Environmental Management Tools

A Training Manual

Edited by

Jayant K. Routray

In association with

Anurupa Mohanty

AIT
ASIAN INSTITUTE OF TECHNOLOGY

UNEP

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Asian Institute of Technology

P.O. Box 4, Klong Luang Pathumthani 12120, Thailand

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Foreword

Achieving environmental sustainability is the current goal of all nations in the world for sustainable living and human security. Human activities for rapid economic gains without rational utilization of available resources and inadequate conservation practices create multiple environmental problems of complex nature that need to be addressed and managed effectively and efficiently at all levels (local, regional, national and global), and by all sections of the population. Managing environment is the greatest challenge that societies face at present. Understanding, adaptation and application, as well as dissemination of environmental management tools in this respect are very crucial to build and create healthy world relatively free from environmental degradation and pollutions. Therefore the need arises to expose and educate the officials, decision and policy makers working at the ministry level for downward dissemination and implementation of management tools in each and every country. The individual and collective actions taken by the nations will certainly rejuvenate and enrich the global environmental quality and situation step by step.

AIT and UNEP's International Environmental Governance process have continuously recognized the need to develop a strategic plan for capacity building for the developing countries. Following the adoption of the Bali Strategic Plan (BSP) for Technology Support and Capacity Building, it was emphasized to provide systematic, targeted, long and short-term measures, taking into international agreements based on national and regional priorities and as well as felt needs. One of the areas identified for the capacity building is on environmental management tools (EMT) including legal, fiscal and technological for the SAARC member countries, recommended in a meeting of Experts held in October 2004 in New Delhi.

With this backdrop, it was prompted by the UNEP-ROAP to organize a training program on "Environmental Management Tools" to strengthen the environmental community in South Asia, including the governments, civil societies, intergovernmental agencies and business. This training was attended by senior officials from 8 South Asian countries, SACEP and SAARC. The training program was designed and implemented by the School of Environment, Resources and Development of Asian Institute of Technology during 27-31 March 2006.

The EMT Training Program at AIT provided the common platform to share the current national environmental situation and experiences with selected management practices, to familiarize the participants with varieties of environmental management tools and techniques with case studies and applications, and exposed field visits in Bangkok to demonstrate few best practices.

UNEP and AIT hope to organize more of similar events in future in close collaboration to benefit the governments, non-government organizations, private, regional and intergovernmental organizations, institutes and individuals in pursuing better environmental quality management.

Said Irandoust
President
Asian Institute of Technology

Surendra Shrestha
Regional Director and Representative
UNEP-ROAP

Preface and Acknowledgements

Environmental Management Tools: A training Manual is the product derived from a training program organized by the School of Environment, Resources and Development of Asian Institute of Technology during 27-31 March 2006. This training program was conceptualized by the UNEP – ROAP following the needs assessment of the SAARC member countries held at New Delhi in October 2004. Mr. Surendra Shrestha, Prof. S. Kumar and Dr. Subrato Sinha were instrumental in shaping this training program. I was given the responsibility of organizing this program on behalf of the School of Environment, Resources and Development.

The participants were from eight South Asian countries (Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh, Sri Lanka and Maldives), SACEP and SAARC. All the participating members were key and high level functionaries responsible for implementation of environmental programs and projects, policy formulation and decision making process. The resource persons were drawn from AIT and UNEP-ROAP, and few others were taken externally. The resource persons were professionally rich and knowledgeable in their respective areas of specializations to deliver the best in assigned topics.

The training program covered different aspects of Environmental Management Tools (EMT). Within the limited time frame of five days, few selected but key areas were chosen from legal, fiscal, and technological tools with overview of environmental issues of Asia, regional and trans-boundary impacts and influences, and policy instruments of EMT for deliberations. Presentations were made sequentially by the resource persons following a schedule. The presentations were comprehensive with case studies and illustrations from Asia and other countries. Two field visits were planned and conducted on ‘solid waste management’, and ‘eco-house’ in the periphery of Bangkok city. In addition, the participants also made country paper presentations on environmental situations of their respective countries with focus on specific practices of management tools.

This training manual is the outcome of the reading materials prepared specifically for this purpose and undergone further revision and editing. There are six sections of this manual. The first section presents an overview of global and regional environmental situation with focus on Asian issues. The second section deals with environmental data, environmental indicators, environmental accounting, GIS applications, spatial and planning tools. The third section explains the legal tools such as Environmental Law, Multilateral Environmental Agreements, EIA, Environmental Auditing, and Strategic Environmental Impact Assessment. The fourth section makes an overview of fiscal tools covering topics such as policy instruments and Clean Development Mechanism. The fifth section concentrates on water quality and waste water management, solid waste management, industrial management tools, and Montreal Protocol. The sixth and last section focuses on environmental security, air quality with trans-boundary issues, climate change and institutional mechanism for environmental management.

I would like to express my thanks to many individuals and institutions who have sincerely contributed their time and energy for preparing the training program as well as documenting the training outputs through this manual. They include Government Departments, Intergovernmental Organizations, and Academic Institutions. A full list of contributors, resource persons, and participants are included in Appendix. Special thanks are extended to Prof. Said Irandoust (President of AIT), Prof. Peter Heddawy (Vice-President for Academic Affairs), Prof. Vials (Vice-President of External Relations), Prof. S. K. Rakshit (Vice-President of Research) and Prof . S. Kumar (Dean, School of Environment, Resources and Development), Mr. Surendra Shrestha,

Regional Director and Representative (UNEP-ROAP), and Dr. Subrato Sinha (Environmental Affairs Officer) for their support and cooperation in making this project a success. Finally, the financial support from the UNEP-ROAP is highly appreciated without which it had not become possible. The assistance extended by Anurupa Mohanty, Leena Divakar and Pravakar Pradhan for conducting the training program and finalizing the training manual for printing in its present form, are duly acknowledged and highly appreciated.

I am sure that the government organizations, academic institutions, professionals and practitioners will find this manual very useful in their regular environmental management activities for improving the quality of environment and sustaining it for the future.

Jayant K. Routray

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Environment in the 21st Century

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ABSTRACT *The purpose of the paper is to explore challenges of the 21st Century building on our experience in the macro environment sector and state the case for a need for institutional reform. It is expected that through discussions the paper will gradually elaborate how UNEP will deliver the results expected by the governments. It discusses major challenges facing on social and economic development state of environment and natural resources, and negative trends of the state of the environment in terms of air pollution, water demand and state of water resources, land degradation, and biodiversity concerns.*

Future Challenges and Prospects

In 1972 at Stockholm, the United Nations Conference on the Human Environment established the United Nations Environment Programme (UNEP) as the environmental conscience of the United Nations system. The Conference proclaimed that the protection and improvement of the environment is the major factor, which affects the well being of people and economic development throughout the world. The Conference led to the establishment of environment institutions and instruments all over the world.

Box 1: Looking Back to Think Ahead: Socio-economic Development

Social Development: World population has doubled over the last half century, from 2.5 billion in 1950 to 6.1 billion in 2000. During the past half century, life expectancy has increased throughout the world with advances in public health, vaccines, antibiotics, and food production. There is, however, disparity in these advances:

- In sub-Sahara Africa, around 700 million people live with HIV epidemic. The HIV epidemic has reduced life expectancy from 62 to 47 years;
- The World Health Organization (WHO) data show that roughly 1.2 billion people are undernourished, underweight and sleep hungry. At the same time, roughly 1.2 billion people are over nourished, over weight and sleep with worries on weight loss;
- Around 1.1 billion people lack access to safe drinking water. Waterborne diseases claim more than 3 million lives each year, mostly as a result of dysentery and cholera.

Economic Development: Income per person worldwide nearly tripled from 1950 to 2000 against double the population growth. The global economic output has grown from just under $7 trillion (in 2001 dollars) of goods and services in 1950 to $46 trillion in 2000, a gain of nearly sevenfold. This growth and gains for livelihoods is focused on a few countries and individuals while large number countries struggle with the reality and challenges of debt and abject poverty.

Source: Brown (2003)

The last decade of 20th century witnessed many Global Summits. World Summit on Sustainable Development (WSSD) brought many of these discussions together. The Rio Summit articulated the Agenda 21, a blueprint for action for the global sustainable development. WSSD focused on the implementation of this blue print through partnerships and focus on the MGDs. The Summit discussed the concerns that the environment and the natural resource base that support life on Earth continues to deteriorate at an alarming rate. The Summit also noted the alarming discrepancy

between commitments and responses that are quoted - too few, too little and too late. Analysis of socioeconomic and environmental developments (box 1&2) shows that the agenda of sustainable development has acquired even more urgency in the 21st century.

Box 2: Looking Back to Think Ahead: Socio-economic Development

Environment - Air Pollution: Releasing air pollutants into the atmosphere faster than nature can absorb creates pressure on several atmospheric related environmental issues. For example, CO_2 levels rose at less than 0.2 ppm each year during the preceding two centuries. This increased by 1.3 ppm per year since 1960, which is a rise of more than six times. Some of the scientific findings and impacts include:

- The latest IPCC report that the temperature will rise 1.4-5.8 degree Celsius and the sea level will rise 0.09-0.88 meters during the 21st century;
- Studies conducted by the US Geological Survey (USGS) report that the number of glacier in Glacier National Park in US had dwindled from 150 in 1850 to fewer than 50 in 2000. Institute of Research and Development, France reports that within the next 15 years, 80 percent of South American glaciers will disappear. A Study of Kilimanjaro shows that its snowcap could disappear entirely within the next 15 years. UNEP/ICIMOD's study in Nepal and Bhutan report glaciers are retreating at 30-40 m annually;
- The American Geographical Union in Dec 2002 reported that the Arctic sea ice is thinned by 42 percent over the last 35 years- from an average of 3.1 meters to 1.8 meter;
- The frequency and intensity of the Dust and Sand Storms from inner Mongolia has increased. The storms in early spring can remove literally millions of tons of topsoil in a single day. China Meteorological Administration reports 5 major dust storms in the 1950s, 14 during the 1980s and 23 in the 1990s. During 2000-2001, there have already been more than 20 major dust storms.

Environment - Water Resources: The world is incurring a vast water deficit due to increase of water demand and the worldwide spread of powerful diesel and electrically driven pumps. Demand for water tripled over the last half century as agriculture, industrial and residential uses increased, exceeding the sustainable supply in many countries. Some of the major reports on water include:

- The Geological Environmental Monitoring Institute (GEMI) in Beijing reported that in Hebei Province the average level of the deep aquifer dropped 2.9 meters in 2000. In India, in the state of Punjab and Haryana, water tables are falling by up to a meter a year. In the agricultural state of Guanajuato in Mexico, the water table is falling by 2 meters or more a year. In the northeastern Iran, the water table was falling by 2.8 meters a year in the late 1990s. Villages of eastern Iran is being abandoned as wells go dry, generating a flow of water refugees;
- Dams on rivers are built for irrigation, for electricity and to supply water for domestic and industrial sector. In most cases, this has an impact on the ecosystem. The Colorado now rarely makes it to the sea. With the states of Colorado, Utah, Arizona, Nevada, and most important California, depending heavily on the Colorado water, the river is simply drained dry before it reaches the Gulf of California. Among other rivers that now fail to reach the sea part of the time are: the Yellow River, the cradle of Chinese civilization; and the Amu Darya, one of the two rivers that feed the Aral Sea in Central Asia.

Source: Brown (2003)

Future Challenges and Prospects

Reduction of Atmospheric Pollutants

The accelerating rise in the earth's temperature calls for simultaneous raising efficiency and shifting to renewable in order to cut carbon emissions in half by 2050. Moving away from auto centered urban transport to a system that would prominently feature public transport in a bicycle and

pedestrian friendly environment would cut fuel use in cities. The wind energy industry has made significant gains in implementation in the last decade. There are many policy instruments for accelerating the shift from a carbon to a hydrogen based energy economy, including the shift of subsidies from fossil fuels to wind, solar, and geothermal energy sources. Some examples of effective policy measures include:

- Finland has stiff tax on non-refillable that has led to 98% container reuse for soft drink. These actions reduce energy use, water use, and garbage generation;
- Replace of all incandescent light bulb with compact fluorescent bulb (CFL), which use one third as much electricity and last 10 times as long;
- Raise energy efficiency of automobiles through a shift from current vehicles with internal combustion engines to cars with hybrid engines, like Toyota Prius;
- Redesign urban transport system, which presently automobile centered to well developed light rail system complemented with buses and bicycle and pedestrian friendly which could increase mobility, reduce air pollution, and provide exercise; and
- Facilitate the research and development of the hydrogen-based economy towards implementation.

The 21st century will witness some innovative technologies for emission reduction. The major challenge will be incorporation of these technologies into the developing economies at an early stage.

Water Resource Management

During the first six decades of the last century, growth in irrigation came from surface water projects, consisting of dams and large networks of gravity-fed canals. Now this potential is either limited or nonexistent in most of the countries. Where rivers are drained dry and water tables are falling, the only option is reducing the growth in demand by stabilizing population and raising water productivity. Some policies that have worked in raising efficiency and reducing demand include:

- Pricing of water to encourage greater efficiency: South Africa introduced lifeline rates, whereby each household receive a fixed amount of water for basic needs at a low price, when it exceeds this level the price escalates; in 1980 Morocco doubled the price of water nationwide, encouraging efficiency; China decided in 2001 to raise the price of water; and Jordan installed meters in all irrigation wells;
- Water harvesting and local water storage can help improve water availability in many rural areas of developing countries. In Rajasthan in India, many small water storage structures have helped to raise income of local people and the quality of life. The success story can be replicated in many arid or semi-arid regions in order to improve waster supply;
- Wastewater should be managed without discharging it into the local environment. Future solutions for management of waste water include: reduction of residential water use through use of composite toilet; use of efficient water appliance, including showerheads, flush toilets, dishwater, and cloth washers; in the urban areas adoption of a comprehensive water treatment/recycling system, reusing the same water continuously.

Major challenge in the 21st century would be water distribution and collaboration among the stakeholders.

Land Productivity

Extraordinary rise in land productivity, combined with the modest expansion of cultivated area, enabled farmers to triple the grain harvest over the last half century. These gains supported a growth on population from 2.5 billion to 6.1 billion. As we look ahead at the next half century, we face a demand situation that was similar to the past half century with a projected increase of nearly 3 billion people. The actions for meeting future food demands include:

- In North America and Western Europe, which in the past have restricted cropped area in order to avoid surpluses, there is a potential for doubling cropping that has not been fully exploited;
- Reduce pressure on land by shifting from fuel wood to renewable energy sources-everything from solar cookers to wind generated electricity;
- Reduce overgrazing by shifting to stall feeding of animals, cutting the forage and bring it to cattle, goat. Stall-feeding is labor intensive and good for developing countries. India has been a leader in adopting this practice, particularly within its thriving dairy industry;
- Policies to reduce desertification include: in Mongolia planting of desert shrubs has helped stabilize the sand dunes; China has allocated 10 million hectares of grain lands to be covered with trees by 2010; in 2003, some 14 million hectares of US cropland roughly one tenth of the total have been planted with grass and trees under the Conservation Reserve Programme.

Supported by the generic revolution, the productivity of the land will be increased by many folds during the 21st century. Impacts on ecosystem by atmospheric changes and improper water distribution will be the major pressure on land during this century.

The Way Forward

Stronger UNEP

The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generation. To fulfill its mandate, UNEP has been working with a wide range of partners, including UN entities, international organizations, national governments, non-governmental organizations, the private sector and civil society. The United Nations has repeatedly acknowledged that environmental considerations are central to sustainable development. The world has entered into the 21st century with many emerging problems that have the potential to jeopardize the life support system of earth as well as its very sustainability. This emerging crisis demands a new world order and leadership to drive the earth towards the ecologically sustainable development. Stronger UNEP is required in terms of partnership and scientific base (UNEP, 2002b).

Institutional Framework

It has taken over two decades for environment institutions to be established across the globe. The local, national, regional, and the global institutions that have the mandate for environment are often the weakest and poorest. Sustainable Development is the agreed global agenda. The local to global effort in sustainability provides the environment with a unique opportunity. Opportunity exists for the redefining the scope and functions of environment agencies. Studies have shown that environment agencies are best placed to picking up signals (early warning), balancing interests in decision making and execute decisions through partnerships with both sectoral agencies and civil society groups (World Bank 2003). Nations are focusing on the preparations of Strategies for Sustainable Development (NSDS). This would be the correct moment to strengthen environment institutions through:

- Ensure the head of government play the key role to guide the NSDS building on existing strategies and plans;
- Together with planning and finance environment agencies play a key role in the formulation of the Strategy;
- Ensure the change in mandate of environment agencies include the role of sensing, balancing interests to arrive at solutions and execution of implementation through partnerships;
- Ensure the agencies play a key role to mainstream environmental concerns through a change from a line agency to one of policy guidance to the head of government;

- Ensure that a longer time frame of 30-50 years being followed during planning for addressing environmental and sustainable development as opposed to conventional 3-5 years.

Focus on Prevention/Mitigation

The above three core areas provide UNEP with the competence to address the major mandate. There are global, regional and sub-regional mega-trends that have enormous impacts on the environment. UNEP is well placed to provide policy advice in following areas: advocate prevention rather than 'end of pipe' solutions; active promotion of regional cooperation through existing political groupings; promote sharing of experiences across regions on good practices; facilitating governments, civil society groups and opinion leaders to come together for collective action to address these mega-trends. The areas where UNEP will make the strategic focus may be guided by criteria such as: issues that are trans-boundary or common across regions; issues that have high value for human development and nearness to critical thresholds. Some areas of strategic focus include in addition to those covered in future challenges and prospects include: Sustainable urbanization, consumption and production, (suggest addition of two more issues that meet the criteria).

Sustainable Urbanization: The developing world is going through a transformation in settlements. Some facts from Asia are presented this would also be true for other developing regions. 37 percent of the total population in Asia lived in urban areas and the number is expected to increase to about 54 percent by 2030. The urban transition will facilitate income generation in the knowledge-based economy and it will receive a massive investment over the next 50 years. Many of these investments are likely to be long-lived and will have an average life of 80 years. Therefore, long term planning would be needed to make the transition of urban cities with zero emission buildings, pollution free transportation, and sustainable energy support systems.

Harness Technology Revolutions for Environment Protection

After the agricultural and industrial revolutions, the world is now witnessing the revolution on information technology, and is expected to witness the revolutions of Genomics and Nanotechnology. Two-thirds of the global economy is already a knowledge economy. The share of service sector in the global economy has grown from 38 percent in 1960 to 62 percent in 1998. It is expected that the economy in 2020 will be even more knowledge driven (UNEP, 2002a). There is a need for harnessing these revolutions for the protection and conservation of environment. Information should be used for raising awareness of all section of the society. Revolutions should be integrated into the decision making as well as delivery mechanisms of environment agencies at the global, regional and national levels.

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Asian Environmental Status: Emerging Issues and Future Scenarios

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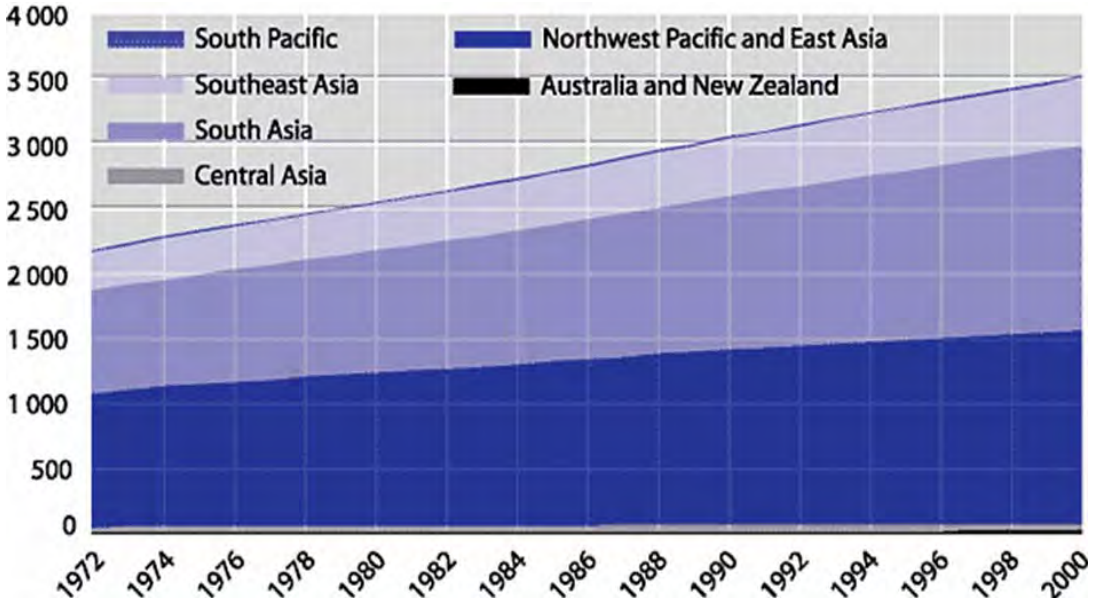
ABSTRACT *Asia and the Pacific is the most populous region where more than 58% of the world population or about 4 billion people inhabit. However, with increasing population and economic growth, there have been serious threats to the environmental and socio-economic conditions, resulting in negative impact on human health and hampering potentials for future development. These environmental issues include land degradation, loss of biodiversity, lack of access to safe water supply and improved sanitation, and improper control of natural disasters, while the socio-economic issues range from poverty to urbanization and related problems arising from mega-cities development. Although, with technological advancement and public awareness, the future economic scenario for the region looks positive to attain sustainable development, more actions are needed on measures to protect the environment and natural resources and the reduction of poverty.*

Introduction

Asia and the Pacific region covers 23 percent of the world's total land area and extends from Mongolia in the north to New Zealand in the south and Cook Islands in the east to the Islamic Republic of Iran in the west. The environmental diversity of Asia and the Pacific is therefore vast, and is contrasted by the regions coldest and hottest deserts, verdant tropical rainforests, extensive grasslands and rich alluvial plains. This great variation in geography, topography and climate provides the unique diversity to the region's ecosystems. Asia and the Pacific houses about thirty per cent of the world's tropical forests, and its marine and coastal environments are amongst the most productive in the world, supporting over two-thirds of the world's coral reefs and two fifths of its mangrove habitats.



Source: UNEP (2002)

Figure 1. Population in Million in Asia and the Pacific

The pressures on these rich natural resources and environmental systems have, however, been continuously increasing over the last decade. Increasing atmospheric pollution, destruction of biodiversity, depletion of aquifers, and the pollution of aquatic and marine ecosystems, as well as increasing loads of municipal, industrial and hazardous wastes, are the current environmental disruptions in the region. Rapid population growth, urbanization, rising economic output and consumptive lifestyles, coupled with an increasing incidence of poverty are some of the other major contributors to the region's environmental degradation.

The population of the region more than doubled in the latter half of 20th century, from 1.7 billion in 1960, to 3.6 billion in the year 2000 (Figure 1) and is projected to reach bout 5 billion by 2025. To date the accompanying demands of this burgeoning population have largely been satisfied through increased economic output, which has quadrupled in the last twenty years. Though the economic growth has no doubt assisted in reducing poverty in the region, the adoption of unsustainable consumption patterns is now becoming a severe problem (UNESCAP and ADB, 2000).

Demographic trends have wide ranging implications for environmental conditions, in particular resource management, pollution, climate change and other related variables. Asian and the Pacific Region is the most populous region of the world. It is home to 58 percent of the world's population. Six countries alone, People's Republic of China, India, Indonesia, Pakistan, Japan and Bangladesh, account for 48 per cent of the world's population.

The vast majority of the region's population is located in the four Asian sub-regions and only 1 per cent in the 19 countries and territories of the Pacific sub-region. Among the four Asian sub-regions, East Asia accounts for the largest share of population (42.0 per cent), followed by South Asia (40.5 per cent), South-East Asia (14.7 per cent) and Central Asia (1.7 per cent). Since 1950, the proportionate share of East Asia has steadily declined, whilst those of the other three Asian sub-regions has increased (Table 1). During the early 1950s, Central Asia was the fastest growing sub-region, closely followed by the Pacific. However, South Asia is now experiencing the fastest annual growth rate (2.2 per cent), and is projected to overtake East Asia in Population before 2010.

Table 1. Population of Asia-Pacific by Sub-regions, 1950-2020

Year	**1950**	**1970**	**1990**	**1995**	**2000**	**2010**	**2020**
Asia-Pacific (millions)	1,365	2,081	3,064	3,318	3,577	4,064	4,502
Sub-regional distribution (%):							
Central Asia	1.5	1.8	1.9	1.9	1.9	1.7	2.0
East Asia	49.0	47.3	44.0	43.1	42.0	39.5	37.9
South-East Asia	13.3	13.7	14.5	14.5	14.7	15.0	15.0
South Asia	35.2	36.2	38.7	38.7	40.5	43.0	44.3
Pacific	1.0	1.0	0.9	0.9	0.9	0.9	0.9

Source: UNESCAP and ADB (1995) compiled from United Nations, World Population Prospectus.

Existing Environmental Condition

Land Use and Land Degradation

The land degradation process in the Asia and Pacific include the erosion, compaction, acidification, declining soil organic matter, weed infestation, soil fertility depletion and biological degradation. The major causes of land degradation include large scale clearance of forest that leads to the significant decline in soil structure and fertility, water erosion, particularly in the Himalaya, China (Figure 2), the South Pacific and Australia and wind erosion in the South Asian sub-region. The agriculture mis-management is another major cause of soil degradation. Soil acidification is the

marked problem in parts of Northern India and Bangladesh as well as in many areas of Cambodia, Malaysia, Thailand and Vietnam. Contamination of toxic metals and chemicals such as cadmium, lead, arsenic, hexavalent chromium, trichloroethylene, tetra-chloroethylene and dioxin concentrates is another serious issue that has brought serious health problems due to chronic poisoning from agricultural land in the 1970s in the northwest Pacific and northeast Asia (MoE Japan, 2000; UNEP, 2002). Human settlement and infrastructure development is another serious cause of land degradation. China lost about 5 million ha of farmland to towns and cities during 1987-92 (UNFPA, 2001). Land degradation, river siltation and soil pollution from acid rain and industrial wastes are some of the environmental issues associated with urbanization and industrialization. Chemical degradation is responsible for 12 percent of global soil degradation.

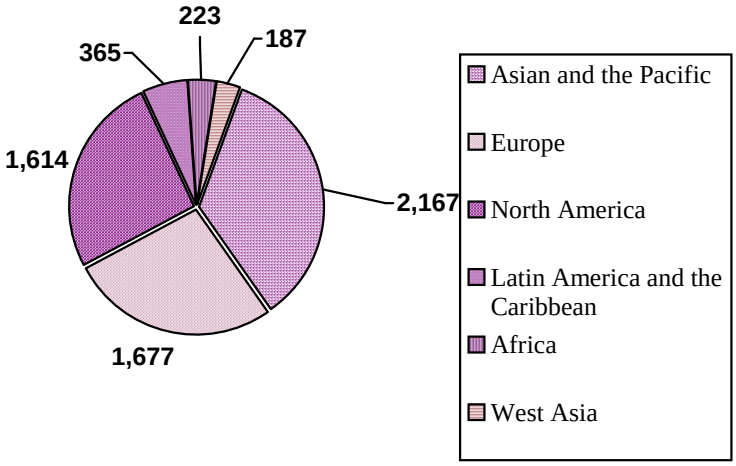
Source: UNEP (2002)

Figure 2. Agricultural Land in China Threatened by Chemical Pollution

Atmosphere and the Air Quality

The air in Asia's cities is amongst the most polluted in the world. Of the 15 cities in the world with the highest levels of particulate matter, 12 are located in Asia (ADB, 1999a and 1999b). Furthermore, six of these cities also have the highest levels of atmospheric SO_2. Levels of air pollution substantially exceed the international guidelines for air quality recommended by WHO. Cities such as Beijing, Calcutta, Jakarta, New Delhi, Shanghai and Tehran are notorious for high levels of suspended particulates, with New Delhi recording the maximum of 420μg/m^3 (UNESCAP and ADB, 2000; ADB, 2001). Tehran has also recorded SO_2 levels four times the guidelines prescribed by WHO (World Bank, 2001). Another crucial issue is the emission of greenhouse gases, particularly CO_2, from industrialized regions, which is in increasing and is a major aspect of climate change. Figure 3 includes the CO_2 emissions from fuel consumption, gas flaring and cements production (UNEP, 2002).

World Total = 6,234



Source: UNEP (2002)

Figure 3. CO_2 Emissions by Region, 1998 (million tons carbon/year)

Forests and Biodiversity

The Asia and Pacific region accounts for 18.8 per cent of global forests. Deforestation and forest degradation are critical issues, threatening biodiversity, ecosystem stability and the long-term availability of forest products as well as depleting the natural resource base underpinning many national economies (UNESCAP and ADB, 2000). The major underlying factors for deforestation in the region are the population pressure, heavy dependence on fuel wood, timber and other products, as well as conversion of forests to agricultural, urban and industrial land, overgrazing and shifting cultivation. Table 2 illustrates the change in forested land in the 10 years time (i.e. 1990-2000) in the sub-regions. However, some 21 per cent of Asia and Pacific is still forested, with deforestation continuing at an average of 0.1 percent a year.

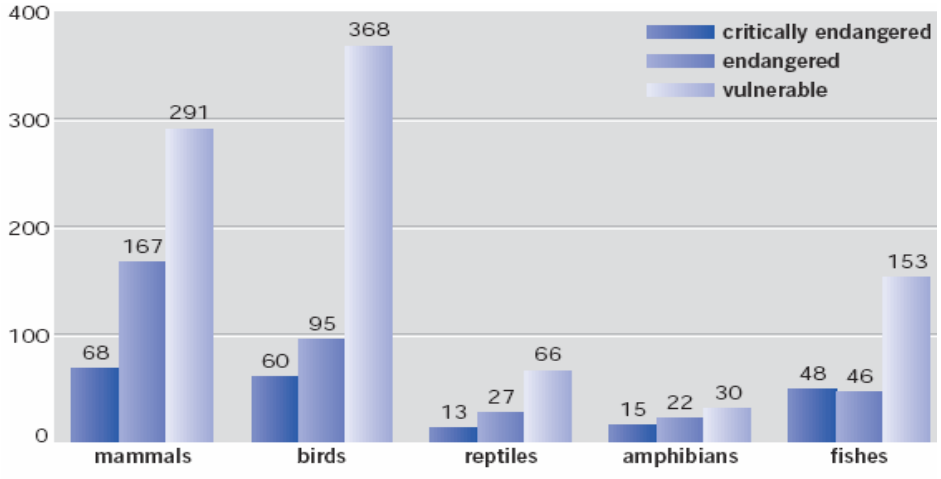
Table 2. Change in Forested Land 1990-2000 by Sub-region: Asia and the Pacific

	total land area (million ha)	*total forest 1990 (million ha)*	*total forest 2000 (million ha)*	*% of land forested in 2000*	*change 1990-2000 (million ha)*	*% change per year*
Australia and New Zealand	795.0	164.9	162.5	20.4	-2.4	-0.1
Central Asia	391.6	16.6	19.3	4.9	2.7	1.6
Northwest Pacific and East Asia	1 147.8	195.2	212.7	18.5	17.4	0.9
South Asia	640.3	86.3	85.3	13.3	-1.0	-0.1
Southeast Asia	434.5	234.7	211.4	48.7	-23.3	-1.0
South Pacific	53.9	36.4	35.1	65.2	-1.2	-0.4
Asia and the Pacific	**3 463.2**	**734.0**	**726.3**	**21.0**	**-7.7**	**-0.1**

Source: compiled from FAO (2001) *Note: numbers may not add due to rounding*

Biodiversity constitutes the most important working component of a natural ecosystem. It helps maintain ecological processes, creates soils, recycles nutrients, has a moderating effect on the climate, degrades waste, controls diseases and above all, provides an index of health of an ecosystem. The region's biodiversity, however, has been under serious threat as a result of habitat loss, over-exploitation of resources, and the introduction of exotic species (UNESCAP and ADB,

2000). The status of threatened vertebrates in the Asia and Pacific at present is as shown in Figure 4. Recently, two large mammal species previously unknown to science have been discovered in one small area, the Vu Quang Nature Reserve in Truong Son, Viet Nam. The Vu Quang Ox (Pseudoryx nehetinensis*)* was first discovered in 1993, followed a couple of years later by a giant muntjac deer (Megamuntiacus vuquangensis*)* from the same area (UNEP, 2002).



Source: UNEP (2002)

Figure 4. Number of Threatened Vertebrates: Asia and the Pacific

Fresh Water and Quality

The global volume of water on earth is about 1400 million km^3 of which, only 25 per cent (about 35 million km^3) is fresh water. The Asia and Pacific region accounts for about 36 per cent of global run-off (UNEP, 2002). The abstraction of freshwater from rivers, lakes and underground reservoirs is increasing in line with population growth, urbanization and economic expansion. The increasing abstraction is causing a growing imbalance between supply and demand that has already led to shortages and depletion of reservoirs (Figure 5). Moreover, the scarcity of water is being accompanied by deterioration in the quality of available water due to pollution and environmental degradation. Dams and reservoirs coupled with deforestation in some watersheds have reduced stream water levels, lowered water tables, degraded riparian wetlands and diminished freshwater aquatic diversity. Excessive demand for groundwater in coastal cities such as Bangkok, Dhaka, Jakarta, Karachi and Manila has led to saline intrusion and ground subsidence. Many countries do not have sufficient water to meet demand, with the result that aquifer depletion due to overexploitation is common (UNEP, 2002).

The water level in Kulekhani reservoir sharply declined in dry season. The water level in the reservoir is decreasing by as much as 30 centimeters a day. An NEA official warned that the reservoir will run dry in three weeks.

Source: The Kathmandu Post, March 04, 2006

Figure 5. Reservoir in Nepal

In general, agriculture is the biggest consumer of fresh water (86 percent), with smaller amounts being used by industry (8 percent) and for domestic purposes (6 percent). The variation in the availability and consumption of water is determined by the individual country's physical topography, climate and catchments size as well as the accessibility of water resources and the level of socio-economic development (UNESCAP and ADB, 2000).

Water quality problems can often be as severe as those of water availability, but less attention has been paid to them, particularly in developing regions. South Asia, particularly India, and Southeast Asia are facing severe water pollution problems. Rivers such as the Yellow (China), Ganges (India), and Amu and Syr Darya (Central Asia) top the list of the world's most polluted rivers (World Commission on Water, 1999). Most water bodies of cities in developing countries are now heavily polluted with domestic sewage, industrial effluents, chemicals and solid wastes. It is reported that rivers in Nepal's urban areas have been polluted to the extent that they are now not suitable for human uses, while drinking water in Kathmandu is contaminated with coliform bacteria, iron, ammonia and other contaminants (UNEP, 2001).

Water pollution has great implications on human health. Major health problems associated with the use of polluted water are- diarrhea, hepatitis, and occasional outbreaks of typhoid and cholera. Groundwater in districts of West Bengal, India, and in some villages of Bangladesh, for example is contaminated with arsenic at levels as much as 70 times higher than the national drinking water standard of 0.05mg/L. Inadequate water supply and poor sanitation cause more than 500,000 infant deaths a year as well as a huge burden of illness and disability in the region (UNEP, 1999). Of the global population without access to improved sanitation or water supply, most live in Asia (Figure 6) and only an estimated 48 percent of the Asian population has sanitation coverage (WHO and UNICEF, 2000). The situation is worse in rural areas where only 31 percent of the population have improved sanitation compared to 78 percent coverage in urban areas.

Source: UNEP (2002)

Figure 6. Improved Water Supply and Sanitation Coverage: Asia and the Pacific

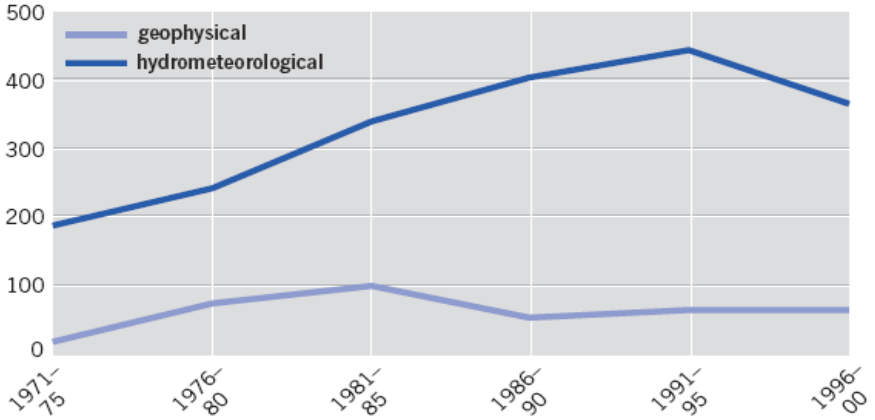
Disasters

A disaster is a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope on its own resource (UNDHA, 2001). Disaster can occur as natural (earthquakes, volcanoes, landslides, tsunamis, tropical cyclones, tornadoes, high winds, river and coastal flooding, wildfires and associated haze, drought and dust storms and infestations) or human-caused hazards (intentional-illegal discharge of oil or accidental or accidental- toxic spills or nuclear melt down). All of these can expose people, ecosystem, flora and fauna to threats. People and the environment are increasingly suffering form the effects of natural disasters all over the world. The causes of such disasters are principally the

high population growth and density, migration and unplanned urbanization, environmental degradation and possibly global climate change (UNEP, 2002).

About 75 per cent of the world's major natural catastrophes between 1970 and 1997 occurred in the Asia and the Pacific region, mostly in poverty-ridden developing countries (UNESCAP and ADB, 2000). The trends in the number of disaster due to hydrometeoro-logical events (cyclones and flooding) and geophysical disasters (volcanic eruptions, earthquakes and tsunamis) are shown in Figure 7. Disasters caused by water and weather (hydrometeoro-logical disasters) have become more frequent while the number of geophysical disasters remains fairly constant (CRED-OFDA, 2002).

Vulnerability to disasters is closely linked with population density and economic resources. The impact of natural disasters in the region is severe, with more than 1.4 million people killed, almost 4000 million affected and US$438 million in damage over the past three decades (Table 4). During 1991-2000 alone, the total number of deaths caused by natural disasters in the region exceeded 550,000 or 83 percent of the global total (IFRC, 2001), the majority of them in Asian countries with low or medium levels of human development. The highest number of deaths occurred in South Asia (the sub-region with the highest population density and the lowest per capita income) and the lowest number in Australia and New Zealand, the sub-region with the lowest population density and a high per capita income (UNDP, 2000; World Bank, 2001). China experienced more than 300 natural disasters and recorded more than 311,000 deaths during 1971-2000; India with more than 300 disasters suffered more than 120,000 deaths; the Philippines, with nearly 300 events, lost about 34,000 people; Indonesia experienced about 200 disasters with more than 15,000 lives lost; and Bangladesh experienced 181 events and more than 250,000 people killed. The Asian tsunami that struck several countries in the Indian Ocean caused more than 200,000 deaths and huge socio-economic impact on the region.



Source: CRED-OFDA (2002)

Figure 7. Trends in disasters (number/year): Asia and the Pacific

Table 3. Impact of Natural Disasters in Asia and the Pacific, 1972-2000

	number killed (thousands)	*number affected (thousands)*	*damage (US$1 000)*
South Asia	761	2 164 034	60 881
Southeast Asia	73	284 074	33 570
Northwest Pacific and East Asia	606	1 447 643	317 174
Central Asia	3	4 895	986
Australia and New Zealand	1	15 761	21 900
South Pacific	4	4 061	3 139
total	**1 447**	**3 920 467**	**437 649**

Source: CRED-OFDA (2002) Note: Central Asia figures are for 1992/93-2000

Different areas are prone to different types of natural disasters such as hilly and mountainous areas (China, India, Nepal, Philippines and Thailand) are most prone to landslides. Countries along or adjacent to seismic zones (Afghanistan, China, India, Iran, Nepal, Philippines and the Pacific Islands) are more vulnerable to seismic events, while countries along the Pacific Rim are at risk from volcanic eruptions, particularly Indonesia, Japan and the Philippines (UNESCAP and ADB, 1995). Environmental degradation and change are becoming increasingly important in relation to both the occurrence and impact of natural disasters. Deforestation, for example, is now frequently linked to severe flood events and landslides. Some of the selected natural disasters and their consequences in terms of economic loss are highlighted in Table 4.

Table 4. Selected Natural Disasters in Asia and the Pacific

- July 1976: an earthquake in China took 242,000 lives.
- February 1990 and December 1991: cyclones in Samoa caused losses of US $450 million, about four times the country's GDP.
- April 1991: a cyclone in Bangladesh accompanied by a storm surge caused 138,866 deaths.
- January 1995: an earthquake in Kobe, Japan became one of the costliest natural disasters in history-5,502 people were killed and more than 1800,000 affected with damage estimated at US $131.5 billion.
- October 1999: the super cyclones in the eastern state of Orissa in India caused more than 10,000 deaths, while 15 million people were rendered homeless, left without food, shelter or water and their livestock population devastated the cyclone damaged 1.8 million ha of agricultural land and uprooted more than 90 million trees.
- Winter of 2000: Mangolian herders had their hardest winter for 30 years- 2.4 million livestock died and 45 per cent of the country's population was affected.
- September and October 2000: in Southeast Asia, especially Viet Nam and Thailand, killed approximately 900 people and left 4 million homeless or with sufficient shelter. Losses estimated at US $ 460 million.
- January 2001: an earthquake of magnitude 7.7 on the Richter scale rocked the state of Gujarat in India, causing more than 20,000 deaths and 167,000 injuries-economic losses estimated at US $ 2.1 billion.
- July 2001: flash floods unexpectedly struck parts of Pakistan. The cities of Islamabad and Rawalpindi were the worst affected, 132 people were killed.
- In mid-November 2001: as many as 576 Vietnamese had been killed by natural disasters, mainly floods and typhoons. Material losses amounted to more than US $ 2000 million.
- November 2001: a persistent multi-year drought in Central and Southwest Asia had affected about 60 million people.
- December 2004: Asian tsunami in the Indian ocean causing more than 200,000 deaths

Source: UNEP (2002)

Asian countries are at different stages of institutional development with respect to disaster reduction. Some, such as Japan, have a long-established system of disaster management. Five newly independent Central Asian states have now established a joint commission for water coordination. Several international organizations and bilateral agencies are providing assistance, and an International Fund for the Aral Sea and the Interstate Council for the Aral Sea Problem have been set up to coordinate initiatives. The Central Asian republics have decided to focus on demand management, aiming to reduce water withdrawal by raising irrigation efficiency. The primary objective is to satisfy crop water requirements. Total water withdrawal in the basin has now been stabilized at 110-120 km^3/year but environmental degradation continues.

Socio-economic Development

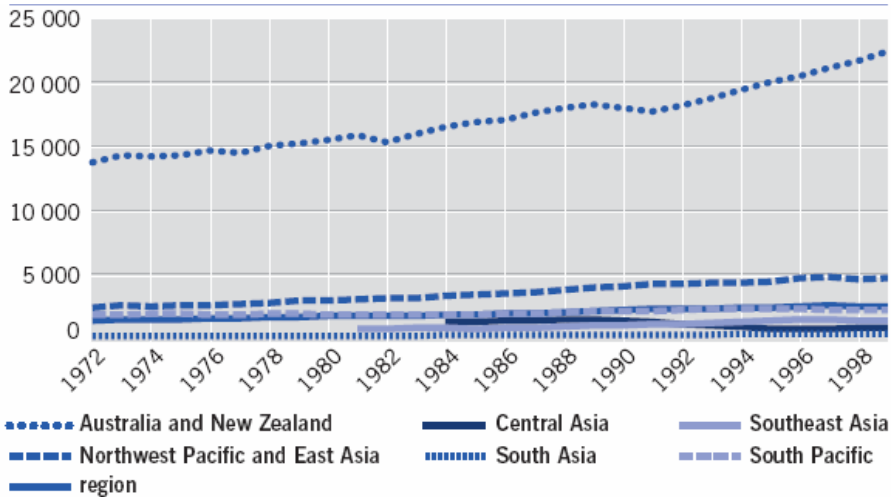
Over the past 30 years, the world has undergone unprecedented social, economic, political and technological changes. There have been some impressive gains in human development, particularly in the developing world where people are living longer, healthier, more literate and better educated than ever before (UNEP, 2002). Some of the major indicators of socio-economic development in the region are given below:

Population Growth

The region's population grew from 2,173 million in 1972 to 3,514 million in 2000. Population growth rates had declined from 2.3 per cent in 1972 to 1.3 per cent (the same as the world average) by 2000 — although there are significant sub-regional variations. This can be partly attributed to declining fertility levels, which have fallen from 5.1 to 2.1 children per woman over the past three decades (United Nations Population Division, 2001). Asia and the Pacific's huge population are dominated by just three sub-regions (Figure1). Life expectancy at birth has improved throughout the region, rising in South Asia from 50 years in 1970–75 to more than 60 years by 1995-2000, and in Northwest Pacific and East Asia from about 61 to nearly 70 years over the same period. Despite gains in life expectancy, an estimated 7.1 million people live with HIV/AIDS (almost 18 per cent of the world total) in Asia and the Pacific. There were about 435, 000 deaths and more than 1 million new cases in 2001 (UNAIDS, 2001).

Economic Development

During the past 30 years, countries in the region have striven for economic development and higher standards of living. However, annual GDP growth rates decreased from a high of 9.76 per cent in 1970 to 2.54 per cent in 1999, with a negative growth of 1.04 per cent in 1998 due to the Asian economic crisis (World Bank, 2001). Overall, however, between 1972 and 1999 per capita real incomes (measured in US$, year 1995) nearly doubled in Northwest Pacific and East Asia, growing by an average of 2.4 per cent annually (Figure 8). Although incomes in Australia and New Zealand dwarf that elsewhere, there has been steady growth in the other sub-regions, except in Central Asia and the South Pacific Islands (UNEP, 2002). However, as shown in Table 5, there is a wide gap in income distribution and the issue of poverty alleviation needs urgent actions from all concerned.



Source: UNEP (2002)

Figure 8. GDP per capita (US$ 1995) by sub-region: Asia and the Pacific

Table 5. World Income Distribution

- Daily income is measured in dollars that varies from <US $1 to > US$ 100 per day.
- > 6 billion people in the world, income is very unequally distributed across the world.
- The richest 20% have 74% of the income, while the poorest 20% have only 2% of the income.
- Poor: 1.2 billions (2000), more than 1 billion people (19%), lived on less than US $1 a day.
- 1970: World population will reach3.7 billion; poor will be 1.4 billion, 38% lived below the poverty line in a world with lower incomes and less people.
- In 1990: The poverty rate had fallen to 26% but due to population growth, the number of poor was the same. The UN goal is to have this population to 13% by 2015.
- In 2000: World population will reach 6.1 billion; poor will be 1.2 billion i.e. 19% means that the world as a whole is on track to meet the goal.
- In 2015: World population will reach 2 billion; poor will be 0.7 billion. The stimulation of the future indicates that the poverty reduction goal can be met on a global level.

There are large margins of uncertainty even in the poverty estimates for 1990 and 2000. The data for 2015 are projections of current growth and distribution trends, not an inevitable outcome.

Source: http://hdr.undp.org-HDR2004-Animation-MicrosoftInterneExplorer

Urbanization

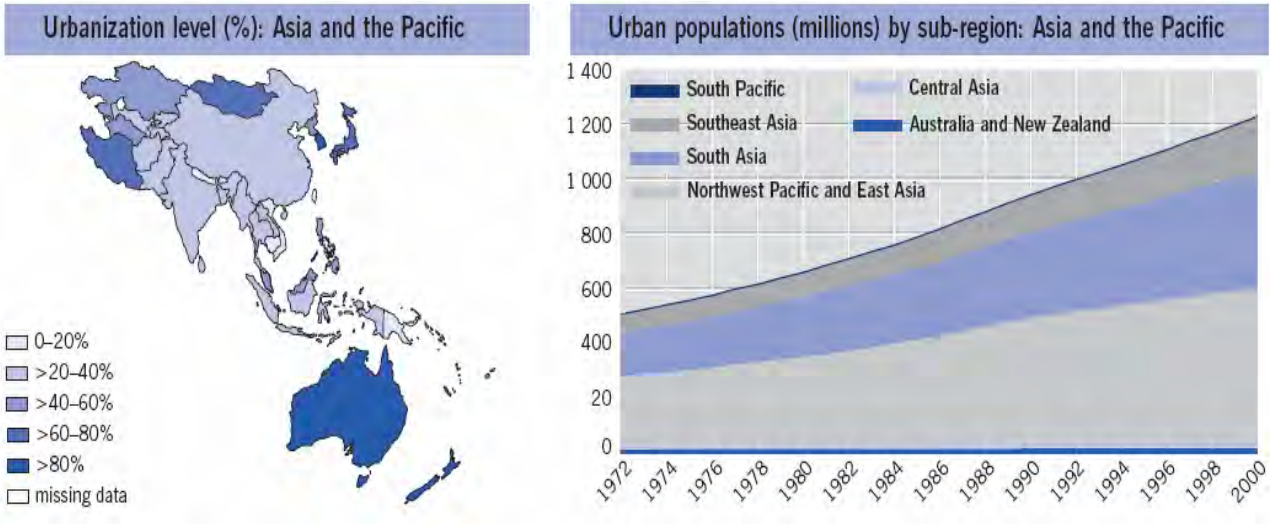
Another major hurdle of environmental degradation in the region is the rapid urbanization. Urbanization in Asia and the Pacific is predicted to grow at an average rate of 2.4 per cent per annum between 2001 and 2015. The current level of urbanization ranges from a low of 7.1 per cent in Bhutan to 100 per cent in Singapore and Nauru. Australia and New Zealand is the most urbanized sub-region (85 per cent) and South Pacific the least (26.4 per cent). In seven countries in the region (Australia, Japan, Nauru, New Caledonia, New Zealand, Republic of Korea and Singapore) the level of urbanization is more than 75 per cent, while the 12 mega cities in the region — Beijing, Calcutta, Delhi, Dhaka, Jakarta, Karachi, Metro Manila, Mumbai, Osaka, Seoul, Shanghai and Tokyo — accommodate 12 per cent of the urban population (United Nations Population Division, 2001; UNESCAP and ADB, 2000). Figure 9 shows a high level of urbanization in Australia and New Zealand compared with other sub-regions. Urbanization is proceeding fast in all other sub-regions except Central Asia.

The major problems associated with the urbanization are: air pollution, solid waste management, water supply and sanitation. Air pollution is common, particularly in developing-country cities, due to the growing number of motor vehicles and increasing industrial activity. In countries such as India, Indonesia, and Nepal, vehicles with two-stroke engines, such as motorcycles and three-wheel taxis, comprise more than one-half of all motor traffic and pollute heavily. Poor maintenance of vehicles, poor fuel quality and poor road conditions also contribute to air pollution problems. The burning of biomass such as firewood and agricultural wastes is a further source of air pollution in many areas (World Bank, 2000).

Most solid wastes generated in urban centers of developing countries remain uncollected and are either deposited in surface waters and empty lots, or burned in streets. The collected wastes are disposed of mainly in open dumps, many of which are neither properly operated nor maintained, and which pose a serious threat to public health. In India, an outbreak of bubonic plague in 1994 was linked to inadequate solid waste disposal (Tysmans, 1996). The treatment and disposal of industrial, toxic and hazardous wastes also cause serious problems. Due to lack of awareness and appropriate technologies, dumping of hazardous wastes is common in South and Southeast Asia.

For most cities in developing countries, providing adequate and safe supply of water for domestic and industrial uses is a major problem. Afghanistan has by far the lowest percentage of urban population with access to improved water sources (19 per cent) and sanitation (25 per cent) in the region. In absolute terms, China and India have the largest number of urban people (more than 20 million each) without access to a safe water supply (WHO and UNICEF, 2000). Sanitation

services are less developed than water supply, with 23 per cent of urban residents still lacking adequate sanitation (compared to only 7 per cent lacking access to improved water sources). By the year 2000, improved water supplies were provided to a larger proportion of the urban population (95 per cent) than improved sanitation (65 per cent) (Figure 9) (WHO and UNICEF, 2000).



Source: UNEP (2002)

Figure 9. Urbanization and Urban populations in the Asia and Pacific

Future Scenarios

Based on the environmental and socio-economic trends mentioned above, the following scenarios are given:

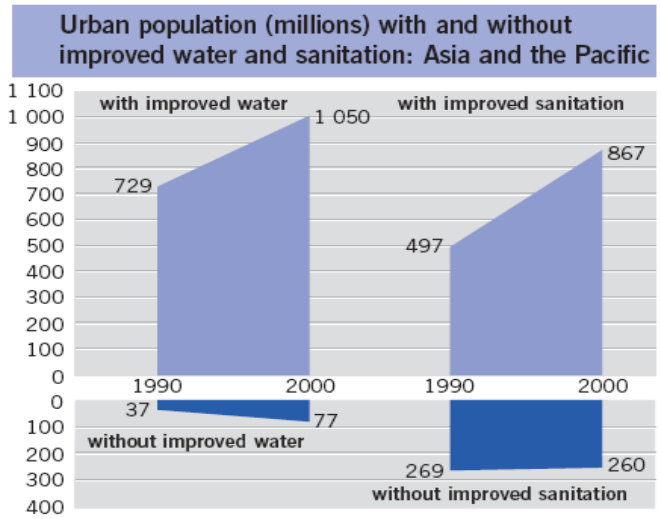
Population and Socio-economics

- The region is expected to continue to have population growth, and the number of cities with a population of more than 10 million is expected to rise from 11 at present to 18 by 2015 (UN ESCAP and ADB, 2000).
- Economic growth is expected to be positive as Asia and the Pacific is projected to continue with its high rates of output growth, which is critical in creating employment, alleviating poverty and making resources available for infrastructure and human development.
- Food security is expected to improve by 2010 based on the trend in food availability in terms of calorie per capita, which is projected to be 2,450 calorie per capita for South Asia, 3,040 for Northeast Asia and 2,730 for all developing countries. Aquaculture will become an increasingly important industry in the region.
- With the continuation of positive economic trends, the region's income and quality of life including health and nutrition profile will also continue to improve. Based on the analysis of future growth in Asia and Pacific, more than 50% of the region's absolute poor are expected to be lifted from poverty by 2025. The region's core poverty will be concentrated in South Asia.

Natural Resources and Environment

- The rate of degradation of land, forest and biodiversity is likely to continue. Increasing population pressure and land use changes will continue to threaten the region's biodiversity. A mass extinction of species in the tropics is being projected within the next 20-25 years (UNEP, 1999).

- Demand for energy in Asia and the Pacific is expected to double every twelve years compared to the world estimate of every 28 years (UNEP, 1999).
- Demand for safe drinking water and improved sanitation is anticipated to increase. Figure 10 shows that the urban population with improved water and sanitation facilities at present decade is much higher than the past decade, which indicates that only a few urban population will lack to have the improved water and sanitation in future. Pollution load in terms of waste discharges to the environment is also projected to be increased with a corresponding high cost to human health. (UNESCAP and ADB, 2000).
- Rapidly growing populations and economies escalate demand for food and living space, leading to greater intensification of agriculture and aquaculture. More irrigation and fertilizer uses in rural areas, together with unimpeded growth of urban centers and mega-cities, mean more competition for water resources between geographic regions and economic sectors. This rivalry reaches crisis proportions around 2010, when the quality of surface and ground waters across the region begins to go into widespread, rapid and accelerating decline (UNEP, 2002).
- Asian countries are at different stages of institutional development with respect to disaster reduction and control. Some, such as Japan, have a long-established system of disaster management. Other countries have either strengthened the existing frameworks or are formulating new ones (UNEP, 2002). World leaders have pledged to achieve the Millennium Development Goals (MDGs) (Table 6), including the overlapping goal of halving poverty by 2015.



Source: UNEP (2002)

Figure 10. Urban population (millions) with and without improved water and Sanitation: Asia and the Pacific

Table 6. The Eight Millennium Development Goals

Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equity and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a global partnership for development

Source: UNDP (2005)

Scenarios analysis can make a difference in shaping the future as they reflect different assumptions about how current trends will unfold, how critical uncertainties will play out and what new factors will come into play. Recently, a set of four scenarios has been developed for GEO-3 (Table 7) (UNEP, 2002).

Table 7. Scenarios Developed for GEO-3

	The Market First scenario envisages a world in which market-driven developments coverage on the values and expectations that prevail in industrialized countries;
	In Policy First world, strong actions are undertaken by governments in an attempt to reach specific social and environmental goals;
	The Security First scenario assumes a world of great disparities, where inequality and conflict prevail, brought about by socio-economic and environmental stresses; and
	Sustainability First pictures a world in which a new development paradigm emerges in response to the challenges of sustainability, supported by new, more equitable values and institutions.

Source: UNEP (2002)

It is a known fact that uncontrolled forces, both human and natural, will contribute to the course of events. By exploring an array of possible future scenarios, today's decision-makers could get a clearer picture of what tomorrow might bring in terms of human well-being and environmental security and what impact of their decisions is likely to be (UNEP, 2002). In the course of development, the impact of environmental degradation needs to be carefully examined and attention must be given to rural development, as it is a pre-requisite for reducing the migration of people to cities and coastal areas. Urgent actions are concurrently needed to reduce poverty levels with a view to maintaining the resource base and protecting biodiversity.

Summary

Asia and the Pacific Region is rapidly developing with increased population growth, industrialization and urbanization. These development activities have resulted in serious impact on the natural resources, environment and socio-economic condition especially of the poor people. Recent actions need to address these problems to ascertain sustainable development in the region in accordance with the Millennium Development Goals (Table 6). The main issues that require special attention involve poverty alleviation, water supply and sanitation, natural resources protection and management of natural disasters. The sustainability scenario as indicated in GEO-3 (Table 7) is a new development paradigm aiming to respond effectively to the sustainability challenge with partnership of various stakeholders. With the increased awareness and willingness of all concerned to be involved in addressing the environmental issues, it can be anticipated that the future of the Asian Environment will be sustainable.

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Environmental Data and its Management

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ABSTRACT *Environmental data are very important for sound planning and decision-making. The paper first discusses the conceptual aspect of environmental data, its importance in environmental assessment and reporting, its management followed by the experience of the six countries of the Greater Mekong Subregion (GMS) where such initiatives have been started over last ten years.*

Introduction

Overpopulation, poverty, and lack of enforcement of policy measures have compounded environmental problems in many parts of the Area and Policy (A&P) region (UNEP, 2002). There are number of key environmental issues in A&P region relating to the major environmental components, viz. land, air, and water. Knowledge about our natural resources and environment has become increasingly important as we plan to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat and other global environmental concerns which requires local actions.

The United Nations Conference on Environment and Development (UNCED) produced a major strategic outlook for the 21st century in Agenda 21. In addition to the many important sectoral declarations, it made some important observations on vital cross-cutting issues. Two of these vital issues are described in Chapter 8 on *Integrating environment and development in decision making*, and Chapter 40 on *Information for Decision Making*, which underlines the importance of strengthening local, provisional, national and international capacity to collect and use multisectoral information in decision making process and enhance capacities to collect and analyze data and information for decision making, particularly in developing countries. In summary it emphasizes the needs for - improved availability, improved collection as well as presentation of data and information on all aspects of environment and development for decision making towards sustainable development.

The attempt to improve resource and environmental information availability and analysis is based on the assumption that rational environmental or natural resource management results from informed decision making. Management of a nation's natural resources would seem impossible without a continuous effort to survey and monitor the qualitative and quantitative characteristics of the resource base or environmental conditions (Hassan and Hutchinson, 1992). Common sense would suggest that more informed judgments have a greater chance of achieving desirable goals than do less informed judgments. Thus, the basic premise of the argument for developing natural resource and environmental information systems is that investments in 'information infrastructure' will yield a stream of benefits to an agency or jurisdiction responsible for managing the environment that will exceed the cost of acquiring and managing the information.

Environmental Data/Information and Their Use

Several different forms are in practice while representing environmental information, in general. They are:

Data: Data are facts or observations about physical phenomena or nonphysical phenomena. Data are objective measurements of the attributes (characteristics) of entities, such as people, places,

things and events. Since every human activity has geographic component, *Spatial data* that describes things relating to shape, spaces, areas are of increasing importance to represent our natural environment and thus plays important role in decision making. They are also called as *Geo-spatial data, Geographical data, Geographic data, Geographic Information, GIS data, Earth-sciences data or Geo-scientific data,* and *Spatial data* as they identify the geographic location and characteristics of natural or constructed features and boundaries on the earth. The main difference between geographical data and other data is that the later helps answer question like, what? or where? as the former answers both what? and where? It is because that it contains *Geometric* or *Spatial* data for spatial elements and *Attribute* data for describing the spatial elements.

Information: Information is data placed in a meaningful and useful context for an end user. In other words, they are value-added data.

Dataset: Dataset is the minimum body of data needed or used for any specific activity or analysis.

Indicator: Indicator is a parameter or a value derived from data, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value.

As the environment plays an increasingly prominent role in development, accurate, meaningful, and current environmental data can contribute to the success of development projects in the following stages.

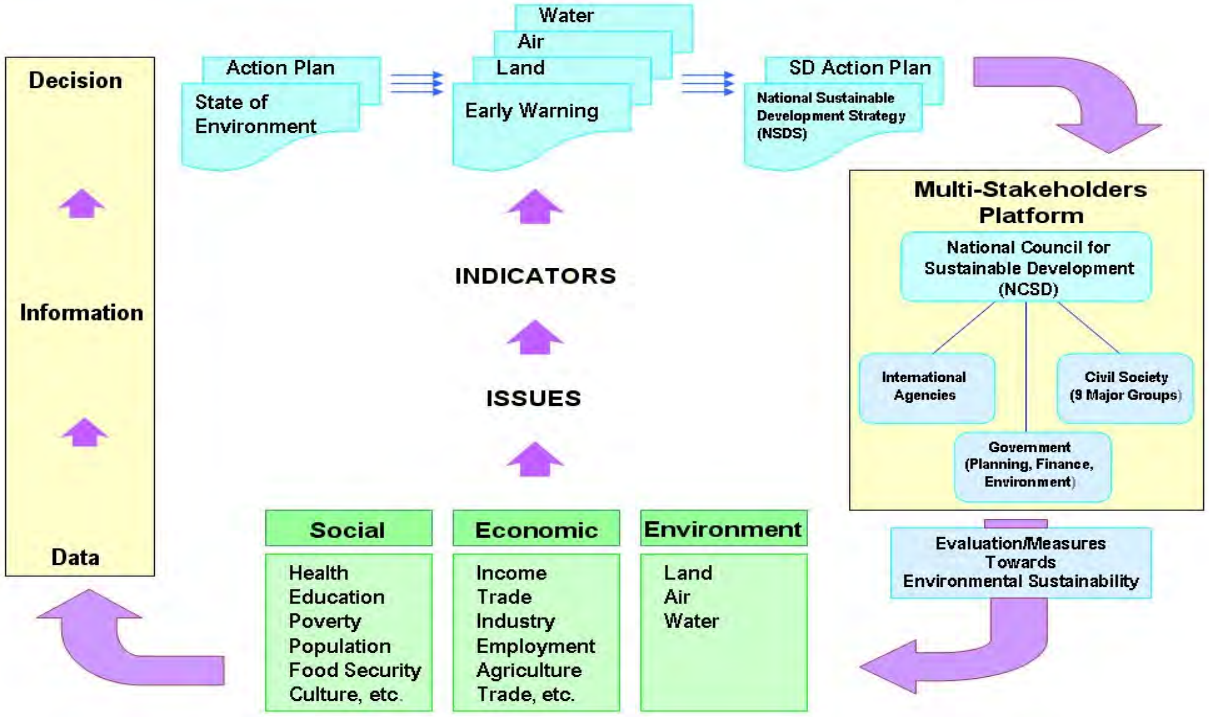
- Planning – A desirable way to deal the potential problem is to avoid them and baseline information is very valuable in the initial planning stage. Similarly, information is useful in identifying opportunities, constraints for the sustainability of the projects.
- Monitoring and Management– Information are used to monitor not only the developments but also the status of resource base through appropriate environmental indicators to formulate the needed management strategies.
- Evaluation and Documentation – while resource inventory and monitoring information are necessary for project planning and management, they play an equally important role in project evaluation and documentation.

With growing concerns on environment, several international agencies and NGOs have been using environmental data/information and indicators to evaluate current conditions and trends to provide information on the state of the environment. Though the frameworks used by these organizations seem to be formulated to meet their own objectives, most state of the environment reporting tend to adapt indicator typology, e.g. Pressure-State-Response (PSR), Driving force-S-R, P-S-Impact-R, DPSIR (ICSU, 2002). Environmental data are thus an important input to indicators development.

In general, three key characteristics that are fundamental to SoER are: a) the interpretation, assessment, and integration of high quality data to generate meaningful information; b) the development of spatial and temporal trend information; and c) the linkage between environment and socio-economic considerations within a sustainable development context. The SoER should be guided by a conceptual framework that facilitates the development of information to answer the following fundamental policy-relevant questions:

- What is happening? Where is it happening?
  (What are the environmental conditions and trends?)
- Why is it happening? How is it happening?
  (What are the human and natural causes of these changes?)
- Why are the changes significant?
  (What are the biophysical and socio-economic implications?)
- What is our response?
  (What are societal responses for protecting the environment?)
- Is the response adequate?

To answer the above questions taking into account the interaction between human and ecological systems, a substantial amount of data representing all pillars of sustainable development needs to be generated. UNEP/RRC-AP (2003) has been following the following approach of environmental reporting for sustainable development (Figure 1).



Source: UNEP/RRC-AP (2003)

Figure 1. Environmental Reporting for Sustainable Development

The types of field data collection are too numerous to list. Table 1 present specific data needs for SoER (UNEP, 2002). Besides, adequate considerations should be given to generate the data needed to meet other national objectives, MDG-millennium development goals.

Table 1. Specific Data Needs for SoE Reporting

Driving Forces:

- demographics (e.g. total population, growth rates, population density, rural-urban migration etc.)
- poverty and social developments (e.g. population below poverty line, employment, education, health etc.)
- technology, trade and life style (e.g. R & D capacity, imports and exports of natural resources, commodity consumption rates etc.)
- natural disasters (e.g. flood, drought, cyclone, earthquake, forest fires, volcanoes, and land slides etc.)

Human Activities:

- use of environmental resources (land - agriculture, forestry, mining, transport etc. and water - agriculture, fishery, industry, tourism and recreation etc.)
- consumption of natural resources (water withdrawal, forest harvest, aquatic fish, wildlife, mineral extraction etc.)
- management patterns (intensity, monoculture etc.)

Stresses:

- level of contaminants/pollutants in the environmental media such as soil, water, air, biota and others (e.g. nitrates, dioxins, heavy metals, SO_2, NO_x, CFCs etc.)

- source of contaminants (e.g. point or non-point sources, industrial sources, domestic sources, agricultural sources, municipal sources etc.)
- human activity stresses (e.g. waste production, urban growth, transportation, ocean spills etc.)

Components of the Environment:
- biological, physical, and chemical characteristics of the atmosphere, hydrosphere (inland and marine), lithosphere, and biosphere (e.g. climate, chemistry, bio/geo-chemistry, geology, physical properties, resource capability/potential etc.)
- bio-diversity (e.g. diversity of flora, fauna, micro-organisms etc.)

Ecological Responses to Stresses:
- changes in the environment (e.g. acid rain, global warming, loss of bio-diversity, land/water degradation etc.)
- human health effects (e.g. mortality incidence rate, geographical distribution etc.)

Societal and Management Response:
- measures of activity (e.g. area protected, amount recycled, area planted, sites rehabilitated, sewage treated, species protected etc.)
- energy and water use/efficiency (e.g. industrial production process, appliance efficiency, change in renewable/non-renewable energy, public transport, change in ground/surface water withdrawal etc.)
- institutional responses (e.g. regulation, EIA, economic instruments, participation in international conventions/agreements/treaties, environmental standards, technological innovations, monitoring stations, SoE reporting etc.)
- individual responses (e.g. changing community attitudes, values, and actions)

Sources: Adapted from UNEP /RRC-AP (1995); Government of Canada (1991)

Data Sources and Database Design

The sources for environmental data are probably more numerous and of great variety. Routinely collected data by sectoral organization in each country can be important source of environmental data. For example,

- *Conventional documents* in registers and files
- Compilations in *scientific reports*
- Collections *of survey measurements* expressed in coordinates or other units
- *Non-digital graphics*, such as conventional maps, photographs, sketches, schematic diagrams, and the like
- In *various digital forms*: vectors, raster, database, spreadsheet tables, satellite data, internet, and so on

In recent days, geomatics techniques, Global positioning systems (GPS), Remote Sensing (RS), Geographic Information Systems (GIS), have been increasingly found as the source of environmental data.

Database: Database is the collection of data/information about things and their relationships to each other (often multiple files) which can be shared by different application systems. The complexity of working with multiple files in a database requires a more elaborate structure for management called database management system (DBMS). The three basic types database system for spatial data are 1) hierarchical data structure, 2) network systems, and 3) relational database structure, and are described in Table 2.

Table 2. Database Systems and Characteristics

Type	Characteristics
Hierarchical	
Store data in hierarchical system. Examples: IBM IMS database software, levels of administration (country, province, district), satellite images in Hierarchical Data Format (HDF)	• Efficient storages for data that have a clear hierarchy • Tools that store data in hierarchically organized files are commonly used for image data • Relatively rigid, requires a detailed planning process
Network	
Store data in interconnected units with few constraints on the type and number of connections. Examples: numerous point locations with multiple plant or animal species	• Fewer constraints than a hierarchical databases • Links defined as part of the database structure • Networks can become chaotic unless planned carefully
Relational	
Store data in tables that can be linked by key fields. Examples: Structured Query Language (SQL) database such as Oracle, Sybase and SQL server, PC database such as dBase and FoxPro	• Widely-used, mature technology • Efficient query • Standard range interfaces (i.e. SQL) • Restricted range of data structures, may not handle image or expensive text well (although some databases allow extensions)

Source: Porter (2000)

Data Management: Guiding Principles

In every country, sectoral agencies at several levels are involved one or other way in collecting or generating data. To be more useful of such regular activities or new initiatives for the majority of the users, data should be managed in an efficient way depending upon the resource available and also the objectives of data use within a context of a country. Depending on the nature of the data itself, they might be managed at the administrative boundary, e.g. district or geographic boundary level, e.g. watershed. Hence, it is also good to have a data management plan within a department or project to efficiently manage the data. That explains the responsibility of the people who are involved in evaluating, interpreting, and presenting the information to do so as clearly and unambiguously as possible- considering the constraints of time and resources. However, the final responsibility for using and presenting data belongs with the client and not the data provider.

Data management involves developing a number of systematic processes and protocols that are designed to provide a framework for providing quality information with a high degree of credibility. The following elements are important in undertaking data management (NRIMS, 2006).

- *User Needs:* Since data and information are increasingly being collected and analysed for multiple clients with different needs, data custodians (collectors, analysts, and providers) must be mindful that they are not the final step in the data use process - the data user provides the final step in working with and presenting data sets. For this reason, custodians, the agencies involved in generating data, should attempt to preserve data 'depth' and variability, along with maintenance of metadata[1]. Since the range of potential end-users can be vast, and so data custodians need to take a pragmatic approach.

[1] Metadata is data about data. It is the background information which describe the content, quality, condition, and other relevant characteristics of data. In a nutshell, metadata answer who, what, when, where, and how about every aspect of the data.

- *Standards and Methods***:** In general, data collection, processing and reporting should comply with relevant state and national standards and policies unless it is necessary - due to the specialised nature of the data or user needs. In the situation where no relevant standards or policies exist, custodians will need to develop new ones in consultation with their clients and, where appropriate, with other standards-setting bodies.
- *Planning for Data Collection:* Data collection program should correctly set up with clearly defined objectives and goals. Appropriate framework should be developed to 1) maintain the quality of the information assigned to them in terms of accuracy, integrity, currency, standardisation and completeness; 2) provide a mechanism to facilitate easy access to the dataset; 3) act as the authoritative source of information for the dataset, among others.
- *Data Custodianship:* Data entry, storage, maintenance, transfer, and archival procedures should be well defined to ensure that correct and complete data are recorded. There should also be a mechanism to ensure that quality control checks are always complete.
- *Data Documentation:* This is important to have metadata and the data holdings should be suitably identified and maintained in a manner consistent with good record-keeping practices. Some of the major documentation include the standards to which the data have been collected (or references to published methodologies given), or new or derived methodologies described in detail; the processes used in calculations and computations; etc.
- *Quality Assurance:* For all stages of data collection, analysis, evaluation, and interpretation, there must be clear and precise documentation encompassing quality assurance / quality control guidelines and principles.
- *Data Validation:* Data validation is an essential element of data quality assurance. It provides for reviewing a body of data against a set of criteria so that assurance can be made that the data of interest are adequate for their intended use. It includes the identification of questionable data and the investigation of apparent anomalies. This can be achieved by 'validation checks' in terms of identifying errors due arising from measurement, recording, transmission/transcription, and processing.
- *Data Compatibility and Comparability:* Data compatibility among data holdings is controlled by the degree of similarity of sampling procedures and measurement systems, analytical techniques, quality assurance / quality control protocols, etc. Data comparability is a measure of the confidence with which one data set can be compared with another.
- *Accessibility:* Natural resources datasets are valuable for a wide range of management tasks across a range of disciplines. Effort expended to provide ready access to these datasets will generally result in increased utility, efficiency, and a reduction of duplication. On the other hand, custodians have a duty to safeguard the intellectual property and integrity of the data collected (and its sources where relevant), as well as protecting the investment of resources that went into collecting and maintaining the dataset. Appropriate pricing structure, licensing, copyrights should be worked out wherever desirable, however it should comply with relevant state and national standards and policies.

Standardization and Harmonization

An examination of data availability and quality, especially on global scale, shows that they can be extremely uneven (UNEP, 1993). Quality variations, differences in compilation methods and poorly documented procedures all lead to difficulties of interpretation and poor management decisions. The past lack of universally accepted definitions and standardized classification systems and inventory methodologies has, however, limited the inter-compatibility of environmental statistics generated to date.

This is true in most of cases of national and sub-national level environmental data where agencies at the various governmental levels have been collecting data for several years but for the most part they have worked independently and without coordination. Too often this has meant

duplication of effort, or it has been found that data collected for a specific purpose were of little or no value for a similar purpose only a short time later. The major problems are related to the application and interpretation of the existing data. These include changes in definitions of categories and data collection methods by source agencies, incomplete data coverage, varying data age, and employment of incompatible classification systems.

Standards provide yardstick against which quality can be evaluated and quantified and documented. These standards may specify, for information (including geographic information), methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. While it might be desirable that new collected data are prepared to meet some set standards, existing data might, in many cases, need to be harmonized to be able to use the data from different sources. Data which meets specific minimum standards facilitates integration in terms of thematic or spatial scale, which is often, needed while addressing environmental issues.

Data Sharing

Sharing of data includes data delivery and interactive viewing/analysis (Web-based viewing). The crucial need for environmental data will only be met if data centers and spatial data clearinghouses focus on making the best available spatial data sets accessible to the environmental assessment community for subnational/national/regional purposes. Progress is being made within the international community towards the harmonization of global environmental assessments (GEAs) with the explicit goal of using the networks, like UNEP-GRID, FAO, CIESIN, and other clearinghouse nodes. Such initiatives are helpful in expanding data access in developing countries.

On the other hand, the vast amount of data that are being collected at the national/subnational level as the result of routine activities of several national sectoral agencies/organizations can be considered to organize and standardize for access by different stakeholders. This would need creating a sound mechanism for data sharing between sectoral agencies at various sub-national levels that are needed for regular environmental reporting and planning. Data sharing would also help reduce the redundant efforts of different sectors. Besides, there is also a need to consider the use of spatial frameworks such as watersheds, ecoregions, and other regional maps. Maps of ecoregions and similar variables provide a means to localize environmental assessments.

There are many approaches to data sharing system, e.g. data replication, data warehouse, and distributed data access with increasing level of sophistication. The general observations that limit data sharing in the developing countries are 1) Lack of data and information, 2) Information is ‘power’ tendency, and 3) Lack of policy and guidelines.

Revisiting Agenda 21: Bridging the Data Gap and Improving Information Availability

Agenda 21, in its Chapter 40, has given a comprehensive framework on the needed activities regarding the generation and use of environmental information. This explicitly mentions that the collected data should be usable to indicate the status and trends of the planet's ecosystem, natural resource, pollution, and socio-economic variables. While considerable data already exist, there still exists a substantial gap in type of data available. The data gaps can be illustrated at two levels. 1) The gap in the availability, quality, coherence, standardization and accessibility of data between the developed and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development. 2) Though some data are regularly collected as the routine work by the sectoral agencies in the developing countries, the collection does not represent the breadth of required data for environmental management.

The important objectives given in Chapter 40 of Agenda 21 are to (a) achieve more cost-effective and relevant data collection and assessment by better identification of users, in both the public and private sectors, and of their information needs at the local, provincial, national and international levels; (b) strengthen local, provincial, national and international capacity to collect and use multisectoral information in decision-making processes and to enhance capacities to collect and analyse data and information for decision-making, particularly in developing countries; (c) develop or strengthen local, provincial, national and international means of ensuring that planning for sustainable development in all sectors is based on timely, reliable and usable information; (d) make relevant information accessible in the form and at the time required to facilitate its use.

Similarly the suggested activities that each national government should carry out are as follows. (a) Development of indicators of sustainable development; (b) Promotion of global use of indicators of sustainable development; (c) Improvement of data collection and use; (d) Improvement of methods of data assessment and analysis; (e) Establishment of a comprehensive information framework by undertaking the necessary institutional changes at the national level to achieve the integration of environmental and developmental information; (f) Strengthening of the capacity for traditional information applying traditional and indigenous knowledge and approaches when appropriate particularly to be relevant for rural and urban populations and indigenous, women's and youth groups.

The improvement in information availability can be brought about by launching the activities like (a) Production of information usable for decision-making; (b) Establishment of standards and methods for handling information; (c) Development of documentation about information; (d) Establishment and strengthening of electronic networking capabilities; (e) Making use of commercial information sources by undertaking surveys of information available in the private sector on sustainable development.

The means of implementation for achieving those objectives call for better financing and cost evaluation; developing/strengthening institutional capacity to integrate environment and development; scientific and technological means; human resource development/capacity building for data collection, assessment and transformation. While these guidelines are appropriate for developing countries, arranging the resources for implementation can be the main hurdle for many resource poor countries, nevertheless, collaborative effort of all the stakeholders is also very much desired.

Environmental Data Generation Initiative: Example from the Greater Mekong Subregion

In the Greater Mekong Subreigon (GMS), The Asian Development Bank (ADB), United Nations Environment Programme (UNEP) and the national Governments have joined hands for the initiatives in the subregion which are geared towards generating environmental data and their use for informed decision making through various projects, e.g. Subregional Environmental Monitoring and Information Systems, Strategic Environmental Assessments, National Performance Assessment since 1995.

The major objectives of these different regional level technical assistance projects have remained as the identification and defining a defined core dataset[2], a conceptual spatial database design, database standards and metadata, and technical capacity for the exchange of data, and build the capacity of the participating Governments to make informed decisions regarding sustainable development through integrated economic and environmental planning. With repetitive consultation with six involved Governments, the following 13 core datasets were identified in the GMS (Table 3).

[2]Core dataset can be defined as the basic, frequently required data necessary for the range of environmental decisions which will arise in subsequent years or the basic data required to support decision making concerning the common subregional issues. This is the principal focus datasets.

Table 3. Core Datasets of SEMIS-I

Core Dataset	Geo-referenced Object/Spatial Data
1. Infrastructure	Major Roads; Railways; Canals; Pipelines; and Major Electric Transmission Lines
2. Soil Class (includes slope and terrain)	Soil Map
3. Vegetation cover	Forest Cover Map; Grassland/Wetland Map
4. Air Quality Measurements	Location of Measurement Locations
5. Demography	(Linked to administrative Boundary)
6. Climate zonation	Climate (Agro-climatic Map)
7. Administrative Boundaries	Administrative/Census Map; Management; Protected Areas
8. Topography	Elevation Contours; Coastlines and lakes; Rivers
9. Land Use	Land Use map
10. Geology	Geology Map
11. Major Harvesting Activities	(Linked to Administrative Boundaries)
12. Water Quality Measurements	Location of Water Measurement Stations
13. Soil Analysis Samples	Locations of Soil Samples

Source: UNEP/RRC-AP (2002)

In addition to core dataset, there are other groups of data identified. They are:

- *Non-core Datasets:* additional environmental datasets of potential value, but which may only be relevant to one country, local region, or a sub-set of projects. Such datasets may evolve into core datasets at a later date.
- *Output Datasets:* these datasets are derived from the core and non-core datasets and from additional project specific data through the use of the processing functions. These datasets are the products, such as maps and charts, used to present information to decision makers, or could be, for instance, summaries for input into the UNEP SoE Database.
- *Auxiliary Datasets:* also called "metadata or "codata". This includes information on current standards, quality of datasets, data catalogues, etc.

Table 4. Scale of Spatial Data in GMS Countries

Country	Available thematic layers	Scale
Lao PDR	infrastructure, land use, topography, forest cover; watershed classification, soil types, and geology	1:50K-1:1M
Cambodia	protected areas; biodiversity; air and water quality monitoring stations; transportation; industrial; geology; soils; forest cover; land use; topographic maps; fishing lots; administrative boundary	1:50K-1:1M
Myanmar	geology; soil; infrastructure; urban centers; industrial zones; land use; topography; cadastral; township	1:18K-1:2M
Thailand	Almost all identified as core data set for GMS	1:4K-1:1M
Vietnam	infrastructure; transportation; soils; topography; administrative boundary; cadastral; land use; hydro-meteorology; air and water quality monitoring stations; industry; mineral; geology; production data on agriculture and forest, labor, health, and general statistics	1:50K-1:1M
Yunnan, China	infrastructure, soil, forest, land use, topography, geology population, and administrative boundaries	1:50K-1:0.5M

Note: In all countries, some data are available in digital format, others as hardcopy map, and rest are text statistics

Source: UNEP/RRC-AP (2002)

- Status of data availability in each GMS country has been reviewed. Although the purpose is to achieve a subregional level integration of environmental data for environmental planning and conservation, not all the countries have same level of achievements in terms of data generation and data management. Yet, the achievement is quite encouraging. Table 4 presents general data availability situation in the GMS.

The following areas of apparent data gaps at the subregional level include:

- Infrastructure (electric transmission lines, pipelines, dams, ports, and airports),
- Air quality measurements,
- Demography,
- Water quality measurements, and
- Major harvesting activities.

The suggested improvements are:

- Separate topography and hydrography into separate layers or themes;
- Consider feature classification schemes and tailor to meet requirements and existing data sources;
- Consider applying a framework approach to the SEMIS II database activities;
- Possible additional core data layers
  - Remotely sensed imagery,
  - Raster topographic maps,
  - Slope and aspect, and
  - Detailed hydrologic information;
- Assign responsibility for data layers;
- Use an easily populated metadata standard;
- Arc/Info export files are a suitable interchange format;
- Devise and use a data validation and accuracy assessment plan;
- Address the issues of multiple datums, projections, and coordinate systems;
- Clearly advertise data distribution fees;
- Strengthen procedures for maintenance of the database and the data catalogue; and
- Generate metadata files for all data catalogue listings.

The core datasets are the principal focus of database design. Early works in the GMS have recommended adopting a conceptual level spatial database design for a hierarchical subregion-wide GIS to support national and subregional environmental assessment, decision making and environmental reporting. The design should consider a distributed system of inter-linked spatial databases at the national level (target scale 1:50K) which can be integrated into a subregional GIS (target scale 1:250K). The review of data generation, availability and sharing mechanism indicated that most agencies in each country held different scales of datasets and many countries start to develop GIS standard design. Many agencies do not tend to follow the design wherever design is available. This situation has led to inconsistent database in some occasions with difficulties in data sharing.

The suggested data management system includes identifying or establishing a national hub (data center) in each country to obtain and exchange data with other countries using the standard exchange formats. The subregional hub, probably an international agency such as UNEP or MRC, can link to the national hubs and other international agencies to exchange data at the regional or global level.

Conclusion

Environmental data play very important role in environmental planning/conservation as well as development planning. Moreover, they are the basis for informed decision making. The role and need of such information is not well recognized in Asian developing countries but the efforts are underway to prepare up-to-date national environmental database which can also be used for regional integration. Although there are several constraints related to inadequate resources and capacity in the developing countries, some achievements have been made in terms of environmental data generation and indicators development as exemplified in case of GMS countries. Continuing efforts with greater commitments from the respective governments are needed to realize a speedy achievement.

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Environmental Indicators and Environmental Accounting

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ABSTRACT *Environmental indicators are important tools in assessing and rational implementation of sustainable development. Sustainable environmental indicators are closely related with socioeconomic indicators because they are interrupted by human activities. This training module discusses about some sustainability principles for the selection of environmental indicators.*

Sustainable Environmental Indicators

Air, water, land—these are three elements of "the environment" those are connected by natural cycles. Sustainable environmental indicators are closely related with socioeconomic indicators because it is interrupted by human activities. A global consensus was established that sustainable development rests on three interdependent pillars: the protection of the earth, social development and economic prosperity.

Sustainable development is environmentally non-degrading, technically appropriate, economically viable and socially acceptable in the agriculture, forestry and fisheries sectors and conserves natural resources (land, water, plant) and animal genetic resources.

Many scientists (Barbier, 1987; Gowda and Jayaramaiah, 1998; Lynam and Hardt, 1989) have attempted to assess the sustainable development and environmental accountability by setting up relevant indicators. The sustainability environmental indicators attempt to incorporate the three dimensions into sustainability framework through demonstrating stronger economy, healthier environment and social acceptance (Figure 1).

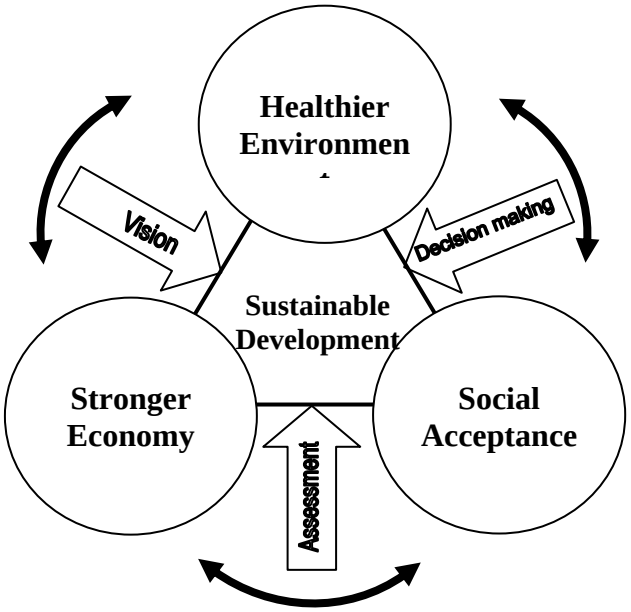

Figure 1. Three Pillars of Sustainable Development Frame

Indicators Selection and Justification

Sustainable environmental indicators are important tools in assessing and rational implementation of sustainable development. It might be suggested the indicators selecting criteria which are: relative availability of data representing the indicators, sensitivity to stress on the system, existence of threshold value and guidelines, productivity, integratability and known response to disturbances, anthropogenic stresses, and change over time.

For example, shrimp aquaculture uses high amounts of lime, fertilizer and other chemicals. As a result, effluent (discharge water) quality deteriorates significantly and saline water intrudes on the nearby agricultural land (Boyd, 2003). This process changes the soil fertility that needs to be monitored and measured because there is a chance for long-term continuation of the aquaculture system along with other practices. Measurement of these indicators can be used to assess the sustainability of shrimp production. Environmental indicators selection should be followed the sustainability principles (Table1)

Table 1. The Principles of Sustainable Development

- Provides both short and long term economic gain;
- Increases access, equity and human rights in the provision of material security and effective choices;
- Improves biodiversity and ecological integrity and builds life support systems;
- Reduces ecological footprint while improving quality of life;
- Builds up community and regions, 'sense of place' and heritage protection;
- Provides conservation benefit and net social-economic benefit;
- Increases 'common good' resources;
- Ensures there are acceptable levels of risk with adaptation processes for the worst scenarios;
- Brings change and a sense of hope for the future as it is linked to a broader strategic vision.

Source: Government of Western Australia (2003)

Table 2. Major Issues/Indicators in Sustainability of Contemporary Aquaculture in Developing Countries

Category	Issues/Indicators
Biophysical	• Over conversion of mangroves
	• Over conversion of wetlands
	• Water quality degradation
	• Over pumping of ground water and salt water intrusion
	• Toxic algal bloom
	• Disease contamination from cultured stock
	• Reduction of wild catches
	• Exotic species introduction
	• Misuse of antibiotics
Economic	• Multiple use of resource conflicts
	• Displacement of traditional subsistence and cash activities
	• Diversion of inputs (e.g. feed, fertilizers) into aquaculture
Socio-cultural	• Competition for resources
	• Visual pollution
	• Acceptance and innovation of technology
	• Increased under and unemployment
	• Degradation of community nutrition
	• Religious and cultural taboos

Source: Corbin and Young (1997)

The environmental indicators should be based on identifying the major problems and issues of relevant physical environment and impacts of human activities. Zen and Routray (2003) have identified ecological indicators for agricultural sustainability in developing countries, which are shown below:

- Amount of fertilizers/pesticides used per unit of cropped land
- Amount of irrigation water used per unit of cropped land
- Soil nutrient content
- Depth to ground water table
- Quality of ground water for irrigation
- Water use efficiency
- Nitrate content of ground water and crops

Corbin and Young (1997) have highlighted the issues for sustainable aquaculture in developing countries. They have also emphasized on three dimensions for aquaculture sustainability as shown in Table 2.

Sustainable Environmental Indicators

One forward-looking way is to link the state of the nation's air, water, land, and living organisms into a broad framework termed "ecological or environmental condition"—the sum total of the physical, chemical, and biological components of ecosystems and how they interact. Ecological condition is ever changing, multifaceted, and specific to place and ecosystem. Understanding ecological condition is crucial because humans depend on, and are responsible for, the nation's ecosystems—forests, grasslands, shrublands, farmlands, urban and suburban environments, fresh waters, coast and oceans. These systems provide food, fiber, and shelter, as well as "housekeeping" functions ranging from water filtration and crop pollination to waste decomposition and recycling.

Trends in ecological condition, like disease trends, reflect the outcome of many different events and activities, both natural and human induced. Ecosystem condition is the result of natural resource management at national and state levels, local zoning and land use decisions, pollution and pollution prevention activities, natural disturbances, and many other factors. Measuring ecological condition should be systematically assessed in order to manage the stressors how do they affect overall ecosystem health.

Figure 2 describes some of the environmental indicators, including indicators which are essential for sustainable development. And identify the other associated indicators closely related to environments are categorized into social and economic subsystems.

Quantification of Indicators

Water Quality or Soil Fertility

The following Formula can be used to evaluate the degree of quality of different aquaculture systems.

$$WQI \text{ or } SQI = \sum WiSi / 100*h \quad (1)$$

Where,

WQI = Water quality index, and SQI = Soil quality index, such that $0 \leq WQI \text{ or } SQI \leq 1$; Wi= Weighting value (%) of ith parameter (i =1, 2, 3,…..n), Si= suitability scoring value ith parameter, (Table 2 indicates the scoring value)

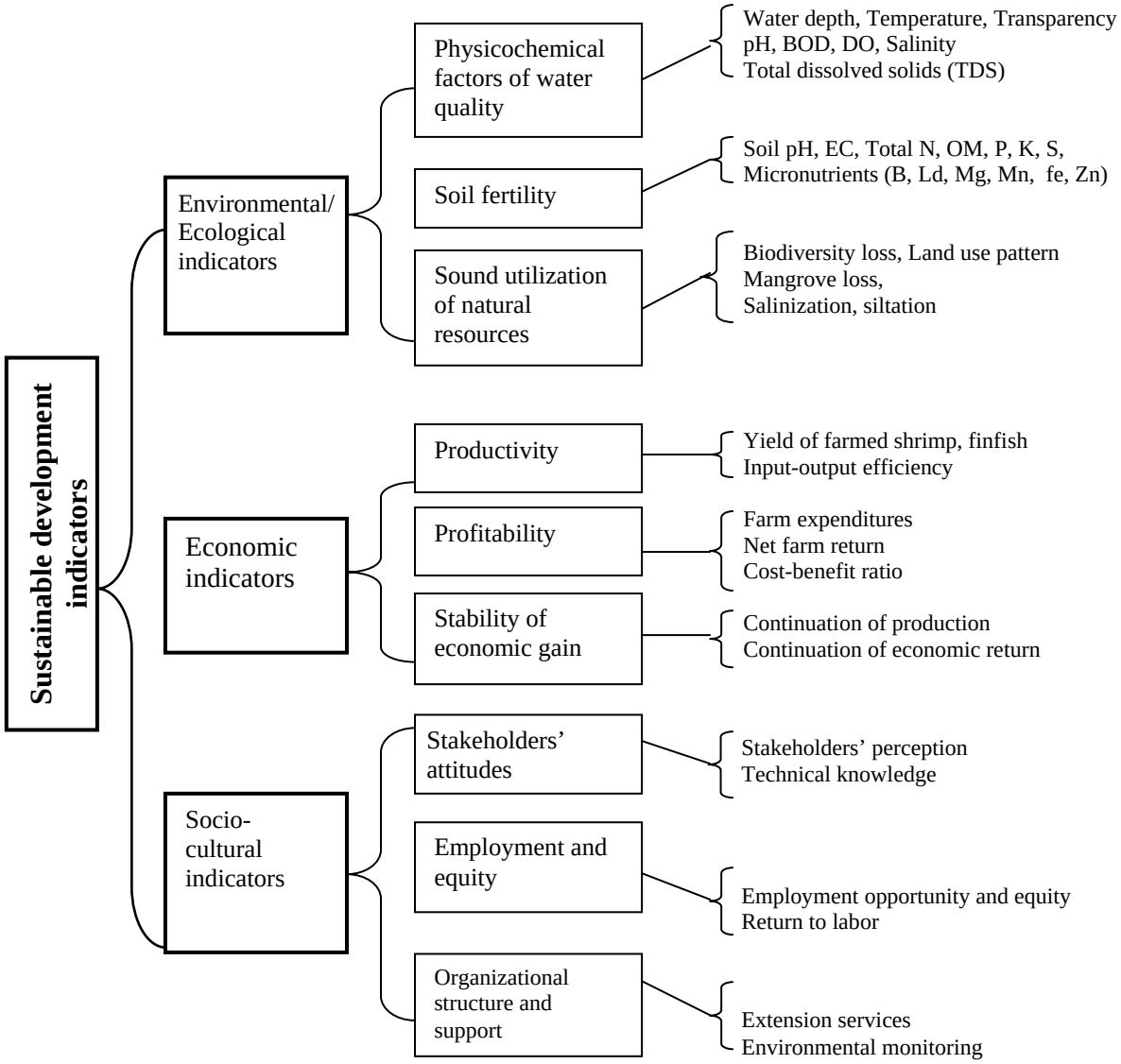

Figure 2. Selected Indicators for Assessing Sustainable Development

Sound Utilization of Natural Resource

SUNRI = (LUP + BDL + ML+ ERU)/n*h (2)

Where,

SUNRI = sound utilization of natural resource index, such that $0 < SUNRI \leq 1$; n= number of indicators, h= highest score,

LUP = Land use pattern, land use pattern or landscape diversity is the number of ecosystems, or combinations of ecosystems and types of interactions, and disturbances present within a given landscape.

Rating can be fixed on highly diverse land use (4), diverse (3), medium diverse (2), not diversified (1) comparing to other non-coastal diverse land use area of Bangladesh

BDL = Biodiversity loss, natural fry collection is one of the causes of biodiversity loss. Every single species of harvested *P. monodon* fry from natural sources is responsible for the destruction of more than 100 numbers of other species of shrimp, zooplankton and fishes (Deb, *et al,* 1994).

The rating of natural fry collection is as per the following protocol: use of natural fry >50% = 1, 20-49% = 2, <20% = 3, and no natural fry use = 4

ML = Mangrove loss: the deforestation of mangroves to accommodate shrimp ponds is the most alarming degradation of natural resources caused by shrimp aquaculture development.
Calculation is to be made by its conversion rate as more than 50% = 1, 20-49% = 2, <20% = 3, and no mangrove destruction = 4
ERU = Education and research use: The ecological education and research for coastal environment use by coastal communities is an essential element for sustainable exploitation of natural resources.
The ERU is categorized as per the following rating: much use = 4, medium use = 3, limited use = 2, and no use = 1.

Profitability

Productivity
$P = \sum Wi / (A*Y)$ (3)
Where, P=productivity (ton/ha/yr),
Wi= total weight (ton) of ith crop of shrimp (i =1, 2, 3,…,) (average production is 207 to 275 kg/ha/yr according to Islam (2003),
A= area of farms, Y= number of year
Productivity index
$PI = \sum CiSi / n*h$
Where PI= productivity index, such that $0< PI \leq 1$, Ci=crops (i =1, 2, 3….n), Si =suitability score of ith crop (4, 3, 2, 1), and n= number of harvested crops, h= highest score.

Production Stability

The production stability index (PSI)
*PSI = (fi*3+fd*2+fc*1)/n*3* (4)
("3" indicates the highest score)
Where, PSI=production stability index such that $0< PSI \leq 1$;
fi=frequency of responses (number of respondents) indicating increasing yield,
fd= frequency of responses indicating decreasing yield,
fc= frequency of responses indicating constant yield, n= total number of respondents.

Stakeholders' Perceptions (like knowledge, attitude)

$WAI=\sum\{fSD(-2)+fD(-1)+fN(0)+fS(1)+fSS(2)\}/N$ (Miah, 1993) (5)
Where,
WAI = weighted average index
fSD = frequency of responses of strongly dissatisfied
fD = frequency of responses of dissatisfied
fN = frequency of responses of neutral
fS = frequency of responses of satisfied
fSS = frequency of responses of strongly satisfied
N = total number of responses
Interpretation:
Very low (VL) = 0.2, Low (L) = 0.4, Moderate (M) = 0.6,
High (H) = 0.8, Very high (VH) = 1.0

Employment Index

$EI= Le/La$ (6)
$Le=\sum Lui/A$
$La= Leap\times 300days$
Where, EI = employment index, such that $0\leq EI\leq 1$; Le= own labor employed per hectare of area, (calculated as common unit as person-day/ha), Lui = total family labor used in ith farm

activities (like pond preparation, guard etc.), A= total area (ha) of farm operated by hh. La=labor available from household. Leap= the economically active population in per hectare (18-59 yrs old).

Organizational Support

$$OSI = (TS + CS + LS)/ (n*h) \quad (7)$$

Where, OSI = organizational support index, thus $0 < OSI \leq 1$; TS = training support (technical education and knowledge, ecological knowledge), CS = credit support (bank loan, risk insurance), LS = logistic support (water quality kit), n = number of indicators, h= highest score.

Rating is calculated using sufficient support = 4, medium support = 3, some support = 3, and no support or very poor support = 1

Environmental Accounting, Gross Domestic Product (GDP) and Sustainable National Income

Gross Domestic Product (GDP)

GDP is the market value of all final goods and services produced within a country in a given period of time. GDP adds together all items of final products (both tangible goods and intangible services currently produced) into a single measure of the value of economic activity using the market prices (the amount people are willing to pay for different goods)

There are, however, some products excluded in GDP because of measurement difficulty. It excludes items produced and sold illicitly and most items that are produced and consumed at home never enter the marketplace.

Gross National Product (GNP)

GNP is another statistic, which takes a different approach to dealing with the goods and services produced by foreigners. GNP is the value of the production of a nation's permanent residents. Thus, income is included in a nation's GNP if it is earned by the nation's permanent residents (called *nationals)*, regardless of where they earn it.

GDP is called the best single measure of the economic well-being of a society. It measures both the economy's total income and the economy's total expenditure on goods and services. Thus, GDP per person tells us the income and expenditure of the average person in the economy and seems a natural measure of the economic well-being of the average individual.

A large GDP does in fact help us to lead a good life but GDP does not directly measure those things that make life worthwhile (health, quality of education, integrity, wisdom, courage, devotion etc) but it does measure our ability to obtain the inputs into a worthwhile life. GDP is not, however, a perfect measure of well-being. Some things that contribute to a good life are left out of GDP. One is leisure. Another is the quality of the environment and other activities that takes place outside of markets are also excluded (child-rearing and volunteer work, etc).

Green National Accounting / Sustainable National Income Accounting

Fundamental to sustainability is the requirement that a non-declining (constant) capital can be maintained. Capital is one of the primary factors that determine the productive capacity of a nation. This requirement for keeping capital intact can be achieved if, and only if, proper accounting is done for capital consumption or depreciation.

Sustainable economic development requires a modification of the conventional national accounting concepts of income, in particular the gross national product (GNP). A nation's income as measured by GNP does not account for all the resource costs that are attributable to the production of goods and services during a given accounting period, and as such cannot reflect a level of income (economic activities) that is sustainable indefinitely. The relevant question is, then,

in what way(s) can the national accounting concepts of GNP be modified so that sustainability of income or economic activity is assured?

Capital is one of the primary determining factors of a nation's productive capacity. Maintenance of a sustainable income - a level of income that a nation can receive while keeping its capital intact - requires setting aside a sufficient amount of current income to preserve capital so that the ability to generate future income is not adversely affected. An income accounting system that attempts to keep capital intact needs to explicitly account for capital depreciation. Thus, the relevant income measurement is the net (not the gross) national income.

Traditionally, the above concern has been met by recognising the depreciation of human capital (machines, buildings, inventories, etc.) as a legitimate deduction from gross income or product (income):

NNP= GNP-DHC (8)

Where, NNP is net national product (income) and DHC is the depreciation allowance of human capital.

However, adjustments of this nature are still incomplete to the extent that they fail to account for the depreciation of natural capital - environmental costs of current production and consumption activities. These environmental costs can be grouped into two broad categories.

The first category consists of the monetary costs of net degradation and depletion of natural assets (forest, air and water qualities, fisheries, oil, etc.) directly attributable to current production and consumption activities.

The basic argument here is that to keep environmental capital intact, provision should be made for its degradation in the same way as for depreciation of human capital. However, there are controversies as to how to account for changes in the stock of available natural resources (both renewable and non-renewable resources) brought about by economic activity. Despite this, the key issue is the recognition that natural assets are depreciable (degradable), and any effort to measure the net proceeds from an economic activity should account for this cost.

The second category of environmental costs that needs to be considered is defensive expenditures. There are real costs incurred by society to prevent or avoid damage to the environment caused by the side effects of normal production and consumption activities. (e.g., extra expenditures on health care for problems due to air pollution; extra expenditures on cars to equip them with catalytic converters; and extra costs incurred in offshore water cleanup of oil spills). In the ordinary calculation of GNP, defensive expenditures of this nature are treated as part of the national income. But this is erroneous, given that defensive expenditures actually represent a loss of income that cannot be spent once again for consumption or investment but can be spent only to repair or prevent environmental damage caused by normal economic activities. Thus, environmentally defensive expenditures should be deducted (not added, as is normally done) from GNP.

Environmentally adjusted national income can then be expressed as:

SNI = NNP - DNC – EDE (9)

Where, SNI = sustainable national income,

DNC= the depreciation of natural capital (the monetary value of the diminution of the natural resource stocks and the deterioration and degradation of the environment) and

EDE = the environmentally defensive expenditures.

Assuming no change in technology, SNI represents the maximum amount of income that can be expended for current consumption without impairing the future productive capacity of a nation (i.e., keeping capital stock intact). Environmentally adjusted national income like SNI would involve estimation of DNC an EDC in monetary terms. In recent years, a great deal of work has been done on developing methodologies for valuing natural resources and the environment in monetary terms. As there are subjective elements involved in the economic valuation of the environment, there appears to be no consensus among national income accountants on how best to make the appropriate adjustments for the environment. Environmentally adjusted net national income accounting is popularly known as "green national accounting".

In some important ways these efforts also reflect the increasing awareness of the global community that the natural environment is a *scarce* resource (not a free good) that needs to be managed prudently.

Traditionally, Gross Domestic Product (GDP) is used for international comparisons, and for measuring economic growth. Higher GDP and higher rate of growth in GDP are often identified as being clear signals of the strong and robust economic performance of a nation. However, this could be misleading if, for example, a country were deriving its prosperity largely from depleting its natural capital stocks. In this case, the current level of income would be unsustainable unless proper allowance was made for the liquidation (depreciation) of the natural capital assets.

To the extent that the depiction allowance was correctly estimated, and exploitation was carried out in the private sector, the national accounts came out right. In the majority of developing countries, however, where natural resources have been worked in the public sector, proceeds from mining natural resources have been treated as income. The faster the depletion, the more prosperous the country would seem to be and the more rapid its apparent economic growth. The fact that such prosperity would be ephemeral, and that the apparent growth was misleading, did not seem to worry most economists, who continued to base their country analysis and policy prescriptions uncritically on the erroneously reckoned national accounts.

Table 3. Percentage Fall in Gross National Product After Environmental Accounting

County	GNP	Green NNP	% fall on GNP
	($ per capita 1993)		
Japan	31,449	27,374	-13.0
Norway	25,947	21,045	-18.9
United States	24,716	21,865	-11.5
Germany	23,494	20,844	-11.3
South Korea	7,681	7,041	-8.3
South Africa	3,582	2,997	-16.3
Brazil	2,936	2,579	-12.2
Indonesia	732	616	-15.8
China	490	411	-16.1
India	293	242	-17.4

Source: Titenberg (2000)

Table 4. Sample Accounts:

AJAX Mining Company, 1997		
Expenses		
Wages		$50,000
Mining Labor	$30,000	
Exploration labor	$10,000	
Land reclamation labor[(a)]	$10,000	
Depreciation of mining equipment		$10,000
Income		
Sales of 5000 tons @ $20/ton		$100,000
Edison Power Company, 1997		
Expenses		
Wages		$100,000
Pollution control	$10,000	
Production labor	$90,000	
Coal purchases		$100,000
Depreciation of generating equipment		$20,000
Income		
Sales of electricity		$300,000

[(a)] This is needed, as land reclamation is mandatory by law.

Source: Titenberg (2000)

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Case Study 1: Variables of Environmental Indicators at Community Level

Ecological Integrity: Effectiveness of Functional Capacity of Natural Systems

Comparison of damage in dollars from floods due to loss of wetlands vs. damage if wetlands had remained intact; % loss in agricultural productivity due to soil erosion; number and variety of rare and endangered species now as compared with a specific past year; % of water bodies meeting environmentally based water quality standards; % of drinking water supplies lost; buffering capacity remaining for withstanding acid deposition in forests; number of watersheds meeting reasonable stream flow threshold standards; % of reduced recharge area in delineated zones of contribution in aquifers and/or in watersheds around reservoirs due to development (e.g. comparing % open space, farmland, wetlands converted to commercial, industrial, or residential use); the increases or decreases in population of habitat-specific song bird species; number of foreign (i.e. exotic) plants and animals in a given area; loss of a natural predator; accelerated eutrophication of surface waters as compared with predicted natural succession rate; % change in volume of first trophic level (i.e. producers); % of fragmentation of habitat

Environmentally Sound Utilization of Natural Systems

% of energy used in a community generated by facilities using renewable energy resources; reduction and prevention from waste stream of highly toxic materials generated in or brought into the community or per household (% and volume); % and volume of waste material converted into beneficial uses (e.g. sludge to fertilizer pellets, waste steam to residential heating); replacement of virgin (raw) material by recycled products used in businesses and public institutions; number or % of products returned in a product take-back program; number of traditional businesses which have new technologies/new processes; number of health and safety workplace citations per year; number or % of acres in a watershed managed using sustainable forestry practices; % of cultivated farmland left fallow for restorative purposes; % of food in community which is imported; number of days shellfish beds are closed per year over the past 5 years; % of yard and food waste composted and used from a facility; % of superfund sites (cleaned up according to EPA and state standards which are then used for some beneficial purpose (not left vacant); daily vehicle miles traveled per person per year in fossil-fuel powered single occupancy vehicles as compared with VMT in electric and/or alternatively fuelled vehicles conveying more than 1 person; number of gallons of water saved per year through leak repair.

Quality of Life: Respect for Self and Others

Qualitative (e.g. survey questions) of self-worth and self-esteem; grade level for introducing a second language; the choice of which second language is taught; presence and effectiveness of programs and activities designed to help people understand and respect people's differences; number of traffic tickets issued and traffic enforcement patterns at key residential intersections; frequency of litter cleanup in public places; presence of ethnic restaurants (number and diversity); availability of public communications in local languages other than English.

Caring

Number of hours volunteered or % of population that volunteers; % of people in businesses, institutions, and neighbourhoods where people returned to help others in situations similar to what they overcame (e.g. successful businessperson mentors start-up entrepreneur; once abused person volunteers to help victims of abuse; financially successful (once poor) person stays in the community or reaches back to neighbourhood residents; students that participated in a mentor program who later become mentors).

Connectedness

Number of neighbours each individual knows by name; number of people who know what neighbourhood they live in; number of people who know distinct ethnic groups of people who have settled in their community; number of decisions made which respond to historical and/or cultural roots; rank on scale of importance value of connecting to nature via actions and desires (e.g. grow plants, vegetables in garden window box, pots; recreate outdoors (walk, ski, skate, hike, bike, etc.); sit in the sunlight; view sky, trees, number of residents who know what watershed they live in.

Basic Coverage

% of parents who have their preferred child care arrangements; % of housing units which are set aside for low and moderate income people; % of people who have health care coverage (availability and access); number of people who use food stamps; number of homeless people; % of low income housing with severe problems, using HUD or state standards; impact of fear of crime on behaviour whether based on crime figures, experience, or awareness from another source such as media (e.g. willingness to go out after dark in your neighbourhood alone/in a group); number of violent crimes per 1,000 population; ratio of money spent on drug and alcohol prevention and treatments to money spent on incarceration for drug and alcohol related crimes; availability and access to services designed for targeted populations; number of benefits and services provided to employees on/near site (e.g. daycare, health care, dry cleaners, banking, food store, post office); teacher/student ratio.

Empowerment with Responsibility Reaching in

Number of community gardens/yard gardens created over a specified time period; number of new participants as well as number of participants who continue (in an organization/process) measured over time; some measure of the sources of ideas/recommendations (to what extent were they generated from within a group or dictated by a group leader or someone outside the group); number of languages translated at public meetings; asking open-ended questions; presence of facilitators at public meetings; level (number and frequency) of contacts by local government staff with informal and formal community leaders; use of diverse and alternative media outlets (number, frequency, results).

Equity/Fair Playing Field

% of students accepted to higher education who cannot afford to go; % of people of colour compared with % of whites of the same economic status who received home mortgage loans; % of city councillors and appointed professional managers who are people of colour/women as compared with the community's breakdown; % and salary of people of colour/women as compared with whites in high level management positions over past 5 years; ratio of ethnic and gender diversity of teachers/administrators/support staff to equivalent student body figures

Capacity

Number of local land use controls and other provisions adopted (e.g. plans, zoning, special permits); number, longevity, and scope of community-run activities; % of adult population 18+ years old involved in organized learning program (e.g. adult education, peer training, personal support group, book club, music group, soccer league); % of people who state a commitment to and involvement in spiritual, ritual, religious group activities; literacy rate in English broken down by race and income; % of population who are environmentally literate; presence and effectiveness of programs designed to enable people so that they take more control over their lives and not depend as much on government.

Accountability

% of community-based loans repaid; % of people in a defined area (neighbourhood or street) acting on behalf of a specific change (e.g. school construction, gas station sitting, street closing) to that area; % of population that rates governmental responsiveness as good or excellent (both administrative effectiveness and delivery of services); % of local government budgets for which goals and outcome measures have been established; number of people making a commitment to act; number of city employees who live in the community.

GIS Applications for Environmental Planning and Management

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ABSTRACT *There has been much debate in recent years about environmental degradation in some sectors such as, air, water, solid waste, climate change, tourism. The ever-increasing urbanization is a major concern in the air quality in most of the metropolitan cities. In this study, a small case of effect of climate change monitoring in Thailand is discussed. Also, there is discussion on the possibility of using solid state gas sensors integrated with Internet GIS for finding out the changes in air quality in dense urban locales of Bangkok.*

Introduction

Air, water, soil and vegetation are important components of environment and dominate the human life. Due to rapid development in many countries there is a serious impact on these components. Urbanization is adversely affecting the quality of air and water. Tourism in coastal areas has increased and it is found that marine and coastal life is having adverse impact too. Mangrove covers are depleting in many countries due to demand for shrimp and other type of aquaculture.

Climate change is another issue of serious concern for humanity. Climate undergoes changes due to changes in environment. Human interference with environment has intensified due to rapid urbanization and industrialization. Climate change is a problem with unique characteristics. It is global, long-term, and involves complex interaction between environmental, economic, political, institutional, social and technological processes. Extreme events in climate can provide a glimpse of what will happen to the environment specially vegetation. These extreme events are El Nino and La Nina. The El Nino Southern Oscillation (ENSO) is the largest know global climate variability signal on inter-annual time scales. It is a periodical fluctuation between warm El Nino and cold La Nina states of the Pacific sea surface temperatures and has a recurrence oscillation period of approximately 2 to 7 years (Manobavan et al., 2003). El Nino is the cyclical warning of East Pacific Ocean sea/ water temperatures off the western coast of South America that can result in significant changes in weather patterns in the United States and elsewhere. This occurs when warm equatorial Pacific waters move in and displace the colder waters, cutting off the upwelling process (Yang et al., 1998).

Another concern in ever-increasing urbanization is the air quality. In Bangkok, where the air is thick with adverse air pollutants, increasing emissions are unavoidable due to excessively rapid economic and industrial growth. The cost of establishing and implementing ordinary monitoring systems is extremely high; use of analytical instruments is time-consuming, expensive, and can rarely be applied for real-time monitoring in the field, even though these can give a precise analysis. Hence, a new generation of detector, WO_3 semiconducting gas sensor, offers an excellent alternative for environmental monitoring due to low cost, light weight, extremely small size and also because of the reason that they can be deployed anywhere so as to receive data that can eventually be transmitted through a Internet GIS network system as a rapid monitoring tool to the general public.

Case Study 1:

Climate Change Monitoring in Thailand by Using NOAA/AVHRR Data

Introduction

The region faced extreme climatic event in form of El- Nino in 1998. Rainfall was lower than normal and temperature were quite high. This has caused adverse impact on agriculture and vegetation. Whereas, the year 2001 was a normal year having no adverse of El- Nino. The vegetation cover and the agriculture were normal. Therefore, 1998 and 2001 data were considered in this case study.

Suphan Buri is selected as the area for case study. It is located in the central region of Thailand and contains an area of 5,358 sq. km (Figure 1). It is administratively divided into 10 districts, Muang Suphan Buri, Doem Bang Nang Buat, Bang Pla Ma, Si Prachan, Song Phi Nong, Sam Chuk, U Thong, Don Chedi, Dan Chang and Nong Ya Sai. The terrain of the province is mostly low river plains, with small mountain ranges in the north and the west of the province. The southeastern part with the very low plain of the Tha Chen river is paddy rice farming area. Ten sample sites were selected in paddy fields using landuse map year 2000 from Land Development Department (LDD).

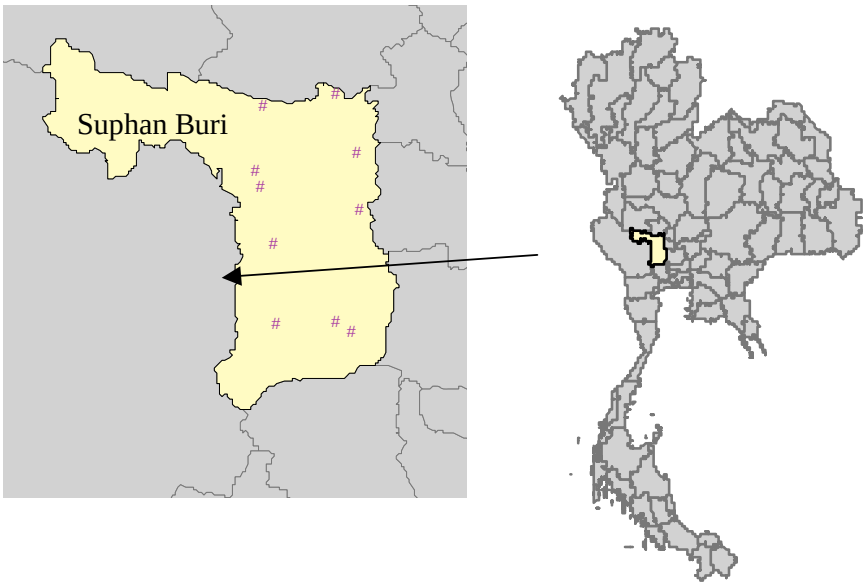


Figure 1. Map of Suphan Buri Study Site for Climate Change

Data Used

Satellite Data

NOAA/AVHRR with 10-day composite time series NDVI at 1 km spatial resolution for the year 1998 and 1-month composite for year 2001 is used. The Normalized Difference Vegetation Index (NDVI) is the mathematical combination of radiation flux recorded in the red and near infrared portion of the electromagnetic spectrum, a sensitive indicator of the condition of green vegetation and can be used as a surrogate measure of the response of vegetation to climatic disturbances (Yang et al., 1998). Previous studies have identified inter-annual NDVI variability signals associated with the ENSO (Asner et al., 2000; Li and Swift, 2000). It is shown in Figure 2.

Figure 2. NDVI 10-day Composite Image Year 1998 of Thailand

Climate Data

Climatic data temperature, relative humidity, and rainfall are considered. Spatial interpolation operation was applied using GIS to obtain monthly climate surface maps for 1998 and 2001. The base data were collected by daily meteorological station (Thai Meteorology Department). Average monthly rainfall surface map is shown in Figure 3. It shows that in the El-Nino year 1998 the rainfall was quite low in most of the province of Suphan Buri.

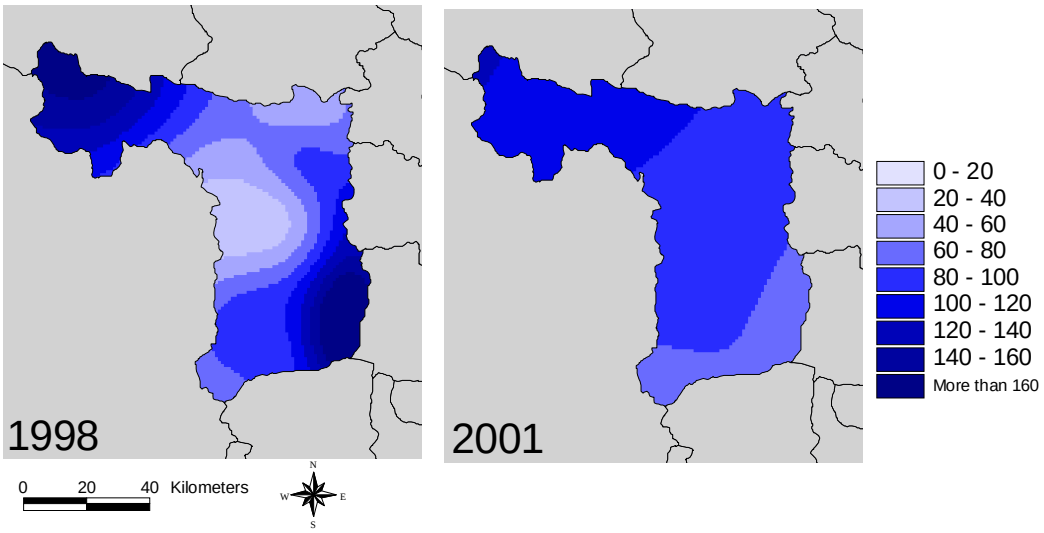


Figure 3. Average Monthly Rainfall (mm)

Figure 4 shows the spatial variability in temperature obtained using GIS interpolation tools. It is found that temperature were quite high in central parts of the province.

Figure 5 shows the plot of rainfall, relative humidity and temperature of 1998 and 2001 for comparison. Data from 10 stations of the province were considered. We can see that rainfall in 1998 was quite low compared to 2001 and very inconsistent. Relative humidity and the temperature were higher in 1998 than the year 2001. We are aware that vegetation cover is dependent on climate

specially rain and temperature. In 1998, the rain was less than normal and temperatures were higher than normal. This has caused adverse effect on vegetation. Suphan Buri is predominantly rice cultivation area. Due to this climate change the province faced the drought situation and crop vigour went down drastically.

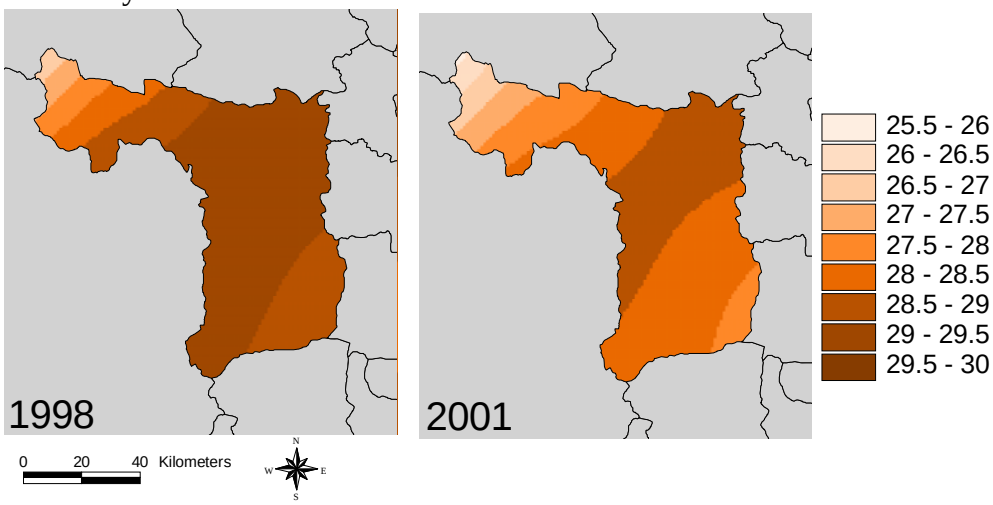
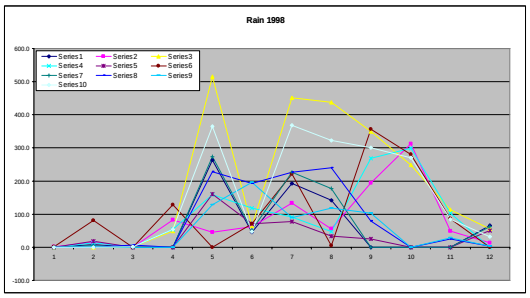
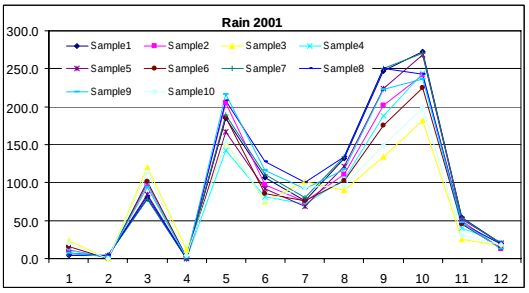


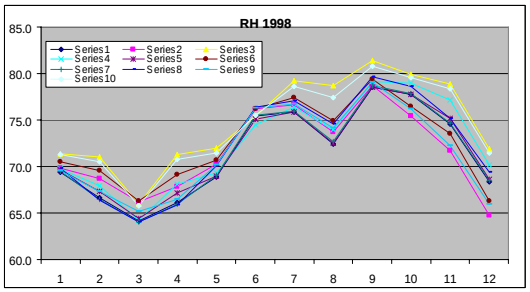
Figure 4. Average Temperature (˚C)



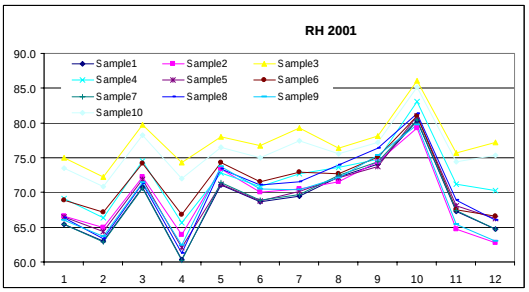
Rain 1998



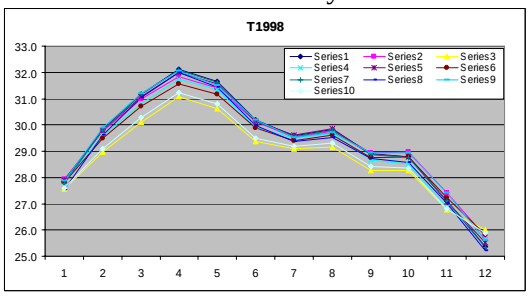
Rain 2001



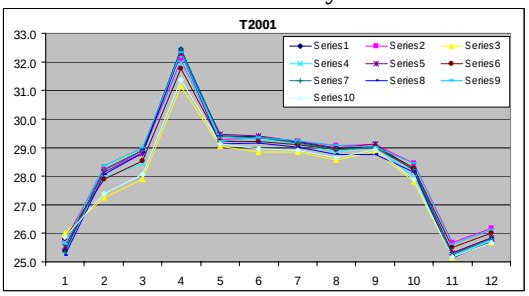
Relative Humidity 1998



Relative Humidity 2001



Temperature 1998



Temperature 2001

Figure 5. Average Rainfall, Relative Humidity and Temperature in 1998 and 2001

This effect is observed in Figure 6. Figure 6 is prepared using the climate data and NDVI. NDVI is the Normalized Difference Vegetation Index. It is computed from the reflectance values received from the satellite image data.

NDVI= (NIR-R) / (NIR+R) (1)

Where, NIR and IR are the reflectance values in near infra red and red bands. These values were extracted from the NOAA satellite data from 1998 and 2001.

Scatter Plot for NDVI and Climate Factors

We can see in Figure 6 below, that climate values of temperature and humidity are on higher side in 1998 and NDVI values on lower side and quite dispersed. Vegetation vigour i.e. NDVI is very low compared to 2001. In 2001, the rainfall is high and NDVI is also high and uniformly clustered.

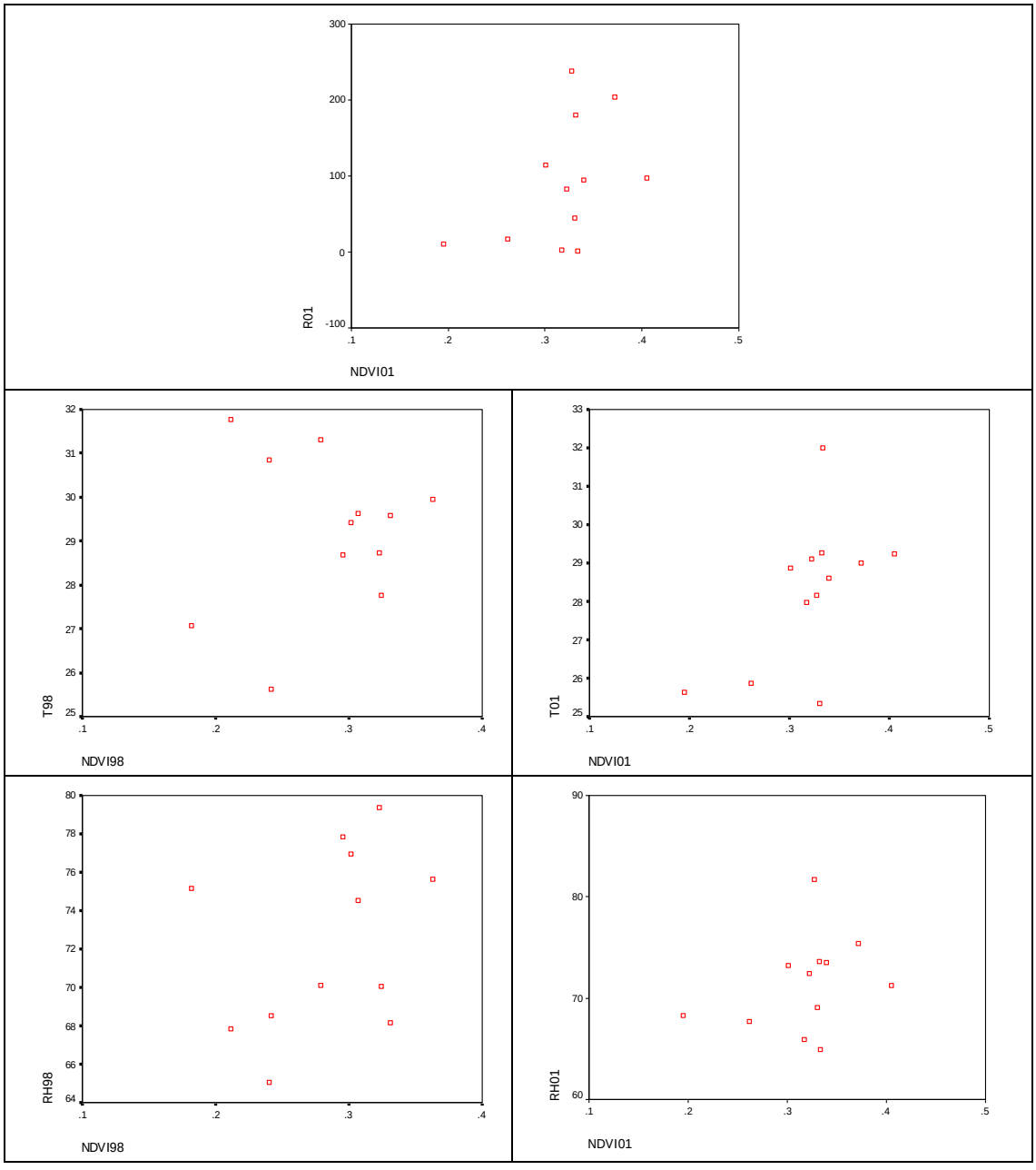


Figure 6. Relationship of Climate Factors with NDVI in El- Nino and Non-El Nino Year

This gives an indication that if we can monitor the NDVI from satellite data as a regular monitoring technique then there is a possibility that we can find the changes on agriculture and vegetation due to climate change events. May be, it can prove to be a technique for warning to the farmers that climate may be favorable in that year or they have to adopt other means to support the agriculture such as switch to irrigation rather depending on rain. They may also think to alter the crop with less water thirsty crop.

NDVI values can be computed by NOAA data, which is available for free. There is a NOAA receiving station in Asian Institute of Technology and data for the research purpose can be received freely.

Case Study 2

Air Pollution Monitoring Using Semi-conducting Gas Sensors and Internet GIS

Introduction

In Bangkok, where the air is thick with adverse air pollutants, increasing emissions are unavoidable due to excessively rapid economic and industrial growth. The cost of establishing and implementing ordinary monitoring systems is extremely high; use of analytical instruments is time-consuming, expensive, and can rarely be applied for real-time monitoring in the field, even though these can give a precise analysis. Hence, a new generation of detector, WO_3 semi conducting gas sensor, offers an excellent alternative for environmental monitoring due to low cost, light weight, extremely small size and also because of the reason that they can be deployed anywhere so as to receive data that can eventually be transmitted through a Internet GIS network system as a rapid monitoring tool to the general public. Because of cost consuming to retrieve satellite imagery, the central parts of Bangkok were chosen to determine the air quality levels. The satellite image from IKONOS (SISEA, 2005), contributed by the Department of City Planning (2005), was included to the air quality monitoring map server and overlaid with relevant GIS base maps. The air pollutants monitored include NO_2, O_3, CO, and PM_{10}. These pollutants were uploaded in real time to the AQM server as concentration levels using data logging technique. The current and daily historical air quality (AQ) data were captured from each *in-situ* AQ station through the telephone modem line using Hyper Terminal program and the data were kept in the map server. Users can simply browse and view the graphical AQ data in real time. Sampling time of each day comprises rush hours in the early morning and in the evening, Additionally, other sampling time is also carried out when the traffic flow is normal, so as to compare the air quality levels between crowded and less crowed traffic conditions.

In laboratory, computer based simulations between air pollutant concentration in 0-7.50 part per million (ppm) range, obtained from WO_3 semi conducting gas sensor, and Internet GIS are integrated in order to test the Air Quality Monitoring System (AQMS) and contribute as easy portable device for real-time air quality monitoring as well as it can initiate other researchers in different fields of applications. The model as developed will then be used for acquiring and monitoring real time air quality levels and also updating information through Internet GIS using Web Map Service (WMS). The results are illustrated information of which air quality levels are monitored and demonstrated in the form of GIS database. The air pollutant concentration levels will be categorized into 3 classes including good, moderate and high relied on the Ambient Air Quality Standard (AAQS) of the PCD (PCD, 2004). This illustration, therefore, can be used to enhance public awareness and participation. After all this simulation can be referred to as an air pollution monitoring system, which will be able to support the PCD to establish priorities and measures air pollution and also facilitate the problem analyzing and monitoring air pollution in Bangkok area. Results will be relevant information to support policy decision makers to appoint issues regarding air pollution monitoring.

The Objectives of the Study

Objective of the study was to apply a suitable gas sensing device coupled to a PDA for continuous monitoring of gas in urban area and disseminate the information in real time through wireless GIS.

The Circumstance of Air Pollution in Bangkok Areas

The PCD (2003) has taken the lead in monitoring key air pollutants, establishing ambient standards and recommending policy measures to reduce air pollution in critical areas. The PCD's monitoring network comprises 71 sites nationwide—37 located in Bangkok and 11 in the suburbs. From air quality measurements in roadside sites of Bangkok (2003), it demonstrates that O_3 one-hour average concentration is higher than air quality standard (lesser than 100 ppb) almost every monitoring station as similar as TSP and PM_{10} are found in high levels. For general sites, O_3 one-hour average and PM_{10} are polluted in high level as well. To monitor atmospheric gases polluted from human activities is possible to carry out by using satellite imaging technologies. SCIAMCHY is referred to as Scanning Imaging Absorption Spectrometer for Atmospheric Cartography which is able to measure the global distribution of many important trace gases, like O_3, NO_2, CO_2, CO, and CH_4, together with aerosols and clouds. The satellite imagery taken by the SCIMACY (Stammes, 2005) show NO_2 concentration levels in Bangkok under high conditions as well as occurred in China, Korea and Japan.

Conventional Air Quality Monitoring System

The PCD has been measuring air quality levels through the automatic monitoring system, referred as to "AIRVIRO SYSTEM" (the PCD, 2003) and reporting real time air quality levels through the Internet as air quality index (AQI) maps. Air quality monitors comprise 16 permanent stations and are set up at roadside and general sites. Unfortunately, the cost of establishing and implementing traditional monitoring systems is extremely high. For non automatic monitoring system used for measuring gases, analytic instruments such as optical spectroscopy or gas chromatography/mass spectrometry, NDIR (non-dispersive infrared), chemiluminescence, and the like can contribute a precise analysis; however they are time-consuming, expensive, and are seldom used in real-time in the field. Moreover, they are difficult to transport from place to place being bulky as well. To substitute the typical analytical tools and adapt or extend the air quality monitoring system of the PCD with a new generation of detectors, WO_3 semi-conducting sensor is a viable alternative which will be elaborated in the next session.

Semi-conducting Tungsten Oxide Thick Film Gas Sensors for Air Pollution

The semi-conducting NO_x sensor applied in this present work is packaged in a commercial electronic package referred to as a TO-39-4 header and cap, developed by the Synkera Technologies Inc. (2004). The deposition of the sensing layer is WO_3 thick film (Alumina substrate) materials, sputtered by screen printing technique. Platinum is used as electrodes to measure conductivity changes of the sensor and the necessary sensor working temperature is about 250 ºC , achieved by ruthenium oxide heater (Deininger, et al., 2003). Fundamentally, the resistance change is caused by a loss or a gain of surface electrons as a result of adsorbed oxygen reacting with the target gas. The WO_3 semi-conducting used in this research is an n-type, there is, hence, either a donation (reducing gas) or subtraction (oxidizing gas) of electrons from the conduction band. The result is shown that n-type oxides increase their resistance when oxidizing gases such as NO_2 or O_3 are present while reducing gases such as CO or CH_4, lead to a reduction in resistance. This then

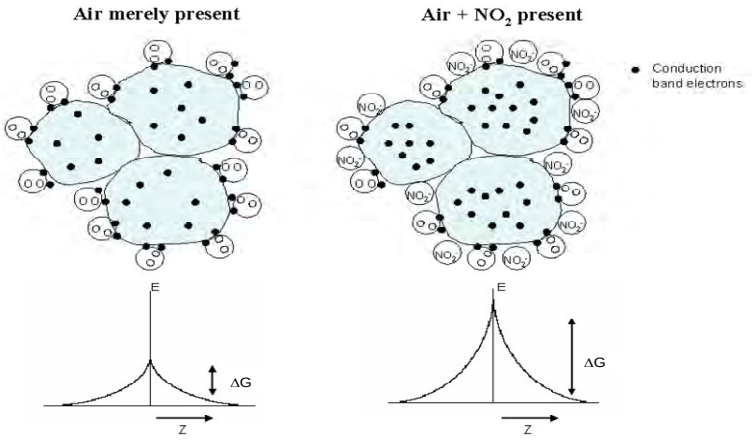
translates into corresponding changes in electrical resistance. The basic adsorption of NO_2 to the WO_3 film surface is a reversible chemisorption reaction as shown below.

$$NO_2 + e^- \leftrightarrow NO_2^- \quad (2)$$

As investigated by Gurlo et al. (1998), sensor response of metal oxide based gas sensors to NO_2 is caused by adsorbed species which capture electrons and hence make sensor resistance (voltage out) increase. The different adsorbed species can be NO_2^- as seen in equation (1), O^- and $2O^-$, dependent on the operating temperature. In any case, these species must adsorb on surface defects-reducing states, such as metal cations in low oxidation states or oxygen vacancies. Accordingly, a possible interaction mechanism between nitrogen dioxide and WO_3 may be through superficial W^{5+} states:

$$NO_2 + W^{5+} \leftrightarrow (W^{6+} - NO_2^-) \quad (3)$$

It can be concluded that the fundamental working mechanism of these materials relies on a change of the resistance of the oxide, dependent on the free electron density in the space charge layer. As WO_3 gas sensor was applied in the study, the electron depletion at the sensing surface is proposed in the Figure 7. The adsorption of atmospheric oxygen is due to O_2^- specie (equation 2) which ties up electron carriers. When WO_3 sensor is sensed to NO_2 as an oxidizing gas, the depletion region is increased which changes the microscopic structure as well. Hence the electric properties are totally influenced by the depletion layer. On the top of that the detection of electric conductivity promisingly contributes sensor signals.



Source: Gurlo et al. (1998)

Figure 7. The Chemisorption of Oxygen Atoms at Semi-conducting Surface and the Associated Potential Barrier Formed at Each Inter particle Contact

Methods and Experimental Setup

The schematic diagram of the calibration system is shown in Figure 8.

Heater voltage adjustment is able to be implemented, which is referred to a target voltage at 4.5V, supplied by the Synkera technology Inc (2004). Sensor zero adjustment is capable of adjusting potentiometer with no gas applied (0 ppm NO_2). With a voltmeter it should be turned counter-clockwise until a minimum signal (approximately 6mV) is reached. The potentiometer ought to be set at the point where the minimum voltage is attained. Sensor gain is adjusted using

potentiometer with full-scale gas. When the V_{out} becomes steady, it should be adjusted to 5VDC or as much as it can be. In this study, full-scale gas applied is 7.37 ppm of NO_2.

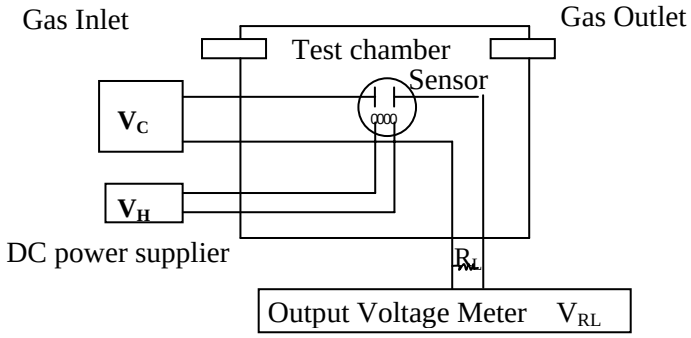


Figure 8. Schematic Diagram of the Measurement System. V_c: Circuit Voltage; V_h: Heater Voltage; R_L: Load Resistance; V_{RL}: Output Voltage

Typical Response of WO_3 Semi-conducting Sensor to NO_2 Gas

This calibration experiment was collaborated by Petro-Instruments Corp., Ltd. It was found that it is not possible to prepare the pure gas of NO_2. It was chosen, hence, 0-7.34 ppm of NO_2 gas which was produced by gas mixtures between O_3 and NO_x using the instrument "Programmable multi-gas calibrator, model 5008, Dasibi Environment Cooperation. This gas calibrator is connected parallel to NO_x analyzer "Dual chamber chemilunescense nitrogen oxides monitor, Environment S.A. (AC 31M)", which is purposed to obtain accurately NO_2 concentrations produced from the multi-gas calibrator. The ratio used for mixing gases was the gas volume of NO_x: O_3 (1:1). Flow rate of air and gas was 70 ml min^{-1} which is according to the proposed recommendation from the Synkera Technologies, Inc. Pump was applied to create vacuum of 70 ml and power supply was provided by adapter of 9V and 1.2 mAH. The sensor was housed inside a plastic chamber of 10 ml volume, which was kept under continuous flowing of testing gas mixtures or at a constant flow rate of 70 ml min^{-1}. The sensor was stabilized for 16 hrs at least at room temperature before measuring NO_2 gas in the chamber**.** At each investigation of sensor response, the sensor was exposed to NO_2 gas for 5 min and exposed to zero air in between each sensor response test for 2 min.

This WO_3 sensor was tested to pure NO gas of 10 ppm for 5 minutes to investigate the selectivity of sensor as seen the results in Figure 10.

Real Time Air Quality Report Using the Internet GIS Setup

Internet GIS Map Server Setup

Open source is not referred to the access to source codes. Free and Open Source Software (FOSS) for Geoinformatics is referred to as GRASS, OpenGIS, and Mapserver. There is a Free Trade Agreement (FTA) among software and programming developer. The word "Free" doesn't mean that the developers provide any software without receiving any profits. In fact of the word, it is meant that there is no restriction for users to use and/or modify software and make it available for others without restriction. On the other hand, ordinary or commercial software is restricted to users which they are not able to modify as specified purposes (Venkatesh, 2005). The license of open source software shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale. In this study, map server is applied for air quality web mapping and developed by the University of Minnesota through the NASA-sponsored,

a cooperative effort with the Minnesota Department of Natural Resources. The map server is a free and open source development environment for constructing spatially enabled Internet-web applications. The map server is able to compile in both Linux/UNIX and Microsoft windows. In this investigation, Linux was chosen to be compiled which is possible to modify as specified purposes. The map server software builds upon other popular open source systems including Proj4, Gdal, and the like. Besides this map server also supports database server which includes PostgreSQL and PostGIS. This PostgreSQL is a relational database management system (RDBMS) that allows data arranged in a tabular form to be related to data in other tables via common fields. This study can give an understanding example.

An RDBMS for air quality monitoring may include a table of historically daily and monthly air quality data linked to the *in-situ* monitoring. Therefore users can simply query the tabular air pollution data for their interest and view the air quality situation polluted in areas. PostGIS includes support for geographic objects to the PostgreSQL object-relational database. In effect, PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for GIS as seen in Figure 9. PostGIS has been developed by Refractions Research Inc. as a research project in open source spatial database technology. PostGIS is released under the GNU (General Public License). The MapServer system includes MapScript that allows popular scripting languages such as Perl Hypertext Preprocessor (PHP) and Java to access the MapServer. This research, for example, PHP is written for uploading, updating and deleting air quality point data to the mapserver, and query the tabular database from PostgreSQL which are shown as map objects.

Internet GIS is a relationship between GIS and Internet. Users will be able to access GIS applications without purchasing GIS software by using a web browser. Detailed maps can be generated from huge databases of spatial information and distributed all over the world (Venkatesh, 2005). The Web is a cost effective way to share or provide public access to data worldwide on the Internet. As shown in Figure 5**,** the wireless GIS Data Logging System being developed in this study is composed of two parts, i.e. hardware and software. On the hardware side, a Mandrake server version 10.0 provides the back-end support. A user has in hand a PDA operated on Pocket Personal Computer (Pocket PC) or ordinary personal computer. So as to be complete, a Global Position Receiver (GPS) and Digital camera can be also integrated through proper extensions.

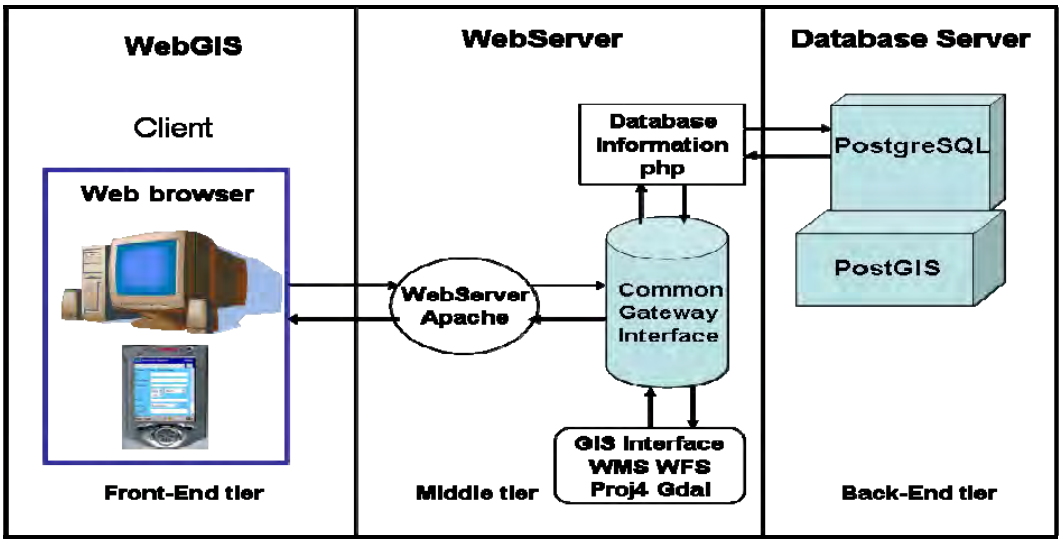


Figure 9. Flow Chart Showing Web Map Server Composition

On the software side, a Minnesota Map server 4.4.0 ensures Web Map Service (WMS), which is an Open Source Common Gateway Interface (CGI) based development environment for building spatially enabled Internet applications. The server setup is made up of PostgreSQL, PostGIS and PHP, configured with each other to execute the client's request and manage the database. The client

setup is composed of interfaces, developed using JavaScript and Hyper Text Markup Language (HTML) (Marshall, 2002). An HTML file is a text file containing small markup tags. The markup tags tell the Web browser how to display the web page. For wireless Data Updating System, it is composed of three tiers, including Front-End Tier, Middle-Tier and Back-End Tier. On the Front-Tier is the client, making a request, Minnesota Map Server in the Middle Tier passes the CGI-request over to the Back-End Tier where PHP and PostgreSQL with PostGIS read the data and execute the request.

This WMS for air quality monitoring provides functions for users to be able to simply browse zoom in-out the map objects and query graphically both historical and daily AQ database. The server setup is made up of PostgreSQL, PostGIS and PHP, configured with each other to execute the client's request and manage the database as well. PostgreSQL RDBMS has been used for managing attribute data of historical AQ levels. The front-end for the RDBMS is coded using the PHP scripting language running on Linux. The only requirement on the client's side is the ability to access the Internet using the Web-browser. This study developed air quality monitoring system which the features of the system comprises spatial and database query, data administration, relevant information links and general information regarding air pollution monitoring issues.

Real Time Air Quality Monitoring in Urban Environment Using GIS Modeling

The data input used for this study are composed of measured NO_2 concentration levels from WO_3 semi conducting sensor, the real-time AQ logged from the PCD's AQM sites, and historical AQ database acquired from the PCD. A limited number of observation sites were taken to test the method at locations which are critical for automobile pollution. The data were collected every hour, which were fed to the GIS for further processing.

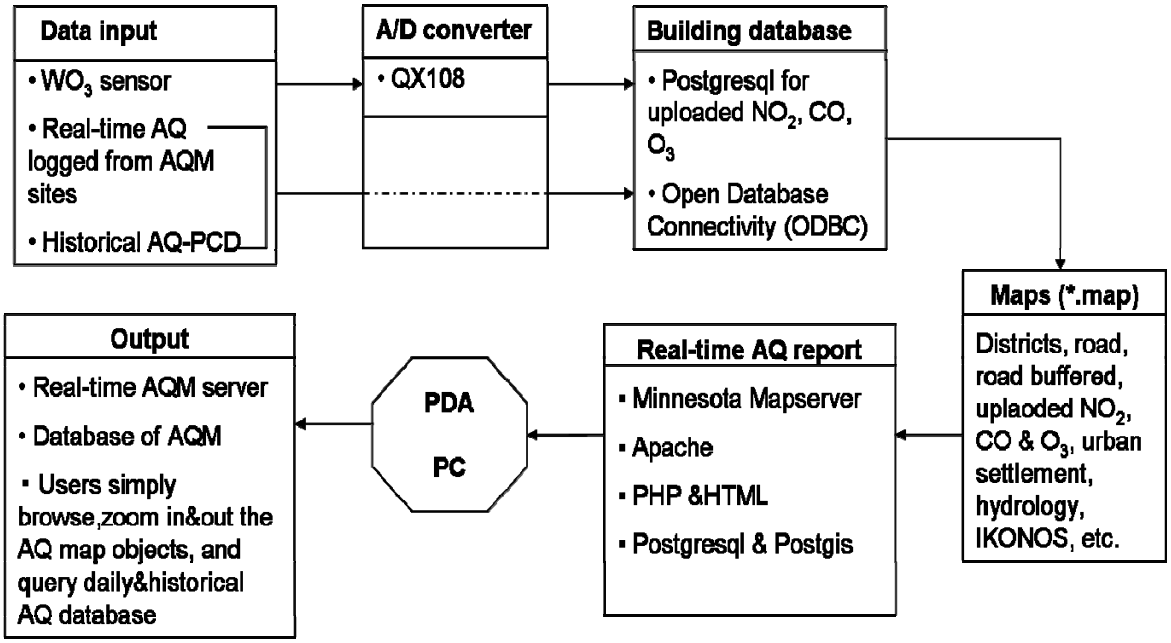


Figure 10. Conceptual Framework for Real Time Air Quality Monitoring Using GIS Modeling

In Figure 10, the WO_3 semi conducting sensor gives out electric signals, dependent on NO_2 concentration. An a/d circuit converter is employed so as to convert the NO_2 concentration values from an analog signal to digital one, and to utilize for PDA application using this a/d converter "QX108". The digital pollutant concentration data are stored in Postgresql, besides CO and O_3 are uploaded to the database as well. For real-time AQ logged from AQM sites and historical AQ of the PCD, both of them are kept in Open database Connectivity (ODBC) running on window operation

system. Pollutant concentration data, GIS base maps, satellite image 'IKONOS" and attributes were uploaded to the map server as a map file compiling together with Apache, PHP, HTML, Postgresql and PostGIS as illustrated in previous section. The results are utilized for air quality level modeling of the study area. The model developed can be applied for acquiring and monitoring real time air quality levels and also updating information through the Internet GIS using WMS. The information of air quality levels can be operated as a monitoring system and displayed in the form of GIS database. PDA and PC users are able to browse, zoom in & out the AQ map objects, and query historical and daily AQ database in graph formats.

Results and Discussion

Sensor Calibration and Sensitivity

Environmental temperature is range of -20 to 50 °C and environmental humidity range is of 0 to 90% RH, non-condensing. The sensor response varies from one sensor to another and is somewhat dependent on environmental conditions (temperature, humidity, etc.). Therefore, the user needs to calibrate the sensor for their use, in their application environment. Influencing factors must be very large range of temperature and humidity. For example, if during the day is 0 °C degree and 10% humidity and at the night time is 40 °C degree and 50% humidity, it will need to have different calibration curves, which in Bangkok it is not such a case.

Sensitivity (Frederic et al., 2000) is one of the most important issues in gas sensing devices applying in air quality monitoring field. In the term of gas sensor, sensitivity can be identified that the detection of gas concentration is measured in part per million (ppm). For Selectivity**,** it can be referred to as the detection of specific gases in mixed gas environment (Frederic et al., 2000; Yamazoe, 1991). Sensitivity can be sensitized differently to each gas (Akiyama et al., 1991) depending on operating temperature, microstructural modification, dopant utilities, catalysts (Azad, 1992) and so forth.

Adjustments

Firstly sensitivity adjustments need to be implemented including sensor zero, sensor gain and heater adjustments. After exposing zero air to the sensor and the sensor responds minimum voltage out (V_{out}) for 90s, sensor zero was adjusted to 6 mV**.** Later on full scale of gas (7.37 ppm of NO_2) was applied, the V_{out} increases from 0.006V to 4.870 V and was stable for 60s. The sensor gain sensitivity was adjusted to maximal 4.880V. In spite of the heater does not need adjustment because the voltage measured is referred to a target voltage of 4.2V, according to sensor specification.

Typical Response of WO_3 Semi-conducting Sensor to NO_2 Gas

The sensor was exposed to the gas of NO_2 in 0-7.54 ppm range to investigate the characteristics of sensor response with different gas concentrations as shown in Figure 6. Across this range of exposed concentrations, the sensor illustrates a strong, reproducible response and this type of sensor is a linear device as seen in Figure 7 as similar as the study of Wang, et al (2003), which the sensitivity of WO_3 film calcined at 500 °C as correlated with NO_2 concentrations shows strongly linearity**.** When viewed on a curve of voltage output versus concentration plot, the characteristic of sensor response can be considered as a linear correlation between NO_2 gas concentration and voltage output measured from the sensor as shown in Figure 7. It can be explained by the equation of $Y = 0.219+1.194X$ which X is referred to as voltage output and Y is called NO_2 concentration. Regression square value of 0.934 shows the accuracy of this correlation with high accuracy. The statistic results explain this calibration curve that voltage output as a constant value predicts NO_2 gas concentration 93 percentage of accuracy. The standard deviation of predictors and predicted values are 2.411 and 1.958 respectively. This sensor was found that there is the limitation to detect

low gas concentration of NO_2 (< 0.5 ppm); therefore it needs further research to improve sensor sensitivity. There are some proposed ideas which will be mentioned later on.

The Sensitivity and Selectivity of Sensor

The voltage detecting method is used to calculate the sensitivity of the sensor which is identified as V_{gas}/V_{air}, where V_{gas} and V_{air} is the electric voltage out in NO_2 gas and clean air, respectively. The result is shown in Figure 11. The sensitivity of this sensor can be explained by this figure, which is between 0.54-7.50 ppm of NO_2. Additionally, it can be referred that the higher concentration of NO_2 gas, the more sensitivity of the sensor. Due to the sensitivity of the sensor is nearly none (V_{gas}/V_{air} =1) at low concentration (0-0.54 ppm), it is identified that this WO_3 sensor has detection limit at low concentration of NO_2 (below 0.54 ppm).

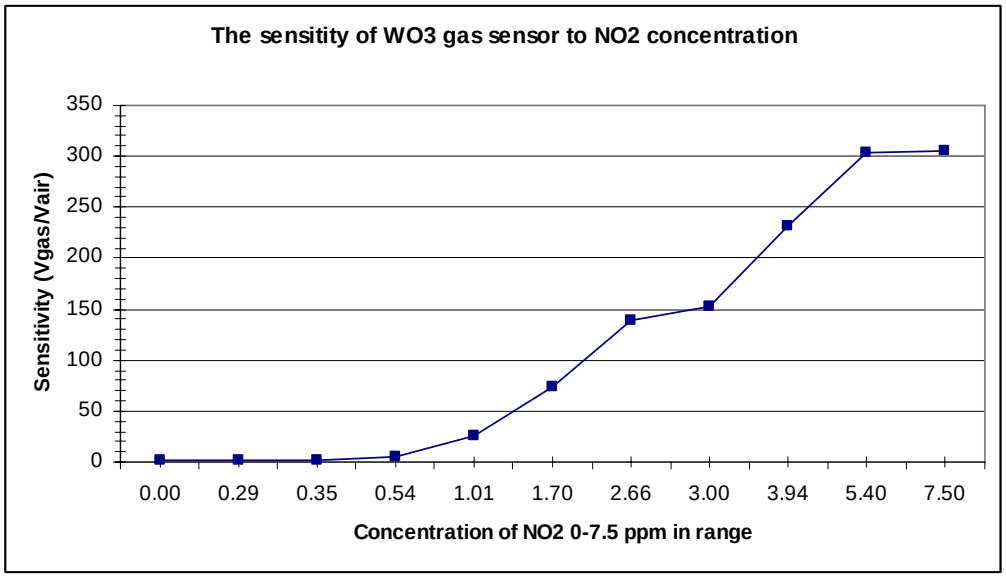


Figure 11. The Sensitivity of WO_3 Gas Sensor to NO_2 Concentration in 0-7.5 ppm Range

Real Time Air Quality Report Using the Internet GIS Setup

IKONOS image is used for air quality report which is able to identify apparently the concentrations of air pollutants polluted from sources by using 4 meters multispectral IKONOS (visible bands). NO_2 concentration levels, acquired from monitoring sites, GIS base maps, satellite image from IKONOS and attributes were input into PDA linked with GPS.

Figure 12. The AQM Map Server for PDA Users

The results were utilized for air quality level modeling of the study area. The model developed were used for acquiring and monitoring real time air quality levels and also updating information through wireless GIS using WMS. The information on the resulting air quality levels can operate as a monitoring system and be displayed in the form of GIS database. The air quality levels were categorized into three classes, overlaid with Bangkok GIS base maps and IKONOS's image. The three classes of air quality levels reported include low, moderate, and high related to the ambient air quality standard of the PCD. Hence, Internet users can browse and query air quality based maps, relating to geographic information, including districts, roads, railways, urban settlement, hydrology and historical daily air quality level as shown basic functions in Figure 12. The Internet based GIS is useful real time interaction on air quality levels and increases public awareness and participation.

As seen in the Figure 12, the fundamental functions are developed for both PDA and PC users including the functional buttons of browse, refresh map, query, zoom in, pan, and zoom out to retrieve GIS layers and IKONOS as background regarding air quality report. Because of space limitation, more functions, icons and information are contributed for PDA users such as legend definition, main menus and so forth.

- Browsing, zoom in and out, pan and query attribute of GIS layers based air quality report. This AQM system is uploaded GIS layers of Bangkok which both users are able to browse, zoom in and out, pan and query attribute data relevant to the AQ levels based Bangkok GIS base maps including: District (Khet), Urban settlement (education, offices, villages, temple, and so forth.), Expressway, Skytrain route (BTS), Air quality monitoring sites, Railway, Road, Buffer from each AQM site to report AQ levels, 2 days earlier and current AQ situation of NO_2, O_3 and PM_{10} situation, Hydrology, IKONOS image as a background
- The air quality report based IKONOS background. Here Figure 13 is an example of the air quality report based IKONOS as background and road layer. The AQM site is Dindang station where shows low concentration of NO_2 with 70-100 meter buffering from the Dindang station. Hence the air quality can be reported that the current situation is under low concentration covering 70-100 meter around the station. Afterwards users can view the current air quality level in graph formats by clicking at exact point of the concentration level and use query function as illustrated the results below.

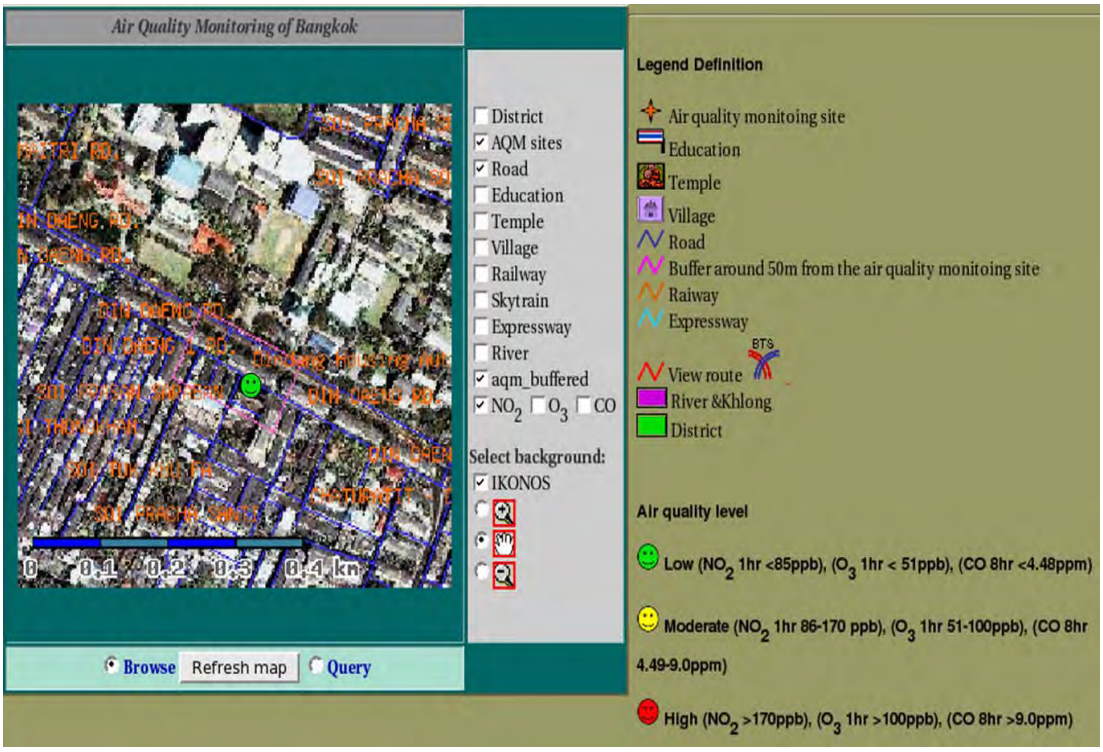


Figure 13. Current NO_2 Level from Dindaeng Station

Conclusion and Discussion

Current air quality of Bangkok is better than a decade ago. However, Bangkok still has been facing serious air pollution problems. The traditional air quality monitoring system, controlled by the PCD, is extremely expensive. Analytical measuring equipment is costly and time consuming, and can seldom be used for air quality report in real time. The PCD has been forecasting and reporting real time air quality levels through the Internet in the form of simple maps. For better contribution of real time air quality report, the air quality report should be illustrated more in details and reported as spatially based other relevant GIS data layers, including information such as air quality maps, relevant to other information for better understanding the air quality level situation. For those reasons, this work was succeeded to propose an easy monitoring system using low cost portable gas sensing system based "WO_3 semiconducting gas sensor" so as to carry out air pollution monitoring over an extensive area and to be able to report real time air quality data through Wireless Internet GIS.

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Spatial and Environmental Planning

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ABSTRACT *Demand of space is steadily increasing due to the increase of number of population; on the other hand, land area is constant; this situation has led to the scarcity of land as natural resources, and brings about the competition among the users. An appropriate anticipation should be in place to avoid unprecedented consequences, for this purpose land use planning has been a tool to cope with this situation. However, land use planning is not the only element to achieve a desirable development, with the demand on integrated planning, spatial planning has been recently emerged to substitute land use planning. Moreover, as environmental concern grows and sustainability becomes buzzword, attempt to maintain balance between human welfare and natural environment sustainability has been perpetuated, environmental planning is then complementing spatial planning. This paper tries to elaborate this emerging issue by looking into the potential use of spatial and environmental planning as a planning and development instrument along with zoning.*

Introduction

People and other living or non-living things occupy certain quantity of space on the earth. While number of people grows over time, the earth is dynamically steady with respect to land and water surface areas, as the result, crowded places are ubiquitous on the earth, particularly in cities. This dynamic process returns in various implications for human-being and their environment. Consider this situation is not controlled and regulated, chaotic conditions will appear everywhere; spatially and environmentally injustice will be a daily menu. The stronger prey the weaker, since jungle law is the only existing law. Fortunately, this hypothetical situation is not happening because as a civilized world, people realize that planned, managed or organized space and environment must be in place. From this point, spatial and environmental planning is emerged.

Spatial planning stems originally from land use planning. Land use itself refers to how the land is being used and developed in terms of the type of activities permitted for certain purposes such as residences, industries, commerce, agriculture, parks, and the likes. In line with this understanding, land use planning is defined as the process of organizing the use of lands and their resources to best

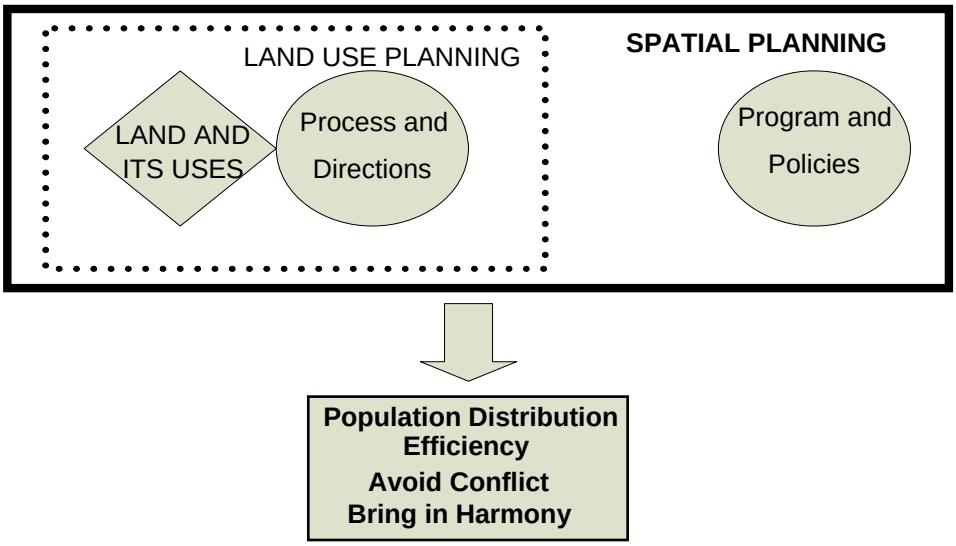

Figure 1. Land Use, Land Use Planning and Spatial Planning Correlation

meet users' needs over time; this is unquestionably stated that land capabilities and other valuable assets of the land should be clearly reflected in order to attain efficient use of the land and best meet the user's need. Spatial planning goes beyond conventional land use planning; spatial planning aims at the integration of policies for the development and use of land with other associated policies and programs which influence the nature of places and how they function. By this comprehension, spatial planning is defined as the methods used by the public sector to influence the distribution of people and their activities, achieve efficiency, avoid conflict and bring in harmony in spaces of various scales. These explanations can be summarized through a schematic depiction on correlation among land use, land use planning, and spatial planning as given in Figure 1.

As "green" issues have been materializing predominantly in the latter part of twentieth century, the environmental concerns have demanded in meticulous attention from the planners and decision makers, particularly after the emergence of buzzword of sustainable development. This issue is resulting in the need of integration of notions of sustainable into planning process, thus environmental planning complements coaxially with spatial planning in achieving sustainable development. It is deemed inevitable because in all situations whether global or local there is an uneasy task to maintain a balance between dynamic stability of natural ecosystems and the advancement of the community welfare where it depends either directly or indirectly on the exploitation of natural resources (Selman, 1992). Spatial and environmental planning should go hand-in-hand at very beginning stages and every steps of planning process to become a *"enviro-spatial"* planning. This concept shows two-in-one element of planning process. This should be a technical tool for implementing the plan in every level of spaces in either rural or urban area. The term of technical tool is raised in the sense that there should be other supportive tools such as legal tool, which is categorized as non-technical tool.

The tool is better devised by more practical instruments of zoning. Zoning was not originated tool for planning rather than planner attempt to use it for implementing plans with mixed results Patterson (1979). However, in fact, zoning was developed in line with land use planning as a means of controlling nuisances and protecting property values through the regulation of land use. Other than zoning system, the term of "district" is frequently used to distinguish different use of planned spatial element; however, to differentiate and avoid confusion between "district", with respect to local administration as usually used in some countries, and "district" as spatial planning term, the use of zoning would be used entirely throughout this discussion. However, with respect to spatial planning, the terms of zoning and district are interchangeable. In the same manner, spatial planning will also be used in this particular context rather than conventional land use planning; this is to reinstate that spatial planning has a broader coverage than conventional land use planning, at least in the consideration of peripheral influencing factors.

Zoning as a Planning Instrument

In spatial planning context, zoning is defined as statutory descriptions of the allowable uses of land as set out by local councils or planning authorities. The descriptions set zones that establish permitted, prohibited and special uses within these zones. Land uses in each zone are regulated according to type of use, density, height, lot size, placement, building bulk, and other development standards. Which such a clear description, zoning may effectively act as a planning instrument in spatial development in either urban or rural areas.

The underlying idea beneath this zoning concept is to create a mutual symbiosis among category of uses (zones) and avoid land use conflicts that lead to adverse and unproductive consequences for people. However, the concept of strict zoning is debatable since pros and cons are somehow balance in quality. The proponents of strict zoning argue that if this instrument is consistently implemented the potential conflict due to contradictory use of the land can be avoided; there are abundant examples on the conflict created by contradictive land use, to name an example is how industrial activities are undergoing within dominantly residential use, if air and water pollutions generated by

industry would have irreversible adverse impacts on residences nearby. While, the opponents of zoning systems argue that traditional land use zoning has created numerous urban structure that generate inefficient and unsustainable cities, predominantly in developing countries cities. With this continuing debate, moderate urban planners and scholars have come up with new set of idea on the concept of, so called, cohabitation, which combines the potential advantages of both. In this concept, all elements of the urban ecosystems may live in harmony on the same systems and use the same resources. However, it is clear that dirty industry, under this concept, cannot be cohabitated with residential area that requires cleaner environment. The discussion on cohabitation, however, will not go further in detail.

Although there is no strict categorization of zoning since it would depend on local councils or planning authorities to define, however, zoning in urban area can be broadly divided into several categories, for example according to type of use such as:

- Residential zone; where the only type of buildings or uses for mainly residential and associate purposes will be allowed in this zone. The residential building will dominate in this zone, however, as a neighborhood type of development emerges, the associate resident activities and facilities such as amenities and utilities are also allowed.
- Commercial zone; where commercial activities the only allowable activities in this zone, while other activities are prohibited or limited. Commercial zone, to some extent, is compatible with other category of uses such as residential; with this potential compatibility, the mix-use zone – generally between commercial and residential categories– were introduced in many cities.
- Industrial zone; where industries and their associate activities are permitted to undergo in this zone. Industries in developing countries are visibly connected to dirty, polluted and contaminate the environment, thus in many cases industrial zone is incompatible with other category of uses, with this thought, the idea on industrial estate and industrial town is coming into sights. Industrial estate is achieved through the physical isolation of industrial activities from others in order to avoid undesirable impacts of the industries such as pollution, contamination and environmental degradation. In the same way of thinking, industrial town is designed to cater the utmost of industrial estate function whilst delivering a town function, especially for their workers; therefore other limited activities like in a town are allowed to go through.
- Green zone; where the only open space, greenery and, to some extent, supporting facilities are allowed within this zone. People activities are allowed as long as compatible with the purpose of zone. Green zone is categorized as amenities, and now becoming an unavoidable demand of the city to improve the quality of life of the citizen, since one of the indicators of citizen's quality of life is per capita area of green zone.
- Agricultural zone; this category is very rare exist in urban area, however there is a propensity in the popularity of urban agriculture or urban forest to be co-exist with other elements of the city. As the name implies, agriculture zone is extended to accommodate agriculture activities within a specific area.
- Forestry zone; this has similar manner with agriculture zone; forestry zone in urban area is manifested with urban forest. As lung of the city, urban forest becomes more important to reduce urban heat island[1], and plantations have also good assimilative capability to absorb certain air pollutants, hence reducing air pollution to some degree and improving urban air quality.

[1] Urban heat island refers to the phenomenon for urban areas to have warmer air temperatures than the surrounding rural landscape, due to the low albedo (reflective capability upon sunlight) of streets, sidewalks, parking lots, and buildings. These surfaces absorb solar radiation during the day and release it at night, resulting in higher night temperatures.

Following Figure 2 shows zonings as reflected by stereotype urban structures according to Burges and Hoyt Model.

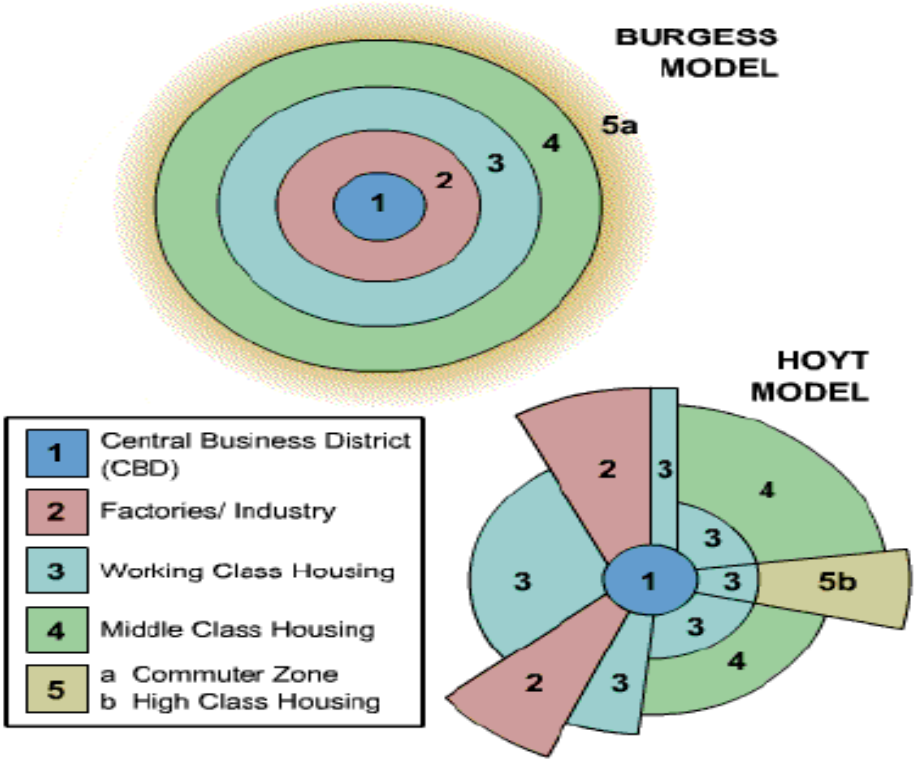

Figure 2. Typical Zoning in Urban Area based on Burgess and Hoyt Model

The first model, as represented by Burgess Model, shows concentric type of urban structure with clear zoning systems. In terms of urban physical mobility, this model implies a clear separation between origin (housing zone) and destination (factories, industries zone and central business district), the opponents of this system argue that it will create unnecessary motorized travel that creates energy inefficiency. The second model, Hoyt Model, reflects more sectoral than concentric urban structure. The vicinity between origin and destination is created to some degree, it can be seen from the closeness between working class housing (residential zone) and factory/industry (industrial zone).

Zoning system can be implemented through the establishment of Zoning Ordinance, which has typically legal power for effective implementation, or Zoning Standard with less legal power if it is not supported by legislative power. The typical purposes of zoning ordinance are to regulate the use of buildings, structures and land for different purposes, as well as to regulate location, height, bulk and size of buildings and structures, the size of yards, courts and other open spaces. In addition to that, the purpose of zoning ordinance is toward the achievement of city vision. It is true that no model of zoning ordinance generally fits to most localities, because the pattern of land use and level of development will differ from city to city and region to region, therefore the zoning ordinance must be tailored to fit to the locality. This requirement will necessitate an extensive survey, public consultation and participation at every level of the process.

In order to attain effective planning instruments, during the course of establishment zoning ordinance or standard, some key aspects must be considered (Patterson, 1979), those key aspects include:

- Drafting the ordinance. Enabling legislations must be followed very carefully otherwise it will not legally valid. The substantive requirements of the ordinance must also be rigidly followed.

Planning agency in cooperation with competent professional planners, legal professional as well as public must be responsible for the drafting of ordinance.

- Interim zoning. If there is no zoning ordinance in existence in the locality, the need of interim zoning ordinance is unavoidable, particularly if urban development cannot wait for little longer of promulgation of zoning ordinance. This interim ordinance should not designate zoning on the map rather than maintaining status quo toward new zoning ordinance.
- Necessary research. Preparation of good ordinance would require two kind of principal information: information on the community itself and information concerning good zoning ordinance practice based on responsible professional observation and successful example on ordinance provision. Research on this kind of information would be required. The information from community must include detail accounting of land use, parcel by parcel, auxiliary uses of the land, building coverages, building heights, yard sizes, and number of occupants, lot dimensions and street width. This information must be gathered and analyzed to determine the predominant pattern of this kind of data, geographic information systems tool can be employed for this purpose.
- Form and content. Zoning ordinances are generally made up of two parts, those are: the map showing the boundaries of the various zones within the locality, and written regulation which explain the way in which property within each zone were used and developed. The map and regulation must be prepared in close coordination. The zoning map must take into account the cumber of zone, the space to be allocated to each type of zone, the geographical relationships of the zone to another. Consideration of use, height, coverage, density and other factors are usually combined for each zone.
- Adoption. Formal public hearing must be held after the tentative draft of the zoning ordinance has been completed. If the hearing results in revision of the proposed ordinance then a second round of hearings on the revised proposal is necessary. The adoption of the ordinance by legislative body of the locality follows the same procedure as for any other kind of local ordinance.
- Despite its popularity in spatial planning practices, zoning is essentially negative tool for the purpose of carrying out comprehensive plans in both developing and developed areas. In developing area, due to economic reasons, low density development usually occurs even where the plan envisions high density development in that particular area. While in developed area, zoning is poor tool for altering existing uses to those envisioned in the plan, especially if they are to be lower intensity uses. However, there are recent, scattered efforts to modify zoning and introduce new instruments in reaction to these shortcomings such as:
    - Amortization of non-conforming uses;
    - Introduction of performance standards;
    - Substitution of density for use as the primary characteristic of zone;
    - Introduction of conditional uses which require special permits and review by either the planning commission or the board of appeal;
    - Introduction of historic, cultural and esthetic zoning requiring development review by panel of experts;
    - Introduction into the ordinance incentives for developers who agree to provide certain amenities.

Those instruments are certainly more flexible and applying economic instruments and performance standards compared with fully regulated by rigid zoning ordinance, however, which instruments would be used, it depends on the local condition.

Industrial Zoning

As briefly mentioned earlier that there are three types of "zones" associated with industries, those are: industrial zoning, industrial estates and industrial town. Industrial zoning is the lowest level of land allocation for industries purposes with respect to possible adverse environmental consequences, while industrial estate vis-à-vis industrial town are the most advance development. Dhanasunthorn (1986) argues why industrial estate was chosen as the best alternatives for industrial development, here are some reasons:

- It creates better environment for industrial development and expansion outside the city;
- It solves the problems of urban congestion and pollution [caused by scattered industries];
- It re-directs the labor force to industrial estates or its environs;
- It maximizes infrastructure and utility investments for concentrated utilization;
- It opens new lands for more efficient commercial use and possibly creates new satellite communities.

However, since industrial estate requires quite large amount of investment, industrial estates are not always feasible and possible to be developed. For poor countries and where the socio-economic and political stabilities are luxury, the real estate development is still in an imagination, thus scattered industrial zoning still the best options for industrial purposes.

Zoning for industry were originally the most cumulative in regard to number of permitted uses and the least restrictive compared with other uses. Industrial zones gave little or no protection to industry and required little or no amenity provided by the authority, since the industries would provide it for themselves as they need it. Industrial zone have customarily been divided into classifications of heavy industry or light industry. More recently "industrial parks" have commonly been added which tends to be very restrictive in comparison to traditional industrial zone.

It is common for some industries, deemed as nuisance or dangerous industries, to be allowed only as conditional or special uses requiring special permission, rather than being allowed by right. In this case the use of performance standard are required to control the externalities created by industries such as noise and vibration, smoke and fumes, odor, dust and dirt, glare and heat, fire hazards, industrial wastes, outdoor storage, traffic generation and appearance. The use of performance standard requires sophisticated techniques of measurement and well-trained personnel in sufficient numbers to ensure continuing compliance. This is costly and beyond the capability of most of smaller cities but is gaining favor in large cities or metropolitan area. With this situation, limited control or more relaxed performance standard of environment could be applied. However, inherent problems associated with scattered and uncontrolled industrial zoning such as:

- Scattered industries would have environmental disturbances to the surroundings particularly with residential areas in the forms of undesirable harmful air or water pollution;
- Movement of material for industrial inputs and outputs as well as people involved in the industrial process create traffic congestion in certain areas;
- Industries' expansion would be difficult due to the limited land availability, thus requires more investment for relocation;
- Facilities within the city may be overloaded and cannot accommodate the huge demand of scattered industries;
- Control would be more difficult compared with centralized complex such as offered by industrial estate.

Although scattered industries within industrial zones are the most creating environmental disturbance, however in many cases, this type of industrial development still the best choices prior to more advance and cleaner industries. It could therefore be synthesized that industrial development with respect to spatial planning follows step-wise continual progress as the followings:

- First phase: scattered and uncontrolled industries, where factories are embedded incompatibly within residential or other areas. Environmental consequences become uncontrollable;
- Second phase: industries within industrial zone, where all activities within this zone are consistent with designated activities. Environmental consequences in this phase become more controllable, therefore irreversible adverse environmental impacts could be mitigated;
- Third phase: industrial estate or industrial town, where industries are bounded within a certain area only. Share in industrial infrastructures become more common, and due to economies of scale product more competitive; on top of that, most environmental consequences could be fully controlled.

Above discussion implies that industrial development may be implemented through three types of modes those are: industrial zone, industrial estate and industrial town. The level of development would depend on the capability of respective countries, however with the rising concern on environment less polluted industries with cleaner and green products are desirable. This is the starting point of the demand on environmentally compatible spatial planning, in other word environmental planning as the complement of spatial planning is inevitable, and an "enviro-spatial" planning would be the new trend in the near future.

Environmental Planning as Complement of Spatial Planning Towards Sustainability

According to FAO, environmental planning is defined as all planning activities with the objective of preserving or enhancing environmental values or resources. With this definition, environmental planning is not quite new emerging issue, since it was envisioned as the concern on environment and sustainable development emerges. The issue is now on how environmental planning should explicitly be reinstated in national policy, plan and program and clearly implemented along with traditional planning such as spatial planning. Environmental planning can be implemented through local environmental plans and regional environmental plans with adequate integration to national environmental planning policies. However, the most recent example of global environmental planning which are implemented in local level is Local Agenda 21 as the results of "Rio Declaration" and were adopted by 178 governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, 3 to 14 June 1992 (for further discussion please visit http://www.un.org/esa/sustdev/documents/agenda21/).

As other planning does, environmental planning adopts similar steps of rational planning process such as (adopted from Selman, 1992):

- Formulation and definition of the objectives;
- Generation of options those practically and environmentally acceptable options for achieving the objectives;
- Options evaluations by analyzing possible and potential options for the benefits of environment;
- Selection of preferred options, choose best practicable environmental options on the basis of impacts, risks and costs;
- Reviewing of the preferred option;
- Implementation of the best options;
- Monitoring and evaluation of the performance against environmental quality target and standards;
- Auditing by looking back at the basis of choosing the options, quality of data, assumptions and evaluation procedures.

Since those processes are compatible with traditional spatial planning process, therefore it can be integrated smoothly into the spatial planning. Landscape design with particular attention to

environmental quality is an example of the integration of environment into space (Turner, 1998), this would lead to a new jargon of an *enviro-spatial* design process.

A simple example on the integration of environmental into spatial *(enviro-spatial)* planning can be illustrated with the example of low and high density residential area, as designated by spatial planning, given the condition of flood vulnerability of this area. It is assumed that severe scarcity of land resources exist in urban area, so that the occupation of flood vulnerable land is unavoidable. Besides, it is convinced that spatial planning will be able to cope with the problem. The problem that should be responded by environmental planning in this regard is that flood water as the result of excessive rainfall should be evaded through appropriate environmental planning deliberation. In this particular case, appropriate response of environmental planning is reducing run-off[2].

Flood depends on run-off coefficient, and run-off coefficients are dictated by urban land use, while urban land use is the most difficult task to control. Not many local authorities are able to appropriately control the land use in order to reduce flood magnitude. Run-off coefficients are not easy to modify, while rainfall intensity is a stochastic process that people cannot totally modify it. Thus, maximum discharge theoretically cannot be modified, but the release of discharge can be regulated through environmental planning which the community should comply with, so flood can be step-wisely released, how it works?

All individuals are asked to provide storage; to be just and fair distribution, the storages which are provided by the community should be based on the area of their individual land plots. Local authority, in this case, designates the design rainfall that will be regulated by the decentralized system, for example design rainfall is designated as of ***h*** mm/hr. The individual, therefore, provides storage according to their land plots area, and defined by the following formula.

$$S_i = 0.001 \times A_i \times h \times D \qquad (1)$$

Where
- S_i Storage that must be provided individually (m^3)
- A_i Individual land plots area (m^2)
- h design rainfall, determined by local authority (mm/hr)
- D design of rainfall duration (hr)

The best situation will be created if those storages are installed underground since it will let the collected rainfall to recharge to groundwater, therefore in the long run, it will provide sufficient groundwater source and ultimately leads to sustainable development. Rain water that fall within individual land parcel is collected, from roof-top is collected through pipe in discharged into underground tank, the similar process is undertaken by collecting rain water from land surface of individual premises through surface drainage canal.

First example of *enviro-spatial* planning is applied to low density residential area as designated by spatial planning through zoning, in this condition, most of houses are detached single dwelling unit, as illustrated in Figure 3. Figure 3 shows the conversion of over-land flow to infiltration (recharge into ground water), there are two-pronged objectives in this regard, reducing flood intensity while maintaining groundwater therefore degree of vulnerability of the residential area is greatly reduced as flood intensity reduced. The ultimate condition of this state is utilizing land resources efficiently without disturbing environmental equilibrium and even improving environmental condition. Without intervention of *enviro-spatial* planning, the environmental condition would be getting worse over time. This fact proves that integration of environmental planning into spatial planning resulting in cumulative favorable impacts to human and the environment.

The effectiveness of individual storage system is depending on the hydraulic conductivity (permeability) of tank storage, groundwater table, as well as rainfall intensity, duration and frequency. The more permeable soil in the storage, the process of emptying the storage will be faster; therefore successive rainfall can be stored properly in the tank. The higher groundwater table and less permeability of the soil will cause the emptying process of the tank will not work well.

[2] Run-off is defined as the quantity of water flows over the land as the result of excess rainfall that cannot be absorbed by soil.

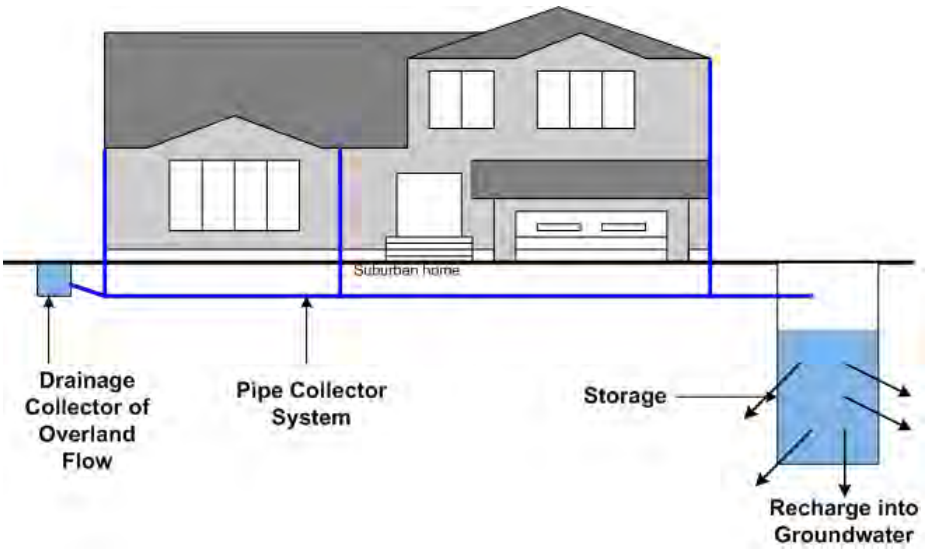

Figure 3. Rainfall Collection Systems

In densely populated urban area or high density as designated by spatial planning, where detached individual houses very rare, and multi-storey building type are dominant. The storage system can be placed at either roof-top or basement. However different operation is applied for the roof-top storage that is at the time when rainfall is stop and underground storage is empty, the roof-top storage can then be released to underground storage (Figure 4). The same principle of the storage calculation for multi-storey building with detached individual houses can be applied. The similar treatment should also be applied to commercial and other land use categories. With this arrangement, and assuming that individual storage system works well, the reduction of flood magnitude will be directly proportioned to the built-up area excluding road and other non-occupancy area. For example if built-up area in an urban system (excluding non-occupancy) is 70 percent, theoretically, the reduction of flood magnitude is about seventy percent as well. This is a significant amount of flood reduction. This reduction can also reduce the need of drainage infrastructure then will also reduce the costs, reduce flood damage and losses, increase groundwater resources, increase environmental sustainability, and it will lead to sustainable development.

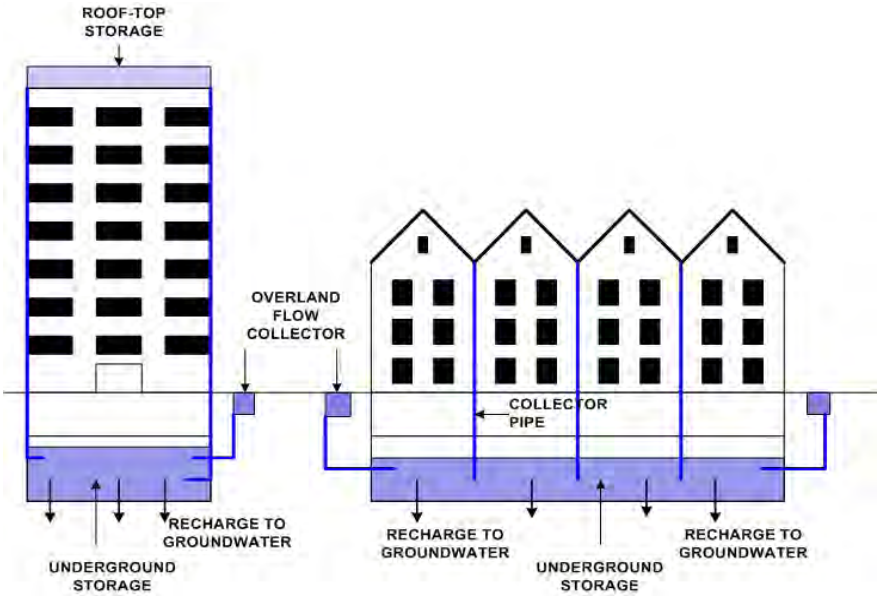

Figure 4. Storage System in High Density Urban-type Residential Building

If all the above mentioned activities are implemented appropriately, pleasant-sounding life will be achieved due to harmonious coexist between human and nature. Flood will no longer be viewed as a disaster creator rather than normal natural phenomena that human must adapt. From the discussion it is obvious that combination of spatial planning and environmental planning if they are implemented appropriately may lead to betterment of human life and environment that directly or indirectly will support sustainable urban development.

Conclusion

Spatial planning and environmental planning as development tools have demonstrated their capability to solve potential urban environmental problems through suitable implementation with appropriate legal support, compliance and performance standards. However, the utmost potential capability of both can be achieved through proper integration of environmental planning into spatial planning. This integration has a potential possibility to have cumulative favorable impacts for human being and its environment. Although further verification would be required, however, the tendency of combination of spatial and environmental planning to become *enviro-spatial* planning, a future tool of development planning particularly in the field of urban environmental planning and management, would be possible.

This integration does not necessarily mean that other disciplines are not required at all, since *enviro-spatial* planning would require support from other disciplines as peripheral complements, and *enviro-spatial* planning would be in the core part of environmentally and spatially related planning. Further evaluation and investigation on this integration to assess its strengths and weaknesses would also be necessary; the evaluation should be based on experiments through real cases by employing individual planning tool in comparison to combined planning tools.

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Environmental Law and Multilateral Environmental Agreements (MEAs)

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ABSTRACT *The concept of environment is like the proverbial elephant and the seven blind men. Everyone describes it according to the perspective familiar to him/her. The underlying aim of environmental law is to regulate society to achieve sustainable development i.e., development which satisfies present day needs and wants without jeopardizing the chances of future generations. This module focuses some environmental laws and Multilateral Environmental Agreements (MEAs) with focusing of some sustainable principles. It also reveals some trends of environmental law making.*

Introduction

Environment is defined as the totality of nature and the natural resources, including the cultural heritage and the infrastructure essential for socio-economic activities. Law generally performs two basic functions in society. Firstly, it is an instrument for social control and for regulating social behavior. This can be done by adopting explicit rules of conduct. Secondly, law is an instrument for dispute settlement. Social relations often engender conflict of interests. If mechanisms for their resolutions are not provided for such conflicts may result in social anarchy.

Environmental Law

Since its creation at the United Nations Conference on the Human Environment in Stockholm in 1972, UNEP has played a leading role in the development and implementation of environmental law. The concept of sustainable development as defined in the Brundtland report of 1987 means "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Agenda 21, a soft-law instrument adopted at the UNCED Rio conference in 1992, mandated UNEP to promote further development of international environmental law. Agenda 21 also noted that laws and regulations suited to country specific conditions are among the most important instruments for transferring environment and sustainable development policies into action.

Evolution of Environmental Law

The evolution of environmental legislation in developing countries can be categorized into two periods. Pre-Stockholm era - largely characterized by use oriented natural resource laws. The Post-Stockholm era - the shift was towards "System oriented" legislation, which gave birth to the concept of a framework for environmental law. Thus the UNCED process witnessed an important shift from environmental protection to sustainable development. Legislative responses to environmental problems in developing countries have been characterized by fragmented and uncoordinated sectoral legal regimes.

The most significant legal development in the field of environmental management at national level is the development of the environmental legislation framework. The framework is a response to the deficiencies inherent in the sectoral approach to environmental management. Several new concepts have emerged in the development of the Framework Environmental Laws drafted and

adopted by developing countries worldwide, which now include the basic principles on sustainable development.

Sustainable Development Principles

- Right to clean and healthy environment and duty to defend it
- Right to sue
- Polluter pays principle
- Inter-generational and intra-generational equity
- Precautionary principle
- Public Participation
- Access to environmental information

Right to Clean and Healthy Environment and Duty to Defend

Examples are found in the Constitutions and Framework of Laws in several countries. Every person shall have the right to a clean and healthy environment and shall have the duty to defend and preserve it for the present and future generations.

Right to Sue

A new development in framework laws is to include the right to sue. A person bringing an action may do so even though he/she is not able to prove that the activity or omission has caused or is likely to cause him/her a loss or injury. This is also known as locus-standi i.e. standing for individuals to have access to justice.

The 'Polluter Pays' Principle

Polluter Pays Principle means that the cost of clearing up any element of the environment damaged by pollution, and compensating the victims of pollution etc. is to be borne by the person responsible for such pollution. It essentially requires the harm-doer to bear the burden of their detrimental actions or inaction. For example Section 69 of the Enhancement and Conservation of National Environmental Quality Act of Thailand requires that, "The owner or possessor of the point source of pollution has the duty to construct, install or bring into operation an on-site facility for waste treatment or waste disposal.

Inter and Intra- Generational Equity

- Inter-generational Equity means that the present generation should ensure that in exercising it's right to beneficial use of the environment, it should be maintained and enhanced for the benefit of future generations. For example the basic Environmental Law (Law No. 91 of 1993) of Japan, states in Article1 (Purpose) that, "the purpose of this law is to comprehensively and systematically promote policies for environmental conservation to ensure healthy and cultured living for both the present and future generations".
- Intra-generational Equity means that all people within the present generation have the right to benefit equally from the exploitation of the environment, and that they have an equal entitlement to a clean and healthy environment.

The Precautionary Principle

Precautionary Principle means that where threats of damage are there to the environment and lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent such degradation. For example the Environmental Protection Law of the People's Republic

of China 1989 (Article 31) states that enterprises and institutions that are likely to cause severe pollution accidents shall adopt measures for effective prevention.

Public Participation

Public Participation means the right to participate from an early stage in environmental decision-making process. For example the Cambodian Law on Environmental Protection and Natural Resource Management (1996), mentions that The Ministry of Environment, following a request from the public, shall provide information on its activities, and shall encourage public participation in environmental protection and natural resource management

Access to Environmental Information

It implies the right of a person to receive environmental information that is held by public authorities, including information on the state of the environment, policies or measures taken. For example the Philippines Bill of Rights (Section 7 and Article 3) prevents that the right of the people to information on matters of public concern shall be recognized. Access to official records, and to documents, and papers pertaining to official acts, transactions or decisions, as well as to government research data used as basis for policy development, shall be afforded to the citizen, subject to such limitations as may be provided by law.

Recent Trends in Environment Law Making

The following aspects are covered under the process and current trends of environmental law making.

- Strengthening co-ordination of environmental institutions – inter-linkages;
- Environmental standards setting;
- Integration of environment into development planning;
- Economic instruments for environmental management;
- Preventive measures and environmental impact assessment (EIA);
- Environmental monitoring and inspection;
- Environmental audit;
- Environmental education and public awareness;
- Environmental restoration;
- Creation of Environment Fund;
- Dispute Settlement-Environmental Tribunal/Green Bench/ Environmental Ombudsman;
- Sanctions and penalties; and
- International Environmental Conventions.

Strengthening Coordination of Environmental Institutions – Inter-linkages

The effective implementation of Environmental Legislation depends on the existence of appropriate institutional arrangements. The Ministry of Environment in close collaboration with specific Environmental Agency plays the central role. The functions of the Ministry of Environment/ Environment Agency are:

- Coordination, monitoring and supervision of all environmental activities;
- Implementation of environmental policy;
- Ensure the integration of environmental concerns in national planning through coordination with all Lead Institutions;
- Initiate legislation proposals and set up standards;

- Review and approve EIA;
- Promote public awareness programs etc.

In addition to the activities of the Ministry of Environment, a National Environment Council usually exists in many countries for cross-sectoral coordination. This is necessary for holistic approach for environmental management. The Council could be inter-ministerial and chaired by the highest authority in the government. The Council is an ideal institution for formulating policy, providing direction and coordinating activities of all ministries dealing with the environment and natural resources.

Environmental Standards Setting

The Environmental quality standards facilitate the effective enforcement of environmental requirements. A variety of standards are required to monitor and control different types of environmental pollution and degradation. The standards are:

- Air, Soil and Water quality standards;
- Emission standards for motor vehicles;
- Standards for discharge of effluent into water;
- Standards for waste;
- Standards for noise;
- Standards for Buildings and other structures; and
- Standards for Industrial products etc.;

Integration of Environment into Development Planning

The integration of environment into development planning is the most important tool for achieving sustainable development. Environmental protection and economic development must be dealt with in an integrated manner. If socio-economic factors are not considered, the environment will not be effectively protected. The Ministry of Environment should provide their inputs when the National Environmental Action Plan (NEAP) is developed.

Economic Instruments for Environmental Management

The following instruments could be used for effective environmental management.

- Tax incentives (to encourage good environmental behavior);
- Tax disincentives (to deter bad environmental behavior); and
- Imposition of user fees (for use of environmental resources). etc.,

These issues are dealt in greater details in the following the chapter of this manual.

Preventive Measures and Environmental Impact Assessment

EIA process is necessary to provide an anticipatory and preventive mechanism for environmental management. EIA is a process with a set of procedures whereby information on likely environmental impacts become a pre-requisite on projects. The assumption is that assessment helps decision-makers to arrive at informed choices so that development projects cause minimal

degradation of environmental resources, which could be further minimized by appropriate corrective measures.

Environmental Monitoring and Inspection

Reasons for poor enforcement of environmental laws have been identified as lack of proper enabling regulations, insufficient trained human resources for inspection and monitoring, lack of public awareness and ignorance of environmental laws. The Ministry should in consultation with the Lead Institutions, monitor the operation of any project or activity with a view to determine its immediate and long term effects on the environment. Environment Inspectors should have powers to enter any land or premises to determine how far activities carried out on that land or premises conform to Environmental Standards and EIA rules and procedures.

Environmental Audit

Environmental audit assesses environmental impact and identifies problem areas. It should be conducted by independent personnel such as environmental auditors. It benefits the identification of environmental risks and can be used as a base for development of environmental management policies and regulations.

Environmental Education and Public Awareness

Formal and informal environmental education and public awareness programs are made compulsory through legislation Integration of environmental education in the school and university curriculum is very much essential as a part of wider and in depth awareness building process to protect and conserve environment against degradation.

Environmental Restoration

The Ministry/Agency may issue to any person who has damaged the environment and order to restore the damage caused to the environment. The courts may issue restoration orders as they decide appropriate.

Creation of Environment Fund

Several countries are creating special environment funds for the Management of the environment and Natural Resources since the budgetary allocations are not enough. This can be practiced at all levels starting from a community at the local level.

Dispute Settlement (Environment Tribunal/Green /Environmental Ombudsman)

Environmental problems arise from human production and consumption patterns. Several countries have established specialized environment courts because of the special nature of environmental cases. Administrative machineries or quasi-judicial bodies are also created to handle appeals from decisions of administrative authorities. Environmental Tribunal with clear rules and procedures can

handle dispute cases and pass judgments for actions and corrective measures. Office of the Environmental Ombudsman can be substituted for the tribunal of the similar process.

Sanctions and Penalties

The penalties should be uniform through out the laws and should reflect the relative severity of the harm, history of non-compliance, and remedial costs or illegal profits.

International Environmental Conventions

The conventions are held periodically to discuss environmental issues of global and transboundary in nature. The countries do participate for negotiations leading to a set of agreements with resolution of conflicting issues. The conventions lead to develop proposals for domestic legislation.

Multilateral Environment Agreements (MEAs)

UNEP has facilitated and played a catalytic role in the development of over 300 multilateral environmental agreements and several soft law instruments. Some are currently under negotiation.

Regional Treaties/Agreements

UNEP is currently assisting the region in negotiation of sub-regional environment treaties based on the millennium development goals (MDG7). All 191 United Nation Members have pledged to meet the Millennium Development Goals by the year 2015. MDG7 states that members shall ensure environmental sustainability. However, the MDG7 does not define any specific targets.

Governments of 3 sub-regions in Asia namely: South Asia, Central Asia, and the Greater Mekong Sub-region have requested assistance in negotiating treaties or agreements for cooperation amongst them in defining clear, geographically and culturally relevant targets on land, air, water and biodiversity.

Many environmental problems are more of a global, regional or sub-regional character than national, and therefore, through co-operation among the countries of the region, they can be addressed with both less effort and a lower cost than if each country works on its own.

Despite the tremendous development of environmental laws, the compliance and enforcement of environmental laws is relatively low and weak in most countries. To assist developing countries in this direction, UNEP has developed guidelines on compliance and enforcement of environmental laws.

UNEP Guidelines and Draft Manual

The guidelines are advisory in nature that provides approaches and techniques for enhancing compliance with multilateral environmental agreements and strengthening the enforcement of laws and regulations implementing those agreements.

A draft Manual has also been prepared to improve and facilitate the use of UNEP Guidelines. Regional Meetings were organized to get the feed back from national experts to finalize the manual, which is a very useful reference tool and is intended to be used by treaty negotiators, judges, lawyers, police, customs officers, legal researchers and so on.

UNEP's Role

UNEP has a mandate from the United Nations General Assembly (UNGA resolution 3436 (XXX)) and its Governing Council to assist developing countries in strengthening their environmental laws and institutional regimes. The recently adopted Bali Strategic Plan enforces this mandate.

Role of the Judiciary

The judiciary is a crucial partner in promoting compliance with, and enforcement of international and national environmental laws.

Global Judges Symposium

Many aspects of compliance and enforcement of environmental laws were discussed by over 120 judges including 32 chief justices from both developing and developed countries at the Global Judges Symposium on the "Role of Laws on Sustainable Development" convened in Johannesburg on 18 – 20 August 2002 by UNEP as a parallel event to the WSSD.

New Areas of UNEP Intervention

UNEP is currently venturing into new areas of environmental law and capacity building such as awareness enhancing of parliamentarians in emerging environmental law issues and challenges, and revival of customary law and ethics

Awareness Enhancing of Parliamentarians

Well informed Parliamentarians could become powerful agents for change by adopting more sustainable and environment friendly policies, enacting suitable and effective environmental laws, and regulations for the proper implementation of environmental strategies. The Parliamentarians could also strengthen environmental institutions by approving increased funding for the environment sector.

UNEP has a plan to address this issue of lack of awareness of environmental laws among parliamentarians in developing countries by organizing short courses (1-2 days) for enhancing awareness in new emerging issues and challenges with appropriate responses in the field of international environmental policies and legislation including MEAs.

Revival of Customary Law

Despite the principles enshrined in environmental legislation, the environment is still facing grave concerns, and therefore, it is strongly felt to revive customary law and ethics. Customary law is unwritten law including the cultural, legal or customs of the indigenous tribal people of a given country. Religious and philosophical concepts are crucial for understanding the views of nature and societal relationships that forms the basis of environmental law and they are relevant to understand the current law and for creating new approaches to environmental protection.

Conclusion

This module covering Environmental Law and MEAs are very complex and diverse cutting across sectors and governments (local to national within a country, and across countries on transboundary

issues), and societies over space and time. An evolutionary process with continuous updating of rules, regulations, and practices should be put in place with focus on holistic and integrated approaches to provide sustainable environment for sustainable living.

Environmental Impact Assessment, Environmental Auditing and Strategic Environmental Assessment

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ABSTRACT *Environmental Impact Assessment (EIA) procedures are described as a planning tool that is now generally regarded as an integral component of sound decision-making. Guidelines for both information gathering, decision making, environmental auditing and monitoring are provided, which give an objective basis for granting or denying approval for a proposed development project. Such an assessment can be undertaken at a strategic level (national, regional or global) as well as at a small scale of an individual project.*

Introduction

EIA can be defined as the process of identifying (i), evaluating (ii) and mitigating (iii) the biophysical, social, and other relevant impacts (effects) of development project (proposals) prior to major decisions being taken and commitments made, thereby ensuring (iv) that environmental management is integrated into planning of the development project (proposal).

Types of Impact Assessments

- Climate Impact Assessment
- Demographic Impact Assessment
- Cumulative Impact Assessment
- Development Impact Assessment
- Ecological Impact Assessment
- Economic and Fiscal Impact Assessment
- Environmental Auditing
- Environmental Impact Assessment
- Environmental Management Systems
- Health Risk and Impact Assessment
- Social Impact Assessment
- Strategic Impact Assessment
- Strategic Environmental Assessment

Public Involvement in EIA of Development Projects

The foremost concern of development at present time should be participation of public in this very development process. The public or typical stakeholders are local people, proponent and project beneficiaries, government agencies, NGOs, donors, private sectors and academics.

Objectives of Public Involvement

- Informing stakeholders while presenting views, concerns and values;
- Maximizing benefits while influencing project design;
- Obtaining local knowledge while increasing public confidence and decreasing conflict; and
- Better transparency and accountability in decision-making.

Principles for Successful Public Involvement

- Provide sufficient relevant information.
- Allow sufficient time to read and discuss.
- Allow sufficient time to present views.
- Provide responses to issues/problems raised.
- Choose venues and times of events to suit stakeholders.

Factors Affecting Effectiveness of Public Involvement

Poverty, rural settings, illiteracy, culture and local values, languages, legal systems, interest groups, confidentiality etc. are the factors affecting the effectiveness of public involvement in EIA.

Minimizing Conflicts Caused by the Development Projects

- Involve all stakeholders
- Communicate the objectives of the proposal
- Listen to concerns and interests of the concerned people
- Treat people honestly and fairly
- Be empathetic
- Be flexible
- Mitigate impacts and compensate for detriment
- Establish communication channels
- Acknowledge concerns and provide feedback

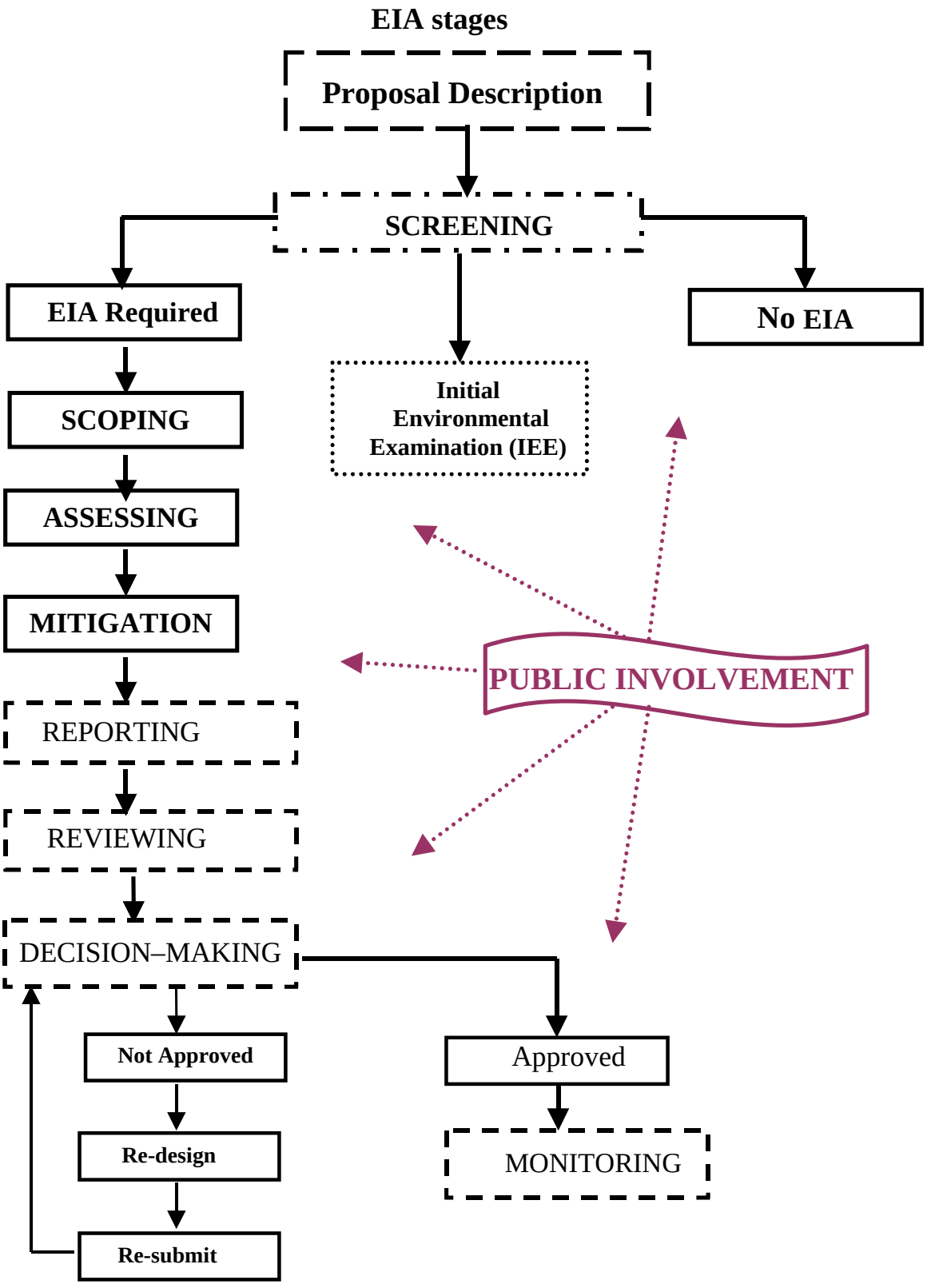
The various stages of EIA have been stated in Figure 1.

Strategic Environmental Assessment

The purpose of the SEA is to ensure that environmental consequences of certain national, regional or global development plans and programmes are identified and assessed during their preparation and before their adoption. The public and environmental authorities can give their opinion and all results are integrated and taken into account in the course of the strategic national or international planning. After the adoption of the plan or programme the public is informed about the decision and the way in which it was made. In the case of likely transboundary significant effects the affected member states (regions) and their public are informed and have the possibility to make comments which are also integrated into the national decision making process. This will help to achieve the goal of sustainable development.

A recent example is the European Directive 2001/42/EC “On the assessment of the effects of certain plans and programmes on the environment”, known as the Strategic Environmental Assessment or SEA Directive.

SEA is conceptually similar to EIA with a difference that it is implemented at strategic, larger, more complex cases of (national, international) development projects. Table 1 below shows different techniques used for the public involvement in the project.



Source: UNEP (2002)

Figure 1. Different Stages of EIA

Table 1. Techniques to be used for Public Involvement in Development Process

Communication Characteristics					Public Information & Participation Objectives						
	Public Participation/Communication Techniques				Inform/Educate	Identity Problems/Values	Get Ideas/Solve Problems	Feedback	Evaluate	Resolve Conflict/Consensus
2	1	1	Public Hearings			X		X		
2	1	2	Public Meetings		X	X		X		
1	2	3	Informal Small Group Meetings		X	X	X	X	X	X
2	1	2	General Public Information Meetings		X					
1	2	2	Presentations to Community Organizations		X	X		X		
1	3	3	Information Coordination Seminars		X			X		
1	2	1	Operating Field Officers			X	X	X	X	
1	3	2	Local Planning Visits			X		X	X	
2	2	1	Information Brochures and Pamphlets		X					
1	3	3	Field Trips and Site Visits		X	X				
3	1	2	Public Displays		X		X	X		
2	1	2	Model Demonstration Projects		X			X	X	X
3	1	1	Material for Mass media		X					
1	3	2	Response to Public Inquiries		X					
3	1	1	Press Releases Inviting Comments		X			X		
1	3	1	Letter requests for Comments				X	X		
1	3	3	Workshops			X	X	X	X	X
1	3	3	Advisory Committees			X	X	X	X	
1	3	3	Task Forces			X	X		X	
1	3	3	Employment of Community Residents			X	X			X
1	3	3	Community Interest Advocates				X		X	X
1	3	3	Ombudsman or Representative			X	X	X	X	X
2	3	1	Public Review of Initial Assessment Decision Document		X	X	X	X	X	X

Level of Participation 1=low, 2=medium, 3= high

Source: UNEP (2002)

Screening

Screening is a process of determining: (i) whether or not an individual proposal requires "a detailed environmental assessment "(full-scale, EIA), and (ii) the level of assessment to occur.

Most proposals need 1-2 hours to screen (no further study). Typical questions to be asked: whether the development project will affect health? Increase pollution? Endanger species, protected areas, bio-diversity, social infrastructure, and economy?

Full Scale EIA is required if proposal involves: natural resources exploitation; infrastructure; industrial activities; extractive industries; waste management and disposal; substantial changes in farming or fishing practices.

Screening involves following techniques:

- Decision makers' discretion (following the logical and common sense analysis)
- Initial Environmental Examination (IEE)
- Project lists with /without thresholds.

Initial Environmental Examination Evaluation (IEE): IEE has the following functions:

- Describes the proposal and examines any alternatives that might improve the environmental outcomes.
- Identifies and addresses the concerns of the local community.
- Mitigates adverse effects and enhances potential benefits.
- Contains environmental-monitoring and management plans.

Project Lists: Project Lists are structured to identify projects *r*equiring (i) FS EIA, (ii) some form of further environmental analysis or (iii) not requiring any further environmental analysis.

Scoping

Scoping is interaction between the following interested parties: Public, Government agencies and Proponent(s) with the purpose of identifying as early as possible:

- Appropriate boundaries of an EIA Study,
- important issues, local values concerns (interests),
- info which is necessary for the decision-makers,
- significant effects and factors to be considered, and
- to establish the Terms Of Reference (TOR).

Who should be Involved?

The proponent, who is responsible for scoping, if not, the most important player. The administering agency which has procedural requirements and which oversees proponent's scoping work and it may change it to conform to the previously agreed scope

Other agencies which contribute detailed knowledge of specific issues (legal information and policies, standards, local data) and provide licenses and permits Environmental Practitioners and experts which provide specialist expertise (academics, consultants etc). Those who are or will be affected by the project (development). They will identify local issues and ensure compliance with local values and for which community liaison staff and funds may be required. The wider community indirectly affected at the regional, national level related NGOs Many of the public Involvement issues and methods relate to scoping (hearings, seminars etc)

Investigating Alternatives

Different ways of introducing and executing development project(s) should be looked into and different demand alternatives considered:

- Demand alternatives: e.g. using energy more efficiently rather than building more capacity;
- Activity alternatives: e.g. providing public transport rather than building new roads;
- Location alternatives: e.g. location for an oil refinery of the oil pipe network;
- Process alternatives: e.g. introduction of water and reagent recycling, high tech novelties, robotization;
- Scheduling alternatives: e.g. new staff shifts;
- Input alternatives: e.g. other raw materials, new energy sources.

The formal result of the scoping is TOR.

Outline of the Terms of Reference (TOR)

- Background of proposal,

- Setting the context for the problem (proposed solution, cooperation amongst jurisdictions),
- Objectives of EIA, legal/policy basis, institutional capacity for EIA,
- Alternatives to the project, within the project,
- Institution and public involvement,
- Required information and data (project description, description of environment, quality of information Analysis of impacts (positive/negative/cumulative?)
  - What are natural and human resources?
  - Relocation and compensation necessary?
  - Transboundary impacts possible?
  - What is the impact significance?
- Mitigation and monitoring (impact management plan, environmental monitoring plan,
- Conclusions, recommendations (technical matters, non-technical) and summary.
- Proposed EI Study schedule,
- The budget allowed for the EI Study,
- Expected outputs (interim and final reports, format for the Environmental Impact Statement, Number of copies, etc.).

Assessing

- Identifying and defining the impacts more specifically (refining the understanding of nature of impacts, identifying indirect, cumulative impacts and their likely causes.
- Analyzing impacts and determining their nature, magnitude, extent, and effects.
- Determining impact significance or acceptability (Does this impact matter? If yes, how to mitigate it?).

Impact Assessment Methodologies

Impact identification methods include *checklists*, matrices (e.g. leopold matrix), networks, map overlays & geographic information systems, computer expert systems, professional experience.

Choice of EIA Method depends on:

- Type and size of the proposal,
- Type of alternatives being assessed,
- Nature of the likely impacts,
- Nature of the EIA methods (direct, indirect effects, cumulative/synergistic impacts),
- Resources available (cost, info, time, personnel),
- Nature of the public involvement,
- Experience of the proponent with the project type, size, and
- Procedural/administrative requirements.

Impact Analysis/prediction

Baseline conditions are established for “no-development” option and are compared to Predicted state of “a future developed option”.

The predictions about the future conditions involve such factors as:

- Current status, current and expected trends
- Effects of proposals already being implemented
- Effects of other proposals, which will be completed before implementation of the proposal under consideration.

The nest stage of mitigating measures will heavily depend on correctness of the predictions. Table 2 in the following page shows the assessment matrix.

Mitigation

It is the stage when a range of methods for mitigating (reducing) and managing environmental impacts are identified. It seeks to:

- Find better ways of doing things,
- Minimize or eliminate negative impacts,
- Enhance project benefits,
- Protect public and individual rights to compensation,
- During this stage proponents have a responsibility to internalize costs felt beyond the project's boundaries
- Avoid or minimize impacts through good design, design modifications, and
- Plan for managing impacts to keep them within the limits of acceptability.

Mitigation Options

- Alternative way of meeting the need: (e.g. going back to the origins of the proposal and finding the "fatal flaw" at the project).
- Changes in planning and design: (e.g. groundworks to be avoided during the rainy season (low surface runoff), blasting outside the nesting season of migratory birds.
- Improving monitoring and management (impacts are of the predicted nature and levels?)
- Monetary compensation
- Replacing, relocation, rehabilitating (e.g. "in kind" compensation: new, constructed wetlands for natural ones which were lost; training for locals; improved transportation for the workers).

Impact Management Plans

- State proponent's environmental policy and standards (how it complies with existing legislation standards).
- Designate responsibility (a person to be responsible for overall plan).
- Provide a schedule of tasks, including training (tasks to be undertaken to comply with the recommendations of the EIA report and the requirement of the approval).
- Allocate responsibility for carrying out the tasks.
- Include a system for reporting on the progress of the tasks and budget.
- Include a system for monitoring and auditing of the plan's achievements in environmental protection/enhancement.
- Contain a contingency plan (if monitoring results indicate that impacts are not in accordance with predictions or required standards).

Table 2 presents an assessment matrix of transport and service infrastructure. Some mitigating measures for large-scale housing projects are presented in Table 3 and Table 4 presents checklist for rural urban water supply and sanitation projects.

Table 2. Assessment Matrix: Transport and Services (Infrastructure)

BIOLOGICAL ENVIRONMENT	Forest Shrubland Grassland Herbfield (alpine) Sand/shingle/rock Cropland Urban land Lakes Rivers Estuaries Inter-tidal Marine Wetlands				
PHYDICAL ENVIRONMENT	River regime Erosion/land stability Sedimentation Surface water Ground water Agricultural soil Foundation materials Climate/atmosphere Nuisance (noise, dust, smell) Landform				
SOCIAL ENVIRONMENT	Public participation Employment Settlement Land value Existing land use Risks and anxieties Personal and social values Historical/cultural Landscape/visual Recreation				
	Environmental Effects / Development	Transport – People -Road -Rail -Air -Water	Transport - Materials -Road -Rail -Air -Water -Pipelines	Energy Supply – Transport to Site -Electricity -Gas -Oil -Other	Water Supply -Source -Transport -Water Disposal -Liquid -Solid Communications Housing -Temporary -Permanent

Source: UNEP (2002)

Table 3. Mitigating Measures: Large Scale Housing Projects

Potential Negative Impacts		Mitigation Measure
DIRECT IMPACTS		
1.	Displacement of existing land uses	Ensure that due consideration is given to the proper trade-offs between land values for housing and those of other uses, such as prime farmland, forests or other land uses or natural habitats of value to society as a whole. Investigate existing planning and design standards to ensure that they are suited to local conditions and not unnecessarily wasteful of land. Assist in drafting new regulations that are more appropriate.
2.	Destruction of environmentally critical areas	Ensure that regionally critical environmental sites such as major forested areas, major water bodies and wetlands, habitats containing rare and endangered species, etc are identified and not threatened by project location
3.	Danger to residents from hazardous natural conditions	Ensure that project site is not located in the following areas: • major floodplain • coastal zone inundation areas • areas of unstable soil or subsurface conditions • areas of highly saline soils • areas subject to landslides • seismically or volcanically active areas • excessively steep or wet areas • areas where significant risk from disease vectors exist or any other areas of significant natural hazard. Design accordingly if site cannot be moved
4.	Danger to residents from hazardous man-made conditions	Identify areas that have significant man-made hazards such as filled land, areas subjects to subsidence from mining activity, groundwater, oil or other extractive process Identify areas where solid or liquid or toxic wastes may be, or have been, dumped. Investigate site conditions with proper geo-technical or chemical testing procedures. Ensure that adequate funding and technical expertise are available to deal with the special conditions. Investigate alternate sites.
5.	Hazard to residents from air, water or noise pollution from other adjacent or nearby land uses	Ensure that the site is located away from such pollution sources. Do not locate down-wind of significant point sources of air pollution such as smoke stacks, from example. Identify noise sheds around airports, major roads etc. Provide buffers of other compatible uses of adequate width between residential areas and sources of pollution. Take measures to abate pollution at the sources, if feasible, such as noise barriers along expressways. Investigate alternate sites.
6.	Hazard to residents from air pollution due to site location being in an area subject to frequent temperature inversions	Seek alternate site locations if pollution is from existing sources that are difficult to abate. Otherwise design project with low densities and non-polluting technologies from heating, cooking etc.
7.	Dislocation of existing resident populations	Ensure that any involuntary resettlement is done in accordance with proper standards or consider alternate sites.
8.	Destruction of historic or cultural resources	Consider alternate sites or make provision for historic culturally significant areas to be set aside in specially zoned areas.
9.	Overloading of existing infrastructure and services	Coordinate with other planning goals and objectives for region. Upgrade existing infrastructure and services, if feasible. Consider alternate sites.
10.	Excessive depletion of resources such as lumber or fuel or overtaxing of traditional industries, such as brickmarking	Review capacity of local resources and industries to provide for large-scale construction and upgrade if feasible. Select materials and design criteria according to local conditions and availability of resources. Design for maximum efficiency in material and energy use. Encourage the study of indigenous customs and techniques for building and incorporate in project design.

Source: UNEP (2002)

Table 4. Checklist for Rural Urban Water Supply and Sanitation Projects

Aspects of EIA	Checklist Questions Will the project		Yes	No	Additional Data needs
Sources of Impacts	1.	Require the acquisition or conversion of significant areas of land for reservoir/treatment works etc. (e.g. > 50 ha rural, > 5 ha urban)?	☐	☐	☐
	2.	Result in significant quantities of eroded material, effluent or solid wastes?	☐	☐	☐
	3.	Require significant accommodation or service amenities to support the workforce during construction (eg > 100 manual workers)?	☐	☐	☐
Receptors of Impacts	4.	Flood or otherwise affect areas which support conservation worthy terrestrial or aquatic ecosystems, flora or fauna (eg protected areas, wilderness areas, forest reserves, critical habitats, endangered species); or that contain sites of historical or cultural importance?	☐	☐	☐
	5.	Flood or otherwise affect areas which will affect the livelihoods of local people (eg require population resettlement; affect local industry, agriculture, livestock or fish stocks; reduce the availability of natural resource goods and services)?	☐	☐	☐
	6.	Involve sitting sanitation treatment facilities close to human settlements (particularly where locations are susceptible to flooding)?	☐	☐	☐
	7.	Affect sources of water extraction?	☐	☐	☐
Environmental Impacts	8.	Cause a noticeable permanent or seasonal reduction in the volume of ground or surface water supply?	☐	☐	☐
	9.	Present a significant pollution risk through liquid of solid wastes to humans, sources of water extraction, conservation worthy aquatic ecosystems and species, or commercial fish stocks?	☐	☐	☐
	10.	Change the local hydrology of surface water-bodies (eg streams, rivers, lakes) such that conservation-worthy or commercially significant fish stocks are affected?	☐	☐	☐
	11.	Increase the risk of diseases in areas of high population density (eg onchocerciasis, filariasis, malaria, hepatitis, gastrointestinal diseases)?	☐	☐	☐
	12.	Induce secondary development, eg along access roads, or in the form of entrepreneurial services for construction and operational activities?	☐	☐	☐
Mitigation Measures	13.	Be likely to require mitigation measures that may result in the project being financially or socially unacceptable?	☐	☐	☐
Comments					
	I recommend that the programme be assigned to Category		☐		
	Signature: Delegation…….Desk…….				

Source: UNEP (2002)

Reporting

Different Names for the Same Document

- Environmental Impact Assessment report (EIA report),
- Environmental Assessment report (EA report),
- Environmental Effects Statement (EES),
- Environmental Impact Statement (EIS) not to mix up with Environmental Impact Study

Effective Reporting

- Assists the proponent to plan and design and implement the project in a way that minimizes the negative effects on the biophysical and socio-economic environments and maximizes the benefits to all parties in the most cost effective manner;
- Assists the decision-makers to decide whether or not a proposal should be approved and if so what are the terms and conditions that should be applied;
- Help the public to understand the proposal and its impacts on the community and environment

Main Elements of the EIA Report

- Executive summary,
- Aims of the proposal (Description of proposal and alternatives): Under the possibility of "No Development" option; the focus should be on the status of the proposal in the project cycle such as pre-feasibility, detailed engineering design etc; description of planning/design and implementation strategies for impact forecasts and management measures to be understood/appreciated; requirements for raw materials, water, energy and equipment; planned operational issues, processes, products, etc; visual aids such as maps, flow diagrams and photographs; comparison of proposal options(such as size, siting, technology, layout, energy sources, source of raw materials) within existing economic, technical, environmental and social constraints,
- Summary of the technical, economic and environmental features of the proposal,
- Relationships to current land use policies: (how the proposal fits into current systems, policies, strategies etc, and whether or not it is consistent with them),
- Description of expected conditions: (spatial and temporal boundaries and temporal boundaries adopted for the various aspects of the study),
- Existing (baseline) conditions of the biophysical, socio-economic environment, etc.,
- Trends and the anticipated future environmental conditions: (if the project would not be approved),
- Evaluation of impacts: (assessment of any impact on the local population (including gender issues; relevant environmental data and predictive methods used and any underlying assumptions made; any gaps in knowledge and uncertainties encountered; compliance with any relevant standards and licensing procedures; assessed significance of the impact, stating the standards or criteria used as the basis for judgment; possible measures for avoiding or mitigating the impact),
- Evaluation of alternatives: (those impacts considered to be of greatest significance and the measures proposed to avoid, reduce and/or manage them; the proponent's is commitment to manage the impacts during proposal implementation, and those impacts that are residual (that is those that cannot be avoided or minimized); distribution of costs and benefits locally and regionally; statement of measures of the protection and/or resettlement of affected population groups, indicating their reactions to proposals on these issues; opportunities for environmental enhancement),
- Impact, monitoring and training plans: (plans containing a description of the proposed mitigation actions, schedule for implementation; assigning responsibility for implementation by

name or position of responsibility, presenting the monitoring program to assess performance, presenting the proposed reporting and review procedures), and
- Appendices: (glossary, explanation of acronyms, summary of management of the EIA process and the public involvement including listings of individuals and agencies consulted during the EIA, sources of data and information and a full list of all reference material used; list of names, qualifications and roles of team members who carried out the study; terms of reference for the EIA and those given to individual specialists).

Reviewing

This stage determines whether the EIA report is an adequate assessment of environmental effects of sufficient relevance and quality for decision-making. It considers the adequacy of:

- Compliance with the Terms of Reference,
- The examinations of alternatives, impacts, mitigation and monitoring,
- The use of scientific and technical analytical information techniques,
- Conduct of the EIA process and the consideration of views of all parties,
- Presentation of information to the public,
- Presentation of info to decision-makers, and
- Sufficiency of information.

Steps in Reviewing an EIA Report

- Set the scale/depth of the review (time framework, monetary framework)
- Select reviewer(s)
- Use public input

Decision-making

EIA is an on-going process of reviewing, negotiating and incremental decision-making, culminating in essentially the political action of making a final decision about whether or not the proposal is to proceed and under what conditions.

Environmental Auditing and Monitoring

EIA monitoring is the planned, systematic collection of environmental data to meet specific objectives and environmental needs. Steps in developing a monitoring program include the following steps:

- Identify the scope,
- Define the objectives,
- Decide how information will be used,
- Define the boundaries and select sites,
- Select the key indicators,
- Define how the data will be analyzed and presented,
- Decide the level of accuracy required in data,
- Consider the relationship between the new data and existing data,
- Record and respond to data provided by the community, and
- Set minimum requirements for monitoring.

Table 5. Monitoring Case Study- ERA Ranger Mine Environmental Monitoring Program and Performance Assessment
BEST PRACTICE ENVIRONMENTAL MANAGEMENT IN MINING ENVIRONMENTAL MONITORING AND PERFORMANCE EPA JUNE 1995

Note: The Ranger Uranium mine located in the Kakadu National Park in the Northern Territory of Australia, has monitoring costs of approximately $A 1 000 000 each year due to the sensitivities associated with uranium mining adjacent to the Kakadu wetlands.

Area	Frequency	Procedure	Analysis And Review Of Results	Compliance Requirements	Other Details
Surface water: • retention ponds • creeks • billabongs • sumps • wetland filters	weekly* monthly* monthly* monthly* as required for research purpose. *daily & weekly during a release	Water samples taken and chemistry analyses completed. Water levels checked via gauge boards and stream gauging.	Results graphed and tabulated for inclusion in reports. Comparisons made with previous reporting period. Collated in quarterly / six monthly water management and annual environmental report.	Limits established for receiving waters during release of water from retention ponds.	Hydrology and chemistry combined for load calculations during release. Results used in research on wetland filtration, seepage management etc.
Groundwater: • monitoring bores • piezometers • dewatering bores • land application bores	Monthly Bi-monthly Six-monthly Some more frequently Weekly during irrigations.	Water level in bores measured using dip-meter and piezometer level read. Water samples taken using bore pump.	As above.	Tailing bores and piezometers needed to monitor stability and seepage aspects of tailings dam. Land application (Irrigation) area monitored for mobility of salts and other elements	Data included in research projects on seepage modeling
Biological screening: • retention ponds • creeks • billabong • wetland filter	During wet season prior to and during release of retention pond water. As required for wetland filter research.	Control water obtained from creek. Pond water at a range of dilutions prepared and microscopic aquatic organisms (hydra, cladoceran and fish embryos) used to assess toxicity.	Results tabulated, statistically analysed and included in reports Internal and external review by government authorities.	Used as part of process to determine dilution rate of release water	Government standards and safety factor (x10 x 100) before applying the results of toxicity tests.
Soils	Three-yearly.	Collection, preparation, digestion and analysis according to standard methods.	Reported three-yearly and in annual report.	Results compared to historical data.	Monitoring sites are located along drainage channels around the lease area.
Uptake of contaminants by biota: • mussels in creeks • vegetation in land application area.	Annually and on non-regular occasions (eg. For retention pond 2 release).	Mussels sampled from down stream billabong. Mussel tissue ashed and analysed for contaminant uptake. Vegetation sampled and analysed for contaminant uptake.	Internal and external review by government authorities in the annual report.	Results compared to previous data. Also judged on relevant ANZEC standards for edible criteria.	

Source: UNEP (2002)

Table 5 presents a monitoring case study. This is in brief covers the issues and aspects related to EIA, Environmental Auditing and Strategic Environmental Assessment.

Reference

UNEP (2002) *Environmental Impact Assessment, Training Resource Manual*. 2nd Edition, EPA, Canberra., Australia.

Further Reading

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Policy Instruments for Environmental Management

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ABSTRACT *This module describes the notion of public good/bad and externalities to motivate the need for policy intervention in the context of environmental management. Starting with the traditional solutions of Pigouvian and Coasean approaches to correct the externality problem the note goes on to elaborate various policy instruments that have evolved over time in literature. Various criteria for choosing among the instruments are discussed and finally the instruments in practice in some of the SAARC countries are described. Need for capacity building, democratic and transparent procedures are stressed for adoption of market-based instruments in place of conventional command and control practices. Scope for third-wave environmental policy making in developing countries is also highlighted.*

Introduction

Environmental pollution is an externality caused by the activities related to production and consumption of goods and services in the economy. Alternatively the waste disposal services offered by the environmental media, namely, air, water and land could be considered as the public goods for which markets are absent. In either interpretation, the management of environmental resources could be seen as a case of market failure and therefore it is prescribed originally for the government intervention in the market process to control environmental externalities. This note discusses the rationale for government intervention, the variety of forms in which the intervention could place – which are broadly referred as policy instruments here, the choice of appropriate instruments, and the various country experiences with regard to the use of these policy instruments.

Basic Concepts

Before elaborating on the government intervention it would be useful to understand a couple of key notions regarding public goods. Economists define two fundamental characteristics of goods: excludability and rivalry.

Excludability: A good is excludable if it is feasible and practical to selectively allow consumers to consume the good. A bad is excludable if it is feasible and practical to selectively allow consumers to avoid consumption of the bad (Kolstad, 2000)

Air pollution is not excludable as it is not possible to selectively target only a few individuals to consume it. The key factors determining the excludability of a good/bad are the cost of exclusion and technology of exclusion. Space also plays an important role in determining excludability. Excludability is important because it is not feasible to attach *price* to good/bad without this property. Without excludability price systems cannot function.

Rivalry: A bad (or good) is rival if one person's consumption of a unit of the bad (good) diminishes the amount of bad (good) available for others to consume. This is a negative (positive) social opportunity cost to others associated with consumption (Kolstad, 2000)

Again air pollution is non-rival – because if one breathes a mouthful of polluted air at a city center he/she will not be reducing the amount of polluted air available for other consumers. If one's breathing of polluted air reduces the amount of pollution, then there would be negative social opportunity cost associate with breathing polluted air. The property of rivalry is important for non-zero prices because with non-rivalry there are no costs associated with incremental use, which

implies that if price equals marginal cost, the price must be zero. The following Table 1 shows a few examples of bads with different properties.

Table 1. Examples of Bads with Different Properties

	Non-Rival	**Rival**
Excludable	Water pollution in a lake Indoor air pollution	Household garbage
Non-Excludable	Greenhouse gases	Household garbage in middle ages

Source: Kolstad (2000)

Externalities as Public Bads: As mentioned above an externality is said to have occurred when one person's action affects another without his/her consent. This is precisely what happens with a non-excludable, non-rival good/bad (i.e., a public good/bad). Hence the concept of public good/bad is sufficient to incorporate environmental problems into economic theory, and one can dispense with the term externality. However due to its intuitive appeal the notion of externalities continues to be used in the literature and policy debates.

Problems with Externalities: Presence of externalities leads to divergence of private optimum from the social optimum. Thus there would be excessive production of goods and bads, excessive exploitation of natural resources, and insufficient provision of public goods if the private decision makers were allowed to operate without government intervention. The following Figure 1 illustrates the point in the context of level of production.

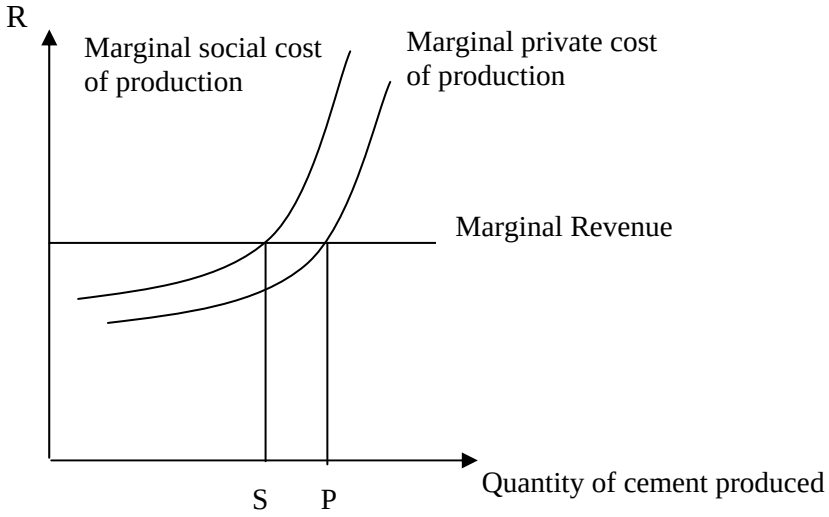

Figure 1. Private Optimum *vs.* Social Optimum

Consider a firm manufacturing cement. For profit maximization the firm will equate its marginal private cost of production with marginal revenue to produce 'P' level of cement. Suppose the cement manufacture also contributes air pollution and that the pollution causes health and other damages to the people living in the neighborhood. The firm owner will not accounting for the damage costs caused by the externality (the air pollution) in her private costs. The cost curve to the left of marginal private cost of production incorporates the external costs associated with the pollution and the optimal level production then would be 'S'. As could be seen the level of production of the good (and also the pollution) would be lower when the externalities are internalized.

Optimal Level of Pollution: Similar production of any other goods/services, pollution control involves costs and benefits. Costs are measured in terms of the various inputs that must be devoted to pollution control. Benefits are measured in terms of the reduction in damages (e.g., health damages) that is allowed by reducing the emissions of pollution. To trade-off the costs and benefits the notions of marginal abatement costs and marginal damages are needed. The marginal abatement cost (MAC) is the cost of reducing pollution by an additional unit. It is generally assumed that the MAC increases as abatement increases. In other words, the more one abates pollution, the more costly it becomes to reduce pollution by an additional unit. The marginal damage (MD) is the damage caused by an additional unit of pollution. It is generally assumed that the MD increases as pollution increases.

Left to itself the firm will produce 'P' level of pollution as shown in the following Figure 2. That is the firm will chose its pollution level as one where the marginal abatement cost is zero. The efficient, or socially optimal level of pollution is determined at the intersection of the marginal abatement cost and marginal damage curves: 'S' is the optimal level of pollution. Thus in the absence of any external intervention there would be too much pollution generated by the firm. The following sections now discuss various forms of intervention and their relative merits and demerits.

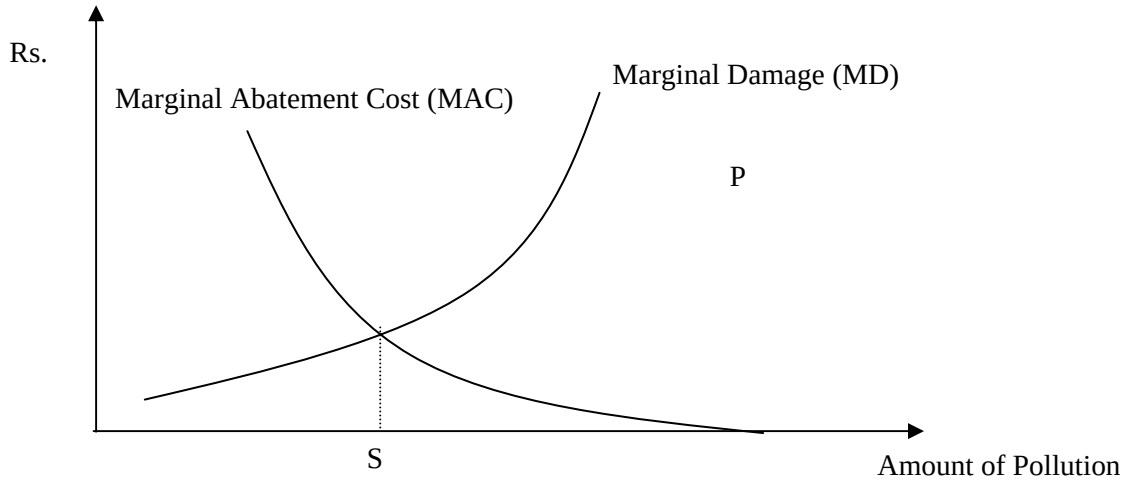

Figure 2. Efficient Level of Pollution

Policy Instruments

The original prescriptions for internalizing the externalities are based on either Pigouvian or Coasean approaches described below.

Pigouvian Approach

Pigou (1920) considered the case of a competitive firm producing a good *q* and a bad (smoke). It is assumed that smoke emission per unit of output is constant. The smoke emitted into the atmosphere has a harmful effect on nearby residents and producers, who bear the costs in the form of higher health costs and production costs respectively. These costs are uncompensated by the polluting firm which treats the atmosphere as a sink, an unpaid factor of production. In the absence of any regulations, the equilibrium output of the industry is determined at the point where the private marginal cost is equal to the price. The socially optimal output is determined at the point where the marginal social cost is equal to the price. The socially optimal level of output of the polluting firm is smaller than the output in the absence of regulation as discussed above. The Pigouvian policy prescription for the correction of the negative externality is imposition of a tax on the output equal

to the difference between the marginal social cost and price at the socially optimal output. It can be shown that such a tax maximizes aggregate welfare defined as sum of consumers' and producers' surpluses[1]. The imposition of tax on the good gives a signal to the producers and consumers about the social harm resulting from the production of the good. The resulting rise in the price of the good gives a disincentive to consumption of that good and therefore to reduce the pollution load. Pigou further adds that 'sometimes, when the interrelations of the various private persons affected are highly complex, the government may find it necessary to exercise some means of authoritarian control'.

Baumol and Oates Second Best Approach

There are many conceptual and measurement problems in translating Pigouvian prescription into a policy instrument. Baumol and Oates (1987) note the following difficulties in applying the Pigouvian approach in practice. First, the very presence of externalities is likely to produce a number of local maxima and it seems impossible to choose any one with some degree of confidence. Second, the optimal tax level on an externality-generating activity is not equal to the marginal net damage generated *initially*, but rather to the damage it would cause if the level of the activity had been adjusted to its *optimal level*. In view of the enormous amount of information needed to estimate the marginal damage function, they propose an alternative approach which 'consists of the use of a set of standards that serve as targets for environmental quality coupled with fiscal measures and other compensatory instruments used as a means to attain these standards'.

Coasean Approach

Coase (1960) argued that the problem which society faces in dealing with actions that cause harmful effects is not simply one of restraining those responsible for them. What has to be decided is whether the gain from preventing the harm is greater than the loss, which would be suffered elsewhere as a result of stopping the action, which produces the harm. He says it is necessary to know whether the damaging business is liable or not for the damage caused since without the establishment of this initial delimitation of rights there can be no market transactions to transfer and recombine them. But the ultimate result (which maximizes the value of production) is independent of the legal position if the pricing system is assumed to work without cost. This proposition is known as Coase Theorem. Coase advocated a role for the state in defining and enforcing property rights for environmental resources and in mitigating transaction costs but rules out government intervention in the form of specifying standards or levying a tax to correct the externality. Creation of rights for emissions into atmosphere and setting up markets for exchange of the rights, and programmes such as green rating of industry and public disclosure of the extent of environmental compliance by polluting units are preferred under this approach.

Classification of Policy Instruments

There is often a misleading classification of policy instruments as either 'market based' or 'command and control'. However as Sterner (2002) argues this classification is poor because regulations often are backed by economic sanctions and as Baumol and Oates (1987) argued purely market based instruments are difficult to design due to enormous information needs. Hence standards or emission targets are necessary in many cases. A more meaningful classification of instruments could be in the form of policy matrix shown below in Table 2.

[1]The same result can be obtained in a general equilibrium model using the Pareto Welfare criterion. According to Pareto, social welfare increases if it is possible to improve the welfare of at least one individual without decreasing the welfare of others. For the general result, see Baumol and Oates (1987).

Table 2. Classification of Instruments

Using Markets	Creating Markets	Environmental Regulations	Engaging the Public
Subsidy reduction	Property rights	Standards	Public participation
Environmental taxes and charges	Tradable permits and rights	Bans	Information disclosure
User charges		Permits and quotas	
Deposit-refund systems		Zoning	
Targeted subsidies		Liability	

Source: Sterner (2002) and World Bank (1997)

Command and Control (CAC) Regulation

Under this regime the regulator commands a desired behavior by the polluter – typically by prescribing a limit on the amount of pollution that that can be produced (referred as standards). The regulator then controls and enforces compliance with the desired behavior. The control takes the form of penalties or sanctions that the polluter may have to face if she does not comply with the command.

Standards are the predominant means for direct regulation of environmental quality throughout most of the developed world. Types of standards include: ambient environmental quality standards, effluent or emission standards, technology-based standards, performance standards, product standards, and process standards. Standards also may include technological specifications for the performance or design of equipment or facilities and the standardization of sampling or analytical methods.

The granting or withholding of permits, licenses, or other authorizations is another important tool for controlling pollution. The permits or licenses are generally tied to an air or water quality standard and may be subject to the fulfillment of specific conditions such as compliance with a code of practice, selection of the location that minimizes environmental and economic impacts, installation of a treatment plant or pollution control equipment within a certain time period, or adoption of other environmentally protective measures.

CAC regulation provides maximum control over the pollution and amount of resources to be spent to achieve environmental goals as under ideal circumstances the regulator can fix firm specific standards at the 'optimal' level of knowing each firm's marginal abatement cost and marginal damage functions. However in reality the regulator will not have information on marginal abatement cost and marginal damage functions. As a result, emissions standards are set keeping in mind the following: (1) Standards are defined on the basis of the best available or economically achievable technology; (2) Standards are often defined and tailored to specific industries (for the same pollutant, standards are typically different across industries); (3) Standards are often different for old sources of pollution and new sources of pollution, generally being more stringent for new sources; (4) Standards are usually uniform.

The main criticism for CAC comes from the economic perspective[2]. The CAC regulation leaves little flexibility for the firm in meeting the prescribed standard. Thus under this regime polluters who could reduce pollution at a lower cost are not given the opportunity. CAC approach gives little incentive for innovation in pollution abatement technology once standards are achieved.

[2]Other disadvantages with CAC regulation include difficulty in enforcement and enormous information requirement.

Pollution Charges

The principle being pollution charges (and also tradable permits discussed below) is simple. Since externalities are not internalized without intervention the consumers and producers do not pay for the external costs they generate; the pollution charges and tradable permits precisely create such a price. The following Figure 3 illustrates the principle behind pollution charges.

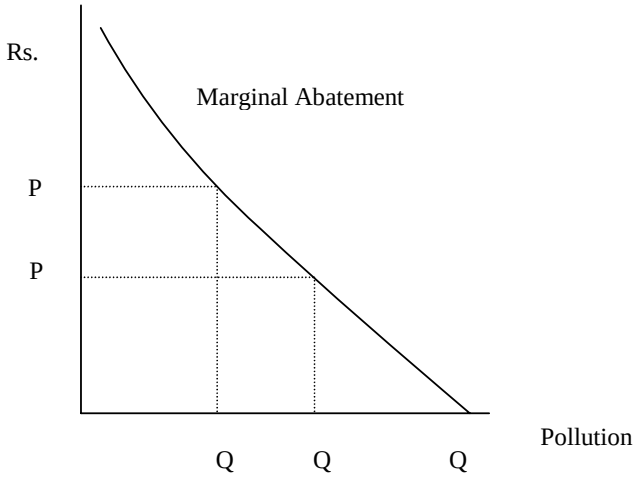

Figure 3. Effect of Pollution Charges

On its own the firm produces Q_0 level of pollution and when faced with a charge P_1 it can choose either to pay the charge or reduce pollution. A profit maximizing firm will reduce its pollution up to the point where the price to be paid per unit of pollution is just equal to its marginal abatement cost. Thus the firm reduces its emissions from Q_0 to Q_1 when faced with a pollution charge of P_1. Similarly lower pollution charges (e.g., P_2) would compel the firm to reduce its pollution to a lower level (Q_2). As noted in Figure 2 the optimal pollution level would result if the polluter were charged at *Pigovian* rate. In practice the pollution charges tend to be uniform because the regulator will not have access to firm specific marginal abatement and marginal damage data.

Tradable Permits

Under this approach, the regulator first determines a desired level of environmental quality and translates that into total number of allowable emission units. The allowable emission units are then distributed across polluters in the form of permits. The polluters are allowed to exchange these permits. A polluter will carry out the abatement as long as the cost of abatement is lower than the cost of purchasing a permit. Hence, given a similar aggregate emissions target, the level of the (uniform) pollution charge necessary to achieve the target would be the same as the equilibrium price of a permit, assuming that the market for permits is perfectly competitive.

While the regulator knows with certainty the quantity of pollution regulated under the permit system, the information on cost of abatement is uncertain. Also if damages are a function of the location of the polluter, then tradable permits may result in what are known as hot spots.

Short Taxonomy of Economic Instruments

Charges, Fees or Taxes

Charges, fees or taxes are prices paid for discharges of pollutants into the environment based on the quantity and/or quality of pollutants. To be most effective the charge is levied directly on the quantity of pollution ('emission tax or charge'), though if this is difficult to measure or monitor, it may be necessary to levy a charge on a proxy for the emissions, typically on the resource that causes the pollution ('product tax or charge'). Product charges occur at different usage points. In practice, they have been levied on products either as they are manufactured (e.g., chemical fertilizers), consumed (e.g., pesticides) or disposed (e.g., batteries).

The effectiveness of the product charges depends on how well the product is linked to the eventual pollution stream. For instance in case of carbon dioxide, the link between carbon intensive fuels and the resulting emissions is very strong and hence there is little difference between taxing the fuel and taxing the pollutant. On the other hand, taxing pesticides as a proxy for release of certain chemicals into water systems is less well established as the degree of chemical infiltration will depend on a mixture of variables relating to soil and slope conditions, the timing of application etc.

Subsidies

Where taxes or charges can be used as a penalty on discharges, subsidies can be used to reward the reduction of discharges in a similar manner. The financial incentive is effectively the same, though the flow of funds is in a different direction. Subsidies may be relatively explicit in the form of grants and soft loans, or be somewhat indirect, such as adjusted depreciation schedules.

Tradable Permits

Tradable permits are similar to charges and taxes except that they operate by fixing an aggregate quantity of emissions rather than charging a price for each unit of emissions. Instead of being charged for releases, one needs to hold a 'permit' to emit or discharge. By controlling the total number of permits, the regulator can effectively control the aggregate pollution quantity.

Charge-Permit Hybrids

It is possible to blend the quantity based permit approach with a price based charge or tax approach to try to harness their different strengths while avoiding their weaknesses. A good example is RFF's proposal to use a hybrid mechanism to control CO_2 emissions in the US. This would consist primarily of a permit program that would require domestic energy producers (and importers) to obtain permits equivalent to the volume of CO_2 eventually released by the fuels they sell. However, by setting the overall permit quantity, one has no idea at what price the permits will be sold. In order to guard against excessively high permit prices that might arise, the second aspect of the proposal would be for the government to release an unlimited number of permits at $25 per ton of carbon should the market price of permits reach that level. This effectively sets up a charge system of $25 per ton, capping the possible market price. A system like this attempts to control on the basis of quantity, which is the most desirable goal, while creating an 'escape valve' should costs rise too high. If the escape valve is utilized, the program amounts to the institution of a charge on carbon.

Deposit-Refund Schemes

Under these schemes, a surcharge is levied on a product at the point of payment. When pollution is avoided by returning the product, or its polluting components, to a specified collection stream the surcharge is refunded. These instruments have been used most often for containers of beverages, batteries etc.

Disclosure Instruments

In the above discussion the instruments focused mainly on the regulator and the polluter. However there is a growing interest in bringing two other players into the design of instruments for environmental management, namely markets and community.

Community

Recent evidence from Asia, Latin America and North America suggests that neighboring communities can have a powerful influence on factories' environmental performance. Communities that are richer, better educated, and more organized find many ways of enforcing environmental norms. Where formal regulators are present, communities use the political process to influence the tightness of enforcement. Where formal regulators are absent or ineffective, 'informal regulation' is implemented through community groups or NGOs. In countries as diverse as China, Brazil, Indonesia and the US, much of the variation in factories' environmental performance is explained by inter-community variation in income, education and bargaining power.

Market

Firms operate in local, national and international markets, where many agents can affect revenues and costs. Environmental considerations now affect the decisions of many of these agents. In both industrial and developing countries, environmentalism in the middle and upper classes is a significant factor in consumer decisions. With the worldwide advent of environmental legislation, investors are also scrutinizing environmental performance. Among other factors, they have to weigh the potential for financial losses from regulatory penalties and liability settlements. In recent years, the importance of investor interest has been increased by the growth of new stock markets and the internationalization of investment. Recent evidence from both the OECD and developing countries suggests that environmental reputation matters for firms whose expected costs or revenues are affected by judgments of environmental performance by customers, suppliers, and stockholders. For reputation-sensitive companies, public certification of good or bad performance may translate to large expected gains or losses over time.

Once the Community and the Market are introduced, we have a much richer and more robust model for explaining the observable variations in factories' environmental performance. Clean factories are perfectly plausible in poor countries, and the survival of dirty factories in rich countries is not hard to understand. Information provision has been referred to as the 'third wave' of environmental policymaking – after legal regulation and market-based instruments. In this area, there have been some interesting experiences from natural resource management in both industrialized and less developed countries (e.g., organic farming, forest certification program). There is some evidence of application of labeling to pollution issues also. The success of eco-labeling in Sweden is cited to be due to presence of strong environmental NGOs and thus consumer demand for green products (OECD, 1997).

Selection of Policy Instruments

There is considerable debate on the choice of policy instruments – especially between standards, charges and permits. Weitzman (1974) in his classic paper first addressed the issue with focus on choice between prices and quantity instruments. He argued that a price based instrument should be used if the cost of abatement curve is steeper than the damage curve, and a quantity based instrument should be used when the abatement cost curve is flatter than the damage curve. In

practice, however, the selection of instruments can be based on a range of criteria as discussed below[3]:

- *Cost-effectiveness*. It is easy to demonstrate that uniform pollution charges and tradable permits allow the desired objective to be reached at a lower cost than uniform emissions standards.
- *Dynamic Incentives* certainly exist under economic instruments. Indeed, since the firm has to pay a price for every unit of pollution it produces (or alternatively must buy a permit for every unit of pollution it produces), the firm always has the incentive to reduce its emissions so as to reduce its total tax payments (or sell permits it does not need anymore). Such incentives are much reduced under command and control since under this policy, the firm can pollute up to the standard free of charge. Once it complies with the standard, it has little incentive to do any better.
- *Implementation Issues*. None of the instruments possess a distinctive advantage in terms of implementability. In all cases, firms must report their level of emissions (self-reporting), the regulator must verify the accuracy these reports, it must monitor the firms, measure the firm's emissions, and enforce either the standards, mis-reporting by the firm, or compliance with the number of permits held by the firm. These are not easy tasks.
- *Flexibility*. While there is a tendency to group together economic instruments, tradable permits may benefit from an important advantage over pollution charges in terms of *flexibility*. Indeed, with pollution charges, the regulator must intervene to change the level of the charge in order to maintain aggregate emissions at their desired level when economic conditions are changing. For example, in times of increased economic activity, the pollution charge may have to be increased so as to keep aggregate emissions constant. With tradable permits, by definition aggregate emissions will remain constant; however, the price of a permit will reflect the intensity of the demand and adjust itself through market forces. There is in this case no need for the regulator to intervene. On the other hand, for tradable permits to work efficiently, the market for permits must be relatively competitive (with a large number of firms trading the permits). This condition may not always be satisfied.

Other criteria for making choice among the instruments could be information intensity, environmental effectiveness, consistency with other existing policies, political feasibility, impact on the economy, and distributional issues.

While pollution charges and tradable permits appear considerably superior, the command-and-control has overwhelmingly been the preferred method of intervention. A large number of reasons may explain this phenomenon. Economic instruments have often been perceived as a "license to pollute" as opposed to a genuine instrument by which social optimality may be restored. The impact of economic instruments on the competitiveness of enterprises has also been a much-debated topic.

Instruments in Practice

Most countries have adopted a second-best pollution control regime based on any one or combination of the following approaches, namely:

(i) Standards and regulation
(ii) Standards and charges
(iii) Standards and permits.

The superiority of (ii and iii) compared with (i) is that the former give flexibility to the polluters in achieving the standards at least cost. Titenberg (1985) and Anderson and Carlin (1999) and many others report cost savings from the adoption of these approaches compared to the use of purely

[3]Sterner (2002) provides a more detailed selection matrix across a wide range of policy instruments.

command and control approach. The following paragraphs discuss the policy instruments in use in some of the SAARC countries.

India

The concern for environment manifested in legislature form in early Seventies in India. The enactment of environmental laws included: Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Water (Prevention and Control of Pollution) Cess Act, 1977; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act, 1986; Motor Vehicle Act, 1988 (amended); and Public Liability Insurance Act, 1991. The Water Act has resulted in the creation of Central and State Pollution Control Boards – initially with the aim of controlling water pollution, but later to include Air and other environmental mediums also under their purview.

India mainly depended on command and control regulation for environmental management. The water cess currently levied on industries can not be seen as pollution tax and the nominal rates (around Rs. 0.015 to 0.07 per kilo-liter) never had any dampening effect on the resource use. Many studies (Murty et al., 1999; Murty and Kumar, 2004) have argued that the pollution tax on the industrial water use should be several times higher than the current rate to realize the desired water quality standards.

Widespread use of subsidies is another anomy with the industrial pollution control in India. Several tax concessions/subsidies are provided to the polluters in anticipation that such concessions would drive them towards cleaner production methods. But subsidies, unlike taxes, do not create the incentive to choose the least cost pollution abatement technologies. Thus the choice of policy instrument appears to have had detrimental effect on pollution control.

However subsidies as policy instrument had significant impact in the context of pollution from small scale units. Given small scale of operation it is not economical for the individual units to establish effluent treatment plant, and pollution taxes would be ineffective as the units may prefer to pay tax than reduce pollution. In such context common effluent treatment plants (CETPs) are considered to be an effective way to reduce pollution. Many studies have shown that CETPs would be beneficial to the firms, affected people, and the regulator (in terms of reducing the monitoring costs). Thus, collective action is now emerging as an institutional alternative to deal with the problem of water pollution. Murty et al. (1999) discuss the historical developments leading to the adoption of CETP technologies by industrial estates in Andhra Pradesh, Haryana and Tamil Nadu states and argue that collective action, especially with pressure from the affected people, has played an important role in the new form of pollution control.

India is presently moving towards adoption of pollution charges and the Ministry of Environment and Forests (MoEF) has taken several initiatives in this direction. With assistance from the World Bank, the MoEF has recently completed a five year project, India: Environmental Management Capacity Building Technical Assistance Project. The project among other things explored the scope for introducing market based instruments for pollution control in India. A Task Force constituted by the MoEF has initiated and successfully completed a project to identify the appropriate tax rates on various inputs and outputs causing negative environmental externalities. The recommendations are presently under review by various government departments and could be implemented soon.

Sri Lanka

Environmental policy in Sri Lanka has been dominated by command and control through the legal, regulatory and planning approach. Some of the legislative acts include: Coast Conservation Act (1980), the National Aquatic Resources Act (1981), and the National Environmental Act (1980 and amended in 1988). The implementation of these acts has been largely poor and much of it could be attributed to the strong enforcement mindset adopted so far. In response to these perceived failures, the government is now focusing on the need to consider market based instruments in environmental

policy[4]. For fiscal macroeconomic reasons many product charges are also increased in recent times including price rise for gasoline, water electricity, and reduction of fishing subsidies. The following Table 3 shows some recent measures and potential future policy instruments for environmental management.

Table 3. Measures and Potential Future Policy Instruments

Instrument	Introduced In	Potential for introduction
Rise in non-compliance fees	Timber fine increased	Coastal and water pollution
Rise in user charges	Irrigation fees introduced, removal of coastal fishing subsidy	Waste and sewage user fess, ground water extraction charge
Export/Import subsidy	Timber import duty lowered	Removal of import tariff on potato and tobacco; introduction of export charge for shrimp etc.
Raise rent taxes	Timber stumpage fee introduced; entry fee raised for national parks	Extending rise in entry fee for all parks including those controlled by Forest Department
Deposit refunds	Deposit refunds exist for paper and glass, large scale clay mining	Extending for car batteries and plastic waste
Environmental subsidies	Subsidies exist for watershed protection, pollution-abatement control	Extending to relocation of industrial estates, unleaded petrol etc.
Environmental charges	Load-based pollution license fee exists	Extending to load-based pollution charge, pesticide tax

Source: Adopted from Steele (1999)

Pakistan

Prior to promulgation of Pakistan Environmental Protection Ordinance of 1983 and the recent passage of Pakistan Environmental Protection Act (1997), Pakistan had laws that contain provisions for environmental protection. These laws dealt with land use, water quality, air quality, noise, toxic and hazardous substances, solid waste and effluents, forest conservation, mineral development, energy, public health etc. They were not very effective partly because the mild punishment and easy access to circumvent. Some of the initiatives taken in Pakistan include:

- The National Environmental Quality Standards (NEQS) in Pakistan are primarily concentration based. Unfortunately, the limits on liquid industrial effluents are neither industry-specific nor do they have any relationship with the quantum of production. NEQS prohibit dilution, but evidence shows that it is easy to circumvent.
- Self monitoring and reporting system makes the country's industry owners and operators responsible for systematic monitoring and reporting of their environmental performance, saving regulator's expense, time and effort, as well as enabling industry to make long-term provision for environmentally friendly production. A pilot phase of this system has started in 2000.
- Through coordination among representatives of industry, government, environmental NGOs and academic researchers, modalities for implementation of pollution charges are evolved. Operational implementation of the same is still pending.

Conclusion

While it is easy to prescribe that developing countries such as SAARC countries should adopt the so-called market based policy instruments and slowly move away from the conventional command

[4]Incidentally Sri Lanka provides perhaps the world's first documented example of an environmental tax with an inscription outside the ruined city of Anuradhapura from AD 65 stating that fishing in large reservoirs were owned by the King and those he allowed to fish paid a tax.

and control approach to environmental management, one may not deny the role of non-availability of resources (in the form of funds, trained staff, technical know-how etc.) as an impediment to policy making. As pointed by Sterner (2002), against the overall staff size of 6000 in U.S. Environmental Protection Agency, the Chinese counterpart has a mere 200 staff.

For successfully managing environment combination of various policy instruments discussed in this note is needed as no single instrument can meet the multiple objectives. In this context it would helpful to keep the following in mind:

- While setting the pollution charges it is important to involve all the stakeholders (including the polluters) to achieve greater political acceptability.
- Following transparent, democratic, and bureaucratically feasible process for decision-making is crucial for successful policy implementation. For the sake of legitimacy all parties affected must be given the opportunity to influence the legislation. But at the same time they should be given too much influence, as it would nullify the overall goal (environmental effectiveness) of the instruments.
- When abatement costs vary considerably, then for efficient outcome the regulator could depend on instruments such as taxes and tradable permits. On the other hand if damage costs vary significantly, instruments such as zoning, differential regulations and differential licenses must be used. In the presence of significant information asymmetry, then instruments designed to be self-revealing (e.g., deposit-refund scheme) should be used.
- When scope for effective environmental management by the regulator and polluter is limited, then other players (namely, market and community) would enter to broaden the environmental policy making process. This third-wave environmental policy making is already showing signs of existence in many developing countries with widespread community participation.

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Clean Development Mechanism: An Overview

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ABSTRACT *Increasing scientific evidence of human interference with the global climate system, along with growing public concerns about the environment, pushed climate change onto the political agenda in the mid-1980s. This led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) to provide policymakers with authoritative scientific information. IPCC reports confirmed that climate change was a threat and called for an international treaty to address the problem. This module presents the overview of cleaner development mechanism.*

Introduction

United Nations Framework Convention on Climate Change- As the Precursor of Clean Development Mechanism

The international treaty resulted the formulation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (URC, 2003). The Convention sets an "ultimate objective" of stabilizing atmospheric concentrations of greenhouse gases at safe levels. The Convention categorizes countries into two groups: Annex I Parties i.e. the industrialized countries who have historically contributed the most to climate change, and non-Annex I Parties, which includes primarily the developing countries. The principle of equity and "common but differentiated responsibilities" contained in the Convention requires Annex I Parties to take the lead in reducing their greenhouse gas emissions to 1990 levels by the year 2000.

Conference of Parties (COP)

The Conference of the Parties (COP) is the "supreme body" of the Convention, that is, COP is the highest decision-making authority under the UNFCCC. It is an association of all the countries that are Parties to the Convention. The COP meets every year, unless the Parties decide otherwise.

Kyoto Protocol

The Kyoto Protocol, adopted in December 1997, creates legally binding obligations on Annex I countries to reduce their emissions of GHGs. As of 27 February 2006, 162 states and regional economic integration organizations have deposited instruments of ratifications, accessions, approvals or acceptances (UNFCCC, 2006a). The protocol entered into force on 16 February 2005.

Emission Mitigation Commitment: The Kyoto Protocol stipulates the commitments of Annex I Parties to individual, legally binding targets to limit or reduce their greenhouse gas emissions. The individual targets for Annex I Parties vary widely and can be found in UNFCCC website (http://cdm.unfccc.int). However, the commitments add up to a total cut in green house gas emissions of at least 5% from the 1990 levels in the first commitment period 2008- 2012. Negotiations on targets for the second commitment period would start once the "demonstrable progresses" are made in meeting their commitments under the Protocol. The emission reduction target in the Kyoto Protocol covers the six main greenhouse gases (GHGs):

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous Oxide (N_2O),
- Hydrofluorocarbons (HFCs),

- Perfluorocarbons (PFCs); and
- Sulphur Hexafluoride (SF6).

The Kyoto Cooperative Mechanisms: The Kyoto Protocol has established three cooperative mechanisms (also called "flexible mechanisms") designed to help industrialized countries (Annex I Parties) reduce the costs of meeting their GHG emissions targets by achieving emission reduction at lower costs in other countries than they could domestically. The mechanisms are:

a. International *Emission Trading* (ET) permits countries to transfer parts of their 'allowed emissions' ("assigned amount units").
b. *Joint Implementation* (JI) allows countries to claim credit for emission reductions that arise from investment in other industrialized countries, which result in a transfer of equivalent "emission reduction units" between the countries.
c. The *Clean Development Mechanism* (CDM) allows participation of Annex I country parties in GHG emission mitigation projects in Non-Annex I countries (developing countries). Projects implemented under the CDM should generate GHG mitigation additional to what would occur in their absence. The projects should assist developing countries in achieving the goal of sustainable development. The projects generate "certified emission reductions" (which could be used or traded by the investor).

Clean Development Mechanism

The Clean Development Mechanism (CDM), a cooperative mechanism established under the Kyoto Protocol, has the potential to assist developing countries in achieving sustainable development by promoting environmentally friendly investment from industrialized country governments and businesses. According to the Kyoto Protocol, the purpose of the CDM shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of UNFCCC, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments. The CDM allows governments or private entities in industrialized countries to implement emission reduction projects in developing countries and receive credit in the form of "certified emission reductions (CERs), which they may use to meet their national reduction targets.

The CDM offers the industrialized countries and private sector companies an opportunity to reduce emissions anywhere in the developing world – wherever the cost is low – and to use these reductions towards meeting their own GHG reduction commitments. The funding channeled through the CDM should assist developing countries in reaching some of their economic, social, environmental and sustainable development objectives, such as cleaner air and water, improved land-use, accompanied by social benefits such as rural development, employment, and poverty alleviation and in many cases, reduced dependence on imported fossil fuels. From the developing country perspective, the benefits of the CDM would include:

- Inflow of capital for projects that assist in the shift to a more prosperous but less carbon-intensive economy;
- Providing a tool for technology transfer, if investment is channeled into projects that replace old and inefficient fossil fuel technology, or create new industries in environmentally sustainable technologies;
- Helping define investment priorities in projects that meet sustainable development goals.
- Creating new sources of funding
- Providing sustainable ways of energy production;
- Increasing energy efficiency & conservation;
- Poverty alleviation through income and employment generation; and,
- Local environmental side benefits

Benefits of CDM for the developed countries would be mainly low abatement cost of their emission reduction.

CDM Institutions and Their Roles

It is important to know how the CDM works before one can develop a CDM project. The CDM involves an institutional set up to facilitate the process of CDM project development. These are discussed in this section.

Executive Board

The CDM Executive Board (CDM-EB) administers and supervises the operation of the CDM subject to the authority and guidance of the COP/MOP. The Executive Board is comprised of representatives of both developing and industrialized country parties. The duties of the Executive Board include the formulation of new policies such as on how small scale CDM activities function, reviewing validation and certification decisions of designated operational entities, reviewing and adjudicating over the conduct of questionable actions taken by designated operational entities (OE), and addressing practical questions as they may arise in the CDM process. A key responsibility of the Executive Board is to develop guidelines on baseline methodologies. It maintains a publicly available list of all designated operational entities (DOE), a database of all CDM project activities, and a repository of its approved rules, procedures, methodologies and standards (UNFCCC, 2006b).

Methodology Panel (Meth Panel)

The Methodologies Panel (also called "Meth Panel") was established to develop recommendations to the CDM Executive Board on guidelines for methodologies for baselines and monitoring plans and prepare recommendations on submitted proposals for new baseline and monitoring methodologies. The panel operates under the guidance of the Executive Board. The mandate of the Meth Panel is determined by the terms of reference, general guidelines for panels of the Executive Board, the rules of procedure of the Board. Two members of the Executive Board serve as Chair and vice Chair of the panel, respectively. In addition to the designated Executive Board members who act as Chair and Vice-Chair, the panel is composed of ten members. The frequency of panel meetings is determined by the Chair and vice Chair of the Meth Panel (UNFCCC, 2006b).

Designated National Authority (DNA)

Participating countries are required to designate a national authority in each of the countries. The role of the designated national authority (DNA) is to ensure that proposed CDM projects meet planning and other legal requirements, and that the project is in accordance with national sustainable development investment needs. The DNA checks that the Project Design Document (PDD) for a proposed CDM project is complete and realistic and decides whether to approve the project. The DNA also provides written confirmation of its country's voluntary participation in each CDM project to the designated operational entities and confirms that the CDM project activity assists it in achieving sustainable development. A DNA could be a person or unit in an existing government ministry. In order for a DNA to effectively undertake its responsibilities, new national regulatory policies may have to be enacted and capacity needs to be developed to ensure that the DNA has the mandate and skills to assess and approve CDM projects (UNFCCC, 2006b).

Designated Operational Entity (DOE)

The CDM process also involves Designated Operational Entities (DOEs). A main role of a DOE is to validate if a project meets CDM requirements before the project is registered with the CDM Executive Board. A different DOE must later verify the GHG emission estimates made for the project once it is in operation. For small projects, the operational entity that validates a project may also verify it. During the verification process the operational entity will determine whether the project's documentation is in accordance with the requirements of its registered project design document and the CDM rules. A DOE can conduct on-site inspections, review monitoring results, verifies if the monitoring methodologies have been properly applied and prepares a verification

report. The DOE that carries out the verification also carries out certification for the project. A certification is a written assurance that the project achieved the stated level of emission reductions (UNFCCC, 2006b).

CDM Project Eligibility Conditions

Participation in CDM

In order to participate in the CDM, all parties (Annex I and non-Annex I Parties) must meet three basic requirements: (i) voluntary participation, (ii) establishment of the National CDM Authority, and (iii) ratification of the Kyoto Protocol.

Project Eligibility

Two critical criteria of CDM could be broadly classified as additionality and sustainable development. Additionality refers to the fact that projects must result in "reductions in emissions that are additional to any that would occur in the absence of the project activity". The additional greenhouse gas reductions are calculated with reference to a defined baseline. The concept of sustainable development specifies that the purpose of the CDM is to assist non-Annex I Parties in achieving sustainable development. There is no common guideline for the sustainable development criterion and it is up to the developing host countries to determine their own criteria and assessment process. The criteria for Sustainable Development may be broadly categorized as (i) social criteria, (ii) economic criteria and (iii) environmental criteria.

Eligible CDM Projects

- The CDM will include projects in the following sectors:
- End-use energy efficiency improvements
- Supply-side energy efficiency improvement
- Renewable energy
- Fuel switching
- Waste handling and disposal
- Agriculture (reduction of CH_4 and N_2O emissions)
- Industrial processes (CO_2 from Cement etc., HFCs, PFCs, SF6)
- Sinks projects (only afforestation and reforestation)

Annex I Parties must refrain from using CERs generated through nuclear energy to meet their targets (UNFCCC, 2001). Although, nuclear energy does not create greenhouse gas emissions, it has other environmental implications such as those associated with waste disposal and decommissioning. This controversy has resulted in developed countries being asked not to use CDM credits from nuclear facilities such as nuclear power stations (UNFCCC, 2001). In order to make small projects competitive with larger ones, the Marrakech Accord establishes a fast track for small-scale projects with simpler eligibility rules.

Financing CDM Projects

Public funding for CDM projects must not result in the diversion of funds for official development assistance. In addition, the CERs generated by CDM projects will be subject to a levy known as the "share of the proceeds" of 2%, which will be paid into a newly created adaptation fund to help particularly vulnerable developing countries adapt to the adverse effects of climate change.

Legal Requirements

Participation in the CDM is limited to Parties (i.e. governments) who have ratified the Kyoto Protocol and private entities authorized by those Parties. For successful registration of a project, the CDM Executive Board would require that the project has met the following conditions:

(i) the project is undertaken in a host country that is a Party to the Kyoto Protocol and by Parties to the Kyoto Protocol or by private entities that have been authorized by such Parties to participate in the CDM;
(ii) the project complies with the eligibility requirements for a registered project under the CDM;
(iii) the project assists the host country to achieve sustainable development;
(iv) the project provides real, measurable, and long-term benefits related to the mitigation of climate change;
(v) the project delivers reductions in emissions that are additional to any that would occur in the absence of the certified project activity; and
(vi) the project does not result in the diversion of ODA

In addition, CDM Projects will also need to comply with any legal requirements in the host country.

Crediting Period

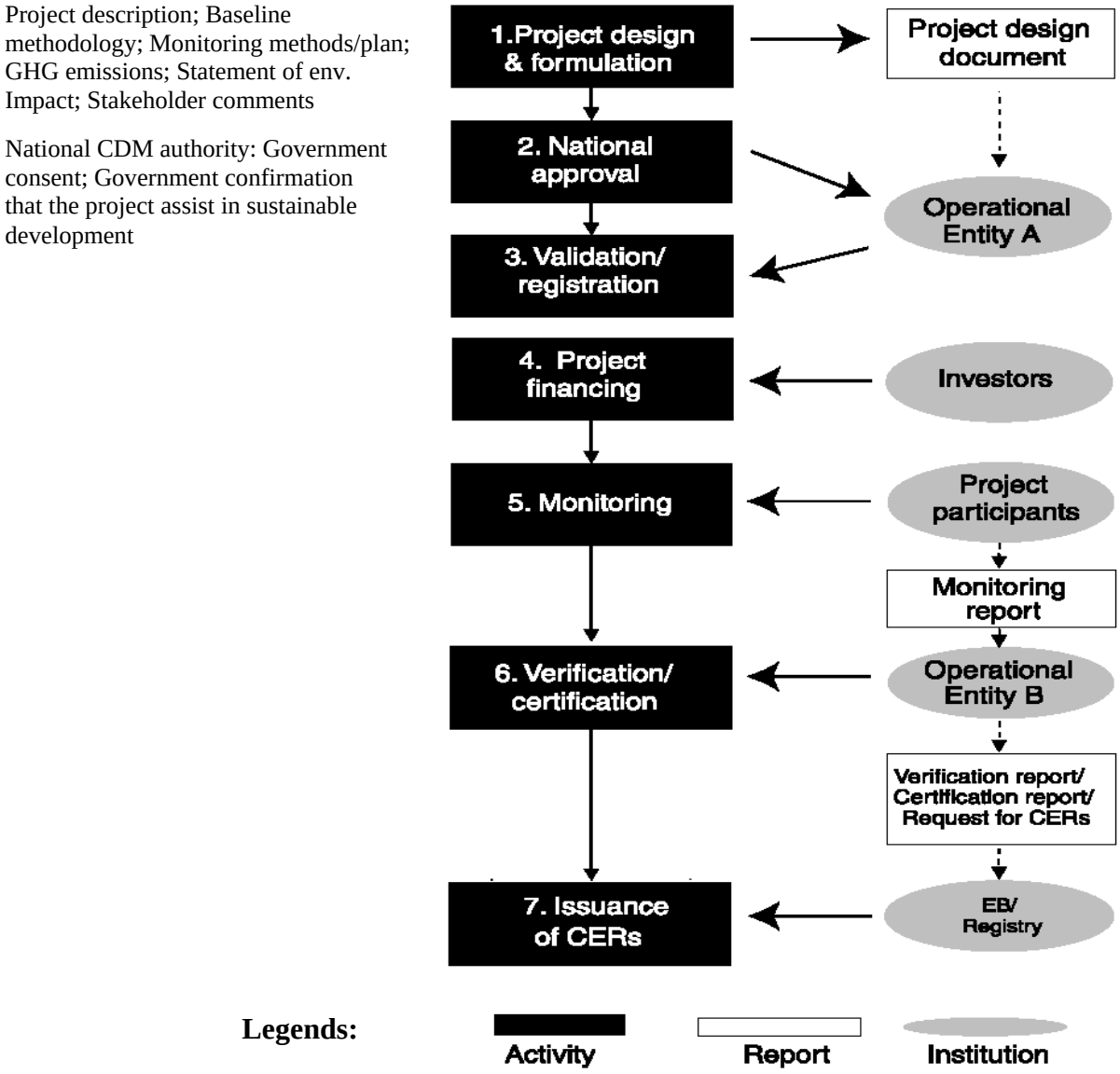
A crediting period is the period of time during which a proposed project's emissions are measured for the calculation of CDM credits that should be issued. Crediting periods may either be for a maximum of seven years (which may be renewed at most two times) or a maximum of ten years with no option of renewal.

The CDM Project Cycle

The CDM project cycle is a series of actions (Figure 1) that are needed to establish an activity as a CDM project and get certified emission reduction credits from it in accordance with established rules and procedure for the CDM.

Project Design

The project participant(s) needs to present the plans for the project in the project design document (PDD). The PDD sets out the terms of operation of the project, its description, its proposed methodology for calculating greenhouse gas emission reductions, an explanation of how greenhouse gas emissions are reduced by the project, information on sources of public funding for the project, and stakeholder comments. The PDD needs to show that emission reductions will occur as a result of the project. It must include the methodologies used to establish the baseline level of emissions that what would have occurred if the project did not take place, and the methodology for monitoring ongoing emissions from the project once it is implemented. The ongoing emissions will be compared with the baseline emission levels in order to demonstrate the additionality of the emission reductions from the project and to calculate the certified emission reduction credits. The document also explains crediting period over which the project will generate certified emission reduction credits, the project boundary within which the emission reductions will occur, and certain other elements such as a description of stakeholder comments (FIELD, 2006).



Source: UNEP RISOE Centre (2003)

Figure 1. CDM Project Cycle

Project Baselines

A project baseline is an estimate of the emissions that would have occurred without the project. A baseline must include an estimate of the level of emissions of all greenhouse gases that would have taken place, if the project had not been implemented, from all of the emission sources within the project boundary. Baselines must be established based on any of the following approaches:

a) Existing actual or historical emissions,
b) Emissions from a technology that represents an economically attractive course of action,
c) The average emissions of similar project activities undertaken in the previous five years in similar social, economic, environmental and technological circumstances.

In addition, the project participant needs to justify why the selected approach is suitable for baseline establishment.

The project participant may use an appropriate baseline methodology already published by the CDM-EB. In case, the project participant wishes to use a new baseline or monitoring methodology, the designated operational entity (DOE) that validates the project must forward the proposed

methodology and other relevant materials to the CDM-EB for review. If the CDM-EB approves the methodology, the designated operational entity may proceed with the validation of the project activity. After a project is implemented, actual emissions are monitored and then compared to the baseline to determine the emissions reductions that the project has created. Figure 2 illustrates the concept of baseline. For detailed methodology of baseline emission, see Shrestha et al. (2005).

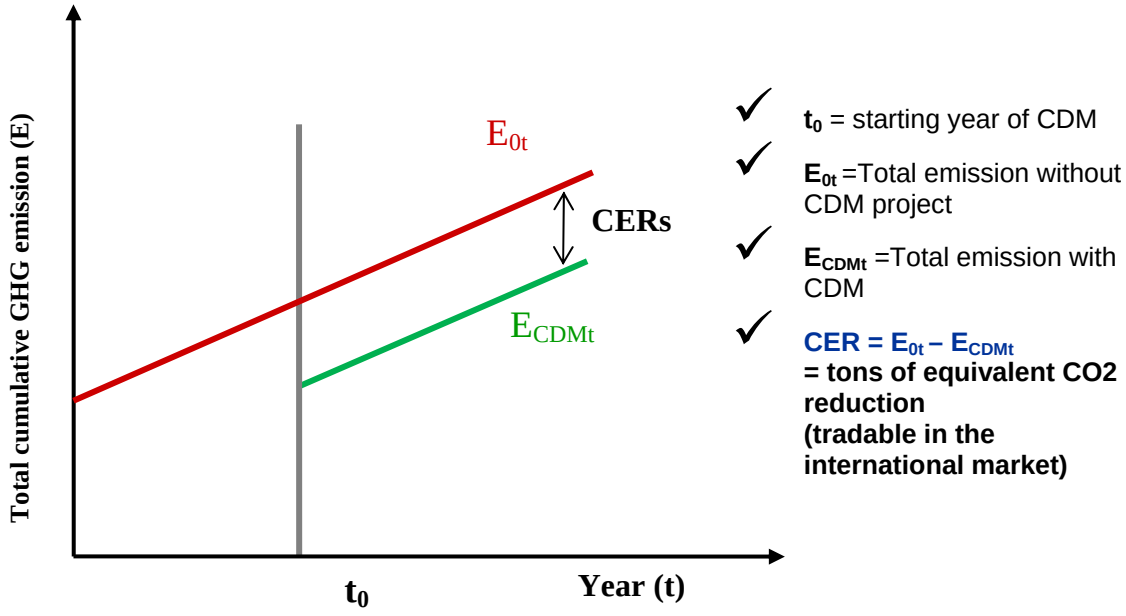


Figure 2. Illustration of Baseline Concept

Validation and Registration

Validation is an independent evaluation of whether a proposed CDM project meets the established CDM requirements. A DOE reviews the PDD to determine whether a proposed project meets CDM requirements, and prepares a validation report. Among other things, the DOE will confirm that the technology used in the project will provide additional reductions in emissions, and promote sustainable development. The DOE will check the assumptions and calculations upon which the PDD is based to determine if the project proposal is realistic and adequate. Once a project has been validated by a DOE, it can be registered with the CDM-EB as a CDM project.

The registration of a project will be final eight weeks after the date of receipt by the CDM-EB. However, if a review of the proposed CDM project activity is requested, then registration will be delayed while the CDM-EB determines whether the activity meets the requirements of the CDM.

Monitoring

Project participants must monitor the emissions that occur from their CDM project once it has been implemented. A monitoring plan for the project is included as a part of the PDD. When validating a project, a DOE must confirm that the project's planned emission monitoring methodologies comply with CDM rules. The monitoring report is verified by a DOE. Proper implementation of the monitoring plan is a condition for verification, certification and the issuance of certified emission reduction credits.

Verification and Certification

The emissions reductions from a CDM project must be verified by a DOE. The DOE's findings are compiled in a "verification report" which is submitted to the CDM Executive Board and made available to the public. Each verification report covers a specific verification period set out by the project participants.

Certification is the written assurance by an independent third party that, during a specified time period, the project achieved the stated level of emission reductions. The certification is done in accordance with the guideline of CDM-EB. The certification constitutes a request by the DOE that the CDM-EB issue CDM credits equal to the verified amount of emissions reductions flowing from the certified project activity (FIELD, 2006).

Issuance of Credits

Once the emissions reductions resulting from the project have been certified by a DOE, the CDM Executive Board and if there is no more review required, the Executive Board issues the CDM credits. Before the CDM credits are issued to the project participants, the CDM registry administrator will allocate a share of credits as a levy to cover administrative and adaptation costs. Then the administrator allocates the remaining credits that are called Certified Emission Reductions or CERs to the registry accounts of the project participants.

Stakeholders' Involvement

Every CDM project should consider the comments of the stakeholders who could be affected by the proposed activity. During the validation and verification process, the Designated Operational Entity (DOE) will either consult the stakeholders or make the methodology publicly available. Any opposition at that stage will delay the project registration process.

Overview of CDM Projects

Scale CDM Projects

While large as well as small scale projects can both be implemented under the CDM, the CDM Executive Board has issued fast-track prompt start procedures for "small-scale" CDM Project activities. The objective of this fast track mechanism is to enable small scale projects to be pursued without the need for going through the rigorous and expensive approval and assessment processes as required for larger scale projects. Small-scale activities include (URC, 2004):

- Renewable energy project activities with a maximum output capacity equivalent of up to 15 megawatts (or an appropriate equivalent);
- Energy efficiency improvement project activities that reduce energy consumption on the supply and/or demand side, by up to the equivalent of 15 gigawatt hours per year;
- Afforestation or Reforestation projects that are expected to result in net human induced greenhouse gas removals of less than 8 kilotonnes of CO_2 per year and are developed or implemented by low-income communities or individuals (as determined by the host country); or
- Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilo tonnes of carbon dioxide equivalent annually.

Afforestation and Reforestation Sinks Projects

Only afforestation and reforestation (A&R) projects are eligible and the maximum use of CERs from A&R projects should be less than 1% of the 1990 emissions of the Party. Other sinks like revegetation, forest management, cropland management and grazing land management are not allowed under the CDM but only as Joint Implementation projects in Annex-I countries. Avoided deforestation is allowed for normal small-scale CDM projects, e.g. where it can be proved that installation of efficient wood stoves reduce the deforestation. The terms "Afforestation" and "Reforestation" are defined in the following way in the context of the CDM:

- Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years into forested land through planting/ seeding.

- Reforestation in the first commitment period (2008-2012) limited to lands that did not contain forest on 31 December 1989.

Unilateral CDM Projects

A unilateral CDM Project would enable a non-Annex I Party to undertake a project with all participants being nationals of the host country and no Annex I Party being directly involved. The CERs created for this project could then later be sold to purchasers in the carbon market. This type of projects will avoid the need for waiting to look for investment in a CDM project by a party from Annex I country. Unilateral CDM projects have been approved on the eighteenth meeting of the CDM Executive Board.

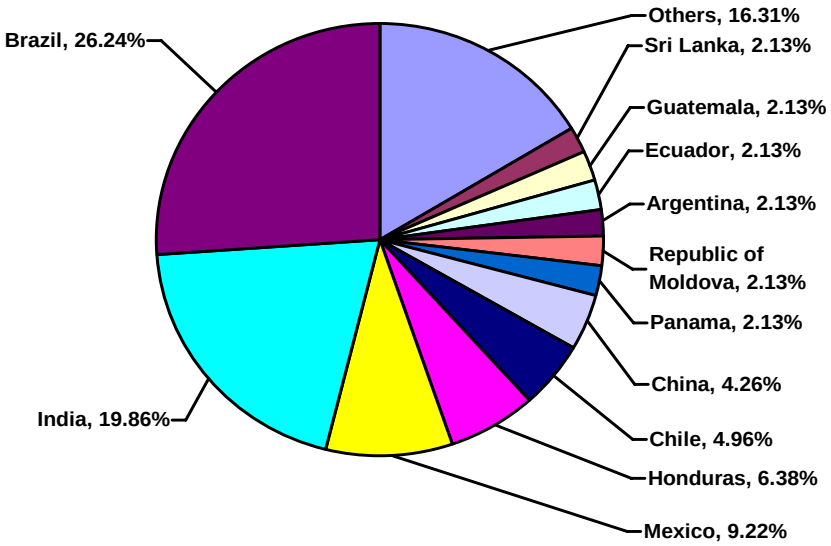
Bundling and Debundling

Bundling is combining a number of small projects in one PDD. This helps to reduce the transaction cost. Projects may be bundled as long as the total size is below the limits for a single project as listed for the 3 small scale project types above. Debundling a large CDM project into consecutive small-scale parts is not eligible for a small-scale CDM project if the total is greater than the small-scale project eligibility level. A proposed small-scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or if there is an application to register another small-scale CDM project activity:

- with the same project participants;
- in the same project category and technology/measure; and
- registered within the previous 2 years; and
- whose project boundary is within 1 km of the project boundary of the proposed small- scale activity at the closest point.

Overview of Registered CDM Projects and Approved Methodologies

CDM projects: As of March 2006, total 630 projects are in pipeline for registration process. Of these, 141 CDM projects have been registered from 29 countries around the world and another 17 projects are in the registration process. The rest are in either validation process or in queue. Figure 3 gives a distribution of registered projects according to the host countries.

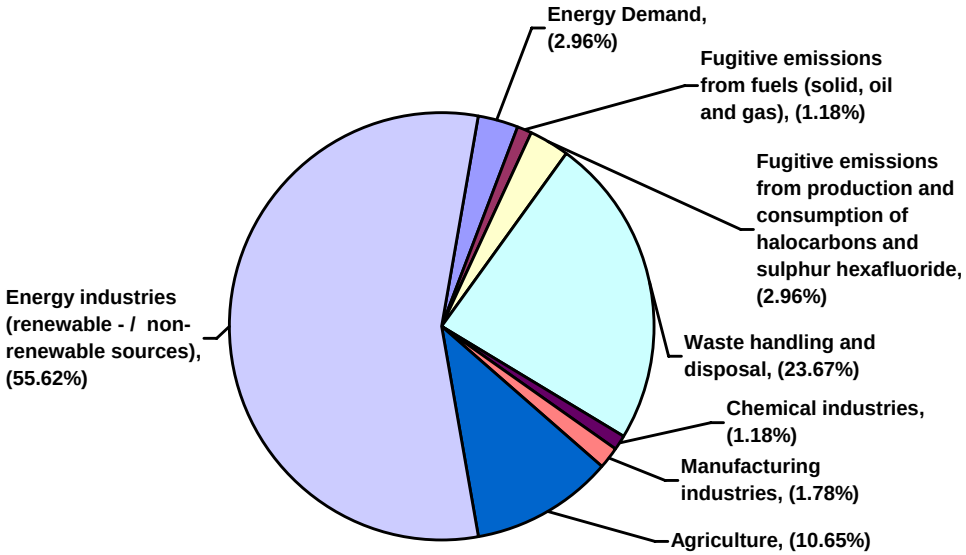


Source: UNFCCC (2006b)

Figure 3. Distribution of Registered CDM Projects by Host Countries

Of these, 89 projects have collaboration with parties from 12 Annex I countries. The maximum number of projects have been developed with the Netherlands (24 projects) followed by Northern Ireland (17 projects). Of the registered projects, 85 projects have been registered as large scale projects and 56 are small scale projects.

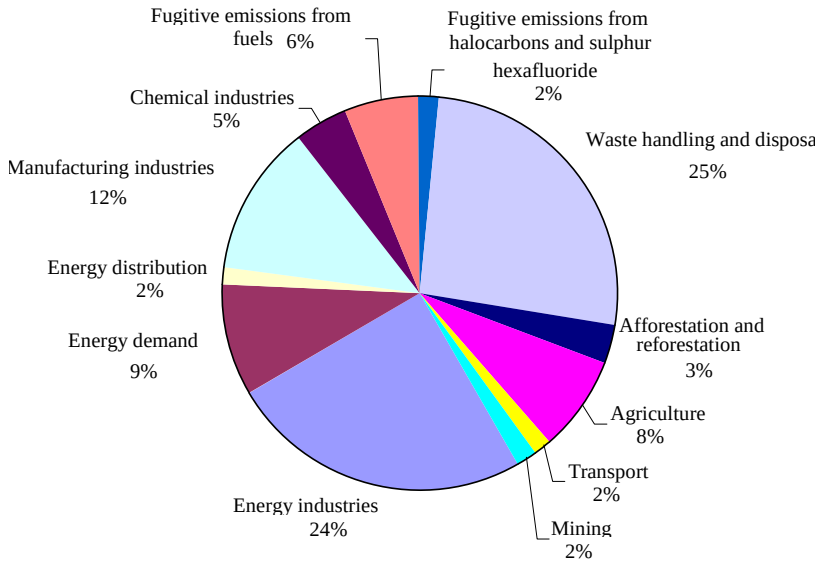
Figure 4 presents a distribution of the registered projects according to the sectoral scope or type of the activity. It is to be noted that some of the projects belong to more than one sectoral scopes. The highest numbers of projects (94 projects) have been registered under 'Energy Industries (renewable / non-renewable sources)' followed by 'Waste Handling and Disposal' (40 projects).



Source: UNFCCC (2006b)

Figure 4. Distribution of Registered CDM Projects According to the Sectoral Scopes

Approved Methodologies: Methodologies have been categorized as (i) Large scale, (ii) small scale and (iii) consolidated. So far, 65 methodologies have been approved, of which 32 are for large-scale projects, 23 for small-scale projects and 10 consolidated methodologies. The maximum numbers of methodologies approved are under 'Waste Handling and Disposal' sector (17 methodologies) followed by 'Energy Industries' (16 methodologies). Figure 5 presents distribution of methodologies according to sectoral scopes.



Source: UNFCCC (2006b)

Certified Emission Reductions (CERs): One Certified Emission Reduction (CER) represents a 'ton of CO_2 equivalent emission reduction" which may be sold in the international market. It is expected that the 141 CDM projects registered so far, will generate an average more than 50 million CERs per year. Based on the estimate, the total amount of CERs generated until the end of 2012 would be more than 330 million units. The highest amount of average annual CERs is expected from China (16.5 million units) followed by Republic of Korea and Brazil (10.5 million units each)

National Issues Related to CDM

Establishment of National Institutional Structure

The National CDM Authority is the host country entity or body that evaluates potential CDM projects and provides written approval confirming that the project activity is voluntary, complies with national and international criteria, and assists in achieving sustainable development of the host country. The National CDM Authority needs to have open communication with the government agencies of the sectors relevant to the CDM. The technical review of projects can often involve the ministries or agencies of the relevant sector (energy, natural resources, environment, etc.).

Synergies between CDM Projects and National SD Priorities

As discussed earlier, the Kyoto Protocol stipulates that CDM projects must assist developing countries in achieving sustainable development (SD) in order to fulfill the eligibility criteria. However, the SD dimension should not merely be seen as a requirement of the CDM, it should be seen as a main driver for developing country interested in participating in the CDM. National authorities can use the SD criteria to evaluate key linkages between national development goals and CDM projects, with the aim of selecting and designing CDM projects in a way, where they explore, create and maximize synergies with local development goals.

Establishment of SD Criteria

One way of establishing a linkage between CDM projects and national sustainable development criteria is through the use of project evaluation indicators that reflect specific CDM project issues such as financial costs and GHG emission reductions as well as development criteria including economic, social, and environmental sustainability dimension. The assessment of SD aspect of a project will involve a set of indicators. The indicators should be (URC, 2004):

- *Complete*: The set of indicators should be adequate to indicate the degree to which the overall objective of sustainability has been met.
- *Operational*: The set of indicators should be such that they can be used in a meaningful way in the analysis.
- *Decomposable*: It is recommended that the set of indicators is decomposable, i.e. that the decisions can be broken down into parts involving a smaller number of indicators.
- *Non-redundant*: The indicators should be defined to avoid double counting of consequences.
- *Minimal*: It is desirable to keep the set of indicators as small as possible. For instance it may be possible to combine indicators to reduce the dimensionality of the decision problem.

Project Idea Note (PIN)

The PIN is normally a five-page document providing information on a proposed CDM project as to whether the project meets general criteria of the Designated National Authority (DNA). In some countries, PIN is a tool to get a letter of endorsement from the DNA of the host country, and can be used by project developers to seek additional financial support from potential investors. The PIN is

used as a marketing tool which is distributed to the potential CDM investors to begin negotiations for partnership (CD4CDM, 2003).

Usually a PIN has three main parts:

a) Project Description (e.g. type of project, location, schedule, etc.)
   - Objective of the project
   - Project description and proposed activities
   - Technology to be employed
   - Project developer/sponsors
   - Type of project
   - Location
   - Expected schedule
   - The position of the Host Country with regard to the Kyoto Protocol
b) Expected Environmental and Social Benefits
   - Estimate of GHG abated/CO2 sequestered
   - Baseline scenario
   - Specific global and local environmental benefits
   - Socio-economic aspects
   - Environmental strategy/priorities of the host countries
c) Finance
   - Total project cost estimate
   - Sources of finance to be sought or already identified
   - Sources of carbon finance
   - Indicative CER price
   - Total emission reduction purchase agreement (ERPA) value

Financial/Cost Issues of CDM Projects

Project Viability

CDM projects produce both conventional project output and carbon benefits (CERs). The value of carbon benefits and its impact on project viability are influenced by several factors such as the amount of CERs generated by the project, the price of CER and the transaction costs involved in securing CERs.

Impact of CERs on Project Viability

The net financial gain derived from the sale of CERs is the difference between the project CER value and the transaction costs. There are three elements that influence the net impact of CERs on project profitability (URC, 2004):

- value of CERs (low CER value implies low net benefits),
- overall transaction costs (high transaction costs yield low net benefits), and
- up-front transaction costs (high upfront payments could also result in low benefits).

Project developers generally expect up-front transaction costs within the range of 5 to 7% of the net present value of the revenue or total transaction costs around 10 to 12% of the net present value of revenue. A positive net financial gain means that CER revenues improve the financial viability of the project (URC, 2004). Table 1 shows the impact of CERs on IRRs in selected projects.

Securing Project Funds

CER trading: Governments and private companies from non-Annex 1 parties are the main buyers of CERs. There are three different models under which CERs are developed and exchanged (URC, 2004):

Table 1. Impact of CER price on project's IRR

Country	**Project**	**IRR without Carbon finance (%)**	**IRR with carbon finance (%)**	**Change in IRR (%)**
Costa Rica	Wind power	9.7	10.6	0.9
Jamaica	Wind power	17.0	18.0	1.0
Morocco	Wind power	12.7	14.0	1.3
Chile	Hydro	9.2	10.4	1.2
Costa Rica	Hydro	7.1	9.7	2.6
Guyana	Bagasse	7.2	7.7	0.5
Brazil	Biomass	8.3	13.5	5.2
India	Solid waste	13.8	18.7	5.0

Source: PCF Annual Report 2001 as cited in URC (2004)

- Unilateral CDM Model – the host country develops and invests in a project, and sells or banks CERs. The project developer bears all risks and benefits related to the preparation and sale of CERs.
- Bilateral Model – this involves partnership between a project developer and Annex 1 country party. The objective of the partnership is for the Annex I country to receive the CERs realized from the project through emission reduction purchase agreement (ERPA) or as a result of some other financial consideration.
- Multi-lateral Model – this is considered as a variant of the bilateral model. CERs are sold to a fund, which manages a portfolio of projects. The fund spreads the risk of investment while the investors spread their risks by investing in several different funds.

Sources of Project Funds

Like conventional projects, financing CDM projects can be arranged either through corporate or project financing. These are described as follows:

- In project financing, a project company is formed and investments are viewed as assets of the company. Investment funds are sourced either from equity or debt. Assets and cash flow secure debts. Creditors do not have recourse to the other resources of sponsors.
- Under corporate financing, new projects are undertaken as extension of assets of the existing company. Capital investments and borrowing are not placed under the project account. Loans are considered as company debts and lenders have full recourse to all the assets and revenues of the company over and above those generated from the new project.

Transaction Costs

Transaction costs are the costs associated with the CDM project preparation, negotiation and validation and those related to secure CERs. These include pre-operational costs (or upfront costs), implementation costs (i.e. costs spread out over the entire crediting period), and trading costs. Pre-operational costs include direct expenses for search, negotiation, validation, and approval. Implementation costs are those incurred for monitoring, certification, and enforcement while trading costs are those incurred in trading CERs such as brokerage costs and costs to hold an account in national registry (URC, 2004). Some definitions and estimates of transaction costs are given in Table 2.

Table 2. Some Definitions and Estimates of Transaction Costs

Transaction Cost Components	**Cost incurred by Investors and Hosts as thy Seek Out Partners for mutually advantageous Projects**	**Relation to Project Size**	**Estimates of Transaction Costs (€ 1000s unless otherwise stated)**
Search costs		Fixed	15
Negotiation costs	Includes those costs incurred in the preparation of the project design document that also documents assignment and scheduling of benefits over the project time period. It also includes public consultation with key stakeholders	Digressive	25-400
Project documentation costs	Development of a baseline and monitoring plan	Fixed	35
Approval costs	Costs of authorization from host country	Proportional	40
Validation costs	Review and revision of project design document by operational entity	Fixed	35
Registration costs	Registration by CDM Executive Board	Slightly digressive	10
Monitoring costs	Costs to collect data	Fixed	10
Verification costs	Cost to hire an operational entity and to report to the CDM Executive Board	Degressive	8 per turn
Certification costs	Issuance of CERs by UNFCCC Executive Board	Degressive	n.a.
Enforcement costs	Includes costs of administrative and legal measures incurred in the event of departure from the agreed transaction	Proportional	n.a.
Transfer costs	Brokerage costs	Proportional	1%
Registry costs	Costs to hold an account in national registry	Proportional	0.03%
Minimum fixed costs			150

Source: Michaelowa and Jotzo (2005)

Status of the CDM Market

Potential Carbon Buyers

Two new multilateral funds have been recently launched at the World Bank: the Community Development Carbon Fund and the Bio-Carbon Fund. In addition, these are CDM funds established up by Japan, the Netherlands and several other European countries. Moreover, these governments have used several vehicles in CER procurement such as government-own tenders, through banks and though multilateral institutions. Bilateral transactions are also emerging. The governments of Canada and the Netherlands have signed Memoranda of Understanding (MOUs) with several Latin American countries for the development of projects and supply of CERs. Following gives a list of CER procurement funds (URC, 2004).

Multilateral Funds (the WB):

- Prototype Carbon Fund (PCF) (US$ 180 million)
- Community Development Carbon Fund (US$ 100 million)
- Bio-Carbon Fund (US$ 100 million)

Government Funds:

- Dutch Government's Certified Emission Reduction Unit Procurement Tender (CERUPT) Program
- Finnish CDM/JI Pilot Program (€ 20 million)
- Sweden International Climate Investment Program – CDM
- Spanish Carbon Fund
- Austria JI/CDM Procurement Program

Own Tender through Commercial/Development Banks:

- Rabbo Bank (Dutch Government)
- Japanese Bank of Industrial Cooperation (Japan CDM Fund – 4 billion yen)
- Development Bank of Japan (Japan CDM Fund – 3 billion yen)

Own Tender through Multilateral Institutions:

- World Bank (The Netherlands Clean Development Facility - € 70 million)
- IFC (IFC-Netherlands Carbon Facility - € 44 million)

Bilateral Transactions:

- Canadian Government signed MOU with Colombia and Chile
- Dutch Government signed MOU with Bolivia, Colombia, Uruguay and Ecuador

Current CERs Prices

The current price spread of CERs is US$ 3–6 per tCO_2e (Table 3). The Prototype Carbon Fund's (PCF's) price average is relatively lower than that of C-ERUPT's. The Finnish Government's offer for CER's from its pilot programme is lower than C-ERUPT's price range since the former focuses on small-scale projects which have higher transaction costs and delivery risks.

Table 3. Carbon Emission Reduction Prices (per TCO_2e)

Project Based		**Allowance Markets**
Clean Development Mechanism	Joint Implementation	
PCF • US$3.0-3.5 • premium of US$0.5 per ton of CO_2e for projects with developmental components (Colombia Wind Farm) **C-ERUPT** (maximum prices) • renewable energy - €5.5 • biomass energy - €4.4 • energy efficiency - €4.4 • fuel switch and methane - €3.3 • average price - €4.7 **Finish Government** • small-scale - €2.47 – 3.2	**PCF** • US$3.5-4.0 **ERUPT** • first tender average price- €8.46 (closed in April 2001) • second tender average price - €4.78 (closed in March 2002) • third tender – expected price range - €3.0-5.0 (closed in January 2003) **Denmark-Romania JI** • estimated price range €5.40-8.10	**Regional** • Eu-ETS (indicative price) - €5.0-7.0 **National** • UK-ETS- Bid price £1.75, offer price £2.25 **Private Firm** • BP Emissions Trading Scheme (Scheme discontinued in 2001) average in 2000 – US$7.6 average in 2001 – US$39.63

Source: URC (2004), p.80.

Final Remarks: Some Constraints on CDM Potential

While CDM offers potential for global GHG mitigation as well as sustainable development for the developing countries, there are several limitations that may hinder the implementation and growth of CDM projects. Some of them are listed below:

- Low price of CER and lack of a well established CER market
- The slow CDM process
- High transaction cost
- Lack of institutional capacity
- Linkage with the Annex I parties
- Skilled human resource
- Country risk for investment (it varies – so projects in high risk country may be less competitive)
- Uncertainties about the second commitment period and policies related that
- Need to develop capacity on CDM in financing/legal institutions in developing countries

Acknowledgement

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Water Quality and Wastewater Management

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ABSTRACT *Water pollution in the Asian region is caused mainly by discharge of untreated domestic wastewater, industrial effluents and run-off from agriculture and mining. Pollution by pathogens from discharge of untreated domestic wastewater into watercourses is quite severe in South Asia, South-East Asia and China. Areas of South Asia and China are severely affected by organic matter pollution due to discharges of domestic wastewater and industrial effluents such as tanneries, paper mills, and food and textile factories. The priorities in developing countries are often different from those in developed countries. Often the main issue is how to control pathogenic material, and any form of sanitation (on or off-site) should have this as its main objective.*

Water Quality Issues in the Asian Region

Water pollution is a major issue in South Asian countries. *Lake eutrophication* is a significant, but localized, concern in a number of countries in South-East Asia. Many rivers carry enhanced nutrient and pollutant loads resulting from changes in land use, industrialisation and urbanisation. The discharge of mine tailings directly into river systems has resulted in localized areas of *heavy metal pollution* throughout the Asian region. *Groundwater resources* are suffering from over extraction and severe salinisation due to the intrusion of seawater.

Typical water quality parameters of unpolluted and polluted water streams are presented in Table 1, while important water quality issues in Asia are presented in Table 2.

In majority of Asian cities, the *domestic wastewater* is discharged untreated into waterways resulting in increase in the organic and nutrient load. This leads to depletion in dissolved oxygen in the water bodies adversely affecting aquatic life. Untreated domestic effluent can also contribute up to 40% of nitrates in surface water. Furthermore, this also increases the risk of pathogen exposure. Likewise, *industrial wastewaters* such as starch and sugar, are highly organic in nature and result in high pollution load. As an example, a typical tapioca starch producing factory with 300 tons/day capacity can discharge effluent up to 1 million-population equivalent. Similarly, aquaculture related activities such as intensive shrimp farming have led to large-scale environmental degradation in many Asian countries leading to abandonment and salinisation of land, and degradation of mangrove forests besides affecting coastal and marine environment. Accordingly, appropriate waste treatment and management methods are necessary which are robust, easy to operate and suitable for Asian conditions.

Waste Water Reuse and Recovery

Traditionally, sewage has been seen as a problem requiring treatment and disposal. Most conventional sewage treatment options are based on approaches to Northern countries' problems, which usually have meant a reduction in biodegradable organic material and suspended solids, plus perhaps some nutrients (nitrogen and phosphorous). Treatment has involved the 'removal' of these pollutants, but removal is usually conversion to another product, usually sludge. The disposal of sewage sludge is a major consideration in any locations, and it is often seen as an offensive product, which is either dumped or burned (Harremöes, 1997).

Table 1. Water Quality Parameters

Parameter	**Unpolluted Water**	**Polluted Water**
Dissolved Oxygen	The higher the amount of oxygen the better the quality. Trout- 10 ppm, for most aquatic organisms Bass- about 7/8 ppm 0-3 Creatures flee; 4-5 Creatures can survive; Greater than 5 Creatures thrive	Less than 5 ppm is considered unacceptable.
pH (Hydrogen ion present)	Water with pH range from 6.5-8.6 will have little effect on life processes support little aquatic life	Water with pH less than 5 or greater than 9 will
Total Hardness	Soft water - 0-60 ppm Hard water 120-180 ppm	Values below 250 ppm are acceptable for drinking Over 500 ppm is hazardous
Dissolved Solids runoff,	Clean water has low amounts of D.S., Clear water is water less than 50 ppm. 50 ppm to 150 ppm is not bad	Caused by erosion, materials from industries, etc. Over 500 ppm for any monthly average is unacceptable single test should not be over 750 ppm
Alkalinity	Good streams have between 100and 200 ppm are able to buffer the water from acidity levels between 20 and 200 ppm are typically found in fresh water	Poor streams have lower alkalinity levels, < 50 ppm. could be effected by acid rain or acid mine drainage
Nitrates and/or Phosphates	Nitrates are necessary for organisms in small quantities Clean water- less than 0.1 ppm	Higher reading indicates fertilizer, industrial waste, sewage and/or other nutrient enrichments Causes algae blooms Greater than 10 ppm is nutrient loading the water
Suspended Solids	S.S. causes turbidity of water Clean water has low turbidity. Clear water is in the 1-15 ppm range	Caused by erosion, plankton growth, or wastewater. Above 50 ppm is turbid
Aquatic Organisms (Macroinvertebrates) numbers	Clean water has higher diversity of organisms – high different species More Taxa I & II	Polluted water - number of organisms may be high of but little variety Mostly Taxa III
Biological Oxygen Demand	The lower the B.O.D. the less organic matter in a stream Less than 2 ppm is good	High B.O.D. indicate large amounts of organic matters Greater than 5 ppm means poor water quality
Coliform (Fecal)	Less than 200/100 ml is considered acceptable, the lower the better Anything > 200/100 ml is unhealthy for human consumption	Streams vary in count, but anything greater than 5,000/100 ml is hazardous

Source: Tchobanoglous and Schroeder (2003)

Table 2. Water Quality Issues in the Asia-Pacific Region

Quality Issues	**South Asia**	**SE Asia**	**Pacific Islands**	**PR China**	**Japan**
Pathogenic agents	1-3	1-2	2-3	1-3	0-1
Organic matter	1-3	0-2	0-1	1-3	0-1
Salinization	0-1	0-1	0-3	0-2	0-1
Nitrate	0-1	0-1	1-2	0-2	0-1
Fluoride	0-1	0	0	0-2	0
Eutrophication	0-1	0-3	0	0-2	0-1
Heavy metals	0-1	0-2	0-1	0-2	0-2
Pesticides	0-1	0-1	0-1	0-1	0-1
Sediment load	0-2	0-2	0-1	0-1	0-1
Acidification	0	0-1	0	0-1	0-1

Source: Kitawaki (2002)

There are treatment options, which can remove pathogenic material, notably waste-stabilization ponds. Increasingly, sewage is being seen as a resource. The water and nutrient content, in particular, can be very useful for agricultural purposes (for example, through irrigation) if the sewage is treated to a suitable standard. There are treatment options, which seek to use this resource potential. Traditional sewage treatment practices in South-east Asia, for example, seek to use wastes generated through pond systems which are used to cultivate fish and generate feed for animals. Some community-based approaches (in Latin America in particular) seek to separate 'grey' wastewater (non-faecally contaminated wastewater) from 'black' (faecally contaminated) water so that they can both be recycled and re-used as appropriate. In principle, the grey water can be re-used as irrigation water, and the black water/waste treated and reused as fertilizer.

Traditionally, sewage treatment has taken place through the implementation of large centralized schemes. Many of these do not work - and when they do not work, the resultant pollution and health problems are often severe. The reason for failure is frequently that the options chosen in the first place are not sustainable. Often, sewage treatment is a low priority when compared to water supply, and municipal councils simply do not have the resources to keep the facilities operational. In such circumstances, there is a growing body of opinion that advocates moves towards decentralized, local systems, which, it is argued, could be supported by community based organizations. Such approaches have been implemented in parts of South America.

Sewage treatment options may be classified into groups of processes according to the function they perform and their complexity:

Preliminary: this includes simple processes such as screening (usually by bar screens) and grit removal (through constant velocity channels) to remove the gross solid pollution.

Primary: usually plain sedimentation; simple settlement of the solid material in sewage can reduce the polluting load by significant amounts.

Secondary: for further treatment and removal of common pollutants, usually by a biological process.

Tertiary: usually for removal of specific pollutants e.g. nitrogen or phosphorous, or specific industrial pollutants.

Waste Water Treatment Options

Very few sewage-treatment facilities in most developing countries work. This is often because most technologies for sewage treatment are big, centralized schemes which have been developed in the North where adequate financial, material and human resources are available. Transferring these technologies to tropical low- and middle income communities has many potential difficulties. Various technologies available for wastewater treatment are presented in Table 3.

However, there are some sewage-treatment options, which are more appropriate to developing country scenarios. Such systems should generally be low-cost, have low operation and maintenance requirements, and, should maximize the utilization of the potential resources (principally, irrigation water and nutrients). Preliminary and primary treatments are common to most sewage-treatment works, and are effective in removing much of the pollution. There are many different types of secondary process. The most common are described in the table opposite, with brief comments on their suitability for low- and middle-income countries. Tertiary treatment processes are generally specialized processes, which are beyond the need of most communities.

Options for Low and Middle Income Communities

Most wastewater treatment processes have been developed in temperate, Northern climates. Applying them in most developing countries will have three main disadvantages:

- high energy requirements;
- high operation and maintenance requirements, including production of large volumes of sludge (solid waste material);
- they are geared towards environmental protection rather than human health protection – for example, most conventional wastewater treatment works do not significantly reduce the content of pathogenic material in the wastewater.

Table 3. Wastewater Treatment Options

Common Options for Secondary Sewage Treatment *(*indicates processes more suitable for developing countries)*		
Activated sludge process (ASP)	Oxygen is mechanically supplied to bacteria, which feed on organic material and provide treatment.	Sophisticated process with many mechanical and electrical parts, which also needs careful operator control. Produces large quantities of sludge for disposal, but provides high degree of treatment (when working well).
Aerated lagoons	Like WSPs but with mechanical aeration	Not very common; oxygen requirement mostly from aeration and hence more complicated and higher O&M costs.
*Land treatment	Sewage is supplied in controlled conditions to the soil	Soil matrix has quite a high capacity for treatment of normal domestic sewage, as long as capacity is not exceeded. Some pollutants, such as phosphorus, are not easily removed.
Oxidation ditch	Oval-shaped channel with aeration provided	Requires more power than WSP but less land, and is easier to control than processes such as SP (see below).
*Reed (or constructed wet lands)	Sewage flows through an area of reeds	Treatment is by action of soil matrix and, particularly, the soil/root beds interface of the lants. Requires significant land area, but no oxygenation requirement.
Rotating biological contractor (or biodisk)	Series of thin vertical plates which provide surface area for bacteria to grow	Plates are exposed to air and then the sewage by rotating with about 30 per cent immersion in sewage. Treatment is by conventional aerobic process. Used in small-scale applications in Europe.
Trickling (or 'percolating') Filter	Sewage passes down through a loose bed of stones, and the bacteria on the surface of the stones treats the sewage	An aerobic process in which bacteria take oxygen from filters the atmosphere (no external mechanical aeration). Has moving parts, which often break down in developing country locations.
*Upflow anaerobic sludge blanket (UASB)	Anaerobic process using blanket of bacteria to absorb polluting load	Suited to hot climates. Produces little sludge, no oxygen requirement or power requirement, but produces a poorer quality effluent than processes such as ASP. (NOTE: other anaerobic processes exist, but UASB is the most common at present).
Waste- stabilization ponds (WSP) ('lagoons' or 'oxidation	Large surface – area ponds	Treatment is essentially by action of sunlight, encouraging algal growth, which provides the oxygen requirement for bacteria to oxidize the organic waste. Requires significant land area, but one of the few processes, which is effective at treating pathogenic material. Natural process with no power/oxygen requirement. Often used to provide water of sufficient quality for irrigation, and very suited to hot, sunny climates.

Source: Metcalf & Eddy (2003); Jetten et al. (1997)

Aerobic Versus Anaerobic Treatment

Most conventional wastewater treatment processes are 'aerobic' - the bacteria used to break down the waste products take in oxygen to perform their function. This results in the high-energy requirement (oxygen has to be supplied) and a large volume of waste bacteria ('sludge') is produced. This makes the processes complicated to control, and costly.

The bacteria in 'anaerobic' processes do not use oxygen. Excluding oxygen is easy, and the energy requirements and sludge production is much less than for aerobic processes - making the processes cheaper and simpler. Also, the temperature in which the bacteria like to work is easy to maintain in hot climates (Lettinga and Hulsffof, 1991).

However, the main disadvantages of anaerobic processes are that they are much slower than aerobic processes and are only good at removing the organic waste (the 'simple' waste, the sugary material) and not any other sort of pollution — such as nutrients, or pathogens. Anaerobic processes generally like 'steady' effluents — they are not good with coping with variations in flow or composition (Alaerts *et al*., 1993). For example, anaerobic processes cannot cope with shock loads of heavy metals (from industrial processes, for example).

The requirement in most low-income countries is for a low-cost, low maintenance sewage treatment system. Waste stabilization ponds (WSPs) provide the best option in most cases – good levels of treatment at low capital and particularly low O&M cost. In addition, it is one of the few processes, which provide good treatment of pathogenic material. This has significant application potential for re-use of the treated effluent in irrigation. The major disadvantage is that significant areas of and are needed for treatment. WSPs are used in many locations worldwide, including Africa and Asia.

Conclusion

Water quality issues in Asia are of acute proportion and need immediate attention. Any wastewater treatment plant needs significant investment and O&M and control, and therefore any decision to implement such a facility should be carefully considered. WSPs provide the best option for a low-cost, low maintenance system, which is most effective in removing the pollutants of major concern.

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Solid Waste Management in Asian Perspectives

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ABSTRACT
Increasing solid waste management problems and its disposal strikes environment and health hazards. This training module covers the essential elements of solid waste management in Asian context. Prevailing scenario of waste handling practices and disposal is exhibited along with its associated problems. Valuable case studies are also discussed. An integrated solid waste management in sustainable approach is presented, as a response to necessary waste management strategy needs. Waste minimization in the form of proper waste segregation and utilization, the importance of pre-treatment of organic waste and combustible waste fraction does not only manage the waste but also generates products such as compost and renewable energy. Direct landfilling of commingled waste in Asian countries should be discouraged due to its high organic waste fraction, which causes potential environmental emissions. The efforts of government to solve this problem from legal aspects through laws and regulations should be supported by an active participation of community, public and private agencies.

Introduction

Solid waste management and disposal is an alarming problem encountered by many of the urban and industrial areas in developing economies in Asia. Waste generation has witnessed an increasing trend parallel to the development of industrialization, urbanization, and rapid growth of population. The problem has become one of the primary urban environmental issues.

Enormous amount of waste is generated daily and its management is a huge task. The prevailing scenario for solid waste final disposal is usually a matter of transporting the collected waste to the nearest available open space and dumping it. However, only a fraction of waste were properly collected and transported. Sometimes it is burnt to reduce its volume and to minimize attraction of animals and vermin and also to retrieve recyclable items.

Despite the degradation of valuable land resources and creation of long-term environmental and human health problems, uncontrolled open dumping is still prevalent in most developing countries (ISWA and UNEP, 2002) which indeed desperately need an immediate action due to the associated harmful impacts. Moreover, in South and Southeast Asia, more than 90% of all landfills are non-engineered disposal facilities. Figure 1 shows the open dumping site in Sri Lanka.

Figure 1. Gohagoda Dump Site Sri Lanka

Aside of the concern on increasing waste generation, and inefficient collection and transportation infrastructure system, the composition of waste (high organic matter and high moisture content) and climatic condition were among the other factors that need to be considered in solid waste management. Moreover financial constraints and weak implementation of waste management policy with poor cooperation of government, public and private sector, educational institutions, and civil society complicates the issues.

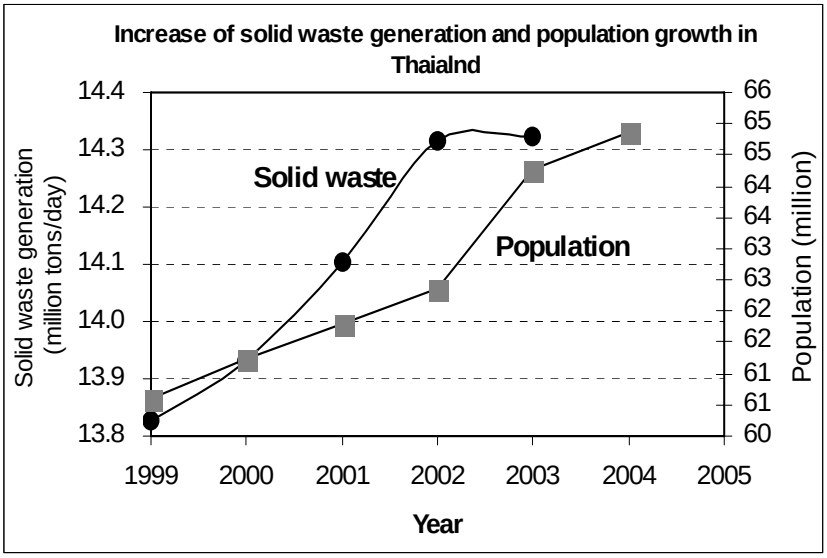
State of Solid Waste Management and Practices in Developing Countries in Asia

Solid waste management includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes. *Solid waste* comprises of all wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. Sources of solid waste are municipal solid waste, agricultural waste, and industrial waste

In the past, managing solid waste was considered simply transporting waste to distant places for dumping and for the nature to take care. However, today, the increasing value of land and inadequate space, limited capacity of nature to handle unwanted emissions and residues pose alarming threats to human lives. Thus, solid waste management has become a matter of paramount concern.

Solid Waste Generation

The trend of solid waste generation in most Asian countries is increasing. The primary factors affecting waste quantity are population, urbanization, industrialization, and the changing lifestyle. For example in Thailand, solid waste generation has witnessed an increasing trend. In 1999, 13.8 million tonnes/day of waste was generated and increased nearly to 14.4 million tonnes/day in 2003 (Figure 2). This was apparently influenced by population and economic growth.



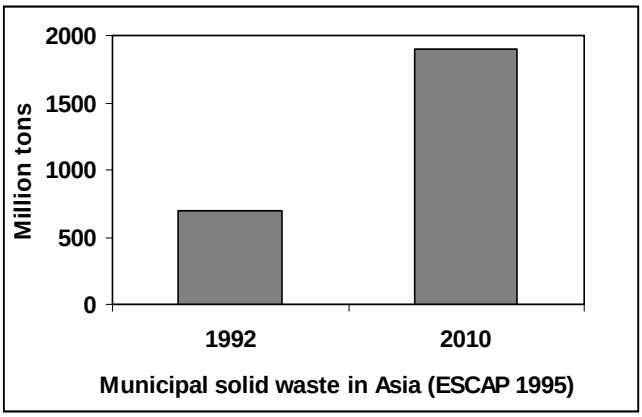
Source: Chiemchaisri et al. (2007)

Figure 2. Increased Solid Waste Generation and Population Growth in Thailand

Urban areas in Asia generate about 760,000 tonnes of MSW or approximately 2.7 million m^3 per day (Figure 3). In 2025, this figure will increase to 1.8 million tones of waste per day or 5.2 million m^3 of waste (World Bank, 1999). Moreover, other related issues that affect solid waste generation are:

- In areas with a large number of tourist, the generation rate is even higher
- In big cities, the waste is more concentrated, and requires expensive removal or collection
- Waste composition is changing with rapid increase in the amount of paper, plastic, metal, and hazardous waste materials
- Poor urban waste disposal service results in even more litter and pollution of the local environment

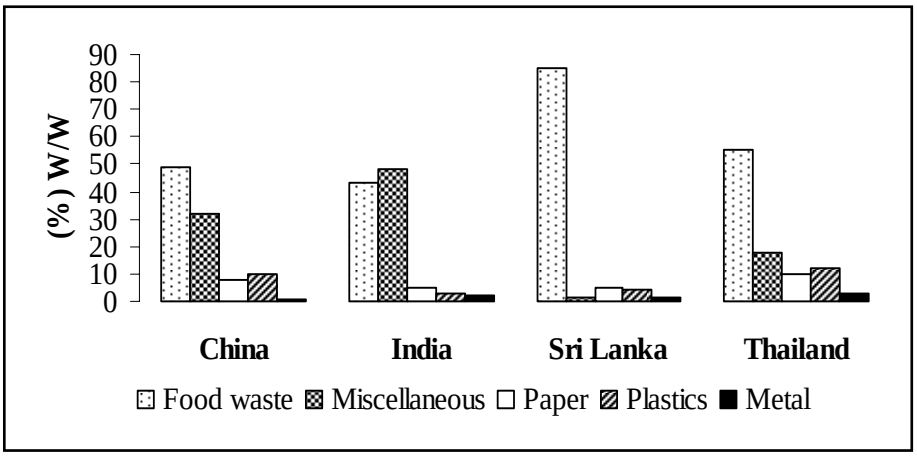
Solid Waste Composition



Source: ESCAP (1995)

Figure 3. Municipal Solid Waste in Asia

Solid waste composition can be affected by economic status and consumer pattern. Feedback on waste composition is important in evaluating the requirements or specifications for equipment need, treatment systems, and management programs and plans. Moreover, potential emissions (leachate and landfill gas) from disposed solid waste can be linked with waste composition, specifically the amount of organic fraction present in waste. The composition of municipal solid waste (MSW) differs for different countries and regions. Moreover major portion of MSW generated in most developing Asian countries was dominated by biodegradable organic fractions composed of food wastes, yard wastes, and mixed paper. Food wastes dominate over the major portion of the waste generated in most developing countries in Asia like China, India, Sri Lanka, and Thailand (Figure 4). In this regard, waste can be characterized as highly biodegrable with high moisture content in which the disposal management should consider this factor.



Source : Visvanathan et al.(2004)

Figure 4. MSW Composition from Selected Asian Countries (2003)

Solid Waste Collection and Transport

Figure 5. House to House Waste Collection

Commonly, most poor cities in developing countries are deprived of proper waste collection services and only a fraction of generated waste is actually collected. Financial constraints and lack of technical expertise severely limit the effectiveness of solid waste collection and transportation. Inefficiency in collection system creates a main constraint on solid waste management capacity.

Typical scheme often observed in urban areas in Asia is the presence of primary collection service (house to house waste collection and transport to an intermediate collection point). Such primary collection often managed by community-based organizations and is often initiated by residents, which desperately need a service wherein the residents are also willing to pay monthly collection fees (Figure 5).

In Thailand, the Bangkok Metropolis Administration (BMA) is responsible for the collection of solid waste and it operates the biggest single solid waste management system in Bangkok. The BMA primary solid waste collection system is consist of collection at households in various areas at accessible time to avoid traffic congestion to transfer station. The application of transfer stations is not widely practiced, but in some transfer points, the wastes collected by smaller vehicles are being transferred to larger trucks and from the compactor truck to a high density transport vehicles which improves transportation performance. The secondary or indirect waste transport collection places the waste into a large hauling truck, weigh, and transport in landfills.

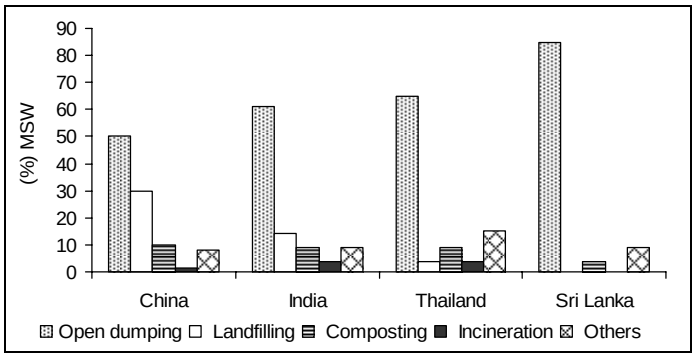
Countless efforts in solid waste management have been undertaken in many countries in Asia but until now, the country still struggling on its collection and transportation schemes. Improving infrastructure and services establishment with the aim to improve waste collection and services needs to be focused. The problems that can be associated to insufficient and inefficient collection and transport are:

- Inappropriate collection techniques. Some systems are expensive to buy and maintain; some collection vehicles are too bulky to enter all parts of the town.
- Inadequate planning on waste transport system and lack of vehicle/equipment and its maintenance that lead to complete breakdown of collection system.
- Most municipalities do not have enough waste bins.
- In some municipalities, weak public cooperation on waste management system.
- Ignorance on solid waste management leads to dumping in open spaces, along the roadsides, or in canals and rivers (Figure 6).
- Dumping waste on vacant lots, canals or river could cause water pollution and would blocked drainage and cause flood when it rains
- Uncollected wastes often end up in drains, causing blockages which result in flooding. Plastic bags litter along the road is a particular aesthetic nuisance and they cause the death of grazing animals which eat them
- Heavy refuse collection trucks can cause significant damage to the surfaces of roads that were not designed for such weights.

Figure 6. Waste Collection

Solid Waste Disposal

In developing economies in Asia, the status of solid waste management is characterized by unsafe practices of open dumping and inefficient administration due to heavy governmental subsidies. However, economic and regulatory pressures are slowly driving towards the adaptation of a timely and efficient solid waste management technique in some Asian countries.



Source: UN (2000)

Figure 7. Solid Waste Disposal in Asian Countries

It appears that in most low-income countries, and many medium income countries in Asia, very little progress has been made in upgrading waste disposal operations, and open dumping remained as the dominant solid waste disposal system. For example in Sri Lanka, more than 80% of municipal solid waste is end up into open dumps (Figure 7).

Open dumps, where the waste is unloaded in piles, make very uneconomical use of the available space, allow free access to waste pickers, animals, and insects and often produce unpleasant odor and aesthetic nuisance. Such inadequate waste disposal creates severe environmental problems that affect health of humans and animals and cause serious economic and other welfare losses. The environmental degradation caused by common inadequate disposal of waste in Asia (open dumping and non-engineered landfill) can be expressed by:

- Contamination of surface and ground water through leachate (water draining from beneath waste disposal sites) from inappropriately located or badly prepared landfill sites. The generation of leachates by percolating rainwater contain run-off of organic and inorganic compounds resulting in the contamination of soil, surface, and groundwater. Groundwater pollution originating from landfills may be at risk even after several centuries.
- Air pollution due to the presence of foul odor associated with open dumping and by burning of waste. Also, a poorly managed landfill sites produce methane gas which is both polluting and explosive and are nuisance for the people, who live in the surrounding areas.
- Soil contamination through direct waste contact or leachate and spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste.
- Insect infestation. Flies breed in some constituents of solid wastes, and flies are very effective vectors that spread disease. Mosquitoes breed in blocked drains and in rainwater that is retained in discarded cans, tires and other objects. Mosquitoes spread disease, including malaria and dengue. Rats find shelter and food in waste dumps. Rats consume and spoil food, spread disease, damage electrical cables and other materials and inflict unpleasant bites.
- Generally, MSW in Asia contains large fractions of organic matter which cause contamination to soil, water, and air upon decomposition. The decomposition of these wastes generates gases which impairs air quality in the immediate vicinity and, on a larger scale, contributes to the greenhouse effect and global warming.
- Risk in landfill stability. Stability of landfills was one of the major geotechnical tasks in landfill design and operation and has been a problem for years. The low density of waste reduced the surface flow of rainwater and evaporation, resulting in high rate of water infiltration. Besides, landfill leachate decreased the shear strength of waste by mobilizing pore water pressure and flow pressure. Finally, this could trigger the possibility of landfill failure and lead to landslides as the landfill settles, festers, and slowly decomposes (Kosch and Ziehmann, 2004).

Due to many environmental drawbacks caused by open dumping or non-engineered landfills, the option to move into modern sanitary landfilling is a better one, but still there would be possible potential problem, risk and contamination. Though, sanitary landfills could minimize emissions, it can only delay emissions. Understanding this problem is very important in handling and managing solid waste in future perspectives. This section provides necessary insights related to problems linked with direct disposal of solid waste in sanitary landfill.

- Modern sanitary landfills are designed with impervious liners, and leachate collection, removal, and treatment systems to minimize the potential for groundwater contamination (Chanthikul et al., 2004). However, even modern landfills that employ state-of-the-art technologies such as liners and leachate collection systems are a quandary for if they are not leaking now; they would probably start leaking within a few decades of their closure (Tammemagi, 1999).
- Fugitive release of landfill gases occurs even in highly engineered system. In this regard, post closure monitoring is necessary and requires additional investment that would make direct landfilling unattractive.
- Fires on disposal sites can cause major air pollution, causing illness and reducing visibility, making disposal sites dangerously unstable, causing explosions of cans, and possibly spreading to adjacent property.

- Natural degradation of solid waste in landfills occurs in a very slow process and may continue over scores for years and may require several decades for completion (Vieitez et al., 2000). Also, they added that waste degradation in landfills extends for periods of 20-40 years and it takes decades for the methane content to reach 50%. In this regard, landfills were known to create lasting detrimental environmental issues.
- Unreasonable standard of disposal site is due to the lack of training of workers on landfill site and insufficient financial and physical resources. As a result, some sites quickly degenerate into open dumps. It is crucial to maintain good operations by having motivated and trained labors.
- Former disposal sites provide very poor foundation support for large buildings, so buildings constructed on former sites are prone to collapse. Large quantities of waste that have not been placed according to good engineering practice can slip and collapse, burying and killing people.

Integrated Solid Waste Management: A Sustainable Approach

Integrated solid waste management involves sustainable planning of all the functional elements that is useful for an effective and efficient waste management system. It includes the selection and application of suitable techniques, technologies, and management programs or system to achieved sustainable waste management.

Waste Prevention

The most preferred element in integrated solid waste management is waste prevention; this can be achieved through source reduction. It is the most effective way to reduce waste quantity, waste handling cost, and environmental impacts. Waste reduction may occur through design, manufacture, and packaging of products with minimum use of material, and longer useful life. Waste reduction may also occur at the household, commercial or industrial facility through selective buying patterns and the reuse of products and materials (Figure 8).

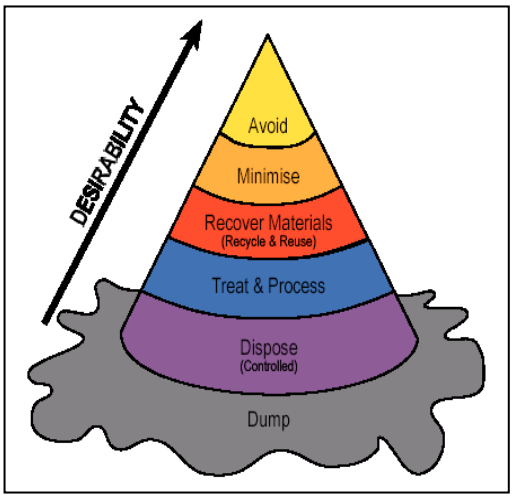


Figure 8. Waste Prevention

Waste prevention can be done also through reuse, recover, and recycling of waste, this can significantly reduce environmental impacts associated with raw materials extraction, materials manufacturing, and transportation. Recycling involves separation and collection of waste materials for reuse, reprocessing, and remanufacture. Reducing the overall generation of solid waste is not just saving landfill space but also benefited our environment.

Some key factors that affect the potential for resource recovery are the cost of the separated material, its purity, its quantity and its location. The costs of storage and transport are major factors that decide the economic potential for resource recovery. In many low-income countries, the fraction of material that won for resource recovery is very high, because this work is done in a very labor-intensive way, and for very low incomes. In such situations the creation of employment is the main economic benefit of resource recovery. The situation in industrialized countries is very different, since resource recovery is undertaken by the formal sector, driven by law and a general public concern for the environment, and often at considerable expense.

Waste Transformation

Waste transformation includes waste treatment and processes. It involves physical, chemical, and biological conversation of waste. This can be typically applied to municipal solid waste stream that improves the efficiency of solid waste management operation system. This uses initiatives to

recover and recycle materials into usable product waste residue (compost, soil conditioner, landfill cover) and the production of energy in the form of heat and combustible gas.

Waste transformation processes include aerobic composting and anaerobic digestion which is suitable to treat organic waste fraction, while inorganic waste fraction such as plastics materials can be process for RDF production for combustion to generate electricity. Thermal destruction of waste could dramatically reduce waste volume. Waste residue from treatment processes (aerobic composting, anaerobic digestion, or incineration) could be safely disposed in sanitary landfills.

This approach provides a sustainable option for solid waste management. However, in most Asian countries, the prevailing technology and manpower on solid waste management does not facilitate treatment before landfilling. Landfilled waste, with high moisture and organic content, contributes to the formation of leachate and landfill gas, which will create a long-term threat to the environment and public health; in which when MSW is landfilled without pretreatment, emissions occur during and after the landfill operation in the form of approximately 150 m^3 biogas/Mg MSW and 5 m^3/ha/day of leachate, depending on the waste composition and climatic conditions (Stegmann, 2002). In this regard, pre-treatment of organic waste fraction by biological process prior to landfill is a sustainable approach.

Aerobic Composting

Aerobic composting is a biological process used for the conversion of organic waste materials into stable humus-like material known as compost. Application of this process includes yard waste, separated and commingled MSW. Most aerobic composting processes (windrow, static pole and in-vessel) involve three steps of preprocessing of waste, aerobic decomposition, and product preparation or marketing. The process offer simple operation however it is a net energy user due to the need of oxygen supply (forced aeration). This process also requires large land area. Other problem associated in this process includes odor, and the quality of compost for marketing. To enhance the economics of compost, it should be of consistent size, free from contaminants such as glass, plastic, and metals, and free of objectionable odor.

Composting is an excellent method of recycling biodegradable waste from an ecological point of view. However, many large and small composting schemes have failed because composting is regarded as a disposal process, and not a production process. It is essential to consider the marketing and quality of the product.

Anaerobic Digestion

Anaerobic digestion is the decomposition of organic waste materials through bacterial action in the absence of oxygen. It involves the breakdown of the organic matter into methane, carbon dioxide, and waste residue or digestate. The mixed gas output of methane and carbon dioxide known as “biogas” which can be burnt directly in thermal applications to generate heat and electricity. The process is complicated compared to aerobic composting. The organic material in placed in large airtight tanks known as digesters, and operated under certain conditions to produce biogas and is captured for use. As a result, odors can be removed and the pollution potential of the waste is minimized.

Incineration

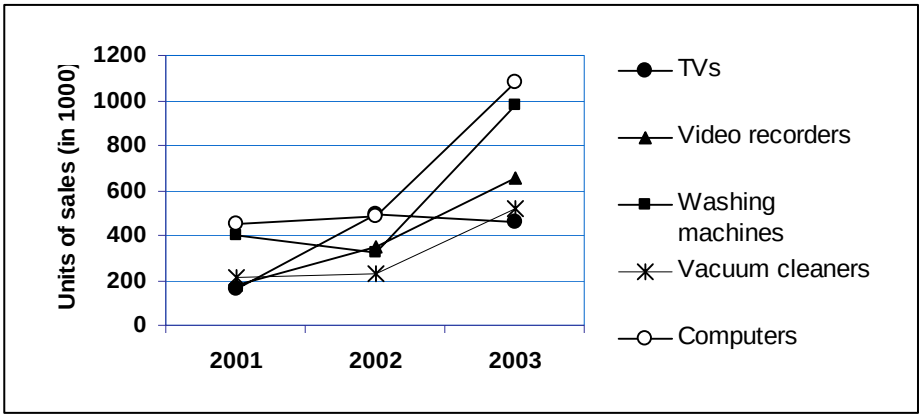
Thermal destruction of solid waste could significantly reduce waste volume; an important consideration for the possibility of incinerating waste (burning of waste under controlled conditions to minimize pollution) is the waste characteristics. If the waste contains a high proportion of moisture, or is mostly inert material, it is not suitable for incineration. Generally, waste characteristics in most Asian countries contain high organic fraction with high moisture content

which is not suitable to be handled by incineration, instead it should be treated by biological process prior to landfilling. However, medical or infectious waste can be incinerated.

Issues on Electrical and Electronics Waste

The problem on electrical and electronic waste (e-waste) is a surmounting issue that could pose dilemma in the near future. Current management of this waste exhibits unsustainable approach which is usually disposed together with MSW in open dumps. Normally in developing countries, management of this waste is not given due attention because most of the local authorities are still struggling on MSW management and disposal. In Thailand, the demand for electrical and electronic equipments is increasing especially for computers and washing machines and this eventually lead to increase waste generation (Figure 9).

Great concern related to e-waste is due to its heavy metal content, which could pose health and environmental hazards. This waste is unsuitable to be disposed in landfill because after some time the hazardous waste components may leach out into soil, surface and ground water and may cause lasting contamination. Also, treatment of this waste by incineration is not environmentally advisable due to dioxin emission. Proper planning concerning on e-waste collection, separation and recovery of reusable items is considered as appropriate approach.



Source: THAIEEI (2005)

Figure 9. Sales of Electrical and Electronic Equipments in Thailand

New Directions in Solid Waste Management Planning

The municipality does not have to carry out all the activities relating to waste collection, transport, and final disposal. The role of the municipality is to ensure that each part of the waste management system works effectively, and that the system as a whole is well coordinated. This requires cooperation with private sector, community groups, and other local authorities.

Private Sector Participation

The participation of private companies in solid waste management is driven by the failures of municipal systems to provide adequate services, and sometimes by pressure from national governments and international agencies. Arrangements with private companies have not all been successful, and as a result some opposition to private sector involvement is now evidence.

However, there are instances that the municipality tends to over power the private companies especially those small enterprises. It may regard the enterprise as a servant without rights, ignoring the agreed contractual arrangements and conditions. Certainly, this condition will likely cause a failure on partnership.

An important factor in the success of private sector participation is the ability of municipal administration to write and enforce an effective contract. Many municipalities lack of know how regarding the cost on services, so they cannot judge if bids from the private sector are reasonable. The contract document must be well written to describe in quantitative terms what services are required and to specify penalties and other sanctions that will be applied in case of shortcomings. Monitoring and enforcement should be effective. The three key components of successful arrangements are competition, transparency, and accountability.

Community Involvement

Community participation in waste management is a process in which the community members are involved at different stages of solid waste management cycle. Community involvement in planning and implementation on waste management projects maybe a complex proposition. However, its benefits provide a clear idea of the possible solutions including perspectives on affordability and desirability and finally the possibility of generating both public consensus and commitment to waste management program.

Community participation may be an appropriate solution when municipalities are unable to handle the waste management needs of a community. For example, a municipality may not be capable of waste collection for financial reasons. Alternatively, inadequate infrastructure may prevent municipal collectors from gaining physical access to the community. Recognizing the importance of community based solid waste management is a key factor for achieving specific goal.

Generally, a community based waste management system collects household wastes from individual residences (primary collection) and deposits them at a central location for municipal pick-up (secondary collection). The collection system often involves use of hired waste collectors, or may entail householders bringing their trash to a central location. It includes garbage collection, community-level diversion of recyclables and organic materials, and street cleaning.

Legal Aspects

The current status of solid waste management in most Asian countries makes it evident that local authorities lack coherence in adoption of measures to effectively cope with growing solid waste menace, while the citizenry appears to be ignorant under their supervision. The existing legal system governing the solid waste management sector needs to be modified to make it executable. The government should emphasize more on the enforcement and implementation of the existing laws and regulations.

The possible reasons for poor implementation could be a combination of social, technical, intuitional, and financial issues. Public awareness, political will, private and public participation are essential for the successful implementation of the legal provision. Moreover, the government should consider environmental impact assessment as a prerequisite for solid waste disposal sites that includes risk assessment and economic feasibility of the project. For instance in Thailand, MSW management policy, goal, guidelines, and strategies to achieve a sustainable system are described in the Table 1.

Table 1. MSW Management Policy, Goal, Guidelines, and Strategies

Policy
• Undertake sanitary solid waste and night soil management, from storage, collection, and transport, to disposal. • Control rates of generating solid waste by the public and promote recycling of solid waste. • Promote and encourage a role for private sector investment, construction and/or administration, and implementation of solid waste and night soil management systems. • Promote and encourage more participation of public and non-governmental organizations in solving solid waste problems.
Goals
• Reduce and control MSW generation to the rate of not more than 1.0 kg/capita/day • Recover MSW at the rate of not less than 15% of the total MSW generated • Increase MSW collection efficiency to 100% in municipalities and to 90% outside municipalities • Ensure that each province has a master management plan for sanitary MSW disposal and every municipality has a proper MSW disposal system
Guidelines
• Apply the "Polluters Pay Principle" for both the public and private organizations that generate or improperly manage solid waste. The owner of the pollution source is responsible for the fee to send their waste to the treatment/disposal plant, and to encourage the reduction in MSW generation. • Introduce buy-back system in which the producers required to buy back used packaging from consumers to disposal or recycling, in order to reduce the amount of solid waste while increasing the recovery rate. • Continuous monitoring, investigation and assessment of the problem, provision of training to government organization, and promotion of private sector participation to improve the operational system. • Preparation of land for a long-term proper MSW disposal system as part of its city planning, rehabilitation of the existing unsanitary disposal site, and establishment of central disposal facilities to improve the disposal practice
Strategies
• Invest in constructing new MSW disposal system • Promote cleaner technology • Promote public awareness and attitudes to protect environment • Improve the cooperation among government organizations and reform the administration structure • Amend regulations and laws related to environment • Promote public and private participation in MSW management activities • Promote study and research on environmental technology in the government organizations • Encourage the establishment of information network between central and local government

Conclusion

Proper solid waste management in developing economies in Asia is an important aspect to consider in minimizing further environmental contamination. Awareness on the problems and impacts associated with solid waste generation, collection and transport, and disposal must be promoted through campaign and education. The government should take an initiative to improve or modify the solid waste management system and create a good monitoring system. Also, the public and private participitation plays an important aspect for the success of the government solid waste management program. A community based solid waste management system could deliver positive

impact towards proper waste collection in certain municipality and should be encouraged. Waste minimization through proper waste segregation of valuable items could not only help in reducing waste generation but also could generate extra income. Direct disposal of solid waste into open dumps or landfills should be discouraged. As already learned, the organic material contained in waste is the primary cause of potential emissions (leachate and landfill gas) and aesthetic nuisance. Processing of organic fraction of waste (kitchen waste and yard waste) by composting or anaerobic digestion is sustainable options that produce reusable material such as compost or biogas. Inert fractions of waste can be therefore managed by sanitary landfill. Plastic and other combustible fraction in waste can be processed for RDF production, which promotes "waste to energy" option. Waste should not be treated as a waste for it is able to sustain part of living needs. Also, should be managed appropriately in order to preserve the environment and resources.

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Industrial Management Tools

Wei Zhao
Environmental Affairs Officer, UNEP ROAP, Bangkok, Thailand

ABSTRACT *This presentation explains the environmental impacts that are related to efficient and effective use of natural resources. Tools to obtain effective use of natural resources can be EIA, land use planning, sustainable industry and infrastructure strategy, and eco system based development. Tools to improve efficiency and prevent pollution can be cleaner production, life cycle assessment, eco-design, company sustainability management. UNEP is playing a major role in industry environment management in terms of cleaner production, accident prevention and response, waste management, energy program with partnership, integrated chemical management, and working by industry sectors. It also emphasized on cleaner production mechanism for the developing countries.*

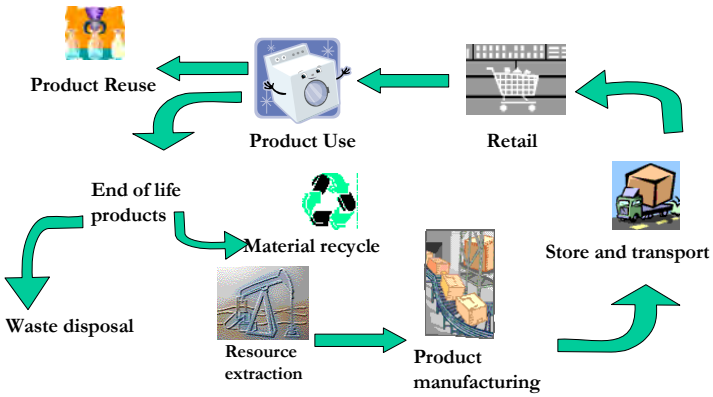
Slide 1

Industry Environmental Management - Tools and means for managing industrial environmental impacts

Wei ZHAO
Environmental Affairs Officer
UNEP ROAP

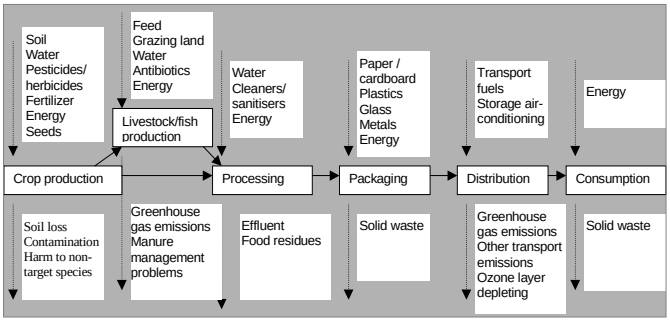
Slide 2

Production and consumption



Slide 3

Environmental impacts of agri-food production and consumption



Slide 4

Environmental impacts are related to

- **How efficient** we use **natural resources**
- The more efficient we convert resources into useful products, the less pollution we produce

- **How Effective** we use **natural resources**
- Effective use of energy, water and material to meet the needs of people

Slide 5

Tools to improve efficiency and prevent pollution – Cleaner Production

- Good housekeeping
- Modification of production processes
- Alternative Material use
- On-site material reuse and recycling

Slide 6

Tools to improve efficiency and prevent pollution – Life Cycle Assessment

- Assess the environmental impacts of entire life of product
- Assist the improvement of environmental performance of a product
- Assist the improvement of environmental performance of a company
- Provide a holistic approach

Slide 7

Tools to improve efficiency and prevent pollution – Eco-design

- Improve product quality and function
- Simplifying manufacturing process
- Replace toxic materials
- Improve resource efficiency during the use phase of the products
- Easy to reuse and recycle
- Reduce costs

Slide 8

Tools to improve efficiency and prevent pollution – Company sustainability management

- Company environmental management system
- Corporate sustainability reporting
- Corporate social responsibility
- Environmental management accounting
- Accident prevention and safe production

Slide 9

Tools to obtain effective use of natural resources

- Environmental impact assessment
- Land use planning (zoning)
- Sustainable industry development strategies
- Sustainable infrastructure development
- Eco-system based development

Slide 10

Policy instruments

Regulations & Laws

Voluntary agreements

Strategies and Plans

Economic instruments

Public information

Slide 11

UNEP's role in industry environmental management

- Identify major issues globally;
- Recommend solutions;
- Developing guidelines and tools;
- Test and demonstrate solutions;
- Building capacity of main actors (government and industry);
- Facilitate global process.

Slide 12

UNEP Programmes – Cleaner Production

- Established cleaner production assessment tool and practiced procedures;
- Jointly operating National Cleaner Production Center (NCPC) Programme with UNIDO;
- Demonstrating CP application on energy, water and material efficiency;
- Provide guidance to CP application in industrial parks;
- Demonstrating financial mechanisms for CP.

Slide 13

UNEP Programmes - Accident prevention and response

- UNEP-run programme – Awareness and Preparedness for Emergencies at Local Level (APELL);
- A tool to coordinate local authority, industry and community in
  - Risk identification
  - Risk prevention
  - Emergency response planning
  - Damage reduction through effective emergency response
- Assist countries to establish APELL centers and environmental emergency management schemes
- Demonstrate the use of the tool in preparing local community to natural and technical disasters

http://www.unep.fr/pc/apell/home.html

Slide 14

UNEP Programme - Waste Management

- Demonstration of waste reduction in industry (within cleaner production programme)
- Demonstration of urban waste management (reduction, reuse, recycle and remanufacturing);
- Piloting options and practices in e-waste management, involving users;
- Identify good practices.

Slide 15

Energy programme - partnerships

- ***UNEP Risø Centre*** (URC)
  - Supports UNEP Energy in its aim to incorporate environmental aspects into energy planning and policy worldwide, with a special emphasis on developing countries
  - 22 staff from 15 countries; energy planners, economists, scientists
- ***BASE*** (Basel Agency for Sustainable Energy)
  - A non-profit foundation which aims to mobilize investment in renewable energy and energy efficiency
  - BASE helps build strategic partnerships between entrepreneurs and investors to finance sustainable energy in developing / industrialized countries
- ***NREL*** (U.S. National Renewable Energy Laboratory)
  - NREL *the* is research laboratory of the DOE's Office of Energy Efficiency and Renewable Energy

Slide 16

Energy programme - Activities

- Rural Energy Enterprise Development
- Capacity Development for the CDM
- Global Network on Energy for Sustainable Development
- Solar and Wind Energy Resource Assessment (SWERA)
- Sustainable Energy Finance Initiative (SEFI)
- RETScreen
- Energy Efficiency in Industry (GERIAP)

Slide 17

UNEP programme – integrated chemical management

- Develop international strategy (SAICM);
- Implement relevant international conventions (Stockholm Convention, Rotterdam Convention, Basel convention);
- Promote chemical use reduction through cleaner production practices.

Slide 18

UNEP activities – working by industry sectors

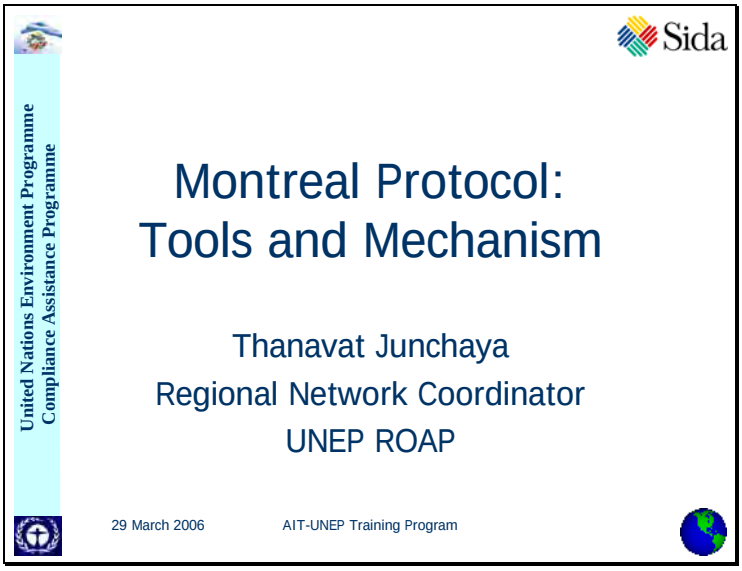
- Sustainable Tourism Programme
- Tour Operators Initiative
- Global e-Sustainability Initiative
- Global Sustainable Mobility Forum
- International Sustainable Building Initiative
- Partnerships with retail and advertising sectors

Montreal Protocol: Tools and Mechanism

Thanavat Junchaya
Regional Network Coordinator, UNEP ROAP, Bangkok, Thailand

ABSTRACT *This presentation discusses on ozone layer depletion and also about 1987 Montreal Protocol convened on the ban of substances that depleted the ozone layer. It mentions about the huge Ozone hole over the South Pole, now extended over south of the South America continent. It shows the phased out schedule for Chlorofluorocarbons (CFCs) and corresponding targets for different countries of South-Asian region. The tools and mechanism involved in the protocol to achieve total phase out of Ozone Depleting Substances (ODS) from the whole world also discussed. Common ODS phase out program includes control and monitoring of ODS import, phasing out existing demand and also prevent new demands. New challenges has to be monitored which are stricter control over illegal trade of ODS, regulations and prosecution issues, new refrigerant alternatives causing disposal and contamination problems and non-compliance by A5 (developing countries) parties even with very small consumption. The issues such as leakage problem of CFCs, and export of used products working on CFCs with low cost to the developing countries, and the recovery of ozone layer due to reduction in CFCs production. It recommends that the leakage should be stopped at any cost and the illegal export should be banned. Though the production of CFCs is reduced, recovery of Ozone layer is not a quick process, and can be realized only after 25-50 years*.

Slide 1



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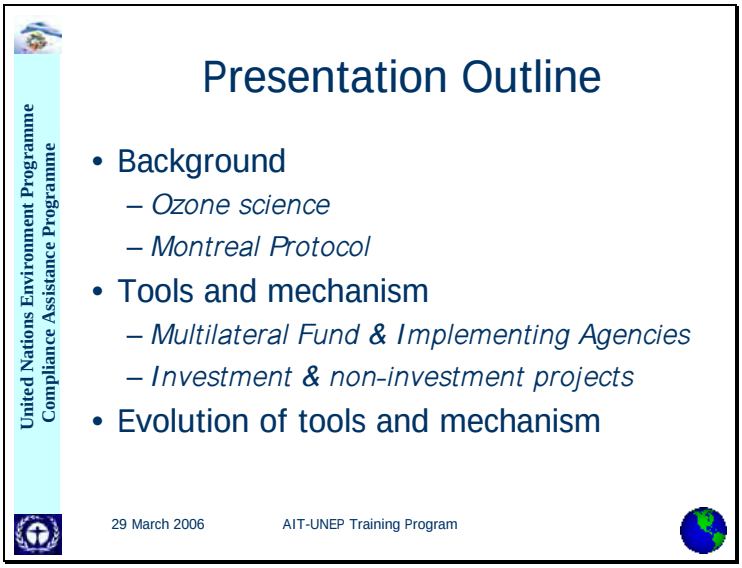

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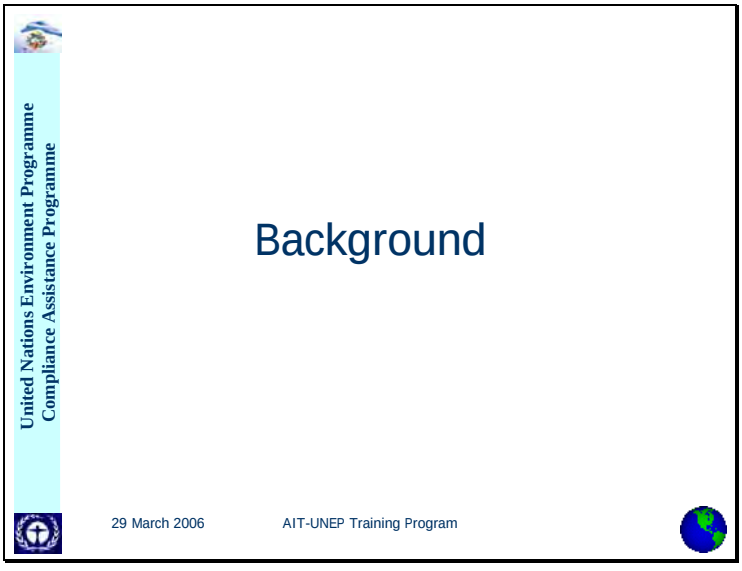

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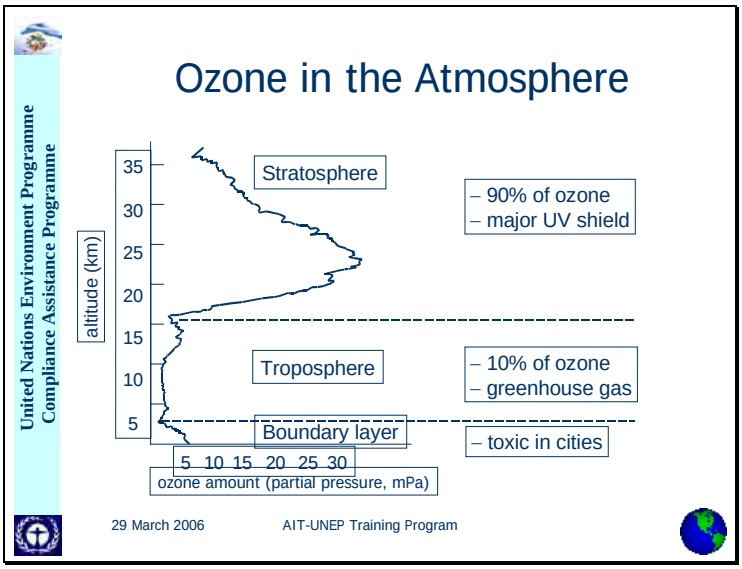

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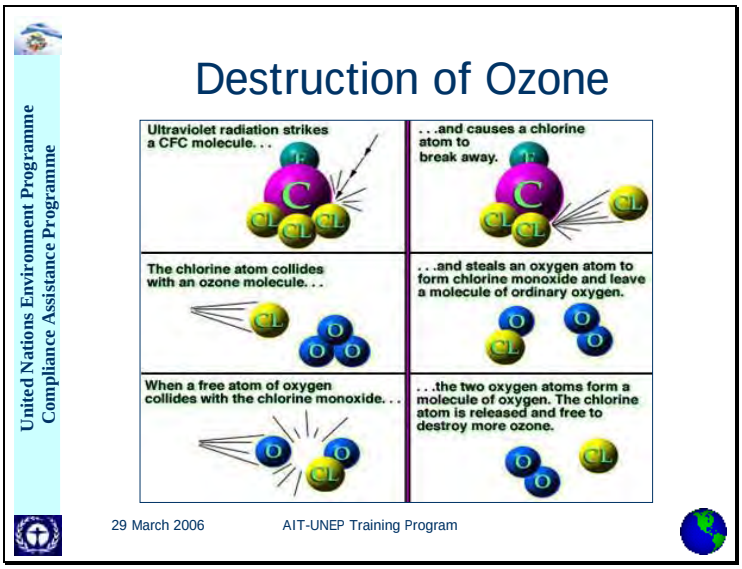

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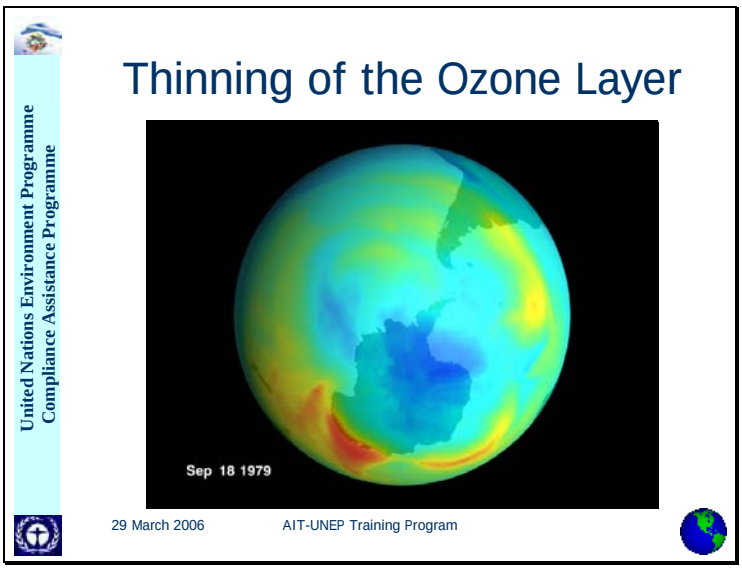

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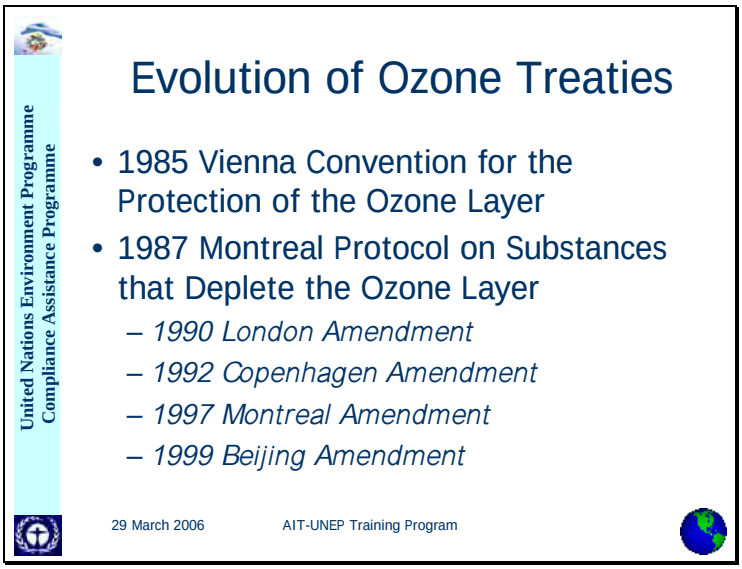

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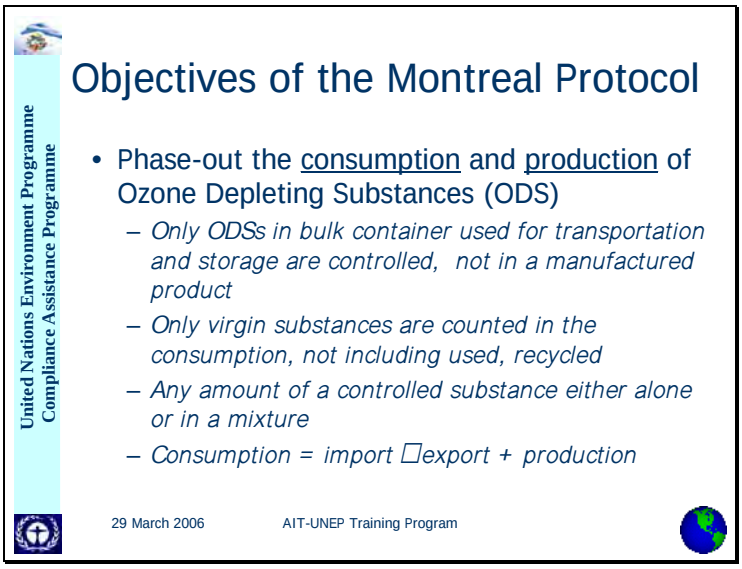

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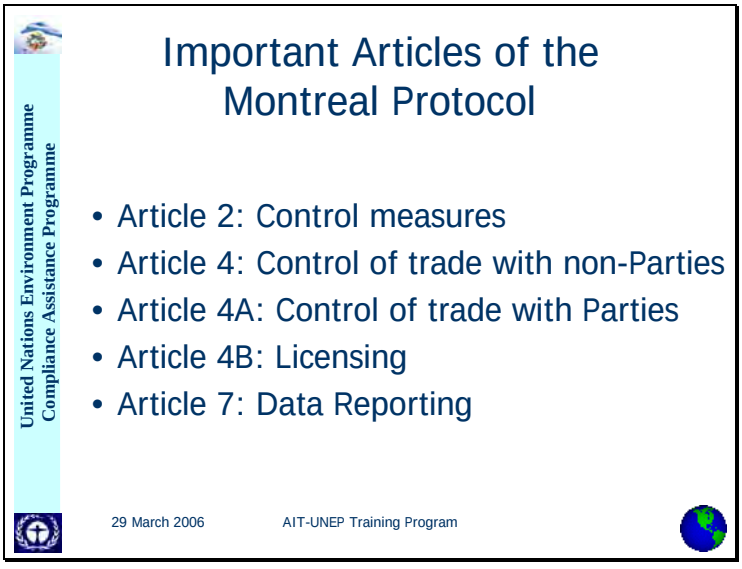


Slide 10

Article 2: Controlled Measures under the Montreal Protocol (A-5 Parties)

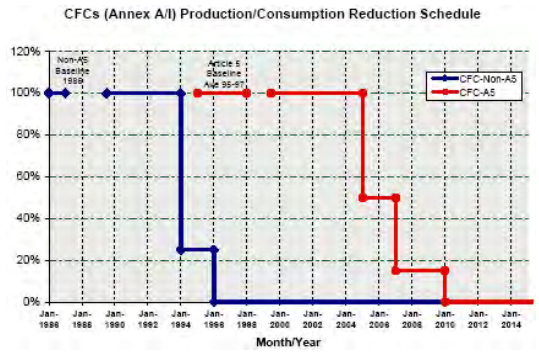
United Nations Environment Programme
Compliance Assistance Programme

Substances / Base Level	1st July 1999	2002	2003	2005	2007	2010	2015	2016	2040
A-I: CFC BL = Avg. 95-97	Freeze at BL			- 50% of BL	-85% of BL	- 100% of BL			
A-II: Halon BL = Avg. 95-97		Freeze at BL		- 50% of BL		- 100% of BL			
B-I: Other CFC BL = Avg. 98-00			- 20% of BL		- 85% of BL	- 100% of BL			
B-II: CTC BL = Avg. 98-00				- 85% of BL		- 100% of BL			
B-III: TCA BL = Avg. 98-00			Freeze at BL	- 30% of BL		-70% of BL	- 100% of BL		
C-I: HCFC BL = 2015 level								Freeze at BL	- 100% of BL
E: MeBr BL = Avg. 95-98		Freeze at BL		- 20% of BL			- 100% of BL		

Slide 11

Phase-out Schedule of CFCs

United Nations Environment Programme
Compliance Assistance Programme



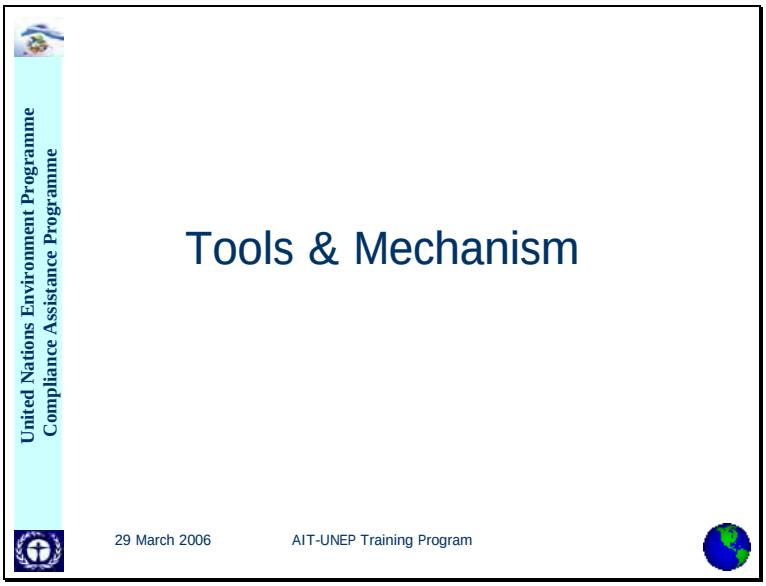
Slide 12

Compliance Status of South Asia Network Countries (2004 data)

United Nations Environment Programme
Compliance Assistance Programme

	CFC	Halon	CTC	TCA	MBr
Afghanistan *	178 / 47	0 / 0	0 / 0	0 / 0	0 / 0
Bangladesh	295 / 50	0 / 0	5.5 / 97	0.55 / 69	0 / 0
Bhutan	0.1 / 50	0 / 0	0 / 0	0 / 0	0 / 0
China*	22,808 / 39	4,959 / 15	22,019 / 39	336 / 47	1,008 / 91
India	2,242 / 33	0 / 0	7,459 / 65	0 / 0	0 / 0
I.R.of Iran	3,471 / 76	0 / 0	2,169 / 2,817	387 / 4,463	8 / 29
Korea, DPR	0 / 0	0 / 0	2,198 / 107	0 / 0	0 / 0
Korea, R.of*	5,171 / 56	2,260 / 61	-57 / -9	499 / 97	0 / 0
Maldives	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Mongolia	4.1 / 40	0 / 0	0 / 0	0 / 0	0 / 0
Nepal	0 / 0	0 / 0	0.8 / 91	0 / 0	0 / 0
Pakistan	805 / 48	7.2 / 50	752 / 182	0 / 0	0 / 0
Sri Lanka	156 / 35	0 / 0	27 / 78	0 / 0	1.5 / 37

Slide 13



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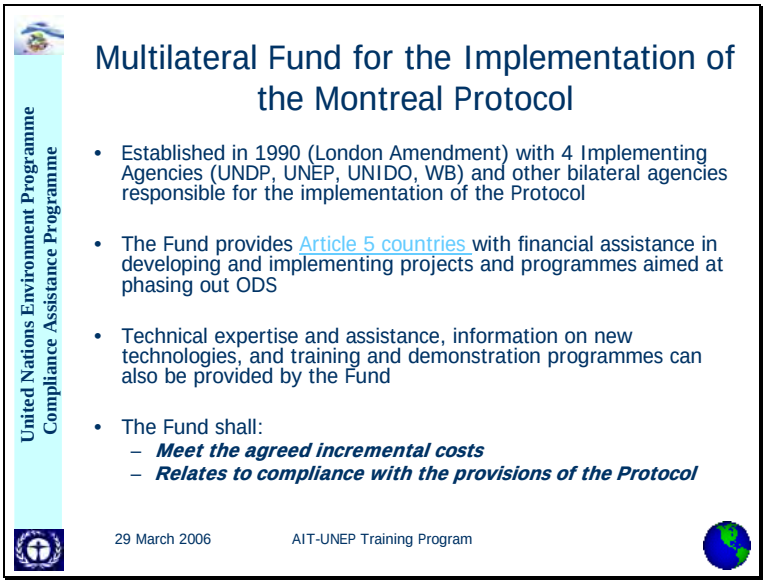

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Slide 16

United Nations Environment Programme
Compliance Assistance Programme

	US$
Pledged contributions	2,046,337,600
Total payments	1,820,509,900
Interest earned/other income	144,116,331
Total income	1,971,211,109
Total outstanding contributions	225,827,700
Outstanding contributions from EITC	103,746,599
Disbursement	1,641,909,418

29 March 2006 AIT-UNEP Training Program

Slide 17

United Nations Environment Programme
Compliance Assistance Programme

Total Approvals by Region*

Region	No. of countries	No. of projects	ODP to be phased out	US$
Africa	**51**	**1,001**	**16,239**	**177,188,738**
Asia and the Pacific	**45**	**2,180**	**172.381**	**1,249,684,783**
Europe	**12**	**263**	**7,455**	**72,538,775**
Latin America / Caribbean	**33**	**1,272**	**26,355**	**373,666,520**
Global projects	**-**	**256**	**-**	**92,566,042**

29 March 2006 AIT-UNEP Training Program

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United Nations Environment Programme
Compliance Assistance Programme

National Tools

- **Country Programme for the Implementation of the Montreal Protocol**
- **Refrigerant Management Plan**
- **Usually contain:**

a) a review of recent production, imports, applications and use of controlled substances by the main producers, users, and consumers;
b) a description of the institutional framework governing controlled substances;
c) a description of policy framework, regulatory and incentive systems;
d) a description of government and industry activities in response to the Protocol;
e) a statement of strategy for implementation of the Protocol, indicating the respective roles of government, multilateral and bilateral agencies;
f) an action plan encompassing investment and technical assistance projects, pre-investment studies, and any policy analysis required;
g) a timetable for each activity and for action plan review; and
h) a budget and financing programme.

29 March 2006 AIT-UNEP Training Program

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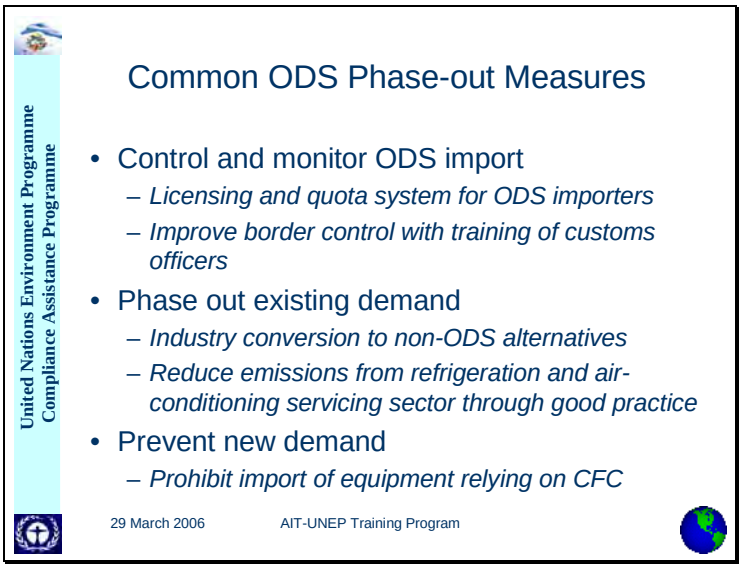

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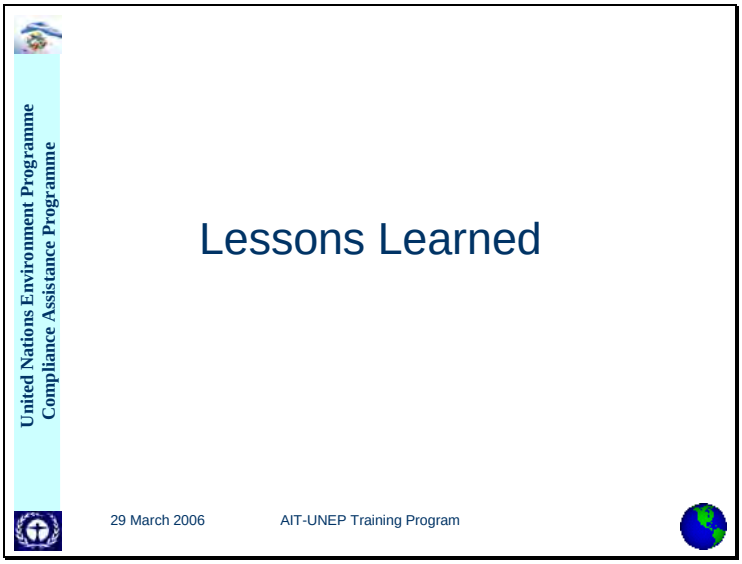

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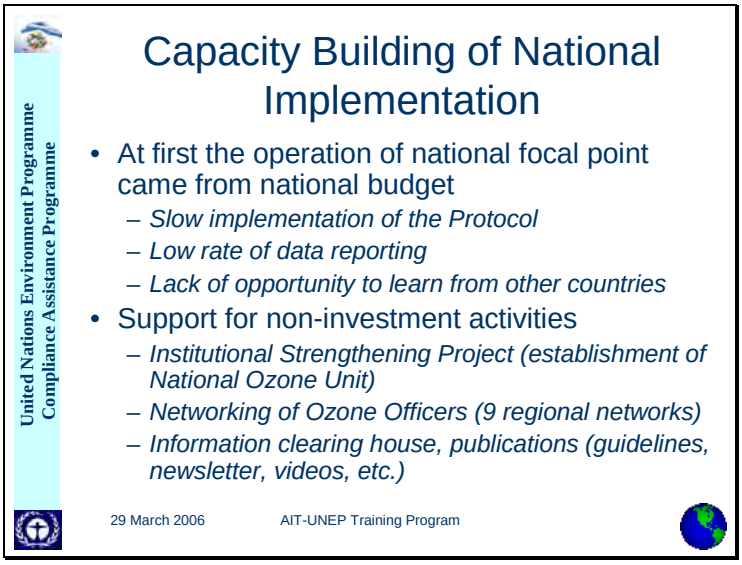

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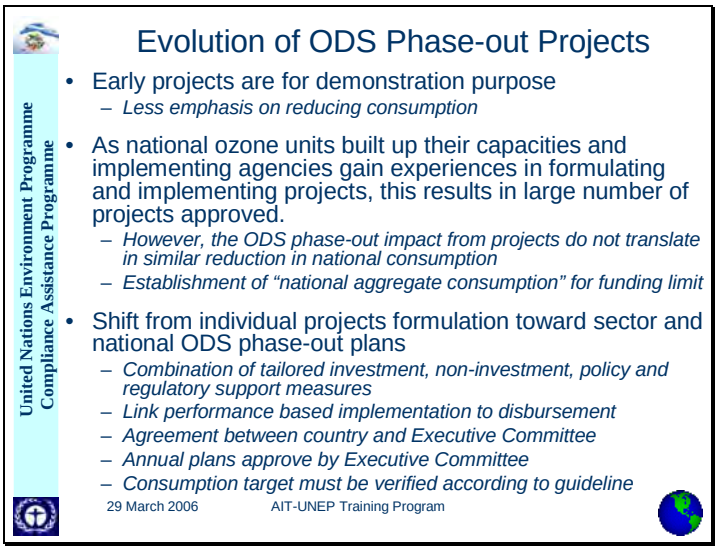

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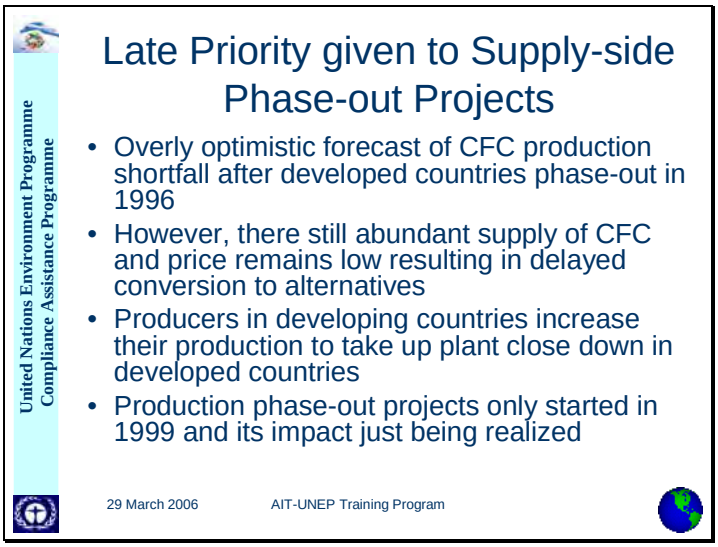


Slide 24

Environmental Security Issues for South Asia

Subrato Sinha
United Nations Environment Program (UNEP), Bangkok, Thailand

ABSTRACT *This paper discusses environmental security in terms of four parameters such as: water security, food security, habitat security and energy security. There is comparative statistical information on the current situation and future trends of South-Asian countries. Many cities are heading towards the 40% water scarcity level, which may be delayed by stopping the free distribution of water and using sprinkler and drip irrigation system for agricultural water supply. About 12.5% of the total hunger is in the region and it follows a declining trend. The alternative energy sources such as: nuclear, wind and solar energy should replace the use of coal and petroleum etc. to secure long term energy sufficiency.*

Introduction

The environment is comprised of air, water, land and biodiversity, which serve to sustain human life. In pursuit of economic development the environment has sustained severe damage in the developing countries of South Asia, including excessive land degradation, desertification and habitat fragmentation. This report looks at the current and future trends of food, water, energy and habitat security in South Asia.

The struggle to combat chronic poverty, uncontrollable population pressures, depleting and degrading natural resource endowments and policy and institutional shortcomings are factors that have contributed to the instability of South Asia's environmental security. The national State of the Environment (SoE) by the United Nations Environment Programme (UNEP), reported in 2001 that the main environmental challenges that face South Asia include: ensuring livelihood security, combating environmental disasters, preventing industrial pollution, managing urbanization and conserving biodiversity.

The South Asian countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka face an ever growing challenge in ensuring livelihood security for its inhabitants. Livelihood security is a concept that aims to create an understanding of the factors that people require in order to access the goods and services they need to make a living. Issues related to food, energy, water and habitat security that has direct bearing on environment and natural resources in South Asia has been briefly covered in the paper.

Food Security

South Asia is known for its severe food-insecurity problems and poverty. A majority of the world's food-insecure people lives in this region. Agriculture is still the dominant sector in South Asia. Soil degradation, decreasing per capita arable land, and water scarcity are all worrying concerns as South Asian nations hope to find ways of becoming agriculturally self-sufficient. It is clear that in order to increase food production to meet the demands of South Asians, more water will be required. Water used in agriculture will have to increase by an additional 15 to 20% over the next 25 years to meet the growing demand. This is a difficult level to achieve, but it's necessary if South Asian countries want to reduce the number of food-insecure people in the region. The following important issues for food security are discussed: land use, food production, and regional food security.

Arable land fell from 0.20 hectares (ha) per capita in 1985 to 0.15 ha in 2000. Irrigated land remained stable at around 0.062 ha/capita, between 1985 and 2000. In 2020, South Asia will lead the world in irrigated area by reaching almost 100 million ha (an increase of about 20% from the

1995 total of 80 million ha). The percentage of land area covered by forests in South Asia will increase from 15.4% in 1990 to 17.0% in 2000 (UNEP/RRC-AP, 2003).

Per capita food consumption for South Asia in 2015 is expected to be 2,700 kcal/day and then grow to 2,900 kcal/day in 2030 (a 7% increase). The number of food-insecure people in South Asia will most likely decrease from about 300 to 200 million people between 1990 and 2010 (FAO 2005).

In 1997, Pakistan led South Asia in net food per capita at roughly 115 kg/yr. Bhutan had the least amount of net food per capita at about 90 kg/yr.

If projections are drawn out until 2025 for India, it will appear as though water supply will exceed water demand, and that food grain supply will be less than food grain demand. An even scarier thought is that in the 1990s food grain growth rate slowed down to 1.7 % annually falling below the population growth rate of 1.9% (UNEP/RRC-AP, 2001).

Water Security

Water security in South Asia entails three different scenarios: water for food, water for people, and water for nature. Water scarcity in South Asia is a huge concern. Water demand in the region is extremely high especially due to large areas of irrigated land (the most in the world). South Asia is also experiencing severe water pollution problems. Indian rivers are among the most polluted in the world, Nepali rivers are contaminated with coliform bacteria, arsenic levels in groundwater in Bangladesh are way above the standard and groundwater overdraft has led to water-logging and salinity in many parts of Pakistan. The three most pressing water security issues in South Asia: water demand and supply, water quality, and groundwater tables.

Bhutan has the highest per capita water resources in South Asia at close to 50,000 cubic meters (m^3) per year, followed by Nepal at 7,705 m^3/yr (figures for 2004). In 1985, per capita freshwater resources available in South Asia was 3,485 m^3/yr and it dropped to 2,511 m^3/yr in 2005 (a 28% decrease).

In 2000, total water withdrawal in South Asia was 918 cubic kilometers (km^3) per year. In 2000, per capita withdrawal was 686 m^3/yr while in 1985 it was 503 m^3/yr (an increase of 36%). Pakistan leads South Asia in per capita freshwater withdrawal with more than 1,100 m^3/yr; although there has been a marginal drop since 1990 (1,269 m^3/yr). Bhutan, on the other hand, has the lowest per capita freshwater withdrawal (less than 200 m^3/yr) (UNEP/RRC-AP, 2004).

In 1990, four of the biggest South Asian nations combined to produce 1,738,823 kilograms (kg) of organic water pollutants per day. In 1997, they produced 2,047,943 kg/day (an increase of 18%).

In 1990, 90% of urban South Asia had access to an improved water source compared to 64% of rural South Asia. In 2002, the figures for urban and rural South Asia increased to 94% and 80% respectively.

Pakistan has the highest per capita annual average level of groundwater withdrawal, which rose from 315.5 m^3/yr in 1990, to 489.5 m^3/yr in 2000, which is an increase of approximately 55%.

In 1995, India withdrew about 20 to 40% of available water while Pakistan withdrew more than 40% of its available water. Bangladesh, Bhutan, Nepal and Sri Lanka withdrew less than 10%.

By 2025, most of South Asia will withdraw over 40% of its available water. By 2025, Pakistan will use more water than it has available (over 100%). India and Sri Lanka will use more than 40% of available water, Nepal roughly 20%, and Bangladesh and Bhutan less than 10% (UNEP/RRC-AP, 2003).

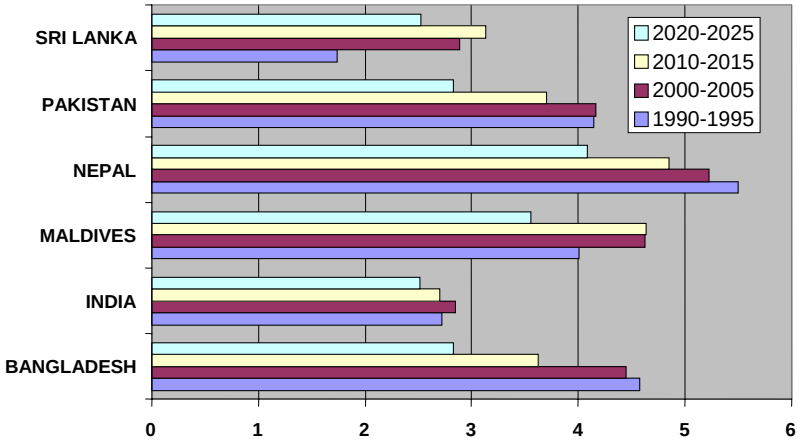
Pakistan has the highest percentage of population with access to safe drinking water in South Asia (roughly 84%) and Bhutan has the lowest percentage (45%). Over 80% of Sri Lanka and India's population has access to safe drinking water (WHO, 2004).

Habitat Security

All human settlements use natural resources (food, construction materials, raw materials for industry, energy, water, air and land) which they consume, process, transport, and from which they subsequently generate waste. Environmental conditions within human settlements are a central concern in sustainable development, primarily for the strong link that exists between poverty and environment in South Asia.

In 2000, South Asia was home to 5 out of the 19 megacities (cities with a population of over 10 million) in the world with a total population of 65.8 million. In 1990, 25% of South Asia's population was urban. In 2003, with an annual growth rate of 2.8%, South Asia's total urban population stands at 28% of the total population.

Nepal's urban growth rate of 6.5% per year makes it the highest in South Asia. Although growth rates are predicted to decrease between 2005 and 2025 the level of urbanization in South Asia is predicted to grow. India's average growth rate over the period 1990-2025 is the lowest in South Asia.

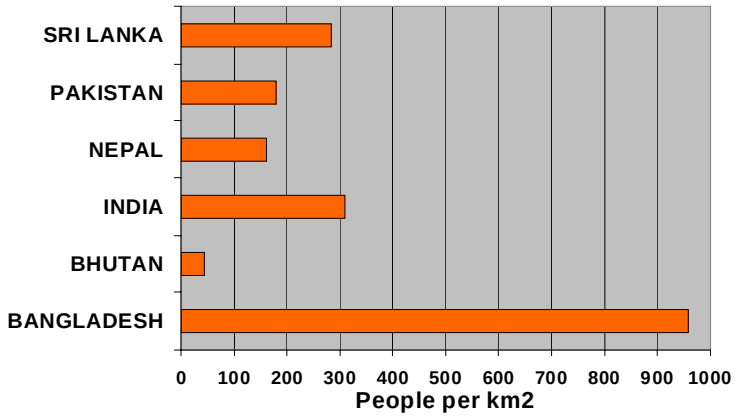


Source: World Bank (2006)

Figure 1. Urban Population Growth

By 2030 Pakistan will be the most urbanized (55.9%) and Bhutan will remain the least urbanized (17.9%).

Population density is highest in Bangladesh (958 people per km²) and lowest in Bhutan (44 people per km²) in 2000.

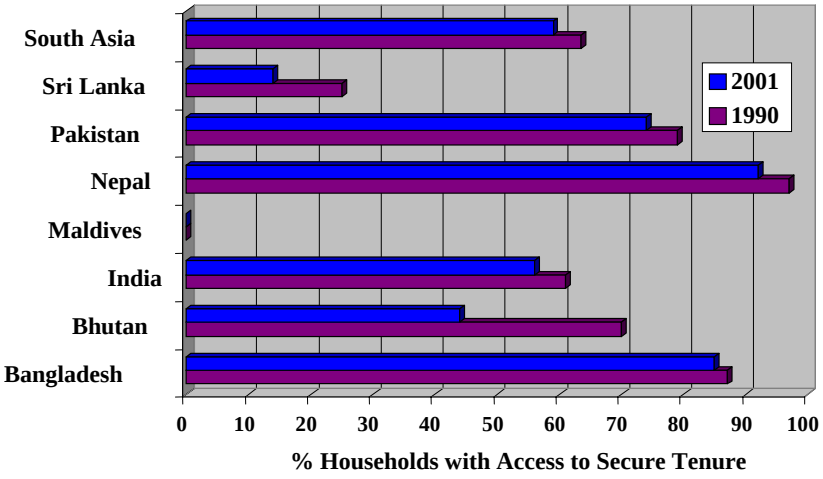


Source: WRI (2005)

Figure 2. Population Density in 2000

In South Asia between 1990 and 2001, the proportion of slum-dwellers shrank from 64 to 59 per cent, but absolute numbers increased by 43 million to a total of 319 million in 2001 (UN-Habitat, 2003*)*.

Security of tenure is fundamental to habitat security. In 2001, 67% of India's urban population and 94% of its rural population owned housing. Renters in urban areas were 29% and 4% in rural areas in 2001(UN-Habitat Housing Policy). In Colombo, about half of the urban poor have no security of tenure, 37% have freehold and 13% have leasehold.



Source: UN-Habitat (2003)

Figure 3. Slum Population as % of Urban Population

UN-Habitat's *Global Report on Human Settlements 2003* states that about 'half' (5 million) of Karachi lives in *katchi abadis* (informal settlements created through squatting or informal subdivisions of state or private land).

Pakistan has largest proportion of households living in insufficient living area (59%). Sri Lanka has the highest portion of households with a sufficient living area (86.2%). Although India is home to the largest proportion of slum dwellers, 79.8% of total population has sufficient living area.

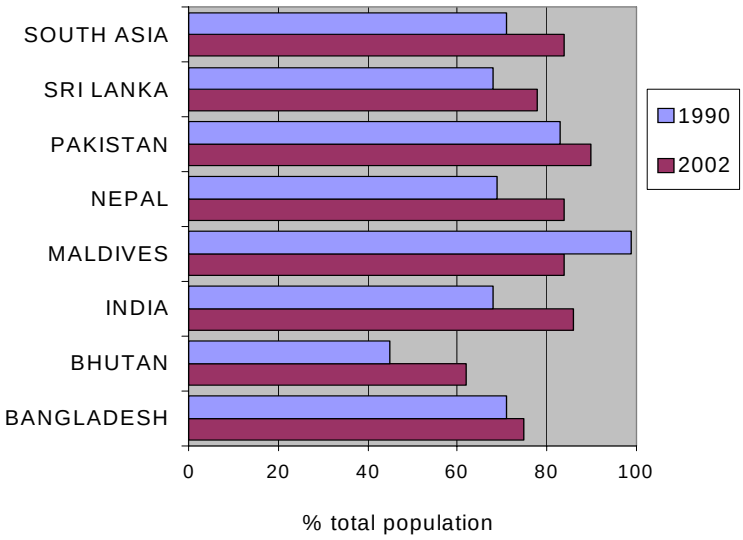
Building-materials industries are recognized as an important source of environmental stress**.** In both India and Sri Lanka, degradation of the coastal environment has necessitated restrictions on the removal of coral and shells for the production of building lime.

Another environmental stress associated with building-materials production is the air pollution caused. Many building-materials industries involve firing or other processes, which release pollutants into the atmosphere. The excessive dependence of building-materials industries on the use of firewood in developing countries adds significantly to carbon dioxide emissions and the production of "greenhouse gases".

Each city has its own method of dealing with solid waste. In Delhi 99.5% of solid waste is disposed of in sanitary landfills. Whereas an open dump is more readily used in Dhaka (50%), Karachi (51%) and Colombo (100%). Recycling methods have been adopted in Dhaka (35%) and Karachi (12%). Karachi still burns solid waste openly (20%) thus increasing the level of air pollutants (UN-Habitat, 2003).

Between 1999 and 2025, municipal solid waste generation rate (kg/capita/day) in Bangladesh will rise from 0.49 to 0.6; in Nepal it will rise from 0.5 to 0.6; in India it will rise from 0.46 to 0.7 and in Sri Lanka from 0.89 to 1. India will experience the largest growth of waste kg/capita/day by approximately 52%. Although Sri Lanka remains as the largest per capita generator of waste at 1 kg/capita/day, which is the highest of the selected countries, it is not the largest total generator of waste.

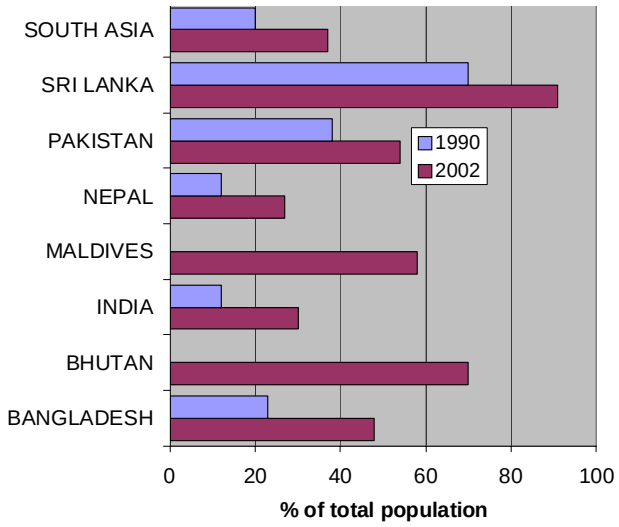
The percentage of wastewater treated in South Asian cities vary. In Delhi 73% of wastewater is treated compared with a low 10% in Karachi and Colombo (UN-Habitat, 2003).



Source: WRI (2005)

Figure 4. Access to Improved Water Security

Over the period 1990-2002, 1.1 billion people gained access to safe drinking water. The region with the greatest progress for achieving Target 10 of the Millennium Development Goals was South Asia. India noted the largest increase from 68% to 86% of the population gaining access to safe water.



Source: WRI (2005)

Figure 5. Access to Improved Sanitation

In 1990, 20% of South Asia's total population had access to improved sanitation and of that number 54% were urban and 7% were rural. In 2002, overall access has improved (37%) and the gap has narrowed (66% urban, 24% rural). Sri Lanka has made the most significant progress where in 2002 approximately 91% of the total population had access to improved sanitation.

Air pollution is the main source of environmental concern in South Asian cities due to the growing number of motor vehicles and increasing industrial activity (UNEP/RRC-AP, 2001).

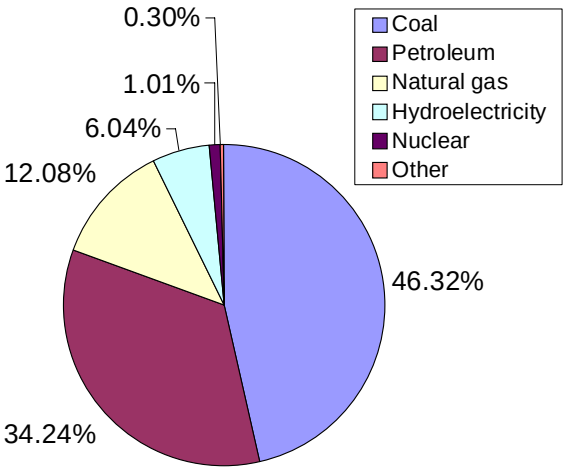
In 2002, the number of excess death per annum due to PM10 pollution in Dhaka was 10,350. The total cost came out to be about taka 124 billion, which shows a tremendous loss to the economy i.e., 3-4 % of national GDP (Clean Air Net).

The average property damage cost due air pollution in Colombo is US$ 118 per year per household. Average WTP (willingness to pay) to avoid property damage is estimated to US$ 5 per year per household. Average WTP to improve air quality in Colombo is estimated to US$ 14 per year per household (Cleanair.net.org).

Energy Security

Economic and population growth in South Asia have resulted in a rapid increase in energy consumption in recent years. A secure and sustainable energy supply is therefore critical for South Asia as it is experiencing high growth rates evidenced by the 4.2% growth in GDP in 2002 and a primary energy consumption increase of nearly 64% between 1992 and 2002 (Energy Information Administration-EIA). Energy security is the continuous availability of energy in varied forms, in sufficient quantities and at reasonable prices (IEA, 2002).

South Asia's commercial energy mix in 2002 revealed coal as its main source of fuel (46.32%). This was followed by petroleum (32.4%) and natural gas (12.08%). Renewable sources of energy (solar, wind) barely contribute to South Asia's energy sources at present.



Source: IEA (2002)

Figure 6. South Asia Commercial Energy Mix 2002

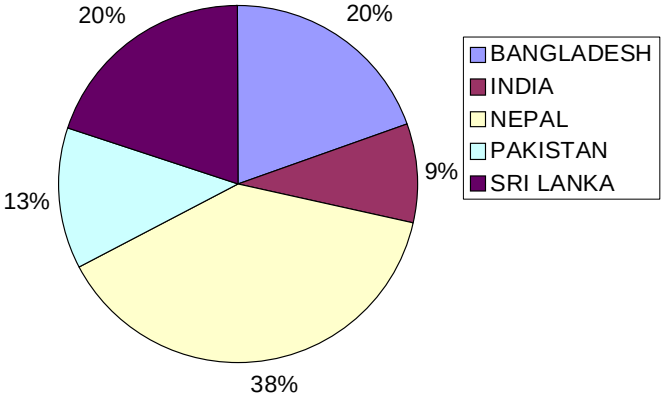
Natural gas production in South Asia is largely domestically consumed. In 2002, the region produced and consumed around 2.1 Tcf of natural gas. Around 42% was consumed by India, 39% by Pakistan and the remaining 19% by Bangladesh. Bhutan, the Maldives, Nepal and Sri Lanka at present do not produce or consume natural gas (IEA, 2002). Consumption of natural gas has risen faster than any other fuel in recent years and is projected to reach 1.2 Tcf per year in 2005 and 1.6 Tcf per year in 2010.

South Asia contains around 0.5% of world oil reserves. In 2002, the region consumed around 2.72 million barrels per day (bbl/d) of oil, and produced approximately 0.70 million bbl.d, making South Asia a net oil importer of around 2.0 million bbl/d (IEA, 2002).

India has 15% of the world's technically exploitable hydropower capacity. Theoretical estimations put the total hydropower potential of Bhutan at about 30,000 MW, with technically and economically feasible sites of about 16,000 MW capacity (TERI). Nepal relies almost exclusively

on hydroelectricity to meet its power requirements with an installed capacity of 400 MW in 2002 (IEA). Its estimated potential is 43,000 MW, which could be developed to provide for the 60% of the population without electricity as well as for export.

South Asian countries rely heavily on biomass for residential energy consumption, particularly in rural areas. According to the International Energy Agency (IEA), biomass accounted for about 80% of residential energy consumption in 2000 and will account for 70% of total residential energy consumption in 2020. In 2003, 72% of South Asia was using solid fuels.

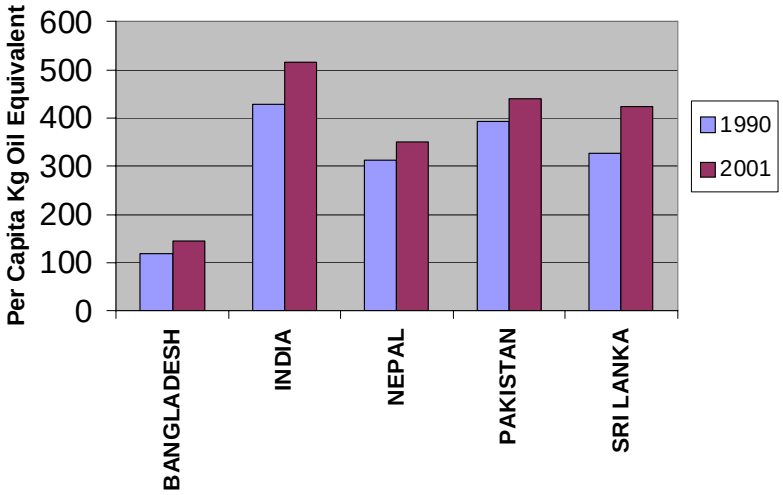


Source: UNDP Human Development Report (2003)

Figure 7. South Asia Traditional Fuel Consumption

In 2004, Nepal was most heavily reliant on traditional fuel (87% of total energy used with 90% being sourced from fuelwood). This is up from 38% in 1997 (UNEP/RRC-AP, 2001)

India leads South Asia in energy consumption of renewables in 1999 consuming 198,107 mtoe. Traditional renewables comprise of biomass products and are widely used across South Asia. In 2002 South Asia accounted for approximately 4.1% of world commercial energy consumption but still averages among the lowest levels of per capita energy consumption in the world and among the highest levels of energy consumption per unit of GDP (5.2 per kgoe in 2002)



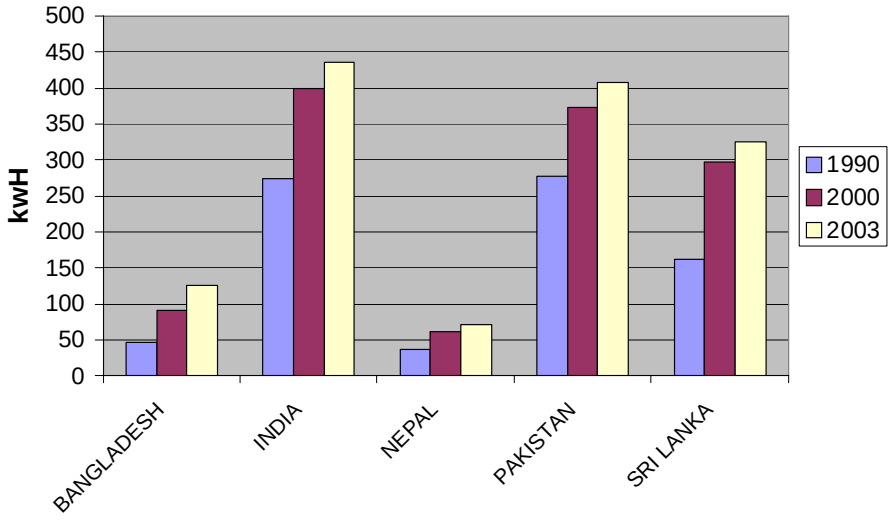
Source: WRI (2005)

Figure 8. Commercial Energy Use Per Capita

India is the biggest user of commercial energy per capita using 429 kgoe per capita in 1990 and 514 kgoe per capita in 2001. Bangladesh consumes the lowest 118 kgoe in 1990 and 144 kgoe per capita in 2001. Sri Lanka experienced the largest rise in energy use per capita of 29% increase between 1990 and 2001.

For the South Asian countries in total, as well as for India, which is the region's biggest producer and consumer, by 2030 the demand/supply gap is set to increase. In India it rose from 1.202 quadrillion btu in 1990 to 3.884 quadrillion btu in 2003 and is predicted to widen to 9.9685 quadrillion btu in 2030.

In 2003 Pakistan was unable to meet its energy demand (1.908 Quadrillion Btu) with primary supplies (1.265 Quadrillion Btu). Sri Lanka is the only country which is experiencing decreasing supplies from 0.045 quadrillion btu in 1995 to 0.030 quadrillion btu in 2003 and demand continues to grow thus widening the demand-supply gap. Bhutan is the only South Asia country to have an energy surplus at the moment with a demand-supply gap of -0.003 quadrillion btu in 2003. Nevertheless as demand only marginally exceeds supply at the moment, Bhutan needs to ensure it has sustainable energy supply as demand is set to grow in the future.



Source: IEA (2002)

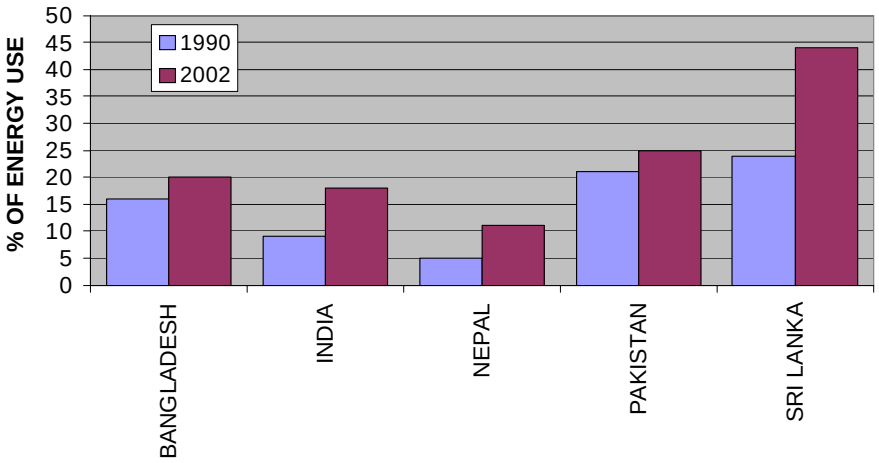
Figure 9. Electricity Consumption Per Capita

In 2002, South Asia generated 642 billion kilowatt hours of electricity. India accounted for 85% of the regions electricity generation, followed by Pakistan (11%), Bangladesh (3%), Sri Lanka (1%), Nepal, Bhutan and the Maldives (1% total). Hydroelectricity is expected to fuel new generations, primarily in Nepal and Bhutan. Non-hydroelectric 'renewable' capacity (i.e., wind, solar, ocean, biomass, geothermal) is small at present, but it is increasing according to the EIA, with solar and wind power considered most promising.

The IEA estimates that in 2002 the level of electrification is South Asia was approximately 42%. Sri Lanka had the highest level (62%) while Nepal had the lowest (15%). In total 775.3 million people in South Asia are without electricity. In the Maldives total electricity consumption in 2001 was 108.8 million kWh (USAID, 2005).

Electricity demand in most of South Asia is currently outstripping supply as the region is characterized by chronic shortages. At the supply end losses in distribution and transmission of electricity range between 15%-25% in India, Pakistan and Bangladesh (World Bank, 2006).

South Asian countries are largely energy importers. As a result they experience severe power shortfalls. Sri Lanka experienced the sharpest increase in energy imports from 1990-2002 of approximately 83%. South Asia's oil imports are projected to more than double by 2020.



Source: World Bank (2006)

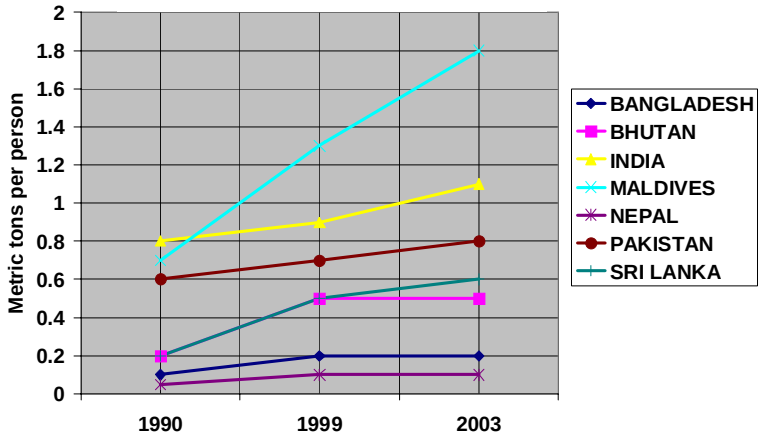
Figure 10. Net Energy Imports

In 2000, India imported 65% of its crude oil requirements and consumed close to 3% of world oil supply. In FY 2002-2003 Pakistan exceeded its Export Target of $10.4 billion by 6%. Pakistani exports reached $11.03 billion that year through consistent government policies and incentives to exporters. The export of petroleum, oil, and lubricants contributed significantly to these figures, with an increase of 63%.

Nepal has sufficient hydroelectric potential to fulfill domestic consumption needs and export to India, Bangladesh, and Pakistan. The demand for clean, renewable energy in Nepal and northern India, is expected to at least double over the next decade, providing a significant potential market for Nepal's hydroelectric resources. Furthermore, India's energy deficit is expected to reach 20,000 MW by 2010 (USAID, 2005).

In South Asia two-thirds of the wood removed from forests is for fuel (UNEP/RRC-AP, 2001). Nepal has the highest level of annual deforestation at 1.8% change between 1990-2000 (World Bank, 2006).

An important implication of rising energy demand is the impact on the region's level of carbon emissions. As of 2002, South Asia accounted for 4.8% of global carbon emissions. In 2003 Pakistan's carbon dioxide emissions were from oil (54.6%) and from coal and natural gas (7.2%) (IEA).



Source: WRI (2005); World Bank (2006)

Figure 11. Carbon Dioxide Emission Per Capita

India is now one of the lowest per capita emitters of CO_2, at 1.1 tonnes, or about one-twelfth the OECD average. But the energy sector's carbon intensity is high, and the country's total carbon dioxide emissions ranked 5th highest in the world. They are projected to reach 2.3 billion tonnes in 2030, up from 937 million tones in 2000.

It is not only outdoor air pollution that has harmful health impacts, but indoor air pollution as well because in South Asia a large proportion of the population still uses firewood for cooking. Typical 24-hour average concentrations of particulate matter (PM_{10}) pollution in homes using biofuels can be as high as 5,000 micrograms per cubic metre which is 33 times higher than the latest standard set by the US Environmental Protection Agency of less than 150 micrograms per cubic meter (World Bank, 2006).

Studies point out that the concentration of particulate matter in homes in South Asia may even be 10 to 100 times more than those prescribed by the World Health Organization.

Sri Lanka has implemented an improved cook stove program in an effort to reduce indoor air pollution. ICS's were distributed to 25% of households (urban and rural). Financial benefits are estimated US$ 37.5 million including environmental and health benefits. Improved cooking stoves lead to lower levels of firewood consumption and drastically reduce total annual emissions by 73%.

The Way Forward

Sustainable management of water resources: Efficient water pricing systems are one step towards sustainably managing water resources. Pricing systems that hardly place value on water are hurting South Asia's chances of dealing with water scarcity.

Drip irrigation is another solution for the water scarcity problem in South Asia. Drip irrigation provides the potential to enhance food productivity and it prevents overexploitation of resources such as water and soil.

Rainwater harvesting is a traditional method of recharging groundwater resources. Harvesting rain is ideal for areas with inadequate water supply.

In the Maldives, the country has turned towards desalination as a solution for the country's water scarcity and groundwater pollution problems.

Sustainable urbanization: Eco-friendly building practices offer an opportunity to create environmentally sound and resource efficient buildings.

Measures to prevent and control air, water and soil pollution and to reduce noise levels, must be adopted where appropriate, as well as developing and ensuring access to appropriate preventive and curative health-care systems in order to tackle related health problems.

According to the UN-Habitat's Global Report 2003 research suggests that if the full costs of negative environmental externalities associated with slums are taken into account, the costs of slum upgrading programmes in the informal housing sector will be the same as, or lower than, the cost of construction of new public housing for the same number of households.

Adequate shelter for all will demand enormous increases in the quantities of raw materials*:* Low-energy materials should be chosen wherever possible. The use of industrial and agricultural wastes as raw materials will need to be greatly increased. Reafforestation is crucial for maintaining timber supplies and protecting the land from large-scale deterioration.

Energy security: The South Asian energy scenario is of low energy consumption, higher energy intensity and of fast growing demand. Possible responses include a pro-poor focus which aims to improve access to and broaden energy choices for households and rural communities, including promoting the use of higher quality fuels to the fullest extent possible.

Using decentralized renewable energy technologies*:* Promote renewable sources of energy such as the adoption of improved cooking stoves or more sophisticated biomass conversion technologies.

Rational energy pricing*:* Price subsidization has supported inefficient energy uses in certain countries and sectors, often with negative economic and environmental consequences.

The use of technology, and not merely its presence, depends on a critical mix of the government and the market forces to create capacity, provide incentives, influence investment decisions, and ensure the integration of sustainable energy priorities into national planning.

Regional cooperation*:* At the SAARC summit November 2005, the Dhaka Declaration endorsed the recommendation for establishing a SAARC Energy Centre in Islamabad to promote development of energy resources including hydropower, energy trade in the region, and renewable and alternative energy, and also to upgrade energy efficiency and conservation in the region. The 7.4-billion dollar Iran-India-Pakistan (IPI) natural gas pipeline project is seen as a vital energy link for the South Asian economies and future energy security.

The largest reductions in indoor air pollution can be achieved by switching from solid fuels (biomass, coal) to cleaner more efficient energy sources such as: liquid petroleum gas, biogas, producer gas, electricity and solar power.

Encouragement of the use of solar heating and cooling and electric technologies, energy efficient design, ventilation and improved insulation of buildings to reduce the consumption of energy in buildings is necessary.

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Air Quality Management with Transboundary Issues

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ABSTRACT *Rapid economic growth, industrialization, urbanization, and motorization with land use/cover change have been observed in the past decades in Asia. The environmental quality management, in general, and air quality management, in particular, does not development at the same pace. As a result, burning dirty fuels in low energy efficient combustion devices without adequate control leads to large quantities of man-made air pollution emissions, and both stationary sources and mobile sources lead to high levels of ambient air pollution. Several of the world's most polluted cities are located in Asia with the extremely high air pollution levels. Monitoring data and modeling simulation show pollution plumes flowing out from mega cities in Asia and spreading to downwind locations. The most important trans-boundary air pollution issues in Asia include 1) Regional haze from forest fires, 2) Atmospheric/Asian brown cloud (ABC), 3) Regional dust, and 4) Acid rain. This training module aims at providing the basic understanding to the air pollution and air quality management as well as the long-range transport of air pollution for the optimal air pollution abatement strategies.*

Introduction: Air pollution

Air pollution is a term used to describe any unwanted chemicals or other materials that contaminate the atmosphere resulting in the degradation of air quality. Air pollution occurs both outdoor and indoor. Outdoor air pollution or ambient air pollution observed in urban areas may be of a different mixture of air pollutants than that found in the countryside.

Ambient air pollution is not a new problem. It dated back to the 13th century, when the London sky was smoky due to emission from coal burning. The sulfurous smog (particles and SO_2 mixed with fog) in London became a significant problem when extensive coal burning was practiced at the height of the Industrial Revolution, 19th and early 20th centuries. The smog was frequently observed during winter due to additional emission from domestic space heating and the special meteorological conditions in the city during this time of the year. It is therefore also called the winter smog. The most notorious episodic smog event was the great smog recorded in London in 1952, which lasted from Dec. 5 to Dec. 8. During this period the total number of deaths in Greater London exceeded the average by 4000. Another example is the photochemical smog pollution in Los Angeles that became known during the Second World War. Photochemical smog is a mixture of ozone and other oxidants as well as tiny particles. This smog is formed when hydrocarbons and nitrogen oxides emitted into the atmosphere where they undergo complex reactions in the presence of sunlight. It is also called the summer smog. It causes respiratory and eye irritation, damage plant and materials, and greatly reduces visibility (Wark et al., 1998).

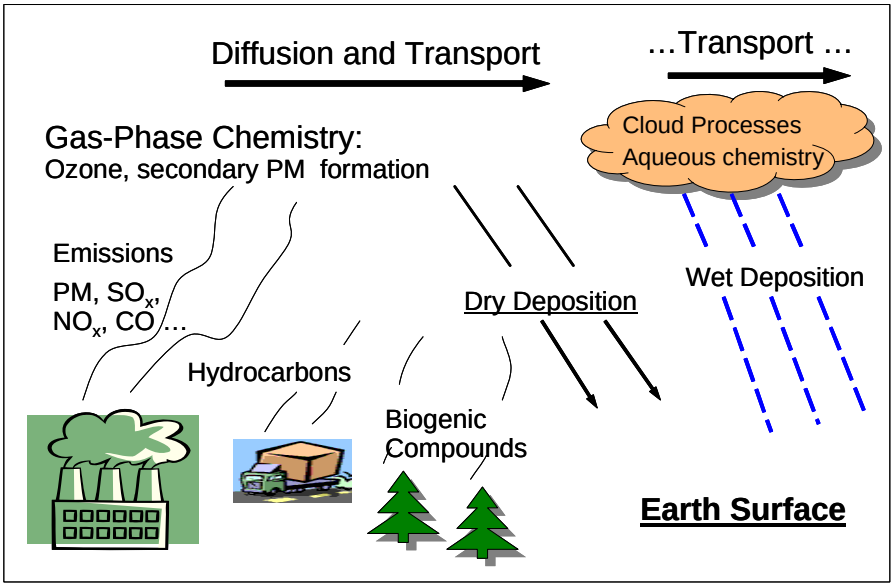
Thanks to the continuous efforts to improve air quality, the smog has become much rare in London, and Los Angeles sky has become clear for most the days of a year. In the developing world, however, urban air pollution has worsened in most large cities, a situation driven by pollution growth, industrialization, and increased vehicle use. Despite pollution control efforts, air quality has approached the dangerous levels in a number of mega cities, such as Beijing, Delhi, Jakarta, and Mexico City. In these cities, pollutant levels sometime exceed WHO air quality guidelines by a factor of three or more. Worldwide, WHO estimated as many as 1.4 billion urban residents breathe air pollutant concentrations exceeding the WHO guidelines (APMA, 2002). Various lessons can be learnt from the experiences in the developed countries to avoid and solve the serious air pollution that occurs in developing countries during the development process.

People living in large cities are thus exposed to higher concentrations of most air pollutants than those living in small villages. Exposure to urban air pollution has resulted in significant adverse effects on human health. On a global scale it is estimated that 200,000-570,000 deaths (around 1%

of the total deaths) occur each year due to exposure to outdoor air pollution. In urban areas of developing countries, 2-5% of total deaths are estimated to be caused by the exposure to high PM levels alone. High urban air pollution also has impacts on economics due to increased in mortality and morbidity, as well as damage to properties and crop, and tourism loss (APMA, 2002).

Air pollution is emitted from multiple sources, which are mainly related to the fuel combustion. The largest source of air pollutants in most urban areas is motor vehicles. Major traffic-generated pollutants include nitrogen oxides (NO_x), defined as the sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOC) and particulate matter. Other important sources are industry and power plants, particularly where these big sources are still situated inside cities. Residential combustion for cooking and space heating can contribute significantly, especially in the cold climate.

Air pollutants emitted into the atmosphere at a location may circulate the Globe within a few days to a few weeks depending on meteorological conditions. In many instances, air pollutants are found many thousands km away from their sources. In fact the air pollution is sent around the Globe and the impacts of human activities are felt on scales from local to global. An example of the global impacts is the climate change which is believed to be enhanced by the man-made greenhouse gases and other radioactive forcing substances. Pollutant level at a location is determined by a combination of processes, including the intensity of local source emission, the atmospheric capacity to dilute the emission, the natural removal processes, the physical and chemical transformation of pollutants, and the amount that being transported from upwind regions (Figure 1).



Source: Kim Oanh (2006)

Figure 1. Atmospheric Pathway of Air Pollution

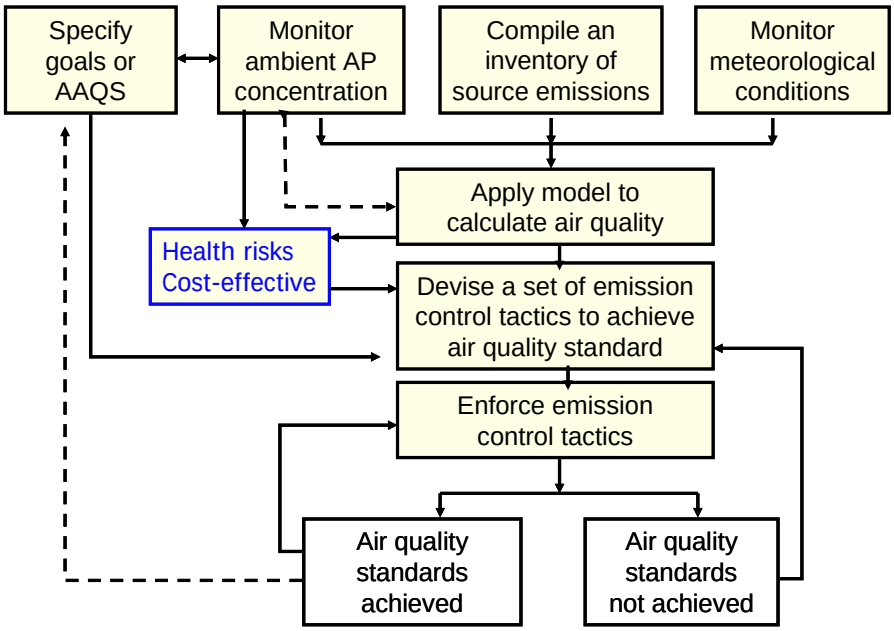
Air Quality Management

The ultimate goal of air quality management is to ensure that air pollution concentrations do not exceed the defined target levels (air quality standards, target values for outdoor air quality), and that human health and the environment are protected.

Air quality management is a crosscutting issue, involving numerous stakeholders from governmental institutions, research institutes, non-governmental organizations and private organizations.

Air quality management is a dynamic, reiterating process. The process of air quality management typically starts with the definition of ambient air quality standards or guidelines. In order to assess the levels of air pollution in a specific geographical area or region, the next step will

be to perform emission inventories, and to perform ambient air monitoring. From the results of ambient air monitoring networks, the compliance with standards can be assessed, and an impact assessment can be performed. The emission inventory is a crucial component of air quality management. An emission inventory is a reasonable quantitative assessment of the emission loads from relevant sources/sectors that can be used to identify the most important sources and the options for control. The quantification of emissions can also be used as input to dispersion modeling, as a way to predict the ambient air concentrations as a result of the emissions from a given source. The basic steps involved in air quality management can be illustrated as shown in Figure 2.



Source: Kim Oanh (2006)

Figure 2. Basic Elements in the Process of Air Quality Management.

Many Asian cities have developed some form of air quality management (AQM) system to address the increasing levels of urban air pollution. One of the first co-ordinated initiatives was taken through the URBAIR project in the 1990'ies, resulting in the suggestion of action plans for Kathmandu, Jakarta, Manila and Mumbai (Shah et al., 1997). Other important co-ordinating initiatives in this field has been the Air Pollution in the Megacities of Asia (APMA) project, initiated in 2000 by the United Nations Environment Programme and the World Health Organization (Air Pollution in the Megacities of Asia, SEI website), and the Clean Air Initiative for Asia for Asian Cities (CAI-Asia), funded by EU with co-funding from a number of organizations (CAI-Asia website). The research program AIRPET (regional air pollution research network) is funded by Sida (Swedish) and coordinated by the Asian Institute of Technology is another example (http://www.serd.ait.ac.th/airpet). The findings of the project indicate high levels of fine particles in the study cities (Kim Oanh et al., 2006).

Regional and Transboundary Air Pollution

The transboundary transport of air pollution is the phenomena that pollutants emitted within a state/country that introduce adverse effects in other states/countries. The regional and transboundary air pollution have been a topic of scientific research for several decades and the importance has been recognized increasingly (UNECE, 2004). For national authorities, transboundary transport poses a severe problem in formulating optimal air quality management strategies. If a large part of

air pollution has the foreign origin then the impact of domestic emission reduction measures would be small. With the advanced monitoring and modeling technology more and more evidences are found that the pollution emitted in one part of the world can create adverse effects in other parts.

The pollutants that have been observed and model predicted with a potential for regional and intercontinental transport include:

- Fine Particles
- Acidifying Substances (SO_2, NO_x)
- Ozone and its Precursors (VOC and NO_x)
- Heavy Metals (mercury)
- Persistent Organic Pollutants or POP

Several of the world's most polluted cities are located in Asia with the notoriously high PM levels. Satellite images show high SO_2 and NO_x concentrations over several locations in East Asia. Modeling simulation shows pollution plumes flowing out from mega cities in Asia and spreading to downwind locations. A number of intensive source regions in Asia emit high SO_2, NO_x, VOC, soot and CO. The monsoon effects in the region enhance the long range transport of air pollution hence the emission from one country/region can affect other downwind countries/regions. Understanding the long range transport will help to formulate the optimal air pollution abatement strategies for a state/country and the region.

Within the Asian continent, the major transboundary air pollution issues of concern, which are discussed here, include: 1) Regional haze from forest fires, 2) Atmospheric/Asian brown cloud (ABC), 3) Regional dust, and 4) Acid rain. In addition, it is noted that the trace elements from coal combustion, particularly Hg, are also of a high potential for long range transport, but more information is required for further discussion.

Regional Haze from Forest Fires

Haze: haze is one of the most basic forms of air pollution when tiny particles (sub-micron range) in the air cause significant visibility reduction because they effectively scatter and absorb sunlight. Haze-causing particles are the fine particles that also cause adverse health effects.

Forest Fire and Haze Crisis in Southeast Asia: Uncontrolled forest fire during the dry season in the Southeast Asia causes smoke haze almost annually. The fires themselves may occur well within the national boundaries of individual country but the effects are felt in other countries. Transboundary haze pollution from forest fires is one of the most severe problems in the ASEAN region.

Fire Episode in 1997-1998: The fire episode that hit the ASEAN region during the El Nino drought of 1997-1998 was particularly severe and most damaging in the recorded history. It started with burning for land clearing and broke into a huge forest fire in Sumatra and Kalimantan, Indonesia. Nearly 10 million hectares of forests were destroyed. The smoke from the fires affected all neighboring countries with Indonesia and Malaysia being the most affected. At the peak of the haze, the particulate matter levels reached unprecedented levels in the region. Late July 1997, the particulate matter levels observed in Sarawak, Malaysia were up to 15 times higher than the normal levels. In Thailand, during the haze episode in late September to early October 1997, PM10 was the major air pollutant observed with maximum 24-hr average was above 200 $\mu g/m^3$. Emergency mitigation measures were taken including closing of schools and kindergartens. It was reported some 70 million people in Southeast Asia was exposed to the poisonous smoke. The haze had been blamed for several deaths in Indonesia, where more than 40,000 people were reported to suffer from respiratory and eyes problems. Due to reduced visibility, traffic accidents occur including an aircraft crashed, tanker collision, sinking of a ferry in the Barito River in the most hit areas. The total costs were estimated at a few billion US$ (*http://www.haze-online.or.id/).*

Fire Episode in August 2005: The most recent fires were recurring in the beginning of August 2005 on the Indonesian island of Sumatra caused serious haze. The haze more seriously affected some areas in Malaysia with the air pollution index reading above the hazardous level (300) and even above the emergency level (500). Visibility in some areas was reported to be <400-500m. A sharp rise in complaints of eye and respiratory ailments was reported. Authorities ordered schools closed as flights were canceled and people stayed indoors to escape the acrid. When smoke hit Southern Thailand the PM10 levels were peaked sharply with hourly levels reached above 200 μg/m^3, the 24h PM10 is also much higher than the normal level but still within the NAAQS of 120 μg/m^3 (Pentamwa and Kim Oanh, 2007).

Asian/Atmospheric Brown Cloud (ABC)

ABC: The Asian/Atmospheric Brown Cloud (ABC) or South Asia haze, hovering over South Asia, has generated interest and concern among scientific community and policy makers. Scientific study of the phenomenon has estimated the brownish cloud to be a 3 km thick blanket of pollution, which is composed of black carbon, organic carbon, sulfates, nitrates, mineral dust and flyash. Anthropogenic sources are estimated to contribute around 75% of this haze. Fossil fuels and biomass burning in the South Asia (India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka and Maldives) and the entire Asia are the main causes for this haze (UNEP and C^4, 2002).

Potential Effects of ABC: This haze is transported far from the source regions hence it is not only a threat for the South Asia but also to the entire Asian continent and beyond. It is reported that the haze is responsible for hundreds of thousands of deaths a year from respiratory diseases. Aside from the health impacts, the haze also reduces the sunlight reaching the earth surface by 10 to 15 percent, altering region's climate, cooling the ground while heating the atmosphere. A reduction in photosynthesis hence agricultural productivity is another potential effect. Erratic weather patterns and flooding in Bangladesh, Nepal and Northeastern India while drought in Pakistan and Northwestern India are some of the serious environmental consequences that have been linked to this ABC.

Acid Rain

Acid Rain: Acid deposition includes both dry and wet deposition. The term 'acid rain' is normally used to address the wet acid deposition though it is sometimes used interchangeably with 'acid deposition'. Rainwater is naturally slightly acidic due to the presence of CO_2 in the air. The "pure" rain's acidity is pH 5.6-5.7. A wide-range of species in the atmosphere such as SO_2, NO_x, ammonia, organic compounds, and wind blown dust, can together lower pH of rain water. Acid rain refers to all types of precipitation that has pH lower than 5.6.

Causes of Acid Rain: Major man-made precursors of acid rain are SO_2 and NO_x gases. These are emitted primarily from fossil fuel combustion in stationary sources and automobile exhausts. These gases may remain in the atmosphere for several days, during which they can travel over large distances, may be well beyond 500-1000 km. In the atmosphere these gases are transformed into acidic compounds by a complex series of chemical reactions, and deposit back to the Earth's surface. The major anion in acid rain water is SO_4^{2-}, which, consequently, dominates the chemistry of acidified water.

Effects of Acid Deposition: Acid deposition is a serious environmental threat. The resulting effects depend on the amount of acid compounds deposited to particular resources and on the sensitivity of the resources to acid deposition. In general, acid rain kills aquatic life, trees, crops and other vegetation, damages buildings and monuments, corrodes metals, reduces soil fertility and can cause toxic metals to leach into underground drinking water sources. In addition, before falling to Earth, SO_2 and NOx gases, and fine matter sulfate and nitrate particles cause visibility reduction and health effects.

Acid Rain in Asia: Acid rain emerged in 1960-1970s in the North America, Canada and Europe. It was one of the first transboundary issues of concern. Nowadays, most industrialized countries have relatively effectively cut SO_2 emissions. But the emissions of NO_x have remained constant or are rising due to the increasing mobile source emission.

Acid rain is now emerging as a major problem in the developing world with the potentially widespread and severe impacts. In Asia and the Pacific region energy use has surged and the use of cheap fuel of sulfur-containing coal and oil increases rapidly. In 1990 the SO_2 emission from Asia was estimated at 34 million metric tons. Fast growth of economics in East Asia would triple the 1990 SO_2 emission level in 2020 if no action is taken beyond current levels of control. Acid deposition levels were reported high in areas such as southeast China, northeast India, Thailand, and the Republic of Korea, which are near or downwind from major urban and industrial centers. Rain with a pH of 4.5 and below has been reported in Chinese cities. The effects in the agriculture sector are reported in India and China. The economical loss due to acid rain could be huge but no figures for Asia are available (Downing et al., 1997).

Counter Measures: Available control strategies for acid deposition and its ecological sequences address both reduction in the SO_x and NO_x emissions, and mitigation of effects on sensitive resources. Use of low-sulfur containing fossil fuels (low S-coal and oil, and natural gas) and low NO_x burners can help to reduce SO_x and NO_x generation during the combustion. Flue gas desulfurization and deNO_x are the post-combustion devices to remove the pollutants from the flue gas. For vehicle emission reduction, low S fuels and NO_x control devices can be applied. Increase energy efficiency from production to the end-use will help to cut down on overall energy demand hence less fuels burned and less emissions.

Emission control technologies may take many years to reduce SO_2 and NO_x emissions to solve problems of acid deposition. Short-term measures, such as liming of acidified surface water bodies, are necessary to save or restore many important resources. Many alkaline materials, such as lime compounds, soda ash, etc., can be used for the purpose. However, the effects of acid deposition are long lasting. If soil is chemically changed it may take many decades for all the linked ecosystems to be recovered.

Asian Dust

Asian Dust: The yellow-sand phenomenon is the dust storm that occurs in East Asia, mainly over arid desert areas of China and Mongolia. This natural origin yellow dust is called “Kosa” in Japan, “Huangsha” in China and “Whangsa” in Korea. It appears as a distinct yellow cloud on satellite images. The highest frequency of occurrence is observed during spring (March-May) when the soil in the arid areas is already thawed out but not yet covered by vegetation. A dust storm occurs when strong winds sweep up large quantities of dust particles and suspend them in the air. Large particles (>10 μm) will settle out near the source within the first day of transport hence cause their greatest impact on the local and neighboring regions. Finer dust particles may be lifted up as high as 1-3 km into the atmosphere. They can residence in the atmosphere for a period of 5-10 days during which they are transported to large distance downwind (Husar and Tratt, 2001; Lin, 2001).

Effects: Dust storms affect not only China, but also have major impacts on areas to the east including Japan, Korea, and the northern Pacific Ocean. The most common pathway of the dust storms is to follow the upper westerly winds and transported eastward to Japan and Korea. Under special conditions, the dust storms can also affect areas to the south including Taiwan, Hong Kong and even the west coast of North America. As the dust storms move over urban centers they pick up particles from industrial pollution. The resulting dust clouds are often so thick they obscure the sun, reduce visibility, slow traffic, and close airports. Dust storms have been reported to cause episodic PM concentrations within and beyond Asia. Downwind countries such as North Korea, South Korea, and Japan regularly report about dust clouds that reduce the solar radiation reaching the Earth surface and cover everything with dust.

Desertification and Dust Storms: Dust storms occur more often during the last 50 years with the highest frequency during the last few years. This is believed to be a result of the severe desertification in China as well as drought and uneven rainfall caused by global climate change. The biggest factor leading to intense dust storms in recent years is inappropriate development which turns the northwest China's once-fruitful agricultural land into useless desert due to overuse of the land for farming/over plowing and grazing. Only by decreasing the damage caused by man and restoring the natural environment will it be possible to improve the problem fundamentally.

Summary and Conclusions: Transboundary Air Pollution – an International Challenge

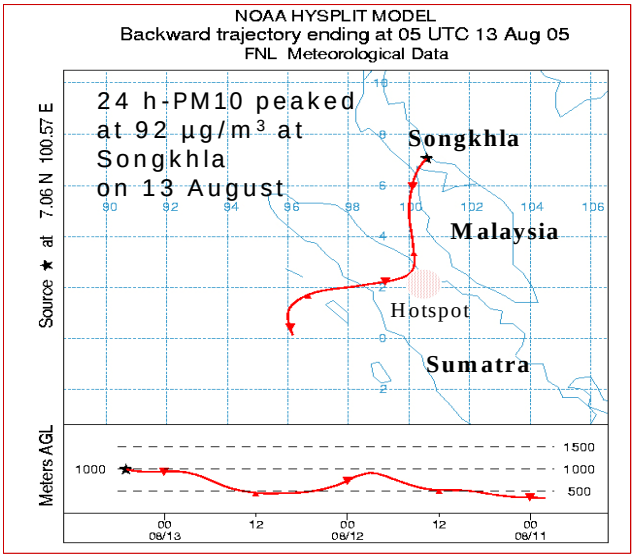
Regional and international cooperation on emissions inventories, ecological research, monitoring and modeling to determine pollutant pathways are important joint efforts to deal with the transboundary air pollution.

Monitoring

Advanced techniques such as satellite, air craft, and harmonized ground monitoring stations networks can detect the transboundary air pollution plumes. Examples of the regional monitoring network are the East Asia Network on Acid Deposition (EANET) run by UNEP, the AIRPET coordinated by AIT.

Modeling

Complicated 3D models such as RAMS or CMAQ may be applied to study the long-range transport of air pollutants. These models however require intensive inputs of the emission and meteorological data, which may not be readily available in Asian developing countries. In many cases, a simple trajectory model may be applied to track the origin of air pollutant plumes or to get the forward trajectory of the plumes. The Hybrid Single-Particle Langrangian Integrated Trajectory model Version 4 (HYSPLIT4) is widely applied for long-range transport studies. This model is available on the NOAA website: http://www.arl.noaa.gov/ready/hysplit4.html and is run with the meteorological data available on line. Example of the HYSPLIT4 result for transboundary smoke from forest fire in Indonesia into Thailand in August 2005 is given in Figure 3 in following page.



Source: Kim Oanh (2006)

Figure 3. Trajectory of Air Mass Arriving at Songkhla, Southern Thailand on the day that PM10 peaked at 92 µg/m^3 as Compared to Normal Levels of 20 µg/m^3

International Cooperation

International cooperation is essential to address the transboundary air pollution problems as it brings states/country together to solve issues that cannot be addressed by each state alone. Examples of the efforts are given below.

Convention on Long-range Transboundary Transport of Air Pollution

The convention was adopted by the United Nations Economic Commission for Europe in 1979. At present it has eight protocols addressing POPs, sulfur emission, NO_x, heavy metals, ground level ozone, and others. It is a successful example of the intergovernmental cooperation to address transboundary transport of air pollution.

ASEAN Agreement on Transboundary Haze Pollution

It was adopted in June 2002 and came into force on 25 November 2003 after Thailand became the sixth state to ratify it. (Six is the minimum number of states needed for the agreement to entry into force). The current state parties are Singapore, Malaysia, Myanmar, Brunei, Vietnam and Thailand. The agreement, resolved, during the dry period, to (i) intensify early warning efforts and surveillance programs, (ii) consider banning open burning in plantation and forest areas, and (iii) have strict enforcement of controlled burning for small-scale farmers and local community, including regulating the timing for burning.

Northeast Asian Long-range Transboundary Air Pollution Initiative

Agreement on joint research on monitoring and modeling long-range transboundary air pollution.

Male Declaration

Inter-governmental agreement on control and prevention and its likely transboundary effects for South Asia, established in 1998.

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Reading 1: ASEAN Agreement on Transboundary Haze Pollution

http://www.haze-online.or.id/

The recurring environmental problem facing Southeast Asia today are the large-scale forest and land fires and associate smoke pollution. Over the last few decades, the deliberate use of fire to clear forests and land, particularly in Indonesia, has led to frequent "haze" pollution episodes in the region, most disastrously in 1997-98. The severe consequences of the fires and haze led the ten member states of the Association of Southeast Asian Nations (ASEAN) to adopt a landmark regional Agreement on Transboundary Haze Pollution ("the Agreement") in June 2002. The objective of this Agreement is to prevent and monitor transboundary haze pollution as a result of land and/or forest fires which should be mitigated, through concerted national efforts and intensified regional and international co- operation. This should be pursued in the overall context of sustainable development and in accordance with the provisions of this Agreement. This Agreement came into force late last year on 25 November 2003 after Thailand became the sixth state to ratify it - six being the minimum number of states needed for entry into force. The current state parties are Singapore, Malaysia, Myanmar, Brunei, Vietnam and Thailand. Very significantly, Indonesia has yet to ratify the Agreement, this poses a particularly thorny problem since the country is the principal source of the haze in the region.

The fact that the Agreement was even adopted is noteworthy in itself, given ASEAN's history of consensual decision-making, abhorrence of challenges to sovereignty and rare resort to treaty adoption. The smoke pall that blanketed the region in 1997-98 and the huge political and financial damages it inflicted changed this attitude to some extent. From an optimist's perspective, the fact that the Agreement was adopted and brought into force relatively swiftly may signal a new willingness among ASEAN member states to deal with issues of transboundary concern in a more formalistic manner, entailing legal rights and obligations for states.

The agreement, resolved, during the dry period, to (i) intensify early warning efforts and surveillance programs, (ii) consider banning open burning in plantation and forest areas, and (iii) have strict enforcement of controlled burning for small-scale farmers and local community, including regulating the timing for burning.

According to the agreement, the ASEAN parties have various activities such as timely and more accurate weather forecasts and early warning measures, strict enforcement of existing laws and enactment of new laws to regulate open burning, training of prosecution and law enforcement officers, dialogue sessions with traditional communities, NGOs, plantation companies and other stakeholders, development of preventive tools such as GIS database, fire danger rating systems and practical guidelines for implementing zero burning and controlled burning policy, information management through the *ASEAN Haze Action On- line* website: *http://www.haze-online.or.id/*, development of fire suppression mobilization plans for the region's fire-prone areas, and a pilot project to develop community-based model and approaches in fire management.

Climate Change – Regional and International Issues, and Perspectives

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ABSTRACT *Climate change is a global and long-term problem. Impacts of climate change through increased climate variability are probably now starting to affect communities across the world. The main cause of anthropogenic climate change is the increase in concentration of greenhouse gases (GHGs), essentially carbon dioxide, in the atmosphere. Asia, as a region, has the biggest share in GHG emission in the world. China and India rank as the second and fifth largest GHG emitting countries in the world. Mitigation of GHG emissions by moving to cleaner energy resources and conserving energy through better technology is the logical strategy to reduce GHG concentrations in the atmosphere. There are number of tools available for climate change/environmental management. This module is aimed at providing an overview of climate change issues and means to address the issues through the application of various tools available for management of climate change/environment.*

Introduction

Climate change is a global and long-term problem involving complex interactions between climatic, environmental, economic, political, institutional, social and technological processes (IPCC, 2001).

The basic cause of climate change is an increase in the atmospheric concentration of greenhouse gases (GHGs), of which carbon dioxide is the most prominent. Carbon dioxide concentrations in the atmosphere have risen from pre-industrial era levels of 280 parts per million (ppm) to 368 ppm by 2000. Figures from the first few years of this millennium indicate a continuing increase, and projections indicate a range of 540 to 970 ppm by 2021 (Pachauri, 2005). Increasing concentrations of GHGs in the atmosphere will result in greater warming of the Earth.

Asia is the most populated and the largest GHG emitting region in the world. Table 1 shows sectoral shares in total CO_2 emission in 2002 and average annual growth rate (AAGR) of CO_2 during 1990-2002 from fuel combustion in selected Asian countries. Energy related CO_2 emission in Asia was growing at an average annual rate of 3.8% during 1990-2002 as compared to 1.1% in OECD countries as a whole and 1.3% in the world.

Table 1. Sectoral Shares in Total CO_2 Emission in 2002 and Average Annual Growth Rate (AAGR) of CO_2 during 1990-2002 from Fuel Combustion in Selected Asian Countries

Country/ Region	Sectoral Shares in Total CO_2 Emission in Year 2002, %						Total CO_2 Emission in 2002, Mt	AAGR of CO_2 Emission during 1990-2002, %
	Public Electricity and Heat Production	Manufacturing Industries and Construction	Transport	Other Sectors	Un-allocated Auto-producers	Other Energy Industries		
Bangladesh	35.9	32.4	12.1	19.4	0.0	0.6	31.5	7.7
India	49.7	23.2	9.2	10.1	4.7	3.1	1016.5	4.6
Nepal	0.0	23.1	30.8	46.2	0.0	0.0	2.6	10.5
Pakistan	33.3	28.1	25.1	12.0	0.0	1.6	100.5	4.6
Sri Lanka	26.8	10.7	50.0	10.7	0.0	0.9	11.2	10.3
Total (Asia)	**40.4**	**25.4**	**13.3**	**12.6**	**3.6**	**4.6**	**7206.3**	**3.8**
OECD	**35.4**	**14.6**	**27.2**	**14.4**	**3.1**	**5.3**	**12554.0**	**1.1**
World	**35.3**	**17.9**	**24.0**	**13.5**	**3.9**	**5.3**	**24101.8**	**1.3**

Source: IEA (2004)

The growth rate of GHG emission in developing countries is significantly higher than that in industrialized countries due to rapid growth of the economies and associated energy demand (especially fossil fuels). It has been projected that developing countries as a group will overtake OECD countries in terms of GHG emission within the next two decades.

Climate change presents the world with an immense challenge in terms of its impacts such as droughts, frequent and intense flood, deforestation, loss of sensitive species, etc. In fact, impacts of climate change through increased climate variability are probably starting to affect communities across the world. Socio-economic impacts of these climatic variations will be suffered most by those communities that are already weak and poor and unable to cope with these shocks.

"Mitigation" of emissions and "Adaptation" to climate change are the two necessary strategies in dealing with the threat of climate change. One strategy deals with tackling the source of the problem and the other deals with building resilience to survive in spite of the problem. Both of these strategies, while complimenting each other, have different implementation approaches.

Mitigation of GHG emissions to reduce the level of GHGs in the atmosphere is the best strategy to start dealing with climate change. Mitigation of GHG emissions can be achieved by switching to cleaner energy resources and conserving energy through better technology.

Box 1. Current Evidence of Climate Change

Extra-strength Weather

- More frequent and powerful cyclones and hurricanes, more frequent and intense floods and droughts. A recent increase in "extreme weather events" is an indication that climate change already has begun.
- In Africa's large catchment basins of Niger, Lake Chad, and Senegal, total available water has decreased by 40 to 60 per cent, and desertification has been worsened by lower average annual rainfall, runoff, and soil moisture.
- The Rhine floods of 1996 and 1997, the Chinese floods of 1998, the East European floods of 1998 and 2002, the Mozambique and European floods of 2000, and the monsoon-based flooding of 2004 in Bangladesh (which left 60 per cent of the country under water).

The Decline of Winter

- Arctic air temperatures increased by about 5oC during the 20th century -- ten times faster than the global-mean surface temperature.
- Snow cover has declined by some 10 per cent in the mid- and high latitudes of the Northern Hemisphere since the late 1960s. The annual duration of lake and river ice cover apparently shortened by about two weeks during the 20th century.
- Almost all mountain glaciers in non-polar regions retreated during the 20th century. The overall volume of glaciers in Switzerland decreased by two-thirds.

Shifts in the Natural World

- Scientists have observed climate-induced changes in at least 420 physical processes and biological species or communities.
- In the Alps, some plant species have been migrating upward by one to four meters per decade, and some plants previously found only on mountaintops have disappeared.
- In Europe, mating and egg-laying of some bird species has occurred earlier in the season.
- Across Europe, the growing season in controlled, mixed-species gardens lengthened by 10.8 days from 1959 to 1993. Butterflies, dragonflies, moths, beetles, and other insects are now living at higher latitudes and altitudes, where previously it was too cold to survive.

Source: http://unfccc.int/essential_background/feeling_the_heat/items/2904.php

GHG emission reduction and propagation of cleaner renewable energy has huge economic and social benefits as well. Improved environmental conditions, better health, employment

opportunities, gender empowerment, alternative livelihoods are some of the wider socio-economic benefits which will help towards sustainable development of Asia.

The objectives of this paper is to provide an overview of climate change issues and means to address these issues and present the tools available for climate change/environmental management. Box 1 presents some current evidence of climate change.

Climate Change Issues and Perspectives

A number of climate change related issues are being pursued in the regional and international level. Some of the major issues are as follows:

- Greenhouse gas (GHG) mitigation and abatement issues as well as issues related to vulnerability of climate change;
- Strategy formulation, technology assessment and promotion activities on issues related to climate change;
- Climate change policy dialogues, information dissemination and awareness raising;
- Facilitation of renewable energy development and energy efficiency by removing barriers and reducing implementation costs;
- Clean Development Mechanism (CDM) activities with emphasis on renewable energy and energy efficiency, carbon sequestration, and adaptation; and
- Capacity building and development on generic climate change issues, greenhouse gas inventory, CDM and renewable energy.

In response to the challenges posed by climate change, a wide range of studies in Asia have been conducted and are currently being carried out by different research institutes and organizations. Some of the major regional studies on climate change are:

- Asian Regional Research Programme in Energy, Environment and Climate (ARRPEEC)
- Asia Least Cost Greenhouse Gas Abatement Strategy (ALGAS)
- Climate Change in Asia: Regional Study on Global Environmental Issues and US Country Studies Programme (USCSP).
- Activities Implemented Jointly (AIJ) and Joint Implementation (JI) programmes of various parties to the UNFCCC conducted in various Asian countries
- Asian Scientific Capacity Building and Enhancement for Sustainable Development in Developing Countries (known as CAPaBLE)
- Global Environment Facility (GEF) Climate Change Programme
- USAID Global Climate Change Programme
- Renewable Energy, Energy Efficiency, and Climate Change (REACH) of Asian Development Bank (ADB)
- United Nations agencies climate change programmes (e.g. UNITAR, UNESCAP, UNEP).

The Asian Regional Research Programme in Energy, Environment and Climate (ARRPEEC) was launched by Swedish International Development Cooperation Agency (Sida) and Asian Institute of Technology (AIT) in 1995, to enhance capacity and preparedness of the Asian developing countries regarding identification and assessment of national green house gas mitigation options. ARRPEEC involved the partnership and co-operation of 22 institutions from China, India, Indonesia, Philippines, Sri Lanka, Thailand and Vietnam. The programme focused on power/electricity; large, medium and small scale energy intensive industries; and transport, which were the major sectors contributing to greenhouse gas emissions; and biomass sector in these Asian countries (ARRPEEC, 2005; ARRPEEC, 2002; ARRPEEC 2000).

Tools for Climate Change

Overview of the Tools

A number of tools are available for climate change/environmental management. The tools can be categorized as those available for analyzing and modeling of energy-environment systems, evaluating/estimating GHG emissions, and carbon accounting. At the early stages, most of the tools were developed for the comparative assessment of environmental effects of energy. The development of these tools has become increasingly relevant since the ratification of Kyoto and the development of national, and other relevant GHG emissions trading schemes both within and outside of the Kyoto framework.

Description of the Tools

This section discusses some of the tools available for analyzing and modeling of energy-environment systems, evaluating/estimating GHG emissions, and carbon accounting.

Energy and GHG Analysis Tools: These tools are generally aimed at analyzing and modeling energy-environment systems. The tools provide technology characterization, material, transportation and GHG emission databases. Scenario and policy analysis related to energy cost and GHG emission reduction could be developed by using these tools.

a) Global Emission Model for Integrated Systems (GEMIS)

GEMIS is a life-cycle analysis program and database for energy, material, and transport systems. GEMIS was developed in 1987-1989 as a tool for the comparative assessment of environmental effects of energy by Öko-Institut and Gesamthochschule Kassel (GhK). Since then, the model was continuously upgraded and updated. Since version 3.0 (1996), GEMIS is freely available as public domain software (GEMIS, 2005). The GEMIS database offers information on:

- fossil fuels (hard coal, lignite, natural gas, oil), renewables, nuclear, biomass (residuals, and wood from short-rotation forestry, miscanthus, rape oil etc) and hydrogen (including fuel composition, and upstream data)
- processes for electricity and heat (various powerplants, cogenerators, fuel cells, etc.)
- materials: raw and base materials, and especially those for construction, and auxiliaries (including upstream processes)
- transports: airplanes, bicycles, buses, cars, pipelines, ships, trains, trucks (for diesel, gasoline, electricity, and biofuels).

GEMIS includes the total life-cycle in its calculation of impacts - i.e. fuel delivery, materials used for construction, waste treatment, and transports/auxiliaries. The GEMIS database covers for each process:

- efficiency, power, capacity factor, lifetime
- direct air pollutants (SO_2, NOx, halogens, particulates, CO, NMVOC)
- greenhouse-gas emissions (CO_2, CH_4, N_2O, SF_6, all other Kyoto gases)
- solid wastes (ashes, overburden, FGD residuals, process wastes)
- liquid pollutants (AOX, BOD5, COD, N, P, inorganic salts)
- land use.

GEMIS can also analyze costs - the respective data are implemented for fuels and energy systems.

b) LEAP - Long-range Energy Alternatives Planning Software

The LEAP software system is a scenario-based energy-environment modeling tool. Its scenarios are based on comprehensive accounting of how energy is consumed, converted and produced in a given region or economy under a range of alternative assumptions on population, economic

development, technology, price and so on. With its flexible data structures, LEAP allows for analysis as rich in technological specification and end-use detail as the user chooses.

With LEAP, the user can go beyond simple accounting to build sophisticated simulations and data structures. Important advantages of LEAP are its flexibility and ease-of-use, which allow decision makers to move rapidly from policy ideas to policy analysis without having to resort to using more complex models.

At the heart of LEAP is the process of scenario analysis. Scenarios are self-consistent storylines of how an energy system might evolve over time in a particular socio-economic setting and under a particular set of policy conditions. Using LEAP, scenarios can be built and then compared to assess their energy requirements, social costs and benefits and environmental impacts (LEAP, 2005).

c) RETScreen - Renewable Energy Technology Project Analysis

The Government of Canada's RETScreen International Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The Software, provided free-of-charge, can be used world-wide to evaluate the energy production, life-cycle costs and greenhouse gas emissions reductions for various types of energy efficient and renewable energy technologies (RETs). The software also includes product, cost and weather databases; and a detailed online user manual (RETSCREEN, 2005). RETScreen Software consists of the following models:

- Wind Energy Project Analysis Model
- Small Hydro Project Analysis Model
- Photovoltaic Project Analysis Model
- Combined Heat & Power (CHP) Project Analysis Model
- Biomass Heating Project Analysis Model
- Solar Air Heating Project Analysis Model
- Solar Water Heating Project Analysis Model
- Solar Passive Heating Project Analysis Model
- Ground-Source Heat Pump Project Analysis Model

Case studies using RETscreen software are given in Annex A.

d) FAIR 2.0: (Climate, Emissions Allocation, Costs MODEL)

FAIR evaluates the Kyoto Protocol in terms of environmental effectiveness and economic costs. The FAIR model consists of three linked models (FAIR, 2005):

- A climate model: to calculate the climate impacts of global emission profiles and to determine the global emission reduction objective, based on the difference between the global baseline emissions scenario and emission profile.
- An emissions allocation model: to calculate the regional emission targets for different climate regimes for future commitments within the context of this global reduction objective.
- A costs model: to calculate the abatement costs for each region using these emissions targets of the regimes and to distribute the global emission reduction objective over the different regions, gases and sectors following a least-cost approach, making use of the flexible Kyoto mechanisms.

e) WARM - Waste Reduction Model

United States Environment Protection Agency (USEPA) created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions from several different waste management practices. WARM is available both as a Web-based calculator and as a Microsoft Excel spreadsheet.

WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model

calculates emissions in metric tons of carbon equivalent (MTCE), metric tons of carbon dioxide equivalent (MTCO2E), and energy units (million BTU) across a wide range of material types commonly found in municipal solid waste (MSW). WARM recognizes 30 material types, their emission factors are available for viewing (WARM, 2005).

f) CCP - The Cities for Climate Protection Software

The Cities for Climate Protection Campaign Greenhouse Gas Emission Software is targeted for use by local governments. This Windows-based tool can analyze emissions and emissions reductions on a community-wide basis and for municipal operations alone.

The community-wide module looks at residential, commercial, and industrial buildings, transportation activity, and community-generated waste. The municipal operation module looks at municipal buildings, fleets, and waste from in-house operations. In addition to computing greenhouse gas emissions, the CCP software estimates reductions in criteria air pollutants, changes in energy consumption, and financial costs and savings associated with energy use reductions.

The software supports quantification of emissions reductions from waste reduction, source reduction, energy savings, and fuel switching. Users can employ the preformatted charts and reports to develop cost-effective action plans to monitor progress on reducing emissions (CCP, 2005).

Corporate GHG Inventory Tools: These tools advice companies to calculate their GHG emissions from various sources, analyse and improve environmental performance, on how to draw up good sustainability report, implement measures designed to reduce costs of production, and harmonizing GHG accounting and reporting according to international standards.

a) The GHG Indicator

"The GHG Indicator: UNEP Guidelines for Calculating Greenhouse Gas Emissions for Businesses and Non-Commercial Organizations" can help organizations in estimating and reporting their GHG emissions, and so stimulate action on climate change.

The Guidelines provide a method for converting information on fuel and energy use readily obtainable by companies to estimated GHG emissions. The Guidelines provide a step-by-step approach based on easy to use worksheets. The Indicator can be applied at different levels of a company regardless of size or location, as well as government agencies, NGOs, and other entities interested in estimating their GHG emissions.

The Guidelines were developed with experts in manufacturing companies, accountants, academics, consultants, environmentalists, financial institutions, government agencies and non-governmental organizations.

GHG Indicator Software version aids data entry and calculation, and is fully compatible with the original version of the indicator. Extensive help menus make the workbook easy to use and present results (UNEP, 2005).

b) The GHG Protocol Initiative

The Greenhouse Gas Protocol Initiative aims at harmonizing GHG accounting and reporting standards internationally to ensure that different trading schemes and other climate related initiatives adopt consistent approaches to GHG accounting.

The GHG Protocol is a broad international coalition of businesses, non-governmental organizations (NGOs), government and inter-governmental organizations. It operates under the umbrella of the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI), and brings together leading experts on greenhouse gas emissions to develop internationally accepted accounting and reporting standards. The participants are working in partnership to design, disseminate and promote the use of globally applicable accounting and reporting standards for GHG emissions.

The GHG Protocol Initiative consists of two modules:

- The Corporate GHG Accounting and Reporting Standard (Corporate Module) which helps companies and other organizations to identify, calculate, and report GHG emissions. The

corporate accounting and reporting standard builds on the experience and knowledge of over 350 leading experts drawn from businesses, NGOs, governments and accounting associations. It has been road tested by over 30 companies in nine countries.

- The Project GHG Accounting and Reporting Standard (Project Module) which aims at developing accounting and reporting standards and/or general guidance for both emission reduction and land use, land-use change and forestry (LULUCF) projects.
- The GHG Protocol also provides practical tools with additional guidance to help companies calculate their GHG emissions from various sources (GHG Protocol, 2005).

c) The Internal Network for Environmental Management (INEM) Sustainability Reporting Guide: A Manual on Practical and Convincing Communication for Future-Oriented Companies

The guide gives advice on how to draw up a good sustainability report. Focusing on the economic interests of companies as well as on reliable and convincing communication, it informs about target groups and their interests in information, outlines the principles of reporting, lists the elements of the sustainability report and gives numerous practical examples for the presentation of company performance and the design of sustainability reports. Further on, it highlights the problem of the credibility of the sustainability report and shows possible ways to sustainable management.

The INEM guide is based on the Sustainability Reporting Guideline of the Global Reporting Initiative, which focuses heavily on indicators. In addition to this, The INEM Sustainability Reporting Guide incorporates the economic interests of the company and focuses on good communication to and with stakeholders (INEM, 2005).

A case study on the use of INEM sustainability reporting guide is given in Annex B.

d) Ecomapping

This visual, simple and practical tool helps small and medium enterprises (SME) managers and employees analyse and manage the environmental performance of small companies and craft industries. The focus of Ecomapping is on improving environmental performance and introducing the basic notion of plan-do-check-act (PDCA). The work process makes SMEs define corrective actions and reduction objectives and the underlying methods leads to verifiable and quantifiable results. The tool can be used as an initial stepping stone to start and support the implementation of EMAS or ISO 14001 (Ecomapping, 2005).

e) Pilot Programme for the Promotion of Environmental Management in the Private Sector of Developing Countries (P3U)

This is a regional pilot programme which promotes institutional and personal apacities in order to reduce environmental impact caused by the industrial sector in developing countries. The programme is implemented by GTZ - German Technical Cooperation (P3U, 2005).
The target group of the project is technical experts and executive personnel in businesses in developing countries.

Profitable Environmental Management - PREMA - is a programme developed for micro, small and medium-sized companies. It aims at practically implementing measures designed to substantially reduce costs of production, improve their environmental performance, and enhance their organisational capabilities.

The PREMA programme consists of several instruments to introduce profitable environmental management in companies, i.e.

(i) Training Module on Resource Management for SMEs

The Training Module Business Resource Management for SMEs in Developing Countries is based on the method and system of the CEFE-methodology (Competency-based Economics through Formation of Enterprise, CEFE), which has been successfully applied in the promotion of small trade and SMEs. It is oriented towards the practical needs of SME entrepreneurs. The module can equally be used for training measures in the areas ‘Environmental and Resource Management’ and

'Promotion of the Economy'. It is available as an additional training unit within the framework of CEFE-training for SMEs.

The everyday realities of an enterprise, which are depicted by the module, concern the areas of natural resources and primary products, the production process itself, the waste problem as well as marketing, quality, and ecological management. The participants take up an active role in the learning process; they acquire the necessary basic know-how of resource management and its transfer into the everyday reality of a business in group-dynamic competition as well as in role plays and practical exercises.

(ii) Good Housekeeping Guide (GHK)

The Good Housekeeping Guide is designed to assist small and medium-sized enterprises in identifying - independently or with little external support - obviously inefficient and ecologically harmful use of resources in their own business. Mostly, simple measures which do not require substantial investments and which help to cut costs within a relatively short period of time are sufficient in order to avoid environmental damage.

The instrument is to interest as many SMEs as possible in taking up Profitable Environmental Management because there are no prerequisites and because it facilitates a positive result within a relatively short period of time and without much expenditure. In addition, GHK offers an introduction to further activities in the framework of Environmental Management.

(iii) Environment-oriented Cost Management

This method is based on studies of Environmental Management in Germany. These studies particularly examine the costs of non-product output (NPO), i.e. those substances which do not form part of the finished product. It includes waste water and waste heat, energy, as well as waste and spoilage. In a typical enterprise in Germany, and certainly also in the developing countries, the NPO comes to 30-50% of the entire output. The objective of Environmental Management is to reduce the amount of non-product output as much as possible with the help of measures directly integrated into the production process and, by doing this, to cut production costs and diminish the environmental damage.

The implementation of Environment-oriented Cost Management begins with an analysis of the most important resource and energy flows by an in-plant EoCM-team and external consultants and the recording of the total costs caused by the non-product output.

f) CAMSAT - Carbon Management Self Assessment Tool

Climate Change is not only the greatest environmental threat of the 21st century; it is a major challenge for business. Policies designed to limit greenhouse gas emissions coupled with demands from investors and customers for real evidence of environmental responsibility require managed responses. The purpose of this tool is to help businesses to assess the quality of Carbon Management – and the ability to respond effectively to these challenges.

CAMSAT comprises 23 multiple-choice questions in 5 sections, covering the major aspects of carbon management (Assessment and Monitoring of GHG Emissions; Emission Reducing Activities; Carbon Offset Strategies; Communication and Reporting; and Assessment of Carbon Risks and Opportunities). The results of the test will give an overall score and identify areas that may require further attention. The exercise should take only 30 minutes to complete.

All companies with an interest in maintaining or strengthening their environmental reputation and/or those whose business that may be affected by policies intended to address climate change can use this tool (CAMSAT, 2005).

Forest, Land Use Tools: These tools are mainly aimed at carbon accounting in the wood products and forests.

(i) TimberCAM

TimberCAM is a carbon accounting model that tracks the fate of carbon stored in wood products through their life cycle from harvest through to manufacture, service and disposal. TimberCAM accounts for the carbon stored not only in the product itself but also in the residues created in all stages of the life cycle of the product. TimberCAM incorporates the carbon stored in products in service and in landfill, as well as the carbon that is not emitted into the atmosphere by using redundant products or residues instead of fossil fuels.
The focus of the model is primarily on carbon stored in wood products; as such it does not take into consideration the emissions associated with harvesting of trees and processing of the timber. The software is provided free for non-commercial use as stipulated in the user agreement (Timbercam, 2005).

(ii) CAMFor

CAMFor is a carbon accounting model for forests, developed by the Australian Greenhouse Office (AGO). It has been created to perform carbon accounting both at stand (or project) level and at estate (or landscape) scale.

The carbon pools of concern within CAMFor are: aboveground and belowground biomass; soil carbon; forest-floor debris, and wood products, as well as other concerns (Camfor, 2005).

(iii) CO2FIX

CO2FIX is a tool, which quantifies the carbon stocks and fluxes in the forest (whole tree), soil organic matter compartment and the resulting wood products. It was originally designed for even aged monospecies stands in the Netherlands, but has also been used for a wide variety of (mostly even aged) forest types from all over the world, including some selective logging systems. The software is available free of charge (CO2FIX, 2005).

Conclusion

Climate change is a regional and a global problem, principally caused by the use of fossil fuels. Two actions need to be undertaken – mitigation and adaptation. Mitigating green house gas emission can be through a number of ways – clean energy use, efficient energy use, etc. Global warming does not recognize national boundaries, and its implications are felt at locations/regions, which were not the cause of green house emissions.

This document has summarized an overview of the various initiatives that have been carried out to mitigate green house gas emissions. Furthermore, details of the various tools available to carry out studies on emissions estimation, scenario analysis, etc. Case studies describing the applications of some of the tools are also given.

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Related Web Sites

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UNFCCC: www.unfccc.int
CDM: cdm.unfccc.int
UNEP: http://climatechange.unep.net/
PEW Center: www.pewclimate.org

Case Studies on the Use of RET Screen

1. Project Title: Wind Energy Project, Grid-connected Windfarm/ Andhra Pradesh, India[1]

Results

The 20-MW Kadavakallu Windfarm in Andhra Pradesh, India was constructed by RCI Power (an Independent Power Producer) with the help of the Non-Conventional Energy Development Corporation of Andhra Pradesh Ltd (NEDCAP). It was completed in 2001 and is the largest windfarm at Kadavakallu in the Ananthapur region of Andhra Pradesh. The windfarm has benefited from the Andhra Pradesh government's favourable policies for wind power development, particularly the wind estate scheme of NEDCAP. The windfarm sells power to the Andhra Pradesh Transmission Company (AP Transco) at a remunerative power purchase price that will be escalated by 5% every year. Debt financing for the project was made available by the Indian Renewable Energy Development Agency (IREDA).

RCI Power maintains staff on location at Kadavakallu and at the nearby town of Thadpatri to provide operation and maintenance services to ensure high levels of turbine availability (95% so far).

System Description

The windfarm consists of 80 LW30/250 wind turbines of 250 kW capacity manufactured by Lagerwey Windturbine BV of the Netherlands. The nacelle assemblies of the two-bladed machines are mounted on 36-m high lattice towers. The windfarm is spread over a length of 20 km over the Kadavakallu ridge in the north-south direction. Power from the windfarm is delivered to the AP Transco central grid. Since the windfarm is located in a relatively remote location, the operator has developed wireless SCADA control systems that are used to optimize operations and maintenance scheduling at the windfarm.

Lessons Learned

- The project was built at a location with a reasonably good wind resource and good financial and fiscal incentives for windfarm development. This enhances the project's financial viability.
- A large number of turbines, concentrated at one windfarm site, allows for favourable economies of scale in regard to planning, development, construction, operation and maintenance costs.
- The project breaks even shortly after the repayment of its debt and continues to generate profits over the remainder of its life. A longer debt term would lead to an even earlier break-even.

The Big Picture

Wind power development in India totaled over 1,500 MW of capacity at the end of 2001 and illustrates that large windfarms can also be implemented successfully in non industrialised regions. Some of the factors which have contributed to the success of wind energy in India are the favourable policies promoted by the Ministry of Non-Conventional Energy Sources, the policy support of several Indian states, the strength of the Indian wind energy industry and the facilitating role of financiers such as the Indian Renewable Energy Development Agency in financing windfarms.

[1]Source: http://www.retscreen.net/ang/pop_cas.php?idModele=1&h=1

2. Project Title: Solar Water Heating Project Single Family Home/British Columbia, Canada[2]

Results

In the summer of 1997, a solar domestic water heating system was installed in the Kadulski residence, located in North Vancouver, British Columbia, Canada. At the same time, this turn-of-the century home underwent a major renovation aimed at improving its energy efficiency; super insulation and high efficiency heating were installed. The 2-storey, 185 m2 home has 3 occupants.

System Description

The system works by circulating water through the solar collectors whenever the controller indicates there is useful energy to be gained. The heated water from the solar collectors is stored in a standard 150-litre water tank. The differential temperature solar controller operates a high-head circulating pump. The pump feeds and returns to a 20-litre drainback reservoir tank. When the pump shuts off, the water in the solar collectors drains back into the reservoir tank to ensure that the system is protected from freezing.

Three 2.2 m2 (0.9 m by 2.4 m) glazed flat plate collectors are mounted on wood sleepers fastened to the rafters below the roof. Copper piping (13 mm in diameter) with foam insulation is used to ensure adequate flow. To save space, a 150-litre storage tank (a standard 40 U.S. gallon electric water tank) was used. A small shell-in-tube side-arm heat exchanger transfers heat by natural convection from the solar loop to the solar storage tank.

Solar energy now provides 2 MWh (7.2 Gigajoules) of energy, about half of the hot water for the home, and avoids 0.5 tonne per year of greenhouse gas emissions.

Lessons Learned

Some clients may prefer to buy used solar collectors and significantly reduce the cost of the system.

- Electric water heater tanks are typically the most economical form of solar storage tank for solar domestic hot water (SDHW) applications.

The Big Picture

Domestic hot water, used for such things as laundry, showers, and dishes, can account for up to 20% of a home's energy use. Next to space heating, it is the home's largest energy requirement. Most hot water heaters in Canada currently use natural gas or electricity. Heating with solar energy is an excellent way to reduce pollution; a system avoids up to 2 tonnes a year of greenhouse gas emissions.

A SDHW system can be a straightforward retrofit to most homes, and can typically provide over 50% of the annual hot water needs. With a projected life of 20 to 40 years, most SDHW systems pay for themselves in 15 to 30 years, while they reduce dependence on non-renewable resources.

Homes off-grid or those using propane or electricity for water heating offer the best economic opportunity for SDHW.

[2] Source: http://www.retscreen.net/ang/pop_cas.php?idModele=4&h=1

Case Study on the Use of INEM Sustainability Reporting Guide

Example in Small and Medium-sized Enterprises[3]

Project Title: *Cleaner Production in an Indian Paper Mill*
Company: Raval Paper Mills
Sector: Pulp and Paper
Number of employees: 300
Country: India

Country Overview

The Indian economy has been conventionally agricultural, but over the years the share of agriculture has declined from 56 per cent in 1950-51, to 32 per cent in 1990-91. During the same period, the share of industry has increased from 15 per cent to 28 per cent, and that of services has increased from 29 per cent to 40 per cent. In the last three years, the economy has been growing at a rate of eight to 10 per cent per year, following the globalisation and liberalisation programmes launched by the Indian government a few years back.

Sector Overview

Dating back more than a century, the paper industry is one of India's oldest industries. Production, at 19,000 tonnes per year, was moderate at the beginning of the 20th century. By 1993 Indian paper production had risen to 2.4 million tonnes per year, as a result of the increasing emphasis on literacy. Demand for paper is likely to increase at a much faster rate in the future. Paper consumption in India was 2.8 million tonnes in 1993-94, and it is expected to reach 4.2 million tonnes by the turn of century, and 6.9 million tonnes by 2010. There are about 350 paper mills in the country, of which only 10 per cent are forest-based. The remaining mills are agricultural residue- or waste paper-based. Over the last two decades there has been a decline in the use of forest-based raw materials, from 84 per cent in the 1970s, to 43 per cent in the 1990s. The use of agricultural residues has increased from 10 per cent to 32 per cent during the same period, and is projected to rise to 60 per cent by 2010.

The pulp and paper industry has been recognised as one of the most highly polluting industrial sectors in the country. Agricultural residue-based mills are of particular concern, due to their relatively small size, with an output of 10 to 40 tonnes per day, their technology constraints, and their larger specific pollution load. Environmental management is particularly necessary in this sector.

Company Description

Raval Paper Mills is a 300-employee enterprise, located in Rae Bareilly, a small semi-industrialised town in Uttar Pradesh, about 500 kilometres southeast of New Delhi. Raval is an agricultural residue-based paper mill. It is privately owned. Depending on the season, various combinations of wheat straw, rice straw and waste paper are fed as raw material. The operating capacity of the plant is 25 tonnes per day. 10 tonnes of the daily output are unbleached semi-kraft paper, which is used

[3]Source: http://www.inem.org/htdocs/case_studies/raval.html

by the packaging industry, and 15 tonnes are bleached and dyed writing paper. Raval sells its products to the government and the packaging and printing industries.

Driving Forces

The main reasons for the company to adopt cleaner production techniques and technologies were:

- shortage of water especially in the summer, leading to poor capacity utilisation. During this period the company normally produced 15 tonnes per day, 65 per cent of operational capacity;
- pressure from State Pollution Control Board (Regulatory Authority);
- pressure from local bodies and environmental NGOs, and;
- the opportunity of participating in a demonstration project on waste minimisation (project DESIRE, Demonstration in Small Industries for Reducing wastes).

Raval's main aims in implementing cleaner production were to:

- reduce water consumption to enable operation at full capacity even during the summer;
- reduce waste water treatment costs;
- reduce raw material costs and thus be more competitive in the market, and;
- meet effluent discharge standards.

Problem Definition

The major environmental issues and problems faced by the company were:

- high process water consumption, ($176m^3$ per tonne compared to the recommended level of $120m^3$ per tonne of paper), and high waste water generation;
- high costs related to raw materials, chemicals and energy consumption, adding up to US$ 237 per tonne of paper, thus eroding the profitability of the company;
- high environmental pollution load, particularly the water pollution load which was:
  0.20 tonnes of biological oxygen demand (BOD) per tonne of paper;
  0.99 tonnes of chemical oxygen demand (COD) per tonne of paper;
  0.34 tonnes total suspended solids (TSS) per tonne of paper, and;
  1.21 tonnes total solids (TS) per tonne of paper.

Implementation

Under the project DESIRE, a Cleaner Production Demonstration Project was launched in the company. The waste minimisation assessment methodology developed by the National Productivity Council (NPC) was used. A waste minimisation team comprising mill employees and NPC consultants was formed. This team was assisted by an expert from the United Nations Industrial Development Organization (UNIDO). The process steps were identified, a material and energy balance was prepared, and the causes of waste generation were determined to enable the team to develop waste minimisation solutions. Towards the end of the project period, 64 waste minimisation measures were identified. Of these, 29 measures which were directly implementable were taken up straightaway.

Another 22 measures required further technical feasibility and economic viability analyses. Their environmental aspects also were analysed. The measures were then prioritised and an implementation plan was drawn up. Towards the end of the project, the company had already implemented 31 measures, and another 20 were being implemented or planned for implementation in the future. 13 measures were rejected because of low expected economic gains and/or poor technical viability.

External support was provided to the company in the form of:

- measurement and monitoring facilities for preparing the material and energy balance, waste stream characterisation, quantification and assessment of pollution load, the required facilities and expertise were provided by NPC, and;
- expert advisory assistance for identifying cleaner production measures and training of company staff provided by UNIDO and NPC.
- The main problems experienced by the company in implementing cleaner production were:
- lack of company-level technical expertise;
- high turnover of employees which limited the ability of the enterprise to work on cleaner production measures which require greater involvement of the employees;
- limited decision-making powers of employees, which meant that the middle-managers had little say in the decision-making process and, consequently, it took longer to implement the cleaner production measures;
- inappropriate pricing of natural resources;
- continued emphasis on end-of-pipe pollution control on the regulatory and policy level, and;
- during the project period, the plant was undergoing a financial crisis, and had serious constraints on financing.

Partnerships

The project was successful because of the partnership of various organisations. The main partners in the project were:

- concerned industry: Raval Paper Mills;
- industry association: Agricultural Residue-based Pulp and Paper Industry Association;
- professional organisation: NPC;
- international support organisation: UNIDO;
- governmental organisation: Indian Ministry of Environment and Forests, and;
- research institute: Central Pulp and Paper Research Institute.

The project team consisted of the Managing Director (overall coordinator), Works Manager (team leader), Project Manager, Pulp Mill Incharge, Maintenance Incharge, Laboratory Analyst, and an operator. Shopfloor personnel were involved from time to time. Being a small industry in a rural location, communication was mainly informal on a person-to-person basis. The company and external support organisations held regular meetings to monitor progress. Interim reports were prepared mainly by the external support organisations to keep track of developments. Towards the end of the project, an overall report was prepared by the experts and submitted to the management, to enable Raval to incorporate the project into its managerial procedures and take the project further on its own.

Results

Production Capacity

The overall production capacity of the plant has risen by about two tonnes per day (eight per cent). This was made possible by implementing double felting in the paper machine and by providing uniform pressure to the edge-cutting nozzle. These alternatives reduced paper breakages by about 18 times a day, equivalent to about two hours of paper production. As this productivity increase was achieved without additional overhead expenditure, profits increased by approximately US$ 118 per day (Table 1).

Table 1. Increase in Production Capacity

Product	**Total Production (Tonnes/day)**	
	Before CP	
Writing & Printing Paper	15	Writing & Printing Paper
Kraft Paper	10	Kraft Paper
TOTAL	25	TOTAL

Source: http://www.inem.org/htdocs/case_studies/raval.html

Water Consumption

The implementation of the following cleaner production alternatives has reduced water consumption by 28 per cent, on average by about 35m^3 per tonne of paper (Table 2):

- installation of a screw press, which after squeezing of pulp requires less water for washing, and;
- substitution of fresh water by fibre-rich back water, where possible.

Table 2. Reduction in Water Consumption

Product	**Water Consumption Per Unit of Product**	
	Before CP	After CP
Total process water consumption (m^3/day)	4,400	3,443*
Writing & Printing Paper (m^3/tonne)	186	132
Kraft Paper (m^3/tonne)	161	121

Source: http://www.inem.org/htdocs/case_studies/raval.html

* For a paper production of 27 tones/day

Electrical Energy Consumption

The electrical energy requirement for the paper-making section alone increased by eight per cent, because the cleaner production measures required additional electricity for transfer of waste materials for recycling, reuse and recovery. However, total electricity consumption for the combined pulp and paper sections decreased by approximately 42 Kwh per tonne of paper. The decrease was mainly due to the reduced electrical energy requirements for waste water treatment. This was achieved by segregating the concentrated black liquor for solar drying.

Steam Consumption

Implementation of the following cleaner production measures resulted in an 8.5 per cent:

- reduction in the steam requirement;
- dedusting of agricultural raw materials;
- insulation of condensate return line, and;
- waste heat recovery through use of an economiser to provide hot water for maintaining the proper bath ratio in the digester.

In addition, the solar-dried black liquor cakes could produce an additional 0.50 tonnes of steam per tonne of paper, equivalent to 12.5 per cent of the existing steam requirement (Table 3).

Table 3. Reduction in Electrical Energy Consumption

Product	Electricity Consumption Per Unit of Product (KWH/tonne)	
	Before CP	After CP
Writing & Printing Paper Manufacturing	910	985
- Pulp Mill	500	548
- Paper Machine	410	437
Waste Treatment	350*	230
TOTAL	1,260	1,215
Kraft Paper Manufacturing	880	948
- Pulp Mill	480	528
- Paper Machine	400	420
Waste Treatment	310	202
TOTAL	1,190	1,150

Source: http://www.inem.org/htdocs/case_studies/raval.html

*The plant is not currently incurring the treatment cost.

Raw Material Consumption

The reduction in fibrous raw material consumption is mainly due to the recovery of fibre from the fibre-rich waste streams. Fibre recovery amounts to about 53 kg per tonne of paper. Taking an average fibrous raw material yield as 54 per cent, the above fibre recovery is equivalent to fibrous raw material of about 98 kg per tonne of paper. The fibrous raw material consumption for kraft-grade paper was further reduced by recycling Johnson screen rejects back into the system after refining. Johnson screens remove rejects in the form of knots and uncooked material, after the cooking and defibration of pulp. The rejects were of the order of 73 kg of fibre per tonne of kraft paper. This was equivalent to 138 kg of fibrous raw material per tonne of kraft paper. The reduction in alum consumption was mainly due to improved washing of the pulp. Caustic consumption was reduced by recycling a portion of the black liquor, and dedusting of raw materials.

Solid Wastes

Solid waste generation from processing decreased by 32 kg per tonne as a result of recycling of Johnson screen rejects. Although dust from raw materials increased by 60 kg per tonne of paper, due to the dedusting operation, it will ultimately be reutilised with solar-dried black liquor cakes in the boiler. Thusly, the process solid waste contribution decreased by about 32 kg per tonne. The sludge from the water treatment facility is reduced because of the black liquor segregation. The total solid waste generation was reduced by 18 per cent due to the cleaner production programme.

Water Pollution Load

The reduction of approximately 46 per cent in the overall water pollution load was achieved after the implementation of cleaner production. About 70 per cent of this impact is due to the solar evaporation of black liquor (Table 4). The other measures which contributed to this impact are:

- recycling of fibre-rich streams for pump dilution;
- installation of Johnson screen showers;
- maintenance of digester bath ratio;

- use of fibre saver at centricleaner, and;
- removal of dust from raw material which would otherwise result in waste water

Table 4. Reduction in Water Pollution

Parameter	**Water pollution load** (Tonne/tonne of water)	
	Before CP	After CP
BOD	0.20	0.12
COD	0.99	0.56
TSS	0.34	0.19
TS	1.21	0.61

Source: http://www.inem.org/htdocs/case_studies/raval.html

Cost Savings

A total approximately US$ 80,000 was invested in the first 30 measures implemented. Annual savings amounted to a total of US$ 88,000 (Table 5). The overall pay-back period was 11 months. The reduction in pollution load saved the company an additional US$ 55,000 per year in effluent treatment costs. So total annual savings realised by the company amount to approximately US$ 143,000. The operation production capacity increased from 25 tonnes per day to 27 tonnes per day. The financial benefit accrued by this increased capacity, particularly in summer months, has not been included in the above figures. The entire expenditure was financed through the company's own resources.

Table 5. Cleaner Production Cost Savings

Area of Savings	**Amount** (US$ per day)
1. Increased Capacity tonnes/day @ US$ 44.12 profit/tonne	88.24
2. Electrical Energy Savings 1,134 KWH/day	83.38
3. Fibre Savings	144.12
4. Steam Savings t/t @ US$ 7.35/tonne	89.32
5. Caustic Savings* kg/t @ US$ 0.29/kg	55.59
6. Alum Savings kg/t @ US$ 0.12/kg	5.09
7. Water Conservation US$ 0.01 /m^3, 1,309 m^3/day	15.35
TOTAL SAVINGS PER DAY	451.68

Source: http://www.inem.org/htdocs/case_studies/raval.html

*Savings Due to Black Liquor Recirculation & Raw Material Dedusting

Other Benefits

Other benefits which followed the implementation of cleaner production at Raval were:

- the company's image among local bodies, NGOs and regulatory bodies has improved and the company is now being considered as "environmentally conscious", and;
- most importantly the cleaner production programme has resulted in improving the work environment, thereby improving worker productivity and morale.

The Future

The most important lessons of the Raval experiences that that need to be taken into consideration for future work with SMEs are:

- cleaner production has immense potential, particularly in SMEs;
- the success of cleaner production can be optimised if workers at all levels, from the shopfloor to middle management are included in the decision-making processes;
- cleaner production is economically very attractive;
- demonstration projects help to convince companies of the scope and potential of cleaner production;
- industrial enterprises require professional support for implementing cleaner production;
- SMEs require equipment and expertise for the measurement and monitoring of waste streams;
- training and involvement of plant personnel is essential for a sustainable cleaner production programme in industry; and
- adoption of a systematic methodology of cleaner production assessment helps maximize benefits.

Social Institutions and Environmental Management

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ABSTRACT *Today's environmental problems have become more pervasive, more intense in certain ways, more serious, and more complex and inter-related. They affect many stakeholders in society at various levels – as resource users and/or as subjects or victims of negative impacts arising from resource use of others and from elsewhere. Environmental management can no longer be regarded as the concern or domain of a single institution (e.g. the state), but of several major institutions interacting with each other. This module focuses on various social institutions and environmental management issues.*

Introduction

Environmental management is a complex domain and often defined in a number of ways. It can be referred to a goal or vision, an attempt to steer a process, the application of a set of tools, a more philosophical exercise that seeks to identify and establish new outlooks on the environment. Its function has been described as to help steer the transition from environment exploitation and largely retrospective responses to challenges and possibilities, to stewardship of nature and proactive stance and assessment of threats and opportunities (Barrows, 2006). It involves problem solving and intervention that may have a sectoral, local, regional or global focus.

Actions of environmental managers are embedded in, and conditioned and influenced by social institutions. Hence, social institutions are a powerful mediating mechanism between individual and group actors on the one hand, and nature on the other hand, in environmental management. In the interaction between societal actors and nature, social institutions as mediating mechanisms also undergo change and development. They should not be imagined as fix and immutable, and immune to changes in society and nature.

Environmental problems affect many stakeholders. Stakeholders may be academics, regional or national state decision makers and planners, non-government organization (NGO) staff, company executives, international civil servants, consumers, commuters, and community people and many others. Environmental management today has thus increasingly veered towards interaction, consensus building, conflict resolution, and mobilization of multiple stakeholders in various fields. This approach in environmental management has entailed the interlocking and increased interdependence between social institutions.

In order to understand the significance and role of social institutions in today's environmental management there is a need first to clarify what we mean here by institutions.

Social Institutions and Organizations

An institution is an enduring set of ideas about how to accomplish goals generally recognized as important in a society. Most societies have some form of family, religious, economic, educational, healing, and political institutions that define the core of its way of life. They are the norms, rules, habits, customs and routines, which govern society at large. These norms and rules can be formal and written. They can also be, as is commonly the case, informal and unwritten. They are often internalized by individuals and groups and become their reference in orienting their views, attitudes, and actions.

Institutions differ from one another on the basis of their focal social function. For instance, academic institutions have traditionally functioned primarily as the provider of education and

scientific research for society. Their function is in domain of systematic knowledge production and formal training of professionals and scholars. On the other hand, modern business' core function in society is production of goods and services for profit gains and accumulation. It organizes its production and marketing primarily along this function, and recruits staff and workers based on this consideration. While often there are common overlaps between two or several institutions (such as for example, the fact that academic institutions also being involved in profit gaining, and business sometimes also conducting its own scientific research) differences in respective core orientation remain strong. These differences in fundamental functions define the distinctive characteristics of various institutions.

While institution and organization are commonly regarded as basically identical or similar entities, they are indeed different. Although many social institutions have forms of organization -- and some have been identified as such -- this does not mean that every social institution has to have a single corresponding form of organization. It also does not mean that every social institution should by its very nature take the form of an organization.

Organizations are generally a large group of individual bound by some common purpose that come together to achieve joint objectives – as actors in society. It also involves a definite set of authority relations. Giddens (1998) highlights the point what while not all organizations are bureaucratic in its formal sense, there are quite close links between the development of organizations and bureaucratic tendencies.

Institutions influence the function, structure and behavior of organizations. They in a way serve as the template upon which organizations are built. Organizations – their sense of purpose and mission, rules, and structure and membership -- are shaped around the institution/s that they are embedded, and which commonly has given rise to them. Institutions therefore pattern and influence the function, structure and behavior of organizations. An illustration of this mutual relationship can be found, for example, between religion (an institution) and the church (an organization).

Key Institutions in Environmental Management

Today, there are three key institutions that are prominently involved in environmental management. These are state, market, and civil society. In varying degrees, these institutions are engaged in many multiple and varied tasks and activities related to responding (or not responding) to problems and challenges of the environmental problems and changes at the local, national, regional and global scales.

While it is convenient to talk of each of these three major institutions as stand-alone entities, existing and working in isolation of each other, in reality their fields overlap and boundaries between them are not that neat either. State agencies may, for instance, 'market' polluting rights to private companies. Market operations may structure forms state services and provisioning such as when water tariff for consumer households in a city is determined by costs and profit-mark-ups and competitive bidding between private providers. On the other hand, civil society's organizations could be working closely with government, as contractual providers in environmental projects such as community forestry for training and delivery of the component of community awareness rising.

Rather than think of institutions as stand-alone entities with neat and clear divide between themselves. It is more useful to understand them as having distinct core normative framework and orientations as well as core competencies while at the same time being in a definite relation/s of interdependencies between and among themselves in responding to environmental problems and situations.

In the following we will be discussing the basic characteristics of each of these key institutions and the particular significance and relationship of each to environmental management.

State

The state is probably the only social institution that enjoys legitimacy to keep a standing army or a professional group of armed men and to deploy and use them as an applied and coercive force when deemed necessary – or even desirable. Thus it is the social institution that holds a monopoly of the use force. In this sense, the state is defined by its authority to generate and apply collective power.

Ideally and normatively speaking, this power of the state should be used to promote people's welfare. In many cases and instances, it can be said that certain states have applied its power in order to promote people's or society's general welfare. However, in certain instances this power of the state can be and has been used in an oppressive or predatory way by those who are the helm of power. Hence, there is a need for governments and its officials to be accountable to their citizens for their actions. Accountability, in turn, requires internalization of this principle as a norm by public officials, and putting in place specific mechanisms accessible to citizens for them monitor and hold in check detrimental actions of the state. In this regard appropriate fora and mechanisms for airing of citizens' voice are also essential. Accountability also requires the rule and transparency of laws and regulations, and the informed advocacy of citizens for transparent and public interest in the conduct of state officials (Minogue, Polidano and Hulme 1998).

The state is organized around a set of social functions, including maintaining law, order and stability, resolving various kinds of disputes through the legal system, providing common defense, and looking out for the welfare of the population in ways that are beyond the means of the individual. By tradition, the state thus is by tradition the particular institution in charge of and mandated to lead public action for promoting public welfare and interests. To fund public services and other public interest projects and activities and to support its machinery and personnel, the state relies primarily on public revenues, mainly in the form of various kinds of taxes drawn from its citizens. Reliance on taxation for the state's maintenance and operations, on the other hand, gives legitimacy to the right of tax payers or to citizenry as a whole to have a voice on matters of how their taxes are being or ought to be allocated and spent for public welfare.

In recent times, new areas of major concerns and activities have been added to traditional state functions. Particular to many developing countries, the state has been at the helm of planning, investment, and formulating strategies for economic development. A number of states in developing countries seem to derive their legitimacy and rationale to rule from its performance the main public actor generating economic development. Aside from this historically new definition and expectations of state's role as the main driver and strategist of economic development and growth, another area has increasingly become an official domain of the state obligation. This particular field of concern is the preservation and upkeep of the environment. Hence, the use, monitoring, regulation, conservation, and development of both natural and built environment have in recent decades been regarded as official state function. The state itself has been regarded as the main -- if not the sole -- institution and organization in charge of managing the environment.

Market

The market is a social mechanism for exchanging goods and services on the basis of the primacy of the principle of competition. In a market exchange is organized according to the principle of competition, whose simplest form is based on the use of price criteria by both suppliers and consumers of goods and services to determine their behavior (Robinson, Hewitt, and Harriss 2000). The market is the institution that organizes this competition where group and individual actors (for example, the firms) maintain competitiveness and survive through price competition.

Competition as the underlying fundamental principle in the operations of the market also generates other important and closely associated 'rules of the game' for those players operating in the market. Market players are expected to have a 'fair deal' of profit in their production and trading activities. Too, actors and competitors in the market are assumed to be striving to gain advantage over the others. These norms are considered fair and legitimate in order to survive in the competition.

The above principle of competition and associated norms and rules of "getting a 'fair deal' profit" and "gaining advantage over others" distinguish the market from other institutions or traditional practices of exchange such as gift-giving, communal sharing, and other forms cooperative institutions in society. Some these non-market or pre-market institutions, particularly those traditional institutions continue to have practical relevance and major role in local management of natural resources.

In recent decades, market institution has increasingly become a force of major significance in the sound (or unsound) management of the environment. This trend is marked by the increasing power and omnipresence of business in resource use as well as in environmental pollution. The major importance of market institution has also come of age today with the growth in magnitude and employment of market-like instruments in environmental management, which are based the principles of pricing and competition. We will elaborate on this point further in the next section.

Civil Society

Often called the 'Third Sector' civil society comprises of voluntary relationships between individuals and groups, motivated by 'affectivity' (love, friendship), or ethical commitment. (For instance, a club in a town would have been founded in the past and continues to exist at present due to a shared strong commitment of its members to civic values and activities.) Civil society includes families, churches, clubs, professional associations, political parties, community-based organizations and non-government organizations. Civil society as an institution is different from the state and the market. Strictly speaking, it can be regarded as being made up of private entities (that is, autonomous and independent of the public/state sector) and which do not depend for its own ordering and discipline on the coercive power of the state. But even as their constitutive elements are private, unlike the private entities in market institution, these associations do not depend on the norm and principle self-interest, where success is determined by the 'measuring rod of money' as their fundamental guiding principle.

Solidaristic organizations of civil society have long existed. They are found both in pre-modern and modern societies. But it is only in recent decades that their developmental role and functions have been duly officially recognized and promoted through various national statutes and international covenants. They are today widely recognized as necessary and desirable partners of the state in development. An important context of this recognition of enhanced civil society role in development is the trend that started in the 80s involving radical cut backs in the state expenditure in public provisioning and public sector operations. State minimalism in public provisioning and development projects encouraged civil society to assume greater role in this sphere. Subsequently, however, it became quite clear that the logic state minimalism is flawed: that there are indeed certain areas of development and public provisioning concerns that civil society institution has an edge in better and more effective delivery compared with the performance of government agencies, but it cannot always and should not principally substitute for the state role in the bulk of public provisioning.

Against this backdrop, civil society today therefore has also become a key institutional mechanism and site of environmental management tasks and activities. We will elaborate on this further in the next section.

Characteristics of Key Institutions' Main Organizations vis-à-vis Environmental Agenda

We can comprehend the significance and basic orientations of key social institutions of the state, market, and civil society vis-à-vis environmental agenda and management by looking at the characteristics of their respective main organizations and describing and understanding their behavior and its context. In the following discussions below, we will briefly outline these characteristics, predispositions and relevant context in relation to the environmental agenda and management function. However, a caveat is in order at this point. While attribution of

characteristics and predispositions to main organizations of the state, market and civil society indeed serves a useful purpose of understanding these institutions' actual and potential role and significance to management of environment, we should not fall into the trap of essentializing or reductionism commonly extending from use of typologies. Every case should be studied concretely and in a nuanced manner, while at the same time being guided and illumined by certain useful and meaningful generalizations and basic characterizations.

The main organization of state institution is the bureaucracy. While state's bureaucratic organization has been known to be effective in routine work and tasks, it is also characterized by rigidity and associated lack of responsiveness to new tasks and problems. Unfortunately, the domain of environmental management commonly poses new situations, tasks, and challenges. Hence, traditional rigidity of bureaucracies both in developed and developing societies has proven to be drag to responsiveness, innovation, and new thinking required in effective management of the environment.

Further, state bureaucracy continues to be saddled with traditional problems of top-down administrative style and administrative separatism. Top-downism in planning and decision making has constrained participatory and multi-stakeholder approach that is deemed necessary to sound environmental management. On the other hand, the rigid separation of functions and activities of government departments (for example, between trade and investment departments, tourism, water authority, environmental department etc.) and associated phenomenon of 'bureaucratic turf wars' have increasingly proven to be incompatible with and hamper the development of a holistic and multi-sectoral problem-solving approach to environmental issues and problems.

Furthermore, particular to developing countries, their states' overarching strategy to achieve economic growth and rapid industrialization commonly ignores the environmental costs of this particular development path. The impact of this omission is serious and enormous, given the context that regulatory structures and public sector's general capacity are hardly developed in these countries.

Moreover, in the intra-government body hierarchy of developing countries, environment departments, ministries, and agencies are generally marginal in significance compared to economic, trade, finance and investment bodies whose functions perfectly fit the state's priority agenda of rapid economic growth. Their marginal status means that these environment-related government bodies have far less power and allocated resources for their projects and operations compared to other priority line agencies.

However, despite the aforementioned factors that seriously constrain public sector's effectiveness in environmental management, there are clear signs today that governments have been increasingly committing themselves to prioritizing environmental agenda and necessary relevant reforms. This enhanced commitment has come in the context of growing pressure of global environmental movements and much strengthened international consensus and covenants concerning the health of the environment. In many cases, growing environmentalism and social movements in the domestic front have also pushed national and local governments to adopt necessary environment-friendly policies and measures, and to agree to pertinent international covenants.

Business firms are the main organizations of market institution. Business firms operating in the market comprise a heterogeneous mass. They widely vary in size, scope of operations, product lines, ownership, locational characteristics and other attributes, which have influenced more or less the way they use resources and protect or damage nearby or broader scale environments. Operations and behavior of business firms, of course, are also influenced by the particular political and policy milieu in countries and localities where they are based.

Studies have identified three main types of business attitudes or predispositions vis-à-vis environmental concerns (Doyle and McEachern 2001). These are the following:

Rejectionists: Generally speaking, these are firms who have a comprehensive rejection of environmental concerns. These firms look at the environmental concern with suspicion and a cloak of their advocates who are considered essentially anti-business. To the extent that these firms have a

degree of recognition of the environmental damage attributed to operations of business, it is easily justified by the economic development that results and the imperative of economic growth.

Accomodationists: These firms are skeptical about the environmental agenda and its effect on doing good business. However, they have sought accommodation by making limited changes. In developed countries, this has become the mainstream position, as the levels of environmental concern have increased and consumers have registered some level of environmental commitment in choosing products and processes offered in the market. As expressed in their advertisement or mission statements, accomodationist firms do not reject environmental concern but seek to identify with it, while advocating prudent response, protecting the position of energy companies and energy-intensive industries.

Environmental/Green: These are firms who have embraced the themes raised by environmental critiques and have redesigned their products and production processes to be environment friendly. The position taken by environmental firms is not a very common. And this particular position is at odds with that of rejectionists and accomodationists alike. Environmental companies have redesigned their production processes and used these environment-friendly redesign as a way of marketing their products. A good example of this is Andy Rodick's Body Shop, which explicitly develops its image, and its product range around improved environmental practices and ethically better relationships with its suppliers, while avoiding products tested on animals.

Especially in North countries, a lot of progress has been made in the development of business perspective in environmental concern, especially in generating serious considerations from the business sector for the environmental agenda. But enormous challenges remain on how to turn business sector to become environmentally friendly. Business' attitude and behavior vis-à-vis sustainable development agenda is of critical importance since they are major resource users, actual or potential polluters, and shapers of consumption patterns and lifestyles of people. They are an indispensable key partner in successfully promoting environmentally desirable goals of society.

Civic groups, NGOs, CBOs, media organizations, church groups, and various advocacy groups comprise the main forms of organization of civil society. Civil society groups have in recent decades been increasingly formally recognized as important partners of the state in development, especially in pursuing environmental sustainability goals of development.

Civil society organizations are important to the state's general agenda of development, and to its sustainable development agenda in particular due to the following reasons: they can encourage governments to adopt innovations from the voluntary sector; they can educate and sensitize the public about their rights and opportunities; they can collaborate in making government programs more effective; they can attune state programs to public needs; they can strengthen local institutions and make them more accountable; and they can act as conduits for citizen consultation and advocacy (Clark, 1995). Civil society's relationship with the state is healthiest when it is in a collaborative partnership – characterized by shared common objective between the two parties, a partnership in work based on mutual respect, and acceptance of autonomy, independence, and pluralism of civil society groups' opinions and positions.

Broadly speaking, civil society groups are generally sympathetic and friendly towards environmental concerns. Some have environment as their focal point of advocacy or development intervention projects. Environmental organizations of the civil society have dramatically multiplied since the Rio Conference of 1992. Many of them have very strong links with the grassroots forces and environmental issues and activities. The latter is an important asset in advancing a widely accepted sound principle of subsidiarity in decision making on the environment.

Civil society organizations' particular role and legitimacy as a key party in environmental management at various levels have been enhanced in the context of greater emphasis put today on the normative of participatory development. Especially in developing countries, bilateral and multilateral development agencies have been requiring meaningful participation of stakeholders and citizens to most development initiatives as a precondition for their continued support and funding.

Under this condition, civil society organizations have also increased in number. Their activities have become more robust and sustained.

New Governance Paradigm and Relations between Social Institutions

There is no single magic policy pill that can address effectively multiple and varied environmental problems and challenges that societies are facing today at various scales. Depending on particular conditions and scales, a package of multiple policy instruments and tools, employed in combination, stands the best chance to make a difference in improving our environment. This package would include various major instruments as the following:

- Legislative controls
- Technological fixes
- Market-like or market-based instruments
- Enablement policies for business and communities, and civil society organizations in general
- Tools of public information

In processes involved in formulating, making decisions, adopting, and implementing the above-mentioned instruments, present-day ascendant paradigm of new governance has been redefining in a fundamental way relation between key institutions of state, market and civil society. New governance resonates too in the particular foci of two aforementioned policy instruments, to wit: enablement for business and communities and civil society in general, and public information tools. This new approach to modern government and public problem solving has actually taken roots in the last 50 years, but has only been increasingly officially recognized and promoted since the last two decades.

New governance is fundamentally different from traditional/classical public administration in thinking and in actual practice of government and public problem solving. It is neither state-centric nor state-exclusive, which was the hallmark of traditional public administration. Rather, new governance is modern government that is essentially collaborative in nature, placing a great reliance on a wide array of third parties -- in addition to government -- to address public problems and pursue public purposes (Salamon, 2002). Obviously, this paradigm too encompasses the way government ought to address and respond to environmental problems and the tasks and challenges of present-day environmental management.

Based on the collaborative nature of new governance, a number of its key characteristics contrast sharply with that of traditional public administration. New governance explicitly focuses attention to network modality in public problem solving, emphasizing partnership and dependency of government on other private (i.e. non-profit and for-profit) actors instead of sole reliance on internal workings of government. Importance of partnership -- albeit often asymmetric -- between various parties is also stressed, instead of a hierarchical and top-down structure with the state as central authority and all the rest regarded as subordinates. New governance de-emphasizes and attempts to minimize mutual exclusion and adversarial stance between the public sector (i.e. government) and private entities, highlighting instead potentials for cooperation, and purposively identifying and adopting win-win relationships between the public and private sectors in public programs and projects. Instead of command and control measures, greater focus is on negotiation and persuasion of third parties and the broad public in general in pursuing public actions and generation of public acceptance of government measures and regulations. Further, the most valued skills among public officials and civil servants in new governance paradigm are those related to enabling skills and not management. The former emphasizes activation and mobilization skills to generate and energize network of public actors to address and public problems. Enabling skills also includes skills in sustaining networks' actions and partnerships as well as striking a good and effective balance between the use of rewards and penalties to elicit cooperative behavior among

interdependent players in the network. A summary of these contrastive characteristics is in the Table 1.

Table 1. Summary of Contrastive Characteristics

Classical Public Administration	**New Governance**
Hierarchy	Network
Public vs. private	Public + private
Command and control	Negotiation and persuasion
Management skills	Enablement skills

Source: Adapted from Salamon (2002, p.9)

New governance paradigm has opened up a new era of interactions and relations between the key institutions of the state, market, and civil society in the field of environmental management. In this new thinking and practice, a new framework of relationship between these social institutions and their main organizations has increasingly gained public acceptance and is becoming firmly established and officialized as the new normative. In the domain of environmental management in particular, this new normative puts core emphasis on synergy of various parties, or the mutual positive enhancement of partners for greater capacity and outcome. It also stresses the importance of dense vertical and horizontal connectivities between the state, market and civil society actors in environmental management

This fundamental paradigm shift in paradigm in environmental management has underpinned a number of present-day management approaches to natural resources and environmental concerns. For instance, integrated water management approach has as its core element multi-stakeholder and participatory approach as well as multi-sectoral perspective in problem solving. Present-day community forestry program emphasizes cooperative partnership between the state agencies, community and NGOs. Another example can be found in the field of urban environmental management. Today's non-conventional urban solid waste management also highlights the component of developing community/private sector/municipal partnerships, a dimension absent in conventional city solid waste management system

Complexity and multiplicity of levels and relationships intrinsic in environmental problem situations and challenges make a collaborative model an imperative in public action. It can be said therefore that it is in the particular domain of environmental management where new governance paradigm has been making significant inroads and where traditional and long-established relationships between the state, market and civil society are being radically redefined and reconstituted in the process. This development certainly holds a lot or promise for the future of the environment.

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Appendix 2

Training Program Time Table

AIT-UNEP Training Program on Environmental Management Tools
27-31 March 2006

School of Environment, Resources and Development
Asian Institute of Technology, P.O. Box 4, Klong Luang
Pathumthani 12120, Thailand

Venue: AIT Conference Center, B 108

Date and Time	Event/Activity
27 March 2006	
8:00-8:30	Registration
8:30-9:00	**Inaugural Session** • Introductory remarks- Prof. J. K. Routray, Course Director, Training program • Opening address- Prof. Sudip K. Rakshit, VP, Research • Opening remarks- Mr. Surendra Shrestha, Regional Director, UNEP-ROAP • Remarks- Prof. Sivanappan Kumar, Dean of SERD, AIT
9:00-9:30	*Group Photo and Coffee break*
9:30-10:30	Environment in the 21st century (Mr. S. Shrestha, UNEP ROAP)
10:30-12:00	Overview of Asian environmental status: emerging issues and future scenarios (Prof. Chongrak Polprasert)
12:00-13:00	*Lunch break*
13:00-14:30	Environmental Laws and Multilateral Agreement (Mr. Manjit Iqbal, UNEP ROAP)
14:30-16:00	Presentation of country reports (Prof. C. Visvanathan, Prof. J. K. Routray and Dr. Dechen Tsering, UNEP ROAP) *Afghanistan, Bangladesh, Bhutan and India*
16:00-16:30	*Coffee break*
16:30-18:00	Presentation of country reports (Prof. C. Visvanathan, Prof. J. K. Routray and Dr. Dechen Tsering, UNEP ROAP) *Maldives, Nepal, Pakistan and Sri Lanka*
18:15-22:00	*Welcome dinner at AITCC*
28 March 2006	
8:30-10:00	Water quality and wastewater management (Prof. Ajit Annachhatre)
10:00-10:30	*Coffee break*
10:30-12:00	EIA, Environmental auditing, and strategic environmental assessment (Dr. O. V. Shipin)
12:00-13:30	*Lunch break*
13:30-15:00	Institutional set up for environmental management (Dr. Edsel E. Sajor)
15:00-15:30	*Coffee break*
15:30-17:00	Solid waste management and cleaner production technology (Prof. C. Visvanathan)

29 March 2006	
8:00-9:00	Environmental indicators and environmental accounting (Dr. Ganesh P. Shivakoti)
9:00-10:00	Environmental security in South Asia (Dr. Subrato Sinha, UNEP- ROAP)
10:00-10:15	*Coffee break*
10:15-11:15	Montreal protocol: Tools and mechanism (Dr. Thanavat Junchaya, UNEP-ROAP)
11:15-12:15	Industrial management tools (Mrs. Wei Zhao, UNEP-ROAP)
12:15-13:15	*Lunch break*
Afternoon	Field Visit (Solid waste management site), Prof. C. Visvanathan
30 March 2006	
8:30-10:00	Fiscal instruments for environmental management, Dr. K. S. Kavi Kumar, Madras School of Economics, Chennai, India
10:00-10:30	*Coffee break*
10:30-12:00	Fiscal instruments in practice, Dr. K. S. Kavi Kumar, Madras School of Economics, Chennai, India
12:00-13:00	*Lunch Break*
Afternoon	Field visit to Eco-House, Dr. Vorasun Buranakam, Faculty of Architecture, Chulalongkorn University and Prof. J. K. Routray
31 March 2006	
8:30-10:00	a. Environmental data sets and its management (Dr. R. P. Shrestha b. GIS applications for environmental planning and management (Dr. Nitin K. Tripathi)
10:00-10:30	*Coffee break*
10:30-11:30	Spatial environmental planning (land use planning, industrial zoning principles, standards, etc.), Dr. L. A. S. Ranjith Perera
11:30-12:30	Climate change – Regional and international environmental issues (Prof. S. Kumar)
12:30-13:30	*Lunch break*
13:30-15:00	Management of air pollution with trans-boundary issues (Dr. Nguyen Thi Kim Oanh)
15:00-15:30	*Coffee break*
15:30-17:00	Clean development mechanism (Prof. Ram M. Shrestha)
17:00-17:30	Training program review session with the Director, UNEP-ROAP
17:30-18:00	**Closing Ceremony** • Closing remarks and certificate distribution by Prof. Said Irandoust, President, AIT, • Vote of thanks by Prof. J. K. Routray.

Appendix 3

Environmental Management Tools
Meeting Report of the Training Program
27 - 31 March 2006

Jayant K. Routray

School of Environment, Resources and Development
Asian Institute of Technology
P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand

April 2006

Introduction

UNEP's International Environmental Governance process recognized the need to develop a strategic plan for capacity building for the developing countries. Following the adoption of the Bali Strategic Plan (BSP) for Technology Support and Capacity Building, the objective was to provide systematic, targeted, long and short-term measures, taking into international agreements based on national and regional priorities as well as needs. One of the areas identified for the capacity building was on environmental management tools including legal, fiscal and technology for the SAARC member countries, recommended in a meeting of Experts held in October 2004 in New Delhi. So the training program was conceptualized by the UNEP-ROAP following the needs assessment of the SAARC member countries held in New Delhi.

A five-day training program was conducted at AIT Conference Centre in Asian Institute of Technology, Bangkok, Thailand, during 27-31 March covering legal, fiscal, technological and voluntary tools including two field visits in the afternoon sessions. The legal tools included standards, policies, strategies, EIA, and spatial environmental planning etc. The technological tools included innovative technology for management of air, water, land and solid waste.

Objective of the Training Program

The broad objective was to organize a training program on "Environmental Management Tools" for midlevel and senior officials, decision and policy makers associated with the Ministry of Environment in South Asian countries, and representatives from the South Asia Association for Regional Cooperation (SAARC) and South Asia Cooperative Environment Program (SACEP) Secretariats.

The specific objectives of this training were:

a. To provide an overview of current national environmental status and issues of respective countries compared with regional and global status.
b. To familiarize the participants with different environmental management tools and techniques.
c. To increase the participants' knowledge and awareness on the environmental policies of South Asian countries through contributions made by the participants of SAARC member countries with illustration of case studies, successful practices and experiences.
d. To expose the participants to Thai environmental management and practices through field visits and demonstration of best practices selectively.

Major Topics Covered

The major topics presented by the resource persons are classified under the following groups:

1. Technological tools: Water quality and wastewater management, Solid waste management and cleaner production technology, Environmental data sets and its management, GIS applications for environmental planning and management
2. Institutional tools: Institutional set up for environmental management, Environmental indicators and environmental accounting
3. Policy, legal and voluntary tools: Environment in the 21st century, Overview of Asian environmental status: Emerging issues and future scenarios of EIA, Environmental auditing, and Strategic environmental assessment, Environmental laws and multilateral agreement,

Environmental security in South Asia, Montreal Protocol: tools and mechanism, Industrial management tools, Spatial environmental planning (land use planning, industrial zoning principles, standards, etc.), Climate change – Regional and international environmental issues, Management of air pollution with trans-boundary issues, and Clean development mechanism (CDM).

4. Fiscal tools: Fiscal instruments for environmental management, and Fiscal instruments in practice.

Participants

Twenty participants including three observer participants had attended the training program. Seventeen participants were from the South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) and the SAARC and SACEP Secretariats. The participants represented the National Environmental Protection Agency, Kabul, Afghanistan; Ministry of Environment and Forest, Bangladesh; National Environment Commission Secretariat, Royal Government of Bhutan; Ministry of Environment and Forests, India; Ministry of Environment, Energy and Water, Maldives; Ministry of Science, Environment and Technology, Nepal; Ministry of Environment, Government of Pakistan; Ministry of Environment, Sri Lanka and Central Environment Authority, Sri Lanka; SAARC Secretariat, Katmandu, Nepal; and SACEP Secretariat, Colombo, Sri Lanka. All the participating members occupy very key and high level positions in their respective countries. The training group was a mixed one with backgrounds in administration, involved in policy and decision making process, whereas few participants having professional background in environmental science and management fields.

Resource Persons

The resource persons for this training program were drawn mostly from Asian Institute of Technology and United Nations Environment Program - Regional Office for Asia and Pacific, and only one resource person was taken externally from India. The resource persons were highly qualified and rich in professional and regional experiences in their respective fields. The Class room presentations were based on some theoretical and technical underpinnings with focus on case studies, policy related instruments in the context of South Asian perspective as far as possible. The training program could able to deliver 20 key topics by internal and external resource persons.

Training Materials

A complete set of reading materials were developed by the resource persons and circulated among the participants as reading cum resource material for their use and reference. As planned, a training manual on Environmental Management tools will be worked out later. Apart from these, the other materials relevant to EMT from AIT and UNEP – ROAP was distributed for the benefit of the participants.

Inaugural Session of the Training Program

The program was started with the introductory speech by Prof. J. K. Routray at 08.30 am on 27th March 2006. In his speech Prof. Routray welcomed all the participants from the SAARC region, extended his thanks for the financial support from the UNEP for this program, and also explained briefly about the purpose and contents of the training program. He also emphasized on the utility of

the program in the current environmental scenario of South Asia and South East Asia regions. A self introduction was conducted by the participants.

Opening address was delivered by Prof. S. K. Rakhsit, Vice-President (Research) of AIT immediately after the self introduction of the participants. He briefly discussed about AIT's participation in regional activities and also future prospects of working together for similar events. He emphasized on the formation of thematic knowledge groups and out of class room education system to fulfill the current needs. He also talked about the environmental stress faced by the agricultural based countries of the South and South East Asian region.

Opening remark was also given by Mr. Surendra Shrestha, Regional Director of UNEP-ROAP, Bangkok. He emphasized on the goals of the training program. He pointed out four major aspects relating to (a) Policy, legal and physical tools, (b) Regional Co-operation (c) Environmental treaties and (d) Utilization of traditional knowledge and wisdom. For solving environmental issues, enforcement of policy and legislation can be considered as a useful tool in the Asian region. The issues should not be limited within a country's boundary rather should be expanded to the surrounding regions considering the wide spread effects of the environmental pollution. Capacity building should be prioritized to control and monitor the consequences. He also discussed about converting the best traditional practices and local wisdom into scientific technology to be used by the region and also different parts of the world.

Prof. S. Kumar, Dean of the School of Environment, Resources and Development also addressed the participants of the training program. In his remarks, he stressed on the population growth in the South-Asian region being home for one fourth of the total world population. He strongly opposed the idea of rapid industrialization which comes at the cost of the environment. He also emphasized on the curriculum of the training program with the importance of incorporating field visits in it. He requested the participants to convey their feedbacks at the end of the training program.

Training Sessions

Mr. Surendra Shrestha made a presentation on "Environment in the 21st Century". The presentation included: the background of sustainable development (SD) processes which were highlighted in Stockholm (1972) and in Johannesburg (2002), major challenges facing on social development (increased population, benefits, disparity), economic development (income per capita tripled, global economic input) and state of environment and natural resources, and negative trends of the state of the environment in terms of air pollution (CO_2 emission, dust storm in India, Atmospheric Brown Cloud, etc), water demand (tripled in last 50 years) and state of water resources (ground water reduction, rivers getting dry, glaciers retreating), land degradation (soil erosion, deforestation, pasture damages), and biodiversity concerns.

Prof. C. Polpraset made a presentation on "Overview of Asian environmental status: Emerging issues and future Scenarios" assisted by Mr. Indra Gurung. He initiated his presentation with a quick glance on the current Asia-Pacific population share and its growth trend, which is emerging as a threat to the existing resources with the predicted population of 5 billion in 2025. Other emerging concerns in the region are current status of land use/land degradation, air pollution and water quality. The quality of the available water is going down and so also the ground water level. The lack of fresh and clean drinking water is forcing people to use unsafe water leading to various diseases. He also mentioned about the air pollution level in the region mentioning the existence of 12 out of 15 most polluted cities of the world.

The participants raised the issues on resource sharing, water quality in terms of river drying up and arsenic contamination etc. In his response, Prof. Polprasert agreed with the points raised with adding the example of the Makeng River as the success story of resource sharing in the South-East region and also suggested for inclusion of cost sharing with sharing of resources for better acceptance.

Mr. Manjit Iqbal started the post-lunch session of the first day with his topic on "Multilateral Laws and Multilateral Agreements". He discussed about the concepts of the environmental laws which took birth in 1972 Stockholm UN conference. Currently the laws are based on the sustainable development principles which include the right to clean and healthy environment, duty to defend, right to sue, polluter pays principle, inter and intra-generalization equity, precautionary principles and public participation. He also proposed to form environmental court in each country with ministries in the central governments. He also showed the recent trends in environmental law making with examples from different country scenarios and status of environmental courts of the region.

The participants raised the issues of making international agreements, funding problems and concern on poor people being the major affected group. The speaker emphasized on the regional treaties and bilateral agreements rather than international treaties considering the diversity between the regions and countries.

Prof. Ajit P. Annachhatre started the second day program with the topic titled as "Water quality and waste water management". He mentioned about per capita domestic water consumption of Asia is 82 lit/head/day as compared to 117 lit of the world average. He discussed the water quality issues of the Asian region. The various stages of water treatment process consist of TSS removal, Grease removal, pathogen removal and nitrogen transformation/removal. He also presented the water treatment scenarios of Bangkok metropolitan city as an example. The ill-impact of low-quality water causes public health problems, threat to aquatic lives, and tourism sector. Steps like awareness among the kids, more teaching and training programs should be organized to aware people on water quality issues and threats. As a future vision, water treatment charge should be imposed to maintain the water quality. In his presentation, he also included some of the best practices such as Starch industry water treatment system, Kuwait water treatment plant with capacity of 375,000 m^3/day and the new water plant in Singapore.

The participants raised questions on domestic level safety measures could be done by septic tanks, legislations and by identifying polluting industries for special attention. Community waste water plant and membrane technology should be encouraged for waste water treatment; and avoiding wet land as solid waste disposal site to prevent leaching.

Dr. O. V. Shipin presented on EIA with the title of "EIA, environmental auditing, and strategic environmental assessment". He discussed about various process involved in environmental impact assessment of any project and also highlighted the reviewing process of EIA. Added the example of Kakadu National Park which is under threat for uranium mining site making tough decision for the administration to go for uranium mining at the cost of environment or preserve it for the sake of sound future. He also illustrated the undergoing impact assessment of Hydro-electric plant under Arun-III project in Nepal. The hydropower station is not the answer to the energy demand but nuclear and other non-convention alternatives should be assessed to prevent the irreversible environment damages.

Some participants raised issue of the applicability of EIA as a compromise between the two parties involved in the project without involving the public. The speaker disagreed with the statement by explaining that the public awareness could change the scenario and help in maintaining the environment. The speaker agreed with the concern of adding social impact assessment with EIA as a tool. Fixed time frame should be given for EIA to overcome the delay in approval process of the project.

The topic with title "Social Institution and Environmental Management" was presented by **Dr. E. E. Sajor.** He emphasized on three major institutions such as: State institution which can be defined as the authority to generate and apply collective power, Market institution based on the principle of a "fair deal" profits and civil society which is bounded by no fixed rules. He also discussed about new governance approach consisting of working private with public rather than competition and

substituting management skills with enablement skills for better result. His forwarded the synergic, bottom up and top down approach, and subsidiary & co-ordination relationship for the social institutions for better environmental management.

In the discussion, concerns were raised on the definition of institution and the organization. The speaker defended it by saying that all the institutions are organizations but not vice versa. A group including mass media can be considered as a civil society institutions depending on the issues handled by them. Defining Chamber of Commerce (business group) as an institution received mixed reaction among the participants and the speaker had no clear conclusion.

Prof. C. Visvanathan presented on "Solid Waste Management in Asian Perspectives" in last session of the second day program. He initiated the presentation by defining solid waste and mentioning the country-wise variation of contents in solid waste and the issues related to its management in the region. He emphasized on the various steps such as collection (primary, community, secondary), separation, treatments and disposal etc. involved in waste management. The sustainable solid waste management approaches like reuses, recycle, incinerate with energy recovery, land fill, dump and open burning, etc. should be used. Issues related to composting of the bio-degradable waste and fuel generation for domestic/industrial use were also highlighted in his discussion. The mechanical equipments can be economical only when enough solid waste has been collected for the operation. Separation at the disposal site rather than at treatment can reduce the amount of work for solid waste management leading to making the operation economical and sustainable. He also explained on the engineered landfill, hazardous waste and burning of hospital wastes.

Queries such as handling plastic waste and agrochemical waste were raised by the participants. He suggested the use of paper and cloth bags which are bio-degradable in place of polythene. Moreover, polythene bags can be recycled and reused or can be used for producing fuel. Removing agro-chemicals from water can be carried out though it required a complex procedure demanding a lot of investments.

Before concluding the session of the second day, the delegates representing the **SAARC** as well as **SACEP** Secretariats shared their experiences related to the environmental practices and issues in the region. SACEP is generally getting funds from the NORAD and the UNEP for their activities and they are working closely with the SAARC in various issues including environmental matters. The SACEP representative mentioned about the inclusion of Afghanistan as a SAARC member country. He also informed about the future programs and meetings related to environmental issues, going to be organized for the SAARC member countries.

Dr. Ganesh P. Shivakoti started the proceedings of the third day training program with his topic on "Environmental Indicators and Environmental Accounting". He discussed on the three pillars of sustainable development frame such as: Healthier environment, Strong economy and Social acceptance. He pointed out three types of sustainable environmental indicators such as environmental/ecological indicators, economic indicators, and Socio-cultural indicators. Various quantification techniques for the environmental indicators can be used. He also discussed on gross national products and the requirement of green national accounting (Green GNP) for the current scenarios with supporting information from various countries.

Concerns were raised by the participants on the calculation of green GNP for different nations. The speaker explained that the system used for Green GNP evaluation varies from nation to nation as there is no fixed international standards to do so. Sometimes, authorities manipulate process of calculation to show good Green GNP values to get more applauds and supports from other nations.

Dr. Subrato Sinha of the UNEP-ROAP presented the topic "Environmental Security in South Asia". He broadly discussed environmental security in terms of four parameters such as: water security, food security, energy security and habitat security. He also presented comparative

statistical information on the current situation and future trends of South-Asian countries. Many cities are heading towards the 40% water scarcity level which may be delayed by stopping the free distribution of water and using sprinkler and drip irrigation system for agricultural water supply. About 12.5% of the total hunger is in the region and it follows a declining trend. The alternative energy sources such as: nuclear, wind and solar energy should replace the use of coal and petroleum etc. to secure long term energy sufficiency. Preventive measures should include long term planning (30-50 yrs) in stead of short term planning spanning over 3-5 yrs. Development should not be acquired in the cost of environment rather the concept of 'environment for development' should be introduced.

The participants requested for documentation on eco-friendly hydropower projects in Bhutan, which can be initiated in other countries of the region. The speaker positively agreed with the suggestion stating that steps would be taken in that direction.

Dr. Thanavat Junchaya, from the UNEP-ROAP, delivered a lecture on "Montreal Protocol: Tools and Mechanism". He discussed on ozone layer depletion and also about 1987 Montreal Protocol convened on the ban of substances that depleted the ozone layer. He mentioned about the huge Ozone hole over the South Pole, now extended over south of the South America continent. He showed the phased out schedule for CFCs and corresponding targets for different countries of South-Asian region. He also discussed on the tools and mechanism involved in the protocol to achieve total phase out of ODS from the whole world. Common ODS phase out program includes control and monitoring of ODS import, phasing out existing demand and also prevent new demands. New challenges has to be monitored which are stricter control over illegal trade of ODS, regulations and prosecution issues, new refrigerant alternatives causing disposal and contamination problems and non-compliance by A5 (developing countries) parties even with very small consumption.

The issues such as leakage problem of CFCs, and export of used products working on CFCs with low cost to the developing countries, and the recovery of ozone layer due to reduction in CFCs production. The speaker agreed with participants' concerns that the leakage should be stopped at any cost and the illegal export should be banned. Though the production of CFCs is reduced, recovery of Ozone layer is not a quick process and can be realized only after 25-50 years.

Continuing the presentation by the UNEP – ROAP officials, **Mrs. Wei Zhao** delivered her talk on "Industry Environmental Management". Environmental impacts are related to efficient and effective use of natural resources. Tools to obtain effective use of natural resources can be EIA, land use planning, sustainable industry and infrastructure strategy and eco system based development. Tools to improve efficiency and prevent pollution can be cleaner production, life cycle assessment, eco-design, company sustainability management. UNEP has playing a major role in industry environment management in terms of cleaner production, accident prevention and response, waste management, energy program with partnership, integrated chemical management, and working by industry sectors. She also emphasized on cleaner production mechanism for the developing countries.

The issue of higher cost involved in cleaner production for developing country situation was raised by the participants. The speaker clarified the concern by mentioning that the cleaner production unit can be worked with industries and associations rather than individuals.

The third day of the morning session lecture was conducted by **Dr. K. S. Kavi Kumar** from Madras School of Economics, India. He delivered lectures on two nearly inter related topics "Policy instruments for environmental management" and "Policy instruments in practice". He discussed about market failure, its causes, monitoring and the tools required for control of the system. Public goods/bads can be classified as two systems such as Excludability (feasible and practical to selectively allow consumer to consume the goods) and Rivalry (one person's consumption of one unit diminishes the availability of the unit to the others to consume). In economic term the efficient

amount of pollution is the cross between total damage cost and total control cost for the graph of unit of pollution to unit cost. He also discussed about market failure solutions such as: Pigouvian solution (calculating social optimal price), Coasian solution and the second best approach of Baumol & Oates. He also suggested some economic, fiscal and financial instruments for solving the pollution problems. Those are tradable permits, taxes (taxing pollution and taxing consumption), environmental subsidies, deposit refund system, liability and legal instruments and information disclosure instruments.

Participants looked for the examples being succeeded in implementing the policy tools for environmental preservation. There are success stories in China and European countries, but are not well-documented. The issue of politically motivated regulations sometimes not fully based on the economic criteria but considered the economic status as the base line for the regulations. Community plant concept can be implemented which could be taken care by the people with the support of government fulfilling the environment requirements. Plants can be classified as high pollutant and low pollutant plants for special attentions.

In the second topic of "Policy Instrument in Practice" Dr. Kavi Kumar focused on the environmental management practices in South-Asian region. The approach in developing countries may be altered from developed countries for better adoptability to the situation. The approach of standard & charges, and standard & permits typically considered superior as compared to standard & regulation approach as the formers provide flexibility to the polluters to achieve the standards at least cost. In South-Asia, the physical regulation is the starting point for environmental policymaking. Small fees with assistance can encourage firms to voluntarily engage the abatement efforts. He sited success stories of industrial pollution controls in case of voluntary participation by Mexican brick makers, information provision in Indonesia, two-tier pollution regulation in India etc. For success of MBIs has to cross the barriers in terms of policy barrier, institutional & organizational barriers, and political & cultural barriers. The third –wave environmental policy making is showing up in many developing countries with wide spread community participation, which occurred as scope for effective environmental management by the regulator and polluter is limited.

The participants expected the participation of leaders and businessmen in these types of studies for better awareness. Dr. Kavi Kumar replied in positive way that the high level participants can pass on the thoughts to the concerned parties for successful implementation. During the formation of policies, the authorities should consider all the aspects including economic aspects and parties for greater success and acceptability of the policy.

The final day lecture program was started with the presentation on "Environmental Data Sets and Its Management" by **Dr. R. P. Shrestha**. He discussed on the conceptual aspects of environmental data, its importance in environmental assessment and reporting, and its management. Environmental data can be used for planning to solve the problems in monitoring and management of the projects and also during evaluation and documentation stage. The database can be of three types, such as hierarchical, network (interconnected units) or relational (can be linked by the fields). He also talked on the standardization and harmonization of the data with special emphasis on data sharing. The use of spatial data management can be beneficial for handling environmental issues as 80% of the data has a geophysical component. He illustrated the successful data sharing between the Greater Mekong Sub-region (GMS) countries and related parties.

The participants raised the issues of data sharing and lack of data maintenance for last two decades. Dr. Shrestha agreed with the concerns of difficulty in making agreements for data sharing and lack of capacity building for database development.

Dr. N. K. Tripathi delivered his lecture on the topic with title "GIS Applications for Environmental Planning and Management". He discussed the current situation of data and data sharing in various parts of the world. With the availability of very high resolution satellites, data are now-a-days no more hidden to the outside world. So, data sharing has been encouraged in many

countries to be applied by the public and private organizations. GIS can be a very important tool in managing the huge amount of data considering its potential in terms of time and cost saving with ease for handling it. He described various successful applications of GIS for solving environmental related issues. The illustrations include i) The climate change monitoring in Thailand by using NOAA/AVHRR data, ii) Air pollution monitoring using semi-conducting gas sensors and internet GIS. The climate change monitoring was carried out using the satellite images by comparing the changes in NDVI values of the good year vegetation with that of a drought year. The pollution monitoring unit is very cheap and can be placed in the target areas and the information can be made available through the internet for real time assessment.

As per the queries, the resolution of the map depends on the resolution of the satellite images for example 2.5 m resolution satellite images can produce 1:2000 ratio maps. Number of GIS specialist in the developing countries can be increased by various training programs and short term courses. GIS can be used for any country irrespective of size and location if data with spatial information is available.

Dr. L. A. S. Ranjith Perera delivered a lecture on the topic of "Spatial and Environmental Planning Tools" to the participants. Environmental management system (EMS) is the most sophisticated tool used for environmental planning and management which includes policy & administrative instruments, legal instrument, planning instrument, economic/financial instrument and participatory tools. Spatial planning is the tool used by the public sector to monitor people and their activities for proper distribution of the resources. For example the 'zoning regulation' such as: land use zoning, height zoning and density zoning. Vertical zoning has been placed in action for building construction in Hong Kong city, as to optimize land area the minimum height of the building should not be less than forty-two stories. For special cases the zoning regulation can be compromised with special arrangements and permission of the authority. The industrial zoning is practiced in many cities to keep the city clean and pollution free with reduction of heavy traffic. As a conclusion, the integration of environmental planning into spatial planning is required.

Prof. S. Kumar, Dean of the School of Environment, Resources, and Development, AIT, presented on climate change with the title "Climate Change: Issues and Perspectives". He discussed the climate change issues and means to address them with special attention towards the tools available for it. The two major aspects are how to reduce (mitigate) and how to learn to live (adoption) with the changes. Generally climate change has no boundaries and mostly irreversible process. Green house gag (GHG) effect is mostly felt in developing countries in terms of drought, sea level rise, frequent and intense floods, etc. GHG mitigation can be achieved by monitoring the use of fossil fuels, Increase the use of renewable energy and increase energy efficiency & related measures. The tools available for mitigation are, energy and GHG analysis tools, corporate GHG inventory tools, and forest, land use tools. He also presented two case studies discussing about i) RETscreen and ii) INEM project. RETscreen is a software used to evaluate the energy production, life cycle costs and greenhouse gas emission reduction for various RETs. The INEM project is a success story of cleaner production in a paper mill situated in India with goal to reduce water consumption, reduce waste water treatment cost, and reduce raw material cost and to meet the effluent discharge standards.

The issue of glacier problem has occurred in the current era as the rate of rise in CO_2, aggravated in the current years. Most of the researchers are concerned about CO_2 as global warming gas not to NO_2 and others, as the total amount of production of other toxic gases is less compared to CO_2. There was concern raised on the non-cooperation of developed nations in the issues of global warming. Regional agreements should be encouraged to protect the environment.

Dr. N. T. K. Oanh presented her lecture on the topic of "Management of Air Pollution with Trans-boundary Issues". Source of air pollution can be of two types such as man made (vehicles, and stationary sources) and natural sources (volcanoes, earthquake, forest fire, dust storm etc. She

discussed about the pollution level in metropolitan cities situated in different parts of the world mostly showing high level pollution of the cities in the developing countries. She discussed on the trans-boundary issues of the Asian region including the SEA regional haze from forest, Asian Brown Cloud (ABC), Asian dust, acid rain, Ozone, heavy metals like Hg. etc. Smoking was found in Malaysia during the forest fire in Indonesia. The effect of ABC was felt in the places located at 1000 kms away from the source. International co-operation is required to handle trans-boundary issues. Joints efforts on emission inventories, ecological research, monitoring and modeling can be useful in controlling the issues.

"Clean Development Mechanism" by **Prof. R. M. Shrestha** was the last lecture of the training program delivered in the late afternoon on the final day of the training program. The United Nations Framework Convention on Climate Change (UNFCCC) set the frame work to solve climate change related problems. Clean Development Mechanism (CDM) allows emission reduction projects that assist in creating sustainable development in the developing countries to generate "certified emission reductions" for use by the investors. Major benefits of CDM can be, attract foreign investments, help in waste management, facilitate land use strategies and practice and contribute to sustainable development. The stages of CDM projects are (i) project design and formulation, (ii) National approval (DNA), (iii) Validation/registration, (iv) Project financing, (v) Monitoring, vi) Verification and Certification (vii) Issue of CERs. Designated operational Entity (DOE) is to validate the project as well as verify the achievements of the project (during and after). In the CDM projects generally two parties are involved, one each from developing and developed (Annex I countries) world. It is also possible to have parties only from developing country for a CDM project. The project types may be, small scale CDM project, afforestation and reforestation sink projects, unilateral CDM projects, bundling (combining small CDM projects) and debundling (dividing big CDM projects). All total 141 projects have been granted as CDM projects until March 2006 and another 17 projects are under consideration. There is some draw backs in the CDM projects such as, low CER prices, legal and financial problems, linking with Annex I countries, high risk situations in developing countries and lack of skilled human resources etc. As per the inquiry from the participants, if the project is financed by the host country government still it has to follow the CDM procedure to be counted as CDM project to receive CER certification.

Country Paper Presentations

Participants were requested to prepare a county paper using recent statistics to high light current environmental status with major issues, short and long term specific needs and areas need to be addressed, environmental policies addressing land, water, air pollution, biodiversity and other related environmental degradation, current practices of environmental management tools (technological, fiscal, legal and others) with interesting case studies and best practices. Participants made country paper presentations on the first day afternoon sessions and provided the country papers for inclusion in the training manual. Following country reports were presented.

Afghanistan: *Afghanistan's Bio Diversity - A Quick Overview*

Focus Point: The first country report was presented by the Afghanistan delegates emphasizing on the current environment status including natural asset, renewable resources, environmental degradation, desertification, urban population and agrochemical issues. Desertification is a major concern considering severe and continuous drought conditions in the north, west and south portion of the country. They discussed some possible effects of climate change in Afghanistan. Participants' discussion included the change in situation of Afghanistan in the last century being target by the powerful countries and groups. Positive initiatives in terms of new treaty on environment issues can be the ray of hope for the future.

Bangladesh: *Best practices in Bangladesh - Banning of Polythene Shopping Bags*

Focus Point: The representatives from Bangladesh presented their report on the best practice. They discussed about the adverse effects of polythene on physical environment, soil, water, air, biological environment, agriculture, public health and also economy. The problems like water contamination causing diseases and blocking of drainage and canal, aggravating flood situation and affecting jute farming are the major concerns in banning the use of polythene. More than 90% of the people are in favor of the ban and for substituting bio-degradable paper and cloth bags against polythene shopping bags. Polythene with more than 100 micron thickness is still permitted for use as fertilizer bags and for other uses. The alternatives for polythene are the traditional jute and cloth bags, paper bags, biodegradable plastic bags. This ban is important in favor of strengthening jute cultivation and jute industries in Bangladesh, simultaneously in support of clean environment to a greater extent.

Bhutan: *Environmental Conservation in Bhutan*

Focus Point: The participants from Bhutan discussed about environmental conservation programs of Bhutan. First they mentioned about the overall development philosophy of the country. They highlighted the rich environmental resources of Bhutan with emphasis on the strong political wills and commitment for conserving the resources from the ill-effects including agricultural intensification, urbanization, industrialization, tourism, mining and climate change. Some of the environmental institutions of Bhutan and their functions were discussed in the presentation. They also discussed on some of the negative effects of small hydropower units on environment. The participants stated some threats to Bhutan's natural resource base which are increasingly being felt from a variety of development related activities including infrastructure development, industrial expansion, employment shifts, growth of foreign tourism, changing consumption patterns. Bhutan participates in all treaties concerning the protection of environment. The public participation is also encouraged in Bhutan with a fixed time period for taking decision on a project.

India: *Overview of Environmental Impact Assessment of Developmental Activities in India*

Focus Point: The Indian delegates discussed about the EIA practices of India. The delegates pointed out how the rapid economic growth is drastically changing the nature and scale of impact on natural eco systems and testing the carrying capacity of the natural resources upon which much of the country's economic growth relies on. Certain environmental legislations of the country were highlighted in the presentation. There are laws concerning environmental issues in the central level. Environment related responsibilities are distributed between the central and state governments. Separate rules are formed in India for new units as well as the existing projects/units affecting environment. Some of the best practices are reduction of fluoride emission from alumina industries and reduction of green house gases etc. Industries are also classified as High COD or Low COD type industry for proper management of environmental issues.

Maldives: *Environmental Management in Maldives*

Focus Point: The representatives of Maldives talked about the existing tools for environmental management in their country. The presentation started with overview, brief introduction of Maldives, issues and challenges. The key issues presented were the population and environment, bio-diversity, sustainable tourism and climate change. Change in the ground water quality coupled with after the Tsunami is a great concern now. School level "eco-clubs" can be considered as one of the best practices in Maldives to create awareness about the environmental issues among the school children. Issues like sea water rise, rain water harvesting for drinking water were raised by the participants. The key challengers like new and young Environmental Ministry, lack of expertise in legal issues and lack of resources for the applications of the existing tools were discussed. New

attempts are being made to document the sea-rise issue, promotion of water treatments plants and tourism sector in the country.

Nepal: *Updates on Environmental Status of Nepal*

Focus Point: The Nepalese participants discussed on current environmental status of Nepal. The report included the statistics of the environmental resources in Nepal, extent of land degradation, significant environmental issues like forest depletion, solid waste management, haphazard urbanization, dwindling biodiversity, ground water depletion etc. Environmental certificate has been enforced for the projects and industries. According to the country regulation, 1:25 rule applied for cutting the trees. It means that cutting one tree should be replaced with 25 trees and providing maintenance for five years. Community forest activity should be considered as the best practice, which can be introduced in other countries. Some of the policy shift in some areas is also highlighted through the presentation. Those areas are forests, fauna, pollution control, and energy etc. They also introduced Strategic Environmental Impact Assessment (SEA) in place of EIA for better management.

Pakistan: *National Environmental Initiatives in Pakistan*

Focus point: The country report of Pakistan was mostly focused on national environmental initiatives, national institutional arrangement, national environmental policy, law and national conservation strategy. Best practices of Pakistan include successful control of air and water pollution reduced to non-threatening level. The issues were raised concerning the awareness level of literate and illiterate groups and the success level of individual attempts for environmental protection. The participants including the presenter agreed that the higher education may not be helpful in environmental protection rather a well-aware low educated person can do a better job for environmental conservation. It was agreed that combined attempts of government, people and organizations are required for securing a sound environment.

Sri Lanka: *Environmental Issues, Policies and Environmental Management Tools in Sri Lanka*

Focus point: The participants from Sri Lanka presented their country report emphasizing on the national environmental policies & action plans with key environmental issues. They identified the key sectors for special attention - land degradation, loss of bio-diversity, pollution of inland water, depletion of coastal resources. In Sri Lanka, sector based environmental action plans are being prepared. The process has three working stages such as Immediate (for example: enforce ban on coral mine), Short Term (for example: managing wetlands) and Medium Term (for example: draft policy formulation for cleaner production), etc. There are six committees for monitoring the environmental issues called as CEPOM. The major problem faced by Sri Lanka is to maintain balance between environment and development, which is very common in developing countries. So emphasis on environment protection should be given to achieve sustainable development.

Summary: Most of the country presentations were of general type, focusing on the status of the environment of the countries, the environmental issues, challenges and constraints, their environmental institutions, environmental policies, action plans and laws. Some of the countries presented the EIA under practice, national and international environmental policy initiatives. Few interesting case studies were also presented such as ban of plastic bags in Bangladesh with radical recommendations to support jute industry in the country.

Field Visits in Thailand

On-Nuch Disposal Site for Solid Waste Management

A filed trip was organized in the afternoon of the third day training program under the guidance of Prof. Visvanathan to provide some practical experience on the solid waste management operations. On-Nuch solid waste management site was selected for the field visit. The site is located in the south of Bangkok Metropolitan city. There are another two disposal sites in Bangkok namely Nong Khaem and Tharaeng sites. BMA uses two private landfill sites located at Kampaengsaen in Nakhon Pathon and Rachatheva in Samut Prakan. The compost plant and the incineration of infections waste are located at On-Nuch disposal site.

The type of solid waste received at the site is of three kinds, such as domestic waste, medical waste and construction & demolition waste. The solid waste is collected by two methods, such as direct method and indirect method. BMA has around 2,000 compaction and side loading trucks in daily operation. The total amount of solid waste collected from Bangkok is around 8,500 to 9,000 tons per day. The projects under the consideration of BMA include (i) Public awareness, (ii) Waste collection improvement, (iii) Waste disposal improvement, (iv) Night soil management improvement, etc. The participants visited the compost plant located near the site and also plastic drying mechanism owned by a private organization, and the other disposal systems around the site.

The land fill site is selected by EIA with a life span of 10 years. A minimal charge of 4-5 baht/ family has been collected for waste disposal. Generally waste is collected in night time to avoid the traffic problems. They are now planning to collect gas to use as fuel. Due to the low ground water depth (around 5 m) the waste disposal is carried out on the soil, in upward direction rather than under soil structure to avoid ground water contamination. Generally hazardous waste is not handled by BMA.

Field Visit to Eco-House

The field visit to the Eco- house was organized in the post lunch session on the third day of the training program under the guidance of Prof. J. K. Routray. Eco-house demonstrated a series of environmental friendly techniques to build house for the residential purpose. The duplex with three bedrooms belonged to and designed by Dr. Soontorn Boonyatikarn, a Professor of Architecture at Chulalongkorn University, Bangkok. The house is situated in Bangkok in the vicinity of Dream World Park. The built up area of the house is 143 m^2 surrounded with trees and plantations in a total area of 210 m^2 area. The total cost of project is five million baht and the whole project is completed in 4 months. Locally available materials have been used for the construction of the building.

The eco-house is working under the principle of energy saving attained by well-designed structure, energy saving construction materials with a double door entry and windows for proper ventilation and lightening. Natural light has been reflected into the house with well-placed glass walls and windows. There are facilities for non-conventional energy from the solar cell and bio-gas plants and wind energy system is under construction for addition in near future. The solar system will be complemented by wind energy system as in the overcast condition always follows with wind at higher speed. The absence of wind and solar system can be fulfilled by the bio-gas plant. The concept of energy saving is properly followed in the operation of air cooler. The steel frame with gypsum boards is used for insulation in both sides of the wall to prevent exchange of heat between the house and the out side. For efficient use of the air conditioner the doors are two stage openings preventing direct contact of out side air with inside. The wall and the floor are also cooled to the temperate as that of the house i.e. 25^0C and 50% RH. The air cooler is continuously working in order to prevent restarting the cooling process of the whole house. The water is generally recycled. The energy produced in the day time is sold in the day time to the EGAT. As per the equation the energy consumed from the commercial electric supply during night time is one-third of the energy sold during the day time. Low-power lights with recommended capacity of the fans are installed in

the house to optimize the energy use. Water collected from the condensed water on the air conditioner and from the roof top and purified for the general application.

Participants appreciated the concept and applied value of the project and spent time in collecting technical as well as general information of the eco-house. The demonstration encouraged all the participants to think and work for promoting such activities in their own countries.

Review of the Training Program

Mr. Surendra Shrestha chaired the last session on the fifth day of the training program to make a review of the training program and identify future needs, and collect feedbacks for future course of actions. Mr. Shrestha highlighted on the capacity building for South Asia. He focused on HRD through training (modular courses for national level actors), linking institutions, regional cooperation through SAARC, SACEP and ICIMOD), and environmental management building on traditional knowledge. Ministries, Environmental institutions, NGOs, and other parties concerned with environmental related issues must be brought together to common platform to share and contribute for making the environment safer and more secured.

Participants' Responses: In reviewing the training program, participants were asked to give their responses and recommendations for future training programs. Following the initial remarks of Mr. Shrestha, the participants reflected from different angles – the role and expected contributions by the UNEP and on the overall outcomes of the training program. The points immersed from the discussions are presented below under different headings.

Training schedule and timing of sessions: Overall the schedule was very heavy in terms of number of topics covered within a short time. There was very little room for discussion in each session and interaction with the resource person. The starting time at 8.00 was considered too early for the participants. The time allocated for the topics were also much less to cover intensively. In each session, 60% time should be given for presentation and rest 40% should be for discussion and interaction.

Field trips: Participants have responded positively about the field visits on solid waste management and eco-house project. They suggested for more such field visits required to acquire practical knowledge and information about best practices. All afternoon sessions should have been devoted for field visits.

Topics covered: Participants felt that the topics in some cases are very basic, theoretical and academic in nature. In some topics the data presented were not updated. The topics were not adhered to the theme of the training program. They suggested few topics for inclusion in the future training program. The topics are CDM projects (with specific cases), GIS and Remote Sensing, and technology with policy issues.

Resource person: It was recommended to involve resource persons with practicing professionals from outside to enrich the training program through contributions made on best practices and sharing directly about management tools and practices.

Course delivery mechanism: Participants mentioned to organize such courses in the workshop format to involve the participants more intensively for mutual interaction and benefits.

Gender equality: With regard to the gender aspect, majority of the participants expressed to involve more women resource persons and also to invite more women participants to make the program gender balanced.

Expectations from the UNEP: Participants expect and request the UNEP to facilitate country officials for regular exposures and acquire new experiences through training and field based

practical activities. UNEP should play the role in filling the environmental data gaps at the regional level and facilitate for data sharing among the countries. It is essential to organize training programs for the members of the National Parliament and Judges of the SAARC countries. UNEP should extend support in building awareness by providing and documenting materials for mass media.

Closing Ceremony

The training program was ended with the presence of Prof. Said Irandoust, President of AIT accompanied by Prof. Peter Haddawy, Vice President of Academic Affairs, Prof. Vilas Wuwongse, Vice President of External Affairs, and Prof. S. K. Rakshit, Vice President Research. Prof. S. Kumar, Dean, SERD, Prof. C. Visvanathan, and Dr. M. M. Ahmad were present in the closing ceremony. Prof. Irandoust delivered the closing remarks for strengthening ties with South Asian countries for collaborative programs and activities in future in the areas of research, outreach and consulting activities. The training program concluded with a vote of thanks by Prof. J. K. Routray to distinguished participants for their active participation and invaluable contribution to the program and followed by the distribution of certificates to the participants by Prof. Irandoust.

Evaluation of the Training Program

Each session was evaluated through a structured questionnaire. Full attendance of the participants was not achieved in each session. In terms of relevance and importance of the training program, majority of the participants has the view of extremely relevant and expect more such training programs in near future.

In terms of the content of the topics, suggestions were made to arrange similar type of training programs with more focus on EIA, GIS and Remote Sensing tools. However a number of suggestions were made to include topics as mentioned below. The topics are:

1. Arsenic problem in ground water
2. Drought and desertification
3. Adaptation to climate change
4. Implementation of MEA including climate change and biodiversity
5. Sustainable development
6. Eco system approach for Environmental Management
7. Eco system based urban planning
8. Biodiversity conservation in the context of traditional knowledge
9. Life Cycle Assessment and SEA
10. Role of women in Environmental management

Appendix 4

Group Photo of AIT-UNEP Training Program

AIT Conference Center, Asian Institute of Technology, Thailand