert conventional economic zones into low-carbon zones that are attractive in terms of green foreign direct investments (FDIs). The literature review revealed that the UK, China, Japan, and South Korea managed to advance the culture of eco-industrial parks (EIPs) using state funded demonstrations. Once it is successfully demonstrated that embracing RECP, the 3Rs and IS makes good business and environmental sense, up take by the private sector becomes automatic. The Kenyan Government should set aside funds that can be used to set up pilot demonstrations that seek to show that investing in the transition to a low-carbon and resource efficient future makes good business and environmental sense. It should be the duty of the Kenyan Government through the Zone Authority to technically assist tenant companies to embrace low-carbon, resource efficient and socially inclusive development trajectories.

The study found out that enterprises resident in the economic zone were not embracing resource use efficiency and cleaner production (RECP) ahead of embracing industrial symbiosis for low-carbon growth as a result of limited awareness and lack of technical know-how. Due to limited

zone company awareness and insufficient R&D support for eco-innovation at Athi River, the zone based enterprises were not actively embracing resource use efficiency and cleaner production in their operations for continual improvement. Such an initiative can only be spearheaded by either an industry focused research institute, a university with programs that address the needs of industry or a national Cleaner Production Center such as the Kenya National Cleaner Production Center (KNCPC). It is a demonstrated fact that waste minimization at source before engaging in waste and by-product exchange through industrial symbiosis advances a sustainable use of scarce global resources. As a result, the Kenyan cluster initiative is different from that of Europe, Asia and South Africa in the sense that its development lacks a structured evolutionary roadmap that is spelled out in a clear and enabling policy framework (Ketels et al. 2005; World Bank, 2006).

The study found out that there was no inter-firm communication platforms for the economic zone clusters to facilitate the exchange of lessons and best practices. The zone had no inter-firm communication platform that could be engaged in facilitating the matching of material and energy needs of zone based companies as was pointed out by (Lowe, 1997; Saikku, 2006; & Bermejo, 2014). There was also no anchor tenant within the zone to aggressively advocate for the adoption of industrial symbiosis by the tenant companies of the zone as was justified by Anbumozhi et al. 2013. According to Chertow, 2008, mutual trust among participating cluster firms is of paramount importance in promoting industrial symbiosis. The culture of secrecy that is prevalent within the management ranks of the zone based companies is likely to frustrate this noble waste and by-product exchange scheme. According to (Wolman, 2014), and reinforced by (UNIDO, 2015), the geographic proximity facilitates the spread of information, and the exchange of information through face-to-face communications.

The zone authority needs to develop a clear vision of its intentions in promoting industrial symbiosis on a cluster wise basis and championed by a motivated leader. These findings are largely consistent with the World Bank, 2014, recommendation that the success of industrial ecology at the cluster level depends on the ability of the industrial symbiosis champion to keep on finding new waste and by-product exchange networks, enhancing dialogue between and among cluster based companies, deliberately facilitating material and energy exchanges, and aggressively recruiting new industrial symbiosis players. The ultimate goal of the inter-firm communication is to help link up those with wastes and those who need the wastes for reuse and recycling. Additionally, waste exchange opportunity workshops can be organized so as to facilitate waste exchange negotiations and also help cement the requisite levels of trust among the players, and

The study found out that there was no cluster development road map for Kenyan SEZs embedded in a development policy framework except for past studies and capacity building sessions. For quick results, Kenya can learn from the successful European and Asian cluster development models in proactively developing its homegrown cluster enabling, policies, institutions, strategies and cluster growth development roadmaps. Successful adoption of the cluster initiative also needs demonstrations. Such demonstrations should be deliberately designed to show that clusters are key instruments for enhanced partnerships between different players of the same value chain; must be private sector driven in order to succeed; and should always consist of a well-balanced combination of companies, research institutes and academia.

4.2 Material Flow Patterns and Symbiotic Relationships

Material flow investigations at the Athi River SEZ yielded the following findings:

The study found out that companies resident in the zone do react to already generated wastes as opposed to being proactive and preventing its generation at source. Instead of zone companies reacting to already generated waste through the end-of-pipe approaches, they should instead look for innovative and cost-effective ways of minimizing waste at source. This approach prioritizes the minimization of waste at source through avoided spillages, leakages, and overflows so that the resultant waste streams are in leaner amounts and changed characteristics that are easier to handle and manage. The reactive approach to already generated waste is currently putting pressure on the carrying capacity of the zone's waste management infrastructure. Preventing waste generation at source will not only relieve pressure on the zone's overstretched waste management infrastructure but also assure prudent use of the country's scarce resources. The Production Managers of the cluster companies seemed to operate with the view that it is alright to generate waste since the generated waste is exchanged for use as a raw material by other companies within the cluster. This mindset goes against the global goal of seeking to promote sustainable consumption and production of goods and services while acknowledging that global resources are finite and inefficient use of virgin materials poses a big threat to our changing climate regime (UNEP, 2014).

The study also found out that there was no deliberate attempt to minimize waste generation at source through resource use efficiency and cleaner production (RECP). Due limited awareness and inadequate technical know-how, the Athi River SEZ companies had not fully subscribed to embracing source reduction of waste through resource efficient cleaner production (RECP). In order to promote this culture within the economic zone, the Zone Authority should partner with the Kenya National Cleaner Production Center (KNCPC) and jointly mount RECP awareness

raising sessions, information dissemination, training and capacity building sessions, setting up of in-plant demonstrations, technical advisory, and engaging in policy dialogue and analysis.

The study found out that zone based companies suffered from a weak input/ output measurement culture with poor and inaccurate record keeping, a development that frustrates the development of key performance indicators (KPIs) for continual improvement. A good input/ output measurement culture that is backed up with accurate record keeping is essential for the development of key performance indicators (KPI) that drive the continual improvement efforts participating companies through benchmarking. Investigations at the Athi River SEZ revealed that tenant companies do not embrace a good measurement culture and therefore do not keep accurate production records. Even for those that kept production records, they never analyzed and trended them to inform decision making. Environmental performance indicators based on accurate measurements will allow companies to quantify their resource productivity and pollution intensities at any point in time and to trace the results of RECP over a given period of time (UNIDO, 2016). Accordingly, indicators help to translate complex data into relevant knowledge that can be used to initiate, focus and sustain RECP promotion activities. These indicators are useful for realistic target-setting and routine reporting (UNEP, 2015). Indicators are important in raising production awareness and understanding; in making informed decisions, and in measuring progress towards established goals (OECD, 2009). This scenario is worsened by the fact that there is no metering and sub-metering of company material input/ output flows leading to the zone company's inability to account for all their inputs and outputs

The study found out that investing in resource use efficiency, cleaner production and industrial symbiosis makes good business and environmental sense in terms of avoiding emissions, cutting down on operational costs, creating green jobs, and diverting wastes from the landfill. It was established that adoption of waste and by-product exchange helped to divert wastes from the landfill, created 20 decent green jobs in the plastic and textile manufacturing clusters of the economic zone, lowered operational costs by eliminating the need for long haulage transport, and avoided emissions through fuel switch investments.

The study found out that there was no evidence of material flow analysis being done by the tenant companies of the zone including those already engaged in industrial symbiosis. Material flow analysis will help the economic zone to develop an up to date data base of what goes into each tenant company's production process, what goes out in terms of products and wastes, and what is done to the wastes and their being dumped into the environment is what causes pollution. The material flows at the Athi River SEZ are largely linear. This linear approach is wasteful in the sense that the extracted raw materials after being value added and used will eventually have to be landfilled as opposed to being recycled again and again. This means that materials are removed from circulation and dumped. Unlike a circular economy, our current mode of production and consumption at the Athi River SEZ is overwhelmingly based on the linear principle. Resources¹⁷ are extracted, processed, used, and ultimately for the most part discarded as waste (Wilts, 2016). Such a linear economic model can only function if endless resources are available to satisfy increasing human demand (UNEP, 2015). A strictly linear economy will inevitably be unsustainable in the long run. The objective of the circular economy is to preserve the value of

¹⁷ Wilts, H. 2016. Germany on the Road to a Circular Economy? A Publication of the Friedrich Ebert Stiftung Foundation of Germany;

utilized resources and materials for as long as possible, to use them as frequently as possible, and to produce as little waste as possible (ideally none at all) (Wilts, 2016). This second objective sought to establish the material flows and symbiotic relations within the clusters. The material flows for the identified four clusters are as explained sections 4.2.1-4.2.4

4.2.1 The Agro-Processing Cluster - Oil Extraction

The zone’s agro-processing cluster comprised of three companies namely oil extraction, manufacture of instant foods, and raw artemisinin extraction. Table 5 shows the quantified inputs and outputs of the Oil Extraction Company at the economic zone. Annually, the oil extraction company uses an average of 543.3 tons of raw materials that translate into 300.9 tons of desired product with a raw material to desired product conversion ratio of 55%. The remaining 45% constitutes a by-product (seed cake) that is eventually used as a raw material in another production line. A seven year production and waste trending shows a reliable source of the seed cake by-product that can be used as input feedstock (Figure 6).

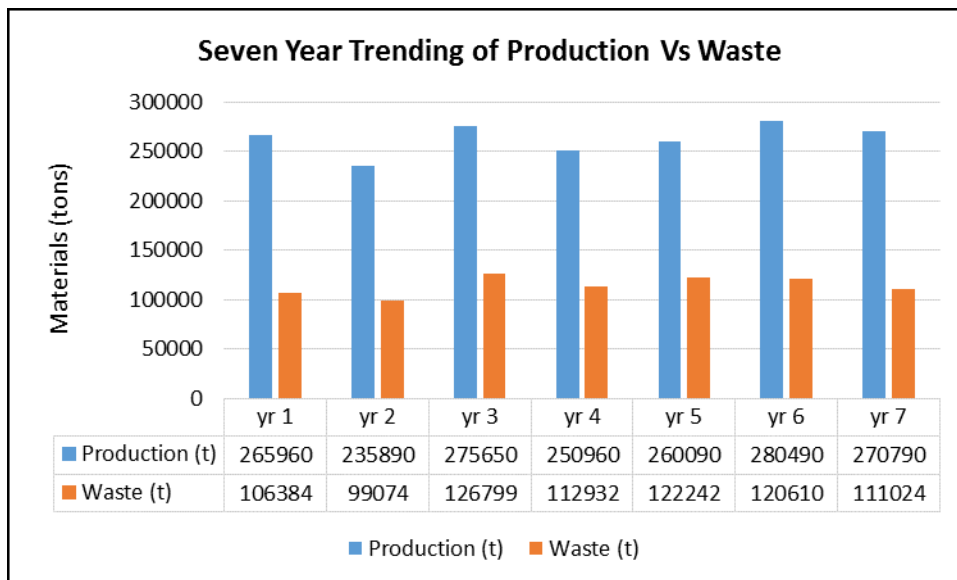


Figure 6: Seven-Year Trending of the Production and Waste Levels for the Oil Extraction Company (Source: Company Records).

Figure 6 above shows the trending of production and associated wastes for the oil extraction company over a seven year period. The trending reveals a raw material to desired product conversion rate of 55%. This means that 55% of the raw material inputs converts into the desired product with the rest 45% being classified as a by-product or a non-product output (NPO). Non utilization of the NPO in another production process as feed stock will demonstrate wasteful use of the country's finite resources with associated environmental and social consequences. At a cost of KES 20 per kilogram, the primary edible oil processing company earns USD 48,000/ year from the sale of its 240.4 tons/year seed cake by-product to the Animal Feeds Manufacturing Company. Absence of this waste exchange network will have meant that the by-product is handled as an added transport and disposal cost to the primary producer. Disposal of 240.4 tons/year of organic waste into the landfill will not only be a significant loss of useful material but also a significant source of methane that has a higher global warming potential than that of carbon dioxide. Manufacturing value addition of this by-product will create more jobs and alleviate poverty amongst the Kenyan population.

Table 6: Material Flow Balance for the Oil Extraction Company (Source: Company Records)

An oil extraction company is one of the companies that is successfully engaged in industrial symbiosis. It is doing this by ensuring that its by-product stream that accounts for 45% of its raw material input is not land filled but is instead used as a raw material by an animal feeds manufacturing company. Doing this creates an additional revenue stream for the company and also assures prudent use of the country's scarce resources.

Oil Extraction Process

Type of Raw Material	In put quantity (tons/year)
Inputs	
Macadamia Kernels	200
Sesame Seeds	200
Moringa Seeds	91.3
Rosehip seeds	26
Pomegranate	26
Furnace Oil	2
Total Inputs	543.3
Raw material to product conversion	55%
Desired Oil Products	
Macadamia	126
Sesame	100
Moringa	43.7
Rosehip	15.6
Pomegranate	15.6
Total	300.9
Composite Seed Cake By-product	
Macadamia	74
Sesame	100
Moringa	45.6
Rosehip	10.4
Pomegranate	10.4
Total	240.4

The oil extraction company extracts oils from a wide range of seeds and nuts that include macadamia, sesame, “moringa”, rosehip and pomegranate mostly drawn from central and coastal regions of the country. The to and fro transport radius is approximately 200 km and 1000 km respectively for central and the coastal regions. The seed cake is the by-product that remains after the oil has been extracted by the primary firm. A secondary Animal Feeds manufacturing company uses this by-product as a raw material for the manufacture of its animal feeds leading to an 80% saving on long haul transport costs of virgin raw material (David Njeru, pers. Comm.) Engaging in this waste exchange entirely diverts 300.9 tons/year of seed cake waste from being landfilled.

Landfilling of such waste quantities would have led to serious environmental and social problems such as increasing the organic loading of the zone's storm water systems (Export Processing Zones Program Annual Performance Report, 2013).

Given that the Animal Feeds Manufacturer sources for his virgin raw materials from both central and the distant coastal region, availability of a nearby cost-effective seed cake alternative will for economic reasons make the manufacturer abandon the distant coastal region and instead focus on the locally available resource. This will not only cut the company's transportation costs but will also lead to avoided emissions and reduced raw material costs. The abandoned coastal farmers will lack market for their produce and eventually abandon the agricultural practice. This will lead to increased poverty as their regular income will have been lost. The resultant raw material transportation radius will therefore reduce from an average of 1000 km to that of 200 km leading to a lower diesel fuel transportation cost with accompanying emission reduction benefits shown below:

Transportation radius reduces from an average of 1,000 km to 200 km per round trip using a 20 ton capacity Isuzu Diesel Truck. Therefore the avoided distance is (1000 less 200) km which is 800 km. Using the Kenya Automobile Association (AA) consumption rate of 1.5 litres of diesel per kilometer for a 20 ton lorry, and holding everything else constant (driving style, age of the truck, frequency of servicing, over loading, etc.), then the amount of avoided diesel use is 1,200 litres per round trip. This is equivalent to 3,201 kg CO₂ e of avoided emissions per round trip given that the emission factor for diesel is 2.6676 kg CO₂ e/ litre (UK Carbon Trust, 2011). The avoided diesel 1,200 litres will lead to a transport cost saving of USD 840 per round trip (1 litre of diesel costs KES 70; 1 USD = KES 100). Given that the annual raw material of the oil extraction plant is 543.3 tons, this translates into a total of 27 round trips in a year using a 20 ton lorry. Therefore

the total annual savings will be USD 22,680. The total avoided annual emissions will be 86,427 kg CO₂ e. The only green jobs established by this development will be those related to the transportation of the seed cake from the oil extraction company to the animal feeds manufacturer. The coastal farmers lost market for their 543.3 tons per year equivalent to an annual income loss of USD 434,640 (cost of 1 kg of assorted seeds put at KES 80; 1 USD = 100 KES).

Pre-processing of macadamia seeds at the Edible oil Factory generates macadamia kernel waste up to the tune of 200 tons/year. Use of this pre-processed seed cake as feed stock for the Animal Feed Manufacturing Company leads to a 20% electrical energy saving (equivalent to 30,250 kWh/year) as the seed cake is already pre-processed (David Njeru, pers. Comm.) This is equivalent to annual avoided emissions of 10,052 kg CO₂ e (Kenya's Grid Emission Factor is 0.3323 kg CO₂e/ kWh). The findings are consistent with UNIDO, 2015 conclusion that, localization of firms allows them to enjoy inputs in greater variety and at lower cost. As a result, reduced transportation and distribution costs will give input suppliers a competitive edge to locate within the same region as their customers (UNIDO, 2015). This reinforces the attractiveness of firms locating within the economic zone.

Ten Percent¹⁸ of this macadamia kernel waste (equivalent to approximately 20 tons/year) is used by the oil extraction company to generate 3 tons/day of on-site process steam that displaces the company's use of 1.5 tons of fuel oil. This makes a monetary saving of USD 1,500 per year that is significant in resource use efficiency and cleaner production (RECP) terms. The associated respective carbon emissions reduction are as calculated below:

- (i) 1.5 ton of Fuel Oil¹⁹ generates $(1.5 \times 3,228) = 4,842$ kg CO₂ e

¹⁸ Source: Oil Extraction Production Manager Estimate

¹⁹ Carbon Trust Emission Factor per ton of Fuel Oil

(ii) 20 ton of Biomass Energy²⁰ generates $(20 \times 183.9) = 3,678$ kg CO₂e

This leads to a CO₂ e reduction of $(4,842 - 3,678) = 604$ kg CO₂e (equivalent to 12% reduction) as a result of the fuel switch from the use of Fuel to the use of Biomass Energy (Figure 6).

Excess macadamia shells (180 tons/year equivalent to 90%) are sold out to other companies within the economic zone as boiler fuel for steam generation

The results show that fuel substitution, in this case switching from the use of fuel oil to the use of biomass leads to a 12% reduced emissions (Figure 7). These findings are in tandem with (OECD, 2012) research conclusions that there is urgent need to accelerate the transition to a truly equitable, sustainable, post-fossil free carbon society. According to OECD, there is need to develop bio-based economies that are characterized by both reduced dependence on fossil fuels and reduced emissions. These OECD conclusions are also similar to the Kenya's low carbon development objectives that seek to reduce energy consumption, pollution, and the emissions of greenhouse gases (GHGs) (NCCAP, 2013). As a result of the need to promote sustainable consumption and production, (UNEP, 2015) is currently calling upon Governments to use energy and products efficiently, alongside the management of end-of-life products and materials through re-manufacturing, recycling, or recovery and reuse with the ultimate goal of realizing sustainable levels of GHG emissions.

²⁰ Carbon Trust Emission Factor per ton of Wood Pellets

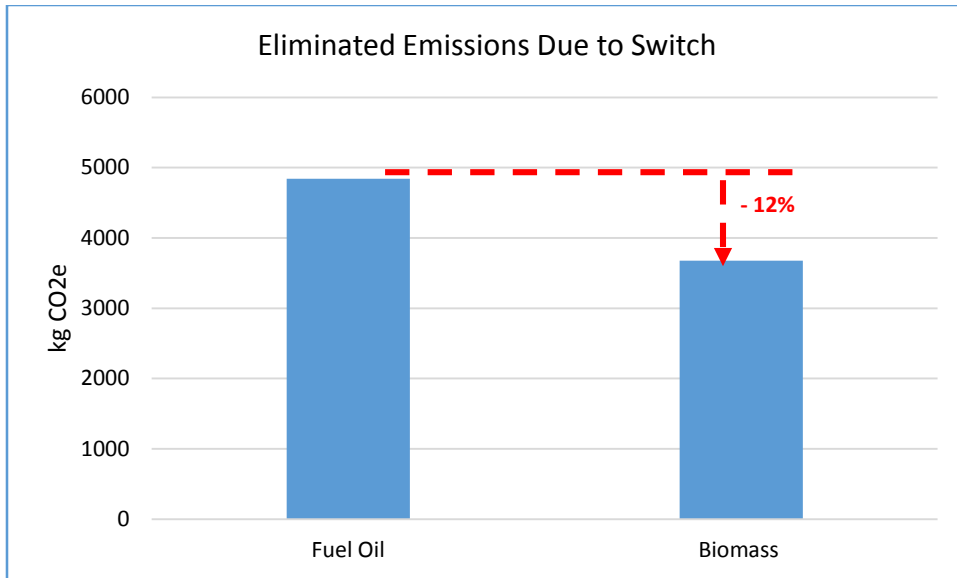


Figure 7: Reduced Emissions due to Fuel Switch

Some of the policy developments in the EU can help the Kenyan SEZ develop its own sustainable waste management response. The findings are consistent with (UNEP, 2011) key principles of sustainable consumption and production promotion that advocate for the decoupling of economic growth from further environmental degradation. The diverted wastes for use as feedstock for another company could otherwise have been landfilled if industrial symbiosis was not currently in practice. Industrial Symbiosis that focuses on waste and by-product exchange between two companies is a subset of industrial ecology and is the initial starting for the wider industrial ecology network (Ghali et al. 2014).

4.2.2 Agro-processing Cluster - Instant Foods Processing

Instant Foods Processing is a Unimix food processing company. Its main raw materials are 75% maize, 15% Soya and 5% Vitamins, 2% Oil and 1% Sugar (Source: Company Records). The company's milling and blending process (powered by electrical energy) is associated with approximately 5% waste that is sold to an Animal Feeds Manufacturing Company (Table 7).

Table 7: Material Balance for Instant Foods Processing (Source: Company Records)

Instant Foods Processing

Type of Raw Material	Quantity (tons/year)
Inputs	
Maize	19,200
Soya	4,800
Sorghum	3,800
Millet	2,400
Total	30,200
Desired Product	
Maize	18,238
Soya	4,558
Sorghum	3,605
Millet	2,278
Total	28,679
Composite Wastes	
Maize	960
Soya	240
Sorghum	190
Millet	120
Total	1,510

Table 7 shows overall raw material to desired product conversion rate of 95%. The raw material to desired product conversion rates are 94.99%; 94.96%; 94.87%; and 94.92% respectively for Maize, Soya, Sorghum, and Millet (Source: Company Records). The remaining 5% constitutes a by-product termed food waste. This by-product that averages 1,510 tons /year is sold at KES 5 per Kg to an animal feed manufacturing plant. This fetches the Instant Foods Processing Company (primary manufacturing) USD 75,500 from what could otherwise be discarded as waste. This waste is therefore diverted from the landfill. Due to the fact that the waste from the instant foods company is semi-processed, the Animal Feeds Manufacturing Company records an estimated 20% saving²¹ on its electrical energy consumption equivalent to USD 5,950/ year. The 20% savings on

²¹ Estimates from the Animal Feeds Production Manager

electrical energy (1,980,000 kWh/yr) is equivalent to 396,000 kWh/yr. This translates to an emission reduction of 132 tCO₂/year (Kenya's Grid Emission Factor of 0.3323 kgCO₂/kWh). Thus the exchange of materials between industries not only saves the environment from possible waste pollution but also plays a role in strengthening the company's bottom line i.e. the environment wins and the bottom line also wins, illustrating that environment and economy can work together in a win-win arrangement – which is what industrial ecology is all about.

The study findings justifies UNEP's push for sustainable consumption and production practices (UNEP, 2015) sustainable consumption and production (SCP) principles that advocate for (i) the need for economic zones to address not only environmental concerns but also key economic and social challenges of their operations; (ii) the decoupling of the zone's economic growth from further environmental degradation through improved resource use efficiency and diversion of wastes from the landfill; (iii) the improvement of quality of life and well-being - alleviating poverty and promoting sustainable lifestyles as well as green job creation; (iv) the application of life cycle thinking to minimize impacts at all stages of the production value chain and consumption process (looking at waste as a useful resource); and (v) the active involvement of stakeholders at all levels of government, the private sector, academia and civil society organizations.

4.2.3 Agro-Processing Cluster - Artemisinin Extraction

The Artemisinin Extraction Botanical Extracts is involved in the extraction of pure Artemisinin (a key ingredient in the manufacture of an anti-malarial drug) from the "*Artemisia annua*" plant using hexane and ethanol for extraction and purification respectively. The company's extraction efficiency is estimated at between 0.8 and 1%, meaning that it generates 198 tons/ year of organic

waste mostly in form of spent leaf and wax out of a raw material input of 200 tons/year. Hexane and Ethanol are both used as solvents that are wholly recycled (Table 8).

Table 8: Artemisinin Extraction Material Balance (Source: Company Records)

Artemisinin Extraction

Type of Raw Material	(Quantity (tons) /year)
Inputs	
Artemisia	200 t/yr
Hexane Solvent	25,000 litres/yr
Ethanol Solvent	8.000 litres/yr
Fuel Oil	27,600 l/yr
Wood	280 tons/yr
Desired Product	
Artemisia	2
Hexane	Closed loop recycling
Wastes	
Artemisinin Waste	198
Boiler Ash ²³	12

Up to 32,000 m³ of water is used for machine cooling with a significant amount being lost through evaporation. The 196 tons/ year²² spent leaf and wax is re-used to supplement wood as steam boiler fuel for the generation of 20 tons/ day of process steam hence eliminating the use of 12 tons/year of fuel oil out of the company’s annual fuel oil consumption total of 26 tons/year. This translates into an annual monetary saving of USD 15,200 besides saving the environment from significant quantities of 2, 324 kg CO₂e carbon equivalents.

The associated respective carbon emissions reduction are as indicated in the equations (i) and (ii):

- (i) 12 ton of Fuel Oil²³ generates $(12 \times 3, 228) = 38,736$ kg CO₂ e
- (ii) 198 ton of Biomass²⁴ generates $(198 \times 183.9) = 36,412$ kg CO₂ e

²² Botanical Products Production Manager Estimates
²³ Carbon Trust Emission Factor per ton of Fuel Oil
²⁴ Carbon Trust Emission Factor per ton of Wood Pellets

This leads to a CO₂ e reduction of (i) – (ii); (38,736 – 36,412) = 2,324 kg CO₂e (equivalent to 6% reduction) as a result of the fuel switch (Figure 8).

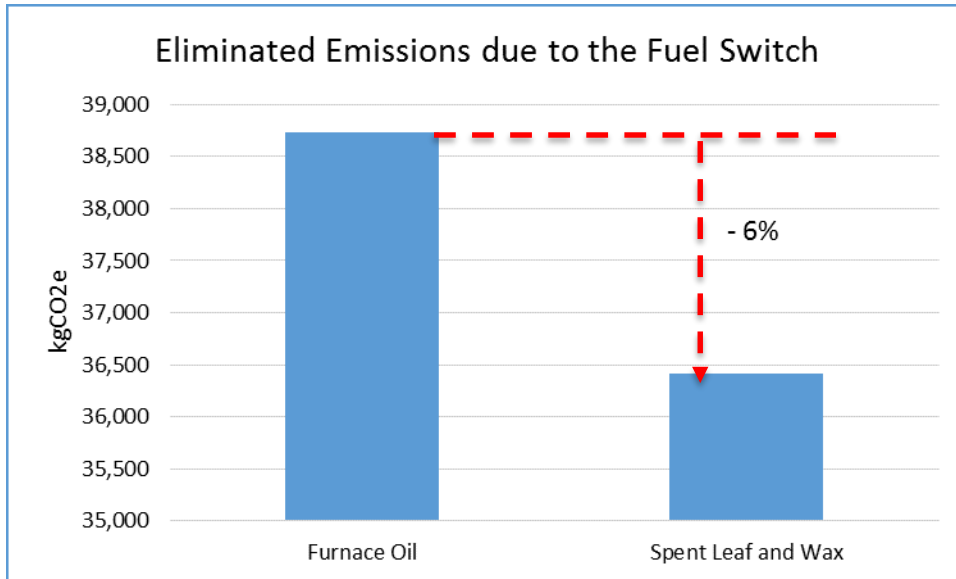


Figure 8: Reduced Emissions due to the Fuel Switch

These findings reinforce (UNIDO, 2015) green industry recommendations that with natural resources declining in both quantity and quality, time has come for companies to start practicing resource recovery. In this case, spent leaf and wax is used as boiler fuel to replace furnace oil. According to (UNIDO, 2015), the materials, water and energy regarded as unproductive and useless by one company can be turned into a business opportunity by another operating nearby. These findings are congruent with (UNIDO, 2015) conclusions that an economic zone such as the Athi River one can become environmentally and economically sound if RECP application is done at the individual enterprise level; collective RECP application practiced at the zone-wide level; and Industrial symbiosis strategically adopted after RECP to deal with inevitable residual waste.

4.2.4 Garment Cluster

The Garment cluster comprises of 5 companies operating a cyclic resource economy. The cluster collectively generates an average of 255 tons/year of fabric textile off cuts from a combined raw material consumption of 9,000 tons/year. The management of fabric off cuts could be troublesome had it not been for the on-going waste recovery and re-use programs. The making of garments has a waste generation rate of approximately 3% (Source: Company Records). Twenty Five percent²⁵ of this generated waste off cuts (equivalent to 64 tons/year) are used as steam boiler fuel while the rest 75% (equivalent to 191 tons/year) is sorted out on the basis of size at a temporary waste transfer station within the zone for use in the manufacture of sofa sets and cleaning mobs (Table 9).

Table 9: Garment Cluster Material and Emissions Balance

Garment Cluster

Type of Raw Material	Quantity (tons/year)
Inputs	
Textile Fabric	9,000
Fuel Oil	4 (replaced by fabric off cuts)
Desired Product	
Finished Garment	8,500
Composite Waste	
Composite Waste	255

The recycling of 64 tons/year fabric off cuts do generate for the cluster 9 tons of steam/ day. This fuel switch substitutes the cluster's reliance on 4 tons of fuel oil in a year with textile fabric off cuts. The discrepancy in the quantification of inputs versus out puts can be attributed to the accuracy of the record keeping process. Given that over 25% of the garment off cut waste (equivalent to 64 tons/year) is cotton based, and is used as boiler fuel to generate 9% less

²⁵ Source: Garment Cluster Production Manager

greenhouse gas (GHG) emissions as compared to the use of fuel oil as demonstrated by the calculation below.

4 ton of Fuel Oil²⁶ generates $(4 \times 3.228) = 12,912$ kg CO₂ e

64 ton of Biomass²⁷ generates $(64 \times 183.9) = 11,770$ kg CO₂ e

This leads to a CO₂ e reduction of 1,142 kg CO₂e $(12,912 - 11,770)$ (equivalent to 9% reduction) as a result of the fuel switch (Figure 9). Substituting the use of 4 tons/year of fuel oil with garment fabric off cuts will lead to an estimated annual monetary saving of USD 4,000.

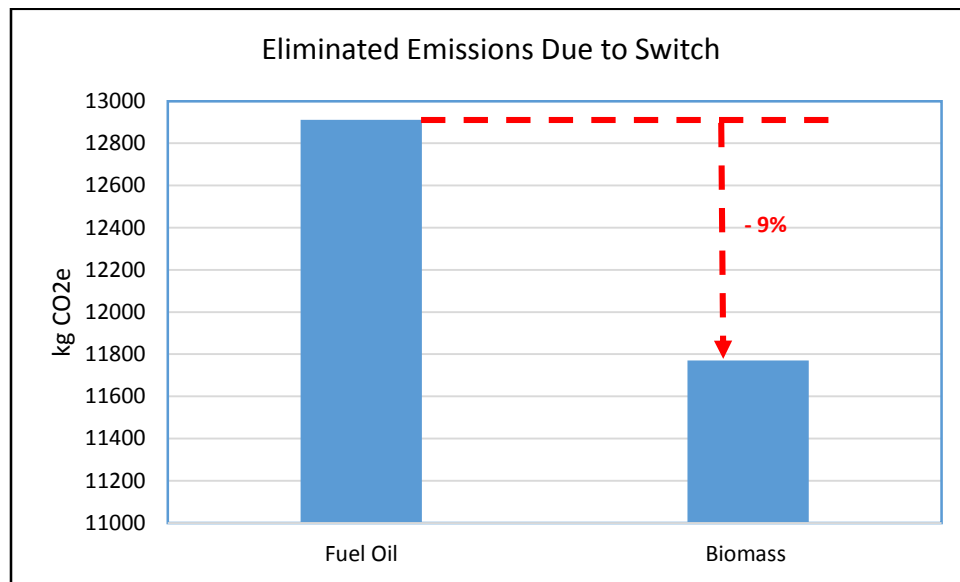


Figure 9: Reduced Emissions due to Fuel Switch

The company's use of spent leaf and wax as a source of fuel raises the environmental legitimacy of the company operations. This innovative finding is similar to Michael Porter's (2011), conclusion that despite growing corporate citizenship activities, the legitimacy of businesses have crossly fallen²⁸. According to him, businesses are currently seen to be prospering at the expense

²⁶ Carbon Trust Emission Factor per ton of Fuel Oil

²⁷ Carbon Trust Emission Factor per ton of Wood Pellets

²⁸ "Creating Shared Value" (*Harvard Business Review*, Jan 2011)

of society. Creation of Shared Value (CSV) can help reverse this social perception (Porter, 2011). To achieve this, Porter says, there is need for corporate policies and practices that seek to enhance competitiveness of companies while simultaneously advancing social and economic conditions in the communities in which they sell and operate. On this front, the economic zone supplies fresh water to the surrounding communities and also allows the Athi River residents to use its sewerage system. The Athi River residents feel the zone should do more for them in terms of helping them to recover and recycle different waste streams that are otherwise littering their environment.

However, the Economic Zone - Community relationship has created an innovative “win-win” working relationship between zone garment factories and informal waste recyclers who reside in the surrounding community. These informal waste recyclers have agreed to be cleaning garment factories for free so that they can easily access the garment textile off cuts for their subsequent resource recovery and re-use. The win for the zone garment factories is that they no longer need to spend money on general factory clean up and waste management in general (leading to estimated savings of up to USD 6,000 per year). The win for the informal garment waste recyclers is that they get the garment textile off cut wastes for free, have them graded and sold out to sofa set and cleaning mob manufacturers. An estimated 15 tons/month of fabric textile waste off cuts are recovered for reuse. The fabric off cuts retail at KES 6 per kg, generating a monthly income of USD 900. By doing this, significant amounts of waste otherwise destined for the landfill are diverted for economic use with enormous environmental and socio-economic benefits. This relationship has created a total of 15 direct “green jobs” and also improves the living standards of the surrounding community (improved incomes) who apart from hosting the zone employees also serve as customers and suppliers of the same zone. However these green jobs are not decent due to the limited level of investments in the zone’s waste recovery and recycling infrastructure. Proper

investments in waste recovery and recycling infrastructure will help convert these green jobs into decent jobs as defined by UNEP below. Green jobs serve the noble function of reducing the environmental impact of enterprises and economic sectors, ultimately to levels that are sustainable²⁹. Green jobs do help to cut on the consumption of energy, raw materials, and water through high-efficiency strategies, to decarbonize the economy and reduce GHG emissions, to minimize or avoid altogether all forms of wastes and pollution, to protect and restore ecosystems and biodiversity¹⁹. According to UNEP, decent work involves the creation of opportunities for work that is productive and delivers a fair income, enjoys security in the work place, has adequate social protection for families, offers better prospects for personal development and social integration, permits freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for both genders.

The results on the garment cluster demonstrate that cyclic waste management can create jobs and improve industry-community relations. All over the world industry-community relations are strained when industries use community territories as waste dumping sites. In this case, waste has created a symbiotic industry-community relationship that protects the environment, creates jobs, and a source of livelihood. The creation of 15 jobs at the economic zone's garment cluster reinforces (UNEP, 2015) argument that investments in green growth will lead to social inclusion and therefore developing countries should commit to working towards changing the way goods and services are produced and consumed so that human development, and the satisfaction of human needs, is decoupled from further environmental degradation. This is a classic green growth social inclusion exercise where waste from the garment cluster is used by the surrounding

²⁹ UNEP, 2010. ABC of SCP – Clarifying concepts on SCP

community members as a resource for green job creation and improvement of quality of life and well-being. Apart from promoting a sustainable lifestyle, the practice also alleviates poverty.

The findings also reinforce (UNIDO, 2015) position that firms are facing growing pressure to become “green” or more environmentally friendly. As a result, these garment cluster firms have had to review their production processes and procedures so that they can use textile fabric off cuts as boiler fuel and also allow the informal waste recyclers to recover and add value to their waste stream and prevent it from being landfilled. That is why UNEP and the EU are currently supporting industry, emerging green eco-entrepreneurs, and policy makers through policy development, that supports the setting up of RECP and IS demonstration projects and other networking activities through the Switch Africa Green project being implemented by the Kenya National Cleaner Production Centre (KNCPC). However, lack of a solid waste recovery and recycling infrastructure (in terms of collection, transport, and disposal systems) at the zone hampers the zone’s full exploitation of the garment cluster’s waste recovery and recycling scheme (WBCSD, 2002). The findings also reinforce the country’s goal of adopting a green development pathway that is spelled out in its Green Economy Strategy and Implementation Plan (GESIP). Figure 10 shows the trending of production and associated wastes for the Garment Cluster over a seven year period.

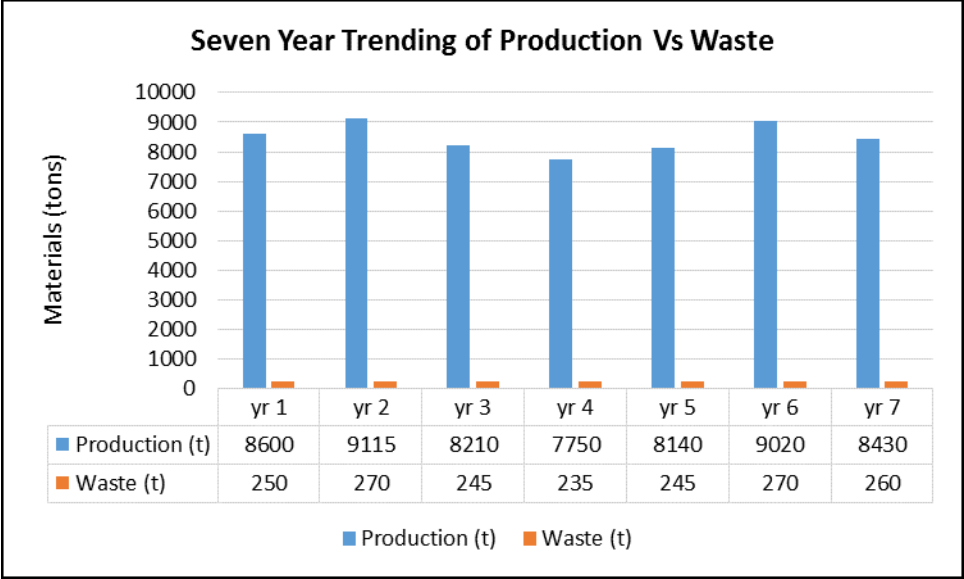


Figure 10: Seven Year Trending of Garment Production Vs Waste Generation

The trending reveals a raw material to desired product conversion rate of 97%. This means that 97% of the raw material garment inputs converts into the desired final product with the rest 3% being classified as a by-product or a non-product output (NPO). Non utilization of the NPO in another production process for energy cascading and manufacture of sofa sets and cleaning mobs will demonstrate wasteful use of the company’s limited resources with associated environmental and social consequences. Luckily, the textile waste off cuts are used both as boiler fuel and as feedstock for the manufacture of sofa sets and cleaning mobs.

4.2.5 The Plastics Cluster - Tarpaulin Manufacturer

The plastics cluster comprises of two companies. One of the plastic cluster companies manufactures plastic tarpaulins from polyethylene and the other collects used PET bottles from the surrounding community for recycling. The tarpaulin manufacturing company consumes an average of 7,200 tons/year of polyethylene that results into the generation of 108 tons/year of non-biodegradable plastic waste. This waste volume is currently being recovered for re-use in the manufacture of plastic water tanks, chairs and jerry cans by a secondary company. Absence of this

plastic waste recovery mechanism would have meant that the company landfills into the environment 108 tons/year of non-biodegradable plastic waste with serious environmental and social impacts (Table 10).

Table 10: Tarpaulins Material Balance

Tarpaulin Manufacturing

Type of Raw Material	Quantity (tons/year)
Inputs	
Polyethylene	7,200
Desired Product	
Desired Product	7,000
Generated Wastes	
Generate Waste	108

This company’s plastic off cuts constitute waste that is re-processed on-site into plastic pellets for sale to the secondary manufacturers of plastic water tanks, chairs and plastic containers (jerry cans). This on-site re-processing of plastic off cuts into pellets has created 5 direct “green jobs” with a total income of USD 1,000 per month. This practice diverts 108 tons/ year of non-biodegradable plastic waste that could otherwise end up at a land fill or at the incinerator. The non-degradable nature of plastics will have ensured that they visibly accumulate at the land fill for a long time. A part from plastics being litter nuisances in the environment, they also do collect water and at times act as mosquito breeding grounds that are responsible for the spread of Malaria that affects the labor productivity of zone employees. Plastic waste recovery and reuse relieves pressure on use of virgin raw materials and also eliminates the environmental risk of having to dispose of non-biodegradable plastic waste into the surrounding environment.

The findings on the plastics cluster are similar to the OECD, 2009 conclusions that plastics manufacturing units across are shifting towards better environmental performance through seeking to reduce their material flows. According to the OECD, a more integrated approach to sustainable

manufacturing, will enable companies to increase their reuse and re-manufacturing potential. As a result, the OECD concludes that the need for virgin materials can be drastically reduced through the adoption of closed-loop production approaches that seek to maximize the recycling of materials that already exist in the production system. The results also demonstrate how closed-loop production distinguishes itself by “closing” the materials resources cycle. This implies that all components that exist in the system are either reused, remanufactured, or recycled in some way. However, recovery, reuse, recycling, and remanufacturing cannot be said to fully address all the environmental concerns.

Good and desirable as they may look, their end processes will put some form of waste into the environment. This is to say that, although industrial ecology can lead to a cyclic industrial economy, further research work is required if it has to be fully equated to nature. These findings on the plastic cluster also conform to UNEP, 2015 observations that a remarkable shift from traditional linear and wasteful production methods to a circular and more efficient perspective in which products and processes are designed with “reincarnation” in mind is desired. These findings further conform to MacDonough and Braungart, 2002 conclusions that the need for virgin materials is eliminated or drastically reduced, when waste is fully recycled back into the system.

4.2.6 The Plastic PET Recycling Company

The business operations of the plastic PET recycling company involves the collection of plastic PET bottles from around the zone for on-site re-processing and eventual export to China. The company collects an average of 360 tons per year of plastic PET bottles, shreds and pelletizes them before packing them for export to China. The idea of collecting plastic PET bottles from the surroundings is good for the environment. If left uncollected, plastic wastes are capable of blocking

drainage systems resulting in unnecessary floods that could affect human settlements as well as infrastructure. This will directly or indirectly affect the operations of the zone. Unfortunately, transportation of the shredded plastic waste over a long distance to China might not make good environmental sense due to the associated generation of greenhouse gases (GHG) emissions during their long haul transportation.

The findings on plastic PET recycling are similar to OECD, 2011 research conclusions that observed that, by tapping into the large resource potential that exists in current waste stream, the need for virgin materials and waste disposal could be significantly reduced. This conclusion is anchored on OECD, 2011 life cycle thinking that goes beyond cleaner production to put emphasis on the need for companies to look beyond conventional organizational boundaries when considering the environmental impacts of their activities and associated products. This life cycle thinking will entail taking into account the environmental impacts and responsibilities that arise from the extraction of materials through to the design of products and production processes to the eventual consumption disposal of final products. This study did not address environmental challenges beyond the industrial clusters.

4.2.7 Darts Board Manufacturing Cluster

The main material inputs for manufacture of darts and darts boards included chip board, sisal, steel wires and glue. Its main waste streams were chipboard saw dust, sisal waste and off cut steel wires (Table 11). The primary manufacture of darts/ darts board in the zone generates 40 tons/year of sisal waste that was being used for manufacture of sofa sets. Waste steel wires are sold out for recycling while sisal waste is used in the sofa set industry. Though sisal waste is biodegradable, any initiative that diverts it from the landfill is commendable. These findings on darts/ darts boards cluster demonstrate a typical case for eco-innovation and is similar to Leiponen, 2005 observations

on the modalities of organizational change for eco-innovation. Leiponen, 2005 notes that the organizational change triggered by eco-innovation increases the technical capability of the company and drives its productivity as was demonstrated at the darts/ darts boards zone of the Athi River SEZ. The identified sisal waste recycling initiative at the economic zone reinforces UNIDO, 2015 observations that the resulting learning, knowledge stock and creative processes leads to enhanced technical capacity in waste recycling, a stronger and supportive skills base, and increased employee engagement and involvement that is interwoven with key business performance indicators of increased productivity and profitability.

Table 11: Darts Manufacturing Material Balance

Darts Board Manufacture

Type of Raw Material	Quantity (tons/year)
Inputs	
Chip Board	980
Sisal	936
Steel Wire	144
Total	2,060
Desired Product	
Desired Product	1,710
Composite Wastes	
Chip Board	204
Sisal	40
Steel Wire	7

The 204 tons/ year³⁰ of chip board saw dust waste was used as steam boiler fuel in place of Fuel Oil for the generation of 20 tons/ day of the company’s process steam. This eliminates the company’s use of 13 tons/ year of fuel oil equivalent to a monetary saving of USD 15,050/year.

The associated respective emissions reduction levels are as calculated below:

³⁰ Darts Board Production Manager Estimates

13 ton of Fuel Oil³¹ generates $(13 \times 3,228) = 41,964$ kg CO₂ e

204 ton of Biomass³² generates $(204 \times 183.9) = 37,516$ kg CO₂ e

This leads to a CO₂ e reduction of $(41,964 - 37,516) = 4,448$ kg CO₂e (equivalent to 11% reduction) as a result of the fuel switch.

4.3 Assessment of the Application of Industrial Ecology Principles

This objective 3 sought to assess the application of industrial ecology (IE) principles in mitigating the environmental challenges of the zone. The baseline assessment of the application of IE principles at the Zone revealed an emerging but promising trend that if well nurtured can yield positive development results. Economic, social, technical, information-related, policy related and absence of key drivers for IE were listed as some of the challenges frustrating an accelerated uptake of IE principles. The Zone's application of IE principles in mitigating its environmental impacts is currently at its infancy and concerted efforts from the zone authority, zone based companies and the Government are required if this practice is to be widely adopted within the Zone. Use of an eco-forum and CEO seminars where zone based companies can dialogue on matters of mutual interest has successfully worked in Europe and Asia in securing top level commitment in promoting IE principles (UNEP, 2015). There was also limited engagement of Government in helping to create an enabling environment for the application of IE principles within the economic zone.

The benchmarking of the four cluster operations of the economic zone against international best practice as regards the application of Industrial Ecology (IE) principles in the key operation areas of management (corporate policy, management involvement, management vision, and

³¹ Carbon Trust Emission Factor per ton of Fuel Oil

³² Carbon Trust Emission Factor per ton of Wood Pellets

environmental management); operations (plant operations, plant management, process operations, employee motivation, innovation, transparency, supplier relations, risk management, external partnerships and communications); and environmental aspects (environmental health and safety, material utilization, and habitat management) revealed an outcome that is at the basic level 1 (Table 12). A lot needs to be done so as to enable the economic zone to graduate from red to green as explained below. Progress from Red through Yellow to Green in the matrix (Annex 2) implies adoption of a more comprehensive strategy that completely addresses the role of IE principles in all dimensions of the zone’s sustainable development (SD) activities (WBCSD, 2002). This will include zone management practices, operational activities as well as key environmental aspects of waste and by-product exchange.

Table 12: Benchmarking Outcome of Baseline Performance of IE at the Economic Zone

Categories and Elements	Rank	Reason	Recommended Policy Actions
Corporate policy	Level 1	Zone company policy is one of compliance with business regulations	<ul style="list-style-type: none"> - The clusters should strive to develop proactive corporate policies that seek to meet and exceed compliance requirements - Company policy should extend beyond compliance with zone business regulations to address potential liability issues. - Systems should be put in place to monitor, update, communicate, and implement policies. - Company policies should be made proactive and include environmental, economic, and social aspects in all business decisions, e.g. public policy, community relations, and social development components.
Management Involvement	Level 1	Management approach is reactive to all business threats	<ul style="list-style-type: none"> - The management response to business threats should be proactive and committed to the art of continual improvement - Management approach should anticipate and address clear business threats – e.g. anticipates future environmental permits. - Management should be actively involved in updating of environment health and safety

			(EH&S) policy and introducing continuous performance improvement systems.
Management Vision	Level 1	The vision is limited to maintaining compliance with the provisions of the economic zone's corporate policy.	<ul style="list-style-type: none"> - Zone company management visions should go beyond the zone's corporate policy and involve voluntary initiatives -The vision should show a willingness to introduce longer-term, voluntary initiatives. In addition, at the Corporate level, Public Affairs management should be perceived to be critical to long-term business sustainability. - Highly aligned at Corporate and Plant level (e.g. Corporate policies should be fully embraced at Plant level and short-term Financial criteria are not as stringent).
Environmental Management	Level 1	Environmental assessment and actions limited to meeting regulatory and compliance requirements	<ul style="list-style-type: none"> -Zone companies should embrace an EMS that also incorporates community expectations - Environmental activities should focus on meeting specific environmental goals identified via the implementation of a formal Environmental Management System (EMS) - Neighboring communities and industrial facilities should play an important role in influencing environmental goals as part of an overall Environmental Management System.
Plant Operations	Level 1	Plant environmental initiatives are control oriented and lack management support	<ul style="list-style-type: none"> - Zone companies should fully embrace resource use efficiency, cleaner production and industrial symbiosis. - Operational initiatives should promote eco-efficient production, RECP, IS and general resource conservation -Plant management should be cognizant of the triple bottom line and incorporate aspects of sustainability in operational decisions
Plant Management	Level 1	Management only supports discretionary environmental initiatives that don't require capital investments	<ul style="list-style-type: none"> - Zone based companies should set up divisions for resource use efficiency, cleaner production and industrial symbiosis - Management should support investments in discretionary environmental investments and comprehensive evaluation strategy is in place - Independent division with dedicated staff for evaluating opportunities for waste recycling,

			alternative fuels and raw materials (AFR), and developing and implementing IE relationships.
Process Operations	Level 1	Operations staff unwilling to explore waste minimization or pollution prevention (P2) activities	<ul style="list-style-type: none"> - Zone companies should be persuaded to invest in cleaner production and industrial symbiosis through training and demonstrations. - Operations staff should value pollution prevention and AFR efforts and should be willing to explore such opportunities. - As part of the R&D process, Operations staff should actively participates in exploring and implementing AFR substitution opportunities.
Employee Motivation	Level 1	No incentives to explore new opportunities in increasing profitability – maintains status quo.	<ul style="list-style-type: none"> - Zone based companies should use incentives to promote and sustain employee interest in cleaner production and industrial symbiosis - Staff award programs for ideas that could lead to increased productivity and/or process efficiencies e.g. energy, material and water conservation - Compensation packages for managerial staff directly linked with increased productivity profits, or other performance measures through AFR or other IE programs.
Innovation	Level 1	No R&D investments For environmental Technology upgrading.	<ul style="list-style-type: none"> - Zone based companies should invest in funding R&D for accelerated uptake of cleaner production and industrial symbiosis. - R&D funding earmarked for innovations in environmental technology initiatives leading to economic benefits (e.g. using recycled material, new and/or improved product and/or process design) - Opportunity assessments actively pursued for innovative options in AFR and/or other IE opportunities.
Transparency	Level 1	Company operations are insulated and do not promote external communications	<ul style="list-style-type: none"> - Zone companies should aggressively establish networks for accelerated adoption of cleaner production and industrial symbiosis. - Company willing to discuss Its environmental management initiatives externally to identify cost-effective material substitution or fuel replacement - Company proactively establishes networks to explore opportunities for waste exchange, AFR and other IE opportunities on a zone-wide basis.

Supplier/ Receiver Relationships	Level 1	Company purchases conventional fuels and raw materials through typical cost-bid process.	<ul style="list-style-type: none"> -Zone companies should promote long-term relationships with suppliers that are sustainable (green supply chain management). - Company should have ad hoc relationships with suppliers and receivers (companies receiving waste and process by-products). No long term or collaborative sourcing arrangements. -Company should have formalized, long-term relationships with receivers (companies receiving waste and by-products) and suppliers and considers collaborating to optimize both the supplier operations and the transport logistics.
Risk Management	Level 1	Limited to regulatory requirement for process operations	<ul style="list-style-type: none"> - Risk analysis for handling, transportation, and storage of AFR should be performed. - Risk considerations broadly consider the full range of negative and positive values of establishing and maintaining an industrial ecosystem.
External Partnerships	Level 1	Very limited external partnerships	<ul style="list-style-type: none"> - Company should perceive its AFR, waste recycling, and material substitution initiative with outsiders as an economic incentive. - Company uses its AFR and other material substitution initiatives for strategic benefits by establishing goodwill and strong relationships with the regulatory agencies and local community members.
Environmental, Health and Safety (EH&S)	Level 1	EH&S activities focus is only on compliance with regulatory and permit requirements.	<ul style="list-style-type: none"> - EH&S principles should extend beyond meeting regulatory compliance requirements - proactive approach in risk management, identifying waste minimization, waste recycling, P2 opportunities - EH&S activities include evaluations of the EH&S implications of logistics management, suppliers, contractors, and other external organizations associated with company's operations.
Material Utilization	Level 1	Material utilization and material energy flow evaluation only within the plant boundary.	<ul style="list-style-type: none"> - Life Cycle Assessment (LCA) approach should be used for a system level material utilization and material energy flow evaluations - In addition to system level LCAs, material utilization and energy flow evaluations, the company considers a broader set of parameters such as resource management issues and stakeholder concerns.

Habitat Management	Level 1	Resource extraction and other habitat areas are managed within regulations	Habitat management and conservation of biodiversity should be evaluated but considered only within the span of control of the company. Habitat enhancement or substitution should be a key component of decisions on fuels and raw materials and waste product utilization both within the company and in partner organizations.
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Interventions such as training, setting up of demonstrations and development of enabling policies are required if the zone clusters benchmarked in (Table 11) can be enabled to migrate from the mostly baseline Red status (level 1) to the desired green status (level 3) via the intermediary Yellow status (Level 2) (WBCSD, 2002). The benchmarking results (Table 11) are largely consistent with WBCSD’s past conclusions that many global companies are constantly re-examining their business operations and relationships in a fundamentally new way. Such sustainable businesses keep constantly seeking to integrate their pursuit of profitable growth with the assurance of proper environmental protection and improved quality of life now and in the future (WBCSD, 2002). The application of the seven industrial ecology (IE) principles at the zone is being hampered by challenges that can be broadly classified as being economic, social, technical, information-related, policy-related, as well as total absence of enabling drivers for IE uptake (Lowe, 2001; Roberts, 2004). Responses from zone based companies that engaged in waste and by-product exchange pointed out hindrances and lack of key drivers to the adoption of industrial ecology principles. These findings were found to be similar to those enumerated by Baumgarten & Nilsson, 2014 and reinforced by Johnsen et al. 2015 (Table 12). Fixing of these challenges and the creation of an enabling policy environment will help increase the productivity and competitiveness of the economic zone (Baumgarten & Nilsson, 2014).

4.3.1 Challenges of engaging Industrial Symbiosis (IS) at the Athi River SEZ

Interviews with the zone based companies already practicing industrial symbiosis (IS) revealed a wide range of economic, social and technical challenges of embracing the concept within the economic zone. Many of the companies complained of a lack of zone wide policies and enabling strategies for IS promotion. Given that the zone companies have a long history of operating singly and not in partnerships, it will not be easy for them to master the art of collaboration within a network setting. The zone authority had no means of rallying the tenant companies around a given IS vision as the complex had no such vision in place. There were reported challenges with the long distances separating the companies that were exchanging wastes and by-products as well as lack of a one-stop-shop for offering advisory on RECP, 3Rs, IS and general green growth advisory. The social challenges that were reported were either individual or organizational and included mind set inertia that resists change, zone employees feeling reluctant to go out of their way to embrace IS; lack of trust among the waste exchanging players, the IS players not seeing the sense of collaborating while competing at the same time for the common good of the entire network, a strong focus on the core mandate of the zone companies that does not prioritize sustainability, and smaller companies not being keen on seeking IS projects in partnership with big companies. Other companies expressed fears about the profitability of such IS partnerships, lack of access to long-term and sustainable financing, and generally high investment costs in operationalizing waste and by-product exchanges. Between zone companies, there was weak cross sectoral cooperation. Lack of an up-to-date data base on raw material consumption, the accompanying products and generated wastes and by-products frustrates interest in the economic viability of waste and by-product exchange. It is generally difficult to tell if investments in industrial symbiosis will make good business sense as there is no baseline data to justify this.

Most tenant companies recommended access to public grants that can enable them make green investments for enhanced competitiveness. They operated with the belief that “going green” will enable them access new markets that are stringent on environmental matters. The companies also recommended stronger partnerships with research institutes and academia for purposes of promoting innovations through R&D. The zone tenant companies recommended the recruitment of a well-respected industrialist from within the zone and has already practiced IS and is convinced that it makes good business and environmental sense to act as an IS champion in promoting the concept among the zone peers. They felt that such an approach is much more convincing and attractive to the private sector. The zone’s waste and by-product recovery and recycling infrastructure needs upgrading. Such an upgrade will help improve on the coverage of waste and by-product exchange through IS. An aggressive and interactive synergy building sessions should be promoted by the Zone Authority among the tenant ranks. An overarching strategy for the development of a circular economy driven by IS should be developed with the active participation of all the zone companies.

There should be strict enforcement of Zone regulations in a manner that encourages on-site reuse and recycling of wastes and by-products. Charging land fill disposal fee on the basis of weight will encourage companies to minimize waste generation at source. The consumer should be enabled to make an easy and informed sustainability choice through eco-labelling. This should be anchored within a broader green procurement framework for the economic zone promoted by the Government that is the greatest buyer of goods and services. The tenant companies were in dire need of training on emerging contemporary tools of environmental management such as RECP, the 3Rs, and IS. This will raise the zone’s awareness on the need to develop waste and by-product synergies using industrial symbiosis (IS). The zone’s industries are eager to see the evolution of

new industries that are actively involved in waste and by-product recovery, reuse and recycling. Above all, trust was taken as the cornerstone of successful synergy building for improved industrial symbiosis.

The findings demonstrated that tenant companies of the economic zone were just beginning to embrace the principles of Industrial Ecology (IE). This is largely being driven by the prevailing market forces of supply and demand. These findings are consistent with Ehrenfeld and Gertler, 1997; Saikku, 2006, who concluded that companies that embrace Industrial Ecology are those that deliberately attempt to (i) connect waste and by-product streams into closed loop ecosystems; (ii) continuously seek to balance their raw material consumption, waste generation and resultant emissions with the carrying capacities of the surrounding environment; (iii) retrofit industrial processes to make them energy and resource use efficient; and (iv) are in constant consultation with the surrounding communities while designing their social responsibility programs.

These developments are just beginning to take shape at the economic zone. Just as was pointed out by Chertow, 2008, the adoption of closed loop production systems at the economic zone can only be through material recovery, reuse and recycling, optimization of the efficient use of materials and energy, embracing of cleaner production to minimize waste generation at source, and adoption of industrial symbiosis to handle inevitable residual waste. Both UNEP, 2011; and UNIDO, 2015; recommended that the successful adoption of IE principles requires awareness raising, training and setting up of demonstration projects. These findings are consistent with Lowe, 2001 and Roberts, 2004, who separately concluded that the application of IE principles should target to improve the total environmental quality of the zone while satisfying its economic and social needs in a win-win situation. This is in line with (Mirovitskaya & Ascher, 2001) definition of total quality

environmental management (TQEM) as a business strategy that seeks to incorporate environmental protection and energy efficiency in all aspects of business operations and at all levels of a company, based on the assumption that both environmental quality and product quality are directly linked to long-term economic zone's profits.

(Mirovitskaya & Ascher, 2001) observed further that achieving total quality environmental management (TQEM) requires zone companies to integrate certain basic principles into their overall business strategy. These principles include (i) adoption of an environmental policy that seeks to eliminate pollution based on life-cycle assessment of the firm's operations and communicating the policy throughout the company and to corporate stakeholders; (ii) objectively assessing the effectiveness of environmental programs; (iii) comparing the company's environmental performance to that of leading firms in the industry through benchmarking and best-practice assessments; (iv) promulgating a company view that environmental performance is the responsibility of all employees; (v) analysis of the impact of environmental issues on the future demand for products and the competitive economies of the industry; (vi) encouraging frequent discussion of environmental issues and activities at board meetings; (vii) developing and applying a formal system for monitoring proposed regulatory changes and for complying with changing regulations; (viii) routinely conducting environmental due diligence on potential acquisitions; (ix) developing budgets for environmental expenditure so that the firm does not incur surprise expenses that materially affect profitability; and (x) identifying and quantifying environmental liabilities from past operations and developing plans for minimizing them. The zone authority is not yet engaged fully in promoting this structured approach to environmental stewardship. An in-depth assessment of how the Zone operations conform to the seven principles of IE as laid down by (Lowe, 2001) and reinforced by (Roberts, 2004) revealed the outcomes shown (Table 13).

Table 13: Conformance of the Zone Operations to the Principles of Industrial Ecology

IE Principles	Status of the Athi River SEZ Conformance to the Principles	Proposed Improvement
Promotion of opportunities for establishing real and genuine partnerships and engagement schemes with communities and Government in developing a more responsive attitude to promoting sustainable industrial development practices	No evidence of such an opportunity at the zone	The creation of the triple helix collaboration that brings together industry, Government, communities and academia will help strengthen engagement partnerships through eco-innovation. The capacity of the Zone Authority should be strengthened through the creation of a “Green Cell” within it.
Locating industries strategically to optimize the capture and concentration of by-products, waste material flows and energy surplus for use by other industries in close proximity	Company location in the zone not informed by industrial symbiosis	The development of green economic zone master plans will guide the zone planning and facilitate easy incorporation of resource use efficiency and cleaner production (RECP) before adopting industrial ecology. The Zone Authority with the assistance of triple helix stakeholders and communities should develop a green zone master plan that prioritizes the setting up of industrial clusters that have infrastructure for by-product, waste and energy exchanges
Co-locating or zoning industries that will benefit economically from trade or exchange of wastes, by-products and energy	Companies that can exchange wastes and by-products are not co-located. Even with this, and due to the prevailing market forces, distant companies are exchanging wastes and by-products.	The zone companies need an inter-firm communication platform for sharing information on which wastes are available and who needs them. Clusters that comprise of companies that can exchange wastes and by-products should ideally be co-located.
Providing a catalyst to help create synergies and an environment for fostering technological advancement in Cleaner Production, resource use efficiency, waste	No evidence of such synergies at the zone	Eco-innovation is only promoted through demand driven R&D that is spearheaded by academia and jointly funded by Government and the private sector. The Zone Authority as well as the proposed “Green Cell”

management and sustainable industrial development		should strengthen their working relationships with the Kenya National Cleaner Production Center (KNCPC), Kenya Industrial Research and Development Institute (KIRDI) and academia for purposes of advancing Cleaner Production and transfer of environmentally friendly technologies.
Providing appropriate “smart infrastructure”, to ensure the growth of eco-industries that support sustainable industry practices to maintain high levels of innovation as the basis for increased productivity and competitiveness.	No such “smart infrastructure” exists at the zone	“Smart Infrastructure” should provide for waste and by-product storage, transportation, exchange, segregation, and recovery, reuse, and recycling before final disposal. The Zone Authority should establish this “smart infrastructure” with active participation of academia and research institutes to promote eco-innovation for increased competitiveness.
Supporting industry promotion policies and incentives to encourage innovation, collaboration and commercialization of new and improved product developments using materials, water and energy surplus to production	There is no such enabling policy framework for the economic zone	The Zone Authority should work with the Government and other stakeholders to develop a cluster promotion policy that has incentives for industry collaboration and commercialization of green products
Demonstrating commitment to the benefit of industries that have strong, sustainable industrial development projects and programs	There was no evidence of such a policy commitment	The Zone Authority should establish an award scheme for zone companies that excel in sustainability issues based on a clear benchmarking criteria for continual improvement

The zone’s incorporation of industrial ecology principles in its mitigation of its environmental impacts is at its infancy. In order to fully embrace these IE principles, Roberts, 2004; Desrochers, 2004 recommend a systematic, comprehensive, and integrated review of all the components of the economic zone and its interaction with the biosphere; the complex patterns of material flows into and out of the economic zone, as opposed to focusing on single flows; and acknowledging the importance of technological dynamics in driving the long-term evolution of a sustainable industrial

ecosystem. Because the adoption of industrial ecology principles is at its infancy at the economic zone, its successful evolution should be informed by best practice experiences that have worked in Europe and Asia. According to (Koenig, 2009) an eco-forum will act as a regular meeting venue for zone based companies. Such meetings are normally held to share information on development issues relevant to the entire economic zone. According to (UNIDO, 2015), it will also serve as the dissemination point for information on best practices in management and eco-efficiency, for regular updates on applicable laws and regulations, and to link stakeholders up. To establish an eco-forum in an economic zone with little or no common activities between companies and the zone authority, (Koenig, 2009) recommends the use of the six step approach:

Step 1. Getting to know the zone companies;

Step 2. Creating a platform for dialogue;

Step 3. Developing partnerships;

Step 4. Developing a forum for Champions;

Step 5. Initiating cluster activities;

Step 6. Sharing the results.

According to Koenig, 2009 this eco-forum should act as an opportunity for open dialogue among zone members. Senior Executive seminars on sustainable business targeting non-technical and non-environmental senior management drawn from finance, planning, procurement, sales, marketing, and production are recommended (UNIDO, 2015). Targeting key-decision makers' within companies, these one-day seminars bring to life the business potential of sustainability, encompassing innovative approaches to product design, process improvement, management and the adoption of new business models (UNEP, 2011). According to (Shi et al. 2012), these seminars cover key topics such as strategy, productivity, management and marketing. (UNIDO, 2015)

recommends the creation of sustainable business networks among zone CEOs. The CEOs have the chance to network for business purposes, while also paying attention to a variety of real success stories illustrating different aspects of sustainable business development (UNEP, 2011).

4.3.2 Key Players in SEZ Promotion

The key players within a SEZ are the Government, the Regulator, the developer, and operator whose primary responsibilities are as stated based on the EPZA's records (Table 14). Constant consultations among these key players is essential for promoting the ideals of sustainability within the economic zone.

Table 14: Stakeholder Primary Responsibilities in a SEZ program

<i>Stakeholder</i>	<i>Primary Responsibilities</i>
Government	<ul style="list-style-type: none"> a) Involved in executing strategic plans for SEZs; b) Helps in selecting appropriate economic zone site(s) and packaging/ zoning land parcels; develops and publishes land use guidelines in consultation with stakeholders; c) Conducts initial feasibility studies; d) Selects developer(s) and enters into zone development agreements with them; e) Develops offsite infrastructure (offsite infrastructure is the responsibility of the host government); f) Supports training/ capacity building/ workforce development and provision of social services; g) General regulation and administration of the SEZ program;
Regulator	<p>Designates SEZs: Designates public and private land as special economic zone (SEZ) and their agents as SEZs developers/operators;</p> <p>Facilitates government services: Facilitates licensing, permitting, and regulatory services within the SEZs, particularly relating to land use, business licensing, environmental permitting, building permitting, labor regulation (including foreign work permits), site inspections; which may also include business registration, utility regulation, and dispute resolution; The regulator may set fees commensurate with the cost of service delivery in the areas concerned;</p> <p>Monitoring compliance: Monitors compliance with the SEZs legal framework, including SEZ policies, regulations, standards, and other requirements, and enforces compliance through appropriate penalties independently from other public agencies.</p>
Developer	<p>Land use planning: Creates a final land-use master plan and prepares the land accordingly (grading, leveling, and other preconstruction activities);</p> <p>Provision of infrastructure: Internal road networks, drainage and sewerage, and conduits and infrastructure for zone utilities.</p>
Operator	<p>Facility leasing: Manages lease and rental agreements with investors and assumes responsibility for the main services of the zone (e.g., maintenance, security, waste management);</p> <p>Utilities provision: Ensure provision of onsite utilities (electricity, gas, water, telecommunications) through own provision or via domestic providers;</p> <p>Provision of other value added services: May include a wide range of services, such as business and training centers, medical and child care services, transport, and recruiting;</p> <p>Marketing: Experienced private developers often have a network of multinational clients across a range of industries to which they can market new SEZ opportunities.</p>

Source: Farole, 2011

4.4 The Management Model of the Athi River SEZ

There is currently no gazetted regulation that limits the type of business activities by economic zones. The Ministry of Industry, Investments and Trade together with the Zone Authority with the support of other interested stakeholders have developed a draft SEZ regulation that is awaiting gazette³³. These draft SEZ regulations creates new institutions that will help strengthen the environmental governance of the country's zones if their responsibilities are reviewed to inject in the ideals of green growth. According to the draft SEZ regulations, the zone authority has the power to consolidate, combine, and replace all approvals and associated procedures required by other relevant Government entities, including all regulations, licenses, permits, certification and similar approvals, as necessary to reduce the overall number or complexity of such documents. As much as this contributes to the desired ease of doing business, the consolidation of all environmental licenses, permits, and certification requirements into a single SEZ Environmental Permit, leads to enforcement conflicts in the sense that, when there is a pollution problem in the zone, the blame is squarely directed to NEMA without recognizing that NEMA can only enforce the law through the Zone Authority that in this case is the lead agency. It is therefore the duty of the Zone Authority to rally resident companies to meet and even exceed the set environmental standards. As currently constituted, the Zone Authority does not have this capacity.

The draft SEZ Regulation permits the secondment of personnel with appropriate skills and experience from Government entities to the Zone Authority to assist it in performing its functions through a signed MOU. This arrangement can be exploited to facilitate and strengthen the triple helix collaboration among research institutes, universities, industry and Government for purposes of promoting eco-innovation research for green growth. In order to strengthen the Zone

³³ Draft SEZ Regulations published by the Ministry of Industry, Investments and Trade and the Export Processing Zone Authority (EPZA) and other stakeholders

Authority's capability in advancing low-emission, resource use optimization and socially inclusive development pathways, the creation of a "Green Cell" to strengthen its green growth capability is proposed. As already stated, the "Green Cell" will be responsible for organizing awareness raising and capacity building sessions on resource efficient cleaner production (RECP) and Industrial Symbiosis (IS) practices; introducing focused RECP and IS improvement programs; partnering with donor agencies to help zone companies conduct detailed energy, water, and material audits; developing new standards, protocols, and guidelines as necessary to improve energy, RECP, IS and resource performance; providing the necessary technical assistance, knowledge, and information support to industries for reviewing their RECP and IS improvement plans; facilitating access to finance for RECP and IS by partnering with banks/ national/ bilateral/ international green funds; and identifying potential options for IS and inter-company collaboration (World Bank, 2014).

The draft SEZ regulations provides for a one stop shop (OSS). The OSS provides for the delivery of business advisory services based on appropriate research and SEZ user demand for services. Demand driven services within the SEZ include assistance with start-ups, operation, and closing of economic activities within the SEZs; technical assistance programs for new and young entrepreneurs; business training, general assistance and counselling; feasibility studies and market research; capitalization and grant assistance; information on production, marketing, operational plans, finance, export opportunities, recruitment and training; and financial support for domestic small businesses. One of the topics that should be covered under training should be on low-carbon, resource efficient cleaner production (RECP) as well as industrial symbiosis for increased productivity and competitiveness (UNEP, 2014). The training content should cover GHG inventorying and improvement target setting, good housekeeping, input material change, better

process control, equipment modification, technology change, on-site reuse and recycling, making of useful by-products and product modification (UNIDO, 2014). The inevitable residual waste after RECP will be subjected to industrial symbiosis exchange. Opportunities for financial support for zone based companies to cut costs and remain competitive can be obtained from the Kenya Climate Change Fund, bilateral green funds as well as international sources such as from the UNFCCC's Green Climate Fund (GCF).

The Zone Authority is mandated with draft SEZ regulations to ensure that all master plans and zoning plans do not conflict with existing land use controls for the areas surrounding the SEZs or related development objectives of the neighboring county. It is the Zone Authority's mandate to issue orders providing procedures and criteria for approving or rejecting land use master plans and zoning ordinances developed by SEZ developers or operators. The Zone Authority in coordination with NEMA, shall implement rules and procedures for assessing responsibility for handling and investigating non-compliance, for taking action to mitigate the impacts, and for initiating and completing corrective and preventive action. The Zone Authority shall then issue orders to responsible parties implementing all recommended and necessary corrective and preventive actions. The Zone Authority shall be responsible for enforcing compliance with the corrective and preventive action orders by ensuring that all actions are undertaken within deadlines specified in the orders. There is no gazetted regulation that limits type of business activities by industrial parks in Kenya. What is in place is a draft SEZ regulation that introduces new institutions such as the SEZ Advisory Committee, SEZ Association and Business Development Services (BDS) support that will help strengthen the economic zone governance capabilities. However, these draft SEZ regulations are weak on the promotion of environmental stewardship and do not address the country's need to promote green growth by prioritizing low-emission, resource use optimization

and socially inclusive and climate resilient development pathways. There is insufficient post park management system support that targets resident industries in their collective efforts of continual improvement. The South Korean Government has demonstrated that well managed industrial parks do provide support services to tenant companies that individual companies cannot secure independently in a cost effective manner in form of well-done roads, electricity and water, as well as environmental installations such as waste water treatment and disposal plants that are collectively built and provided for by the public sector in advance to enable tenant companies lower their overall investment costs (KIET, 2016). Though the same approach is mirrored in Kenya, field inspections revealed that there is a mismatch between the level of industrialization within the zones and the accompanying support infrastructure.

There is need for a well-structured approach to the establishment of SEZs/ IPs in the country. Such an approach will involve developed guidelines on selection of locations, establishment of industrial complex development plans, approval of industrial complex development plan, compensation, and creation of industrial complexes (KIET, 2016). Although the country has developed draft SEZ regulations, they are not comprehensive enough to offer guidance on low-carbon, resource efficient and climate resilient development pathways. There are no particular incentives for companies that want to fully embrace green growth by adopting RECP and IS. As a result, a “Green Cell” is proposed to augment the Zone Authority’s capability in green growth advisory support. The draft SEZ regulations do not talk about the need to undertake a strategic environmental assessment (SEA) that is increasingly becoming popular with planned industrial parks/ SEZs as per the provisions of section 57A of the Environmental Management and Coordination (Amendment) Act 2015 that states All policies, plans, and programs determined by NEMA as likely to have significant effects on the environment ... shall be subject to a strategic environmental

assessment (SEA). SEA comprises of analytical and participatory approaches that aim to integrate environmental consideration into policies, plans, and programs and evaluate the interlinkages, with economic and social considerations³⁴. According to NEMA, the SEA process extends the aims and principles of an EIA upstream in the decision making process, beyond the project level, when major alternatives are still possible (UNEP, 2002).

Benchmarking of South Korea's industrial parks with those of Kenya reveals important differences that can inform Kenya's industrialization policy. Kenya's industrial development complexes tend to be small in size, dispersed around the country and located around logistical urban centers. In order to promote knowledge intensive industries using high quality work force, larger sized industrial complexes are preferred and should be developed around metro areas where labor sourcing is easy³⁵. Apart from providing an enabling physical infrastructure such as transportation, power, and a reliable water supply, the industrial park should also provide pertinent innovation infrastructure that revolves around a strengthened University/ Research Institute – Industry – Government collaboration that will permit industry easy access to Universities, laboratories and specialized research institutes. The Kenyan SEZ development "land use plan" exclusively allow uses of the sites only for factories and warehouses. This restriction should be lifted to allow uses of the sites for residential, commercial as well as multi-cultural facilities (KIET, 2016). The country's industrial location policy in SEZs/ IPs should be cluster based while also embracing other urban development rules for green growth. A techno-park model of industrial development is recommended for Kenya. It is a concept of planned industrial development that includes

³⁴ NEMA – National Guidelines for SEA in Kenya

³⁵ Korea Institute for Industrial Economy and Trade – KIET, 2016. Knowledge sharing program with Kenya through Senior Policy Dialogues

technology, R&D and space in which universities, research institutes and enterprises gather and closely collaborate with one another (World Bank, 2014).

The country's draft SEZ Regulations do provide for the establishment of an advisory committee for each of the country's SEZs. Its membership is drawn from the relevant county and local authorities; SEZ developers, SEZ operators, SEZ enterprises and representatives from an established SEZ resident associations from adjacent communities. This Advisory Committee will be the best forum in which issues of RECP and IS can be discussed in a manner that justifies the business sense of embracing it. In other words, it should be the responsibility of this advisory committee to champion for the uptake of RECP and IS whose successful implementation will help create green jobs that will benefit the surrounding communities. Unfortunately, this is not one of the listed functions of this advisory committee. According to the draft rules, these advisory committees will perform the following rules and responsibilities: advising on the development of the SEZs; organization of fairs and market days for local job seekers; supplier-buyer match-making, and other mechanisms for fostering linkages with the surrounding economy and culture; locating sources of assistance for development of the SEZs; coordinating the connection of the SEZ to infrastructure networks in the adjacent areas; disseminating information to the public regarding the SEZ program in general, as well as regarding the specific SEZ in their locality; promoting investments in the SEZ; contributing to proper security and policing in the SEZ; devising and promoting activities linked to the SEZ for the benefit of the local population, including as regards the production and supply of raw materials, miscellaneous products and services, and food stuffs for SEZ users; assessing and reporting on any difficulties in the operation of the SEZ in their locality; and advising on the resolution of implementing stated problems.

Learning from the experiences of the EU and South Africa, one of the key recommendations that this advisory committee can make to the Kenyan SEZs is the need for them to embrace RECP and IS clubs in helping to disseminate best practices as regards RECP and IS methods, approaches, and techniques³⁶. A RECP and IS club is a regional community made up of industrial companies who are willing to independently study best practices and techniques of RECP and IS, apply them in companies, reduce production costs and negative environmental impacts resulting from their activities and increase their profits (SCU, 2013; WCG, 2013). The EU's RECP and IS experiences demonstrate that club members benefit through having complete access to information concerning the world's best practices, innovative techniques, best managerial approaches; improving the qualification and competence of the company's staff; reducing the environmental impact produced by the company; reducing the company's operating costs by increasing its productivity and efficiency; promoting the goods and services of the company (through activities organized by the RECP Clubs, media and communication with the Clubs' members)²¹; sharing practical experience, ideas and possibilities with other like-minded people and professionals; getting a chance to become a part of progressive-thinking, innovative community, creating your own success story (SCU, 2013; WCG, 2013).

The RECP and IS club member companies will benefit from professional assistance from the team of national experts on how to implement RECP and IS approaches; methodological guidelines and manuals; sharing experiences with other members of the clubs and the program experts; and an opportunity to take part in a series of module-based seminars on topics such as environmental profiting of the company; energy efficiency; industrial symbiosis; water consumption and withdrawal, materials use and waste generation; chemical substances and emissions; and making

³⁶ Primer – Resource Efficient and Cleaner Program in Belarus - 2015

action plans for RECP and IS implementation²¹. The SEZ advisory committee should embrace this approach while seeking to accelerate the adoption of RECP and IS in Kenyan SEZs. In order for this SEZ Advisory committee to promote IS successfully, China presents very relevant and workable solutions. According to the Chinese experience, the sequential steps of establishing an IS network according to the Chinese experience that is borrowed from the UK is to firstly recruit new business members; secondly, facilitate exchange of information between businesses through quick win workshops; thirdly, undertake resource mapping to record resources and facilitate potential matches/ synergies; fourthly, develop an on-line tool for symbiosis management detailing information on resources and contact details; fifthly, facilitating synergies through negotiations and technical advice; and sixthly, summarizing output and verifying inputs (Lei, 2006; Geng et al. 2012).

This SEZ Advisory committee should champion for the assessment of low-carbon resource availability, for example the potential for generating and/or sourcing renewable power in the economic zones; incorporation of low-carbon considerations into industry and technology selection for enterprises and utilities within the SEZs – performing global benchmarking studies for the same; establishment of infrastructure and logistics to maximize the potential for industrial symbiosis opportunities; incorporation of GHG, energy, water, and waste management reporting within the overall framework for performance reporting; and selection of skilled employees with experience in operating sustainable industrial processes (World Bank, 2014). The guiding principles should be articulated for both Zone Authorities and enterprises. In addition, planning of new processes should be based on global best practices (UNEP, 2014). The proposed SEZ Association in the draft SEZ regulations should ideally spread the message that economic zones that attract green foreign direct investments (FDIs) are those that are low-emission, resource

efficient and socially inclusive by virtue of their ability to create decent green jobs (UNEP, 2014). The proposed SEZ Association within the SEZ Regulations will be established as a non-profit organization consisting of SEZ developers, operators, sub-developers and sub-operators, specialized service providers, and SEZ enterprises. The Association will be directed by a General Assembly of members and managed by a 15 member board of Directors elected for two year terms, including a President, Executive Vice President, Secretary, Treasurer, and Directors representing specific investment sectors. As stated in the draft SEZ regulations, the mission of the SEZ Association shall be to promote its members development and competitiveness in the international market place.

The goals of the Association will be to represent and defend the interests of the SEZ program and to promote an enabling climate for its development and to position Kenya's SEZs as the country's economic growth engine and to contribute to making the country an ideal destination for foreign investment as well as the production of world class goods and services. By virtue of its strong governance structure, the proposed SEZ Association with the help of the SEZ Advisory Committee should lobby to bring on board the political leadership of the country, along with relevant Ministries, to formulate a unified vision for low-carbon industrial development and translate this vision into a national policy for economic zone design and development (World Bank, 2014). To accomplish these goal, this SEZ Association shall participate in various business, trade, investment, industry, management, economic, and vocational training organizations and bodies; and conclude institutional arrangements with bodies that enhance SEZs' vocational training, labor relations climate, social responsibility, and Government policy; raise knowledge about and promote investments in its member SEZs; and secure benefits for its members from various parties. In order to realize this noble and ambitious goal, the SEZ Association must lobby Government to

review the draft SEZ Regulations and include in them the provisions for the country's green growth agenda that is currently the bedrock for accelerated green FDIs. The Association should lobby Government for the establishment of incentives that will make it attractive for the current economic zones to become low-carbon zones (LCZs).

There was no deliberate attempt by the Kenyan zone authority to create an enabling policy environment for the growth of its embryonic clusters as was successfully done in the EU, China, Japan, South Korea and South Africa through the creation of cluster based technology service centers, supporting the development of export networks, promoting the use of incubators, investing in cluster-based R&D, creating policies that support and encourage clusters rather than prevent and discourage them from emerging, encouraging cluster collaboration and cooperation in formal networks, creating and supporting communication channels, re-organizing service delivery structures and information delivery services, creating entrepreneurial support and learning networks, using clusters as a context for learning, promoting the development of cluster skill centers, stimulating innovation and entrepreneurship, creating enabling financial vehicles, allocating resources and investments, and promoting competitive funding programs (Ghali et al. 2014; MELE, 2013). Embracing the actions explained below will help Kenya nurture successfully its embryonic clusters the way it was done in Asia and Europe (World Bank, 2009). A total of 20 waste recovery and material recycling jobs have been created at the economic zone as a result of innovative interventions in waste recovery and recycling.

The conceptual framework of this model is premised on the fact that the Zone Authority alone cannot be able to fully drive the green growth agenda of the economic zones. It there calls for development of partnerships that seek to strengthen the Zone Authority's capacity to drive the

green growth agenda. As stated in the model this is achieved through the strengthening of the triple helix collaboration between Academia/Research Institute-Industry-Government collaboration. The key role of knowledge institutions is to undertake demand driven research that will help the economic zone adopt best practices of waste and by-product exchange. The “Green Cell” whose main purpose will be to help strengthen this triple helix collaboration will also seek to work with parent ministries as a way of seeking to influence policy development from a green growth perspective. The “Green Cell” will also work with financial institutions with a view to encouraging them to develop low interest loans for green growth through their sustainable financing initiatives. A cluster wise approach is adopted as a way of improving the spatial planning of the economic zone to facilitate easier waste and by-product exchange. The ultimate goal is to divert wastes from the landfill and instead use them as raw material inputs for another production line through industrial symbiosis. The aim of waste management within a green economic zone is to combine different production processes, industries and enterprises together through resource sharing, by-product exchange and waste symbiosis, with a view to realizing a closed loop flow of materials.

The proposed governance model of the Athi River SEZ is based on a strengthened triple helix collaboration framework. The study proposes the creation of a “Green Cell” that will be housed at the Zone Authority with the sole purpose of strengthening the Zone Authority’s capacity in promoting green growth through resource use efficiency, cleaner production, industrial symbiosis as well as working to minimize the generation of climate changing GHGs. The “Green Cell” will among other activities promote the Zone’s green growth agenda and climate resilient development pathway on a cluster-wise basis. This is realized through a continuous search for waste and by-product exchange synergies among all the economic zone’s clusters. In order to strengthen its R&D capabilities the “Green Cell” will partner with knowledge institutions in form of

Universities, Research Institutes, and specialized centers of excellence (Figure 11). This strengthened University/ Research Institute-Industry-Government collaboration will create an innovation ecosystem that will drive the Zone's green growth agenda. It will be the sole responsibility of the "Green Cell" to not only promote RECP among the zone clusters but also accelerate the uptake of IS through: (i) building of IS networks; (ii) facilitation of exchange of information between businesses; (iii) mapping of zone wide resources; (iv) facilitating of potential matches/ synergies; (v) creation of an online symbiosis management tool; (vi) facilitation of company negotiations and provision of technical advice; and (vii) verification of outputs (Shi, 2010). Feedback from the implementation of RECP and IS will inform policy development at the country's Ministry of Industrialization. Financial institutions will also be engaged so that they can help operationalize the emerging sustainable financial initiatives.

For a special economic zone (SEZ) to operate in a green way, it has to establish and make functional an enabling waste and by-product exchange infrastructure. Such infrastructure will broadly comprise of enabling support institutions, a functional and interactive industrial symbiosis network, and a supportive governance structure. An environmental service center, a technology service center, and an information center all operating under the umbrella of a "Green Cell" will constitute key institutions that will be entrusted with the Zone's green growth. The "Green Cell" will also benefit from the triple helix collaboration with Research Institutes and Universities. As zone industries consume raw materials, water and energy, they will generate a wide range of wastes and by-products. Some of these wastes and by-products will be recycled on-site with a residual fraction being forwarded to the waste exchange center. This waste exchange center will operate on the strength of an information platform and data base that helps to build synergies between waste generators and those who need the waste for use as their raw material feedstock. A

technological infrastructure is required to smoothly facilitate these waste recovery efforts. The exchange of wastes and by-products through an information platform and data base will help divert useful materials from being landfilled. This will not only lower pressure on the use of virgin materials but also reduce the negative environmental impacts of landfilling. Governments, Zone Administrators, the market environment, enabling laws and financing mechanisms should jointly work together to promote industrial symbiosis.

The Athi River SEZ does not have a management model that is capable of driving it towards a low-emission, resource efficient, and climate resilient development pathway. Such a model should ideally comprise of a set of management objectives, an accompanying management content, an enabling implementation environment, and a monitoring and evaluation framework³⁷. The study proposes the creation of a “Green Cell” to be based at the Zone Authority for the sole purpose of promoting resource efficient and cleaner production (RECP) and Industrial Symbiosis (IS) among the identified clusters of the zone. The management objectives of the Green Cell will target efficient utilization of the zone waste as a resource so as to demonstrate it’s economic, environmental, social, and public health benefits. The Green Cell’s management content will address issues of comprehensive management of generated zone waste through source reduction at enterprise and zone-wide levels; how recycling can be optimized through proper waste collection and categorization; how useful wastes and by-products can be re-generated from the common waste pool through useful material recovery, on-site material and energy conversion, and adoption of environmentally sound technologies for managing emissions from landfills and incinerators. All these noble actions can only work successfully in an enabling environment of

³⁷ UNIDO, 2013. China Center for South-South Industrial Cooperation – Guidelines for Green Industrial Parks

supportive laws and regulations, functional management systems, adequate technological support, and an up to date information exchange platform that are non-existent at the zone at the moment²⁰. An independent waste exchange clearing house should be established at the zone to facilitate companies that embrace industrial symbiosis through matchmaking and synergy building;

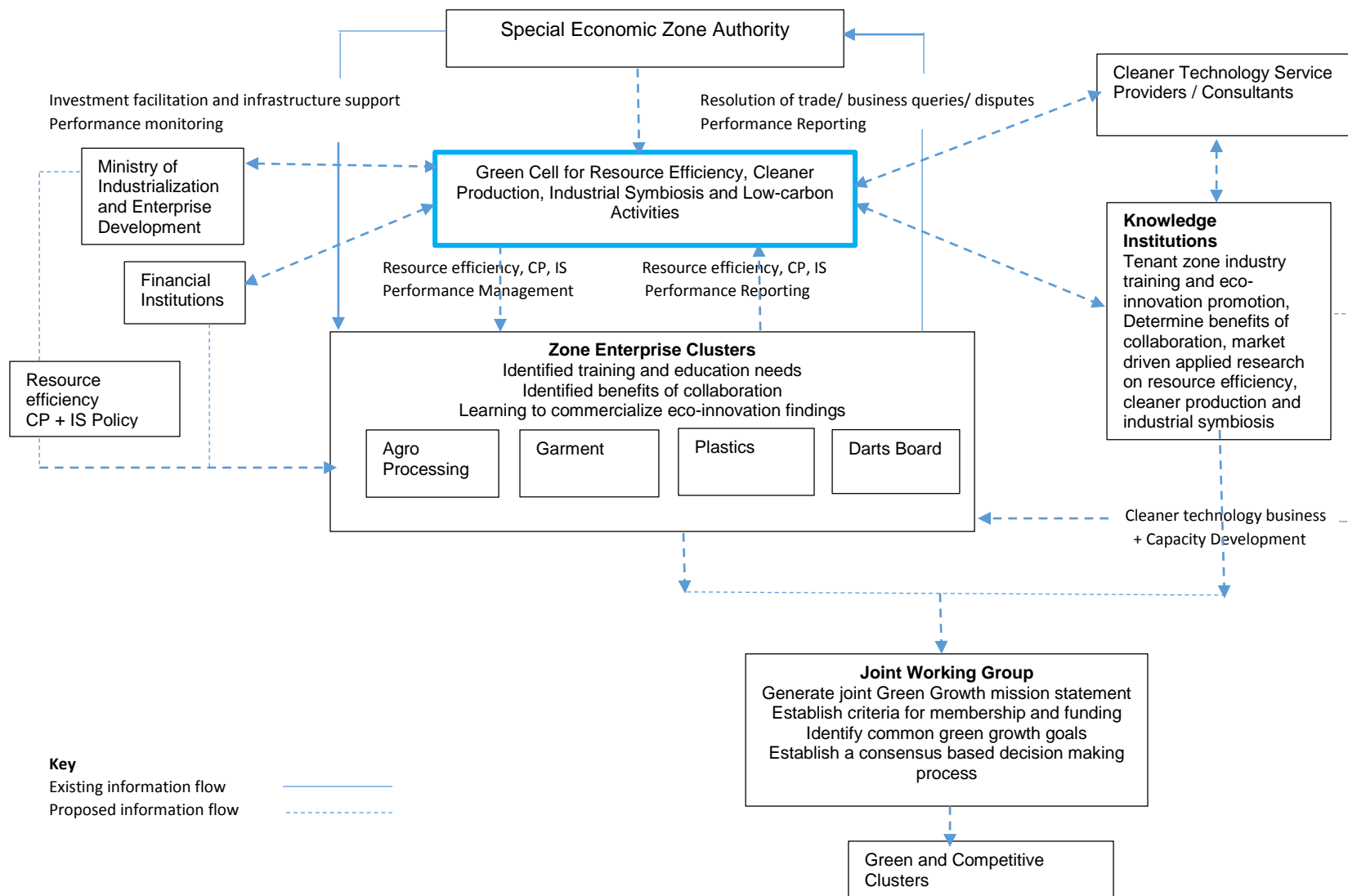


Figure 11: Industrial Ecology Model for the Athi River SEZ

4.5 Policy Implication of RECP and IS Promotion on Kenya's Green Growth Agenda

This study sought to investigate the possibilities for waste and by-product exchange among the resident companies of the Athi River SEZ. The investigations established that though not planned, the art of waste and by-product exchange was on-going among the zone's four clusters, namely agro-processing, plastics, garments, and darts board manufacturing. These are the initial stages of an emerging and promising circular economy whose successful development will depend on how well the Government develops enabling policies and strategies. There is strong international consensus that linear economic models can only function if endless resources are available to satisfy endless and increasing demand. The objective of a circular economy is to preserve the value of utilized resources and materials for as long as possible, to use them as frequently as possible, and to produce as little waste as possible (ideally none at all) (Wilts, 2016). On-site reuse and recycling of wastes and by-products will divert them from the landfill and fundamentally reduce pressure on the country's use of virgin resources. This will help create new and innovative products from wastes, reduce the environmental impacts associated with landfilling and also create green jobs. This will contribute strongly to the country's green growth agenda that is spelled out in the draft Green Economy and Strategy Implementation Plan (GESIP). The country's green growth agenda puts priority on development pathways that are low-emission, resource efficient and socially inclusive in terms of creating innovative green jobs.

It prioritizes a shift from the traditional linear development model that is characterized by linear flows of matter, where raw materials are extracted, processed into products, consumed, and discarded with a trail of waste at each stage of the supply chain to the adoption of a circular economy driven by RECP, the 3Rs and IS. However, absence of an enabling policy framework for RECP and Industrial Symbiosis is frustrating the accelerated uptake of this emerging and

promising green industrial revolution. In order to fully actualize waste and by-product exchange within the SEZ, there is need for infrastructure that will facilitate waste recovery for recycling. There is also need to make the monitoring, reporting, and review mechanisms work more efficiently and the Zone Authority will need to implement and operate a zone-wide information system that will (i) support inter-enterprise communications; (ii) provide a centralized data acquisition and analysis system to monitor energy, GHGs, and waste flows; (iii) inform enterprises on latest developments in the areas of waste reduction, reuse, recovery and recycling. Some of these innovative initiatives should be driven by the Government through a supportive incentive scheme. Closer interactions between academia, industry, and Government will help promote the development of jointly funded and demand driven research programs in the areas of resource use efficiency, cleaner production and industrial symbiosis that will yield environmentally sound technologies for waste recovery and recycling. The ultimate approach is to ensure that priority is granted to waste reduction through resource use efficiency and cleaner production (RECP) before engaging industrial symbiosis (IS) to deal with the inevitable residual waste.

Adoption of the green growth agenda will require a new skill set that is developed through training and re-training in RECP and IS. Unfortunately, the Zone Authority as is currently constituted does not have capacity in promoting the Zone's green growth Agenda. That is why the study is recommending the creation of the "Green Cell" to be working hand in hand with the Zone Authority and other lead agencies in promoting low-carbon, resource efficient and climate resilient development pathways. According to the World Bank, the chief objectives of such a "Green Cell" are to: (i) drive the transition of current and upcoming EPZs to LCZs, by conducting regular and focused capacity-building programs on the environmental and energy performance of enterprises; (ii) support EPZ enterprises in implementing energy efficiency projects and other low-carbon

projects by acting as the first point of contact (FPOC) and the single point of contact (SPOC) for all low-carbon development-related queries and activities within EPZ; (iii) formulate and implement EPZ-level rules, guidelines, and governance mechanisms on GHG emission mitigation, energy efficiency, RECP, IS, and waste and water management (These policies will be aligned with national acts, laws, regulations and other development priorities; and (iv) facilitate and assist the Zone Authority in inter-departmental and inter-ministerial coordination and communications, to ensure that respective government agencies are informed and their policies are taken into consideration, and to encourage these agencies to provide necessary inputs and feedback.

Adoption of resource use efficiency, cleaner production, and industrial symbiosis will enable Kenyan industrial establishments meet and even exceed their climate change duty obligations of demonstrating continual reduction of GHG emissions. An economic zone that embraces RECP and IS will clearly be contributing to the country's projected wish to attain a low-emission and climate resilient development pathway as is stipulated in its 2015 Intended Nationally Determined Contributions (INDC)³⁸. By embracing project activities such as enhancement of economic zone energy and resource use efficiency; adoption of clean energy technologies to reduce over-reliance on wood fuels and adoption of sustainable waste management systems will help the country realize its goal of abating its GHG emissions by 30% by 2030 relative to the BAU scenario of 143 MtCO₂eq. The four green growth mainstreaming mechanisms that Kenya should embrace includes public environmental expenditure review (PEER), strengthening of the strategic environmental assessments (SEAs) for upcoming industrial parks, establishment of a council for Sustainable Development and adoption of green accounting principles (Bennet & James, 1997). According to

³⁸ Ministry of Environment and Natural Resources, Kenya's Intended Nationally Determined Contribution (INDC), 23 July 2015

the OECD, the eight green growth policy instruments relevant for Kenya include certification of sustainable products and trade; embracing of subsidy reforms; adoption of payments for ecosystem services (PES); adoption of an environmental fiscal reform; creation of green energy investment frameworks and incentives; embracing of inclusive green social enterprise; adopting sustainable green public procurement; and embracing green innovation (ADB, 2012; OECD, 2012).

In order for Kenya to embrace and fully benefit from its green growth agenda, it has to invest in green technological innovation and development (UNIDO, 2011). As a result, the Kenyan Government has to invest in: (i) the strategic expansion of its green technologies (ii) establishment of an efficient green technology development system; (iii) facilitation of the transfer and commercial industrialization of green technologies; (iv) expansion of infrastructure for the development of green technology and industry; (v) promotion of international cooperation for green technology, research and development and transfer; and (vi) development of green technology and industry as the country's new growth engine (GGGI, 2015a). Kenya's Science, Technology and Innovation (STI) Act of 2013 proposes the establishment of the National Research Fund that will be equivalent to 2% of the country's GDP on annual basis³⁹.

³⁹ The Science, Technology and Innovation Act, 2013, No. 28 of 2013 - *Date of Assent: 14th January, 2013*

CHAPTER FIVE: SUMMARY OF KEY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Key Findings

Though not pre-planned, the clusters at the Athi River SEZ have started taking shape naturally due to the prevailing market forces of supply and demand. Proper planning of the economic zone guided by the development of green economic zone master plans will have helped to locate companies that exchange wastes and by-products in close proximity for ease of material exchange. A more sustainable approach dictates that companies should first embrace resource efficient cleaner production (RECP) before engaging in waste and by-product exchange as a way trying to prevent the temptation seeking to generate more waste for exchange. However, due to limited awareness, the zone based companies were not yet embracing (RECP) practices and techniques. Waste and by-product exchange through industrial symbiosis was just starting to take shape at the economic zone. Industrial symbiosis should focus on managing the inevitable residual waste after engaging (RECP). The ultimate goal is to use industrial symbiosis as a tool for diverting wastes from the landfill. Doing this will not only lower the pressure on the use of virgin materials but also eliminate the environmental problems associated with landfilling. However, its progress will likely be slowed down by the economic zone's weak infrastructure for waste recovery and recycling. Ongoing waste and by-product exchange within the economic zone has led to the creation of 20 decent green jobs, avoided GHG emissions, and lowered costs of production. Through awareness raising, information dissemination, training and setting up of demonstration projects, zone based companies can be enabled to fully embrace the principles of industrial symbiosis that is already spontaneously evolving within the ranks of the zone clusters. The institutional capacity of EPZA needs to be strengthened so that the Zone Authority can be able to promote low emission, resource efficient and socially inclusive development pathways.

5.2 Conclusions

The identified clusters at the economic zone were not pre-planned but instead evolved on their own due to the prevailing market forces of supply and demand. Although clusters do provide a powerful framework in which companies organize, work together with the Government and academia in promoting their growth interests, their meaningful growth can only be assured if there is an enabling policy, legal and institutional framework. Proper initial planning of the zone will have ensured that those cluster companies that exchange wastes and by-products were located in close proximity to each for purposes of easing the exchange.

Waste and by-product exchange through industrial symbiosis was at its infancy at the economic zone. Detailed investigation of the material flows in the selected clusters revealed that some cluster companies were already exchanging wastes and by-products. However, the industrial symbiosis's much anticipated progress is likely to be slowed down by the zone's weak infrastructure for waste recovery and recycling. Though at infancy, waste and by-product exchange has already helped to create green jobs, lowered GHG emissions, and lowered costs of production. There was no metering and sub-metering of material flows through the production lines. This has dampened the full exploitation of the benefits of industrial symbiosis by the economic zone.

The tenant companies of the zone were just beginning to embrace the principles of industrial ecology by deliberately attempting to connect waste and by-product streams into closed loop supply chains. By seeking ways to "close-the-loop" on material cycles, IE extends the useful life time of material resources and reduces the impact of their acquisition on the environment (WBCSD, 2002). On a prioritized basis, the zone companies should fully embrace the principles of resource use efficiency and cleaner production before engaging industrial symbiosis in

mitigating its environmental challenges. This will entail awareness raising, training and setting up of demonstrations by the proposed “Green Cell”.

It was established that the EPZA as is currently constituted does not have the human and techno-managerial capacity to promote low-carbon, resource efficient and climate resilient growth pathways for companies that reside within the zone. The global trend has shifted to increasing economic zone competitiveness through improved resource use efficiency, cleaner production, and industrial symbiosis. This new development paradigm is meant to decouple economic growth of zones from further increases in greenhouse gas (GHG) emissions and harmful waste generation (UNEP, 2011; World Bank, 2014). Speedy adoption of Industrial Ecology in Kenya will depend on the country’s ability to set up demonstrations that show that embracing the concept makes good business and environmental sense as has been successfully done in Europe and Asia. There will also be need for incentives to help accelerate the rate of adoption.

5.3 Recommendations

Policy Recommendations

1. The economic zone’s industrial clusters were spontaneously evolving. For them to mature and serve the intended purpose of tenant company cooperation towards the common and shared vision of embracing waste and by-product exchange through industrial symbiosis; strengthening of business networking and best practice exchange; engaging team effort in solving waste related environmental challenges, and linking and aligning the different stakeholder interests from the a triple helix perspective, there will be need for the establishment of an industrial cluster promotion policy framework for our special economic zones (SEZs)/ industrial parks (IPs). The industrialization process of our SEZs/ IPs should therefore be cluster based and that this requirement should be incorporated early during the

development of SEZ/ IP master plans. A cluster approach to industrialization will enable the country's SEZs/ IPs strengthen their consensus building capabilities on key issues of mutual interest such as industrial symbiosis; enhance company-to-company interaction; and strengthen the University/ Research Institute – Industry- Government collaboration in promoting eco-innovation for the much needed green growth.

2. The material flow patterns within the within the Athi River SEZ were largely linear in the sense that raw materials are mined, value added to produce products that are consumed with a trail of waste at each stage of this supply chain. This waste certainly finds itself to the landfill. There is therefore need to create an enabling policy and institutional framework that will work towards converting the economic zone's current wasteful linear production economic model into a circular economy that seeks to divert wastes from the landfill. Embracing such a circular economy will help reduce pressure on the use of virgin raw materials and also avoid the negative environmental impacts of landfilling wastes. This is why this research is recommending the creation of a "Green Cell" to be housed at the Export Processing Zones Authority (EPZA) and work closely with KIRDI's Green Growth Advisory Centre (GGAC) in advancing the economic zone's green growth agenda based on a circular economy approach. There will also be need to strengthen the zone's waste recovery and recycling infrastructure so that zone companies are enabled to exchange wastes and by-products. Doing this will help create decent green jobs and also conserve the environment. There will be need for an on-line data base of wastes and by-product generation within the economic zone for purposes of seeking to establish industrial symbiosis synergies.

3. The application of industrial ecology principles for mitigation the environmental challenges of the Athi River SEZ were rather low and in most cases non-existent. As a result, zone based Production Managers were reacting to already generated waste (end-of-pipe approach) as opposed to being pro-active and preventing its generation at source. There is therefore need for awareness raising, information dissemination, training and capacity building, and setting up of convincing demonstrations on contemporary tools of environmental management such as resource efficient cleaner production (RECP), the 3Rs, and waste and by-product exchange through industrial symbiosis as a way of seeking to obtain top management buy-in.
4. The Export Processing Zones Authority (EPZA) as is currently constituted did not have the technical and human resource capacity to promote the green growth agenda for all the companies that operate within its licensed economic zones across the country. These shortcomings can be strengthened through triple helix collaborative framework between Universities, Industries, and Government that creates an innovation ecosystem powered by Research, Development and Demonstration (RD&D).
5. The SEZ Act of 2015, the draft SEZ policy, and the draft SEZ regulations were all inadequate in as far as the incorporation of the elements of sustainability in the management and governance of SEZs. All the three documents did not address the need for Kenyan SEZs to go green and by doing so be in a position of attracting green foreign direct (FDI) investments. Therefore the country's special economic zone (SEZ) Act, draft SEZ policy, and draft SEZ Regulations, should be reviewed to insert priorities on Resource use Efficiency, Cleaner Production, the 3Rs of reducing, reusing and recycling wastes, and Industrial Symbiosis as the most preferred low-carbon, resource efficient, and socially

inclusive development pathway that will enable the country's SEZs to realize increased productivity and competitiveness.

6. The country should develop inclusive green growth development strategies, action plans, and implementation plans for all its SEZs that puts priority on resource use efficiency and cleaner production (RECP), and industrial symbiosis as a way of advancing the green growth agenda through the 3R philosophy of reducing, reusing and recycling.

5.4 Future Directions of Research in the Area

Developed and developing countries alike have committed themselves to promoting green growth. According to the International Institute for Environment and Development (IIED), green growth needs to become a human agenda if it is to mobilize the energies, creativity and assets of the majority of people. In other words, green growth can and should engage people where they are – in small businesses, on farms and in informal economies – and not just in the major formal sectors . The green growth agenda should address the pressing problems which hold people back from better use of environmental and other assets – notably poverty and inequality. In the context of this research, the following future directions for research as recommended: Determination of incentives that will help accelerate the adoption of resource efficient cleaner production, the 3Rs, and industrial symbiosis by both the service and manufacturing sectors of the special economic zones (SEZs); The Role of RECP, the 3Rs, and IS in promoting the green growth agenda of countries through the Paris Agreement especially as envisioned by the Global 2030 agenda; Determination of how industrial symbiosis (IS) contributes to the realization of the country's sustainable development goals (SDGs); Development of tools/ software for resource mapping and facilitation of potential resource matches/ synergies for purposes of

facilitating industrial symbiosis networks within the existing and planned SEZs/IPs; Operationalization of incentives necessary for strengthening University-Industry-Government (UIG) collaboration in promoting eco-innovation research for green growth; How to innovatively promote the governance of the country's cross-cutting green growth agenda in an environment where Government Ministries and Departments hardly talk and engage each other, but instead adopt a "silo" approach to development promotion; and How best to overcome the barriers of social inclusion in green growth and promotion of pro-poor inclusive green growth (IGG) development trajectories. Barriers to the inclusive greening of Kenya's economy have hindered progress towards sustainability. The issue being that many Government policies do not adequately address and align government interests with those of the poorest of the poor, and while high formal environmental standards have been put in place, they are not reaching out to the poor – leading to serious environmental mismanagement.

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Annex 1: PhD RESEARCH QUESTIONNAIRE 2014
CENTER FOR ADVANCED STUDIES IN ENVIRONMENTAL LAW AND POLICY
(CASELAP)

GENERAL INFORMATION

1. How big is the EPZA/ SEZ land area?

.....

2. When was the SEZ established?

.....

3. Total Number of employees at the EPZA?

.....

4. Total Number of Companies in the zone

.....

5. What is the Governance structure of the EPZA?

.....

.....

6. Which national laws are administered by the zone?

.....

.....

7. How has the EPZA concept evolved in the country over the decades?

.....

.....

8. Which percentage of the park is already developed? Does the EPZA have a development master plan?

.....

.....

9. Outline your facilitatory roles at the EPZA. What rules does the EPZA enforce?

.....

.....

Regulations applicable to the Zone as a whole

For which of the following items does the estate have responsibility by law? Kindly tick

	Yes	No
<i>Environmental Impact Assessment</i>		
<i>Environmental Audits</i>		
<i>Meeting emission/discharge standards</i>		
<i>Occupational health and safety</i>		
<i>Undertaking waste disposal</i>		
<i>Other (specify)</i>		

Regulations Applicable to tenant companies
What regulations exist in the following areas?

	Zone by-law	National regulation
<i>Environmental Impact Assessment</i>		
<i>Site or operational permit</i>		
<i>Emissions/ discharges</i>		
<i>Waste treatment and disposal</i>		
<i>Occupational safety</i>		
<i>Chemical storage</i>		
<i>Fire protection</i>		
<i>Building standards</i>		
<i>Landscaping</i>		
<i>Other</i>		
<i>(please give details on separate sheet)</i>		

10. What type of infrastructure already exists in the zone?

.....

11. Are there green building codes, energy efficiency standards for different sectors or climate change impact assessment procedures currently being enforced by the EPZA?

.....

12. From your knowledge, which companies are currently reusing and recycling resources at the EPZA? Do they already have networks for exchanging waste from one company to the other?

.....

13. Do you promote climate friendly investments? If so how

.....

14. What are the environmental challenges of managing the EPZA industrial park?

.....

15. Is there a functional waste reuse and recycling system at the EPZA?

.....

16. Type of Land Use

Percentage of Area

- | | |
|----------------------------------|-------|
| a. Free Port | ..... |
| b. Free Trade Zone | ..... |
| c. Science and Technology Park | ..... |
| d. Incubators | ..... |
| e. ICT Park | ..... |
| f. Regional HQs | ..... |
| g. Tourist and Recreational Zone | ..... |
| h. EPZs | ..... |
| i. Industrial Park | ..... |
| j. Landscaped green areas | ..... |
| k. Undeveloped areas | ..... |

17. In what way have research institutes and/or academia been of help to the EPZA? Please tick

	Yes	No
Environmental training and education		
Environmental Audits		
Environmental Impact Assessments		
Technology Assessments		
Environmental monitoring		
R&D on pollution options		
Other (specify)		

.....

.....

18. Nature of Industries in the SEZ

Type of Industry	Number of Plants	Number of Employees	Production Volume (tons)
Petrochemical processing			
Iron and steel processing			
Non-ferrous metal industries			
Chemical manufacturing			
Energy generation			
Construction industry			
Transportation sector			

<i>Communication technology</i>			
<i>Food processing</i>			
<i>Drinks manufacture</i>			
<i>Textile manufacturing</i>			
<i>Leather processing</i>			
<i>Electronic manufacturing</i>			
<i>Pharmaceutical production</i>			
<i>Plastics formulation/processing</i>			
<i>Paint manufacture</i>			
<i>Ceramics/glass manufacture</i>			
<i>Pulp and paper production</i>			
<i>Packaging manufacture</i>			
<i>Metal plating</i>			
<i>Other (specify)</i>			

.....
.....

Service industries on site

	<i>Number of Plants</i>	<i>Number of employees</i>	<i>Production volume</i>
<i>Incineration</i>			
<i>Transport</i>			
<i>Warehousing</i>			
<i>Chemical storage</i>			
<i>Recycling</i>			
<i>Waste treatment/disposal</i>			
<i>Laboratories</i>			
<i>Information technology</i>			
<i>Consultancy</i>			
<i>Banking, finance, insurance</i>			

.....
.....

19. List your quantified amounts of all your inputs, products, wastes and by-products as tons per year (tons/yr) for the last three years

	<i>Quantified inputs(tons/yr)</i>	<i>Quantified products(tons/yr)</i>	<i>Quantified wastes(tons/yr)</i>	<i>Quantified by-products(tons/yr)</i>

<i>Petrochemical processing</i>				
<i>Iron and steel processing</i>				
<i>Non-ferrous metal industries</i>				
<i>Chemical manufacturing</i>				
<i>Energy generation</i>				
<i>Construction industry</i>				
<i>Transportation sector</i>				
<i>Communication technology</i>				
<i>Food processing</i>				
<i>Drinks manufacture</i>				
<i>Textile manufacturing</i>				
<i>Leather processing</i>				
<i>Electronic manufacturing</i>				
<i>Pharmaceutical production</i>				
<i>Plastics formulation/processing</i>				
<i>Paint manufacture</i>				
<i>Ceramics/glass manufacture</i>				
<i>Pulp and paper production</i>				
<i>Packaging manufacture</i>				
<i>Metal plating</i>				
<i>Other (specify)</i>				

.....
.....

Service industries on site

	<i>Quantified inputs(tons/yr)</i>	<i>Quantified products(tons/yr)</i>	<i>Quantified wastes(tons/yr)</i>	<i>Quantified by-products(tons/yr)</i>
<i>Incineration</i>				
<i>Transport</i>				
<i>Warehousing</i>				
<i>Chemical storage</i>				

<i>Recycling</i>				
<i>Waste treatment/disposal</i>				
<i>Laboratories</i>				
<i>Information technology</i>				
<i>Consultancy</i>				
<i>Banking, finance, insurance</i>				

.....
.....

20. How familiar are you with the concept of eco-industrial parks (EIP)?

.....
.....

21. What do you think will be the challenges you will face as regards embracing EIP management?

.....
.....
.....

22. Do you have any training or education programs for your own staff or park businesses on making them more resource efficient and ecologically friendly?

.....
.....

23. How does the EPZA currently link and network with businesses within the park?

.....
.....

24. What are the drivers for collaborative relationships within the zone?

.....
.....

25. What parameters influence the zone's collaboration and partnerships?

.....
.....

26. How well do you think economic and ecological concerns are integrated into the EPZA policy to enable its park businesses to minimize ecological impacts of buildings, optimize energy efficiency, reduce ozone depletion as well as generation of climate changing emissions, maximize efficient use of resources, maximize water use efficiency and integrate ecological principals in social and economic development policy while facilitating and promoting greener industrial development.

.....

 27. What kind of role would you like EPZA to have in the promotion of EIPs?

28. Who provides or is responsible for the following services, tools, or actions within the Park.
 Kindly tick

	<i>Industrial authority</i>	<i>Operational units</i>	<i>Government authority</i>	<i>Private sector</i>	<i>Other</i>
Energy					
<i>Centralized energy supply</i>					
<i>Individual energy supply</i>					
<i>Supply and recovery of waste heat (cogeneration)</i>					
<i>Energy from waste facility (incinerator)</i>					
<i>Energy from renewable resources facility</i>					
Water / Waste					
<i>Solid waste disposal including collection, storage and treatment</i>					
<i>Composting of biological waste including collection, storage and treatment</i>					
<i>Sewage disposal including, collection, storage and treatment</i>					
<i>Industrial liquid waste disposal including collection, storage and treatment</i>					
<i>Hazardous waste disposal including collection, storage and treatment</i>					
<i>Waste exchange clearing house</i>					
<i>Waste transfer station</i>					
<i>Multi-material resource recovery</i>					
Transport					
<i>Traffic and transport management plan</i>					
Management					
<i>Environmental monitoring</i>					
<i>Effluent monitoring</i>					
<i>Environmental auditing</i>					
<i>Environmental impact assessment</i>					
<i>Environmental technology assessment</i>					
<i>ISO 14001 certification</i>					
<i>Resource efficiency training and education</i>					
<i>Environmental operations and information centre</i>					

<i>Emergency preparedness and response capability</i>					
<i>Register of legislation</i>					
<i>Self-regulation and operational standards</i>					
<i>Green building codes</i>					
<i>Finance and insurance services</i>					
Miscellaneous					
<i>Restoring natural features of the site</i>					
<i>Landscaping and gardening</i>					
<i>Analytical and laboratory services</i>					
<i>Protection and security system</i>					

Specific Industry Information

29. Name and address of the industry?

.....

30. Year Operations started

.....

31. What category of the industry are you?

.....

32. Number of employees?

.....

33. What is the industry's main product (s)?

.....

34. What are your annual production volumes?

.....

35. What are the main raw materials – including water and energy (quantity and price)?

.....

a. Water use m³/yr

.....

b. Electricity use kWh/yr

.....

c. Material use tons/yr

36. What are your products (quantity and price)?

a. Products tons/yr

.....

37. What are your by-products (quantity and estimated cost)

.....

38. Which types of waste characterize your operations?

a. Dust and dirt

.....

b. Trimmings and off cuts

.....

c. Liquid effluents

.....

d. Steam losses

.....

- e. *Compressed air losses*
- f. *Unused raw materials*
- g. *Reworks*
- h. *Damaged stock*
- i. *Damaged products*
- j. *Inspection rejects*
- k. *Obsolete stock*
- l. *Unnecessary packaging*
- m. *Others*

39. *What are your waste streams (quantity of solids, liquids/effluents)?*

- a. *Solid wastes generated tons/yr*
- b. *Waste water generated m³/yr*
- c. *Yearly cost of solid waste management*
- d. *Yearly cost of wastewater treatment*

40. *Do you have waste water with high energy content, e.g. heat, organic material or other? If yes, please specify*

41. *How do you dispose the waste? (sale/ open dumping/exchange/incineration)*

42. *Do you generate any of these wastes? If yes, what are your annual production volumes:*

- a. *Metal*
- b. *Glass*
- c. *Paper*
- d. *Plastic*
- e. *Wood*

f. *Textile cuttings*

g. *Organic*

h. *Tyre/rubber*

i. *Ash*

j. *Oil*

k. *Special wastes*

l. *Other*

43. *Please state some examples of actual initiatives that have been initiated within recent years in order to reduce the environmental impacts of: solid waste and by-products; emissions to air; emissions to aquatic recipient/waste water; and energy in-efficient processes*

44. *Is there a possibility for recycling/ reusing the waste?*

a. *If not, why?*

b. *If so, is it being done?*

i. *At what price do you sale the waste?*

ii. *Who buys your waste?*

iii. *How is it used?*

45. *Do you receive by- or waste products from other companies that are then used as input to your production? If yes, please specify*

46. *Could any of your raw materials possibly be replaced with a by- or waste product? If yes, please specify*

47. *Which parameters are of importance to whether or not a by-product can be used as an input to your production? See list below for inspiration*

i. *The content of heavy metals and other polluting substances*

ii. *Geographical and seasonal limitations*

iii. *Problems related to hygiene*

iv. *Regulation and fees*

v. *Problems of odour or aesthetics*

vi. *The environmental policy of your company*

- vii. Tradition
- viii. Safe / stable and reliable delivery
- ix. Technical limitations

.....
 48. Are there any factors that might influence the applicability of these fractions?

.....
 49. Do chemicals make up a large part of your production / maintenance / other? If yes, please specify

.....
 50. Would it be possible to replace these with other similar substances?

Used chemical	Could be replaced by
Used chemical	Could be replaced by
Used chemical	Could be replaced by
Used chemical	Could be replaced by

.....
 51. Were any permissions/ license required to start this business? If so, from which departments?Did those departments support you in any way (financial support, market support, tax benefits, training, sample analysis etc.)?

.....
 52. Do you belong to any association of industries?

a. If so, what are the main activities of the association?

b. Are they helping to solve any problems faced by industries?

.....
 53. What do you see as the main motivators for developers and businesses to improve on their ecological performance?

.....
 54. Do you think the EPZA provides you sufficient education on new rules, regulations and strategies for developers that are economically and ecologically sound?

.....
 55. What kind of role would you like the EPZA to have in the promotion of greener industrial development for the SEZ?

.....
 56. Is your company involved in any CSR activities? If so, what are they?

57. *What in our view has the Government done to improve the competitiveness of industries like yours? Do you have any specific suggestion to be made to the Government?*

.....

Stakeholders

Questions to Academia, Government Ministries, Development Partners, State Corporations, Research Institutes, County Leaders, Business Associations, EPZA, etc

58. *What do you think of the concept of eco-industrial parks?*

.....

59. *Do you think business and industry would improve their ecological performance 'because it is the right thing to do' regardless of environmental regulations?*

.....

60. *Do you see permitting and zoning for industrial development as an issue for improving the environmental performance of industry? If yes, in what ways?*

.....

61. *Are there any areas you can think of where transferring greater control to county governments would facilitate eco-industrial park development?*

.....

62. *Do you think national governments/ county governments should develop market based incentives to encourage adoption of eco-industrial approaches?*

.....

63. *What kind of role would you like to see county governments have in eco-industrial park development? For planners specifically*

.....

64. *What would be some elements of an ideal planning process for eco-industrial parks?*

.....

65. *What kind of policy or regulatory innovations might motivate business to improve ecological performance and facilitate EIP development?*

.....

66. *What do you think will change public attitudes and behavior as regards consumption of recycled products?*

.....

67. *Is there any agency you can think of that could champion EIPs at the national/county level*

.....

68. *What are the success factors for a fully-fledged SEZ in terms of land, supporting infrastructure and administration?*

.....

69. *How can the current SEZs be reformed to embrace Industrial Ecology and by-product exchange?*

.....

70. *How can knowledge and skills sharing be improved among the players of the SEZ?*

.....

71. *How can the SEZ's technology transfer infrastructure be strengthened?*

.....

72. *How can one improve on the techno-managerial skills of the SEZ players?*

.....

-
73. *How can the legal, institutional and regulatory framework of SEZs be improved?*
-
74. *Which incentives are required for a smooth operation of a SEZ?*
-
75. *What pertinent issues should be addressed in a SEZ's strategic framework?*
-
76. *What policies enable accelerated proliferation of low carbon green SEZs?*
-
77. *Which institutional framework is ideal for the efficient functioning of SEZs?*
-
78. *How can innovation be fostered within the SEZ?*
-
79. *How can forward and backward linkages be established and strengthened with a SEZ setting?*
-
80. *What are the key problems currently facing SEZs?*
-
81. *What needs to be done so as to enable SEZ players deal with each other with mutual trust and respect?*
-
82. *In your view, what are the disadvantages of embracing Industrial Ecology?*
-
83. *How can we create low-carbon SEZs?*
-

Question to the surrounding Community

85. *How does the existence of the EPZA next to you affect you?*
-

END

Annex 2: Guidelines on the Assessment of the IE potential

Categories and Elements	Status Level 1 (Red)	Status Level 2 (Yellow)	Status Level 3 (Green)
Corporate Policy	Company policy is one of compliance with business regulations.	Company policy extends beyond compliance with business regulations to address potential liability issues. Systems are in place to monitor, update, communicate, and implement policies.	Company policies are proactive and include environmental, economic, and social aspects in all business decisions, e.g. public policy, community relations, and social development components.
Management Involvement	Management approach is reactive to all business threats.	Management approach anticipates and addresses Clear business threats – e.g. Anticipates future environmental permits.	Management is actively involved in updating of environment health and safety (EH&S) policy and introducing continuous performance improvement systems.
Management Vision	The vision is limited to maintaining compliance with the provisions of the economic zone’s corporate policy.	The vision shows a willingness to introduce longer-term, voluntary initiatives. In addition, at the Corporate level, Public Affairs management perceived to be critical to long-term business sustainability.	Highly aligned at Corporate and Plant level (e.g. Corporate policies are fully embraced at Plant level and short-term Financial criteria are not as stringent).
Environmental Management	Environmental assessment and actions limited to meeting regulatory and compliance requirements	Environmental activities focus on meeting specific environmental goals identified via the implementation of a formal Environmental Management System (EMS).	Neighboring communities and industrial facilities play an important role in influencing environmental goals as part of an overall Environmental Management System.

Plant Operations	Plant environmental initiatives are control oriented and lack management support	Operational initiatives promote eco-efficient production and resource conservation	Plant management is cognizant of the triple bottom line and incorporates aspects of sustainability in operational decisions
Plant Management	Management only supports discretionary environmental initiatives that don't require capital investments.	Management supports investments in discretionary environmental investments and comprehensive evaluation strategy is in place.	Independent division with dedicated staff for evaluating opportunities for waste recycling, alternative fuels and raw materials (AFR), and developing and implementing IE relationships.
Process Operations	Operations staff unwilling to explore waste minimization or pollution prevention (P2) activities	Operations staff value pollution prevention and AFR efforts and are willing to explore such opportunities.	As part of the R&D process, Operations staff actively participates in exploring and implementing AFR substitution opportunities.
Employee Motivation	No incentives to explore new opportunities in increasing profitability – maintains status quo.	Staff award programs for ideas that could lead to increased productivity and/or process efficiencies e.g. energy and water conservation.	Compensation packages for managerial staff directly linked with increased productivity profits, or other performance measures through AFR or other IE programs.
Innovation	No R&D investments For environmental Technology upgrading.	R&D funding earmarked for innovations in environmental technology initiatives leading to economic benefits (e.g. using recycled material, new and/or improved product and/or process design).	Opportunity assessments actively pursued for innovative options in AFR and/or other IE opportunities.
Transparency	Company operations are insulated and do	Company willing to discuss	Company proactively establishes networks to explore opportunities for waste

	not promote external communications.	Its environmental management initiatives externally to identify cost-effective material substitution or fuel replacement.	exchange, AFR and other IE opportunities on a zone-wide basis.
Supplier / Receiver Relationships	Company purchases conventional fuels and raw materials through typical cost-bid process.	Company has ad hoc relationships with suppliers and receivers (companies receiving waste and process by-products). No long term or collaborative sourcing arrangements.	Company has formalized, long-term relationships with receivers (companies receiving waste and by-products) and suppliers and considers collaborating to optimize both the supplier operations and the transport logistics.
Risk Management	Limited to regulatory requirement for process operations.	Risk analysis for handling, transportation, and storage of AFR performed.	Risk considerations broadly consider the full range of negative and positive values of establishing and maintaining an industrial ecosystem.
External Partnerships	Not applicable in this category.	Company perceives its AFR, waste recycling, and material substitution initiative as an economic incentive.	Company uses its AFR and other material substitution initiatives for strategic benefits by establishing goodwill and strong relationships with the regulatory agencies and local community members.
External Communication	Company does not communicate its AFR and other waste recycling and material substitution programs to external stakeholders.	Company in a reactive mode and provides information to the external stakeholders only when requested or challenged for its actions.	Company has a proactive external stakeholder communication program in place to communicate company policies and initiatives on AFR substitution.
Environmental, Health & Safety (EH&S) activities	EH&S activities focus is only on compliance with regulatory and permit requirements.	EH&S principles extend beyond meeting regulatory compliance requirements - proactive approach in risk management, identifying waste	EH&S activities include evaluations of the EH&S implications of logistics management, suppliers, contractors, and other external organizations associated with company's operations.

		minimization, waste recycling, P2 opportunities.	
Material Utilization	Material utilization and material energy flow evaluation only within the plant boundary.	Life Cycle Assessment (LCA) approach used for a system level material utilization and material energy flow evaluations	In addition to system level LCAs, material utilization and energy flow evaluations, the company considers a broader set of parameters such as resource management issues and stakeholder concerns.
Habitat Management	Resource extraction and other habitat areas are managed within regulations.	Habitat management and conservation of biodiversity are evaluated but considered only within the span of control of the company.	Habitat enhancement or substitution is a key component of decisions on fuels and raw materials and waste product utilization both within the company and in partner organizations.

Source: Modified from WBCSD, 2002. Guidelines on the Assessment of the IE potential.