# Chapter 2. Resource Use and Efficiency

***Asians are producing and consuming more, but the economies of most Asian countries are still based on an inefficient growth pattern featuring a linear and wasteful one-way flow of resources. Per unit of output, developing countries use far more energy, raw materials, and other resources in producing goods and services than do their counterparts in developed countries.***

This chapter explores the efficiency (and inefficiency) of use of material, energy, and water resources in Asia and the Pacific. Inefficient use of resources in the region is due to such factors as weakly enforced environmental laws, subsidies and other inappropriate price signals, inadequate knowledge of available clean technologies, low levels of environmental awareness, and poor enterprise management.[20]

## Materials

As countries in Asia experience an increase in material consumption and a related increase in the residuals (wastes and polluting emissions) from material extraction, production, and use, their governments are realizing that new strategies must be followed to achieve more efficient and cleaner use of both renewable and nonrenewable materials.

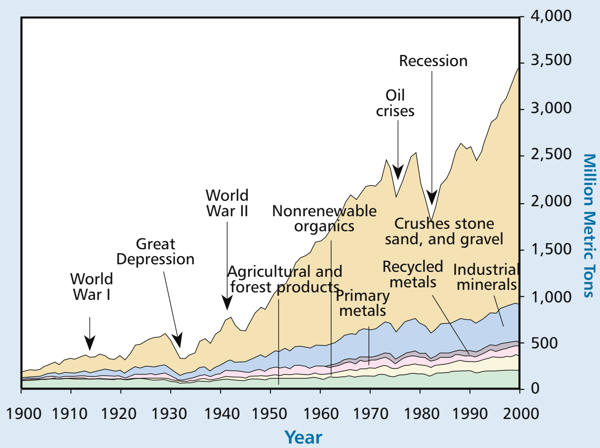
### Material-Use Patterns in Asia

As economies of developing Asia continue to grow, the default assumption is that they will follow similar raw material consumption trends as those experienced in the US and other industrialized countries over the last century. As shown in Figure 2.1, raw material consumption in the US dramatically increased as the economy expanded, despite periods of economic downturns.

In addition, as is already being witnessed, the types of materials needed to sustain growth in Asia are shifting to nonrenewable resources, i.e., those that form over geologic time. Construction materials, such as crushed stone and steel, are needed for roads, bridges, and buildings. Cement is needed for ready-mix concrete; ferrous and nonferrous metals for machinery; oil for petrochemicals; potash and phosphate for fertilizer; gypsum for drywall and plaster; fluorspar for acid; soda ash for glass and chemicals; and sulfur, abrasives, and various other materials for use in chemical manufacture.

Another regional and global trend is the increased use of nonrenewable organic materials, which are derived from feedstocks of petroleum, natural gas, and coal, for nonfuel applications. These

**Figure 2.1: US Flow of Raw Materials by Weight (1900–1998)**




Source: US Geological Service.

[20] UNEP. 2000, April. *Promoting Cleaner Production Investments in Developing Countries: Issues and Possible Strategies*. Paris.

**Table 2.1: Contribution to Global GDP and Resource Demand for Asian Economies**

| | Contribution to Growth, 1991–2004 | | |
|---|---|---|---|
| Region | Gross Domestic Product (GDP) | Petroleum Demand | Steel Demand |
| World | 100.0 | 100.0 | 100.0 |
| Developing Asia | 41.2 | 63.0 | 75.3 |
| East Asia | 26.3 | 36.0 | 65.3 |
| South Asia | 8.9 | 9.8 | 3.7 |
| Southeast Asia | 5.1 | 12.8 | 6.3 |
| Central Asia | 0.3 | -2.3 | – |

– = no data.

Source: Park, Cyn-Young. 2006. Asia's Imprint on Global Commodity Markets. Paper presented at the International Conference on Sustainable Resource Management, Raw Materials Security, Factor-X Resource Productivity -Tools for Delivering Sustainable Growth in the European Union. Bruges, Belgium, 6–7 December.

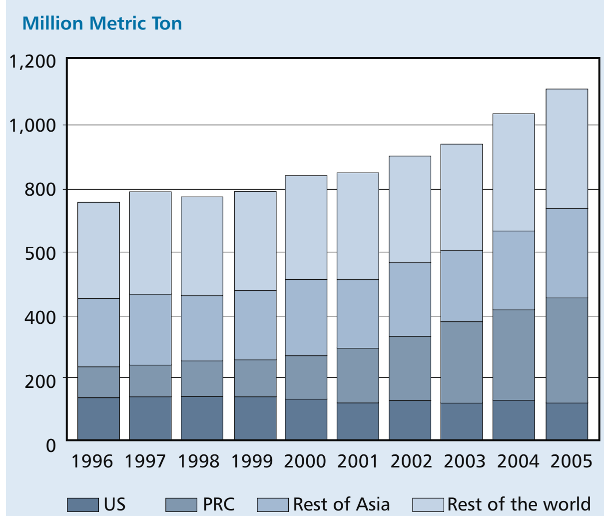
include resins used in the production of plastics, synthetic fibers, and synthetic rubber; feedstocks used in the production of solvents and other petrochemicals; lubricants and waxes; and asphalt and road oil.[21] New materials have replaced old because of cost advantages and/or more desirable properties. Synthetic fibers are replacing natural fibers and plastic is often replacing wood, metal, and other mineral-based commodities.

Source: ADB.

A recent study showed that the demand of petroleum and steel in East and Southeast Asia is proportionately much larger than these regions' contribution to the world economy (Table 2.1). This suggests that the current stage and pattern of economic development in Asia is highly resource demanding.

The demand for resources in the PRC is particularly eye-opening. The PRC is currently in the middle of its most commodity-intensive stage of development and is using staggering amounts of nonrenewable materials. In 2003, half of the world's cement output, a third of its steel, a quarter of its copper, and a fifth of its aluminum were consumed in the PRC.[22] And as shown by Figure 2.2, PRC's consumption of steel continues to expand relative to the rest of the world. Even if PRC's demand for raw materials slows, India's economy is now taking off. India's demand for raw

**Figure 2.2: World Consumption of Steel (1996–2005)**




PRC = People's Republic of China, US = United States.

Source: World Coal and Steel Institute.

[21] Wagner, Lorie. 2002, February. Materials in the Economy—Material Flows, Scarcity, and the Environment. *US Geological Survey Circular* 1221. US Department of the Interior.

[22] PriceWaterhouseCoopers. 2004. *The China Challenge: Opportunity & Risk in the World's Fastest Growing Market*. Available: http://www.pwc.com/Extweb/manissue.nsf/docid/8FC5CCD285CC07CACA256F1E000DE9AD

**Box 2.1: Copper Mining—Problems and Prospects**

Most of the increased consumption of copper will take place in developing countries. Consumption in the People's Republic of China and India will increase from 2 million metric tons (Mt) and 400,000 tons in 2000 to 5.6 Mt and 1.6 Mt, respectively, in 2020. Much of this projected copper consumption will have to come from mine production from reserves because recycling of copper is still limited, as is the availability of substitute commodities.

To meet anticipated copper consumption between 2000 and 2020 and to maintain a proportional amount of reserves will require more than three times the amount of copper contained in the five largest deposits currently known. Although some of this material exists in discovered deposits, much of the material will need to come from undiscovered deposits.

In addition, if current practices persist, mining and milling of copper ores will produce about 130 billion tons of waste rock and 56 billion tons of tailings between 2000 and 2020. Further, copper smelting usually releases both sulfur dioxide and arsenic to the atmosphere and hydrosphere.

Source: AFP.

Source: Menzie, David, Geologist, US Geological Survey. 2006. *Hearing on Energy and Mineral Requirements for Development of Renewable and Alternative Fuels Used for Transportation and Other Purposes*. Speech before the House Resources Committee, Subcommittee on Energy and Mineral Resources. 18 May.

materials could triple over the next 10 years as capital expenditure and infrastructure spending increase.[23]

It is important to note that despite the increase in demand for nonrenewable resources, the world still has abundant supplies of most mineral resources (fossil fuels are discussed separately in the energy section below), although rapid increases in consumption may lead to temporary shortages of certain mineral resources. One of the main challenges over the coming decades will be discovering new mineral deposits (Box 2.1). Such deposits will be more difficult to discover and will likely be more costly to produce. Production will depend on such factors as adequate levels of mineral exploration, development of new technologies for mineral discovery and extraction, and social and legal environments governing mineral exploration and production.[24] However, the pace of mine development may become slower and the costs higher.

In addition, conventional development, operation, and closure of mines have very high environmental, social, and economic impacts on communities and their regional ecosystems. Pollution of air, groundwater, and surface water often creates dead rivers, toxic water supplies, and barren landscapes. Economic benefits of mining seldom reach local communities. In response to these problems, the international mining industry has launched a major initiative to define sustainable mining policies and practices.[25]

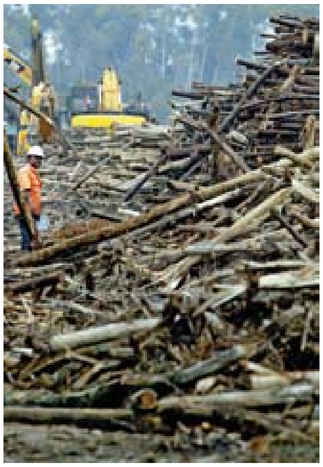
Many countries in the region have also wasted or are in the process of squandering their renewable resources by harvesting and using them in unsustainable ways. Renewable material resources are those that regenerate themselves, such as agricultural, fishery, forestry, and wildlife products. If entire ecosystems are destroyed, losses of species and ecosystem services can be irreversible.

An example is the loss of forest resources in the Philippines. In the 1960s and 1970s, the Philippines was a regional leader in timber exports, selling about 10 million cubic meters yearly. However, due to unsustainable and corrupt management practices and a failure to invest in the industry, forest resources dwindled and exports fell to less than a tenth of that level by 1980. The Philippines must

23 *The Economist*. 2006. More of Everything: Does the world have enough resources to meet the growing needs of the emerging economies? 16 September.

24 Menzie, David. 2006. Hearing on Energy and Mineral Requirements for Development of Renewable and Alternative Fuels Used for Transportation and Other Purposes. Speech before the House Resources Committee, Subcommittee on Energy and Mineral Resources. 18 May.

25 Mining Minerals and Sustainable Development. 2002. *Breaking New Ground*. Available: http://www.iied.org/mmsd/


Source: AFP.

now import most of its wood resources, buying from countries that reforested (e.g., Australia, Malaysia, and New Zealand) at a time when Asia-Pacific demand for wood-based panels, paper, and paperboard has exploded.[26] Unfortunately the damage from deforestation does not stop there—watersheds are invariably degraded, causing even more economic and environmental problems. The burning of formerly forested lands also releases large quantities of carbon dioxide, contributing to climate change. The experience of the Philippines provides an important lesson for still forest-rich countries, such as Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Papua New Guinea, and Solomon Islands.[27] If there is a shift to the use of plant and crop-based resources for energy and chemical products, as is expected over the coming decades (page 42), then the management of renewable resources will become even more vital.

Throughout the region and the world, continued growth in the use of renewable resources will inevitably lead to expansion in the size of developing countries' "ecological footprints," a measure that attempts to weigh humanity's past and present demand on the Earth's renewable natural resources.

An ecological footprint, either on a national, regional, or global scale, is the total area required to produce food and fiber, absorb waste from production and consumption, and provide space for the built environment and infrastructure. Although footprints are not among the agreed indicators of the MDGs and require difficult and debatable estimations, they can nonetheless be used as indicative yardsticks. Freshwater consumption is not included in the ecological footprint.

One of the most powerful uses of the ecological footprint approach is in the assessment of sustainability. By comparing the ecological footprint with biocapacity (the available supply of natural resources), it is possible to assess the ecological sustainability of current consumption—if demand is greater than supply, the level of consumption is not sustainable.[28]

In its recent *Living Planet Report*, the World Wildlife Fund (WWF) reports that humanity's footprint first grew larger than global biocapacity in the 1980s and that this overshoot has been increasing every year since. According to their estimates, we are now spending nature's capital far faster than it is being regenerated. In 2003, the global ecological footprint was estimated at 14.1 billion global hectares, or 2.2 global hectares per person (a global hectare is a hectare with world-average ability to produce resources and absorb wastes), while the total supply of productive area, or biocapacity, was only 11.2 billion global hectares, or 1.8 global hectares per person. Water resources are not included in these calculations.[29]

Furthermore, increases in per capita consumption, in Asia and elsewhere, will enlarge both per capita and national footprints substantially. The Worldwatch Institute estimates that if everyone on the planet were to reach the current consumption level of the affluent nations with the highest ecological footprints, we would need the resource equivalent of five Earths to support it. On a planet that is reaching its limits, nations must learn to plan strategically how to achieve far more resource-efficient economies, and then commit the financial resources and develop the political will to implement their strategies before it is too late.

## Waste Generation in Asia and the Pacific

As income levels and consumerism have increased, Asia and the Pacific have also witnessed an expansion in the volume of waste and a diversification of the types of wastes generated in daily life—similar to waste generation patterns in developed countries. Although developing countries still have lower rates

26 Mercado, Juan L. 2004, 14 November. *Stumbling into National Hara-kiri.* Sunstar Cebu. Available: http://www.sunstar.com.ph/static/ceb/2004/11/14/oped/juan.l..mercado.html
27 Ibid.

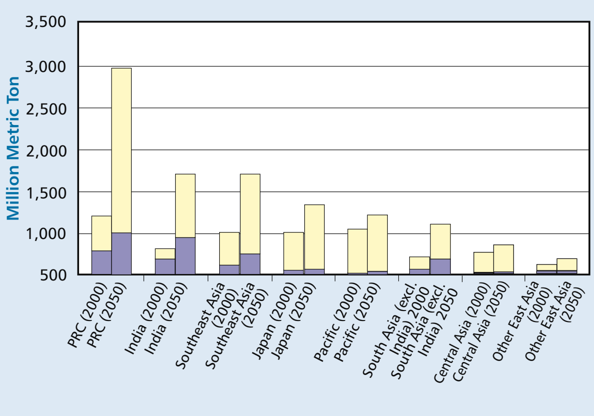
28 http://www.steppingforward.org.uk/tech/index.htm
29 WWF International, Zoological Society of London, Global Footprint Network. 2006. *Living Planet Report.* Gland.

of per capita waste generation than do developed countries, urbanization is accelerating and industrial and manufacturing sectors are expanding at rates that far exceed the capacity of many developing countries to cope with the resulting environmental stress and degradation. Most cities throughout Asia and the Pacific are struggling to cope with already overflowing landfills.

For a long time, the main concern in Asia and the Pacific was receiving hazardous wastes unloaded by developed countries. More prosperous countries and cities have practiced a strategy of "out of sight, out of mind," mostly through industrial relocation and waste export. While it has improved environmental quality in places that export pollution, this process has had negative social, economic, and environmental effects on places that receive the waste or host the industries (this issue is discussed in more depth in Chapter 10).

While this remains a significant problem in the region, Asian countries also have to manage increasing amounts of waste that is generated within their own boundaries as they reach middle-income status and become more urbanized (Figure 2.3). In addition, as countries develop, their waste composition changes, which compounds their waste disposal challenges. These changes typically include a decline in the percentage of compostable matter, a substantial increase in use of paper and paper packaging, and a higher proportion of plastics, multimaterial items, and "consumer products" (along with related packaging materials). As countries in the region develop, their waste streams, which previously included mostly organic material from garbage and farm residues, increasingly include medical, electronic, and construction and demolition waste.

**Figure 2.3: Projected Solid Waste Generation in Asia (2000–2050)**




PRC = People's Republic of China.

Source: Solid Waste Projection Study by Tanaka et al.

Source: AFP.

However, it should be noted that low-income countries still have a high (40–70%) proportion of compostable organic matter in their urban waste stream (Table 2.2 on page 20), and this effects the technologies and processes that should be employed.[30] This is especially true in agricultural economies like Lao PDR, Myanmar, and Nepal. Higher organic matter in the waste stream results in high waste density (weight to volume ratio) and high moisture content. Systems that operate with low-density wastes, such as in industrialized countries, will not be suitable or reliable in many low-income countries. Instead, biological treatment, such as composting and biogasification (i.e., anaerobic digestion) is more suitable. Further, wastes with a high water or inert content will have low calorific value and also not be suitable for incineration.[31]

Unfortunately, only a few Asian cities, such as Hong Kong, China; Singapore; and Tokyo, have adequate solid waste disposal facilities. Most cities in the region are not taking adequate measures to dispose of their waste safely, nor are they doing enough to divert the organic fraction of their waste from landfills by composting or other appropriate

30 Shastri Applied Research Project (SHARP). 2005, June. *SHARP Profile*. Available: http://www.sici.org/2004shastri/PDF/Engaging%20Communities%20in%20Solid%20Waste%20Management.pdf

31 Zurbrügg, Christian. 2002, November. Urban Solid Waste Management in Low-Income Countries of Asia: How to Cope with the Garbage Crisis. Presented for Scientific Committee on Problems of the Environment (SCOPE), Urban Solid Waste Management Review Session. Durban, South Africa.

**Table 2.2: Waste Composition in Urban Settings of Asia**

| Country | Waste Categories (average percentage of wet weight) | | | | | |
|---|---|---|---|---|---|---|
| | Organic | Paper | Plastic | Glass | Metal | Others |
| Bangladesh (urban) | 70.0 | 4.3 | 4.7 | 0.4 | | 20.6 |
| PRC (using coal) | 65.0 | 9.0 | 13.0 | 2.0 | 1.0 | 10.0 |
| PRC (using gas) | 41.0 | 5.0 | 4.0 | 2.0 | 1.0 | 47.0 |
| Indonesia (urban) | 65.0 | 13.0 | 11.0 | 1.0 | 1.0 | 9.0 |
| Japan | 17.0 | 40.0 | 20.0 | 10.0 | 6.0 | 7.0 |
| Korea, Republic of | 31.0 | 27.0 | 6.0 | 6.0 | 7.0 | 23.0 |
| Malaysia | 43.0 | 24.0 | 11.0 | 3.0 | 4.0 | 15.0 |
| Philippines | 41.0 | 19.0 | 14.0 | 3.0 | 5.0 | 18.0 |
| Singapore | 44.0 | 28.0 | 12.0 | 4.0 | 5.0 | 7.0 |
| Thailand | 40.9 | 12.1 | 10.9 | 6.6 | 3.5 | 17.2 |
| Viet Nam | 49.0 | 2.0 | 16.0 | 7.0 | 6.0 | 20.0 |

PRC = People's Republic of China.

Source: Compiled from information in 3R Knowledge Hub Secretariat. 2007. *Gap Analysis in Selected Asian Countries*. Bangkok: Asian Institute of Technology.

means (see Chapter 6 for discussion of solid waste management practices in developing countries). Ever-increasing quantities of waste could prove disastrous in these countries unless policy frameworks for environmental protection and occupational health and safety are improved and enforced.

Different types of wastes that countries must manage are discussed below. Some waste statistics from the two leading generators of waste among developing countries in the region—the PRC and India—are presented in Figure 2.4.

**Municipal solid waste.** Municipal solid waste (MSW) is generally defined as waste collected by municipalities or other local authorities. However, this definition varies by country. Typically, MSW includes household waste; commercial/institutional waste; and waste from municipal services, such as street cleaning and maintenance of recreational areas. It even includes metal scrap from old vehicles, which is posing a problem in the Pacific Islands (Box 2.2). It typically excludes waste from municipal sewage networks and treatment, and municipal construction and demolition waste.

Among Asian countries, there is a marked range of waste generation per capita. MSW generation rates and composition are related to the rate of urbanization, the types and patterns of consumption, household revenue and lifestyles, and waste management practices.[32] Waste generation rates can also differ among cities in the same country.

**Industrial solid waste.** While the generation of industrial solid waste (ISW) differs greatly among countries in Asia, in general, far more ISW is generated in Asian countries than MSW, in some cases by a large margin. For instance, the generation ratio of municipal waste to industrial solid waste is estimated to be 1:7 for the PRC[33] and 1:8 for Japan.[34] Industrial solid waste includes a variety of materials, most of which are not hazardous or toxic. These include packaging materials, paper, food wastes, resins, plastics, metal and plastic scraps, wood waste, fly ash, bottom ash, boiler slag, and gangue.[35] Like MSW, the generation of ISW differs

32 OECD Factbook. 2006. *Economic, Environmental and Social Statistics*. Available: http://oberon.sourceoecd.org/vl=52787404/cl=12/nw=1/rpsv/factbook/07-01-03.htm

33 Huang, Qifei, Qi Wang, Lu Dong, Beidou Xi, and Binyan Zhou. 2006. *The current situation of solid waste management in China*. J Mater Cycles Waste Management, pgs 63–69.

34 UNEP International Environmental Technology Centre and ASEAN Working Group for Multilateral Environmental Agreements. 2002. State of Waste Management in South East Asia. Available: http://www.unep.or.jp/ietc/publications/spc/State_of_waste_Management/index.asp

35 Gangue is rock surrounding a mineral or precious gem in its natural state. Slag is composed of vitreous materials that contain impurities from ore and form on the surface of molten metals. Fly ash is the finely divided mineral residue resulting from the combustion of

### Figure 2.4: Waste Statistics in the PRC and India

**PEOPLE'S REPUBLIC OF CHINA**

**Municipal solid waste.** In 1981, the quantity of MSW collected and transported was 26.1 million metric tons (Mt). In 2002, it was 4.2 times that amount, representing an annual rate of increase of 8.2%, higher than the average annual rate of population increase of 4.4%.

**Industrial solid waste.** The People's Republic of China (PRC), along with India, is unique in the region in that it traditionally uses coal as a household fuel source. The coal mining and processing industry generated the most industrial solid waste (ISW) among industrial sectors, producing 16.0% of the total. The largest component of ISW is mining gangue, followed by coal gangue and coal ash. The recycling rates of these categories of waste are low—8.48%, 32.0%, and 36.2%, respectively.

**E-Waste.** The PRC had the highest growth in number of computer users per capita during 1993–2000. It grew a massive 1,052%, compared to a world average of 181%. In addition, of global personal consumption items, roughly 20% of mobile phones and 23% of televisions (TVs) were sold in the PRC. In 2003, an estimated 4.48 million personal computers (PCs), 33.5 million TVs, 9.76 million refrigerators, 7.56 million washing machines, and 0.65 million air conditioners became obsolete in the country. Further, the total e-waste from these sources is expected to increase from 55.95 million units in 2003 to 105.28 million units by 2010, an increase of 88% within 7 years.

**INDIA**

**Municipal solid waste.** Waste generation rates vary in relation to the cities sizes. Data show average rates of 0.21 kilogram (kg)/person/day for cities of 100,000–500,000 people and 0.5 kg/person/day for larger cities.

**Industrial solid waste.** There are about 13,000 producers of hazardous waste that generate approximately 4.4 Mt of hazardous waste per year. While many producers have been granted permission to temporarily store hazardous wastes on site, this method has become permanent in many cases.

**E-Waste.** The annual growth rate of PCs in use has been estimated to be 25%, while for TVs, refrigerators, and washing machines, it is 15–20%. The obsolescence rate of PCs is about 7 years while for the remaining items it is about 15 years. The e-waste inventory is expected to be 16 Mt by 2012.

**Agricultural waste.** Agriculture in India contributed high methane (a greenhouse gas [GHG]) levels from livestock (45%), paddy cultivation (22%), and biomass burning (15%). Indian farming generated nitrogen oxide ($N_2O$), another GHG, from nitrogen fertilizer (60%), biomass burning (10%), fertilizer production (11%), and livestock (9%).

Note: The effective application of material resource efficiency requires an understanding of existing and future waste generation and its composition. However, statistics on waste generation is currently hard to come by. It is based on available data, which varies significantly from country to country. In most Asian developing countries, common challenges in properly classifying waste includes the following: (i) There is no system to identify and classify waste into domestic, commercial, and/or industrial wastes. Typically, all types of solid waste are mixed together and not sorted, and there is usually no differentiation during collection by public or private contractors; (ii) The nontoxic or nonhazardous waste generated by various industries is included in the municipal solid waste stream; therefore, it is difficult to obtain data of the industrial waste separately. As a result, the exact rate of industrial waste generation in many countries is not known; (iii) Different ways of classifying and defining hazardous wastes have led to some difficulties in creating a uniform database for hazardous waste in the region.

greatly among countries in Asia and also between rural and urban environments. The categories of ISW in a country are closely related to its level of industrial development and industrial structure.

As countries in the region develop further, there will be a substantial increase in ISN generation, which will pose a serious challenge to those countries that do not have adequate waste collection, transportation, and processing and disposal systems. Many countries need to increase the conversion of ISW into usable resources or energy. Examples of such use are fertilizers, building materials, and road materials.

**Hazardous waste.** As Asian countries continue to develop, the region will generate more toxic chemicals and hazardous waste. Ensuring the proper management of hazardous waste is a fast-evolving area. Most hazardous waste comes from industrial, agricultural, and manufacturing processes, and from hospitals. Products and industries that generate a high volume of hazardous waste include chemicals, petrochemicals, petroleum, metals, electronic manufacturing, transport, wood treatment, pulp and paper, leather, textiles, and energy production.[36]

By volume or weight, hazardous wastes account for a low percentage of total waste generated (hence

powdered coal in electric generating plants and boilers.

[36] Ibid.

**Box 2.2: Metal Scrap on the Pacific Islands**

Pacific islands are overloaded with metal scrap from old vehicles. Based on a recent analysis, about 75,000 metric tons of scrap metal exist on Saipan, Guam, and Palau; 35,000 metric tons on the Federated States of Micronesia; and 35,000 metric tons on the Marshall Islands.

The process of reducing this waste stream is encumbered by such complexities as

- unevenly developed disposal systems (including significant unregulated dumping);
- relatively recent interest in integrated sold-waste management plans; hence, the absence of requirements that maximize the streams of scrap through source-separation or waste-stream-separation processes;
- incomplete and insufficient scrap-cost-recovery tariffs;
- burgeoning populations (with attendant increases in waste production);
- real estate limitations for solid-waste disposal sites;
- relatively small-scale scrap streams, resulting in efficiency-of-scale limitations; and
- scrap-recovery inefficiencies related to remoteness from principal scrap-processing centers.

There are some recent signs of progress. Recently, the United States Environmental Protection Agency awarded $30,000 to the Electicore Consortium to organize a scrap material-recycling program in the Pacific called the Green Island Alliance. Consolidating the scrap material from various islands will make recycling economically feasible, create jobs, and facilitate the sustainability of a regional recycling program.

In January 2005, a new law took effect on Guam that requires advance disposal fees on automobiles, trucks, heavy equipment, automotive batteries, tires, and certain other goods. The law requires consumers to pay deposits ranging from $3 for a tire up to $200 for a car or truck. The funds will be used to dispose of the items properly, including the abandoned vehicles, refrigerators, and tires that dot Guam's landscape.

Sparked by the increased demand for commodities in the growing economies of the People's Republic of China and India, the private sector in New Zealand and Australia has stepped in to help Pacific countries solve this problem. For instance, the American Samoa Power Authority (ASPA), which manages a scrap metal yard, sends several shipments of scrap metals to Sims Pacific Metals, the most widely known company buying scrap metal in the region.

Sources: Environment News Service. 2005, 8 February. EPA Funds Pacific Islands Scrap Metal Recycling Survey. Available: http://www.ens-newswire.com/ens/feb2005/2005-02-08-09.asp#anchor6
http://sprep.org/solid_waste/documents/Solid%20Waste/Guidelines/The%20Scrap%20Metal%20Recycling.pdf

the need to evaluate these wastes separately), but their generation is rising rapidly as chemical use in products and processes becomes more generalized. Where industrial or other hazardous waste is mixed in and dumped openly with the rest of the municipal waste, the entire waste stream becomes "hazardous," because it is not feasible to separate it from mixed waste.

While many industries under foreign direct investment in developing Asia are, if anything, more modern (and lower waste) than their counterparts in the developed world, some industrial locations far from the free-trade centers and coastal port areas still serve as pollution havens. Many factories in developing countries do not have access to disposal services for solid industrial toxic waste, forcing many to use rivers, landfills, or open burning. Some hazardous industrial waste is also stored on site without an adequate form of management.

**Electronic waste.** Harmful chemicals are also increasingly embedded in common products and everyday processes. There are growing problems related to commercial users of chemicals and the use of toxics from consumer products that are discarded or recycled. One prominent example is electronic waste (or E-waste), which can contain more than 1,000 different substances, many of which are toxic (e.g., arsenic, mercury, cadmium, beryllium, and hexavalent chromium). E-waste includes discarded mobile phones, audio-video equipment, PCs, copiers, and household appliances.

One of the more troubling aspects of e-waste is the incredible rate at which it is accumulating.

The electronics industry is the world's largest and fastest growing manufacturing industry. Meanwhile, the lifespan of the products is dropping. As a consequence, e-waste is one of the fastest growing waste streams in the industrialized world.[37] While most of the attention in the region is focused on imports from the US and other developed countries, Asian nations also have to manage the increasing amount of e-waste that is being generated on their own soil. E-waste is discussed in detail in Chapter 10.

**Medical waste.** The management of medical waste poses a major problem in most countries in the region. Large urban hospitals can generate more than 2 million tons (Mt) of waste, including dressings, needles, medicines, pharmaceutical products, human tissues and liquids, and even radioactive wastes yearly.[38] The quantity and composition of medical waste varies depending on the size of the establishment, proportion of in- and outpatients, type of institution and specialization, available waste segregation options, proportion and use of reusable items, and the prosperity of the country.

The problem of medical waste, however, is not as much about quantity as it is about the nature of the waste and the way it is disposed. Largely as a result of a lack of waste segregation practices in most hospitals, waste from hospitals poses significant health threats. Oftentimes, hospitals simply dump all their waste streams together, from reception-area trash to operating-room waste. As a result, many hazardous materials are mixed into general solid waste for disposal in municipal bins, are mixed into wastes which are incinerated as potentially infectious waste, or are flushed down wastewater drains that flow directly to open sewers or rivers. Such practices represent serious health hazards to workers and to the public and diminish the possibility of recovering some parts of the waste stream for recycling.

Source: C. Visvanathan.

In many countries, such as India, Malaysia, Thailand, and Viet Nam, incineration is a common method of treatment. Many of the incinerators lack pollution control equipment to capture targeted pollutants, such as dioxins, mercury, and cytotoxic emissions. The expansion of the private health sector and proliferation of unregistered clinics have aggravated this problem.

**Agricultural waste.** Conventional petrochemical farming generates a varied mix of material wastes, many of which may damage rural ecosystems, degrade farmland, and pose risks to human health. Non-crop agricultural waste includes toxic waste (pesticides, herbicides, fungicides, chemical fertilizer, and motor oil); discarded chemical containers; plastics, such as silage wrap, bags, and sheets; used packaging; old machinery; used oil; and veterinary medicines like antibiotics and growth hormones (through animal waste or discard of the medicines themselves). Residual chemical and oil supplies are often dumped on the land or in waterways. Crop wastes include spoiled food, stalks, leaves, tree and vine pruning discards, animal manure, dead animals, and discards from farm food processing. Excess biomass from farm animals and household sewage causes health problems and nitrogen-rich runoff that contaminates groundwater and surface water.

Soil degradation from overproduction, chemical fertilizers and pesticides, and low input of organic soil building amendments is itself a major waste of a scarce resource. Chemical farming weakens soil structure and quality, enabling more rapid erosion and lowering productivity over time. GHG emissions are another important farm waste, coming from animal manure, some farm chemicals, composting, and farm equipment. This is especially true for concentrated animal feeding operations, such as feedlots, factory chicken farms, and dairies.

37 Basel Action Network and Silicon Valley Toxics Coalition. 2002, 25 February. *Exporting Harm: The High-Tech Trashing of Asia*.

38 *Health Care Without Harm*. Available: http://www.noharm.org/globalsoutheng/medicalwaste/issue

**Construction and demolition waste.** Commonly known as C&D debris, construction and demolition waste includes materials produced during the construction, renovation, or demolition of structures. Structures include buildings of all types, both residential and nonresidential, as well as roads and bridges. Components of C&D debris typically include asphalt, bricks, concrete and other masonry materials, soil, rock, wall coverings, drywall, plumbing fixtures, insulation, roofing, shingles, glass, metal, wood waste, carpet, and electrical wires.

In developed countries, such wastes occupy a significant portion of the volume of landfills. Because C&D debris is variously classified as industrial waste or MSW, municipal and national figures vary widely. Although much more C&D discard material is generally reused in developing Asian countries, the construction and demolition process still represents a significant load on landfills and a good opportunity for recycling. The proportion of C&D debris normally increases with economic development because of the construction and renovation that accompanies it. So even those countries of Asia that do not now have a serious problem with the disposal of C&D debris will face a growing problem as they achieve the economic growth they are pursuing.

## Energy

***Rapid economic growth in Asia, increases in global energy prices, and the growing impact of climate change have made energy supply and efficiency a critical issue in the future of Asian economies, requiring new technologies and new approaches to the efficient use of energy resources.***

Increasing EE to wring more value from each primary energy unit consumed has huge environmental and economic benefits. EE measures can ease growth in fossil energy demand and upward pressure on energy prices, reduce or eliminate power cuts, improve energy security, and improve air quality. EE is also a key strategy in combating potential problems associated with global warming.

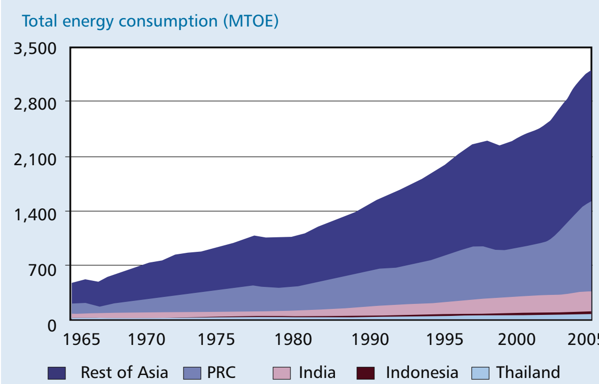
Energy systems are key drivers of economic and social development. Ten billion tons of oil equivalent is consumed per year worldwide to generate electricity and power industrial processes and transportation systems.[39] Securing affordable energy supplies is vital to any countries' economic outlook. Developing energy supplies must proceed along with efficient energy utilization, the development of alternative energy sources, and the reduction of oil subsidies.

### Energy Use in Asia

Energy use in Asia is still lower than in other parts of the world but has grown rapidly over the past 30 years (Figure 2.5). During 1973–2003, Asia's energy consumption rose 230%, compared to the average worldwide increase of 75%. Between 2003 and 2030, energy use in the region is estimated to increase another 89%. The region could account for as much as 30% of total world energy consumption by 2030.[40]

The rapid increase in energy demand has led to economic problems in many countries, due in large part to low prices that have encouraged overconsumption. The growing gap between debt burden and revenues has resulted in a financial crisis for many developing-country utilities. Increasing

**Figure 2.5: The Growing Demand for Energy in Selected Countries in Asia**




MTOE = million tons of oil equivalent, PRC = People's Republic of China.
Source: British Petroleum. 2006. *Statistical Review of World Energy 2006.* London.

[39] Gupta, K.P. 2006. *Energy Conservation by Demand-Side Management by Standardization and Energy Labelling*. Gujarat Electricity Regulatory Commission. India Electricity. Pragati Maidan New Delhi. 11–13 May.

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

power demand has also created electricity shortages when electricity supply cannot keep up with rising demand. Shortages have led to massive economic losses. In 2004, the PRC experienced a power supply gap of 30,000 megawatts (MW), and more than 27 municipalities, provinces, and autonomous regions had restricted power supplies. Zhejiang suffered from a power shortage of over 7,500 MW, leading to direct GDP losses of 100 billion yuan ($12 billion).[41]

Increased demand for energy will require the region to invest up to $5 trillion in its energy supply by 2030.[42] To meet demands, the PRC's power market will require an average 48 gigawatts (GW) of new capacity every year, equal to two thirds of the United Kingdom's total installed capacity.[43] In India, the soaring power demand will necessitate increasing installed generation capacity from 101,000 to 292,000 MW over the next two decades, even under a best-case scenario that envisions intensified efforts to modernize power plants, improve transmission and distribution efficiency, and adopt more efficient generation technologies.[44]

A large share of the growth in energy demand will be due to rapid industrialization. In most developing countries, energy use in industry outstrips all the other sectors. In India, for instance, industry accounts for as much as 55% of the total consumption, followed by the transport and household sectors.[45] Another important factor increasing demand will be extending energy to the 1.7 billion people in the region who rely on noncommercial energy sources for cooking and heating.[46] This is certainly the case in South Asia, where the challenge will be to provide electricity for the first time to one billion people.

[41] Ying, Wang. 2005, 20 Jan. *China Daily*. Spotlight Shone on Energy Conservation. Available: http://news.xinhuanet.com/english/2005-01/20/content_2484389.htm.

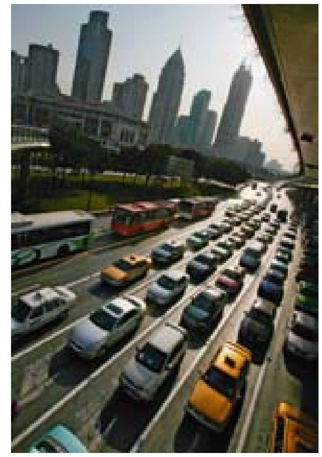
[42] Ibid.

[43] UNEP. 2006, May. Fighting Climate Change through Energy Efficiency: Local Financing to Slash Energy Waste in China, India, Brazil Said Crucial to Forestalling Global Climate Change. Available: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=477&ArticleID=5276&l=en

[44] Ibid.

[45] Gupta, K.P. 2006. Energy Conservation by Demand-Side Management by Standardization and Energy Labelling. Gujarat Electricity Regulatory Commission. India Electricity. Pragati Maidan New Delhi. 11–13 May.

[46] ADB. 2006. Toward a Cleaner Energy Future in Asia and the Pacific. Manila.



Source: AFP.

At the same time, energy use for transportation is projected to grow by 6–9% per year in the PRC and 5–8% per year in India. Under a business-as-usual scenario, the total number of cars and sports utility vehicles in the PRC and India combined could rise from around 19 million in 2005 to 273 million by 2035. India is also expected to have 236 million motorcycles in 2035, up from 35.8 million in 2005.[47] Largely because of increased energy use for transportation and also because there are few competitive alternatives to petroleum, emerging Asia (including the PRC and India) is expected to account for 45% of the total world increase in oil use through to 2025.[48]

## Energy Efficiency in Asia

The transition in many countries from agriculturally-based economies to more industrialized and urbanized societies has been largely marked by inefficient use of energy resources. Despite recent EE improvements (Figure 2.6 on page 26), inefficiencies and waste abound during energy production, distribution, and end use. There is a sizeable EE gap in terms of per capita energy utilization between Asian developing countries and developed countries.

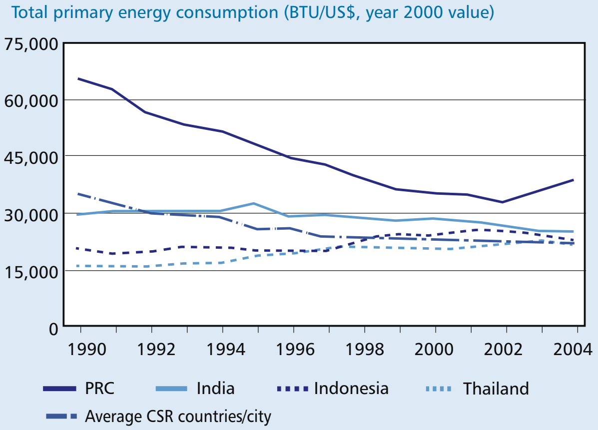
On the supply side, the energy conversion process remains inefficient in most developing countries. For instance, the PRC's average efficiency of thermal power generation is 33.8%, 7% lower than that of developed countries.[49] Furthermore, most countries experience energy losses of 20% or

[47] ADB and Department for International Development (UK), in collaboration with the Clean Air Initiative for Asian Cities. 2006. *Energy Efficiency and Climate Change Considerations for On-road Transport in Asia*. Manila.

[48] Ibid.

[49] Ying, Wang. 2005, 20 Jan. Spotlight Shone on Energy Conservation. *China Daily*. Available: http://news.xinhuanet.com/english/2005-01/20/content_2484389.htm.

**Figure 2.6: Energy Intensity in Selected Asian Countries**




BTU=British thermal unit, CSR=country synthesis report, GDP=gross domestic product, PRC=People's Republic of China, US=United States, $=US dollar.

Source: Energy Information Administration. 2006. www.eia.doe.gov/emeu/inernational/contents.html

higher during transmission and distribution due to the inherent "line loss" of present best technology.[50]

End-use inefficiencies exist across a broad range of sectors. There are three major energy-intensive sectors—industry, construction, and transportation—and all of them are key factors in maintaining a country's GDP growth rate and improving the daily life of its people. The rapid development of these three sectors creates a growing demand for raw materials, such as steel and cement, as well as for energy, such as electrical power and gasoline.

In the industrial sector, companies typically use inefficient production technologies. Studies indicate that as much as 23% of industrial end-use energy is wasted as the result of inefficiencies.[51] A key strategy to improving EE in this sector is to ensure that funding exists to pay for industrial investment in EE.

In the commercial, governmental, and residential sectors, inefficient buildings are the main culprit. The design, construction, and maintenance of buildings have tremendous impacts on environmental quality, resource use, and human health and productivity. According to the US Department of Energy's Center of Excellence for Sustainable Development, buildings consume 40% of the world's total energy (90% from electric power and about 10% from natural gas), 25% of wood harvest, and 16% of water consumption.[52]

Meanwhile, most cities in the region are following the inefficient transportation patterns of developed countries by becoming increasingly dependent on resource-intensive private transportation instead of on public transport. Transportation is one of the largest and fastest-growing energy users by sector, so changes in transport patterns must play a significant role in reducing energy demands to sustainable levels while simultaneously addressing local air pollution and the threat of climate change.

This situation described above is due in large part to subsidized prices of certain forms of energy, which are maintained to improve industrial competitiveness or to reduce energy cost burdens to household consumers. However, the overall effect is to encourage more energy consumption and to discourage development and diffusion of more energy-efficient and cleaner technologies and policies. Increasing energy prices will make the returns of efficiency-related investments more attractive and provide correct signals to potential investors. (See page 72 for discussion on policies to promote greater EE.)

## Climate Change Implications

To meet energy demands, countries in the region are expected to continue their heavy reliance on fossil fuels (Figure 2.7). Energy demands are currently met mainly by coal (41%), oil (25%), and natural gas (7%).[53] The current energy path, which focuses on expanding these fossil fuel supplies, is neither environmentally nor economically sustainable.

The International Energy Agency estimates that cumulative investment in renewable-based energy is likely to reach $1.6 trillion by 2030, with nearly 38% of that allocated to hydro sources. Renewable energy other than traditional biomass is expected to increase from 1,400 metric tons of oil equivalent in 2002 to 2,200 metric tons of oil equivalent in 2030. Despite this significant increase, renewable energy consumption as

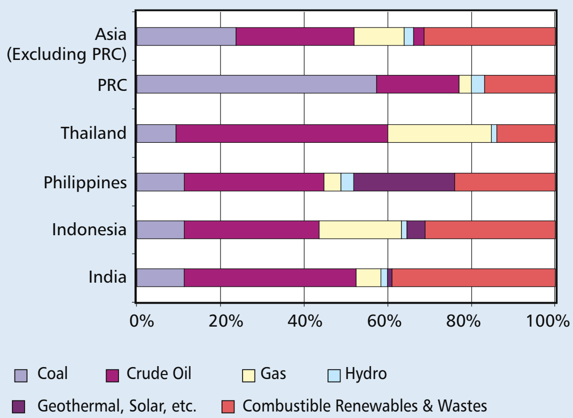
50 ADB. 2006. *Toward a Cleaner Energy Future in Asia and the Pacific*. Manila.

51 United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2005. *End-use Energy Efficiency and Promotion of a Sustainable Energy Future*. Bangkok, Thailand.

52 Fahey, Valerie. 2005, 11 September. *Building Green Always Made Sense – Now It's Beginning to Pay Off*. Available: http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2005/09/11/REG-4DEKFQD1.DTL

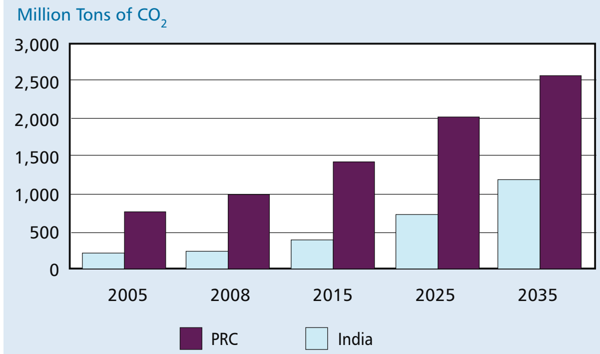
53 Ibid.

**Figure 2.7: Energy Mix in Selected Asian Countries in 2005**




PRC = People's Republic of China.
Source: International Energy Agency. 2005. *Key World Energy Statistics 2005*. Paris.

**Figure 2.8: Total Carbon Dioxide Emissions (Well to Exhaust) from On-road Vehicles in the PRC and India**




$CO_2$ = carbon dioxide, PRC = People's Republic of China.
Source: ADB. 2006. *Energy Efficiency and Climate Change Considerations for On-road Transport in Asia*. Manila.

a percentage of overall energy consumption is expected to remain stable at around 14%.

Perhaps the most significant impact of reliance on fossil fuels is emission of GHGs. Climate change concerns have taken a prominent part in development thinking as scientific consensus on the nature and scope of the problem has been reached. Climate change may result in wide-scale changes in the existing environmental and ecological balance, which would, in turn, exacerbate poverty conditions.

Much of the global increase in carbon dioxide emissions over the next 20 years is expected to occur in the developing world, where emerging economies—such as the PRC and India—base economic development on large-scale use of fossil energy derived from hydrocarbons. According to the International Energy Agency, worldwide carbon dioxide emissions are expected to increase by 1.9% annually from 2001 to 2025, while developing countries' emissions are expected to grow by 2.7% annually over the same period. Their emissions may surpass emissions of industrialized countries by 2018 unless significant policy shifts occur. [54]

GHG emissions per unit of GDP, or carbon intensity, in developing Asian countries is typically twice the level in developed countries, reflecting relatively low levels of EE in many sectors. These intensity levels will likely decrease gradually in all countries as they institute EE measures. However, if production and consumption trends in developing countries follow the previous path of developed countries, these improvements will be more than offset by population growth and per capita increases in energy use. For instance, use of cleaner fuels and vehicles may minimize pollution, but gains from these measures will be outstripped by increased motorization unless structured change in transport patterns occurs. Emissions from on-road transport alone can be expected to increase by 3.4 times for the PRC and 5.8 times for India between 2005 and 2035 (Figure 2.8).[55]

The assumed continued reliance on coal is a major contributing factor in such estimates. Two thirds of the PRC's energy is now supplied by coal. The burning of coal releases twice as much carbon dioxide per unit of energy as natural gas combustion and also releases harmful sulfur dioxide and particulates that affect local air quality.[56] Between the PRC, India, and US alone, there are announced plans to build 850 new coal-fired plants by 2012, which would emit five times as much carbon dioxide into the atmosphere as the Kyoto Protocol aims to

54 Energy Information Administration, US Department of Energy. 2004. Available: http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html

55 ADB and Department for International Development (UK), in collaboration with the Clean Air Initiative for Asian Cities. 2006. *Energy Efficiency and Climate Change Considerations for On-road Transport in Asia*. Manila.

56 Institute for Global Environmental Strategies, Ministry of the Environment, Japan. and Chinese Renewable Energy Industries Association. 2005. *CDM Country Guide for China*. Available: http://www.iges.or.jp/en/cdm/pdf/countryguide/china.pdf

Source: ADB.

reduce.[57] While coal in the PRC's overall energy mix is projected to decline from 66% in 2002 to 41% in 2030 as the country increases its use of natural gas, oil, hydropower, nuclear power, and renewable energy, its total annual carbon dioxide emissions are still projected to increase from 3,307 to 7,144 Mt. This would make it the leading source of climate-altering gases.[58]

The impacts of climate change are already unfolding sooner than previously anticipated and require proactive planning to prepare for and adapt to the changes. A few of the likely impacts are:

- rise in sea level and chemical and temperature shifts in seawater, affecting coastal areas and islands everywhere;
- increase in air temperatures and more variable, often more extreme, climate patterns;
- higher incidence of extreme weather events, such as typhoons, hurricanes, tornadoes, floods, draughts, heat waves, and cold snaps;
- less reliable access to water for all human and natural uses, with greater variability of rainfall, accelerated glacial melting, and other impacts;
- shifts in wild and farm habitats, with corresponding impacts on crops, biodiversity, and insect pests and weeds; and
- new demands on municipal infrastructure to handle flooding, water shortages, heating and cooling, and water treatment.

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, infrastructure, and internal displacement. Asia's vulnerability to climate change is dictated by its unique physical and socioeconomic attributes, including high population density, relatively low economic development, long coastlines, and the prominence of agriculture and fishing in providing livelihoods. Undoubtedly, the hardest hit will be the poor. This is both because of their more direct exposure to nature and its extremes, such as droughts, heat and cold waves, storms and heavy rainfall, and their greater dependence on natural resources for their livelihoods (e.g., crops, livestock, biomass fuels). The rural poor, in particular, remain extremely susceptible to the short- and long-term changes brought about by global warming and associated effects on weather patterns (e.g., pestilence, incidence of disease and epidemics, and reduced productivity of land and water resources).[59]

In addition to its global warming effects, the combustion of fossil fuels can rapidly degrade the local environment, especially air quality. Many of the cities in Asia face problems with urban ambient air quality and there is increasing evidence that demonstrates the high impact of local pollution on the environment and human health. Ultra-fine particles, such as those emitted by uncontrolled diesel vehicles, have been shown to have particularly high health impacts. $PM_{10}$ (amount of particles of 10 or less micrometers in diameter) average concentrations in many Asian cities still far exceed World Health Organization (WHO) guidelines, which for $PM_{10}$ is an annual average of 20 micrograms per cubic meter (broken horizontal line in Figure 2.9).[60] WHO estimates that urban air pollution contributes each year to approximately 800,000 deaths and 4.6 million lost life-years worldwide. Approximately two thirds of the deaths and lost life-years occur in the developing countries of Asia.[61]

57 Clayton, Mark. 2004. New Greenhouse Gas Emissions from China, India and the US Will Swamp Cuts from the Kyoto Treaty. Christian Science Monitor. 23 December. Available: http://www.csmonitor.com/2004/1223/p01s04-sten.html

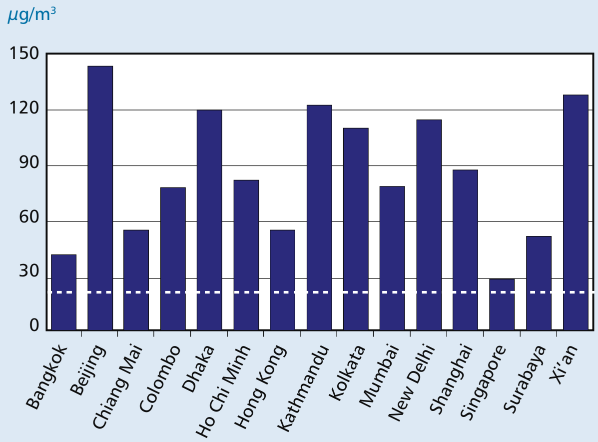
58 UNEP. 2006. *Improving Energy Efficiency in Industry in Asia: A Policy Review.* Bangkok, Thailand.

59 ADB. 2007, April. *Energy for All: Addressing the Energy, Environment, and Poverty Nexus in Asia*. Manila.

60 Clean Air Initiative (CAI)-Asia. 2006. Urban Air Quality and its Management in Asia. Status Report 2006. Presented at the Regional Dialogue of Air Quality Management Initiatives and Programs in Asia. 12 October. Bangkok.

61 World Health Organization (WHO). 2002. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva.

**Figure 2.9: Annual Average Ambient Concentrations of $PM_{10}$ in Selected Asian Cities**




Note: WHO annual $PM_{10}$ guideline value is 20 μg/m³.
$PM_{10}$ = particulate matter with diameter not more than 10 microns, WHO = World Health Organization, μg/m³ = micrograms per cubic meter.

Source: Clean Air Initiative-Asia. 2006. Urban Air Quality and its Management in Asia. Status Report 2006. Paper Presented at the Regional Dialogue on Air Quality Management Initiatives and Programs in Asia, 12 October. Bangkok.

In addition, two thirds of acid rain deposition in Asia and the Pacific are presently caused by outdated pollution controls in coal-fired power plants in the region. Rampant oil and coal use, industrial emissions, and biomass burning have caused extensive smog and haze over many Asian cities, such as the infamous atmospheric "brown cloud" stretching over large portions of Southeast Asia. Annual sulfur emissions are estimated to increase from 33.6 Mt in 1990 to over 110 Mt by 2020, a 230% increase.[62]

Another risk of depending so heavily on fossil fuels, and especially oil, is that countries will expose themselves to price and supply fluctuations that can undermine their economic stability and energy security. Delaying preparations for eventual supply gaps could have severe economic and political consequences. After decades of debate about how long the age of petroleum abundance might last, it now appears that the year of peak petroleum production worldwide may be in sight. While nobody knows for certain how much reserve exists, it seems certain that the second half of the oil age will soon commence, characterized by the decline of oil (followed by gas) and all that depends on these prime energy sources (Box 2.3).

**Box 2.3: Society's Reliance on Oil**

Society's reliance on oil is staggering. Perhaps most important, oil is the source of our mobility. Much of the world's incremental oil demand (as much as half) is projected to be used in the transportation sector, and much of this increase will be due to the rapid increase in vehicle ownership in Asia. What is often overlooked, however, is the use of oil for other common uses. Through refining, petroleum can be turned into many types of petrochemicals, which are used to make hundreds of products often taken for granted. Products that are made at least partially from oil include all plastic products, synthetic fibers (used to make clothes or carpets), shoes, tires, compact discs, fertilizers and pesticides, cosmetics, detergents, and even food additives. Of the projected increase in world oil consumption in 2003–2030, the industrial sector will account for 39%, mostly for chemical and petrochemical processes.

Source: AFP.

Source: Energy Information Association. 2006. *International Energy Outlook*. Available: http://www.eia.doe.gov/oiaf/ieo/oil.html

Several research organizations have offered sobering projections of petroleum reserves and depletion dates. The energy section of the Organisation for Economic Co-operation and Development (OECD) forecasts that peak production will occur between 2010 and 2020, while the World Resources Institute puts the peak between 2007 and 2014.[63] In addition, in 2002, Exxon Mobil published discovery data, with reserve revisions properly backdated, showing that world discovery has been in relentless decline for 40 years. The study showed that existing field production is declining at 4–6% a year, producing a growing gap to be filled by new discovery if projected demand is to be met to 2020.[64]

One day, increasing consumption will collide with a falling supply, which will bring about rapidly rising fossil fuel prices. The effects could be devastating. The permanent terminal decline of our oil-based economy could remove the confidence in perpetual

62 ADB. 2007. *Energy for All: Addressing the Energy, Environment, and Poverty Nexus in Asia*. Manila.

63 Kerr, R. 1998. The Next Oil Crisis Looms Large—and Perhaps Close. *Science* 281 (August 21): 1128–1131.

64 The Association for the Study of Peak Oil and Gas. 2005. Newsletter No. 50. February.

**Box 2.4: ADB's Energy Efficiency and Sustainable Transport Initiatives**

The Asian Development Bank (ADB) launched the energy efficiency initiative (EEI) in 2005 to explore ways to expand ADB's public and private sector investments in energy efficiency (EE) projects with the goal of expanding ADB's annual investments to $1 billion to improve both supply-side and end-use EE and to fund clean/renewable energy projects. EEI is developing country specific strategies to promote clean energy projects in the People's Republic of China, India, Indonesia, Pakistan, Philippines, and Viet Nam. Additional resources are being mobilized to focus on smaller countries. Helping to fund EEI is a financing facility with a targeted size of $250 million to finance: (i) smaller energy efficiency investments; (ii) technology costs; and (iii) grant assistance for activities such as advocacy, institutional capacity building, project preparation, and establishment of ADB's monitoring and evaluation mechanisms.

ADB is also developing a sustainable transport initiative, which will act as the focal point in the organization for transport-related activities and their impacts on energy use and the environment. The links between air quality, energy production and consumption, and the use of motorized transport are clear, and this initiative will develop new policy and investment options for improving energy efficiencies in transport.

Sustainable urban transport will increasingly become an area of activity for ADB because this is where energy use and pollution from the transport sector are most concentrated. Transport solutions to meet the increasing travel demand must look toward mobility strategies that are more energy efficient. This will require an integrated approach, linking land-use planning, promotion of efficient modes of public transport, and looking at measures to ensure that private vehicles pay their full transport costs, such as congestion charges or road fees.

Source: ADB.

growth on which the global financial system depends. The transition could very well be marked by significant international tension, the first signs of which are already evident.

The dire outlook described above is not inevitable. With the help of market incentives, appropriate public policies, and new technologies, along with international efforts to reduce demand of fossil fuel use on an equitable and sensible basis, the world can experience a more gradual—and peaceful—transition. EE and the expanded use of renewable energy sources will be at the core of these adjustments (Box 2.4 illustrates some new initiatives by the Asian Development Bank [ADB]). It is estimated that any one of the available global renewable resources employing existing and near-term conversion technologies would be more than sufficient to meet today's global energy requirements and even the level of demand expected by the end of the 21st century.[65] The costs of such a transition will be huge, but the costs of inaction will be even greater.

## Water

***"The world is heading for a water crisis that is unprecedented in human history. Water development and management will change more in the next 20 years than in the last 2,000 years." Asit K. Biswas, Director, Third World Centre for Water Management[66]***

### Water Use in Asia

Availability of water is an emerging, if not a present crisis, in many parts of Asia. Certain parts of the region have already started to face water shortages and, if present trends continue, the situation will undoubtedly become worse. Some experts claim that water will soon become one of the major constraints for future economic development.[67] Without major improvements in efficiency of water use, more and more water will be required to meet human needs and future growth and human welfare in the region will be compromised.

65 Eberhard, A., M. Lazarus, S. Bernow, C. Rajan, T. Lefevre, M. Cabrera, D. O'eary, R. Peters, B. Svensson, R. Wilkinson. 2000. *Electricity Supply and Demand Side Management Options*, Thematic Review IV.1 prepared as an input to the World Commission on Dams, Cape Town. Available: www.dams.org.

66 Biswas, Asit. 1999. Water Crisis: Current Perceptions and Future Realities in Groundwater: Legal and Policy Perspectives. Proceedings of a World Bank Seminar. Washington, DC.

67 Shanahan, Mike. 2006. Improve Water Efficiency in Farming, Urges Report. *SciDev.Net*. 23 March. Available: http://www.unu.edu/unupress/unupbooks/80157e/80157E02.htm

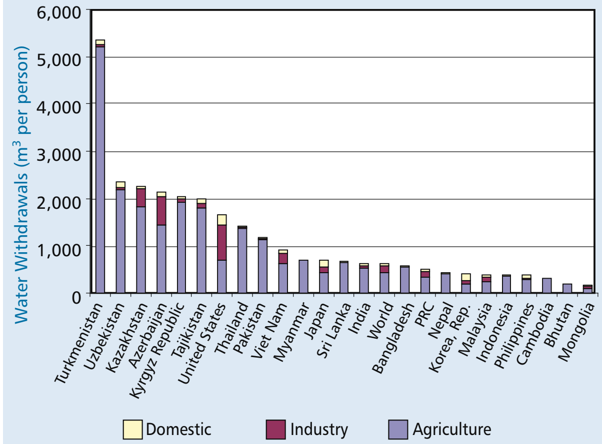
Water is a unique resource in a number of ways. Unlike other resources on the planet, water cannot be replaced by an alternative. Water is a vital natural resource with multifaceted uses (e.g., domestic use, industrial use, power generation, recreation, fisheries) cutting across class, economic, and political boundaries. In addition, riparian, marine, and terrestrial ecosystems are important "consumers," whose needs must be met in order to restore and conserve natural capital, which is the ultimate foundation for all economic activity.

Water is also a socially vital economic good and should be managed in an integrated manner and allocated among competent users through participation and negotiation.[68] The quality and quantity of water resources and services, including basic sanitation, are critical to addressing problems of poverty, health, and education and to achieving sustainable and equitable development.[69] Thus, efforts to minimize the amount of water used to produce certain goods or services must take into account issues of environmental sustainability and social equity.[70] Planners must balance all these considerations.

Source: ADB.

The extent of water use for any one purpose varies from one country to another, and is dependent on a variety of factors, including the level of economic development, importance of specific sectors in the national economy, efficiency of water use, and sociocultural practices.[71]

**Figure 2.10: Annual Per Capita Water Use by Sector in Selected Asian Countries**




$m^3$ = cubic meter, PRC = People's Republic of China.
Source: World Resouce Institute Data Tables (http://earthtrends.wri.org/) from Food and Agriculture Organization of the United Nations; data are from 2000.

In developing countries, including those in Asia, by far the biggest use of water is the agriculture sector (Figure 2.10). Agriculture is water intensive. It uses up to 70 times more water to produce food than is used in drinking and other domestic purposes. On average, it takes approximately 1,000 tons of water to grow 1 ton of grain, 2,000 tons to grow 1 ton of rice,[72] and 43,000 tons to produce 1 ton of beef.[73] Water requirements for agriculture depend on different factors, including total land under agricultural production, types of soils and crops cultivated, climate, availability and pricing of irrigation water, efficiency of water use, and management practices.[74]

As populations expand, so too will the demand for water for agricultural uses. For instance, if the pattern of PRC food consumption emulates current US consumption patterns, PRC grain consumption will be 1,352 Mt in 2031 (from 382 Mt), or two thirds of the current global grain harvest.[75] The production of an additional 1 billion tons of grain

68 ADB's Water Policy. Available: http://www.adb.org/Water/Policy/default.asp

69 ADB. 2006. *Water for All: Translating Policy into Action*. Comprehensive Review of ADB's Water Policy Implementation. Final Report and Recommendations. Manila.

70 Brooks, David. 2002. *Water: Local-level Management.* Ottawa: International Development Research Centre. Available: http://www.idrc.ca/water/ev-9440-201-1-DO_TOPIC.html

71 Shanahan, Mike. 2006. Improve Water Efficiency in Farming, Urges Report. *SciDev.Net.* 23 March. Available: http://www.unu.edu/unupress/unupbooks/80157e/80157E02.htm

72 Ibid.

73 Pimentel, David et al. 2004. Water Resources: Agricultural and Environmental Issues. *BioScience* 54(10): 909.

74 Shanahan, Mike. 2006. Improve Water Efficiency in Farming, Urges Report. *SciDev.Net*. 23 March. Available: http://www.unu.edu/unupress/unupbooks/80157e/80157E02.htm

75 *People's Daily Online*. 2005, 8 September. China Cannot Afford to Follow US Example in Economic Development. Available: http://english.peopledaily.com.cn/200509/08/eng20050908_207306.html

with existing technologies will put great strain on the PRC's water supplies unless drastic measures are taken.

## Water Scarcity in Asia

Water is a renewable resource and, unlike nonrenewable resources like oil or natural gas, there is no danger that the world is going to run out of water. However, as the world's demand for water has tripled over the last half century, water is increasingly emerging as a scarce commodity in some places, fueled by population pressures, intensive irrigation, and erratic weather patterns brought on by global warming.

In most places, the best and cheapest sources of water are already overextracted. Rivers have been diverted, lakes have been tapped, and aquifers have been depleted. In some places, upgrading water supply systems amid growing demand have already become prohibitively expensive and, in some cases, environmentally dangerous.[76]

A recent assessment of water management found that a third of the world population is affected by water scarcity.[77] The results of this assessment, which was carried out by 700 experts over the last 5 years and spearheaded by the International Water Management Institute (IWMI), showed that one quarter of the world's population lives in river basins where water is physically scarce. In these places, water is overused, leading to falling groundwater levels and dying rivers that no longer reach the sea. Another 1 billion people live in river basins where water is economically scarce. In these places, water is available in rivers and aquifers, but the infrastructure is lacking to make this water available to people.[78]

Compounding the problem of water quantity is one of quality. Water quality in many places in the region is deteriorating due to industrial discharge, municipal sewage, and overload of fertilizers and agrochemicals (Box 2.5). Despite progress made so

Source: AFP.

**Box 2.5: Water Pollution in Viet Nam**

Almost all river basins in Viet Nam are polluted with residential and industrial waste. In Ha Noi, Ho Chi Minh City, and other major cities, residential, hospital, and industrial wastewater remains untreated, flowing directly into lakes and canals crossing residential and production areas. Over 70% of industrial zones and 90% of production units do not have adequate waste treatment facilities. As a result, millions of cubic meters of untreated raw sewage are discharged into the surrounding environment every day, polluting Viet Nam's major rivers, including the Cau, the Nhue-Day, and the Saigon-Dong Nai.

The Viet Nam Environment Water Monitoring 2004 reported that industrial parks and export processing zones in the Southern Key Economic Zone discharge over 137,000 cubic meters of wastewater containing nearly 93 tons of waste into the Dong Nai, Thi Vai, and Saigon rivers each day. Meanwhile, only 2 of 12 industrial parks and export processing zones in Ho Chi Minh City, 3 of 17 in Dong Nai, 2 of 13 in Binh Duong, and none in Ba Ria-Vung Tau have wastewater treatment facilities. Not surprisingly, pollution levels in almost all major rivers for most pollutants are higher than the national water quality standards. In rural areas, water bodies are also polluted from household and livestock waste, as well as pesticides and insecticides. Only 30–40% of rural households have access to clean water, and only 28–30% have sanitary latrines.

Sources: Ministry of Natural Resource and Environment. 2004. *Vietnam Environment Water Monitoring*. Ha Noi.

Ministry of Natural Resource and Environment. 2004. *Report on 10 year Implementation of Law on Environmental Protection*. Ha Noi.

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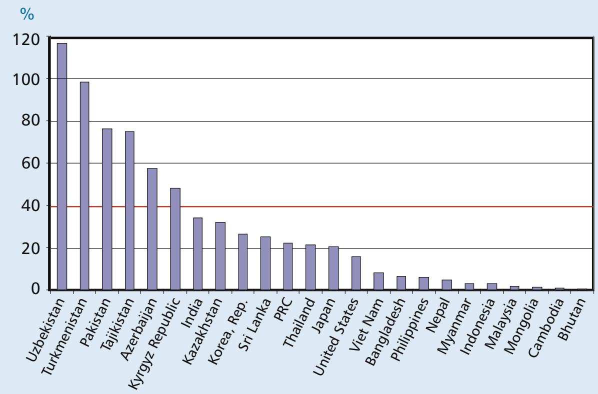
76 Brennan, Donna. 2001. Australian Centre for International Agricultural Reseach. Water-policy Reform Issues: An Overview. Prepared for International Workshop on Water Policy Reform: Lessons from Asia and Australia. Bangkok, Thailand. 8–9 June.

77 Global Policy Forum. 2006, 21 August. *A Third of the World Population Faces Water Scarcity Today*. Available: http://www.globalpolicy.org/socecon/envronmt/2006/0821waterstudy.htm

78 Ibid.

**Figure 2.11: Annual Water Withdrawals as a Percentage of Annual Water Resources in Selected Asian Countries (2000)**




PRC = People's Republic of China.

Source: World Resource Institute Data Tables (http://earthtrends.wri.org/) from Food and Agriculture Organization of the United Nations; data are from 2000.

far, approximately 700 million people in the region were without access to safe drinking water, and 1.9 billion lack sanitation facilities.[79] Poor water quality reduces the useable quantity of water even further, so addressing water quality must be a key strategy in addressing water supply.

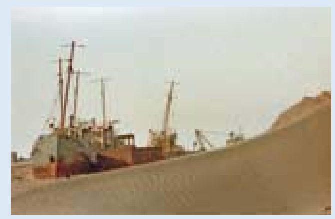
According to one United Nations (UN) indicator, a country can be considered to be water scarce if total withdrawals are greater than 40% of annual water resources. As is shown in Figure 2.11, drier basins in Central Asia are among those most at risk The Aral Sea is perhaps the most glaring example (Box 2.6). However, shortages are even occurring where rainfalls and river volumes seem abundant. For instance, development in Cambodia's section of the Mekong Delta had proceeded for years on the assumption that monsoon rains and seasonal river flooding reliably recharge groundwater and the underlying aquifer. Research now demonstrates that the Mekong replenishes only a narrow strip of the adjacent aquifer, and rainwater is quickly shed by a layer of impermeable clay. [80]

According to Lester Brown, president of the Earth Policy Institute, the depletion of fossil aquifers, which are nonreplenishable, would bring water pumping to an end, yet many countries, such as the

**Box 2.6: The Aral Sea Disaster**

When the former Soviet Union diverted the Ama Dariya and the Syrdariya rivers, which fed the Aral Sea, they created an ecological and human disaster. What was the fourth biggest inland sea is now mostly desert.

Decades of heavy irrigation have raised the water table and brought all the salts the soil held to the surface. Tuberculosis is rife and on the increase. Cancers, lung disease, and infant mortality are 30 times higher than they used to be because the drinking water is heavily polluted with salt, cotton fertilizers, and pesticides.



Source: AFP.

All of this was done in the name of cotton—grown where it would not grow naturally. It remains the main source of income for the newly independent republics. By changing farming methods, they have slowed down the rate of shrinking. Still, it will be years yet before what is left of the sea begins to grow again.

Source: Welsh, Paul. 2000. *The Aral Sea Tragedy*. BBC News. 16 March. Available: http://news.bbc.co.uk/1/hi/world/asia-pacific/678898.stm

PRC and India, continue to deplete them anyway. In a survey of India's water situation, the 21 million wells drilled are lowering water tables in most of the country, *New Scientist* magazine recently reported. Pakistan, which is also mining its underground water, is experiencing similar water table issues. Observation wells near the capital Islamabad show the water table sinking 1–2 meters a year during 1982–2000.[81]

Perhaps the most severe effects will be felt in agriculture. If underground water sources dry up entirely, farmers will have to rely on surface water, but in more arid regions, the loss of irrigation water could mean the end of agriculture. As water shocks become food shocks and as falling water tables translate into higher food prices, the world could change fundamentally almost overnight. [82]

Water supply interruptions in water-short areas could also have profound negative effects on industry. In the PRC, for instance, supply interruptions may occur in six

79 ADB, UNDP, UNESCAP, and WHO. 2006. *Asia Water Watch 2015*. Manila. Available: www.adb.org/Documents/Books/Asia-Water-Watch/default.asp

80 Brooks, David. 2002. *Water: Local-level Management*. Ottawa: International Development Research Centre. Available: http://www.idrc.ca/water/ev-9440-201-1-DO_TOPIC.html

81 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

82 Ibid.

industries that account for approximately two thirds of all industrial water demand—electric power, iron and steel, petroleum production and refining, chemicals, paper making, and textile dyeing. Such shortages will have far-reaching economic impacts, as investment projects will risk brownouts and interruptions.[83]

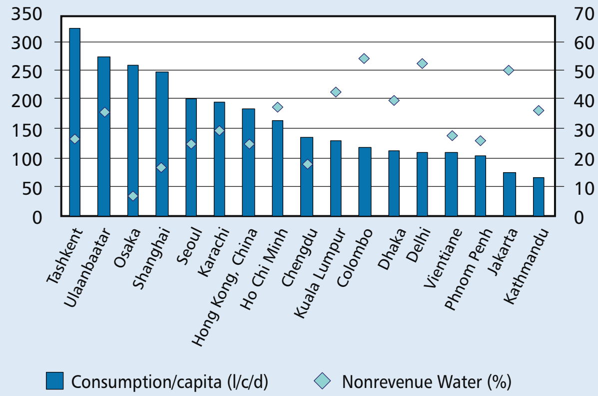
In addition, while the world's attention is focused on record high oil prices, water is increasingly emerging as a catalyst for international instability. In the 21st century, Asia may become a focal point of water-related conflict given the rapid growth of the region, the concentration of long-standing internal and inter-state tensions, and the lack of cooperative management mechanisms. Three regions in Asia are the most likely candidates for water-related conflict: Central Asia, South Asia, and the Mekong subregion in Southeast Asia.[84] Water disputes could exacerbate current tensions in these regions.

If current trends continue, the shortage of water will extend well beyond the semi-arid and arid regions. Potentially compounding the problem, climate changes linked to global warming may lead to shortened rainy seasons and longer droughts, which will provoke new economic, social, and health crises. Therefore, it is imperative that countries start getting the most out of the water supplies that they have. New water supplies are likely to result from conservation, recycling, and improved water-use efficiency rather than from large development projects.

## Water Inefficiencies in Asia

To combat these problems, some countries in the region are focusing on expanding water supplies and irrigation networks, but most of these efforts will likely prove to be uneconomical, and some will be environmentally disastrous. Supply-side technological fixes are also costly and are unlikely to significantly enhance production in the foreseeable future. For instance, despite recent technological breakthroughs that have helped reduce costs, desalination of seawater—sometimes embraced as a panacea

**Figure 2.12: Water Supply Indexes in Selected Asian Cities (Consumption/Capita and Nonrevenue Water)**




l/c/d = liters per capita per day.

Source: ADB. 2004. *Water in Asian Cities.* Available: http://www.adb.org/Documents/Books/Water_for_All_Series/Water_Asian_Cities/default.asp (as of 2001 or 2001/2002 fiscal year)

for water problems—still has many implications, especially in energy and technology management, which need to be carefully assessed before it can be successfully and extensively used on a sustainable basis in Asia.[85]

The best, and perhaps only, way to avoid the grim scenario described above is to improve the efficiency of water use. In the agricultural sector, this will involve increasing agricultural yields per unit water used, or in the parlance of IWMI, "growing more crop per drop." The potential for more efficient water use in the agricultural sector and other sectors in Asia is enormous, as some recent statistics suggest:

- In developing countries, as much as 75% of water intended for irrigation, whether from the surface or pumped from the subsurface, is lost to evaporation, leakage, seepage, or simply bad management.[86]
- In many mega cities, including Colombo, Dhaka, Delhi, Jakarta, Kathmandu, and Kuala Lumpur, nonrevenue water of water supply utilities is around 40% or more of production

83 Butler, Tina. 2005, 30 May. *China's Imminent Water Crisis.* Available: http://news.mongabay.com/2005/0531-tina_butler.html

84 Bajpaee, Chietigj. 2006. Asia's Coming Water Wars. *The Power and Interest News Report* 22 August. Available: http://www.pinr.com/report.php?ac=view_report&report_id=545&language_id=1

85 ADB. 2007. *Asian Water Development Outlook: Achieving Water Security for Asia*. Manila. Available: http://www.adb.org/Water/Knowledge-Center/AWDO/AWDO.pdf

86 Brooks, David. 2002. *Water: Local-level Management.* Ottawa: International Development Research Centre. Available: http://www.idrc.ca/water/ev-9440-201-1-DO_TOPIC.html

(Figure 2.12). In many cities, stand-pipe water is free to users.[87]

- Many cities in Asia use around 200 liters per capita (for those connected to piped water). Unlike in Europe, domestic conservation efforts, such as through toilet or shower retrofitting, is limited in the region.[88]

This inefficiency in water use in Asia not only reflects backward production technology but also inadequate water management and institutional arrangements. Despite recent progress in the region, the effectiveness of new water policies in some countries as been limited because policy, legal, and institutional reforms are still lacking and there is no distinction between water as a resource that must be managed and water as a service for delivery.

Many countries lack adequate pricing mechanisms and integrated approaches. The block tariff systems employed by Asian utilities usually have large volumes at lifeline rates, thereby providing subsidies to all, including the rich. In the agricultural sector, cheap and abundant water provides an inducement to implement water-heavy measures. In most countries, relevant authorities have no incentive to take water-conserving measures like supplying water on a volumetric basis, and farmers have no incentive to economize their use of water.

However, Asian countries can take hope in the fact that there is presently enough water to go around. It is possible to reduce water scarcity, feed people, and address poverty over the long term, but this can only happen if tough decisions are made about how to allocate and manage water. There will be trade-offs between city and agriculture users, between food production and the environment, and between fishers and farmers.

The experience in developed countries offers some promise. In the 1960s, the first long-range forecasts of water consumption made in the US predicted an increase in annual freshwater consumption by 2–2.5 times from 1970 to 2000, mainly due to increases in water use in industry and thermal power generation. However, in the 1970s and 1980s, a transition from extensive water resource consumption to intensive and multipurpose water resource use brought about a stabilization of water consumption. Similar trends were observed in northern and western European countries.[89]

Innovative approaches can help Asian countries stabilize their water consumption. Agriculture can be made more water efficient in developing countries if farmers harvest rainwater or use small-scale, inexpensive irrigation technologies. Low-cost technologies will also make it possible to increasingly use urban wastewater. Consumers can switch to more water-efficient household appliances that will raise water productivity. Possible national and local measures are discussed on pages 86 and 109, respectively.

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87 ADB. 2004, January. *Water in Asian Cities – Utilities Performance and Civil Society Views*. Manila. Available: http://www.adb.org/Documents/Books/Water_for_All_Series/Water_Asian_Cities/default.asp

88 McIntosh. Arthur. 2003. *Asian Water Supplies, Reaching the Urban Poor: A Guide and Sourcebook on Urban Water Supplies in Asia for Governments, Utilities, Consultants, Development Agencies, and Nongovernment Organizations*. Manila: ADB and International Water Association.

89 Shiklomanov, I. A. 1994. World Water Resources: Assessment and Prediction. In *Innovation, resources and economic growth,* edited by A. Q. Curzio, M. Fortis, and R. Zoboli. Berlin: Springer-Verlag.