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## Research article

## Building green supply chains in eco-industrial parks towards a green economy: Barriers and strategies

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## ABSTRACT

As suggested by UNEP, the key to sustainable development is to create a “green economy” which should encapsulate all three sectors: the industry, the people, and the government. Therefore, there is an urgent need to develop and implement the green technologies into the existing facilities, especially in the developing countries. In this study, the role of green supply chains in eco-industrial parks (EIPs) towards a green economy was investigated. The strategies and effective evaluation procedures of the green economy were proposed by assessing the barriers from the perspective of institution, regulation, technology, and finance. In addition, three case studies from iron and steel-making, paper mill and pulping, and petrochemical industries were presented and illustrated for building the green supply chains. For example, in the case of Lin-Hai Industrial Park, a total of 15 efficient green supply chains using waste-to-resources technologies were established by 2012, resulting in an economic benefit of USD 100 million per year. It suggests that the green supply chains should be established to achieve both economic growth and environmental protection. With these successful experiences, building a green supply chain within industrial park should be extensively promoted to make traditional industries around the world being environmentally bearable, economic viable, and social equitable.

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## 1. Introduction

The negative impacts of human activity on the environment have long been known; from the depletion of the ozone layer, to the destruction of various ecosystems, even to the formation of increasingly severe weather phenomena, human activity has impacted nearly every aspect of the environment. In response to climate change, several key challenges of the 21st century were identified, such as protection of the population against natural hazards, mitigation of and adaptation to global warming, and optimization of water/energy/food nexus. To prevent such destructive consequences, individuals and groups have taken concerted efforts to protect the environment beginning as early as the twentieth century. However, a major setback to the environmental protection movement is the common misconception that

protecting the environment necessitates a slowdown of economic development. For example, those opposed to extensive environmental protection measures may argue that creating the national parks prevents the development of land and efforts to scale back on greenhouse gas emissions prevents industrial growth (Buckley and Carney, 2013). In recent years, international organizations such as the United Nations Environment Programme (UNEP) have moved to dispel such misconceptions by promoting a movement towards sustainable development.

Fig. 1 shows the history of important international movements towards a sustainable development and green economy. In 2009, the Global Green New Deal, released by the United Nations Department of Economic and Social Affairs (UNDESA) (UNDESA, 2009), presented a global strategy for attaining a green economy that involves a mixture of public investments and new policies. In 2011, there had been much discussion regarding the necessity of a green economy, and methods for obtaining one in recent international meetings and publications. According to UNEP (UNEP, 2011), a green economy could encapsulate all industries, people and

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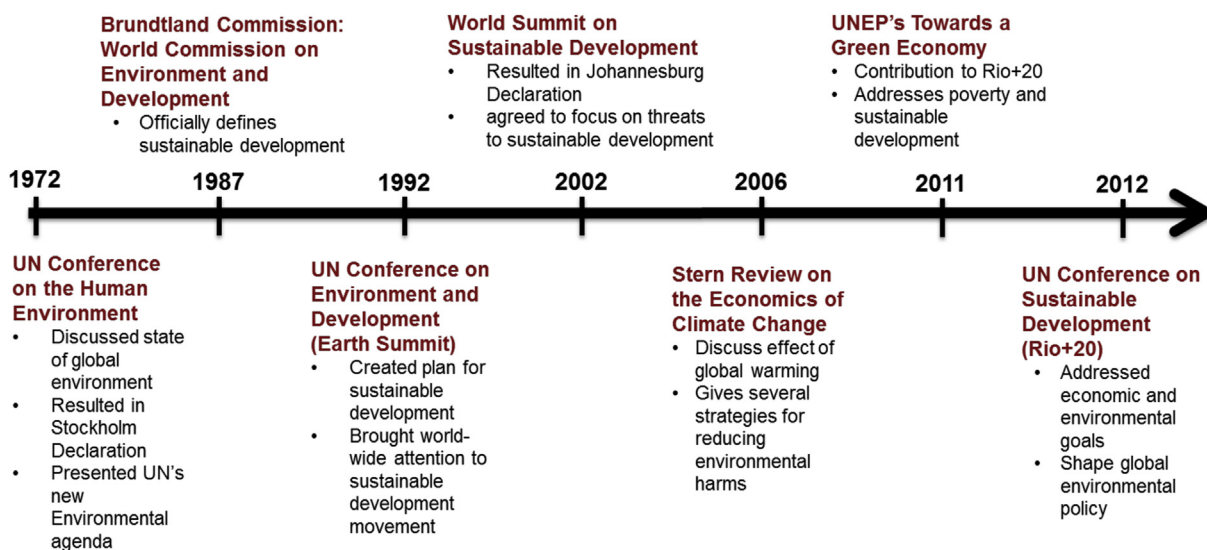


Fig. 1. Important international movement on the sustainable development and green economy.

governments, and result in “improving human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”. Moreover, it can support the development of technology and infrastructure that “reduces carbon dependency, promotes resource and energy efficiency, and lessens environmental degradation” (UNEP, 2011). The standard of excessive consumption is problematic as it necessitates a trade-off between economic development and environmental sustainability. However, with sustainable development, such a trade-off becomes unnecessary. Sustainable development, as defined by the World Commission on Environment and Development (WCED), is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UNEP, 2012b).

Sustainable development allows for the goals established at the 1992 Earth Summit and reaffirmed at the 2012 United Nations Conference on Sustainable Development (Rio 2012) to be realized. The achievements of the “Rio+20 Summit” held on June 2012 include: (1) “Future We Want” outcome document, (2) sustainable development goals (SDGs), (3) high-level political forum on sustainable development (HLPF), (4) strengthened UNEP, (5) civil society participation and commitments, and (6) green economy. In addition, the Rio+20 passed responsibility of the “Post-2015 Dev Agenda” to two bodies: (1) UNEP Governing Council and (2) UN General Assembly. The thematic consultations of the Post-2015 process include inequalities, governance, growth and employment, health, education, environmental sustainability, food security and nutrition, conflict and fragility, population dynamics, energy, and water. Therefore, the green economy has been one of the main themes in the international debates on sustainable development towards the Rio+20 summit in 2012.

Since the sustainable development depends on a green economy, it can only be implemented if fundamental changes are made to the existing energy supply chains, especially in industrial parks (Pan et al., in press). In Taiwan, both increased exports and elevated domestic autonomous final demand levels were the main reasons for increasing CO<sub>2</sub> emissions, reflecting the evidence of export-oriented and continued growth characteristic in the Taiwanese economy (Huang and Wu, 2013). According to the Taiwan's sustainable energy policies, development of eco-industrial parks (EIPs) is one of the key strategies to reduce carbon emission (CO<sub>2</sub>) intensity over 30% by 2025 (CEPD, 2004; Huang and Wu, 2013). In

2009, the “Green Energy Industry Promotion Act” announced by Ministry of Economic Affairs of Taiwan was intended to promote the renewable energy industries towards a green economy, targeting an increase of gross green industrial output value of 390 billion USD by 2015 (MOEA Taiwan, 2009).

To achieve the goal of being environmentally bearable, economic viable, and social equitable, the objectives of this paper were (1) to examine the role of green supply chains in EIPs for creating a green economy, (2) to establish the evaluation criteria to assess the effectiveness of green supply chains implemented in EIPs, (3) to identify the challenging barriers in establishing the green supply chains in EIPs, and (4) to propose the strategies for overcoming the barriers toward a green economy. In addition, three case studies of different industries including iron and steel-making, paper mill and pulp, and petrochemical industries were reviewed and illustrated.

## 2. Barriers and challenges

### 2.1. Regulatory barriers and challenges

Regulatory barriers often prevent institutions from efficiently developing technology and processes that are crucial for green supply chains. Laws regulating intellectual property rights (IPR) frequently make it difficult to share information among the industries because the laws determine who controls information and technology, making the spread of technology dependent on the groups controlling the information. This can cause a slowdown in the transformation process by posing a problem for the transfer of environmentally sound technology (Steiner, 2010). This barrier is so great that Committee of African Heads of State and Government on Climate Change (CAHOSCC) has also taken a position of calling for the removal of restrictions on intellectual property to allow African countries to develop clean energy and infrastructure (Keating, 2009).

In Taiwan, the development of renewable energy was sluggish during the period between 1996 and 2006 (Huang and Wu, 2013). Overly strict laws and regulations also prevented development and implementation of green technology and thus green supply chains. The amount of time it takes to receive permits and complete the proper procedures in order to develop and implement technology would be a main impediment factor in the expansion of renewable

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