Chapter 1. Resource Efficiency: What is It and Why is It Important?

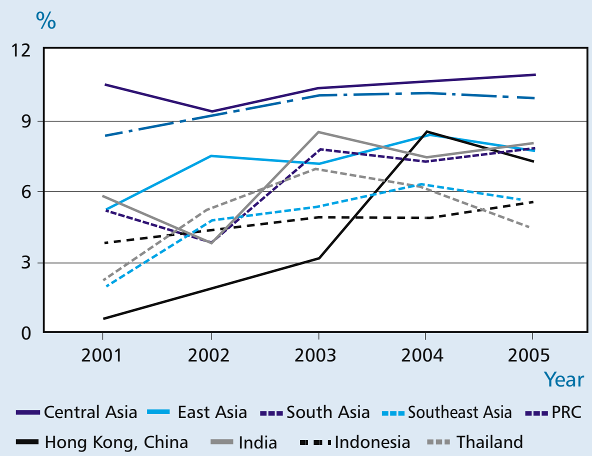
Production and consumption in Asia and the Pacific are outpacing the renewal capacity of natural resources and the capacity of local governments to manage wastes. New approaches to reducing, reusing, and recycling wastes are essential to the sustainable future of Asian and Pacific economies.

The Environmental Challenges of Economic Growth and Urbanization in Asia

Asia is now the most economically dynamic region in the world. Sustained economic growth, especially in the People's Republic of China (PRC), India, and parts of Southeast Asia, has been truly impressive over the past 40 years. In 1960, the 10 biggest Asian economies accounted for just over 12% of world gross domestic product (GDP). Today, that share has doubled to about 25%.[1] Developing Asia is expected to continue its upward economic trend, with an 8.3% growth rate projected for 2007 (Figure 1.1).[2] GDP per capita is also growing at a high level (Figure 1.2). This economic progress has helped raise tens of millions of people out of poverty.

Much of this economic expansion has been associated with rapid urbanization (Figure 1.3). Within the next 15–20 years, at least 50% of Asian populations will be living in huge urban sprawls that also contain some of the world's most important industrial facilities, such as in the Pearl River delta

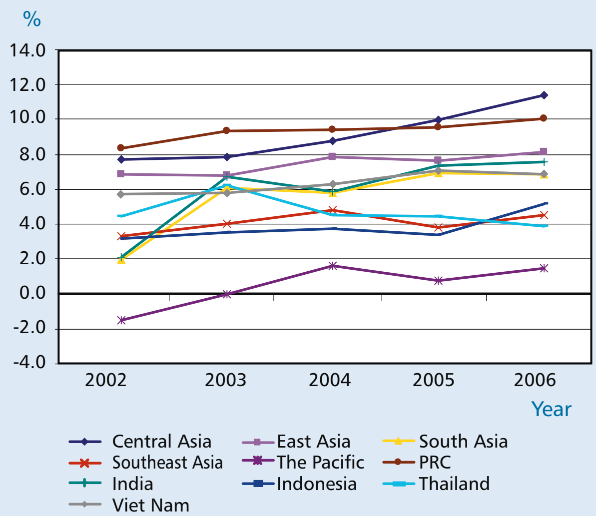
Figure 1.1: Growth Rate of GDP in Selected Countries in Asia



GDP = gross domestic product, PRC = People's Republic of China, % = percent.

Source: ADB. 2006. *Asian Development Outlook 2006*. Manila.

Figure 1.2: Growth Rate of GDP Per Capita in Asia



GDP = gross domestic product, PRC = People's Republic of China, % = percent.

Source: ADB. 2007. *Asian Development Outlook 2007*. Manila.

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1 Krueger, Anne. 2005, 14 December. Still Achieving, *Still Pursuing: The Global Consequences of Asian Growth.* Remarks by First Deputy Managing Director, International Monetary Fund to the Asia Society, Hong Kong, China. Available: http://www.imf.org/external/np/speeches/2005/121405a.htm

2 Asian Development Bank (ADB). 2007. *Asian Development Outlook 2007 Update*. Manila.

in the PRC.[3] About 1.56 billion people live in the region's urban areas, projected to grow to 2.21 billion by 2020.[4] Urbanization is bringing enormous economic and social benefits to most Asian countries. Cities form the main link between national economies and the global economy, and as engines of job creation, cities are an important basis for poverty reduction.

Despite bringing many benefits, economic growth and rapid urbanization have not come without a price. These trends have triggered a decline in Asia's natural capital—shrinking forests, declining biodiversity, disappearing water sources, and barren lands. At the same time, much of the region's urbanization is occurring with little or no environmental controls. The result is uncontrolled urban sprawl, fetid slums, unprecedented levels of air, water, and land pollution, and inadequate urban services (e.g., water supply, sanitation, wastewater treatment and sewerage systems, drainage, and solid waste management). These deficiencies inhibit economic growth, place further stress on natural systems, and damage public health and the investment climate. They severely constrain

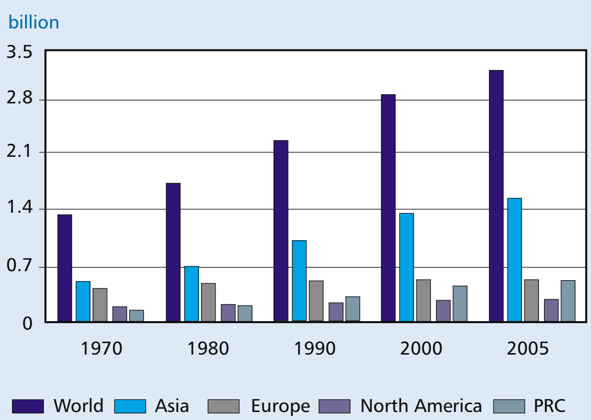
Source: AFP

the potential for urban areas to contribute fully to economic growth.

While the management of urban areas is getting increased attention, agriculture for food, fiber, and energy production remains the largest single user of energy, water, materials, and land resources, and is the largest source of waste. Conventional, petrochemical farming has serious liabilities. The green revolution increased energy flow to agriculture to 50 times the energy input of traditional agriculture. Agriculture is also a major consumer of water resources in most countries, much of it consumed inefficiently and with free or subsidized cost to the user.

While developing countries cannot be denied the chance to share in the planet's wealth, it is important to acknowledge that negative environmental effects will continue if they continue to follow current development patterns. For example, the PRC's rapid economic growth demands major supplies of all basic industrial commodities in competition with other nations, and its contribution to greenhouse gases (GHGs) is rising rapidly. Based on ambitious development targets set by the Government, a population of 1.8 billion will likely reach a per-capita GDP of $4,000 per year by 2050, five times the current level.[5] This growth will demand a tremendous increase in production and will multiply pressure on natural resources and the environment unless the development path becomes more environmentally benign.

Figure 1.3: Asia's Growing Urban Population



PRC = People's Republic of China.
Source: United Nations. 2005. *World Population Prospects. The 2004 Revisions Population Database.* New York.

[3] Boyd, Alan. 2002, 26 November. Environmental Cost of Asia's Development. Asia Times Online. Available: http://www.atimes.com/atimes/Asian_Economy/DK26Dk01.html

[4] Brockerhoff, Martin. 1999. Urban Growth in Developing Countries: A Review of Projections and Predictions. *Population Council Paper* No. 131. Available: http://www.popcouncil.org/pdfs/wp/ See http://esa.un.org/unpp/ for the latest projections by the UN Population Division.

[5] Indigo Development. 2005 July. *China Seeks to Develop a "Circular Economy"* (CE). Available: http://www.indigodev.com/Circular1.html

Given the present trends in consumption and the growing world population, it is questionable whether our globe can continue to withstand growing levels of pollution and resource extraction without major adverse consequences in the near future. Human populations cannot expand indefinitely with everyone expecting to live at the current levels of consumption and production in developed countries. Adjustments are needed in both the developed and developing worlds.

The international concern over global climate change is intensifying attention to these issues. The impacts of climate change may be disastrous to developing Asian countries, many of which will be ill-equipped to deal with the resulting effects on agricultural output, labor productivity, health, and internal displacement. Another worrying development throughout the region is the inefficient use of water, leading to such adverse impacts as overpumping of aquifers. As water tables fall and surface water variability increases, harvest cutbacks could occur simultaneously in many countries, creating potentially unmanageable food scarcity.[6]

If the grim climate change scenarios being forecast by some experts come to pass, the hardest hit will undoubtedly be the poor. They are more directly exposed to pollution and the extremes of nature brought on by climate change and have a greater dependence on natural resources, such as crops, livestock, and biomass fuels.

Opinions differ on the resilience of social, technological, and market systems to the environmental problems we face today. Some contend that the Earth cannot continue to support demand for oil and other exhaustible resources for long, given current development patterns, without enormous price increases and severe resource degradation. Others claim that the Earth can amply provide for society's needs for the indefinite future with the help of markets, appropriate public policies, and new technologies.

This report explores the basis for both viewpoints. The authors believe that if humanity does not change its current production and consumption patterns, it will eventually be shocked into adjustments through the blunt instruments of economic recession, environmental disasters, or increased civil strife (or all three simultaneously). This report, while presenting these global and regional realities and problems, also offers hope for the future based on positive changes already apparent.

Most of the paper is focused on identifying an alternative path that could avoid economic and environmental decline. This path involves countries breaking away from current patterns of economic growth and embracing more resource-efficient norms. By taking this path, countries can reduce mounting levels of wastes and pollution along with associated environmental and economic impacts and costs. The choice should be clear—make the necessary sacrifices now or pay dearly later. This must be done with the understanding that only by realistically confronting the challenges of the present and thinking systematically about consequences and interactions can a sound blueprint for change be developed and implemented.

Resource Efficiency, Waste, and Related Concepts

Before embarking on a review of resource efficiency in the region, it is important to define some concepts. In this report, we define resource efficiency as the amount of resources (materials, energy, and water) consumed in producing a unit of product or services. Practicing resource efficiency involves using smaller amounts of physical resources and generating less waste to produce the same product or service. It also encourages patterns of consumption that use fewer resources through the design of products and services and their delivery to consumers. This requires a perspective and a decision-making process that simultaneously considers both economic value and environmental sustainability.

Renewal and conservation of natural capital form the foundation for achieving sustainable resource efficiency. Natural capital assets are embodied in land (forests, farms, aquifers, grasslands, urban space); aquatic systems (rivers, lakes, wetlands, coastal and marine ecosystems); the atmosphere; and the dynamic cycles of nature. The route to sustainable development is, in part, through minimizing net

[6] Rizvi, Haider. 2007, 28 July. OneWorld.net. *Washington Pressed to Lead as Water Tables Fall*. Available:http://www.iwmi.cgiar.org/Press/coverage/pdf/Washington%20Pressed%20to%20Lead%20as%20Water%20Tabl.pdf

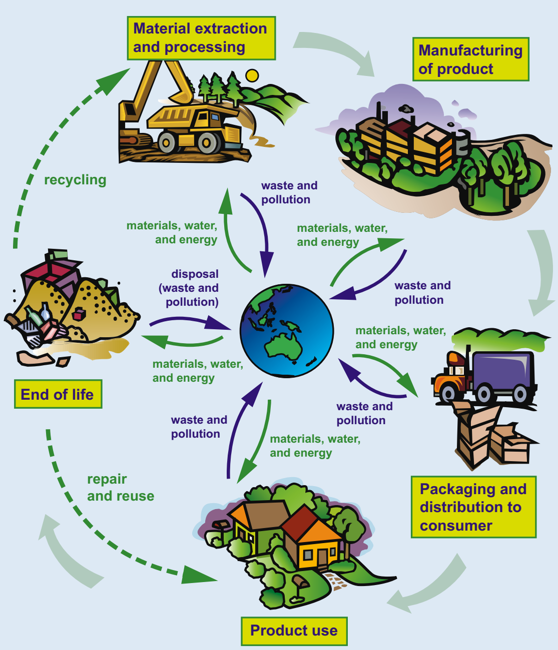
natural capital inputs throughout the entire life cycle of the products and services that drive local, national, and global economies.

Every product has several stages in its life cycle, including

- extraction of natural resources,
- processing of resources,
- design of products and selection of inputs,
- production of goods or services,
- distribution,
- consumption,
- reuse of wastes from production or consumption,
- recycling of wastes from consumption or production, and
- disposal of residual wastes.

Every one of these stages can create waste and environmental residuals that can become chemical or organic pollutants and can contribute to climate change, among other impacts (Figure 1.4). Pollutants include carbon monoxide, lead, nitrogen dioxide, particulate matter, sulfur dioxide, carbon dioxide, hazardous chemicals, and many more.

Figure 1.4: Life Cycle of a Product



Source: Modified from www.environment.gov.au/settlements/industry/corporate/eecp/publications/shop.html

Life-Cycle Assessment

Life-cycle assessment (LCA) looks at environmental impacts across the full product life cycle, from the mining or extraction of raw materials used in its production and distribution, to its use, possible reuse or recycling, and eventual disposal. An LCA can quantify how much energy and raw materials are used and how much solid, liquid, and gaseous wastes are generated at each stage of the product's life. Research is currently being devoted to developing and applying models for predicting the service life and life-cycle costs of reinforced concrete structures, including developing methods for evaluating the durability of high performance concrete, and evaluating repair systems for deteriorated reinforced concrete structures. The International Organization for Standardization (ISO)14040 series of environmental management guidelines provides a consistent methodological approach commonly used since 1997.

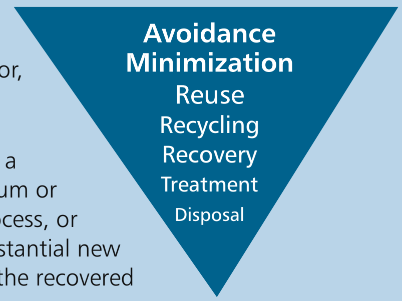
Using LCA, the true environmental effects of our consumption choices become clearer. Many consumer electronics, for example, are manufactured efficiently but are difficult to dispose of in an environmentally sound manner at the end of their useful lives. Most electronics manufacturers still use hazardous materials in their products and do not design their products for easy disassembly, and most government policies fail to hold manufacturers responsible for end-of-life management of their products. Thus, manufacturers continue to externalize these costs by allowing their products to go to landfills or poorly regulated waste-recovery schemes. This status quo—where end-of-life costs are not incorporated into the upfront price of new products—ensures that electronic waste (or e-waste) will only have positive value in poor countries that have low labor costs and weak environmental and health standards.

Even products that are considered environmentally friendly look less desirable when their impacts are assessed over their life cycle. For instance, hybrid vehicles may not always offer the net energy savings that many environment-conscious drivers would like to believe, largely because their batteries contain heavy metals, such as cadmium and nickel (and they still run on fossil fuels). Nickel must be mined (sometimes at significant environmental cost), transported, refined, and transported again before

Box 1.1: The 3R Hierarchy

Reducing wastes by all feasible means is the first in a hierarchy of priorities. From either a business bottom line or a national economy perspective, it costs much less to make processes more efficient and prevent wastes from occurring than to later consume more energy and materials to capture the waste streams and then to reuse, recycle, or dispose of them.

Reusing wastes is the next level of priority. It involves using resources in their existing forms (e.g., glass bottles, wood scraps, chemical process by-products, secondary water, or surplus energy) so that minimal additional labor, material, water, and energy are required to achieve beneficial use.



Recycling wastes is the third priority. It involves transforming resources into a form that can be used as an input to a new process (e.g., recovering aluminum or plastic from drink containers, reprocessing a by-product from a chemical process, or processing wastewater for secondary use). This third level often requires substantial new inputs of materials, energy, and water so that the net gain is limited, unless the recovered resource has a relatively high value.

Source: ADB.

the battery is produced. The environmental costs associated with these activities must be compared against the energy savings that accrue from increased fuel efficiency to assess the true environmental benefits of driving these vehicles.

Applying LCA across an entire economy requires an understanding of the consumption patterns that have the greatest life-cycle environmental impacts over the long term. For instance, investments in large infrastructure or building projects lock in environmental and economic impacts for decades. Therefore, resource-efficient, high performance, and integrated designs need to be promoted over conventional designs.

It should be noted that there are some limitations to broadly applying LCA. For instance, the LCA method used is not suitable for expressing the most important environmental impacts caused by the use of resources, such as loss of biodiversity and the environmental impacts of agriculture. Another unsolved problem is how to deal with imports and exports in determining life-cycle impacts.

The 3Rs

The 3Rs—**reducing** resources and wastes generated throughout the life cycle of products and services, **reusing** products and waste materials (including production by-products) independently or as inputs to other production processes, and **recycling** wastes into a form suitable for use as an input to production—lie at the heart of any effort to achieve resource efficiency (Box 1.1).

LCA allows to compare the benefits of recycling resources with extraction and production of materials from virgin resources. For example, the energy used in recycling aluminum is only 5% of that used in aluminum production from bauxite, and recycling of copper uses only 15% of the energy required for production from copper ore.[7] The British Metals Recycling Association (BMRA) claims that using recycled steel to make new steel can lead to reductions of 86% in air pollution, 40% in water use, and 76% in water pollution.[8] In addition, some estimates show that a ton of paper from recycled fibers instead of from virgin pulp can save about 26,500 liters of water, 4,000 kilowatt-hours (KWh) of electricity, and about 27 kilograms (kg) of air pollutants.[9]

7 International Aluminum Institute's Webpage. Available: http://www.world-aluminium.org/production/recycling/index.html

8 British Metals Recycling Association website. Available: http://www.recyclemetals.org/whatis.php

9 Estimate of United States.

LCA can also reveal the benefits of promoting reuse and recycling over landfilling. As discussed in Box 1.2, there is an opportunity to capture much higher benefits from biomass, which accounts for a major share of the waste stream in many Asian and Pacific countries.

Thinking about Waste: From Loss to Gain

Part of the transition to more resource-efficient societies will entail a shift in thinking about the definition of waste. Waste is traditionally thought of as having no value. Moreover, waste is widely assumed to be inevitable. This leads to economic and

Box 1.2: Life-Cycle Decision Making and Biomass

A major share of the Asia-Pacific countries' waste stream is biomass, most of it discarded in landfills. There is an opportunity to capture much higher benefits. The use of biomass at the end of production and consumption cycles is the last point for increasing the efficiency of its use. Life-cycle analysis suggests additional points of intervention along the metabolic flow to improve materials management by optimizing the utilization of resources and minimizing the environmental impacts of using them.

Actors at any point along the life cycle of products make decisions that can increase efficiency and reduce impacts. The sources, materials, routes, options for processing, markets, and agencies responsible for biomass are highly diverse. Many biomass processing companies use either virgin or discarded materials, which adds another level of complexity. Therefore, the effective use of biomass requires a framework for more integrated materials management. Each decision maker needs to see the whole system and know how to make choices that optimize the use of this resource stream and minimize the environmental impacts of its use.

This is illustrated by reviewing some key factors at different points of intervention.

- **Extraction of raw materials.** Policies should encourage farm and forestry operations to perceive all material outputs as products and to maintain the value of what were formerly considered wastes. Practices to encourage include minimizing wastes in harvesting, balancing the sale of by-products with on-site use for soil regeneration, separating by-products in terms of requirements of the biomass processors; and following the basic practices of cleaner production for energy efficiency and pollution prevention.
- **Processing of materials.** Similar policies and practices are needed for food, fiber, and wood-processing companies.
- **Selection of materials.** Policy changes are required to eliminate subsidies that favor virgin over-recycled materials and fossil energy over renewable energy.
- **Transportation of materials and products.** The relatively low economic value of many biomass discards makes the efficiency of transportation and distance to market crucial to the financial feasibility of their use.
- **Using materials to create products and services.** Policies governing food-processing plants, wood mills, restaurants, and other processors are similar to those for extraction, but specific to these industries. Product and process design guidelines help assure low waste and ease of recycling or reusing of products.
- **Using products and services.** Policies for consumers in all sectors support awareness building, and encourage consumer practices of waste minimization and preservation of value of discards.
- **Recovery or disposal of used products and material.** Biomass is a major part of the present waste stream and using it has major implications for the public sector. Policy governing these resource flows needs to account for the reductions in public investment and other public benefits achieved by this transition. (These include avoided cost of new landfills and public collection, and the health and environmental benefits.) These savings can be used to support the creation of a niche collection infrastructure, the startup of new materials processing companies and energy generators, research and development, and the coordination required for allocation of resources.

Source: Lowe, Ernest A. 2007. Integrated Regional Action Planning of Biomass Utilization. Presentation to California Association of Resource Conservation and Development Councils Fall Conference, 25 April 2007. Indigo Development. http://www.indigodev.com/RCDC_biomass_Lowe_apr25.ppt

Box 1.3: Why Do We Waste?

Most societies have historically believed that the world has unlimited resources and that things can be thrown away without negative consequences. Even though we increasingly know better, we still largely act as if this were true. Our prevailing economic system does not provide adequate incentives for conservation and efficient resource allocation. Societies everywhere—including their governments, managers, and consumers—still act as though resources are to be used and then disposed of, and, by doing so, fail to take advantage of the many benefits of increased resource efficiency.

Governments concerned about making local industries more competitive often subsidize key inputs such as water, electricity, fuel, and food commodities, thereby creating artificially low prices. Moreover, prices of most goods and services do not reflect the full environmental and social costs of resource extraction, processing, production, and consumption, or the full costs of waste management. As a result, resources are routinely overused, creating both pollution and shortages. The overall effect is to encourage greater resource consumption than is economically or even financially efficient and to discourage development and diffusion of more resource-efficient and cleaner technologies and policies.

Most managers fail to understand the extent of waste in their systems or its cost to the bottom line. One reason is weak measurement of input and waste streams. Another is that decision makers lack adequate information on the technological and operational options available to them. Waste remains invisible in accounting systems and organizational reward systems. The costs of producing and disposing of waste are buried in a company's or agency's overhead and are not reflected as line items in management or cost accounting. National accounting systems also misrepresent the benefits and costs of resource use efficiency. The costs of services for collecting, transporting, and disposing of wastes, and for storing, treating, and disposing of hazardous materials actually adds to gross domestic product.

Many consumers do not fully appreciate their role in the inefficiency equation. Wasteful practices are still the norm. For instance, consumers are increasingly using and discarding voluminous materials, such as food containers and plastic bags that are frequently dumped in waterways and clog sewerage systems. In addition, rapidly increasing consumption in both developing and developed countries is driving up resource utilization beyond the rate of efficiency improvements.

Quantities of waste that must be managed for final disposal will continue to grow until production processes and consumption patterns become more resource efficient. Until then, the enormous costs of wasteful practices should serve as a strong motivation to pursue resource efficiency of production and consumption and to search every avenue to reduce, reuse, and recycle "wastes."

Source: ADB.

management practices that actually tend to promote the generation of waste (Box 1.3).

In a resource-efficient economy and society, the term "waste" would refer only to those residual materials that have absolutely no potential to be used and, therefore, have no economic value. Under this definition, traditionally "valueless" streams of waste can be considered resources for a new tier of the economy. They can be recovered (or prevented from being lost) through greater efficiency and management at every stage of production and consumption. Even many hazardous or toxic materials may be recycled or re-refined for reuse. For instance, the Recycle Engineering Co. refinery in Thailand re-refines cleaning solvents, returning them to manufacturers at near virgin quality.[10] Businesses devoted to resource recovery recommend phasing out the word "waste" altogether from the lexicon of bureaucracies and supporting legislation. It is a word that hides the value of the by-products of industry and commerce.

Source: AFP.

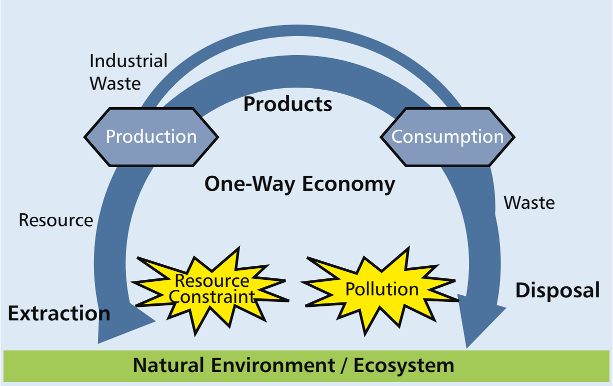
10 Lowe, Ernest A. 2001. *Eco-Industrial Handbook for Asian Developing Countries*. Manila: ADB. Available: www.indigodev.com/Handbook.html

This shift in thinking about waste is evident in a number of emerging applications of the life-cycle approach. These include policies to apply the 3Rs, extended producer responsibility (EPR), and design for environment. They also include innovative market-based mechanisms to encourage environmentally beneficial behavior, such as the clean development mechanism (CDM) and demand-side management (DSM).

Figures1.5–1.7 illustrate the changes in the flow of resources and waste as different resource-saving measures are applied to an economy, from resource extraction and production to consumption and final disposal.

Figure 1.5 shows a "one-way" economy in which little effort is made either to reduce the amount of materials consumed in production (and thereby the wastes produced) or to reuse or recycle those wastes. Both the materials embodied in the production and the wastes produced in the production make a largely one-way trip from extraction to landfill, with that portion of the materials captured in the products only being delayed in completing the journey.

Figure 1.5: The One-Way Economy



Source: ADB.

This was the basic model followed when many developed countries were mainly focused on end-of pipe disposal of wastes, which was the case until the 1970s. In most industries, little attention was paid to how wastes were produced or what could be done to reduce their volume or toxicity. Instead, environmental policy and regulation focused on avoiding pollution at the end of the pipe. Environmental management generally had a narrow focus on operating pollution control equipment and basic housekeeping of the production process to stop spills and leaking pipes. It should be noted that a one-way economy has never fully existed, especially in the developing world, because of the very effective informal waste management sector, which has always recycled portions of material wastes. Nevertheless, the economies of many developing countries in Asia are still largely dominated by a linear and wasteful flow of resources.

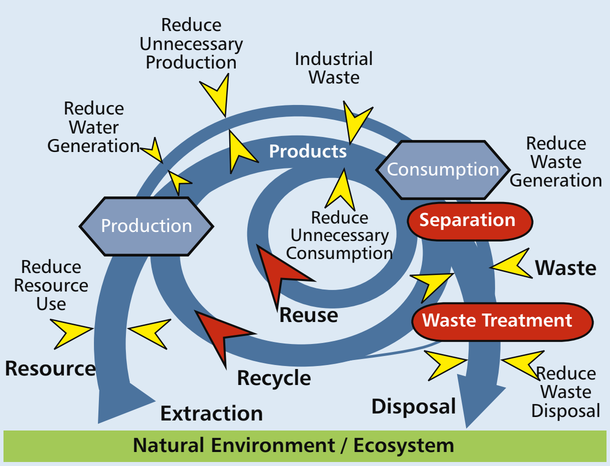
Over time, particularly as economies and production technologies advance and as the middle class increasingly makes its voice heard, pressure builds to implement more comprehensive approaches to reducing environmental impacts. This typically results in legislative, social, and market pressures on industry to exercise greater responsibility for its environmental performance. As these pressures mount, programs focused on end-of-pipe treatment and disposal evolve into those stressing greater efficiency in the production process, through cleaner production or eco-efficiency programs.

At this stage, scientists, engineers, industrial managers, and many others recognize that true long-term sustainability of economic systems requires that societies learn to break their dependence on single use throughput of natural resources and growing production of wastes. There is a shift from an after-the-event, "react and treat" approach to a forward-looking, "anticipate and prevent" philosophy, as advocated in cleaner production and eco-efficiency programs.[11] Where end-of-pipe waste disposal is a sunk cost with no financial return (other than avoidance of fines), improvement of the production process brings financial benefits to the producer as well as improvement of the quality of the products. Building-in environmental considerations early in the process, before capital equipment is purchased and distribution channels are developed, is arguably the least expensive time to make proactive design decisions that can, in turn, influence the entire life-cycle chain.

Design for environment (DfE), also known as green design and ecodesign, is part of this movement. It involves reducing environmental impact and resource consumption by improving the design of a product. The major characteristic that distinguishes DfE from more traditional

[11] United Nations Environment Programme (UNEP). 2001. Cleaner Production – Key Elements. Available: http://www.uneptie.org/pc/cp/understanding_cp/home.htm

Figure 1.6: The More Efficient Economy



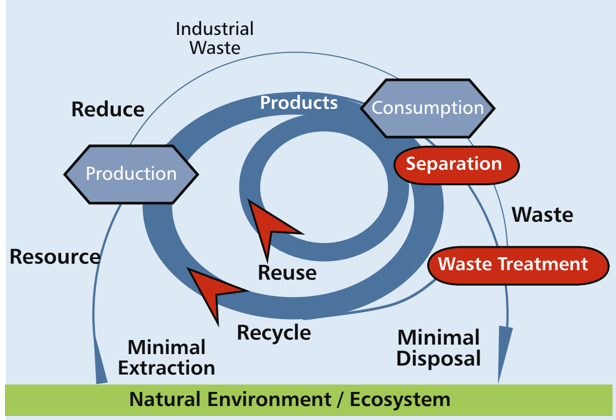
Source: ADB.

environmental compliance is its scope, extending well beyond the factory walls.[12] DfE is associated with a life-cycle perspective because it builds in long-term considerations, from extraction of virgin materials to customer use, to reuse or recycling, and to disposal, recognizing that every engineering decision is also an environmental one. Effective DfE incorporates techniques to help designers improve the environmental performance of their products, such as design for recycling, disassembly, energy efficiency (EE), remanufacture, and disposability. Organizations that describe and discuss DfE and other design issues are proliferating throughout Asia, such as the Thailand Creative and Design Center and the Malaysia Design Innovation Centre.

In addition, consumption-side programs are typically developed at this stage to bring about shifts in purchasing behavior and lifestyle choices. Such measures serve to promote better public understanding of the environmental consequences of the "consumer society." For instance, ecolabeling programs are designed to modify consumers' selection criteria by drawing their attention to the energy consumption of household appliances or sustainable harvesting practices of timber or fish products. Increasing public awareness and attitudes about resource efficiency can also affect a population's willingness to cooperate and participate in local programs, such as segregating waste to assist recycling activities. The emphasis on the consumer side is also apparent in DSM in both the energy and water sectors, often relying heavily on the use of appropriate price signals to influence consumption behavior (page 82).

Figure 1.6 illustrates the achievement of greater resource efficiency by reducing consumption and waste of materials, and by reusing and recycling by-products. By implementing measures on both the production and consumption sides, countries may be able to reduce (per unit of product) both the quantity of the resource extraction stream (lower left) and the quantity and environmental impact of the residual materials flow (lower right) that ultimately reaches disposal sites.

Figure 1.7: The Closed-Loop Economy



Source: ADB.

At the far end of the resource efficiency spectrum is the "closed-loop economy" (Figure 1.7), where nearly all outputs either become inputs to other manufacturing processes or are returned to natural systems as benign emissions rather than as pollutants. For example, a closed-cycle processing plant takes in freshwater and does not discharge any liquid effluents. Rather, the water is constantly recycled and possibly utilized in the final product itself.

It should be noted that achieving truly closed cycles is difficult, if not impossible, for many raw materials and industrial processes, although technological advances are leading to greater reuse rates (page 121). However, the **pursuit** of such systems has transformed entire industries. The pulp and paper industry, once an energy-intensive and

[12] Graedel, T., and B. Allenby. 2003. *Industrial Ecology*, 2nd Edition. Englewood Cliffs, New Jersey: Prentice Hall. Chapter 8.

highly polluting industry throughout the world, was forever changed when it was found that the residues from chemical pulping—so-called "black liquor"—could be recovered and used as a fuel along with bark and other wood wastes. Modern pulp and paper mills now derive a significant portion of their internal energy requirements from such renewable wood by-products, while water consumption in new plants has dropped precipitously as pollution treatment requirements are less. As a result, the sector is no longer considered a dirty industry.[13]

While no country has come close to reaching an advanced stage in applying closed-loop economic principles, some countries, such as the Netherlands are beginning to take the needed steps to get there (page 44). Japan, Germany, and, recently, the PRC have created laws and resource-based policies under such terms as the sound material-cycle society (page 60) and the circular economy (page 48). In addition, companies in Europe, Japan, United States (US), and elsewhere are seizing competitive advantage through the higher resource productivity created by improved resource efficiency.

Industrial Ecology and Systems Approaches

The realization that industrial systems can mimic biological ecosystems, in which one organism's waste is the source of food for another organism, led to the concept of industrial ecology (IE). IE is a philosophy and a field of research and practice that examines industrial systems in the context of the natural, social, and economic systems that surround them.[14] The term was coined in the small municipality of Kalundborg, Denmark, where a well-developed network of dense firm interactions was encountered.

One of the strengths of IE is its systems view of patterns of production, consumption, and resource recovery, all perceived in their context in natural systems. It is systems science applied to the management of human activity as a subsystem of natural systems (Box 1.4). This integrative function may be the unique contribution of industrial ecology to environmental management. In their textbook, *Industrial Ecology,* Graedel and Allenby provide the following short definition of IE:

> Industrial ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural, and technological evolution. The concept requires that an industrial system be viewed

Box 1.4: Systems and Systems Science

What are systems? What is systems science? These words are overused and often abused. Following is a brief introduction to their meaning.

Below are some of the basic elements of a system:

- A system is a set of elements interrelating in a structured way.
- The elements are perceived as a whole with a purpose.
- The elements interact within defined boundaries.
- The behavior of the system results from the interaction of the elements and between the system and its environment (system + environment = a larger system) .
- The properties of a system emerge from the interaction of its elements and are distinct from their properties as separate pieces.
- A system's behavior cannot be predicted by analysis of its individual elements.
- The definition of the elements and the setting of system boundaries are subjective actions. Conflicts often develop because different parties have defined very different systems without realizing it. Thus, the assumptions of the definers or observers of any system must be made explicit.

Systems science ranges from highly theoretical work defining research methods to applied work in virtually all areas of life (often called "systems practice"). Some modes of applying systems thinking include the learning organization, systems dynamics, sociotechnical systems, and the viable system model.

In this time of complex and rapid change, systems thinking has immediate, pragmatic value for companies and agencies of any size. Understanding that we construct a system from a particular point of view is crucial to working with systems thinking and industrial ecology. This concept often helps to resolve conflicts between different points of view.

Source: Lowe, Ernest, John Warren, and Stephen Moran. 1997. *Discovering Industrial Ecology: An Executive Briefing and Sourcebook*. Cleveland, Ohio: Battelle Press.

[13] World Energy Council. 1995. *Global Energy Perspectives to 2050 and Beyond*. London.

[14] Brewster, J. Allen. 2001. Industrial Ecology and Its Relationship to Cleaner Production. Paper delivered at International Conference on Cleaner Production, Beijing, People's Republic of China. September.

> not in isolation from its surrounding systems, but in concert with them. It is a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal. Factors to be optimized include resources, energy, and capital.[15]

Like any living system, a community consumes material and energy inputs, processes them into usable forms, and eliminates the wastes from the process. This can be seen as "metabolism" of industry, commerce, municipal operations, and households. Understanding the pattern of these energy and material flows through a community's economy provides a systemic reading of the present situation for goal and objective setting and development of indicators for sustainability (Chapter 9 for a discussion of industrial metabolism).[16]

One of the basic principles of systems approaches like industrial ecology is that planning for greater resource efficiency and reduced pollution must be integrated across resource flows, economic sectors, public and private activities, and both short- and long-term time horizons, as discussed in Chapter 3. At its highest level, a systems perspective can be used to pursue greater resource efficiency across whole countries and regions, thus allowing policy makers and investors to

- understand short-term decisions in the context of their long-term implications,
- identify regional and global impacts of local actions and the nature of global impacts on local systems, and
- gain practical whole systems guidance on investment in environmental and energy technologies and services.

In this way, policies, investments, and action strategies can be developed in a holistic context, not in isolation. Otherwise, improvements in one realm may create major problems in another. For instance, a technology for producing ethanol from energy-dedicated crops like corn may cost more in energy, land, and water inputs than it yields in energy.

This report will not dig deeply into the rich field of science surrounding industrial ecology and industrial metabolism. However, it is important to acknowledge that pursuing greater resource efficiency across whole countries and regions is a complicated undertaking requiring highly advanced processes and methods for analysis. It is not simply a matter of measuring materials flows (although that is important), but also understanding the relationship between economic activities and materials flows and appropriate pricing, and the importance of spatial scales, trade flows, and the interactions between stakeholders.

Why Should Asian Countries Care About Resource Efficiency?

Practicing resource efficiency is not simply a response to environmental objectives; it very much concerns questions of economic competitiveness and sustainable economic growth. Following are several reasons why Asian countries should care about resource efficiency.

Tackling local environmental problems. The inefficient use of resources can lead to environmental burdens. Environmental effects include a host of localized environmental problems, such as high levels of urban air and water pollution, floods induced by solid waste clogging drainage canals, reduced availability and quality of freshwater supplies, and land degradation. High pollution levels put public health at risk, which translates into economic costs that are higher than what society would be willing to bear if prices were appropriate and decisions were made with full information about these consequences. According to recent estimates, government spending on environmental protection amounts to less than 1% of GDP in Asia and the Pacific, while the region's economies are losing as much as 8% of annual national growth due to environmental degradation.[17] In September 2006, the PRC released its first assessment of the cost of pollution in the country. Based on the report, PRC's

[15] Graedel, Tom, and B.R. Allenby. 1995. *Industrial Ecology*. Englewood Cliffs, New Jersey: Prentice Hall.

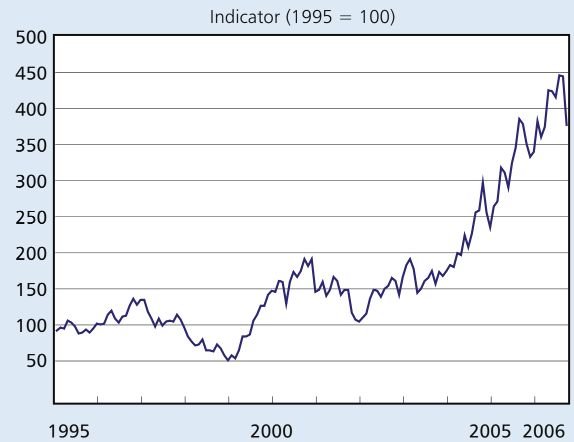
[16] Indigo Development. Available: http://www.indigodev.com/Sustain.html

[17] Boyd, Alan. 2002, 26 November. *Environmental Cost of Asia's Development*. Asia Times Online. Available: http://www.atimes.com/atimes/Asian_Economy/DK26Dk01.html

pollution caused $64 billion worth of environmental damage (3.05% of GDP) in 2004. The PRC is the first country to assess the cost of its pollution; the benefits are the creation of a model for developing countries and the advancement of public and business awareness.[18]

Addressing climate change. Some of these costs are visible at the global scale. Emissions of carbon dioxide and other GHGs are accelerating global warming. Because of increased use of fossil fuels, Asia's global share of GHG emissions grew from 8.7% in 1973 to 24.4% in 2003 and is expected to increase to 30% by 2030.[19] Improved resource efficiency is a key strategy to help move economies in Asia and the Pacific onto a lower carbon path, because efficiency measures can greatly reduce GHG emissions from energy generation and use, materials extraction and processing, transportation, and waste disposal. (See page 26 for a more detailed discussion of climate change.)

Figure 1.8: Brent Crude Prices (1995–2006)



Source: International Monetary Fund. Primary Commodity Prices. Available: www.imf.org, downloaded 9 October 2006;

Source: ADB.

Ensuring energy security. By depending on fossil fuels and inefficiently using (especially imported) energy supplies, countries become more exposed to price and supply fluctuations that can undermine energy security. Amid rising natural gas and oil prices and increasing geopolitical tensions, countries can dampen their demand for oil, electricity, and natural gas by renewing their emphases on EE measures (page 72). This is especially important for countries, such as those in the Pacific, that import a large portion of their energy supplies.

Preserving natural capital. There is a strong economic incentive to use renewable resources, such as water and forests, efficiently, guided by principles of sustainable water and land conservation planning. Future economic development depends on conservation of such natural capital assets and the services they provide to the economy.

Improving economic competitiveness. Continued growth of the economies of the PRC, India, and other large developing countries is resulting in higher commodity prices. As many countries in Asia enter more resource-intensive stages of development, they will be especially affected by competition for ferrous and nonferrous metals and plastics. These countries will also have to cope with

18 3R Knowledge Hub Secretariat. 2007. *Gap Analysis in Selected Asian Countries*. Bangkok: Asian Institute of Technology (AIT).

19 ADB. 2006, April. *Report of the Energy Efficiency Initiative. Manila*. Available: http://www.adb.org/Documents/Reports/Energy-Efficiency-Initiative/execsum.pdf

Source: ADB.

the long-term upward trend and volatility of oil prices (Figure 1.8). As a result, resource efficiency has become a major determining factor in the competitiveness of firms and nations.

Minimizing disposal costs. Overreliance on simple waste disposal is unsustainable. Countries cannot afford to build landfills or incinerators fast or safely enough to solve their waste dilemmas if current waste generation rates persist, especially in the face of continuing "not in my back yard" attitudes. Waste disposal must be viewed as just one part of an integrated waste management program. (See page 59 for a discussion on waste management.)

Developing new business opportunities. Many profitable business opportunities are available both in input-efficient production and in environmentally responsible recycling and waste disposal. Developing countries in the region should take full advantage of their chance to leapfrog over conventional solutions to more profitable and sustainable opportunities, such as resource recovery and waste-to-energy schemes. More advanced economies in the region should promote new technologies and technology transfer in the areas of "green" chemistry, biotechnology, nanotechnology, and renewable energy. (See Chapter 8 for a discussion of some of these opportunities.)

Pursuing social benefits. Developing countries can benefit from viewing the environment industry as a potential source of employment and long-term asset protection. The potential exists to improve social conditions while protecting the environment. Given that the Asian region is the world's fastest-growing market for environmental goods and services, there will be significant and growing opportunities for Asian-based small and medium-sized enterprises (SMEs) to meet local demand. Increasing employment opportunities and reducing environmental impacts from harmful wastes are two key factors in reducing poverty, thus contributing to achievement of the MDGs.

Avoiding resource conflicts. Environmental degradation could lead to intensified competition for scarce resources in certain regions. Should the grimmest scenarios come to pass, climate change may intensify already-worrying trends, such as desertification, sea-level rise, more frequent severe weather events, and shortages of freshwater (page 28). In turn, this could lead to violence over scarce necessities. In the worst scenarios, civil wars, uncontrollable migration, and global violence could ensue. Improved resource efficiency would lessen such pressures and help to avert some important root causes of social conflict.