Eco-efficiency Indicators:

Measuring Resource-Use Efficiency and the Impact of Economic Activities on the Environment

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Greening of Economic Growth series

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ESCAP
Economic and Social Commission for Asia and the Pacific

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The Director
Environment and Development Division
United Nations Economic and Social Commission for Asia and the Pacific
United Nations Building
Rajadamnern Nok Avenue
Bangkok 10200, Thailand

Electronic version available at <www.unescap.org/esd> and <www.greengrowth.org>.

Publications team: Masakazu Ichimura, Sangmin Nam, Sophie Bonjour, Hitomi Rankine, Brian Carisma, Ying Qiu
Contributors: Yujia Wu, Dongju Yu, Jiyoun Lee
Design and layout: Ruedee Arunkhajohnsak

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The greening of economic growth series

ESCAP, its partners and Asia-Pacific countries have advocated 'green growth' as a strategy to achieve sustainable development in the resource-constrained, high-poverty context of the Asian and the Pacific region.

The conventional 'grow now, clean up later' approaches to economic growth are increasingly placing the futures of regional economies and societies at risk. The forward-thinking policymaker is tasked to promote development based on *eco-efficient* economic growth and at the same time, record more inclusive gains in human welfare and socio-economic progress. In order to assist policymakers in responding to such challenges, ESCAP's activity on green growth has been developed to focus on five paths: sustainable infrastructure development; investment in natural capital; green tax and budget reform; sustainable consumption and production; and the greening of business and markets.

The ESCAP "Greening of economic growth" series provides policymakers with quick access to clear, easy-to-read guidance to specific 'green growth' policy tools and actions. For more information, please contact the Environment and Development Division at <escap-esdd-evs@un.org> and visit <http://www.greengrowth.org>.

Abbreviations and acronyms

- BOD biochemical oxygen demand
- CIEM Central Institute for Economic Management
- COD chemical oxygen demand
- EEI eco-efficiency indicators
- EF Ecological Footprint
- EPI Ecological Performance Index
- ESCAP Economic and Social Commission for Asia and the Pacific
- ESI Environmental Sustainability Index
- GDP gross domestic product
- GHG greenhouse gas
- HDI human development index
- IEA International Energy Agency
- ISIC International Standard Industrial Classification
- MDG Millennium Development Goal
- OECD Organisation for Economic Co-operation and Development
- REPI Resource Efficiency and Performance Index
- UNCED United Nations Conference on Environment and Development
- VND Vietnamese Dong
- WBCSD World Business Council on Sustainable Development

Unit Abbreviations

km kilometre

m3 cubic metre

Chemical formulae

CH4 methane

CO carbon monoxide

CO2 carbon dioxide

N2O nitrous oxide

NOx nitrogen oxides

SOX sulphur oxides

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Chapter 1: Introduction: Green growth and eco-efficiency indicators

ESCAP defines eco-efficiency as a key element for promoting fundamental changes in the way societies produce and consume resources, and thus for measuring progress in green growth. The concept of eco-efficiency can be traced back to 1970s as the concept of "environmental efficiency" (Freeman et al., 1973; McIntyre and Thornton, 1978) [1]. In the 1990s, Schaltegger and Sturm (1990)[2] introduced eco-efficiency as a "business link to sustainable development". Later, it was popularized by the World Business Council for Sustainable Development (WBCSD) for the business sector in the course of the United Nations Conference on Environment and Development (UNCED) in 1992. Not surprisingly, eco-efficiency has received significant attention in the sustainable development literature (Schaltegger and Synnestvedt, 2002; Bleischwitz, 2003)[3]. Eco-efficiency plays an important role in expressing how efficient the economic activity is with regard to nature's goods and services. It was intended to be a practical approach for the sector to play its role in contributing to sustainable development: through the pursuit of long-term profits by incorporating activities that respect the carrying capacity of the earth. Since then, the concept of eco-efficiency has been embraced by hundreds of companies and proven as a practical tool for enhancing both economic and environmental benefits.

As a practical tool for the business sector, the concept focuses on practices of resource-use attaining economic and environmental progress through more efficient uses of resources and lower pollution. Thus, eco-efficiency is a more general expression of the concept of resource efficiency – minimizing the resources used in producing a unit of output – and resource productivity – the efficiency of economic activities in generating added value from the use of resources. It also incorporates the production of waste. In this regard, the WBCSD suggests that eco-efficiency concept should be applied throughout all operations of a company: reducing the consumption of resources, reducing the impacts on the natural environment, and increasing the product or service value.

While eco-efficiency is a useful tool for the business sector to achieve greater value with lower adverse environmental impacts, it should also be applied beyond the business sector and production patterns. The adoption of eco-efficiency principles in production patterns can be mandated by government policies/regulations, market-based instruments and technological improvements. However, the improvement of eco-efficiency of consumption patterns would be more complex and challenging than in production patterns due to the characteristics of society's culture and existing socio-economic systems.

1 See Freeman, M.A., R.H., H., A.V., K., 1973. *The Economics of Environmental Policy*. John Wiley & Sons, New York.

2 Schaltegger, S., Sturm, A., 1990. *Öologische Rationalität (German/in English: Environmental rationality)*. Die Unternehmung 4, 117–131.

3 See Schaltegger, S., Synnestvedt, T., 2002. The link between "green" and economic success: environmental management as the crucial trigger between environmental and economic performance. *Journal of Environmental Management* 65, 339–346. Bleischwitz, R., 2003. Cognitive and institutional perspectives of eco-efficiency. *Ecological Economics* 46, 453–467.

By applying the eco-efficiency principal only to the micro level the huge pressures on the natural capital will not be alleviated. Particularly, one of the possible unintended consequences of eco-efficiency policies at the micro level is the rebound effect. Rebound effects are, in essence, the loss of potential efficiency gains when a gain in resource efficiency corresponds with a lesser improvement in resource-use. In other words, the rebound effect means that improving the efficiency of resource-use per unit is outstripped by the absolute increase in demand for the goods and the deterioration of resource efficiency in consumption. Thus, the concept of eco-efficiency should be applied to both production and consumption patterns as well as macro-levels.

A number of measures or indicators have been suggested in recent years, such as the Ecological Footprint, sustainability and other indicators and indices, none has presented a tool clearly showing the direction for economic growth with less resource consumption and pollution, a key ingredient and prerequisite of sustainable development. Even the popular environmental indexes, the Environmental Sustainability Index and the Environmental Performance Index (developed by the Earth Institute, CIESEN, Columbia and Yale Universities) still focus mainly on the environment with little consideration of the relation of the environment to the economy. Their greatest contribution is, however, that of simplicity and ease of understanding for the policymaker unfamiliar with environmental issues and for the general public.

In this regard, ESCAP has expanded the scope of eco-efficiency beyond the production side and the business sector to the economy-wide level. Furthermore, ESCAP has explored developing eco-efficiency indicators (EEI) to measure the status and progress of eco-efficiency in the economy in order to help policymakers attain clear views on the concept of eco-efficiency and its policy implication. EEI is particularly envisioned to respond to the different challenges of sustainability in the context of attaining both economic and ecological goals. These challenges include:

1. Impacts of economic activity on the environment (e.g. resource consumption, pollution emissions, waste);
2. Effects of resource productivity in the economy (e.g. economic efficiency);
3. Impacts of environmental degradation to economic productivity (e.g. reduction in adsorptive capacity, loss of forest cover);
4. Effects of environmental improvement on society (e.g. congestion costs, improvement in well-being, social costs).

The ultimate goal of EEI is to provide governments with a practical tool to measure their performance in the context of eco-efficiency and harness the concept of eco-efficiency for socio-economic policies pertaining to environmental sustainability.

This publication *"Eco-efficiency Indicators: Measuring Resource-use Efficiency and the Impact of Economic Activities on the Environment"* is produced as an output of an ESCAP project titled *"Pursuing Green Growth by improving eco-efficiency of economic growth in Asia and the Pacific"* under the Korea-ESCAP Cooperation Fund.

Chapter 2: Eco-Efficiency Indicators

2.1 Basic concept of eco-efficiency indicators

Making the concept of Green Growth operational for public policies requires a measurement that would capture the pattern of the quality of economic growth over time. Without indicators or a conceptual framework to guide policymakers, Green Growth as paradigm shift in policymaking would prove an elusive goal. To enable countries in the Asia and the Pacific region to improve the ecological efficiency of national, system-wide economic development planning, the use of EEI has been identified as one of the key tools for measuring Green Growth. EEI can be used to:

1. Measure the eco-efficiency of different sectors within the country
2. Compare the eco-efficiency of economic growth of different countries
3. Identify policy areas for improvement for achieving economic benefit
4. Track trends in eco-efficiency over time.

The EEI shall strengthen the role of the public sector and provide it with policy formulation tools to increase its influence on the pattern of economic growth of the countries in the region on a national and sectoral system-wide level.

The EEI is designed to capture the ecological efficiency of growth by measuring the efficiency of economic activity both in terms of consumption and production (resource-use) and its corresponding environmental impacts. It is composed of set of indicators rather than a single index of economic performance.

Figure 2-1 provides the conceptual definition of EEI. Eco-efficiency may be derived by looking at the intensity of resource-use, intensity of environmental impacts, or both. EEI is defined as:

Box 2.2 Measuring eco-efficiency

Eco-efficiency:

Environmental Cost

Economic Output

Environmental costs can be:

- Pollution emissions (CO2 or SOx emissions, BOD,etc)
- Resource-used (energy or water-used)
- Cost associated to an environmental burden (traffic congestion costs)

Economic output can be:

- Value added of benefit (GPD per capita)
- Unit of product or service (per km, per m2)
- Cost associated to an environmental burden (traffic congestion costs)

2.2 Application of EEI: From the business sector to the economy-wide level

Originally developed for the business sector, the eco-efficiency concept focuses on creating more goods and services using fewer resources and generating less waste and pollution. The same concept of eco-efficiency, however, can be applied in regards to economic activities, in terms of local and national scope, hence improving the overall functioning of the economy.

The application of eco-efficiency indicators in the business sectors is usually based on the ratio of product or service value/ environmental impact. Most indicators focus on the consumption of energy, materials and water and the emission of greenhouse gases, wastewater and pollution emission.

Several companies integrate eco-efficiency into their business strategy, including their operational, product innovation and marketing strategies. Companies such as Toyota and Toshiba have implemented eco-efficiency in their production and operations to assess the product's environmental performance relative to their business and production operation performance and communicate the results openly to the public. Eco-efficiency is also being promoted to influence consumer buying behavior in regards to a wide array of products available on the market.

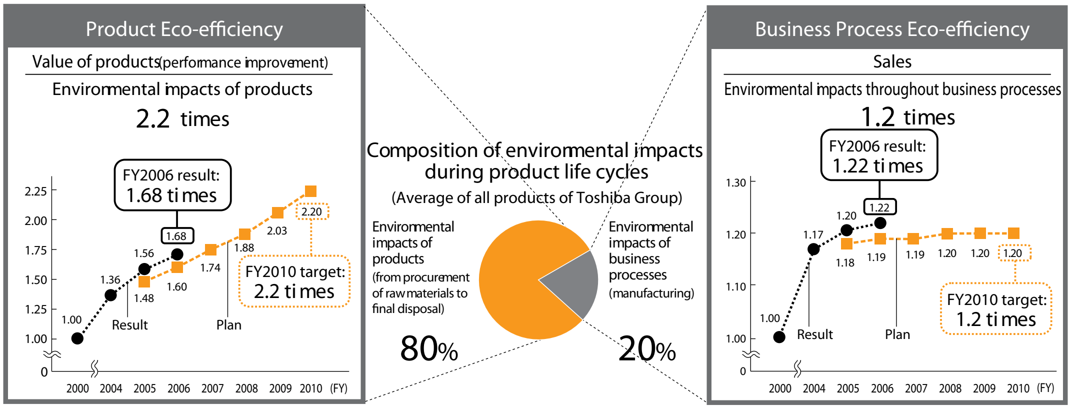
Figure 2.1 Eco-efficiency in the business sector

$$\text{Eco-efficiency} = \frac{\overset{\blacktriangle\ \text{Enhancing the quality}}{\textbf{Value of a product}}}{\underset{\blacktriangledown\ \text{Reducing the impacts}}{\textbf{Environmental impact of a product}}}$$

Elements for Eco-efficiency in the business sector

- Reducing material requirements for goods & services
- Reducing energy intensity of goods & services
- Reducing toxic dispersion
- Enhancing material recyclability
- Maximizing the sustainable use of renewable resources
- Extending product durability
- Increasing the service intensity of goods and services

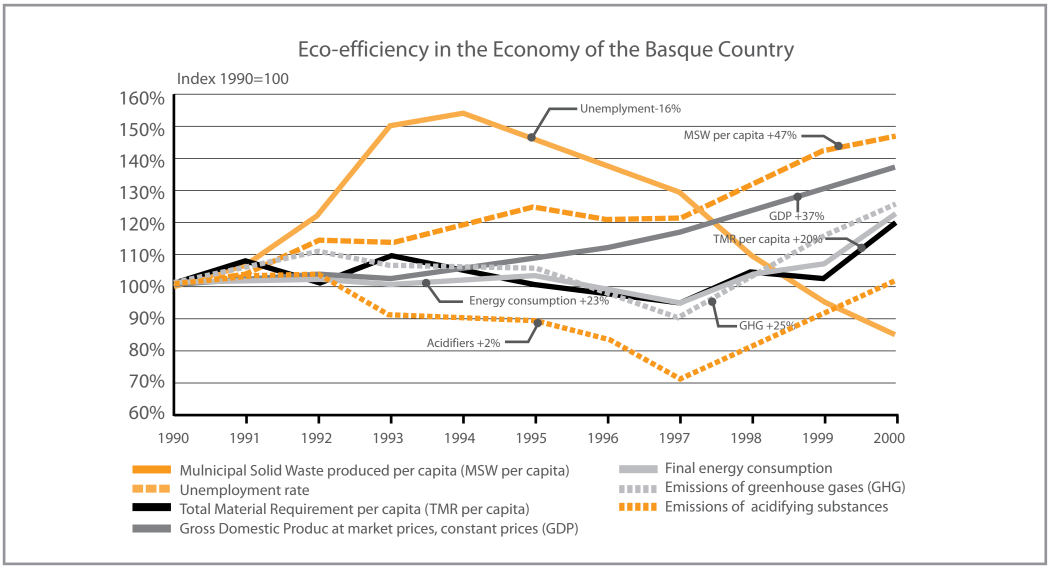
Figure 2.2 Eco-efficiency at the Toshiba Group



Adopting eco-efficiency at the economy-wide level can be done at different levels of the economy – micro, macro and regional. Governments may set both micro and macro-economic eco-efficiency targets that correspond to their sustainable development goals, and reflect them in the national development strategies.

In 2003, the Basque Country in Spain adopted the concept of eco-efficiency to analyze the relationship between economic growth and environmental impact, and to begin de-linking economic activities from environmental pressures. The application focused on the eco-efficiency of four economic sectors, namely; transport, industry, energy and residential. Figure 2.3 shows the economic growth of the Basque country relative to its resource-use and environmental impacts and provides clear policy directions in order to improve the overall eco-efficiency performance and quality of growth overtime.

Figure 2.3 Application of eco-efficiency at the micro-level: Basque Country, Spain

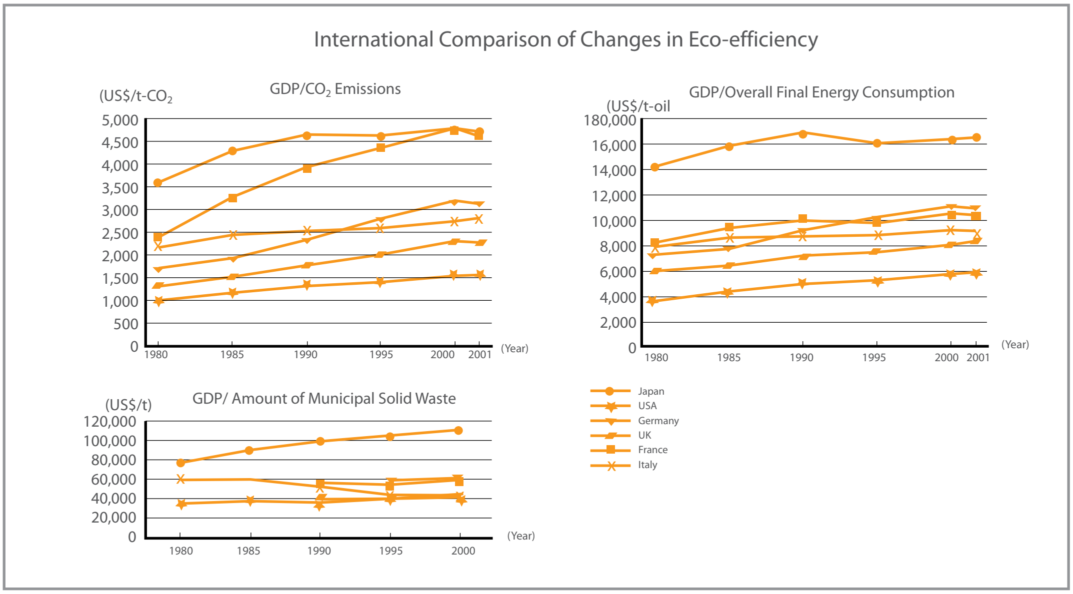


Source: Drawn up in-house using data from Basque Government Department of Land Use and Enrivonment, IHOBE, EVE and EUSTAT.

At the macro level, the government of Japan assessed its own eco-efficiency relative to the performance of other OECD countries in the area of CO_2 emissions, final energy consumption and the amount of municipal solid waste generated. The eco-efficiency is expressed in terms of **environmental load per unit of economic activity** (e.g CO_2 per GDP), which is used as a yardstick in comparing performance of countries. Similarly, the Resource Efficiency and Performance Index (REPI) is an attempt by the Chinese Academy of Sciences to assess the resource efficiency performance of China relative to other countries by looking at their resource-use intensity of non-renewable energy, fresh water, cement, non-ferrous metals and finished steel.

The existing application cases of eco-efficiency or its related indicators provide a useful basis for further exploration of EEI application at the micro-level and present the need for developing a more comprehensive set of indicators for the region.

Figure 2.4 Application of eco-efficiency at the macro-level: Japan



Source: compiled by the Ministry of *the Environment based on the EDMC Handbook of Energy & Economic Statistics in Japan 2004 and OECD Environmental Data Compendium 2002.*

2.3 Sustainability indicators: measuring the immeasurable?

Sustainability indicators are essential in illustrating to policymakers and the public alike the relationship and trade-offs amongst the three dimensions of sustainable development. It is also crucial in monitoring progress and performance in terms of achieving economic, social and ecological goals over time, and in evaluating the future implications of existing decision and policy direction. However, capturing the whole dynamics of sustainable development and presenting them in terms of measurement indicators that could be unambiguously interpreted and easily communicated to policymakers for public policies remain a challenging task.

Several sustainable development indicator initiatives have tried to capture the synergies and trade-offs amongst the economic, environment and social dimensions of sustainable development yet they are facing the same dilemma in presenting sustainability indicators in a comprehensive manner that is easily comparable across countries and could provide clear policy guidance.

There are more than ten widely recognized indicators that are used in the sustainable development policy debate (e.g. HDI, ESI, EPI, EF)[4]. One common characteristic of these sustainability indicators is that they are presented in an aggregate index (composite indicator) that facilitates comparison of performance of countries in achieving their economic and ecological goals. Although they have been extremely useful for raising awareness, many of these sustainability indicators face criticism from policymakers and academe alike. One of the main challenges of sustainability indicators is in terms of presenting them in an aggregate index that ought to be comprehensive assessment of changes in economic, environment and social conditions, yet failed somehow in this respect.

Bohringer and Jochem (2006) assess the technical soundness of the different sustainability indicators and identify the common pitfalls in indicator development that include *normalization*, *aggregation* and *weighting*. Because policymakers tend to prefer aggregate index to assess their performance relative to other countries, development of sustainability indicators is prone to subjectivity (value judgment) in *normalizing* variables to make them comparable and bias in assigning *weights* (perceived degree of importance) to different variables. Aggregating the different variable indicators into a single index often dilutes the message and importance of given socio-economic and environmental conditions and the impact of policy measures. They are not sharp enough to provide specific policy options to improve production and consumption patterns necessary to promote Green Growth.

Measuring sustainability need not be comprehensive covering every aspect of economic, environment and social linkages rather requires simple measures and an adequate framework that informs policymakers about major trends and issues as well as support in-depth analysis and identify concrete policy options. For Asia and the Pacific, being one of the most ecologically vulnerable regions on the planet, there is pressing need to present an easy tool clearly showing the direction for economic growth with less resource consumption and pollution, a key ingredient and prerequisite of sustainable development.

EEI presents a set of indicators that capture the linkage between economic activity, resource usage and environmental impact in order to evaluate economic policies more effectively and thereby assist policymakers in improving the eco-efficiency of economic growth. Rather than presenting a single index, EEI provides a range of economy-wide and sectoral wide indicators that clearly establish the pattern and relationship between economic activity and environmental issues.

2.4 Principles and concepts of selecting EEI

The selection of indicators is to a large extent determined by the purpose of the indicator set. The EEI is structured primarily to capture resource-use, in terms of production and consumption, and their corresponding environmental impacts. The set of EEI is composed of indicators of the economy-wide and sectoral-wide economic activities. The set of EEI is limited in number but never meant to be final or exhaustive, but rather flexible and adaptable to new issues where

4 Some of the widely applied sustainability indices include: the Human Development Index, Environmental Sustainability Index, Ecological Performance Index, Ecological Footprint, Living Plant Index, City Development Index, Environmental Vulnerability Index, Genuine Progress Index, Genuine Savings Index and Environmental Adjusted Domestic Product.

policymakers have the options to choose and incorporate other indicators according to their environmental relevance, structure of the economy, data availability and consistency with their national sustainable development strategies. The principles in choosing the EEI are discussed below.

Guided by sustainability principles – one of the primary considerations for selecting EEI is that the indicators reflect the sustainability challenges of the countries in the region. The set of EEI is also composed of indicators that are regarded as measures of sustainable development by other development agencies (e.g. energy intensity, CO_2 intensity). The value added of an EEI framework is that it provides another dimension for looking at the principles of sustainability. For instance, rather than looking at energy intensity as a criteria for measuring economic development, EEI takes into account the energy intensity of economic activity- that is energy consumed associated in producing a dollar of GDP. In effect, economies would be able to measure the functioning of their economy and eco-efficiency relative to other economies of the same size, while at the same time be able to take into consideration the valuation aspect of resource-use. The same framework is applied to other EEI indicators as well.

Taking the structure of the economy into account – EEI take into consideration the diversity of economic structures in the Asia and Pacific region. The region is composed of least developed, developing and developed economies each with an unique economic base – highly agriculture based to highly industrial based- thus exhibit varying paths of economic growth. While sustainability indicators should be applied universally, EEI take into account this uniqueness in the region in order to assess the quality of growth of Asia and the Pacific economies accordingly. The EEI gives flexibility to policymakers to measure their eco-efficiency with other countries relative to the size of economies or economic base. For instance, some Mekong countries are highly agriculture based while pacific countries are more tourism-based economies. Thus, geographical considerations come into play in EEI.

Considered data availability and methodological issues- One of the challenges to indicator development is the data availability, especially from the Asia and the Pacific countries. The merit of indicator development is dependent on cost effective data of a known quality, in which most member countries in ESCAP are struggling with. The set of EEI has to reflect upon the on the ground reality of data quality and reliability. In addition, the methodological development of EEI should be within the capabilities of national governments to develop. Instead of offering policymakers indexes to measure their eco-efficiency performance, EEI offers a set of indicators with established methodological guides to choose from in assessing their quality of growth overtime.

Attuned to the national sustainable development strategies – The set of EEI is relevant in assessing the temporal sustainable development progress of countries. Most of the selected EEI have been identified and adopted by countries in the region as part of their criteria in achieving their national development strategies. EEI also reinforce other socio-economic development targets of countries such as the Agenda 21 and MDGs.

2.5 Generally applicable indicators

From their inception, the overarching purpose of the EEI has been to inform policy both at the national and sectoral levels. The set of EEI maybe divided into Scope-wide Indicators, covering both economic-wide and sectoral-wide issues and Subject-wise indicators, covering other relevant issues as identified by policymakers. The set of EEI leaves room for flexibility in terms of incorporating new indicators or non-adoption of the existing ones according to their environmental relevance and economic and ecological goals.

Scope-wide indicators

- Economy-wide Indicators: Indicators that represent the micro and macro-level eco-efficiency of society or economic growth.
- Sector-specific Indicators: include Agriculture, Industry, Manufacturing, Public and services sector, and Transport.

Subject-wise indicators

Intensity or Productivity of Resource-use: Indicators for energy supply and consumption, non-renewable resource-use, renewable resource-use, land-use for built environment, etc.

Table 2.1 Framework & set of EEI using monetary output as numerator

	Resource-use intensity	Environmental impact intensity
Economy-wide indicators		
	Water intensity [m³/GDP] Energy intensity [J/GDP] Land-use intensity [km²/GDP] Material intensity [DMI/GDP]	Emission to water intensities [t/GDP] Emission to air intensities [t/GDP] GHG emissions intensities [t/GDP]
Sectoral indicators		
Agriculture	Water intensity [m³/GDP] Energy intensity [J/GDP] Land-use intensity [km²/GDP]	CO_2 intensity [t/GDP] CH_4 intensity [t/GDP]
Industry	Energy intensity [J/GDP] Water intensity [m³/GDP] Material intensity [DMI/GDP]	CO_2 intensity [t/GDP] Solid waste intensity [t/GDP]
Manufacturing	Energy intensity [J/GDP] Water intensity [m³/GDP] Material intensity [DMI/GDP]	CO_2 intensity [t/GDP] BOD intensity [t/GDP] Solid waste intensity [t/GDP]
Public & services sector Private ownership, but open or accessible to public (commercial, schools)	Energy intensity [J/GDP] Water intensity [m³/GDP] Land-use intensity [km²/GDP]	CO_2 intensity [t/GDP] Wastewater intensity [m³/GDP] Municipal solid waste intensity [t/GDP]
Transport sector (use of vehicles only, not manufacturing of vehicles)	Fuel intensity [J/GDP]	CO_2 intensity [t/GDP]

Notes:

1. The framework for EEI and the selected indicators taking into account the above considerations (using GDP as numerator) reflected the discussions at the EEI Second Expert Group Meeting held in April 2008, which was organized under the Project of "Pursuing Green Growth by improving eco-efficiency of economic growth in Asia and the Pacific".
2. DMI refers to direct material input.
3. Emissions to water comprise biological oxygen demand (BOD), chemical oxygen demand (COD)..
4. Emissions to air comprise the following pollution (GHG are not included): NO_x, SO_x, CO etc.
5. GHG missions include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbon, hydrofluorocarbon and sulphur hexafluoride. While the unit for CO_2 emissions is tonne CO_2, the unit tonne of CO_2 equivalent is used for other molecules.
6. ISIC codes (version 3.1): Agriculture: 1-5; Manufacturing: 15-37 (Industry, 10-45, include manufacturing); Services: 50-99.

Chapter 3: Case studies: application of EEI

The application of the EEI has been investigated by ESCAP to assess the performance of countries on a subregional level. A number of potential indicators have been applied to test the resource-use efficiency and environmental impact intensities of member countries of North-East Asian Subregional Programme for Environmental Cooperation (NEASPEC), namely; China, Democratic People's Republic of Korea (DPRK), Japan, Mongolia, Republic of Korea and Russian Federation. This preliminary test of EEI for the countries aims to support NEASPEC's plan for eco-efficiency partnership, which will facilitate its member countries to undertake joint activities for promoting the roles of the public and private sectors and the civil society in improving eco-efficiency. Countries in North-East Asia show different implications of economy-wide eco-efficiency owing to their substantially different levels of economic development, economic structure and natural resource endowment. Thus, this comparative analysis has a limitation to determine the absolute level of eco-efficiency of each country while it clearly shows trajectories of development in the subregion. Nevertheless, this test confirms the significance of lowering intensities of resources and environmental impacts, thereby improving an overall eco-efficiency of economy.

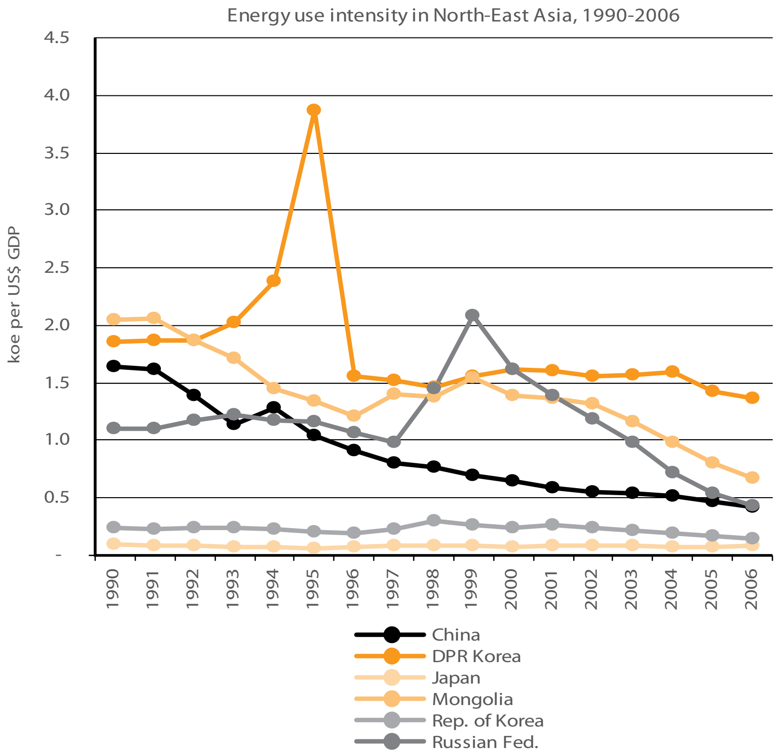
In addition this subregion is well-known for its enormous heterogeneity of economies, from the developed industrial countries such as Japan and the Republic of Korea, to the least developed and landlocked country of Mongolia. It also consists of the large transitional economies with a high growth speed such as China and Russian Federation. DPRK, a closed economy, is also located in this subregion. These countries have different levels of economic development, structure of economy and "resource availability". The composition of countries shows a comparable performance of a least developed, developing and developed economies. Hence, it is believed that the North-East subregion case can provide insights into the different trend and patterns of eco-efficiency of economic growth.

3.1 Subregional assessment of EEI trends: North-East Asia

3.1.1 Resource-use: energy use intensity5

The ratio of energy use to GDP indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a wide range of production and consumption activities. Energy use intensity is a performance indicator to measure the efficiency of countries both at the macro-level and the different sectors of the economy.

Figure 3.1 Energy use intensity in North-East Asia



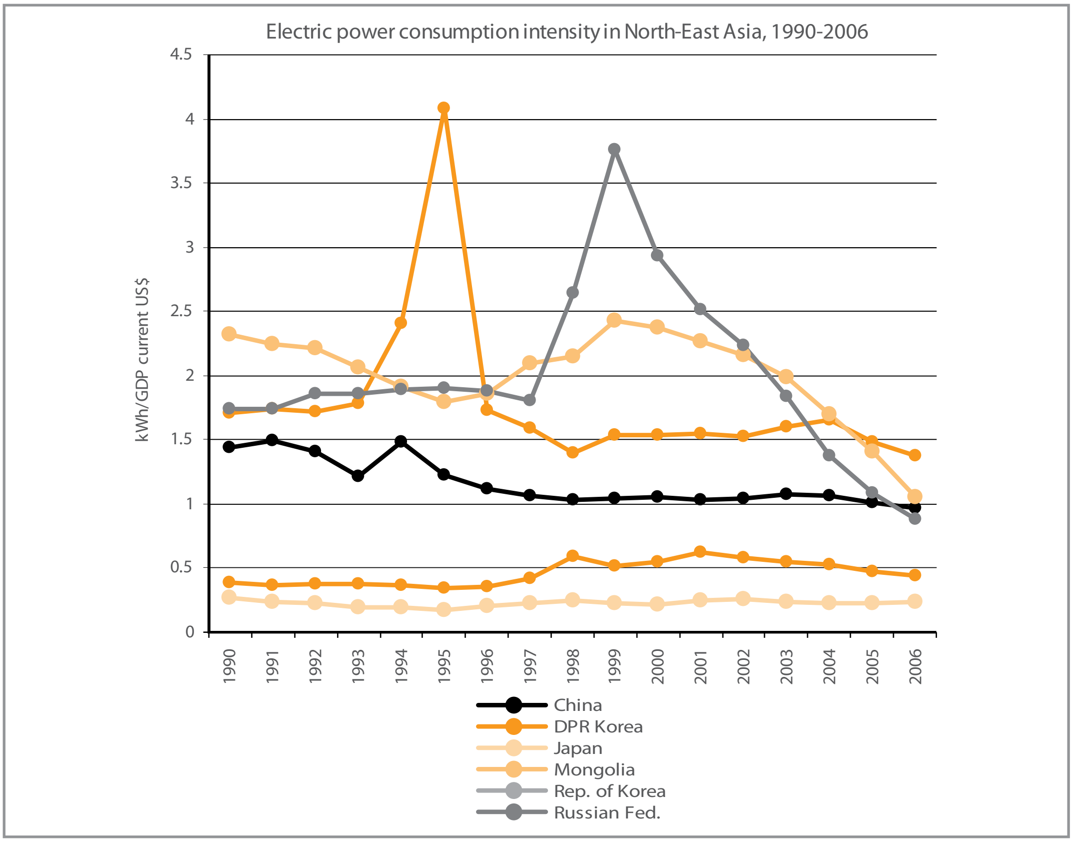
Overall North-East Asian economies have become less energy-intensive. Between 1990 and 2006, the average decrease of energy intensity in the six North-East Asia countries was 0.043 per annum. Mongolia and China achieved the most rapid average decrease of 0.087 and 0.075 per annum respectively, followed by Russian Federation (0.045), DPRK (0.044), Republic of Korea (0.006) and Japan (0.001).

Although countries such as, China, DPRK, Mongolia and Russian Federation have witnessed a gradual decline in their energy intensity, their levels of energy intensity were high compared to Japan and the Republic of Korea with the latter two countries being energy efficient to begin with.

5 Energy-use intensity is defined as the energy use of economic activity per unit dollar contribution to GDP.

The sudden rise in energy intensity of DPRK and the Russian Federation in 1995 and 1999 respectively is due to their low GDP in these particular two years. In 1995, DPRK suffered a famine and significant economic disruptions, including a series of natural disasters, economic mismanagement and serious resource shortages after the collapse of the Eastern Bloc. As for the Russian Federation, since 1992 its economic development, as measured by GDP, experienced a steep decline until 1999. In addition, a severe financial crisis hit the country in 1998 resulting in recession.

Figure 3.2 Electric power consumption intensity in North-East Asia



Source: ESCAP Online Database, http://www.unescap.org/stat/data.

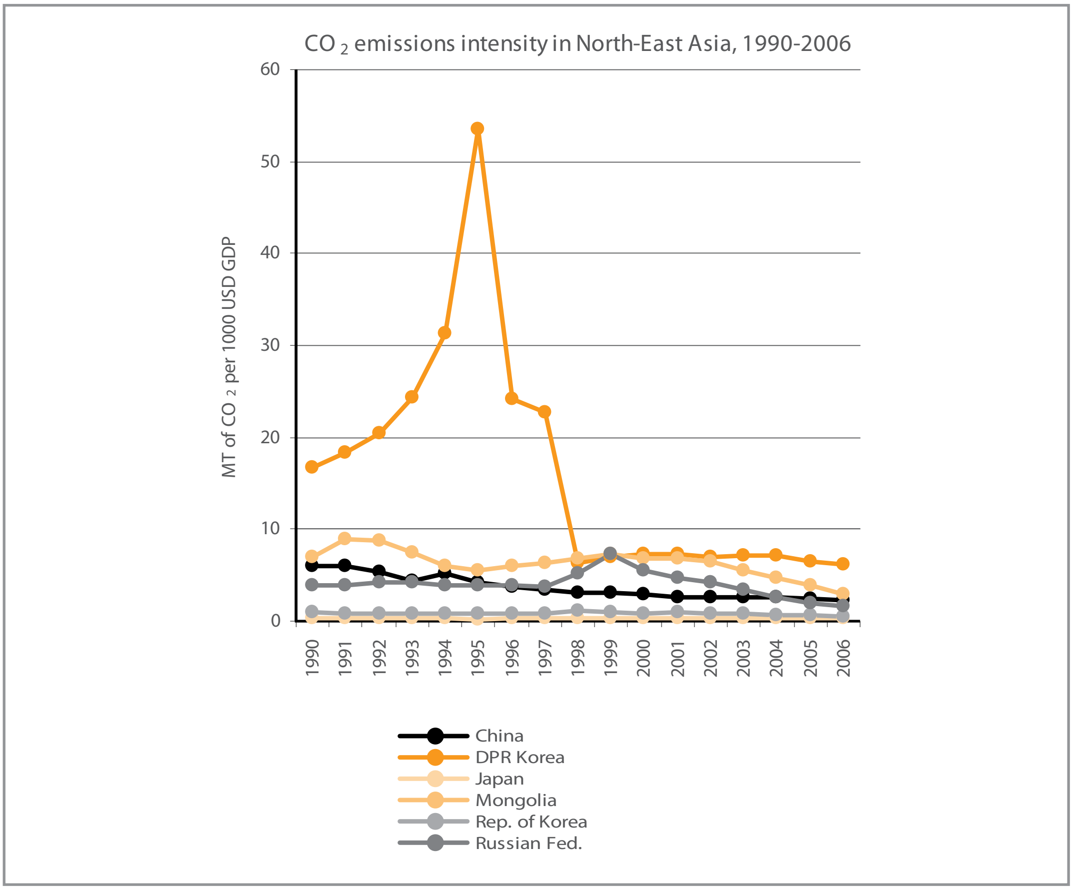
The electric power intensity in North-East Asia also witnessed a gradual decline in most countries between 1990 and 2006. The Republic of Korea is the only country that experienced a slight growth in its electric power intensity. However, Japan and the Republic of Korea were the most efficient countries in the subregion in regards to electric power intensity with an annual average value of 2.226 and 0.459 kWh per GDP current US$ respectively. These two countries were followed by China (1.163), DPRK (1.789), Russian Federation (1.995) and Mongolia (2.000).

The low GDP values for DPRK and Russian Federation in 1995 and 1999 also explained the sudden rise of electric power intensity in the two countries.

3.1.2 Environmental impact intensity

The environmental impact intensity of the economic activity to the environment covers all environmental pressures, other than direct resource-use, and ideally includes all emissions from production and consumption of goods and services and waste generation.

Figure 3.3 CO_2 emissions intensity in North-East Asia



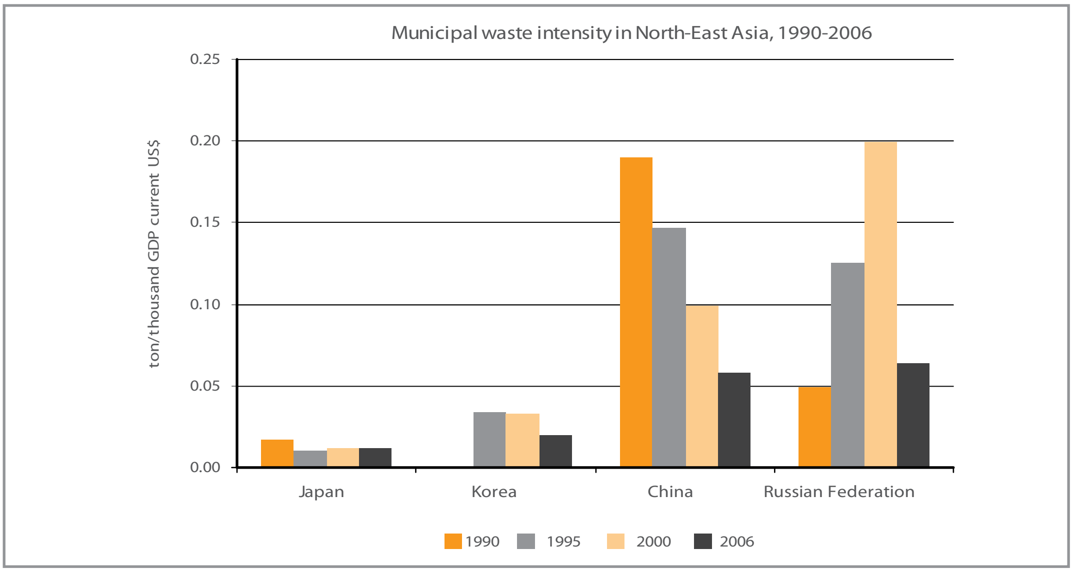
Source: ESCAP calculation based on data from CDIAC.

Although the majority of North-East Asia countries show certain progress towards reducing CO_2 intensity between 1990 and 2006, the absolute value of CO_2 intensity remains high in the subregion. The annual average value of DPRK was as high as 16.07 ton per thousand GDP at current US$ followed by Mongolia (6.31), Russian Federation (4.01) and China (3.67). In DPRK outdated and energy-inefficient industries as well as a fluctuating GDP caused by its vulnerable economy are the main reasons for the high and fluctuated pattern of CO_2 intensity.

With average decease rates of 0.66, 0.25 and 0.24 ton per thousand GDP current US$ respectively, DPRK, China and Mongolia are the three countries that have achieved the most dramatic decline in its CO_2 intensity, followed by Russian Federation (0.15), Republic of Korea (0.02) and Japan (0.01).

As with other EEI indicators, Japan and the Republic of Korea are the most efficient countries in regards to CO_2 intensity in the subregion. They remained at an average low level of 0.3 and 0.82 ton per thousand GDP at current US$ per annum per annum.

Figure 3.4 Municipal waste[6] intensity in North-East Asia



Note: Waste refers to total amount generated of municipal waste.

Source: ESCAP calculation based on data from OECD Factbook 2009

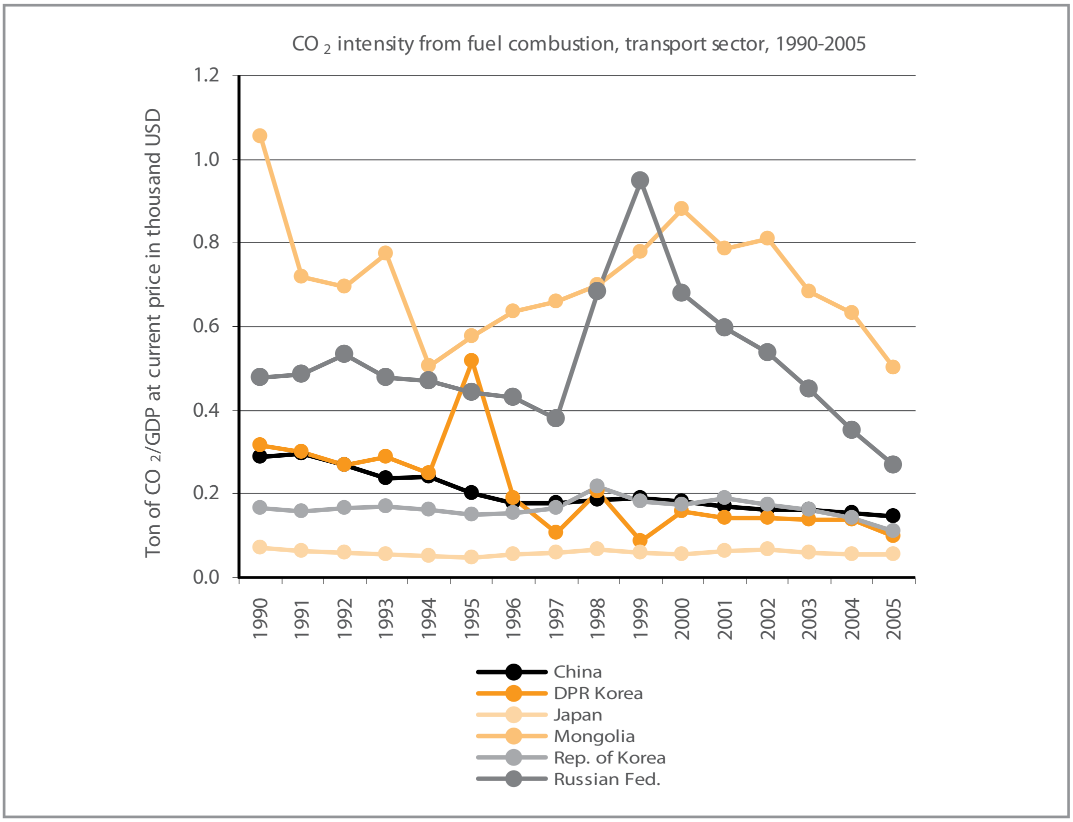
Countries had mixed performances for their municipal waste intensity. Based on the available data for four countries in four selected years in the subregion, China is the only country that witnessed a continuous drop of its municipal waste intensity level, from 0.19 ton per thousand GDP current US$ in 1990 to 0.06 ton per thousand GDP current US$ in 2006. The municipal waste intensity level in the Russian Federation rose dramatically from 0.05 ton per thousand GDP current US$ in 1990 to 0.20 ton per thousand GDP current US$ in 2000; however, in 2006, the value suddenly lowered to 0.06 ton per thousand GDP current US$. The average value of municipal waste intensity per annum remained at constant levels of 0.01 for Japan and 0.02 for Republic of Korea.

3.1.3 Selected sectoral perspective

The sector-specific indicators refer to the same indicators as resource-use intensity and/or environmental impact intensity indicators with breakdown by sectors, which can include energy, manufacturing, agriculture, transport, household consumption etc.

6 Municipal waste Municipal waste is waste collected and treated by or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden waste, street sweepings, the contents of litter containers, and market cleansing waste. The definition excludes waste from municipal sewage networks and treatment, as well as municipal construction and demolition waste.

Figure 3.5 CO_2 emissions intensity from transport sector in North-East Asia



The majority of the countries in the subregion including Mongolia, Russian Federation, DPRK and China have made progress in reducing their CO_2 intensity from fuel combustion in the transport sector particularly since 2000. However, these countries have also experienced much fluctuation in their CO_2 intensity levels from fuel combustion for the transport sector with the only exception of China.

Japan and the Republic of Korea were the best performers in the subregion in their levels of CO_2 intensity from fuel combustion for the transport sector. However, they did not make obvious progress in terms of reducing the CO_2 intensity level from fuel combustion since 1990.

3.2 National assessment of EEI trends: Viet Nam[7]

The national assessment of EEI trends in Viet Nam focuses on four intensity indicators of resource-use, i.e. water, energy, land and raw materials and fuels (petroleum products, coal, electricity, steel, cement and fertilizer) and four intensity indicators of environmental pollution, i.e. NOx, SOx, CO_2 and GHG compared with per unit of GDP.

7 The assessment was conducted by Central Institute for Economic Management (CIEM) of Viet Nam. Technical support was provided by ESCAP as a national pilot project under the eco-efficiency indicator project.

3.2.1 Eco-efficiency at the national level

The analysis shows that Viet Nam's GDP grew faster than its use of key resources, whereas the pace of growth in usage of highly polluting raw materials and energy inputs exceeds that of GDP growth. Viet Nam has achieved significant economic growth during the period 1990-2007, during which the use intensity of some basic natural resources such as land, water and energy tended to decrease. In other words, the country tended to use fewer resources to generate VND one million of GDP. While the use intensity of some basic resources declined, however, some key materials have been used more intensively in the same period. Raw materials such as oil and petroleum products, steel, electricity and cement have been used with greater intensities in the period from 1990-2007. This can be explained by the rapid industrialization and urbanization process in Viet Nam over the past couple of decades. Along with such processes, demand for electricity to support industrial production and household consumption increased sharply.

Figure 3.6 Trends of resource-use intensities, Viet Nam

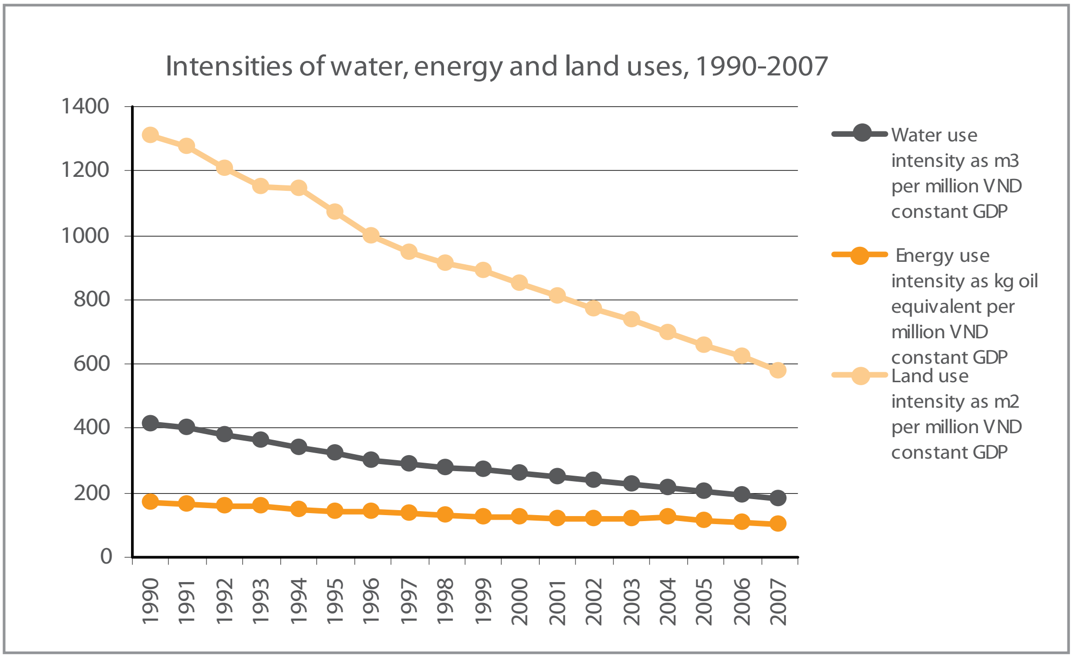
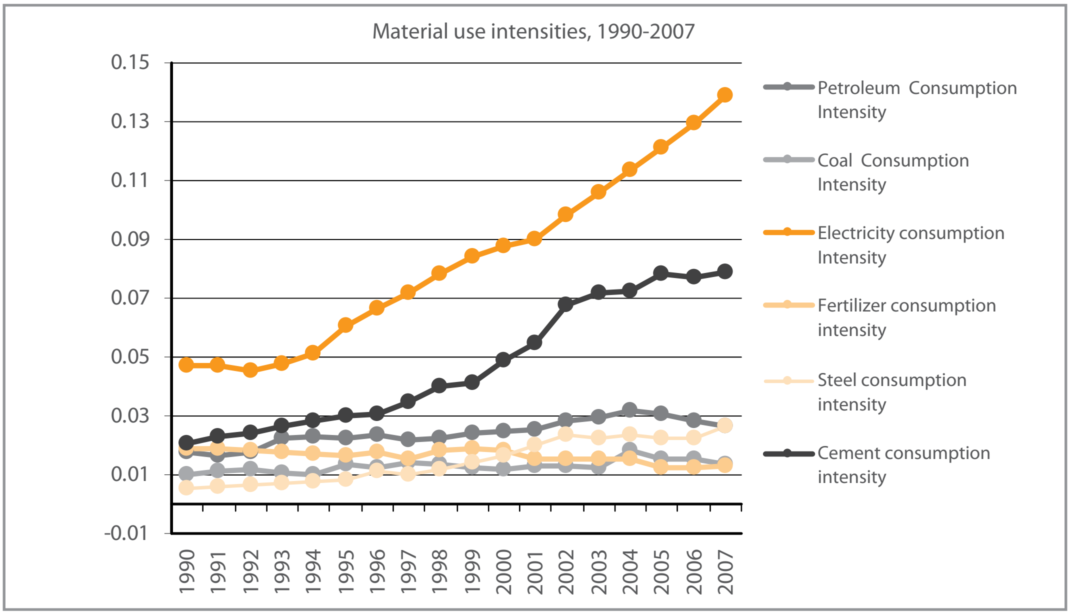


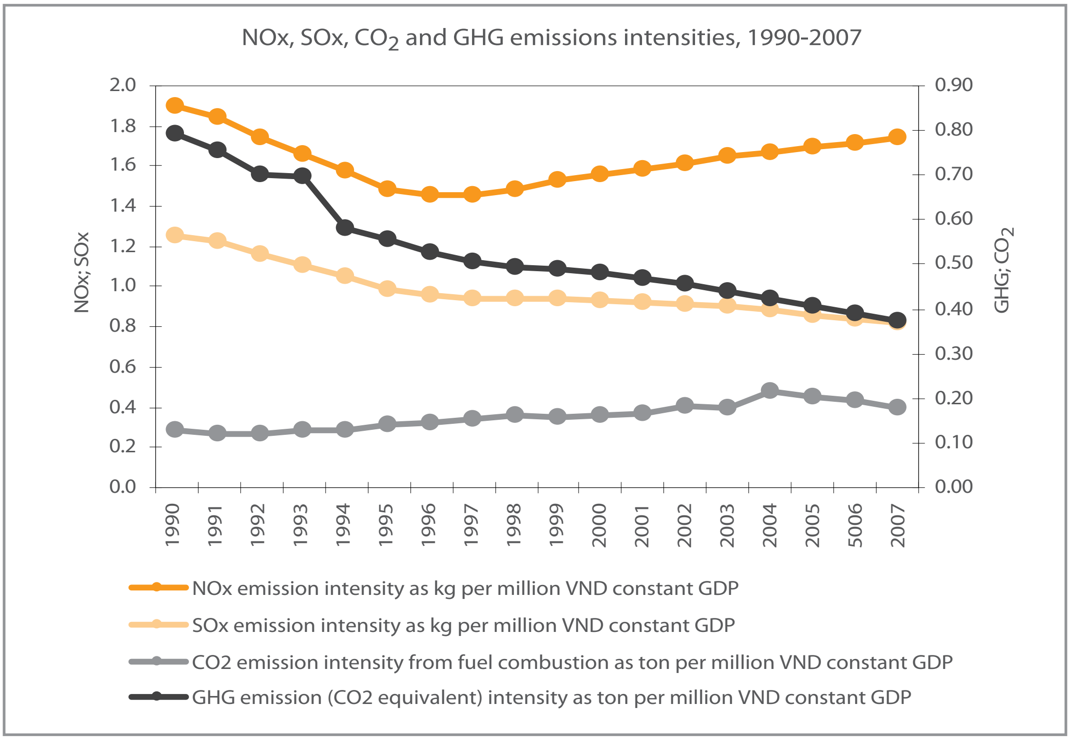
Figure 3.7 Trends of material use intensities



(Unit: unit of material use per million VND – GDP at 1994 constant prices)

In analyzing the eco-efficiency in terms of environmental impacts, data show that NOx and CO_2 emission intensity tended to increase in recent years, while those of SOx and GHG decreased gradually. In 1990-2007, growing trends of polluting compounds such as NOx, SOx and GHG were all slower than the GDP growth index. However, the gap between the GDP growth index and that of NOx has been decreasing, indicating the growing trend of NOx intensity in recent years. Meanwhile, CO_2 emissions went up much faster than GDP growth in the same period, indicating the upward trend in CO_2 intensity. The reasons for this include the increased use of CO_2 emitting fuels, rapid deforestation which reduced the capacity of forests to clear the air, outdated technology which increased the intensity of energy consumption, and the ineffective administration of polluting industries.

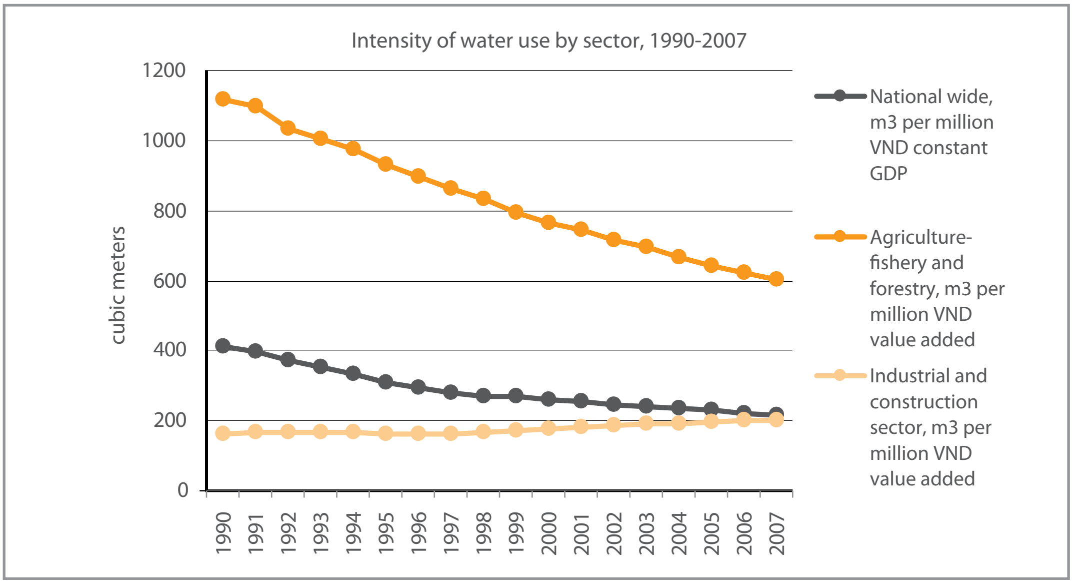
Figure 3.8 Trends of pollution intensities



3.2.2 Eco-efficiency of economic sectors and the public and services sector

During the period 1990-2007, water-use intensity of the agriculture-forestry-fishery sector decreased by 46%, while that of the industry-construction sector increased by 30%. The decline in water-use intensity of the agriculture-forestry-fishery sector can be explained by the productivity growth in agriculture rather than a change in farmers' behavior in regards to the more efficient use of water resources. The increase in water-use intensity of the industry-construction sector comes from the fact that Viet Nam paid more attention to developing water-intensive industries such as textiles, aquacultural and fishery processing, food processing, mining and quarrying and mineral processing, etc.

Figure 3.9 Intensity of water-use by economic sectors



In terms of energy, the industry-construction sector showed the highest use intensity. The intensities of energy consumption in both the agriculture-forestry-fishery and services sector are shown to be dramatically smaller, albeit trending upward in 1990-2007. Meanwhile the intensity of land-use in different economic sectors moved in the same direction during this period. The agriculture-forestry-fishery sector still used land intensively and much more intensively than other economic sectors and the economy as a whole since 2000. The intensity of land-use in services dropped sharply in 1990-2007, a trend which might have resulted from impressive growth in the services sector in recent years relative to the increase in land areas used by the sector.

Figure 3.10 Intensity of energy use by economic sectors

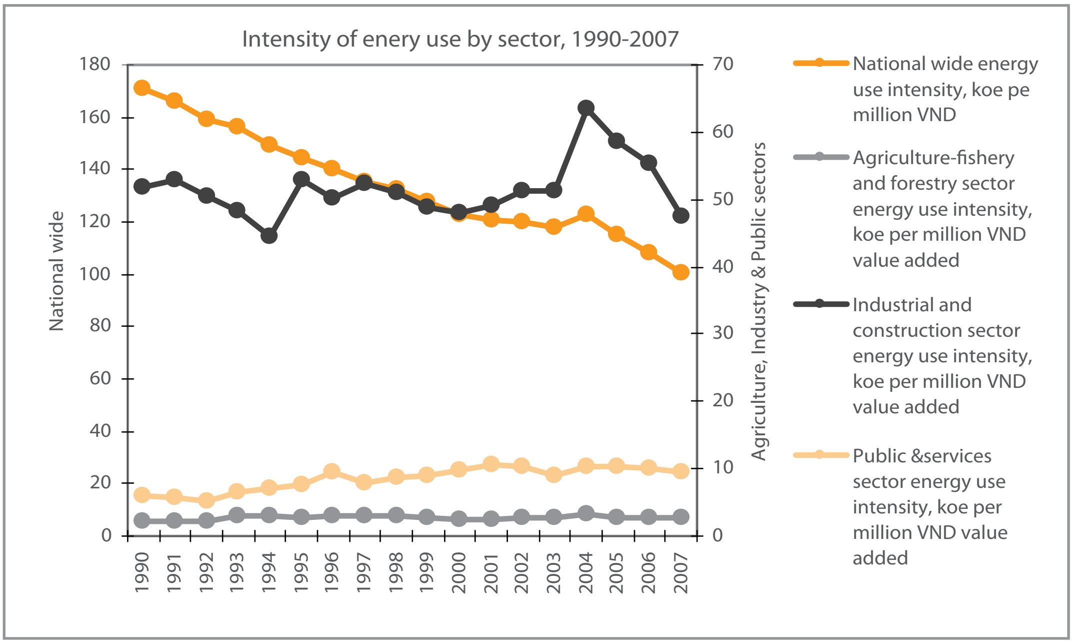
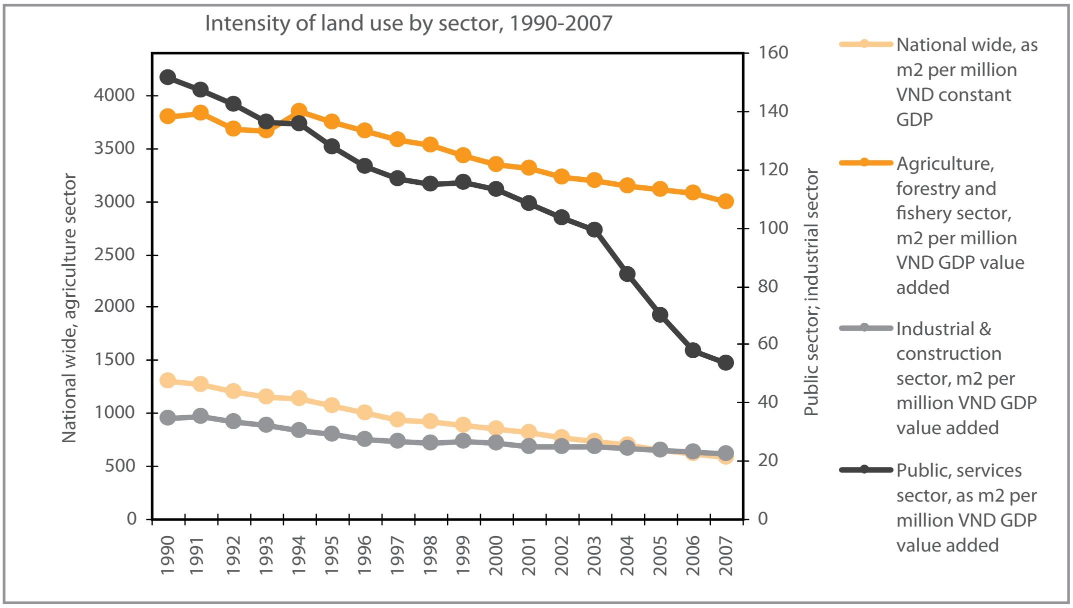


Figure 3.11 Intensity of land-use by economic sectors



The efficiency of resource-use in each economic sector may be analyzed by comparing the growth in resource-use with that in value added for each sector. In the agriculture-forestry-fishery sector, the use of water and land increased more slowly, while the use of energy rose more rapidly, than the value added. In the industry-construction sector, the uses of energy and water changed almost in line with the value added, while land-use increased more slowly. In the services sector, energy consumption grew more rapidly, while land-use increased more slowly, than value added in the sector.

Figure 3.12 GDP and resource-use in agriculture, forestry and fishing

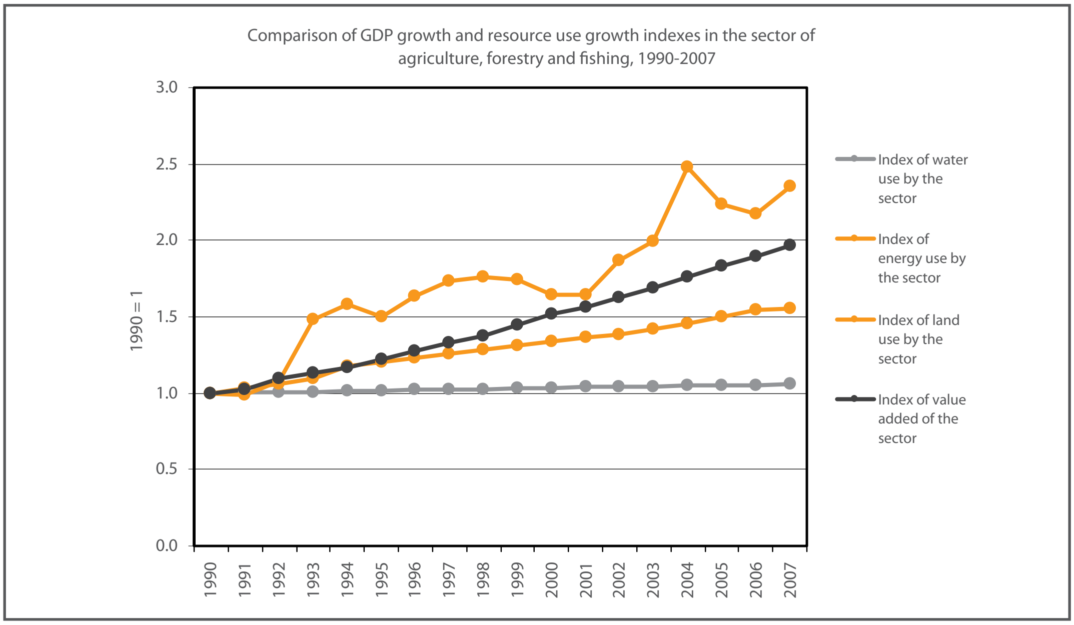


Figure 3.13 GDP growth and resource-use industry and construction

Pollution intensities vary by sector. The intensity of NOx pollution in the agriculture-forestry-fishery sector was always the highest, trending downward in 1990-1995 but subsequently increasing rapidly. This can be attributed to the fact that farmers used more fertilizers than necessary, without measures to deal with pollution. The industry-construction sector has the highest intensity of SOx pollution, but the intensity has decreased considerably over the years, which can be explained by the shift in economic structure with a greater share of manufacturing industries. The intensity of CO_2 pollution from consuming fossil fuels was the highest in the industry-construction sector, and exhibited rather erratic movements in 1990-2007. The intensities of CO_2 pollution in the agriculture-forestry-fishery and services sectors tended to increase gradually. The increase in intensity of CO_2 pollution for the economy as a whole is due to the growth in demand for fossil fuels and the presence of outdated industrial technology which increased the use of highly CO_2 polluting energy inputs.

Figure 3.14 NO_x pollution intensity by economic sector

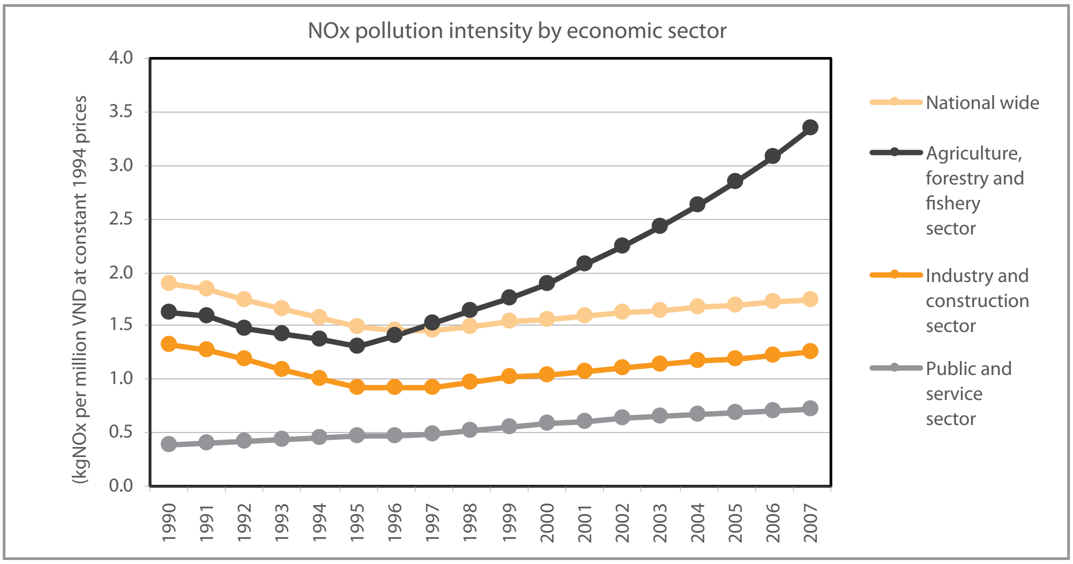


Figure 3.15 SO_x pollution intensity by economic sector

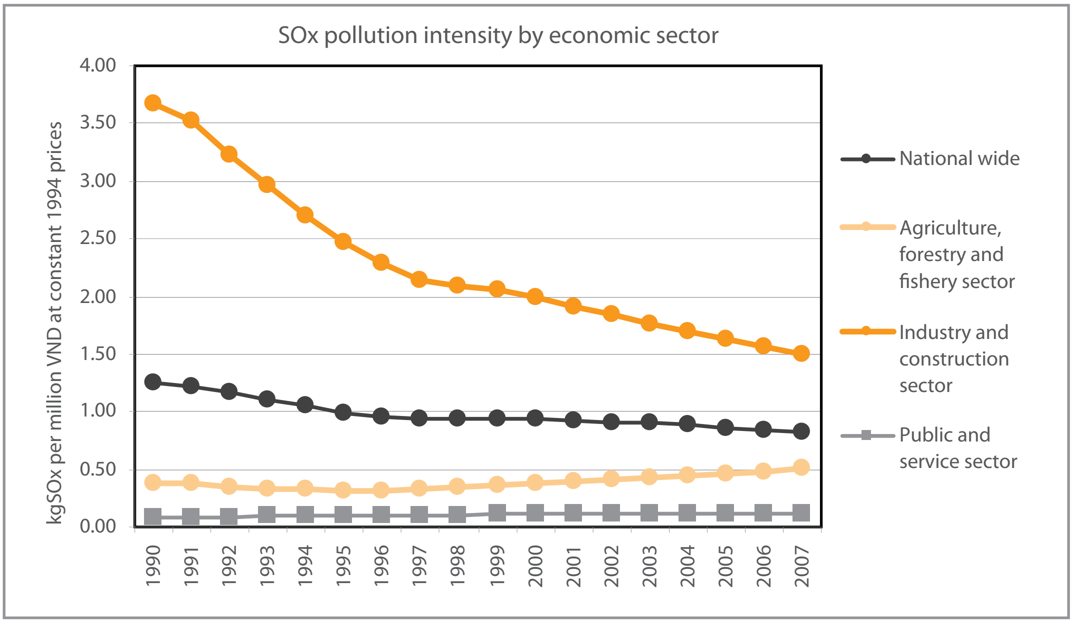
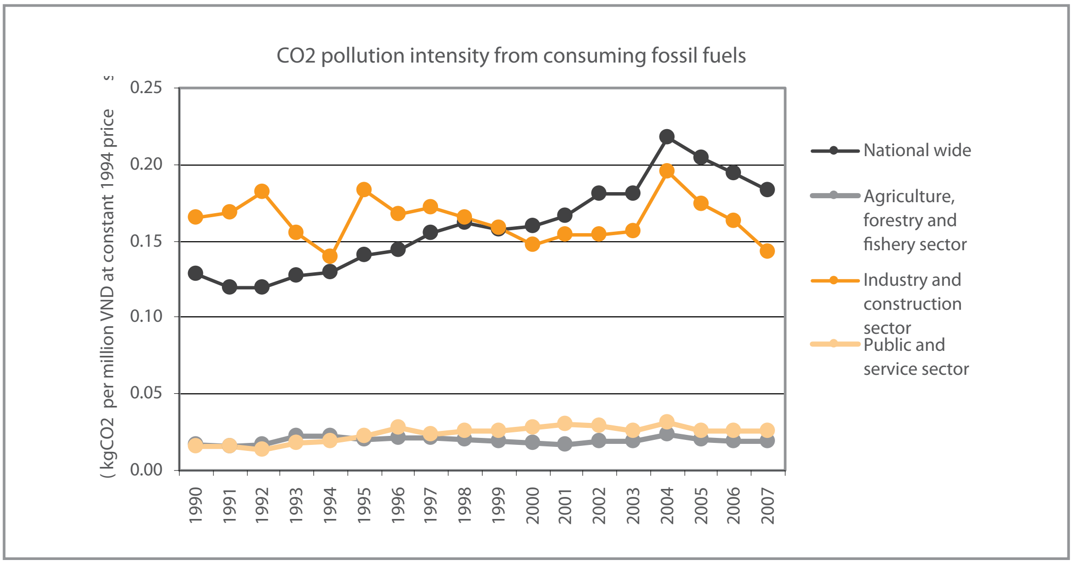
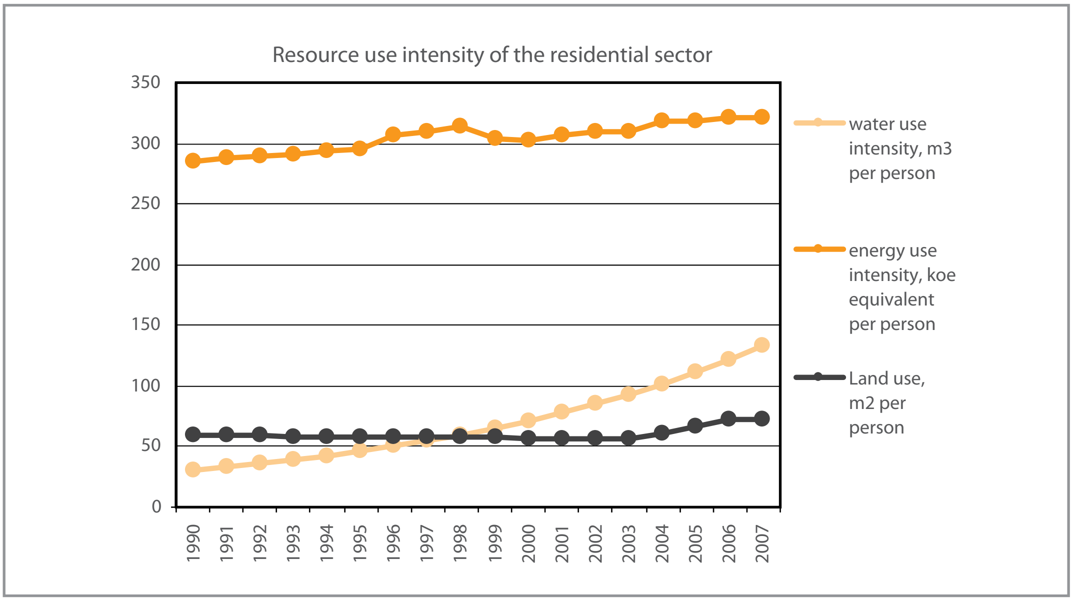


Figure 3.16 CO_2 Pollution intensity from consuming fossil fuels



Meanwhile the use intensities of all key resources of the residential sector have increased continuously since 2000. In particular, water-use intensity continued to rise from 1990-2007, showing an increase of 4.4 times during this period. The pollution intensity of the residential sector has shown a generally upward trend. Except for SOx, pollution intensities of both NOx and COx increased. This can be explained by the processes of urbanization and industrialization, lack of public awareness of environmental impacts from consumer habits, and the lack of policy instruments to encourage people to use environmentally-friendly products.

Figure 3.17 Resource-use intensity of the residential sector



3.2.3 Policy implications and recommendations

The study bears several implications. During the period 1990-2007 the use intensities of some raw materials and fuels tended to increase rapidly in Viet Nam. In particular the power-use intensity is currently higher than some countries in the region, which necessitates measures in the future to improve the efficiency of power through the reduction of power-use intensity. While decreasing production costs and increasing production efficiency, those measures will also help reduce the emission of CO_2.

Viet Nam risks higher levels of pollution both at the national and sectoral levels. The increase in pollution levels necessitates further in-depth studies to identify relevant solutions for the future. The industry-construction sector poses great challenges to water and air quality, and to solve these issues from a policy perspective Viet Nam needs to promote less-polluting industries and implement policies to enact environmental protection, technological progress, improvement of resource-use efficiency in industrial production, and pollution reduction. The services sector is relatively cleaner compared to industry and agriculture but risks increased pollution or resource-use if the focus is shifted to developing land-intensive, water-intensive, or highly-polluting services. The residential sector of Viet Nam has been using more and more resources due to the change of lifestyle and consumption patterns among the population, but if encouraged to use resources in a rational and economic way, Viet Nam's EEI indicators will be significantly improved.

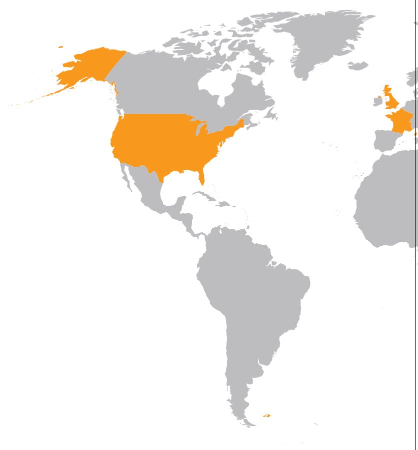
Chapter 4: Conclusion

The EEI is designed to capture the ecological efficiency of growth by measuring the efficiency of economic activity both in terms of consumption and production (resource-use) and its corresponding environmental impacts. The ultimate goal of EEI is to provide governments with a practical tool to measure their performance in the context of eco-efficiency and harness the concept of eco-efficiency for socio-economic policies pertaining to environmental sustainability.

In this regard, ESCAP work on EEI does not intend to develop a single index aggregating trends in every aspect of economic, environment and social linkages, but a set of simple indicators that inform policymakers about major trends and issues regarding the eco-efficiency of the economy. The EEI framework is flexible for countries to choose most relevant indicators based on two major conditions, i.e. (1) priority national policy areas in the pursuit of economic growth with less resource consumption and pollution, and (2) the availability of concrete supporting data for assessment. Thus, the EEI framework attempts to present a set of indicators that capture the linkage between economic activity, resource usage and environmental impact in order to evaluate economic policies more effectively and thereby assist policymakers in improving the eco-efficiency of economic growth.

Testing EEI at the subregional level in North-East Asia shows different paths of economic growth in relation to eco-efficiency and the need to further review the current national economic and environmental policies and programmes to integrate components of eco-efficiency into the development strategies. The subregional assessment also highlighted the need to improve the availability of comparable and reliable data and policy information at national and subregional levels for in-depth assessments of eco-efficiency-related trends.

The national assessment in Viet Nam involved in collection of data from various sources while the priority was given to data published by the General Statistics Office of Viet Nam, and consultations with experts from various fields. This process proved that using EEI at national and sectoral levels is useful for monitoring the efficiency of resource-use and the intensity of pollution in Viet Nam. However, the process also showed the need for improving data systems and human capacity for analyzing, consolidating and updating EEI-related information. And the process also proposed that some EEI indicators should be incorporated into the system of indicators to monitor the implementation of Viet Nam's socio-economic development plans and strategy for the periods 2010-2015 and 2020, which could be pursued in many other countries for monitoring and improving eco-efficiency of economic growth.



UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

Environment and Development Division
United Nations Building
Rajadamnern Nok Avenue
Bangkok 10200, Thailand
Tel: +66(0)2 288 1234; Fax: +66(0)2 288 1025
E-mail: escap-esdd-evs@un.org
Website: <http://ww.unescap.org/esd> <http://www.greengrowth.org>