APN

Asia-Pacific Network for Global Change Research

Application of the Human Ecosystems Model (HEM) to Urban Environmental Management in ASEAN

Final report for APN project: ARCP200602CMY-Marcotullio

The following collaborators worked on this project:
Peter J. Marcotullio, United Nations University, Institute of Advanced Studies, Japan, pjmarco@ias.unu.edu
Loh Ah Tuan, Chairman, ASEAN Working Group on Environmentally Sustainable Cities, Director Singapore National Environment Agency, loh_ah_tuan@nea.gov.sg
Raman Letchumanann, Deputy Director, Environment, ASEAN Secretariat, Indonesia, raman@aseansec.org
Gopal Thapa, AIT, Professor, School of Environment, Resources and Development, Thailand, gopal@ait.ac.th
Gary Machlis, University of Idaho, Professor, College of Natural Resources, USA, gmachlis@uidaho.edu

United Nations University
UNU/IAS
Institute of Advanced Studies

ASIAN INSTITUTE OF TECHNOLOGY 1959

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National Environment Agency

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Final Report submitted to APN

Overview of project work and outcomes

Non-technical summary

Resolving current environmental challenges in cities of Southeast Asia demands new planning and management approaches. The ecosystem approach to urban environmental management provides opportunities to reveal policy leverage points not articulated in more traditional, sectoral engineering approaches. The Human Ecosystem Model (HEM) represents an example of this new holistic, integrated thinking about cities. It presents a way to examine the relationship between the major social, economic and biophysical elements responsible for the emergence of environmental challenges, and hence provides a roadmap for addressing harms and for proposing effective actions that are locally appropriate. This project uses the HEM as a basis to create a capacity building tool for the application of the ecosystem approach for ASEAN urban environmental planning and management. Specifically, we address water related urban environmental issues. The project has produced a draft capacity building tool for training city managers to use the HEM, a draft guidelines policy paper on the basic principles of the HEM and how to identify policies through its application and research papers on water challenges in ASEAN and fundamental elements of the ecosystem approach for planning.

Objectives

The main objectives of the project were:

1. Provide 3 capacity building workshops within the Association of Southeast Asian Nations (ASEAN) region. The first two target urban environmental decision makers and the last workshop is a "train-the-trainers" workshop;
2. Develop a capacity building tool in the form of a CD-ROM that can be used by others in the region to continue convening workshops using the HEM; and
3. Produce background research (case study of urban water related issues in ASEAN and the potential of the ecosystem approach for urban planning and policy) and a guideline paper for how to apply the HEM to policy analysis.

Amount received and number years supported

2005/06: USD35,000

2006/07: USD25,000

Activity undertaken

- Attendance at the ASEAN Working Group on Environmentally Sustainable Cities to present the project to delegates and receive feedback from members, June 2005;
- Co-PIs (Peter J. Marcotullio and Gary Machlis) planning meeting, in Moscow, Idaho (USA), September, 2005
- Contract issued to Gary Machlis, October, 2005
- Administrative meeting with ASEAN Secretariat and ASEAN Working Group on 13 February 2006 resulting in endorsement of the project by ASEAN
- Selection of Wayde Morse as research assistant to Gary Machlis, January 2006

- The first workshop was held on 28-29 June 2006, at the Asian Institute of Technology, Bangkok, Thailand.
- First draft of HEM training manual August 2006.
- Co-funding for the project awarded from ASEAN Secretariat through a grant from Singapore (US$20,000).
- APN Newsletter submitted for publication (see APN Newsletter 2006, 12(2)).
- Second year contract awarded to Wayde Morse research assistance to Gary Machlis, October 2006.
- Acceptance of research paper to *Sustainability Science* on urban water related challenges in ASEAN, November 2006.
- The second capacity-building workshop of the “Application of the Human Ecosystem Model (HEM) to Urban Environmental Management in ASEAN” project was held on 26-27 January 2007, with support from the National Environment Agency, Singapore.
- Second draft of the HEM training manual 26-27 January 2007.
- First draft of HEM guidelines for policy, January 2007.
- Publication of an article related to the project in *Sustainability Science*, January, 2007.
- Submission of the research paper on the application of the ecosystem approach to planning, *UNU-IAS Working Paper series*, September 2007.
- Last ‘train-the-trainers” workshop currently being organized for 8-9 November 2007, AIT, Bangkok, Thailand.

Results (as of July 2007)

- 2 Capacity building workshops (23 urban environmental decision makers from cities throughout ASEAN);
- 1 published journal article;
- 1 working paper completed;
- Draft manual for the application of the HEM for water related urban environmental challenges in ASEAN;
- Draft policy guidelines for the application of the HEM.

Relevance to APN’s Science Agenda and objectives

The human ecosystem model as applied to urban areas has relevance for local and global ecological and environmental integrity. For example, water systems and their related dimensions (including infrastructure, demands on ecological services, human behavior and health, industrial development policy and trade) have implications for local health, regional water quality and global climate change. The HEM helps us understand the relationships between the social and biophysical drivers, their complex interrelationships and the impact on the local ecosystem in a comprehensive and integrated manner. Moreover, the approach helps to provide planning with important information through forecasting and backcasting techniques. Finally, the approach provides the basis for capacity building training that can successfully be implemented in developing countries.

The project touches on many aspects of the APN research agenda including and most importantly, the impacts of and potential response to climate change. The APN research agenda includes this focus in a series of formats including changes in atmospheric composition, changes in coastal zones and inland waters, climate change and variability, and changes in terrestrial ecosystems and biodiversity. This project, with its focus on environmental change, water related urban challenges and the application of the ecosystem approach includes issues within many APN flagship areas.

Self evaluation

The project was effective. We believe that the ecosystem approach and specifically, the HEM can provide new insights into solutions for both potential and actual environmental challenges currently being experienced by ASEAN cities. To this end this project trained city managers in the application of the HEM in two different workshops. We will also provide a training manual for application of the HEM to water-related issues as a tool for future training sessions. We believe that this training was valuable to participants and that the research effort was fruitful.

Unfortunately, however, we were not able to convene the last "train-the-trainers" workshop within the dates planned. We will do so, at no extra cost to the APN or other funding organizations, in November 2007. Thereafter, within several months of the completion of the final workshop, we will produce the final CD-ROM and Policy Guidelines as originally proposed.

Potential for further work

There are several future pathways for work related this project. First, in terms of research we are interested in further exploring the differences in environmental conditions between rapidly developing urban areas and those of the now developed world. We believe that current globalization driven growth as well as domestic and local drivers of change are significantly different now than experienced in the past and that therefore the structure of environmental conditions (that they are appearing at lower levels of income, changing faster and emerging in a more simultaneous fashion than previously experienced) demand new environmental policy approaches. Further elaboration on these differences and how they are related to differences in drivers is of interest to this project and the larger global environmental change academic community.

Second, there is also work to be done exploring how integrated approaches, such as the HEM, can be applied to applied in the developing world context. While there has been some work in the developed world there is yet to be a significant amount of policy research in this area within the developing context.

Finally, we remain committed to the idea of capacity building training using this approach. We have already developed a funding proposal for the continuation of this work using the HEM as the fundamental conceptual paradigm to apply the training. We are currently considering where to send the proposal to and how to further promote this type of capacity building training. While we are currently focusing on the Asia Pacific region, we are also open to moving to other developing regions.

Publications

Peter J. Marcotullio, (2007) Urban water-related environmental transitions in Southeast Asia, *Sustainability Science*, 2(1): 27-54.

Peter J. Marcotullio, (2007) Ecosystem approaches and urban environmental planning, *UNU-IAS Working Paper,* (forthcoming).

Acknowledgments
We gratefully acknowledge the financial support from the Asian Institute of Technology, the ASEAN Secretariat and the United Nations University, Institute of Advanced Studies. Our workshops have been organized through the ASEAN Working Group on Environmentally Sustainable Cities, chaired by Loh Auh Tuan. Mr. Loh as Director at the Singapore National Environment Agency has also been able to support this work with his very knowledgeable and effective staff including Chua Yew Peng, Bin Chee Kwan, Soh Suat Hoon, Koh Mei Leng, Jacin Chan, Desmond Lee and Wesley Wong. We could not have convened the Singapore workshop without their help. Those at the ASEAN Secretariat, lead by Raman Letchumanan were also helpful, lending their administrative expertise and time for the project. Members of our ASEAN Secretariat team include Wendy Yap, Aprianto Masjhur and Vinca Safrani. The AIT team component of the project, led by Prof. Gopal Thapa, helped us with the initial development and initiation of the project, as well as helped with the organization and implementation of the first workshop in Bangkok. We are also grateful for the support of Professor Thammarat Koottatep, AIT, who is helping us with the last workshop. Lastly, we had assembled a particularly effective capacity building training team, co-led by Gary Machlis (U. Idaho) including Wayde Morse (U. Idaho), Niels Schulz (UNU-IAS), Clarice Wilson (UNU-IAS), Tatiana Gadda (UNU-IAS), Jean McKendry (U. Idaho) and Ademola Braimoh (UNU-IAS). We owe all of them a special debt of gratitude.

Technical Report

Preface

Given the complexity of problems arising from environmental impacts, policymakers require information that will allow them to identify the driving forces responsible for conditions and to weigh trade-offs related to future pathways. The project, "Application of the Human Ecosystems Model (HEM) to Urban Environmental management in ASEAN," consisted of both research and a series of capacity building workshops on the application of the HEM in ASEAN. The purpose of these workshops was to introduce HEM as a decision making tool for urban planning and management of water-related issues in the ASEAN region. The audience for the training was city managers working with urban environmental planning issues. The research results were used in the training and published for the academic community.

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1.0 Introduction

Resolving environmental challenges being experienced by cities in Southeast Asia demands a new management approaches. The ecosystem approach to urban environmental management provides opportunities to reveal policy leverage points not always articulated in more traditional, sectoral engineering approaches. The Human Ecosystem Model (HEM), for example, presents a way to examine the relationships between the major social, economic and biophysical elements responsible for the emergence environmental challenges and their impacts at different scales. Hence, the HEM can potentially provide a roadmap for addressing harms through effective actions that are locally appropriate. This project provides the background for addressing water related issues in the region, a theoretical understanding of the promises of the ecosystem approach and uses the HEM as a basis for capacity building training for resolving water related urban environmental burdens in the region.

The project is designed to create a capacity building tool for the application of the HEM for ASEAN urban environmental management. It also has produced research findings, in the form of a case study of urban water related issues in ASEAN, and a study of the potential of the ecosystem approach for addressing these types of issues. Moreover, we were able to convene 2 capacity building training workshops in which 23 urban managers and young scholars across the region participated.

We introduced the application of the HEM to local and/or metro-wide environmental issues related to water access, supply and quality (topics that could be addressed include, *inter alia,* flood vulnerability and drainage; cross-sector competition for water supply; water quality and sanitation services) in ASEAN cities. We used the HEM framework in workshops with city managers to identify a set of issues related to environmental pressures and enhance the understanding of city managers to potential solutions. We also will produce a guidelines paper for how to apply the HEM to policy analysis. These two final aspects of the project required convening capacity building training workshops, of which we have completed two and will shortly convene the final (November 2007).

This technical report introduces the work accomplished over the last two years. In the next section, Methodology, we introduce how we produced the research, used the results in the training and proceeded to convene two of the three workshops. In the results and discussion section is describe the findings of our research and provide the details of the capacity building training. As such this section is sub-divided into three further sub-sections. In the fourth section we conclude and in the fifth section we address further work in this area. Appendices contain important information concerning data, workshop agendas and participants, funding sources and workshop evaluations.

2.0 Methodology

The project focused on using the ecosystem approach as a capacity building training tool to address water related issues in ASEAN cities. As such, there were essentially three major parts to the effort: water-related urban environmental issues, the ecosystem approach and specifically the HEM and capacity building training. We addressed the first two parts of the project as research and review tasks. We then used this information while also developing a capacity building training tool.

The research products include two different papers. The first on a survey of water related issues in the ASEAN region experienced by cities, but at different scales (in terms of effect of urban activities and impact on urban areas). This information was subsequently included in a research paper and published in *Sustainability Science* (2007, Volume 2, No. 1). The second paper focused on the potential of the ecosystem approach for addressing the complex environmental conditions, particularly in the developing world. It elaborates on the fundamental aspects of the ecosystem approach and how they can benefit urban managers. This product is a working paper to be published at the United Nations University Institute of Advanced Studies (UNU-IAS).

The capacity building training tool was developed through convening workshops designed to introduce techniques involved in the ecosystem approach to city managers from 23 different cities in the ASEAN region. These cities were selected as they were all member of the ASEAN Working Group on Environmentally Sustainable Cities, with which we worked closely. Members from each city within the Working Group attended one of two of these workshops. During each workshop we focused on teaching the basics of the HEM and how to apply it to urban management in a particular water-related issue area. Active engagement with participants was essential in order to produce the draft manual (currently included in the CDs but not in hard copy) and draft guidelines (see Appendix E). A final workshop entitled, "train-the-trainers" will focus on training young academics from the ASEAN region on how to hold future workshops on their own. This final workshop will be held at AIT, 8-9 November 2007. Thereafter the final manual will be produced in CD-ROM form.

3.0 Results & Discussion

This section is divided into three further sub-sections as related to the outputs of the project. The first section surveys urban water related issues in the region, as this provided the background for the capacity building effort. The second sub-section elucidates how the ecosystem perspective is relevant to contemporary urban water environmental challenges. The last sub-section summarizes how the transfer of knowledge on the application of the human ecosystem model to water related urban environmental challenges in ASEAN occurred through the capacity building training workshops.

3.1 ASEAN cities awash in water-related burdens[1]

Water related urban environmental challenges can be divided into categories by their scale of impact (**Table 1**). This section provides evidence that urban water decision makers in the region are increasingly forced to address similar sets of water-related challenges, at all scales and at lower levels of income than experienced during previous times. It does so, by presenting data on both the state of the environment within cities of the region as well as status of the driving forces impacting the environmental conditions.

[1] This information was included in an article entitled, "Urban water-related environmental transitions in Southeast Asia," *Sustainability Science*, 2(1): 27-54.

3.1.1 Local water issues

Local water-related environmental issues include access to safe drinking water and sanitation and appropriate drainage. These are associated with local environmental health, which in turn, are associated with urban poverty (Hardoy, Mitlin, & Satterthwaite, 2001).

While Asia economic growth has accompanied reductions in both relative inequality as well as absolute poverty (Fields, 1995), levels of poverty in the ASEAN region remains high in some countries **(Table 2)**. In Cambodia, Lao PDR and Vietnam, poverty levels are between 35 and 40 percent. For other countries, such as Indonesia, Myanmar and the Philippines, the situation is slightly better with poverty at levels between 17 and 28 percent. Then there are counties with lower but significant levels of poverty, such and Thailand and Malaysia with 10 and 8 percent respectively. Brunei Darussalam and Singapore, on the other hand, can boast of small populations in poverty.

Until recently, the problem of poverty throughout Asia was considered predominately rural (Quibria, 1993). With increasing urbanization, poverty has urbanized (see for example, UN-HABITAT, 2003a). Indeed, in a review of urban poverty in Asia, Mills and Pernia (1994, p. 2) predict that "because of continuing urbanization and urban population growth, poverty will increasingly become an urban phenomenon and, regardless of economic growth performance in the short to medium term, will remain a formidable problem in many countries for years to come."

In the urban setting, the poor typically live in slums or squatter developments. Globally, there are approximately 900 million people living in slums, which include 43 percent of the urban population in developing regions (Garau, Sclar, & Carolini, 2005). As there is no simply way to measure slums, this figure probably underestimates the extent of urban poverty (Satterthwaite, 2005).

Table 3 presents figures on poverty in the region's cities.[2] These data suggest that the percentage of households in poverty is prevalent in most of the region's cities. Examples of slums in the region include Bangkok's 866 slum areas typically located along canals or in concentrated nodes, which hold 16 percent of the cities population. In Jakarta, 20-25 percent of the city's population lives in *Kampungs*, with an additional 4 to 5 percent squatting illegally. In Manila, poverty is located in the 526 slum communities housing 2.5 million people. While these communities are fairly discrete, the urban poverty in Metro Manila can be found wherever there is space and opportunity. In the relatively high-income Klang Valley, Malaysia, the location of Kuala Lumpur, approximately 9.2 percent of dwelling units are squatter housing (Bunnell, Barter, & Morshidi, 2002).

Poverty and slums are typically known for local environmental issues associated with ill-health. Two important indicators of poverty, slums and the brown agenda, for example, are the numbers of people without access to water and sanitation (UN-HABITAT, 2003a). Globally, the number of urban dwellers who have inadequate access to water and sanitation is underestimated and reaches into the hundreds of millions. Perhaps as many as 100 million urban dwellers world-wide have to defecate in open spaces or into waste paper or plastic bags because there are no toilets in their

[2] Estimates for the number of people living in slums in Southeast Asia are as high as 56.7 million or 28 percent of the total urban population in the region (UN-HABITAT, 2003a).

homes and public toilets are not available, not safe, too distant or too expensive (UN-HABITAT, 2003b).

International efforts to measure local access to water and sanitation can be confusing. On the one hand, one set of indicators suggest that there are those that have access to “improved” water and sanitation. For example, 85 per cent of the urban population in Africa, Latin America and Asia have “improved” water and 84 per cent has “improved” sanitation **(Table 4**). Many of those populations classified as having “improved provision,” however, may be sharing facilities with hundreds of people (Garau et al., 2005). That is, while provision may be “improved” it may not be “safe” and “adequate” (UN-HABITAT, 2003b).

Another important limitation to urban data is the misleading quality of aggregated statistics, which hide the scale or depth of deprivation among poor urban populations. That is, concentrations of middle and upper-income populations within cities, which have good provision to services, can bring up averages (Garau et al., 2005). For example, in a review of demographic change in developing country cities, Montgomery *et al*, (2003), documented differences between urban poor and non-poor child health (in terms of height and weight) and household access to public services (water supply, sanitation, electricity). The distinctions between the urban poor and urban non-poor were similar amongst a number of variables. Access for the urban poor to services is sharply worse than that of the urban non-poor and childhood health of the urban poor is worse than that of the urban non-poor. These authors conclude that it is likely that poverty-related differences in children’s health are due, in part, to differences in access to environmental and other services. These differences are hidden by averages for entire cities.

On top of the confusing nomenclature and misleading quality of aggregated information, urban data for water issues are hard to come by. More often than not, the data are not standardized across cities and can only be used in comparative studies with care. Moreover, either numbers change without adequate explanation or data cited are old and may be out-of-date. Given this state of confusion it is not surprising that some have called for a region-wide assessment of urban conditions so that policies can be adequately elaborated (Savage, 2006; Sonnenfeld & Mol, 2006).

Given these caveats, one approach to using data is to present a number of different datasets for analysis. Information complied at the regional or national level may be conservative, but these data can be supplemented by figures from more detailed studies of individual Southeast Asian cities. Together this information provides a fairly accurate picture of what is happening in the region.

As shown in **Table 4**, the numbers that do not have access to safe water and sanitation in Asia are in the hundreds of millions; up to 700 million without access to safe drinking water and up to 800 million without access to sanitation. Data at the national level for Southeast Asian access to water supply demonstrates improvement over the decade **(Table 5)**. The recognized improvements are likely due to a number of recent reforms to local environmental governance including increased decentralization, community participation and privatization of water facilities (Mushtag Ahmed Memon, Imura, & Shirakawa, 2006). Despite the improvements, however, countries such as Cambodia, Lao PDR, Indonesia, and Myanmar still have more than 70 percent of the urban population without access to drinking water. Vietnam has almost half its urban population without safe access, 40 percent do not have safe access in the Philippines and 20 percent do not have safe access in Thailand. **Table 5** also demonstrates the difference between those with “improved” provision of water supply and those with household connections (which might be the basis for a definition of “adequate”). For example, while in 2002, 78 percent of the urban population in Indonesia had “improved” access to water supply, only 17 percent had household connections.

Data from studies of individual cities within the region tell a more detailed story **(Table 6)**. Not only does a large proportion of the population with “improved” services, lack safe, convenient and adequate services, but current percentages of those with safe and adequate services may have been overestimated. Within the major metropolitan centers in the higher income countries (except Singapore) there are large differences in statistics concerning numbers of people without access to water. For example, The UN-HABITAT (2003b) suggest that while the official statistics for Kuala Lumpur suggest 100 percent of the population has access to water, only 45 percent have access to outlets in their homes. In Bangkok, the same publication suggests that while the utility claims 82 percent have access to water only 63 percent have taps in their homes. In Manila, only 38 percent have taps in their homes and up to 33 percent do not have any access to piped water.

Moreover, many cities in the region have very low levels of water consumption per person. In Phnom Penh, average water consumption is 32 liters per person per day. In Hanoi average water consumption is 45 liters per day and in Yangon water consumption is 67 liters per day. Given that these are averages for whole city populations, they probably hide significant proportions of each city’s population that use less than 20 liters per person per day (UN-HABITAT, 2003b).[3] The low levels of water provision do not necessarily mean that citizens in these cities are more conserving of the resource than others, or that water is scarce. More likely fresh water isn’t being provided in sufficient quantities. These statistics underlay the serious problems of potable water in many of the region’s cities (Laquian, 2005).

The other side of water supply is sanitation and waste water removal. This aspect of water management is crucial as if done poorly can create obnoxious if not unhealthy conditions. **Table 7** suggests there also have been significant increases in access to improved sanitation services throughout the region during the 1990s. Thailand has reached almost complete coverage. Myanmar’s improvement jumped from 45 to 64 percent access during the decade (UNEP Regional Resource Center for Asia and the Pacific, 2004). Improvements at the urban level have been even more impressive. Improved sanitation reached 66, 84 and 96 percent of the urban populations of Indonesia, Vietnam and Myanmar. Again, these figures may not present the entire story. They are records in “improved” sanitation, not access to safe (i.e., in household) sanitation.

Within many cities of the region, water supply systems are not well integrated with the sewerage, drainage, storm water and flood control systems. The Asian Development Bank has recently reviewed the performance of utilities in selected cities in Asia (Asian Development Bank, 2004). **Table 8** presents some of their findings. As can be seen, none of the urban centers of the Lao, PDR are serviced with a sewerage system (UNEP Regional Resource Center for Asia and the Pacific, 2001a). Vientiane’s small bore sewer system is not working properly. In Phnom Penh, only 41 percent of the city is

[3] 20 liters per day per person is considered essential and between 50-60 liters per person per day is needed to allow sufficient water for such domestic needs as washing, food preparation, cooking, cleaning laundry and personal hygiene (more would be needed if flush toilets were being used) (UN-HABITAT, 2003). According to the World Commission on Dams (2000), in 1990, over a billion people had access to less than 50 litres of water a day.

covered by the city's sewerage programme. Approximately 12 percent of households have not toilet facilities. Ho Chi Minh has even lower levels of sewerage coverage (about 12 percent)
In Metro Manila, 7 percent of the population of those served by the Metropolitan Waterworks and Sewerage Service, have sewerage connections (Mushtaq Ahmed Memon, 2003).

In Jakarta, there is no comprehensive water sewer system. Only 2 percent of the city is currently served with sewerage. Approximately, 73 percent of households have private lavatories in their homes,[4] while 16 percent had shared private toilets and 12 percent used public toilets. Of 851 household toilets observed, more than half have no hand-washing basin in the vicinity. One third of respondents report that some people in their neighborhood defecate outside; this was mostly done by children and the most common sites were drains and gutters (UN-HABITAT, 2003b).

Other cities within the region demonstrate similar trends. In Cebu, the Philippines approximately 45 percent of households have access to water-sealed toilets (of which sharing is common), with 18 percent relying on pit latrines and 36 percent having no toilets. For this last group, the convenient recourse is open defecation (UN-HABITAT, 2003b). Even in higher income Bangkok and Kuala Lumpur there is yet to be full sanitation coverage. Only 2 percent of Bangkok's households are connected to the city's sewerage system, 25 percent rely on septic tanks, and the rest use pit latrines and other means for disposing of human waste and gray water (Laquian, 2005). In Kuala Lumpur approximately 80 percent of the city has sewerage, and the remaining use septic tanks.

Many cities in Southeast Asia do not have formal drainage systems, but merge combined sewer overflow systems with a series of canals, called *klongs* in Thailand or *esteros* in the Philippines. There are approximately 1,145 *klongs* left in Bangkok. These waterways are remnants of previously extensive systems that ran throughout the city intimately weaving water into the urban form. Indeed, Bangkok started as a city of floating houses, as is still found in some parts of the region. Only the Grand Palace and the temples were initially on firm ground. The city initially grew in a ribbon pattern of settlement which clung to the banks of the Chao Phraya River. By 1864, there were few inland roads. One observer at that time wrote "Bangkok is the Venice of the East and whether bent on business of pleasure you must go by water" (quoted in Smithies, 1986, p. 38).

As Bangkok and other cities close to waterways grew, particularly after the 1950s, however, they changed in nature and in regard to these transport and drainage systems. Inland roads were developed and canals were filled in as people and activities moved onto higher ground. The canals that remain, in cities as economically diverse as Bangkok, Ho Chi Minh City and Jakarta are now primarily used for drainage. In Jakarta, for example, entire sections of the city lack formal drainage (Cybriwsky & Ford, 2001) and much of what acts as a drainage system is made up of former canals local rivers (Laquian, 2005).

In other cities, there is even less adequate drainage. In Lao, PDR, for example, storm water drainage in most urban areas consists of roadside ditches leading ultimately to

[4] Cybriwsky and Ford (2001) estimate that about half of Jakarta's residential facilities lack toilet facilities. Hadiwinoto and Lietmann (1994) suggest that among the lowest income quintile of the city only 6 percent have piped-in water and 64 percent share toilets.

natural streams or rivers. Drains are not adequately interconnected and do not form networks. Storm water drainage is a serious issues in Vientiane (UNEP Regional Resource Center for Asia and the Pacific, 2001a). Invariably in all these cities, the canals, roadside drains and small streams are contaminated with faecal matter from latrines and septic tank effluent, become clogged and overflow during floods, creating health problems.

Within all but the wealthiest cities in the region, such as Singapore, local brown, water related challenges continue to be important. The impacts of these conditions are significant. When provision for water and sanitation is poor, diarrhoeal diseases and other diseases linked to contaminated water or contaminated food are among the most serious health problems within urban populations (Hardoy et al., 2001; UN-HABITAT, 2003b; UNESCO, 2003).[5] In the Asia Pacific Region in 1999, diarrhea-related diseased killed more than one million people and accounted for nearly 50 percent of the global diarrhea reported deaths. Contaminated water and poor sanitation were the main causes of the disease (UNEP Regional Resource Center for Asia and the Pacific, 2004). In Bangkok, for example, cases of acute diarrhea have varied between 877 and 677 per 100,000 a year for the last 10 years. The highest risk groups were those under 4 years of age and those between 5 and 9 years of age (Panich, 2003).

3.1.2 Metro-wide water issues

Southeast Asia receives abundant rainfall and has abundant water resources. Annual renewable water resources per unit of land area range from 2,200 to 14,000 cubic meters per hectare throughout most of the Southeast Asian countries. There are several important river systems in the region including 200 in Indonesia and 20 in Thailand. The international Mekong River is approximately 1,000,000 km in length and drains over approximately 800,000 square kilometers of land. Among the largest lakes in the region are the Tonle Sap (Cambodia), Lake Toba (Indonesia), Laguna de Bay (Philippines) and Lake Songkhla (Thailand) (UN ESCAP, 2000).

Despite the abundance of water, concerns over the sustainability of water supply and protection of water quality have become important issues (UNEP, 2002). Threats to water resources come from many sources, but one of the most important is pollution. Moreover, much of the region's river pollution is associated with urbanization. Urbanization and surface water pollution problem cascade as they are associated with over extraction of groundwater and subsequent ground subsidence. Moreover, many cities in the region are helping to degrade coastal zones. Finally, almost all cities in the region are subject to seasonal flooding. These are the metro-wide water related challenges that most cities at all income levels within the region face.

For most Asian countries, a surface water quality monitoring programme under United Nations Global Environmental Monitoring System (GEMS/Water) is available.[6] The GEMS/Water Programme provides scientifically-sound data and information on the state and trends of inland water quality. GEMS/Water is a UNEP programme, and since 1978, has been hosted at Environment Canada's National Water Research Institute. Currently, more than 100 countries participate in the programme and data for river quality start from 1977 to continue to the present. These data are important sources of

[5] Diarrhoeal diseases are still a primary cause of infant and child death for large sections of the world's urban population.
[6] See http://www.gemstat.org/queryrgn.aspx.

information, as national level data are sometimes difficult to obtain. This report uses GEMS/Water data to examine several water pollutants including pathogens, suspended solids and heavy metals. Regional and global environmental assessments and individual city case studies supplement this information.

Urban related river pollution results from the delivery of untreated solid and liquid wastes into rivers (from both domestic and industrial sources), the increase in slit loads due to expansion of urban land uses into peri-urban areas and overflows of wastewater plants due to high surface runoff associated with increased impermeable areas.

In cities on or close to coasts, untreated sewage and industrial effluents often flow into the sea with little or no provision to pipe them far enough out to sea to protect the beaches and inshore waters, thereby posing a major health risk to bathers (Savage, 2006). Besides damaging the tourist industry, however, pollution from cities can also negatively impact coastal fisheries and therefore livelihoods and sources of protein, create serious health problems in downstream settlements and reduce the usability of water for agriculture. **Table 9** presents data on the amount of urban sewage treated by cities in the region before it is returned to water bodies. These data demonstrate that within developing countries of the Asia Pacific only 10 percent of urban wastewater undergoes any form of treatment (UN ESCAP, 2000).

Pathogenic bacteria and viruses are found in untreated sewage and effluents from animal husbandry, storm water run-off and leaching from open waste dumpsites. Increases in pathogen levels in water bodies are directly proportional to density of population. Hence the levels of pathogens found in streams and lakes are related to the concentration of people in cities. This is particularly true when waste water is not treated.

The level of pathogens is measured by a variant of either oxygen demand (OD), biological oxygen demand (BOD) and/or chemical oxygen demand (COD). BOD measures the load of biodegradable organic substances and COD measures the chemical degradability of nearly all water-soluble organics. The higher the BOD or COD measure the greater the oxygen needed to break down material in the water, the higher the level of organic pollution. In a sample with a fixed supply of oxygen, it is possible to measure the amount of oxygen consumed over a period of time (usually 5 days) (Dunne & Leopold, 1978).

The levels of BOD in Asian rivers are 1.4 times the world average. While levels declined in the early 1980s, they increased in the 1990s because of increased organic waste loading (Asian Development Bank, 1997). Asia's rivers contain three times as much bacteria from human waste (faecal coliform) as the world average, ten times higher than Organization of Economic Co-operation and Development (OECD) guidelines and the median faecal coliform count in Asia's rivers is 50 times higher than the World Health Organization (WHO) guidelines (Asian Development Bank, 1997). Hence the BOD and faecal coliform counts in Southeast Asia are rated very severe (UN ESCAP, 2000). In Vietnam's urban areas, surface water COD and BOD are typically 2-5 times higher than the acceptable limits set for surface water. In some streams and rivers it is 10 to 20 times higher than national standards (UNEP Regional Resource Center for Asia and the Pacific, 2001b). In Jakarta, all rivers crossing the city are heavily polluted from household grey water (Hadiwinoto & Leitmann, 1994). Approximately 7 percent of the total nitrogen inflows into Bangkok from food, fertilizer, animal feed, atmospheric deposition and waste water are retained and 97 percent of the remaining nutrients are passed into the Chao Phraya River and result in elevated nitrogen levels

(Faerge, Magid, & Penning de Vries, 2001). For food alone, nitrogen volumes are approximately 19,400 tons per year.

Table 10 presents GEMS/Water data for water courses near large cities in the region. The measures presented are for indicators of nutrients, organic matter, microbiology and physical characteristics of the cities. Average BOD levels of 2 mg per liter indicate a limited degree of organic pollution. Much higher observed values are found in North American rivers, for example. Average levels of 5 mg per liter indicate pollution and those over 10 are troubled. On the other hand COD levels are typically higher. Average COD levels as experienced by the Klang River are signals of extreme pollution. Indeed, the BOD of the Banjir Kanal, in Jakarta and the COD of the Klang River, in Malaysia, suggest that these water bodies are devoid of oxygen.[7]

Bacterial contamination counts are expressed in number per 100 ml. They vary over several orders of magnitude at a given station, as they are the most variable of water quality measurements. Typically, in rivers that receive untreated sewage, coliform counts can well exceed 100,000 colonies per liter. This is seen in the Klang River, the Chao Phrya, Ciliwing and Banjir Canal. WHO drinking water standards suggest the objective of zero *E. coli* per 100 ml of water is the goal for all water supplies and should be the target (WHO, 2004).

Water quality tests performed near Hanoi demonstrate levels of ammonia and nitrites that exceed country standards by a factor of 1.5-2 times. The Saigon River, on the other hand, exceeds Vietnamese BOD standards by 4 times and the coliform levels are 50 – 100 times higher than acceptable (UNEP Regional Resource Center for Asia and the Pacific, 2001b).

Since the late 1990s, there have been improvements in some of the region's waters. While specific GEMS/Water data for all rivers are not available, there is enough to suggest general improvements in the region. Sonnenfeld and Mol (2006), for example, report that river biological oxygen demand levels dramatically improved from 1980 to 2000 in Indonesia (16 percent decrease in BOD per day per worker) and Malaysia (27 percent decrease per day per worker). River water pollution, particularly biological and nutrient levels, however, remains an important environmental concern (UNEP Regional Resource Center for Asia and the Pacific, 2004).

Another urban related water polluting activity that creates metro-wide river pollution is land clearing for urban land use construction. This facilitates soil erosion and enhances natural processes of siltation, particularly in tropical climates with heavy rainfall (Douglas, 1968). Siltation is impacted by deforestation, but also through urban activities. Indeed, urban development can generate up to 100 times more soil erosion than natural systems (Douglas, 1986). While it is difficult to account for the exact proportion of the region's river sediment changes due to urban activities, urban development is not an insignificant factor in changes in river suspended solid levels.

Currently, in Asia's rivers levels of suspended solids have almost quadrupled since the late 1970s (Asian Development Bank, 1997) and rivers typically contain 4 times the world average and 20 times OECD levels. This level of sedimentation poses critical problems for most coastal zones and large water bodies (UNEP, 2002). Examples of high siltation affected water bodies in Southeast Asia include Lake Tonle Sap,

[7] For further information see the GEMS/Water Digital Atlas of Water Quality at http://www.gemswater.org/atlas-gwq/intro-e.html.

Cambodia. Sediment deposits are reducing the lake's depth and affecting the yield of the lake's fisheries. In Malaysia the Dungun River in Kuala Terrengganu has also been polluted by sandy sediment exacerbated by dredging activities along the river (UN ESCAP, 2000).

The indicator for Total Suspended Solids (TSS) includes both organic and mineral particles transported in surface water. TSS is closely linked to land erosion and to erosion of river channels. According to GEMS/Water suspended solids are frequently poorly measured. Values higher than 1000 mg per liter affect water use by limiting light penetration and can limit reservoir life. In 1995, the Mekong near Vientiane experienced levels approaching this value.[8]

Along with human and animal waste and sediments levels, urban related water pollution occurs when industrial effluent isn't treated before release into waterways. Many rivers and lakes in Southeast Asia are severely polluted by industrial processes. Asia's surface water contains 20 times more lead than surface waters in OECD countries, mainly from industrial effluents. The worst of these examples is heavy metal and toxic chemical pollution in the water bodies of Southeast Asia (Asian Development Bank, 1997; UN ESCAP, 2000; UNEP, 2002). A survey of river water quality in Thailand revealed heavy lead contamination (in a number of major rivers including the Pattani and Colok in the south, the Moon river in the Northeast, the Pa Sak river in the north and the Mae Klong in the central region), mercury contamination (in the lower central region's Pranburi River, the Mae Long, Chao Phraya and Petchburi rivers of the central region and the Wang River in the Northern region) and high levels of arsenic poisoning in the Tambon Ron Phibun (UN ESCAP, 2000). Urban industrial pollution in Indonesia is also significant. Of Jakarta's 30,000 factories, for example, only 10 percent have wastewater treatment (Tibbetts, 2002).

Table 11 presents the levels of heavy metals in selected rivers and the WHO (2004) guideline values. The sources of heavy metals are numerous, but many are related to industrial and urban activities (**Table 12**). For the rivers examined, the levels of heavy metal concentration meet or exceed those recommended by the WHO. For example, levels of Arsenic (As), Cadmium (Cd) and lead (Pb) for the rivers examined all exceed WHO guidelines. For the Klang River, levels of chromium (Cr) and Manganese (Mn) also exceed WHO guildelines. For iron, levels above 0.3 mg/l are likely to give rise to consumer complaints (creating disagreeable taste and odor conditions and staining laundry and sanitary ware) (UN ESCAP, 2001). Zinc is typically not a health concern, but may affect water acceptability.

Recently, global attention has turned to monitoring persistent organic pollutants (POPs) in air, land and water. POPs encompass many different groups of human-produced chemicals. The United Nations Environment Programme (UNEP) has listed certain POPs, such as organochlorines, as being chemicals of particular concern.

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[8] Paradoxically, while human activities increase sediment flows in rivers by approximately 20 percent, reservoirs and water diversion projects prevent about 30 percent of sediments from reaching the oceans, resulting in a total net reduction of sediment delivery to coasts of roughly 10 percent (Agardy, Alder, & et al, 2005; Vorosmarty et al., 2003). In Southeast Asia, dam building begun in the 1950s. In 2000, Thailand had the most dams (204) followed by Indonesia (96), Malaysia (59), Philippines (15), Myanmar (5), Vietnam (3), Singapore (3), Brunei (2) and Cambodia (2) (World Commission on Dams, 2000). Recent evidence suggests that globally both water and energy demand may require more dams and hence dam building may yet increase from 2000 to 2050 (ICOLD-CICB, 2006). Several nations in Southeast Asia are considering building new large dams and some on these are slated for the Mekong River (Dore & Yu, 2004) (see below). Projected increases in dam building within the region may ultimately decrease the amount of sedimentation reaching the oceans.

Specifically the high priority 12 organochlorines (known as the dirty dozen) come from four groups. These include: 1) Dioxins and furans, which are produced as products of municipal and medical waste incinerators, open burning, landfill fires and during the production of polyvinyl chloride (PVC) products; 2) Polychlorinated byphenyls (PCBs) (industrial chemicals that have been banned but are still released to the environment from old sources and as unintentional byproducts of combustion and processes involving the manufacture, use and disposal of organochlorines); 4) Hexachlorobenzene (HCB), which are used as a pesticide and in the manufacture of pesticides and produced as an unwanted by-product of various industrial processes involving organochlorines; and 4) Organochlorine pesticides, including 8 pesticides; DDT, chlordane, toxaphene, dieldrin, aldrin, endrin, heptachlor and mirex. POPs have been identified in Southeast Asian waters. For example, high residues of chlordane are apparent in the rivers of Southeast Asia and PCBs can be found uniformly distributed in rivers across the region (Allsopp & Johnston, 2000).

Table 13 presents some data on organochlorines in selected water bodies in Southeast Asia. The data demonstrate the levels of pesticides found in rivers of the region, particularly those in Selangor, Malaysia. Comparative work in the region suggests that POPs are being used more in the tropical developing areas than in the developed parts of Asia (Iwata, Tanabe, Sakai, Nishimura, & Tatsukawa, 1994) and that there is increasingly a shift in the airborne and water distribution POPs from Northern to Southern air and water systems (Iwata, Tanabe, Sakal, & Tatsukawa, 1993). Concentrations and prevalence of POPs in water around Singapore, for example, are most likely due to the increasing presence and importance of the petroleum industry in the city (Basheer, Obbard, & Lee, 2003).

The results of these pollution levels are evident in the quality of the rivers that run through the region's cities. High levels of pollution from Phnom Penh Cambodia are contaminating wetlands nearby. Contamination is from industries and the result is high levels of heavy metals. Farmers in the region make a living by growing vegetables and selling them in local markets. These vegetable then pose serious health hazards to consumers in the city (Muong, 2004). Water quality tests performed near Hanoi and those for the Saigon River have detected heavy metals such as lead, mercury, chromium and cadmium (UNEP Regional Resource Center for Asia and the Pacific, 2001b). The Pasig River in the center of Metro Manila is effectively dead (UN ESCAP, 2000). Studies of Thailand's Chao Phraya River suggest this river is also heavily polluted. The Chao Phraya River exhibits serious organic and bacterial pollution that was a threat to many species of aquatic life. Acute diarrhea and food poisoning are still increasing, whereas between 1983 and 2001, the incidences of enteric fevers, dysentery and helminthes decreased. Also alarming is the increasing number of diseases caused by chemical and toxic substances contaminating water resources. These contaminants are of domestic, industrial and agricultural origin (UNESCO, 2003). In Malaysia, of the 110 rivers monitored for pollution, 16 were found to be seriously polluted and 71 slightly polluted (Savage, 2006). As the figures for the Klang River (**Tables 10 and 11**) demonstrate both feacal contamination and chemical pollution are high. This river is the most polluted in the country and like the Pasig, has been characterized as "dead" or no longer suitable for drinking nor habitation by aquatic species (Hussain & Hassan, 2003). The Malaysian case is interesting, as the country has a relatively high level of income. Notwithstanding its economic development, however, it still faces a number of different environmental challenges that are representative in quality of its rivers. For example, while obviously, there is a need to address wastewater treatment, the rivers, and general environmental quality, are threatened by a number of activities, including palm oil plantations, logging, housing construction, agriculture and industrial activity (including metal finishing, rubber-based production facilities, food and beverage producers and paper factories). The industries in Kuala Lumpur, are typically small to medium sized and operate without proper wastewater treatment facilities (Shapiee, 2003). Thus, in this upper-middle income country, both brown issues and gray issues are important to urban water quality managers.

The cost of environmental remediation (COR) for the region's rivers varies. The COR is calculated as the cost to reduce the pollutant load within rivers by 90 percent in 10 years. Calculated costs are presented in **Table 14**. Results suggest that the costs to clean up the region's rivers within 10 years varies between US$260,000 (for Lao, PDR) and US$100 million (Indonesia) (Jalal & Rodgers, 2002). Despite the relatively lower cost levels for some countries, these values are still a significant part of the annual GDP. This suggests that remediation for some countries may necessarily only be plausible over a longer period of time.

Poor quality river water and low access to piped water promote the use of groundwater in cities. According to UNESCO (2003), almost 1.2 billion urban dwellers rely on groundwater globally. Groundwater resource availability in the region is typically in the range of 10-20 percent of the magnitude of internal surface water resources (ASEAN, 2005). Extensive groundwater extraction, however, has resulted in serious problems of subsidence in for example, Bangkok, Jakarta and Metro Manila (Das Gupta & Babel, 2005; Hadiwinoto & Leitmann, 1994; Laquian, 2005).

Bangkok is an example of how groundwater extraction can have metro-wide impacts. Unplanned groundwater extraction in the city has had three major results: 1) depletion of near surface levels of aquifer water; 2) land subsidence; and, 3) water quality deterioration by saltwater encroachment. Associated problems such as flooding, loss of properties, deterioration of infrastructure facilities, groundwater pollution and health hazards have also been attributed to the effects of groundwater withdrawal (Das Gupta & Babel, 2005).

Large groundwater usage for the public water supply in Bangkok began in 1954. At the time water extraction amounted to approximately 8,000 cubic meters per day (m^3/day). The daily withdrawals increased over the years. In areas were public water was not available private wells appeared. By 1982, the total groundwater withdrawals from Bangkok and its adjacent areas reached 1.4 million m^3/day. The city implemented control measures in 1983 and the pumping rate decreased from 1985 to 1990. However, groundwater abstraction started increasing after 1991. By 2003, groundwater wells withdrew over 2 million m^3/day (Das Gupta & Babel, 2005).

Initially groundwater levels in the Bangkok area were very close to the ground surface and some areas had abundant free-flowing artesian wells. Over the decades the water table has fallen, at a maximum rate of 2-3 m/year. The lowest levels have been recorded in Samut Sakhon area in the range of 65-70 meters below ground surface. Lowering the water table to these levels makes it more difficult and expensive to access the water (Das Gupta & Babel, 2005).

The second result has been massive land subsidence over large parts of the city. Between 1940 and 1980 some parts of the city subsided by 1.14 meters. Between 1978 and 1980 the maximum land subsidence was 54 cm. After the control measures on groundwater pumping were introduced in 1983, the rate of pumping declined in the central Bangkok area: however, the pumping started increasing in the suburban areas of the city and the pumping zone expanded. By 1997, the rate of subsidence in downtown areas was 1-2 cm/year, whereas in the suburbs areas of Samut Prakan, Lat Krabang and Samut Sakhon, subsidence increased to 3.0-3.5 compared with 2.0-3.0 cm/year observed in 1989-1990 in the eastern suburbs area (Das Gupta and Babel, 2005).

The third major metro-wide environment consequence from lowered water tables is the contamination of aquifers due to saltwater encroachment. In Jakarta and Bangkok, the pumping out of groundwater further causes the intrusion of saltwater into the aquifer.

Bangkok also experienced a substantial increase in hardness, iron and manganese content in water (Das Gupta & Babel, 2005). Metro Manila has also experienced seawater intrusion into aquifers whilst in the major river basin and coastal plain of Vietnam, the average salinity of groundwater is approximately 3,000 – 4,000 ppm, a level unsuitable for drinking (UN ESCAP, 2000).

Water pollution also impacts coastal ecosystems, were freshwater and saltwater mix. These ecosystems are the most productive and also among the most highly threatened ecosystems in the world. Examples of the global impacts of these pressures include a loss of 35 percent of mangrove areas, destruction of 20 percent of the world's coral reefs, loss of 20 percent of coastal wetlands and increases in harmful algal blooms and other pathogens, which affect both humans and marine organisms (Agardy et al., 2005).

The deterioration of coastal ecosystems is due to a complex association of activities including urbanization (i.e., port development, dredging, recreation development, pollution from industry and domestic wastes). While agriculture is the largest influence on nitrogen increases into coastal marine systems, wastewater from urban centers is also a significant component of change, contributing 12 percent of the nitrogen pollution in rivers of the USA, 25 percent in Europe and 33 percent in China (Howarth, 2004). Every year sewage treatment facilities discharge 5.9 trillion gallons of sewage into coastal waters, and an estimated 160,000 factories dump between 41,000 to 57,000 tons of toxic organic chemicals and 68,000 tons of toxic metals into coastal waters (UNEP & UN-HABITAT, 2005). The World Resources Institute (2002) identified a number of indicators of coastal degradation including the development of coastal areas, marine-based pollution, sedimentation pollution, overfishing and destructive fishing. Urban activities, including land consumption and waste emissions dominates the inputs to some coastal ecosystems (see for example, Howarth, 2004).

The degradation of coastal zones by urban centers should not be a surprise. Historic urban development patterns demonstrate that people have always agglomerated near ecologically important areas. Hence, 58 percent of the world's major reefs occur within 50 kilometers of major urban centers of 100,000 people or more, while 64 percent of all mangrove forest and 62 percent of all major estuaries occur near such centers (Agardy et al., 2005). This trend is increasing, as in many parts of the world giant densely populated coastal cities continue to grow (Small & Nicholls, 2003; Tibbetts, 2002). Indeed, coastal populations on every continent have grown with global trade into cities. Most trade is shipped by boat and this encourages the growth of international ports, which create jobs and economic growth. Hence, urbanization and all that it entails is an important driving force in coastal zone change.

Significant environmental challenges have emerged in coastal and near marine environments in and around cities in Southeast Asia (Lebel, 2002). Degradation can be seen in indicators of marine pollution, loss of mangrove forest and degraded condition of coral reefs. Within the Asia Pacific region, coastal and marine pollution has increased mainly due to domestic and industrial effluent discharges, atmospheric deposition, oil spills and other wastes and contaminants from shipping as well as land development, dredging and up-stream river modifications (UN ESCAP, 2000; UNEP, 2002). Both urban and agricultural areas produce significant quantities of organic wastes in such concentrations that the nutrient filtering mechanisms of the coastal zone are unable to neutralize their effects. Thailand and Cambodia contribute approximately 30 percent of the BOD entering the South China Sea (**Table 15**). Of all the nitrogen entering these coastal waters, Thailand and Cambodia contribute 20 percent. Vietnam contributes approximately another 21 percent (UN ESCAP, 2000). Sewerage effluent from urban and tourist areas make substantial and increasing contributions to pollutant loads in the upper Gulf of Thailand (Lebel, 2002). Metro Manila's sewerage system pumps effluents into Manila Bay with only rudimentary treatment and as a result serious cases of "red tide" disease outbreaks occur each summer and subsequently, the Philippines Health Department has banned the consumption of oysters, clams, mussels and other shellfish from the bay (Laquian, 2005).

More than 40 percent of the world's estimated 18 million hectares of mangrove forest occur in South and Southeast Asia (UN ESCAP, 2000). Unfortunately, globally large areas of mangrove have been removed for industrial, residential and leisure developments, and in particular for establishment of ponds for fish and prawns aquaculture. Within Southeast Asia the loss of original mangrove areas is high; less than 20 percent in Brunei, more than 30 percent in Malaysia, more than 40 percent in Indonesia, more than 55 percent in Myanmar, more than 60 percent in Vietnam, more than 70 percent in Singapore and more than 80 percent in Thailand (UN ESCAP, 2000). In the Philippines, 210,500 hectares of mangrove (approximately 40 percent of the country's mangrove cover) were lost to aquaculture from 1918 to 1988. By 1993, only 123,000 hectares of mangroves were left, equivalent to a loss of 70 percent by that time (Agardy et al., 2005; Nickerson, 1999; Primavera, 2000).

Another measure of coastal zone degradation is the condition of coral reefs. Southeast Asia is endowed with over 85,000 km^2 of coral reefs (approximately 29 percent of the world's total). These reefs have some of the highest biodiversity in the world, especially for coral reef fish, mollusks and crustaceans (World Resources Institute, 2002). The reefs of Indonesia and the Philippines are noted for their extraordinarily high levels of diversity, each containing at least 2,500 species of fish. Presently, however, only 30 percent of these reefs are in good or excellent condition (UN ESCAP, 2000). Moreover, in Indonesia approximately 49 percent of the reefs highly threatened (**Table 16).** In the Philippines 70 percent of the coral reefs are highly threatened and in Vietnam over 73 percent of the reefs are highly threatened. For the entire region approximately 46,000 km^2 (54 percent) are under high risk of degradation (World Resources Institute, 2002)

The climate in Southeast Asia, which is predominantly wet equatorial, is characterized by a substantial rainfall supply of about 3,800 cu km annually, about two-thirds of which is accounted for by Indonesia (UNEP Regional Resource Center for Asia and the Pacific, 2000). Given climatic conditions that produce monsoon rains, flooding is common. In ASEAN, tropical wet/dry season cycle flooding is exacerbated by the short, steep nature of many rivers which results in characteristic short, sharp peaks in stream flows. The seasonal climate exacerbates water challenges for cities.

Globally, floods affected the lives on average, of 65 million people between 1972 and 1996, more than any other type of disaster, including war, drought and famine (World Commission on Dams, 2000). In 2005 alone, floods around the world claimed the lives of 6,135 people.[9] Floods affect a large number of people throughout Southeast Asia. Between 1990 and 2006 there were approximately 208 flood events, which affected approximately 58 million people and killed 9,912 people.[10]

Metro-wide flooding continues to be a challenge for most cities in the region. **Table 17** presents some of the flooding challenges for selected cities in the region. Floods are annual occurrences in Vientiane. When the Sap River, a tributary of the Mekong River, floods during the rainy season, the river reverses course and sewage discharges from Phnom Penh flow upstream to the water supply intake (Dany, Visvanathan, & Thanh, 2000). In Jakarta, habitual flooding of the northern third of the city is due to heavy seasonal rains combined with high tides in Jakarta Bay (Hadiwinoto & Leitmann, 1994). Parts of Kuala Lumpur are flooded for short periods of time. Flooding in Bangkok, results during the monsoon season when run-off exceeds the Chao Phraya River's drainage capacity. This problem is exacerbated by infilling of *klongs*, deforestation upstream and loss of marshes and empty areas that acted previously as retention ponds (ASEAN, 2005; Panich, 2003; UNEP, 2002).

This analysis suggests that all cities in the region, across the income scale spectrum, are affected by metro-wide water challenges. These water-related burdens include water pollution (biological, nutrients, suspended particles, heavy metals and POPs), over extraction of groundwater, subsequent ground subsidence, salt water intrusions, coastal zone degradation (large nutrient and pollution loading, loss of mangroves and natural habitat and declining quality of coral reefs) and flooding. Moreover, a recent study suggested that these issues will only increase in importance. UN ESCAP (2005) suggests that high levels of industrial growth, expanding tourism and related infrastructure, particularly in coastal areas are environmental driving forces that will continue into the future. As the costs for remediation of these water challenges is relatively high, it may take more than local and national efforts to bring rivers and coastal systems back to national standards.

3.1.3 Regional and global water issues

Much of the growth and development of the region has been centered on the major metropolitan centers (see for example, Lo & Yeung, 1996). The region's water supplies are managed to provide the necessary requirements for this growth and development. Both economic growth and previous management schemes have also brought further water-related environmental impacts including increasing water consumption (through both direct and indirect means), water shortages (including seasonal physical water scarcity and economic scarcity) and rising tensions created by use of international waters. Moreover, given global emissions of greenhouse gases and subsequent changes in climate, some cities within the region have become vulnerable to extreme water related events (including flooding, droughts and sea level rise). These are among the green issues that are typically on the global environmental agenda.

[9] See EM-DAT: The OFDA/CRED International Disaster Database, www.em-dat.net - Université catholique de Louvain - Brussels - Belgium
[10] Ibid.

People need water for a variety of reasons including drinking, personal hygiene, cooling, lawn watering, urban agricultural and gardening, household and street cleaning, fire fighting, recreation, industry, etc. The result is that the largest flow of material into any city is water (Decker, Elliott, Smith, Blake, & Rowland, 2000). In high-income cities where there is more or less universal provision of services and high consumption of water the average city of one million people use approximately 625,000 tonnes of water a day (Haughton & Hunter, 1994; Wolman, 1965).

Per capita water consumption within cities of the region is not yet a regional issue. Bangkok, for example has some of the highest water consumption figures for urban inhabitants within Southeast Asia (352 liters/capita/day), but consumption is still 43 percent lower than current per capita water use in Denver (670 liters/capita/day) 40 percent lower than Boston (643 liters/capita/day) and 25 percent lower than New York City (515 liters/capita/day) (Roberts, 2006). While this is true, daily water consumption in Bangkok is more twice as great as that of Singapore (167 liters/capita/day) (UN-HABITAT, 2003b).

Despite Singapore's higher income, the city-state has promoted successful water quality and conservation policies and as a result water consumption remains relatively low. Singapore's policies are in response to its prevailing natural situation; as a small island it suffers from physical water scarcity.

Singapore's history is an example of efficient water supply development. Up until 1986, the main thrust of the country's water supply management programme was building reservoirs. By that time approximately 50 percent of the island was designated as catchments. Little land was left for this purpose. Thereafter the City-State refocused efforts on three fronts: optimizing water yield from their natural catchments; conservation, including retarding water demand and reducing wastage; and, creating access to alterative supplies through diplomacy and by exploiting modern technologies (Long, 2001). These strategies produced some of the most advanced water management schemes in the world including, *inter alia*: 1) building the Newater facility, a sewage-to-potable water recycling plant; 2) lowering system leakage to an internationally recognized minimum; 3) manipulating water prices to prevent waste; and 4) instituting efficient rain-harvesting infrastructure. The country is now seriously considering building desalination plants that will further lower its dependence on non-domestic water and hence the footprint of the city (Savage, 2006). While lowering the water footprint of the city is laudable, creating potable water from desalinization plants is expensive (approximately US$ 1-1.6 per meter) and the processes to make this water are highly energy intensive, although new technologies are becoming available at lower prices (Postel, 1997). While Singapore's programmes have been and continue to be successful, they may not be transferable to other locations. For example, not every country in the region can afford such sharp trade-offs between increases in energy use and increases water consumption that would be demanded by building desalination plants.

For other cities in the region the condition of ample water resources is rapidly changing. Importantly, consumption within the region continues to rise as urban lifestyles are leading to more water demand. For example, between 1995 and 2000 demand for refrigeration increased by 22 times in both Thailand and Vietnam (UN ESCAP, 2005). Future grow in wealth will bring increases in water consumption for cooling, industrial, and domestic household uses.[11] Also, as nations within the region grow in wealth they will continue to urbanize adding more and more people to each city. Given expectations for increases in urbanization in the region, ASEAN (2005) predicts that overall demand for water will increase by about one-third over the next 20 years.

At least three important constraints face cities in the region as they battle increasing water consumption. First, as was mentioned in detail in the previous section, many of the region's rivers and water bodies are contaminated limiting their use as potable supplies. Pollution alone has reduced the annual per capita availability of freshwater in the developing countries of the region from 10 000 m^3 in 1950 to approximately 4 200 m^3 by the early 1990s (UNEP, 2002).

But not all the water taken by cities makes it way to consumers. The second constraint on meeting increasing demand in cities of Southeast Asia is the old, poorly maintained water systems and poorly managed watersheds. The Bangkok waterworks, for example, was initially constructed in 1914 (Smithies, 1986). The water supply system in Phnom Penh was originally constructed in 1895 (Dany et al., 2000). Manila's waterworks system was built in 1878 by Spanish colonialist and designed for a city of 300,000 (Laquian, 2005). Jakarta's basic water supply system was built by the Dutch between 1900-1940 (Argo, 1999). It is not unusually for half the water within these systems to be lost in distribution. **Table 18** presents data on water loss in selected cities in the region. In most cities it is over 40 percent. Moreover, given inadequate infrastructure, poor levels of maintenance and a large informal sector that taps into the system, 24 hour service is not always possible. Together these influences create local and short term or seasonal water shortages.

Water shortages also occur for a number of other reasons, related to large scale anthropogenic activities within watersheds. For example, in January 2004, Metro Manila reduced water supply from the Metropolitan Waterworks and Sewerage System (MWSS) by 5 percent (increased to 20 percent in April). This reduction was caused by a drop in the water level in the Angat reservoir, the main reservoir for the city. Dangerously low water levels were caused, in part, by logging in the Marikina watershed reservation, and hence rapid runoff (Laquian, 2005). Development in Peninsular Malaysia also resulted in water shortage problems in urbanized areas of Selangor (Jahi, Toriman, Hashim, & Aiyub, 2003).

The third constraint on meeting water demand is economic water scarcity. Absolute water scarcity, such as that faced by Singapore, occurs when a country that does not have sufficient annual water resources to meet reasonable per capita water needs (Seckler, Barker, & Amarasinghe, 1999).[12] Economic water scarcity, is the condition were there is sufficient potential water resources to meet projected 2025 requirements, but that expensive water development projects are needed to develop these resources.[13]

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[11] Haughton and Hunter (1994) write that in the UK one toilet flush is 10 liters, a shower is 30 liters, a bath 80 liters, one dishwasher cycle 50 liters and one cycle in a clothes washing machine can be 100 liters. Moreover, simply leaving the tap running while teeth brushing wastes between 25 and 45 liters.

[12] Another term is physical water scarcity when the primary water supply of a country exceeds 60 percent it potentially utilizable water resources (ASEAN, 20005). In physical terms, Singapore suffers from water scarcity.

[13] It should be noted that water scarcity has little to do with access to water. As pointed out by UN-HABITAT (2003) many countries that have water scarcity have high percent access and those that are located in water rich areas have low access. Hence, while many cities in the region have a significant population without access and water within many cities is provided for a limited number of hours a day, availability of water for

In a global assessment of physical and economic water scarcity, several countries in the region were categorized as falling into the latter group including Cambodia, Indonesia, Malaysia and Myanmar which will need to increase water development by between 25 percent and 100 percent. Also suffering from economic water scarcity are Philippines, Vietnam and Thailand, but these three countries have only modest (less than 25 percent) requirements for additional water development (Seckler et al., 1999).

The capital investment requirements for advanced infrastructure to meet water supply access and sanitation and provision for industry, agriculture, energy and leisure has major ramifications for ASEAN member countries. Financing these projects will be a major challenge in the future (ASEAN, 2005). In Phnom Penh, for example, the increased demand by 2025, cannot be met financially by the government alone (Dany et al., 2000).

One way to circumvent water scarcity is to indirectly import water through the purchase, use and consumption of goods and services produced elsewhere that implicate water use and consumption. 'Virtual water,' as it is called, is the amount of water needed to produce a commodity or service. Trade in primary commodities and some goods implies the flow of this water from one location to another, sometimes over great distances.

The amount of water needed to produce different commodities varies. The amount of water to produce 1 kg of rice is approximately 3,000 liters. The amount of water to produce 1 kg of beef is 16,000 liters. Between 1997 and 2001 the global use of water amounted to 7,450 Gm^3/year of which 1,625 Gm^3/year was in international virtual water trade. Approximately 80 percent of the total 'virtual water' trade is due to trade in agricultural goods (Chapagain & Hoekstra, 2004).[14]

For the eight countries examined within Southeast Asia the total external flows were 71.3 Gm^3/year (**Table 19**). This is only 1 percent of the region's water resources, leaving seemingly little to worry about. Regional averages, however, can hide local differences. Water consumption patterns vary by country, with some countries, such as Malaysia, meeting significant levels of water needs (28 percent in this case) through non-domestic resources. Moreover, Indonesia, a water rich country is already one of the world's largest net importers of water (Hoekstra & Hung, 2005).

As cities and nations grow in wealth we can expect to see changes in the water trade budgets. Dependence upon non-domestic water resources may continue to rise. While to trade economists this may not present a problem, considering that global estimates suggest that by 2025, absolute water scarcity, will affect 1.8 billion people (Seckler et al., 1999), questions arise as to where water to grow food and help make goods will come from. Within the next 20 years more than a quarter of the global population will be living in countries were water extraction is higher than total supply by domestic sources. As clean water grows scarce the prices of goods made with it will rise. The outcome of these dynamics remains unpredictable, but has potentially adverse consequences for developing nations that are virtual water dependent.

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drinking is not physically scarce. This global or "green" issue should not be confused with the local or brown issue. Importantly, increasing access to water for the poor bears little relationship to creating water scarcity.

[14] See also http://www.waterfootprint.org/.

As water sources will be increasingly sought after, the management of larger bodies will also increase in importance. Today, around 3800 km^3 of fresh water is withdrawn annually from the world's lakes, rivers and aquifers. This is twice the volume extracted 50 years ago. Given increasing extraction, countries have turned to creating artificial water bodies through dam building. Over 45 000 dams have been built in over 150 countries (World Commission on Dams, 2000). In the future, dam building is expected to continue and most of it will occur within developing countries. During the 1990s, for example, an estimated US$32-46 billion was spent annually on large dams, four-fifths of which were located in developing countries (World Commission on Dams, 2000).

Dams provide for a variety of water management needs. Approximately half the world's large dams are primarily for providing irrigation water. Globally, about 12 percent of large dams are to supply water for drinking and those are related directly to urbanization. Hydropower dams currently provide 19 percent of the world's total electricity supply. Approximately 24 percent of countries developing hydropower depend on it for 90 percent of their energy supply (World Commission on Dams, 2000). The trend is that cities need increasingly more water and energy and this demand translates into demand for dams.

Dams on rivers that traverse several countries can create tense international relations. In the Mekong River Basin dramatic changes are being played out forecasting increasing future tensions for the region (World Commission on Dams, 2000).

The Mekong is of great interest to five nations in Southeast Asia. These include Cambodia, Lao PDR, Myanmar, Thailand and Vietnam. The Lower Mekong Basin covers 600,000 sq km and supports 60 million people. The Mekong River is an important river for transport, food, water, tourism, recreation, water management, irrigation, energy, industry and biodiversity. The different countries in the region have different end uses planned for Mekong River water. Laos wants to use dams to generate electricity for export, Cambodia wants to secure sustainable fishery resources, Vietnam seeks to ensure the flow of water for its rice crops without salinity rising to dangerous levels, and Thailand wants to ensure consumption for its cities. As such, international management of this water resource is important for all these countries. Unfortunately, however, management of this common-pool resource has been difficult. Importantly, China, from whose boundaries flow up to 20 percent of the Mekong's discharge (Mekong River Commission, 2005), has put into place an aggressive dam programme to meet its water and hydro-electric power needs (Dore & Yu, 2004; Liebman, 2005).

Current development trends in China have created a demand for the water. Some of the most fertile areas of China now face chronic water shortages. The Chinese governments' decision to build three massive canals connecting the water-abundant south to the drier north indicates their concern. There are several signs that water usage is beyond sustainable levels in China including the long period of time that the Yellow River runs dry, the abandonment of old wells and the drilling of 300,000 per year new deeper wells, the sinking water table, the return to less efficient rain-based agriculture and the decreasing quality of water available to farmers (Liebman, 2005).
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Moreover, China has an increasing demand for energy, particularly modern energy (electricity). Currently, the country still relies heavily on fossil fuels for its energy supply, with 70 percent coming from coal. In 1993, China became a net importer of oil, importing approximately 100 million tons of crude oil a year, second only to the US (Liebman 2005). In this context, the Mekong's resources are immensely valuable to the country.

There are currently plans to build eight dams on the river by 2019 (Dore & Yu, 2004), helping to fill the growing gap between electricity demand and supply through hydropower. Two dams (at Manwn and Dachaoshan) have already been built; two more (Xiaowan and Jinghong) have begun construction and are expected to be complete by 2010; and four more have been designed. These are large dams and the major component in the country's drive to double the amount of hydro-energy production by 2010. They are equivalent of constructing another four three-Gorges Dams (Dore & Yu, 2004).

The implications of damming the river are economically high. As 50 percent of Vietnamese rice production is located in the Mekong delta and 50 percent of the protein Cambodian eat (and a large source of employment) comes from their domestically caught fish supply. If the Mekong were to fail to reach the sea for half the year, as the Yellow River currently does, this would not only impose huge opportunity costs for lost hydro-power and trade, but the immediate economic losses and dislocations in the riparian states would be severe (Dore & Yu, 2004). Indeed, some argue that the current damming of the river has already had impact (Dore & Yu, 2004; Liebman, 2005; Lu & Siew, 2005). For example, some have claimed that during the first quarter of 2004, the Mekong reached record low flows in the downstream riparian states (Liebman, 2005). These claims, however, may be linked to the previous years' higher than average low-flows, as there is no long-term evidence of systematic change in low-flow hydrology of the river (Mekong River Commission, 2005). Whether Mekong River flows are impacted by water infrastructure will continue to be debated as each country attempts to use the water in the river for its own purposes.

Finally, all low lying cities in the region are facing the consequences of climate change and its potential impacts on water. Globally, anthropogenic activities are changing climates (including temperature increases, changes in precipitation and sea level rise), both regionally and globally and this in turn is affecting a number of physical and biological systems. Examples include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, pole ward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees and emergence of insects and egg-laying in birds (Watson & the Core Writing Team, 2001).

Some areas of Earth have been affected by increases in floods and droughts, making them more vulnerable to extreme events. Moreover, projected changes in climate extremes are dramatic and could have major consequences. While there are uncertainties attached to predictions and trends, estimates suggest that the frequency and or severity of extreme events are likely to increase in some regions (Watson & the Core Writing Team, 2001). Importantly coastal areas are increasingly physically vulnerable and many are already experiencing increasing flooding, accelerated erosion and seawater intrusion into fresh water (Agardy et al., 2005).

Within Southeast Asia many cities are barely a meter above sea level and floods and droughts in the region are increasing. The Intergovernmental Panel on Climate Change (IPCC) (2001) estimate that sea-levels will rise between 0.09 to 0.88 m by 2100, with regional variations. This places the delta regions of Myanmar, Vietnam and Thailand and the low-lying areas of Indonesia, the Philippines and Malaysia at risk (Nicholls, Hoozemans, & Marchand, 1999). Specific areas identified as vulnerable to the impacts of extreme events include the Tonle Sap lake and southern region of Cambodia and the coastal Koh Kong town, Bangkok, East Bangkok, Pattaya, Cha-Am and Hua Hin and those areas in the sandy coastal plans including Rayong in the eastern region, the coast north of Songkhla, between Hua Hin and Cha-am, and the bays on the east coast, such as Rayong Bay in Thailand, many of the cities in Metro Manila as well as entire provinces in the Philippines (in the Philippines alone almost 2 million people live in low lying areas), Ca Mau province, Ho Chi Minh City, Vung Tau and Xuan Thy sea areas as well as large parts of South Vietnam, areas in the Red River delta and much of Singapore (ASEAN, 2005).[15]

Many cities in the region are facing green agenda, global water issues. While those on the upper end of the scale are experiencing higher levels of water consumption, physical or absolute water scarcity remains unimportant to all cities but Singapore. On the other hand, however, many cities are experiencing economic water scarcity. Moreover, many cities are also vulnerable to changes within international waterways and to the impacts of climate change. Singapore's most dominant water concerns are in this category, but other cities, particularly those low lying coastal cities on the Mekong are also facing such issues.

3.1.4 Summary

This survey attempts to point out a number of water related issues that cities across the region are currently experiencing. All cities have multi-scale water challenges ranging from water supply and sanitation access to water pollution and threats of future vulnerability from climate change. **Table 20** summarizes the various water related environmental burdens that each set of cities (based upon level of income) currently faces. While individual cities may have slightly different concerns, as a group each faces similar problems and challenges.

While these issues have been reported before, what is new in this analysis is a holistic look and comparison to experiences of cities in the now developed world. Doing so brings a new perspective on urban environmental history and an understanding of the relationship between development and the urban environment. For example, as mentioned, Melosi (2000) chronicled the changes in water supply, sanitation and solid waste management in US cities. His history presents a story of sequential policies that addressed environmental challenges of the period. The solutions too challenges at any given time lead to, in part, subsequent burdens in later periods. For example, comprehensive sewerage systems weren't even considered until water supply systems brought tremendous amounts of water into the city. Once the water was in, then engineers, city planners and decision-makers identified the need to remove the wastewater. Hence, most sewerage systems were built after water supply systems were developed (see also, Tarr, 1999).

As opposed to a more sequential or staged scenario, many cities in the Southeast Asian region have to address all issues simultaneously. This makes the identification of environmental transitions difficult. Moreover, they must do so with much lower tax revenues than developed world cities had. For example, as explained cities such as Hanoi, Ho Chi Minh and Phnom Penh are suffering from the entire gamut of challenges. When cities in Europe and North America were at similar levels of income they had yet

[15] Lebel (2002) points out that a 1 meter rise in sea level could lead to 34,000 km^2 land losses in Indonesia, 7,000 km^2 land losses in Malaysia, 5 ,000 km^2 land losses in Vietnam (in the Red River Delta) and 15,000 to 20,000 km^2 of land could be threatened in the Mekong Delta.

to experience all these challenges. The national levels of income in the year 2000 of some developing countries, at PPP, are comparable to those of the USA in during the 1800s (Maddison, 2001). This period in US history was even prior to implementing water supply systems for their cities (the New York City's first comprehensive supply system was developed in 1850s and the sewerage system in the 1870s). It was only during the early 1900s that New York was able to finance most it current water supply system (Galusha, 1999).

Given the challenges they face, it is indeed wondrous that the cities of the Asia Pacific are operating as well as they do. Cities in region continue to show signs of viability and growth potential (Laquian, 2005). Moreover, there are examples of how they have grown with lower levels of environmental burdens, when compared to the now developed world. This can be seen in terms of water consumption per capita. Singapore's GDP per capita (PPP) is similar to that of the USA (World Bank, 1999), yet water consumption per capita there is at least 50 percent lower than most US cities. Studies have also shown that the amounts of per capita CO_2 emissions from their road transport sectors in comparison to those of the USA, are lower comparable income levels (Marcotullio, Williams, & Marshall, 2005). Also, all countries in the region use less energy per capita at similar levels of GDP (PPP) compared to the USA (Marcotullio & Schulz, 2007). What this suggests is that despite the seemingly daunting challenges of sooner, faster and more simultaneous emergence of environmental conditions, there are other aspects of contemporary development that are promoting more environmentally efficient growth. Rapidly developing cities have arguably taken advantage of new technologies, information and knowledge and have used these tools to their benefit (see for example, Angel & Rock, 2000)

Yet cities in the region are indeed in need of new policies and modalities of planning and management to address their challenges. That is, they must address different water related challenges simultaneously and at a range of different scales. Given this enormous dissimilarity with the developed world experience, the effectiveness of policy transfers from North to South is questionable.

Specifically, given the simultaneous emergence of environmental burdens and the appearance of challenges at lower levels of income then previously experienced, holistic and integrated methods in which to address these new circumstances are urgently needed. One type of integrated method is the ecosystem approach. What the ecosystem approach has to offer urban managers is explored in the next section.

3.2 Potential of the ecosystem approach for addressing the new conditions in rapidly developing cities[16]

In order to examine how the ecosystem perspective is relevant to contemporary urban water environmental challenges, the section elucidates upon six premises. The first, an ecosystem approach integrates the bio-geophysical aspects of the environment with the socio-cultural aspects of human society. The second, an ecosystem approach provides a way of linking the multitude of socio-cultural and bio-geophysical elements, processes and structures that form the basis of environmental problems, in a coherent manner. The third premise emphasizes the importance of addressing environmental burdens at all scales, from the very local to the global. The fourth, an ecosystem

[16] The information in this section appears in an article entitled, "Ecosystem approaches and urban environmental planning," *UNU-IAS Working Paper,* (forthcoming).

approach focuses on human well-being as well as the environment. Fifth, the ecosystem approach provides meaningfully ways to understand, measure and monitor environmental quality. The sixth premise concerns both the process and output orientation of the ecosystem approach. The ecosystem planning process demands the inclusion of those stakeholders whose livelihoods depend upon the environment, as well as relevant governmental, private, non-governmental organization officials and other stakeholders who manage the system. Ecosystem planning produces "useable knowledge," which may be presented as, *inter alia*, assessments, future scenarios, or training methods.

3.2.1 Integrating bio-geophysical and socio-cultural aspects

An understanding of the dynamics of urban environmental challenges must integrate the behaviours and structures that make up human societies in conjunction with the elements and mechanisms of the "natural" world. This is no small task as it attempts to overcome centuries of sectoralisation and fragmentation beginning with Descartes and blossoming throughout the late Nineteenth Century. Indeed, during the Twentieth Century, academic disciplines and their related professions became even more specialized, focused and isolated. In particular, the social and bio-geophysical sciences increasingly lost contact as they developed different methodologies that prevented their working closely together.

Today, however, scholars suggest that the only way to address environmental issues is to integrate the sciences and hence their related professions (see for example, Holling 2001; Kinzig 2001; Lubchenco 1998; Norgaard 1989). Nowhere is this integration more needed than in understanding the environmental burdens of the world's cities. Of particular importance are the ways and means to combine social issues (e.g., economics: income, employment, poverty; health: nutrition, access to water, sanitation, disease, demography: urbanization, fertility, gender, etc) with the physical science issues (e.g., ecology, physics, chemistry, meteorology, geology, physical geography).

In order to integrate disciplines and sectors, scholars and practitioners must find common ground on which to share understanding. One way to do this is to simultaneously focus on specific issues or problems. Overcoming fragmentation must start with agreement from different disciplines (each of which brings to bear their own theories and tools) on a set of objectives. An example of how the ecosystem approach accomplishes this task is through focusing on how the "natural" environment provides the necessities for human health and well-being. The Millennium Ecosystem Assessment (MA), a four-year international multi-disciplinary assessment of the world's ecosystems, concentrates on the condition, trends and future ways in which the world's ecosystems can continue to support human well being through the provision of nature's services The main question of the MA effort is: "what are the consequences of ecosystem change for human well-being?"[17] The first part of the question, "ecosystem change" was defined as the ability of ecosystems to provide services (i.e., food, water, fibre, timber, etc) which makes it an attractive proposition for a host of life and physical scientists. The second part of the above question concerns human activities and well-being. This falls within the ambit of the social sciences.

[17] See http://www.millenniumassessment.org/en/about.overview.aspx.

Moreover, the MA suggests that humans are vitally dependent upon improving ecosystems, playing off the capabilities of ecosystems to meet current human demand and a burgeoning population with ever increasing per capita requirements. Hence, the MA also focuses on assessing planning, policies and other interventions. This aspect brings in practitioners, policy makers and other policy-oriented stakeholders.

A second way to integrate sectors and disciplines is to focus on the forces of urban environmental change as well as their inter-linkages. For example, the ecosystem approach advocates including anthropocentric drivers of change in the history and evolution of natural systems and the understanding of how human social systems respond to and have evolved in conjunction with natural ecosystem cycles. Hence, the ecosystem approach portrays the environment-human interaction as an interactive loop. Human activities produce environmental impacts that result in changing ecosystem patterns. Humans then respond to these new conditions through societal responses, such as changing management practices, institutional arrangements, strategies and policies. These additional responses create new environmental conditions, and so on.

Integrating the socio-cultural and bio-geophysical aspects of urban systems facilitates an appreciation of the complex inter–relationships between the various and diverse phenomena that gave rise to urban development. In terms of water supply, for example, in the past, inadequate access necessarily translated into the engineering of larger hydrological systems, including collection, distribution and treatment facilities. Combining knowledge from different fields highlights not only the engineering aspects of water resource management, but also behaviour alternatives (such as using demand management to regulate consumption), equity in the provision of water (identifying the needy) and the possibility of both centralized and de-centralized water projects. Indeed, any set of policies can be advocated by the approach, as long as they are based upon an integrated understanding of the demands placed by humans upon natural resources (and vice versa), the planning and management of natural resources and their related consequences and the bio-geophysical properties and conditions upon which a city can grow.

3.2.2 Linking the elements, processes and structures that form the basis of environmental challenges

To comb through the socio-cultural and bio-geophysical aspects of cities requires a system theory and a set of premises upon which the system can operate. The city as a system has been a central metaphor for urban management in the second half of the 20th century. The systems approach is essentially a formalised method of determining the role of components within the overall operation of the unit of study. Each system has coherence or unity, which enables distinctions to be made between it and other systems. With the subject defined in spatial terms the system can be viewed as a complex whole. What can make a particular system distinguishable from others are the interconnections of its parts and the flows that enable processes of change. The structure of a system is determined by the predictable ways in which parts interact and how flows operate. For example, using the Human Ecosystem Model, an integrated ecosystem approach, one can trace the cascading effects, or linkages between individual critical resource and social system variables. Changes in one set of variables directly relates to changes in others. Following these linkages and estimating their strength helps to define potential points for policy interventions (Machlis *et al.* 1997; Pickett *et al.* 1997).

Systems are thought to exist in two forms: open and closed. An open system interacts with its environment; a closed system is isolated from it. Cities are open systems because they interact with larger systems within which they operate and have within them nested sets of partially closed systems. As open systems, cities exchange energy and materials with larger and smaller scale systems. Urban system elements may not be tightly linked. That is, changes in some elements may take a long time before they affect other elements, and they may do so in only a miniscule way. At the same time, linkages can be found and in some cases, changes in some elements may produce unforeseen large differences (see for example, Gladwell 2000).

The systems approach has been embraced by the urban planning discipline since the 1960s. Urban planners focus on the articulation of various components of a city and the flows and processes between them. In this sense, urban planners seek to exercise control over the workings of parts of the entire system. The systems approach to planning was a radical departure from previous views of about how urban environmental problems should be addressed. Before the application of the urban systems approach, planning was largely an exercise in design (Friedmann 1987; Taylor 1998). Unfortunately, as there was no larger theory under which urban dynamics could be explained, the systems approach to planning became increasingly less popular.

Applying the ecosystem approach to systems thinking means the inclusion of flows, processes and driving forces that create healthy, liveable and resource efficient cities. Hence, focusing on urban growth, form and size are no longer relevant if these tasks do not fundamentally address the way that these conditions impact upon environmental health and the natural environment (and vice versa). Ecosystem planning focuses on the flows that create urban areas whereby internal environments are healthy for humans and other creatures. It also aims to reduce demands on resources outside urban borders, or at least couples the use of urban waste with production processes (or other viable consumers of this waste) elsewhere.

3.2.3 Integrating urban activities with their impacts at different geographic and temporal scales

The history of provision of ecosystem services to urban areas can be understood in terms of the increasing scale of urban environmental impacts. The search for adequate water supplies and safe locations for dumping waste water for example, can be seen as the extraction of ecosystem services from larger geographical areas or those further away from urban areas, as well as search for larger scale sinks into which wastes can be dumped (Tarr 1996). When one examines how urban environmental challenges were historically resolved at one scale level, it is relatively easy to understand how these burdens were shifted to larger geographic or longer time scales. Indeed, the way in which environmental burdens were ‘resolved’ at one scale facilitated their escalation to another. For example, solving local air pollution problems often meant building taller smokestacks on factories so that the pollutants could be absorbed by a larger air shed.

Environmental burdens have been delayed temporally as well. The transfer of risks associated with environmental burdens has increasingly been displaced to future generations. For example, some of the first environmental burdens were related to clean water provision. The impacts of providing less-than-fresh and clean water were immediate and often deadly. Currently, one of the important environmental impacts of urban activities is CO_2 emissions (from both transport and industry). The result of these emissions together with other greenhouse gas emissions is still unclear, but what is known is that the burden of the problem will largely fall upon future generations. Another example of shifting environmental burdens elsewhere is the decreasing availability of water resources as a result of development pressures. Will we be able to clean up water courses in time to provide potable water for domestic and agriculture needs for an expanded population of between 8-10 billion people by 2050?

Ecosystem approaches differentiate between geographic and temporal scale, by explicitly incorporating scale into analyses. The concept of the ecological footprint, an ecosystem perspective, was first developed to understand the impact of cities on ecosystems in locations outside cities (Rees 1992; Wackernagel & Rees 1996). The ecological footprint analysis is one ecosystem approach that helps us calculate the amount of land required to grow the food and other ecosystem services needed for sustenance and the land needed to absorb the wastes from all those living in a city.

Adding scale to urban planning assessments, allows for the recognition of emergent phenomena, the concept that properties at one scale do not necessarily transfer to other scales or organisational levels. What might be visible at the community level may not be visible at the household level. The aggregation of poor or slum settlements in flood plains cannot be detected at the household level, but, conversely, can be detected at the watershed level. Fundamental to understanding urban ecosystems are the why's, the how's and the extent that urban centres themselves are emergent phenomena. They emerge from the dynamic interactions of socio-economic and bio-geophysical forces which create an ecosystem with distinctive properties (Alberti *et al.* 2003).

Ecosystem planning approaches do not limit assessments at political boundaries and typically include future scenarios as outputs (see below). Linking scales of impact with driving forces at other scales is another key component to the approach. Moreover, ecosystem planning suggests that the appropriate management and action strategy should stem from the scales at which the mediation of the environmental burden finds the greatest leverage. In most cases, this is not only at the local level, but includes actions at a combination of different scales. Creating community-based problem-solving solutions to environmental conditions, particularly those that cross scales, is challenging. It calls for the creation of new institutions, based on networks that evolve across administrative and political boundaries (Schneider *et al.* 2003). Networking has been found successful in approaching both urban generated global burdens as well as local environmental challenges that are cumulative globally (Bulkeley & Betsill 2003; D'Cruz & Satterthwaite 2005). Incorporating scale into planning analyses highlights these new aspects of urban environmental management.

3.2.4 Measuring ecosystem quality

Traditional planning focused on solving problems arising within sectors, independently of what was occurring in other areas. Traffic problems were solved by the Department of Transportation and water supply problems by Agencies within the Department of Environment, Water or Public Works or Infrastructure. A holistic perspective of the city was envisioned, but never realised. A major reason for this fragmentation was the bureaucratic inability to prioritize amongst a number of unique sector challenges. One barrier to prioritization was the inability to coherently define urban quality across sectors.

The ecosystem approach embraces holism and does so by advocating concepts and measures for urban environmental quality in a broad sense. There are a number of different ways in which the ecosystem approach applies measures of environmental quality including ecosystem health, provision of ecosystem services and ecosystem resilience.

Ecosystem health extends the term health, which typically applies to individuals, to regional communities (ecosystems). It developed in response to the accumulating evidence that ecosystems, worldwide, have become stressed and highly dysfunctional. The definition of ecosystem health includes the concepts of system organization, resilience and vigour, and the absence of signs of ecosystem distress. The definition also includes the presence of essential functions and key attributes that sustain life systems. A healthy ecosystem is therefore defined as being stable and sustainable, maintaining its organization and autonomy over time and its resilience to stress (Rapport *et al.* 1998). Ecosystem health was a popular conception in the early 1990s, but later was supplemented by the concepts of ecosystem services and resilience.

Ecosystems provide a wide variety of services, such as water, food, fibre, timber and beautiful scenery (Daily 1997). It is easy to understand that these services are vital to human welfare. At the same time, not all ecosystems provide all services in the same quantity and that the delivery of these services from any one ecosystem varies depending on conditions of that ecosystem. The ability to provide ecosystem services necessary for human well-being, therefore, has emerged as a measure of ecosystem quality and can point to what types of services, within any given system, deserve protection (Ewel 2001).

The Millennium Ecosystem Assessment (2005a) identified a number of ecosystem services that impact upon human well-being including supporting services (such as nutrient cycling, soil formation and primary production), cultural services (aesthetic, spiritual, educational and recreational), regulating (climate, flood and disease regulation and purification) and provisioning (food, freshwater, wood and fibre, fuel) services. When ecosystems are functioning well, they provide these services in required quantity and quality to humans and their social systems. From this list, scientists were able to identify the conditions of ecosystems and develop a set of plausible global future scenarios for the delivery of these services based upon different development trajectories. Each scenario allowed for trade-offs among services depending upon the dominant set of driving forces. For example, in some scenarios globalization and trade dominated, in others technological answers to ecosystem challenges dominated. Using trends of ecosystem services as a baseline, the scenarios pointed out plausibly what the future might hold. These different scenarios facilitate an understanding of how current stakeholder decisions and structural aspects of development affect ecosystems and hence our future.

Ecosystem resilience describes the capacity of an ecosystem to cope with disturbances without shifting into a qualitatively different state. Measures of resilience describe how much shock a system can absorb and still remain within a desirable state (a value judgment predicated on social debate and consensus); the degree to which the system is capable of self-organization; and the degree to which the system can build capacity for learning and adaptation (Gunderson and Holling 2001). In this conception of environmental quality, urban environmental management becomes a task of creating or enhancing resilience. This task is imperative, as increasingly, the sustainability of our urban centres, in common with all ecosystems, will depend upon their ability to absorb unpredictable and surprising environmental shocks. The key to creating resilience is a diversified decision-making structure, successful common property institutions and a focus on maintaining biodiversity (as this is a crucial factor in natural ecosystem structure and function) (Swedish Environmental Council 2006).

Obviously, the definitions of each of these concepts overlap to varying degrees. Neither is one measure always appropriate, nor in all cases is one concept better than another. What is important is that the quality of the ecosystem can be identified and measured, in more than economic terms, and, at the same time, also monitored for change. Baseline information can then be used for evaluating policies or creating future plans.

The degradation of ecosystems, whether it is defined by health, provision of ecosystem services or resilience, stems from a host of structural aspects of the social system such as economic growth, demographic changes and those related to human agency (choices). Importantly, market mechanisms do not always ensure the conservation of ecosystem integrity. Where markets do exist as part of the ecosystem, policies and institutions can also exist that allow others outside the ecosystem to benefit while those living within it do not. Using these concepts to define and attempt to measure ecosystem quality provides space for a diverse array of policies, institutions and market mechanisms to keep ecosystems in a socially acceptable state.

3.2.5 Focusing on Human well-being

The ecosystem approach is partially based on the application of scientific methodologies to understand the organization (processes, functions and interactions) among organisms and their environment. Many may be put-off by the extensive reliance on biological concepts, and suggest that the ecosystem approach is nothing more than a way to study and advocate "natural" systems, green spaces or only ecological concerns. The ecosystem approach to planning and managing natural resources, however, recognizes that humans (including their cultures) are integral components of ecosystems. Indeed, it places the well-being of humans at the centre of, for example, ecosystem assessments and ecosystem management schemes (Millennium Ecosystem Assessment 2005a; Sheperd 2004). For example, the definition (emphasis added) promoted by the MA for ecosystem is:

> "…a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit. *Humans are an integral part of ecosystems*. Ecosystems vary enormously in size: a temporary pond in a tree hollow and an ocean basin can both be ecosystems." (Millennium Ecosystem Assessment 2005b, p. 27)

Furthermore, the ecosystem approach not only includes humans as part of the larger system, but focuses on how ecosystems matter to human health in a number of important ways. For example, the provision of clean water is vitally important to human health. Currently, over 1 billion people lack access to safe water supplies, while 2.6 billion people lack adequate sanitation. The lack of these services (fresh water from and neutralizing aspects of ecosystems) are associated with infectious diseases that claim up to 3.2 million lives each year, approximately 6 percent of all deaths across the globe. The WHO (2005) suggests that the burden of disease from inadequate water, sanitation and hygiene totals 1.8 million deaths annually and the loss of more than 75 million healthy lives years. The promise of provision of safe water and adequate sanitation for health reasons alone is a compelling reason to examine the approach.

The ecosystem approach, however, is not simply focused on human health. Human well-being, a more appropriate term and focus of concern, is considered to be more than just the absence of disease. Well-being helps us to focus on a varied range of inputs to daily life, including those from the environment that reduce illness and make cities more pleasant, safe and valued by inhabitants (Hardoy *et al.* 2001). Human well-being is the main focus of urban ecosystem assessments (McGranahan *et al.* 2005).

One way in which to address ecosystem – human well-being interactions has been formulated by the MA (Millennium Ecosystem Assessment 2005a). In this approach, multiple constituents in human well-being are identified including, basic material for a good life (adequate livelihoods, sufficient nutritious food, shelter, access to goods), freedom of choice and action (opportunity to be able to achieve what an individual values doing and being), health (strength, feeling well, access to clean air and water), good societal relations (social cohesion, mutual respect, ability to help other) and security (personal safety, secure resources access and security from disasters). Poverty is defined as the pronounced deprivation of the sense of well-being. Strong linkages have been found between regulation and provisioning services and security, basic material for good life and health (Millennium Ecosystem Assessment 2005a).

Placing humans at the centre of ecosystem analyses, demonstrates that the approach is not only about natural systems, or the provision of green spaces but that it can also be used to help focus attention on all of the environmental agendas from brown to green. That is to say, that overcoming issues of access to water supply and sanitation will necessarily focus on improving human health while addressing issues of environmental pollution and ecosystem degradation will likely include the broader conception of human well-being.

3.2.6 Including relevant stakeholders and producing "useable knowledge"

The Convention on Biological Diversity has identified 12 principles of ecosystem management (Sheperd 2004). The first principle states that "The objectives of management of land, water and living resources are a matter of societal choices."[18] The management of ecosystems is not just a scientific exercise, but also includes values.

In the past, planners opted for environmental solutions, appearing to suggest that there were purely scientific answers to social questions (Friedmann 1987). Increasingly, scientists and planners understand that these exercises were useless without incorporating differences in values among the relevant stakeholders. Inherent to the resolution of environmental challenges is social justice (Ludwig 2001).

A way to address the creation of greater equity includes the participation of stakeholders and other interested parties in collaborative planning efforts. In recent planning literature on sustainable cities, attention has focused on the different "ways of seeing" experienced by different groups. This understanding recognizes that urban challenges are "shaped by different social interests, based on different interpretations of the problem and characterized by quite different pathways towards a range of sustainable urban futures" (Guy & Marvin 1999, p. 273). In this conception, the

[18] See www.biodiv.org/programme/cross-cutting/ecosystem/sourcebook/home.shtml

preferred pathway to create a more sustainable future is not to immediately identify concrete goals and endpoints, but rather re-focus attention on unpacking the competing claims for what the sustainable city might become. Importantly, attention must be paid to the potential political domination of particular avenues in policy debates that squeeze out alternative environmental logics (see for example, Robbins 2004).

The ecosystem approach attempts to address these issues through its process. The ecosystem planning process emphasises inclusion, dynamism, and change within the system and therefore eschews detailed 'end–state' master plans. On the contrary, ecosystem planning focuses on ongoing processes and monitoring, as well as, analysing and intervening in fluid situations. Those developing and participating in the planning process include a wide variety of stakeholders.

By recognizing the diversity of social and cultural factors affecting natural resource use, the ecosystems approach to planning includes all relevant sectors of society and indigenous and local knowledge, innovations and practices. Ecosystem assessments, for example, are structured to encourage the use of multiple knowledge systems across scales, including scientific, practitioner and local/traditional knowledge. This is facilitated through multi-stakeholder teams, the sharing of practitioner knowledge and the involvement of local resource users (Ericksen *et al.* 2005). In this way competing "ways of seeing" incorporate into the either assessments or evaluations of alternative development pathways.

The emphasis of ecosystem planning is not only on process, however, it also produces valuable outputs. The output of ecosystem planning is "useable knowledge," meaning "knowledge that generates tools, materials, and curricula that are then used and further studied in practice."[19] Usable knowledge addresses pressing questions, it is grounded in sound theory, it is cost-effective, it is innovative in design and it is well-reasoned and subject to peer review (Machlis 1996). Some examples of "useable knowledge" for urban ecosystem planning include assessments, scenarios and the tools for capacity building.

Assessments include documenting in measurable terms, the quantity, quality and/or value of a particular object of study (in this case some aspect of the ecosystem). One approach to ecosystem assessments highlights the need to generate "useable knowledge" for management decisions which involve trade-offs among ecosystem services. Hence, emphasis is on quantitative evaluations of trade-offs (i.e., those for clearing land may be between food production and protection of biological resources, or those for providing timber are between the income from the timber and watershed protection) (Millennium Ecosystem Assessment 2005b).

Scenarios are envisioning experiments. They include plausible stories, accounting for uncertainties, told in both words and through numbers, about how the future might unfold (Raskin & et al 2005). Estimates of the mix of bio-geophysical changes within ecosystems and hence their ability to provide services for human well-being are another valuable contribution~~s~~ to planning and therefore form the basis of "useable knowledge."

Another output of the ecosystem approach for planning is the creation of tools for capacity building exercises. For example, the Human Ecosystem Model is currently

[19] See http://www.gse.harvard.edu/scalingup/definition.htm, definition by Ellen Condliffe Lagemann

being applied to capacity building efforts for urban environmental decision makers in the Association of Southeast Asian Nations (ASEAN). These exercises are part of a joint effort by the ASEAN Working Group on Environmentally Sustainable Cities, the United Nations University Institute of Advanced Studies and the Asia Institute of Technology. The ecosystem approach forms the basis of teaching material on water-related urban environmental challenges in the region.[20]

What is important about all of these outputs is the use of the approach in delivering relevant knowledge (in different forms) to those that desire it. "Useable knowledge" must be requested by end users (relevant stakeholders). That is, ecosystem planning outputs are user driven or directly related to what stakeholders want to know.

3.2.7 Summary

The ecosystem approach incorporates six premises that are necessary to overcome the fundamental environmental challenges faced by urban decision makers and relevant stakeholders in the developed and developing cities. The information in this section suggests that the approach does not merely tinker with current models and practices, but that it is fundamentally different in perspective and therefore calls for fundamentally different planning and management practices.

Whether the approach can be applied in contemporary urban areas to environmental decision making processes is yet another question. New institutions and modalities of action are required in order to fully implement its visions. Whether these can become fully operational remains unknown.

At the same time, using the ecosystem approach for the creation of usable knowledge can be a very worthwhile exercise, even if the appropriate institutions and ways of operating are not well developed. It helps to focus participants in environmental planning processes on the underlying forces of change in linked socio-ecological systems, promotes greater inclusiveness and therefore ownership of strategies and does not bias particular planning strategies. For example, strategies advocated by the MA include creating markets and property rights for ecosystem benefits, educating and dispersing knowledge and investments in improving ecosystems and the services they provide. An effective strategy for managing ecosystems involves a mix of interventions (Millennium Ecosystem Assessment 2005b).

Integrating the many dynamic aspects of urban environmental challenges will continue to be an aspiration and vision of many urban planners. The ecosystem approach theoretically provides one way of integrating environmental and ecological dynamics within urban systems and may prove to be a valuable asset in helping cities contribute to sustainability. Therefore it can be useful as the basis of capacity building training. We next elaborate on how we used one such ecosystem approach, the HEM, as a basis for capacity building in the region in the next section.

[20] See http://www.apn-gcr.org/en/activity/list2005projects.htm and http://www.ias.unu.edu/events/details.cfm/articleID/795.

3.3 Application of the human ecosystem model to water related urban environmental challenges in ASEAN – capacity building training[21]

This final sub-section presents the fundamental learning objectives of the workshops, a list of materials that were used in the workshops and that are included in the full in the accompanying CD, reports from each workshop and the results of questionnaires as to the value of the workshops.

3.3.1 Fundamental learning objectives of the workshops

The workshops were designed so that by their conclusion, participants would be able to:

a) Define an ecosystem approach for urban management.
b) Explain why a human-ecosystem model is a useful model (theoretical framework) for urban ecosystem management.

The workshops were divided into sections 5 sections including:

a) Environmental change and water related issues in ASEAN cities
b) The Human Ecosystem Model
c) Applying the Human Ecosystem Model
d) Using results of the Human Ecosystem Model
e) Conclusion

Environmental change and water issues in ASEAN cities.

At the conclusion of this module participants will be able to:

a) Describe current knowledge of environmental change and its causes and consequences related to urban water issues.
b) Identify general categories of urban water issues including; access, supply, quality, distribution (cross sector distribution), flow (drainage and flooding), and usage (sanitation, industrial, private).
c) Explain causes and consequences of specific water issues found in ASEAN megacities throughout the region.

The Human Ecosystem Model

At the conclusion of this module participants will be able to:

a) Define what the human ecosystem is, and when it is appropriate to use the model.
b) Identify, describe, and explain the components of the model and the reason for the component groupings.
c) Operationally define the variables and flows of the HEM, and how to select key variables and flows to monitor.
d) Identify potential indicators and measures of the key variables and flows.
e) Understand how scale effects influence variables and flows and the selection of indicators and measures.
f) Identify cascading effects across model components.

Applying the Human Ecosystem Model

At the conclusion of this module participants will be able to:

[21] Materials developed for the draft manual are included in the CDs submitted with the hard copy report. These include the handouts and copies of presentations.

a) Identify a number of different methods of data collection and measures for the different variables.
b) Explain how GIS can be used to present data useful for HEM analysis
c) Identify a number of different methods of data analysis appropriate to different measures.

Using results of the Human Ecosystem Model
At the conclusion of this module participants will be able to:
a) Identify cascading effects on variables that will help to direct management and policy decisions.
b) Select from different forms of data display to create effective tools for decision-making.
c) Use the model for planning (backcasting, prediction), management and decision-making on water related issues in ASEAN megacities.

Conclusion
At the conclusion of this module participants will be able to:
a) Explain the implications of using the human ecosystem model for; 1) science, planning, management, and policy decision-making, 2) water related issues in ASEAN cities, 3) understanding environmental change and its affect water management in ASEAN cities.
b) At the completion of the course, those that attended the entire two days receive a "certificate of completion" which are delivered individual in a final ceremony.

3.3.2 Elements of the workshop manual

All elements of the Manual are included in the table below. Each section is a separate electronic document. There are 37 separate parts to this manual. The documents were printed on plain white paper. All materials were placed in a simple binder or notebook. Most of the documents have been prepared as "Word" documents using Microsoft Windows XP and Microsoft Office XP Professional. Other documents are "PDF" attachments that can be opened using standard Adobe Reader software. The final set of documents are in PowerPoint (please print these out in sets of 3 slides on a page. The order of the documents was critical and documents were therefore numbered. All pages were designed to use standard US 8 ½ by 11 inch paper and adjusted if printed out in A4 size. Dividers are to be included between sections and labeled as indicated.

Page length	**Description of document**	**Name of document**	**Single side or duplex**	**Document Number – Special Instructions**
2	Instructions for assembling manual	.doc		1 DO NOT INCLUDE IN MANUAL
1	Cover	.doc	Single	2
1	Introduction letter	.doc	Single	3
1	Title page	.doc	Single	4
2	Instructors	.doc	Single	5
4	Workshop schedule	.doc	Single	6
	'Day 1' divider in folder			

1	Workshop introduction	.doc	Single	7
9	Environmental change	.pdf	Double-sided	8
??	Urban water challenges Presentation		Double-sided	9
54	Survey of ASEAN urban water challenges	.doc	Double-sided	10
31	UN 2003 World Water Development Report Chapter 7	.pdf	Double-side	11
1	Notes page for Environmental change	.doc	Single	12
8	HEM Overview	.doc	Double-sided	13
1	Six basic elements	.doc	Single	14
1	Image of HEM model	.doc	Single	15
31	Singapore HEM1	.pdf	Double-sized	16
1	Notes page for HEM	.doc	Single	17
9	Day1 ICBR Atlas Example	.pdf	Double-sided	18
	'Exercise 1' divider in folder			
2	Exercise 1	.doc	Single	19
1	HEM model notes page	.doc	Single	20
1	Notes page for Exercise 1	.doc	Single	21
	'Day 2' divider in folder			
1	Notes page for data collection and analysis	.doc	Single	22
1	Day2 What is GIS	.doc	Single	23
4	Day2 GIS Case study	.pdf	Double-sided	24
1	Notes page for cascading effects	.doc	Single	25
5	Tokyo Presentation	.pdf	Double-sided	26
1	HEM model notes page for Tokyo	.doc	Single	27
3	Phnom Penh Presentation	.pdf	Double-sided	28
1	HEM model notes page for Phnom Penh	.doc	Single	29
	'Exercise 2' divider in folder			
2	Exercise 2: Cascading effects	.doc	Single	30
1	HEM model notes page for cascading effects	.doc	Single	31

1	Notes page for Exercise 2	.doc	Single	32
1	Notes page for application	.doc	Single	33
12	Day 2 Displaying data	.pdf	Duplex	34
6	General guidelines	PPT/handout		35
1	Notes page for conclusion	Notes_Conclusion.doc	Single	36
4	Evaluation	(Not included in manual)		37

3.3.3 Workshop reports

1st workshop in Bangkok

The workshop was attended by approximately twenty representatives of cities from Myanmar, Thailand, Lao PDR, Cambodia and Vietnam and observers. Representatives from key organizations, namely the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC), the ASEAN Secretariat, United Nations Environment Programme (UNEP) and AIT also attended.

The key objective of the workshop was to introduce the HEM as a decision making tool for urban management of water-related issues in the ASEAN region. The HEM defines the human ecosystem as a coherent system of biophysical and human social factors capable of adaptation and sustainability over time. Dr. Gary Machlis, one of the originators of the model, explains that it has the potential to provide urban managers with practical knowledge for resource management as well as guide strategies for solving complex resource management problems. Machlis, the Canon Professor of Conservation at the University of Idaho, and his colleagues from Yale University developed the model over a number of years, as a tool for predicting and evaluating cascading effects in ecosystems across geographic scales and social and ecological systems.

Over the course of the two day training workshop, participants were introduced to the elements and processes of the HEM. They also went on a field trip and took part in a number of activities designed to illustrate the practical uses of the HEM.

Lectures were given by Dr. Niels Schulz and Dr. Ademola Braimoh, Post-doctoral Fellows at the UNU-IAS, on the current knowledge, causes and consequences of environmental change related to urban water management. Case studies on water access, quality, flow and usage in Asia, and the institutional imperatives for effective water management were highlighted.

Wayde Morse, University of Idaho, led participants through an initial exercise to identify key water related variables and their linkages to other factors within the model. The exercise was designed so that attendees could interpret information from a field trip subsequently taken to an “eco-house” in Bangkok. The eco-house uses solar energy to power household equipment, a system of recycling and water harvesting and a biogas generator using waste for creating cooking energy. The trip to the eco-house not only served as an introduction to an important urban management innovation, but also as a tool to promote a greater understanding of how to use the HEM.

Another exercise focused on identifying the potential cascading effects related to either flooding, drought or sea-level rise. Groups presented issues of flooding in Phnom Penh and Bangkok, drought in Laotian cities and sea level rise in Phuket. These exercises were designed to demonstrate how the HEM can help managers understand potential linkages among socio-cultural and biophysical factors in their own cities.

Participants then engaged in discussions on how to identify key indicators and measures for specific variables. Attendees addressed the quantitative capabilities of the model and learned how to develop databases. Participants were introduced to techniques that will enable them to identify methods of data collection and measures for the different variables, and methods of data analysis appropriate to different measures. The workshop then focused on how to apply the HEM to develop predictive scenarios with back-casting and forecasting techniques and to policy evaluation.

In the final sessions, participants formally evaluated the workshop by completing questionnaires and through group interviews. These evaluations will provide necessary feedback to improve future workshops. At the close of the workshop, participants who had completed the two-days of training were presented with certificates of completion.

2nd workshop in Singapore

The second capacity-building workshop of the "Application of the Human Ecosystem Model (HEM) to Urban Environmental Management in ASEAN" project was held on 26-27 January 2007, with support from the National Environment Agency, Singapore. The workshop was organised by the ASEAN Secretariat and the United Nations University Institute of Advanced Studies (UNU-IAS). It was co-funded by the UNU-IAS, the Asia-Pacific Network for Global Change Research (APN), the Asian Institute of Technology and ASEAN Secretariat through a generous grant from Singapore

The workshop was attended by eighteen representatives of cities from Brunei Darussalam, Indonesia, Malaysia, Philippines and Singapore, as well as a number of observers. Representatives from key organisations, namely the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC) and the ASEAN Secretariat also attended.

The key objective of the workshop was to introduce the HEM as a decision making tool for urban management of water-related issues in the ASEAN region. The HEM defines the human ecosystem as a coherent system of biophysical and human social factors capable of adaptation and sustainability over time. Dr. Gary Machlis, one of the originators of the model, explains that it has the potential to provide urban managers with practical knowledge for resource management as well as guide strategies for solving complex resource management problems. Machlis, the Canon Professor of Conservation at the University of Idaho, and his colleagues from Yale University developed the model over a number of years, as a tool for predicting and evaluating cascading effects in ecosystems across geographic scales and social and ecological systems.

Over the course of the two day training workshop, with the use of a specially designed manual, participants were introduced to the elements and processes of the HEM. Background lectures provided basic knowledge, of the causes and consequences of global environmental change and issues related to urban water management in ASEAN. Case studies on water access, quality, flow and usage in Asia, and the institutional imperatives for effective water management were highlighted.

The participants were led through an initial exercise to identify key water related variables and their linkages to other factors within the HEM. A second exercise focused on identifying the potential cascading effects related to either flooding, drought or sea-level rise. Groups presented issues on the relevance of these issues in their respective cities. These exercises were designed to demonstrate how the model can help managers understand potential linkages among socio-cultural and biophysical factors in their own cities. At the end of each exercise, participants presented their findings to the entire group.

The workshop progressed to engage participants in discussions on how to identify key indicators and measures for specific variables. Attendees addressed the quantitative capabilities of the model and learned how to develop databases. Participants were introduced to techniques that will enable them to identify methods of data collection and measures for the different variables, and methods of data analysis appropriate to different measures. Participants then focused on how to apply the HEM to develop predictive scenarios with back-casting and forecasting techniques and to policy evaluation.

In the final sessions, participants formally evaluated the workshop by completing questionnaires and through group interviews. These evaluations will provide necessary feedback to improve future workshops. At the close of the workshop, participants who had completed the two-days of training were presented with certificates of completion.

This second workshop is part of a two year effort. The first workshop was held on 28-29 June 2006, at the Asian Institute of Technology, Bangkok, Thailand. At that meeting, practitioners from Cambodia, Laos, Myanmar, Thailand and Vietnam participated. All participants in these workshops are from cities represented in the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC), chaired by Mr. Loh Ah Tuan, Singapore.

3.3.3 The value of the 2 workshops to participants[22]

Comments regarding the HEM presentation suggested it was applicable, "real" and useful. Exercises and case studies were reported to contribute to this sense of usefulness. This was particularly the case for the explanation of cascading effects. There were several comments about the visual presentation of both the projected images and the printed manual. In both cases, it was suggested that only the important details should presented and that what is presented ought to be visibly large, legible and clear.

4.0 Conclusions

There were three main goals of the project which included:

1. Provide 3 capacity building workshops within the Association of

[22] A full explanation of the workshop evaluations can be found in Appendix D.

Southeast Asian Nations (ASEAN) region. The first two target urban environmental decision makers and the last workshop is a "train-the-trainers" workshop;

2. Develop a capacity building tool in the form of a CD-ROM that can be used by others in the region to continue convening workshops using the HEM; and
3. Produce background research (case study of urban water related issues in ASEAN and the potential of the ecosystem approach for urban planning and policy) and a guideline paper for how to apply the HEM to policy analysis.

We accomplished these goals with the exclusion of the last "train-the-trainers" workshop which we are organizing now. We will convene this workshop before the end of the year and thereafter produce the final CD-ROM and policy guidelines paper (both of which are currently in draft form).

We found that the use of the ecosystem approach for addressing water related challenges in the region was welcomed by city managers. It was found by the project coordinators to be an exciting and useful way to develop capacity building training exercises. We view this effort as a pilot study and intend to continue working within the area. In the next section we provide some ideas as how to proceed.

5.0 Future Directions

We believe that this project was a success and that there are also several future pathways for work related this project. First, in terms of research we are interested in further exploring the differences in environmental conditions between rapidly developing urban areas and those of the now developed world. We believe that current globalization driven growth as well as domestic and local drivers of change are significantly different now than experienced in the past and that therefore the structure of environmental conditions (that they are appearing at lower levels of income, changing faster and emerging in a more simultaneous fashion than previously experienced) demand new environmental policy approaches. Further elaboration on these differences and how they are related to differences in drivers is of interest to this project and the larger global environmental change academic community.

Second, there is also work to be done exploring how integrated approaches, such as the HEM, can be applied to applied in the developing world context. While there has been some work in the developed world there is yet to be a significant amount of policy research in this area within the developing context.

Finally, we remain committed to the idea of capacity building training using this approach. We have already developed a funding proposal for the continuation of this work using the HEM as the fundamental conceptual paradigm to apply the training. We are currently considering where to send the proposal to and how to further promote this type of capacity building training. While we are currently focusing on the Asia Pacific region, we are also open to moving to other developing regions.

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Appendix A - Data tables

Table 1

Various scales of urban water-related challenges

Water-related challenge	Scale of impact
Brown issues	
Access to water supply	Household
Access to sanitation	Household
Adequate drainage	Neighborhood
Gray issues	
River pollution	Metropolitan region to regional
Overdrawn groundwater supplies	Neighborhood to Metropolitan region
Ground subsistence	Neighborhood to Metropolitan region
Coastal area degradation	Metropolitan region to regional
Flooding	Neighborhood to Metropolitan region
Green issues	
Increasing water consumption per capita	Metropolitan region to regional
Water scarcity	Metropolitan region to regional
Increased vulnerability due to climate change/variability	Regional

Table 2

Percent of total population in poverty

Country	Poverty (percent)
Brunei Darussalam	0
Cambodia	36
Indonesia	17
Lao PDR	39
Malaysia	8
Myanmar	23
Philippines	28
Singapore	0
Thailand	10
Vietnam	37

Source: ASEAN Statistical Yearbook 2004

Table 3

Percent households below poverty in selected Southeast Asian cities

City	Country	Households below poverty (percent)
Phnom Penh	Cambodia	16.4
Bandung	Indonesia	2.0
Jakarta	Indonesia	6.6
Semarang	Indonesia	24.8
Surabaya	Indonesia	0.9
Vientiane	Lao PDR	19.0
Penang	Malaysia	6.1
Yangon	Myanmar	-
Cebu	Philippines	-
Bangkok	Thailand	15.9
Chiang Mai	Thailand	9.7
Hanoi	Vietnam	2.1
Ho Chi Minh	Vietnam	10.6

UN-HABITAT, 2003a

Table 4

Estimates as to the number of urban dwellers lacking provision for water and sanitation in 2000 based on who has "improved" provision and who has "adequate" provision

Region	Number and proportion of urban dwellers without "improved" provision for:		Indicative estimates for the number (and proportion) of urban dwellers without "adequate" provision for:	
	Water	Sanitation	Water	Sanitation
Africa	44 million 15 percent	46 million 16 percent	100-150 million 35-50 percent	150-180 million 50-60 percent
Asia	98 million 7 percent	297 million 22 percent	500-700 million 35-50 percent	600-800 million 45-60 percent
Latin America and the Caribbean	29 million 7 percent	51 million 13 percent	80-120 million 20-30 percent	100-150 million 25-40 percent

Source: UN-HABITAT, 2003b

Table 5

Progress in safe drinking water coverage, national and urban populations
(percent)

		Improved drinking water coverage			
		Total population		Urban population	
Country		Total improved	With household connections	Total improved	With household connections
Brunei Darussalam	1990		-	97	100
	2002	99	100	98	100
Cambodia	1990	-	-	-	-
	2002	34	6	58	31
Indonesia	1990	71	10	92	26
	2002	78	17	89	31
Lao PDR	1990	-	-	-	-
	2002	43	8	66	25
Malaysia	1990	-	-	96	-
	2002	95	-	96	-
Myanmar	1990	48	3	73	11
	2002	80	8	95	23
Philippines	1990	87	21	93	37
	2002	85	44	90	60
Singapore	1990	-	-	100	100
	2002	-	-	100	100
Thailand	1990	81	28	87	69
	2002	85	34	95	80
Vietnam	1990	72	11	93	51
	2002	73	14	93	51

Source: UNEP RRCAP, 2004; ASEAN, 2005

Table 6

Provision for water supplies in selected Southeast Asian cities, mid-1990s

City	Population with house taps (percent)	Population served by public taps (percent)	Persons per public tap	Notes
Phnom Penh	83.1	0		17 percent without piped water; rely on wells and ponds
Bandung	31.4	10.4	100	58 percent without piped water: relying mostly on tube wells and dug wells
Jakarta	20.5	6.7	300	73 percent without piped water relying on tube wells, dug wells and rain collectors
Medan	57.1	5.7	60	37 percent without piped water; most use tube well and shallow wells
Vientiane	54.2	0.1	16.25	Utility claims 8 percent without piped water relying on wells, rivers and rainfall
Johor Bahru	99.9	0		
Kuala Lumpur	45.9	0		Utility claims 100 percent coverage
Penang	100	0.1	50	
Mandalay	36.6	0.4	50	Utility claims 20 percent without piped water relying on tube wells or rivers
Yangon	56.4	11.8	180	40 percent without piped water relying on tube wells, ponds and rain collectors
Cebu	20.9	1.6	128	77 percent without piped water; 47 percent relying on wells, rest from vendors
Davao	52	0		48 percent without piped water relying on tube wells and rain collectors
Manila	38	5.7	357	33 percent without piped water; most depend on wells
Singapore	100			
Bangkok	62.8	0		Utility claims 18 percent without piped water relying on wells, ponds and rain water
Chiang Mai	64.8	0		35 percent without piped water relying on wells and rain water
Chonburi	79.8	0		Utility claims 11 percent not covered relying on tube wells and rain water
Hanoi	70.8	4.9	116	24 percent without piped water relying on wells, ponds and rain water
Ho Chi Minh City	50	0.1	1270	48 percent without piped water relying on tube wells

Source: UN-HABITAT, 2003b

Table 7

Progress in safe sanitation coverage, national and urban populations
(percent)

Country		Improved sanitation coverage	
		Total	Urban
Brunei Darussalam	1990	-	-
	2000	100	-
Cambodia	1995	14	-
	2000	18	53
Indonesia	1990	54	66
	2000	55	71
Lao PDR	1990	19	-
	2000	30	61
Malaysia	1990	94	94
	2000	100	-
Myanmar	1990	45	39
	2000	64	96
Philippines	1990	74	63
	2000	83	81
Singapore	1990	100	100
	2000	100	100
Thailand	1990	79	95
	2000	98	97
Vietnam	1990	29	46
	2000	47	84

Note: For urban coverage all starting dates are 1990 and latest date is 2002

Source: UNEP RRCAP, 2004; ASEAN, 2005

Table 8

Sewerage access in selected Southeast Asian cities

City	Coverage (percent)	Notes
Vientiane	0	No piped sewerage system in this or any city of the country. the small bore sewer system currently installed in limited areas of the municipality is not working due to blockages. In areas with onsite sanitation, septic tank effluents discharge into storm drains and into watercourses
Phnom Penh	41	37 percent of households use septic tanks and 12 percent have no toilet facilities.
Ho Chi Minh	12	Sewerage system is combined with the storm drainage system. Coverage is low in new urban (1 percent) and rural districts (0.3 percent). About 79 percent of households have septic tanks
Manila	7	Existing system is old without improvement over the last 10 years. Many households rely on individual septic tanks with effluent that discharges into storm drains.
Jakarta	2	Sewerage is restricted to high rise buildings and a small number of households. About 39 percent of households use septic tanks and 20 percent use pit latrines.
Kuala Lumpur	80	Septic tanks are still in use in the city. All new housing subdivisions are required to provide adequate hookups to the central sewerage system.

Source: ADB 2004

Table 9

Percent wastewater treated in selected Southeast Asian cities

City	Country	Waste water treated (percent)
Phnom Penh	Cambodia	0.0
Bandung	Indonesia	23.4
Jakarta	Indonesia	15.7
Semarang	Indonesia	0.0
Surabaya	Indonesia	0.0
Vientiane	Lao PDR	20.0
Penang	Malaysia	20.0
Yangon	Myanmar	0.0
Cebu	Philippines	-
Singapore	Singapore	100.0
Bangkok	Thailand	-
Chiang Mai	Thailand	70.0
Hanoi	Vietnam	-
Ho Chi Minh	Vietnam	-

UN-HABITAT, 2003b

Table 10

Selected biological water quality indicators and measures for rivers in Southeast Asia, annual averages for last year on record

River	Nearest Major Metropolitan Center	Year	Organic matter: COD ($mg/L\ O^2$)	Organic matter: BOD ($mg/L\ O^2$)	Microbiology: Feacal Coliform Bacteria (No/100 ml)	Physical Characteristics: Suspended Solids 105° C (mg/L)	Physical Characteristics: Temperature (°C)
Klang river	Kuala Lumpur	1992	42.56	-	606,750	311.3	27.00
Mekong	Vientiane	1995	1.52	-	-	930.0	29.28
Pampanga River	Metro Manila	1984	-	4.36	2,026	-	29.29
Laguna Lake	Metro Manila	1990	-	-	-	-	27.98
Chao Phrya	Bangkok	1993	-	5.13	278,000	-	30.63
Ciliwing	Jakarta	1981	18.24	-	99,999	399.4	29.20
Banjir Canal		1995	-	8.90	999,999	94.5	27.56
Mekong	Phnom Penh	1994	3.73	-	-	87.3	29.12

Source: UNEP GEMS-Water

Table 11

Selected heavy metal water quality indicators and measures for rivers in Southeast Asia, annual averages for all years on record

River	Nearest Major Metropolitan Center	Years	Total Arsenic (mg/L)	Total Cadmium (mg/L)	Total Chromium (mg/L)	Total Copper (mg/L)	Total Iron (mg/L)	Total Lead (mg/L)	Total Manganese (mg/L)	Total Mercury (ug/L)	Total Nickel (mg/L)	Total Zinc (mg/L)
Klang river	Kuala Lumpur	1979-92	0.07402	0.0040	0.0609	0.0200	3.1400	0.0388	0.4794	0.0024	-	0.0683
Chao Phrya	Bangkok	1991-93	-	0.0036	0.0377	0.0231	0.8265	0.0526	0.2204	0.4163	-	0.1735
Banjir Canal	Jakarta	1985-94	0.0030	0.0074	0.0221	0.0270	3.5915	0.0957	0.3000	0.2000	0.0137	0.1247
WHO 2004 Guidelines			0.0100	0.0030	0.0500	2.0000	NA	0.0100	0.4000		0.0200	

Source: UNEP GEMS-Water, WHO, 2004

Table 12
Potential sources of heavy metals

Element	Source
Arsenic	Pesticides, fertilizers, plant desiccants, animal feed additives, copper smelting, sewage sludge, coal combustion, incineration and incineration ash, detergents, petroleum combustion, treated wood, mine tailings, parent rock material
Cadmium	Phosphate fertilizers, farmyard manure, industrial processes (electroplating, non-ferrous metal, iron and steel production), fossil fuel combustion, incineration, sewage sludge, lead and zinc smelting, mine tailings, pigments for plastics and paint residues, plastic stabilizers, batteries, parent rock material
Chromium	Fertilizers, metallurgic industries, electric arc furnaces, ferrochrome production, refractory brick production, iron and steel production, cement, sewage sludge, incineration and incineration ash, chrome-plated products, pigments, leather tanning, parent rock material
Nickel	Fertilizers, fuel and residual oil combustion, alloy manufacture, nickel mining and smelting, sewage sludge, incineration and incineration ash, electroplating, batteries, parent rock material
Copper	Fertilizers, fungicides, farmyard manures, sewage sludge, industrial processes, copper dust, incineration ash, mine tailings, parent rock material
Lead	Mining, smelting activities, farmyard manures, sewage sludge, fossil fuel combustion, pesticides, batteries, paint pigment, solder in water-pipes, steel mill residues
Manganese	Fertilizers, parent rock material
Mercury	Fertilizers, pesticides, lime, manures, sewage sludge, catalysts for synthetic polymers, metallurgy, thermometers, coal combustion, parent rock material
Zinc	Fertilizers, pesticides, coal and fossil fuel combustion, non-ferrous metal smelting, galvanized iron and steel, alloys, brass, rubber manufacture, oil tires, sewage sludge, batteries, brass, rubber production, parent rock material

Sources: O'Neill, 1995, Alloway, 1995, McGrath, 1995, Baker and Senft, 1995, Davies, 1995, Smith and Paterson, 1995, Steinnes, 1995, Kiekens, 1995, Brady and Weil, 2002

Table 13

Persistent organic pollutants (organochlorine pesticides) in local water environments in Southeast Asia

Location	BHC ng/L	Aldrin ng/L	Dieldrin ng/L	Endrin ng/L	a-Endosulfan ng/L	b-Endosulfan ng/L	Heptachlor ng/L	Lindane ng/L	p,p'-DDT ng/L	p,p'-DDE ng/L
Selangor River		884	850	10970	8.9	12270	13710	40950	44770	2310
Surabaya River									50	
Philippine coast	21	7								
Dmapha and Balat estuaries									30	
Singapore	7		18	2		2			1	1

Source: Basheer, et al, 2003

Table 14

Cost of river water pollution remediation in Southeast Asia

Country	Annualized Cost of remediation (1990 millions US$)	As percent of GDP
Singapore	24.42	0.24
Thailand	67.00	0.83
Myanmar	3.56	1.23
Malaysia	43.15	1.32
Philippines	39.59	1.40
Indonesia	100.10	1.43
Cambodia	0.31	5.62
Vietnam	12.97	7.30
Lao PDR	0.26	7.43

Source: Jalal and Rogers, 2002

Table 15

Pollutant fluxes from rivers in Cambodia and Thailand to the South China Sea

Country/River	Annual discharge (km^3)	BOD (t/y)	Total Nitrogen (t/y)	Total Phosphorus (t/y)	Total suspended solids (t/y)
Cambodia					
Tonle Sap Lake-River system	36.46	6,022	1,084	303	13,250
Mekong River, Cambodia section	128.38	4,964	894	255	10,950
Thailand					
Center, Eastern Southern Rivers	144.2	299,224	130,044	7,137	12,587
Total South China Sea for Continental Countries		1,015,936	636,840	58,202	58,642,827

Source: UN ESCAP, 2000

Table 16
Coral reefs at risk by country and risk level

Country	Total coral reef area (km^2)	Share of regional total (percent)	Risk Level: Low (km^2)	Low (percent)	Medium (km^2)	Medium (percent)	High (km^2)	High (percent)	Very high (km^2)	Very high (percent)	High and Very high (percent)
Indonesia	50,875	59.4	6,930	13.6	19,809	38.9	23,403	46.0	733	1.4	47.4
Philippines	25,819	30.2	559	2.2	7,099	27.5	16,311	63.2	1,850	7.2	70.3
Malaysia	4,006	4.7	533	13.3	1,771	44.2	1,541	38.5	161	4.0	42.5
Thailand	1,787	2.1	419	23.4	427	23.9	917	51.3	24	1.3	52.7
Myanmar	1,686	2.0	742	44.0	604	35.8	336	19.9	4	0.2	20.2
Vietnam	1,122	1.3	43	3.8	252	22.5	551	49.1	276	24.6	73.7
Brunei	187	0.2	147	78.6	30	16.0	10	5.3	0	0.0	5.3
Singapore	54	0.1	0	0.0	0	0.0	54	100.0	0	0.0	100.0
Cambodia	42	0.0	0	0.0	0	0.0	38	90.5	4	9.5	100.0
Regional totals	85,578	100	9,373	11.0	29,992	35.0	43,161	50.4	3,052	3.6	54.0

Source: WRI, 2002.

Table 17

Flooding in selected Southeast Asian cities

City	Notes
Vientiane	Long history of inundation problems caused by overflowing of the Mekong River. Drainage is inadequate to carry storm water runoff and the situation is deteriorating. The districts of Sikhottabong, Sisattanak and Hatxaiphong are flooded at least once a year.
Phnom Penh	The city is susceptible to flooding from surrounding river and water back up during peak flood events. Controls include outer and inner dikes in rings, 10 drainage pumping stations, drainage channels and a small sewer network. Dikes are eroded and drainage channels clogged.
Ho Chi Minh	Parts of Ho Chi Minh City experience floods several times each year during the rainy season (June-November) and during the high tide season (October-January).
Manila	Flooding is recurrent related to water flows from Pasig-Marikina River and Laguna Lake basin combined with high tides and inadequate drainage.
Jakarta	Approximately 50 percent of the city is prone to flooding when several or all of the 13 rivers in the city overflow. About 40 percent of the city is below sea level during high tide. Only a quarter of this areas is protected by dikes leaving the remaining areas subject to floods.
Kuala Lumpur	Low lying areas of the city are susceptible to flooding during heavy downpours. Flood waters typically subside within 5-6 hours

Source: ADB 2004

Table 18

Water availability and cost in selected cities of Southeast Asia, mid-1990s

City	Water availability (hours a day)	Average tariff (US$ per meter^3)	Unaccounted for water (percent)
Phnom Penh	12	0.15	61
Bandung	6	0.369	43
Jakarta	18	0.611	53
Medan	24	0.266	27
Vientiane	24	0.081	33
Johor Bahru	24	0.186	21
Kuala Lumpur	24	0.131	36
Penang	24	0.208	20
Mandalay	24	1.201	60
Yangon	12	0.456	60
Cebu	18	0.663	38
Davao	24	0.271	31
Manila	17	0.232	44
Singapore	24	0.553	6
Bangkok	24	0.313	38
Chiang Mai	20	0.299	35
Chonburi	16	0.461	37
Hanoi	18	0.113	63
Ho Chi Minh City	24	0.131	34

Source: UN-HABITAT, 2003b

Table 19

Water footprint of selected Southeast Asian nations

Country	Total renewable water resources Gm^3/year	Internal water footprint Gm^3/year	External water footprint Gm^3/year	Total water footprint Gm^3/year	Water scarcity percent	Water self-sufficiency percent	Water import dependency percent
Cambodia	476.11	20.45	0.54	20.99	4	97	3
Indonesia	2838.00	242.30	27.66	269.96	10	90	10
Laos	333.55	7.44	0.21	7.64	2	97	3
Malaysia	580.00	38.87	15.01	53.89	9	72	28
Myanmar	1045.60	74.38	1.11	75.49	7	99	1
Philippines	479.00	104.40	12.45	116.85	24	89	11
Thailand	409.94	123.24	11.22	134.46	33	92	8
Viet Nam	891.21	100.21	3.12	103.33	12	97	3

Notes:

Water scarcity: The ratio of the total water footprint of a country or region to the total renewable water resources. National water scarcity percentages can be more than 100% if a nation consumes more water than domestically available

Water self-sufficiency: The ratio of the internal water footprint to the total water footprint of a country or region. Self-sufficiency approaches 100% when national water demand is taken from within domestic boundaries.

Water import dependency: The ratio of the external water footprint of the country or region to its total water footprint. The dependency ratio increases as countries import more of the water demanded by domestic activities.

Source: Chapagain and Hoekstra 2004.

Table 20

Summary of various water related challenges for cities in different income categories in Southeast Asia by scale of impact

City	Local	Metro-wide	Regional and global
Low-income cities			
	Low levels water supply coverage	River and coastal water pollution	Economic water scarcity
	Low levels of sanitation coverage	Overdrawn groundwater	Vulnerability due to climate change
	Poor drainage	Subsistence	
		Coastal area degradation	
		Flooding	
Middle-income cities			
	Low levels of water supply coverage	River and coastal water pollution	Economic water scarcity
	Low levels of sanitation coverage	Overdrawn groundwater	Vulnerability due to climate change
	Poor drainage	Subsistence	
		Coastal area degradation	
		Flooding	
Upper-middle income cities			
	Low levels to incomplete sanitation coverage	River and coastal water pollution	Increasing water consumption per capita
	Water supply coverage not complete	Overdrawn groundwater	Vulnerability due to climate change
	poor to inadequate drainage	Subsistence	
		Coastal area degradation	
		Flooding	
High income cities			
		River and coastal water pollution	Physical water scarcity
		Coastal area degradation	Increasing water consumption per capita
			Vulnerability due to climate change

Notes:

Cities in low income category include Vientiane, Phnom Phen, Hanoi, Ho Chi Minh, among others

Cities in the middle income category include Manila, Jakarta, among others

Cities in the upper-middle income category include Bangkok, Kuala Lumpur, among others

Cities in the high income category include Singapore

Appendix B - Workshop agendas and participants

Bangkok workshop schedule with field trip

Application of the Human Ecosystem Model (HEM) to Urban Environmental Management in ASEAN: Addressing Potential Impacts of Environmental Change
Presenter/preparer codes: G=Gary Machlis, P=Peter Marcotullio, W=Wayde Morse, PD=Postdocs

Time/Module	Topic/Presentation Time	Learning Objectives	Delivery mechanisms	Presenter (Preparer)
8:00a - 8:45a	**Opening remarks and introductions by hosts, introduction to participants**			Presenter: P & Guests Preparer: P
8:45a - 9:30a	**Introduction to workshop**			
	8:45a – 9:00a	A. Define an ecosystem approach for urban management.	Lecture	Presenter: G Preparer: G
	9:00a – 9:15a	B. Outline the workshop; day 1 and day 2.	Lecture/handouts	Presenter: G Preparer: W
	9:15a – 9:30a	C. Explain why a human-ecosystem model is a practical tool for developing useable knowledge for urban ecosystem management.	Lecture/questions	Presenter: G Preparer: G
9:30a - 10:45a	**The Human Ecosystem Model (HEM)**			
	9:30a – 9:45a	A. Define the human ecosystem, and when it is appropriate to use the model.	Lecture/questions	Presenter: G Preparer: G
	9:45a – 10:05a	B. Identify, describe, and explain the components of the model and the reason for the component groupings.	Handout/lecture/ powerpoint	Presenter: G Preparer: G & W

	10:05a – 10:25a	C. Operationally define the variables and flows of the HEM, and how to select key variables and flows to monitor.	Lecture/powerpoint	Presenter: G Preparer: G & W
	10:25a – 10:35a	D. Identify potential indicators and measures of the key variables and flows.	Discussion/lecture	Presenter: G Preparer: G & W
	10:35a – 10:45a	E. Review HEM; Questions and answers	Discussion	Presenter: G Preparer: G
10:45a - 11:15a	**Break**			
11:15a – 12:00p	**Environmental change and urban water issues**			
	Environmental change 11:15a – 11:30a	A. Describe current knowledge of environmental change and its causes and consequences related to urban water issues.	Lecture/powerpoint	Presenter: PD & W Preparer: PD & W
	Urban water issues 11:30a – 11:45a	B. Identify general categories of urban water issues including; access, supply, quality, distribution (cross sector distribution), flow (drainage and flooding), and usage (sanitation, industrial, private).	Lecture/powerpoint	Presenter: P & PD Preparer: P & PD & W
	Environmental change and Urban water issues 11:45a – 12:00p	C. Questions and answers	Discussion	Presenter: P Preparer: PD & P
12:00p – 1:00p	**Lunch**		Film clips	Preparer: W & G
1:00p - 2:00p	**Exercise 1: Selecting variables for field trip on sustainable homes**			
	1:00p – 1:20p	D. Introduction to scenario building and team activity for field trip exercise. Form groups.	Lecture/handout	Presenter: W Preparer: W
	1:20p – 2:00p	C1. Individuals group by city (or country) to meet and discuss variable selection for presentations on water issues for households in ASEAN megacities.	Participant brainstorming/ handout	Presenter: W & P & G & PD Preparer: W
2:00p – 5:00p	**Field Trip to visit sustainable homes project**			

Day 2: Bangkok

8:00a – 8:15a	**Review**	Review material from previous day and outlines day 2 of workshop.	Discussion/film clip	Presenter: G Preparer: G
8:15a – 9:00a	**Field trip presentations**	City (country) presentation of variable selection on water issues for households in ASEAN megacities.	Oral presentations/ overhead/discussion	Presenter: Participants Preparer: W
9:00a – 10:30a	**Applying the Human Ecosystem Model**			
	9:00a – 9:05a	A. Introduction to cascading effects across model components.	Lecture	Presenter: G Preparer: G & W
	9:05a – 9:20a	A1. Bangkok: Case Studies on cascading effects	PPT (model with cascading effects)	Presenter: G Preparer: W
	9:20a – 9:35a	A2. Tokyo: Case Studies on cascading effects	PPT (model with cascading effects)	Presenter: P Preparer: W
	9:35a – 9:50a	A3. Singapore: Case Studies on cascading effects	PPT (model with cascading effects)	Presenter: PD Preparer: PD
	9:50a – 10:05a	A4. Phnom Penh: Case Studies on cascading effects	PPT (model with cascading effects)	Presenter: W Preparer: W
	10:05a – 10:15a	B. Identify different methods of data collection and measures for the different variables.	Lecture/discussion	Presenter: G Preparer: G
	10:15a – 10:30a	C. Identify different methods of data analysis appropriate to different measures.	Lecture/discussion/ handout	Presenter: G Preparer: G & W
10:30a - 11:00a	**Break**			
11:00a – 12:00p	**Exercise 2: Cascading effects**			

	11:00a – 11:15a	A. Introduction to Team exercise 2. Form groups.	Lecture/handout	Presenter: W Preparer: W
	11:15a – 12:00p	B. Individuals group by city (or country) to meet and discuss cascading effects.	Participant brainstorming	Presenter: W & P & G Preparer: W
12:00p – 1:00p	**Lunch**			
1:00p – 2:00p (Module 5 applied)	**Exercise 2: Cascading effects continued**			
	1:00p – 2:00p	C. City (country) presentation of cascading effects of ASEAN water issues and relevant indicators and measures (5 groups of 5)	Oral presentations/ overhead/discussion	Presenter: Participants Preparer: W
2:00p – 2:30p	**Using results of the Human Ecosystem Model**			
	2:00p – 2:10p	B. Selecting from different forms of data display to create effective tools for decision-making.	Powerpoint/maps	Presenter: G Preparer: W & G
	2:10p – 2:20p	C. Using the model for planning (backcasting, prediction), management and decision-making on water related issues in ASEAN megacities.	Lecture/questions	Presenter: G Preparer: W & G
	2:20p – 2:30p	D. Understand how scale influence variables and flows and the selection of indicators and measures	Lecture/questions	Presenter: G Preparer: W & G
2:30p – 2:45p	**Conclusion**			
	2:30p – 2:45p	A. Explain the implications of using the human ecosystem model for;1) science, planning, management, and policy decision-making, 2) water related issues in ASEAN megacities, 3) understanding environmental change and its affect water management in ASEAN megacities.	Lecture/powerpoint	Presenter: G Preparer: G
2:45p – 3:00p	**Evaluation**	Written formal feedback on the seminar.	Evaluation form	Presenter: W Preparer: W
3:00p – 3:30p	**Break**			
3:30p – 5:00p	**Evaluation**	Evaluation of the workshop.	Focus Groups; Semi-structured interview	Presenter: W & P & G & PD Preparer: W
5:00p – 5:30p	**Closure**	Presentation of certificates	Discussion	Presenter:

				P & G & W Preparer: P

Participants in the Bangkok workshop

Name	Post	City & Country	Email
1. Mr. Vichai Kunaratskul	Director, Public works bureau, Chiangmai municipality	Chiangmai, Thailand	
2. Mr. Somsak Larpadisorn	Director, Sanitary Engineer Division. Chianmai Municipality	Chiangmai, Thailand	
3. Mr. Vongkot Owatsakul	Head, Wastewater Treatment, Chiangmai Municipality	Chiangmai, Thailand	vongkoto@yahoo.com
4. Ms. Suthimol Kessomboon	Sanitary Engineer, Dept. of Drainage and Sewerage, Bangkok Metrop. Administration	Bangkok, Thailand	suthimol1@hotmail.com
5. Ms. Sureeporn Kerdkankaew	Environmental Officer, Office of Natural Res & Env. Policy & Planning.	Bangkok, Thailand	nutch_kk@yahoo.com
6. Mr. Dawnden Suwanachet	Environmental Officer, Office of Natural Res & Env. Policy & Planning	Bangkok, Thailand	No email
7. Ms. Kamonthip Konprasetamorn	Environmental Officer, Office of Natural Res & Env. Policy & Planning	Bangkok, Thailand	kongpra@yahoo.com
8. Mr. MONGKOL SONGKAO	Director - Bureau of Public Works	Phuket, Thailand	engineer@phuketcity.go.th
9. Mr. PRACHUM SURIYA	Chief of Environmental Group, Phuket City Municpaity	Phuket, Thailand	envigroup@phuketcity.go.th
10. Mr. U THEN MIN	Executive Engineer – Engineering Dept. (Water & Sanitation), Yangon City Dev. Committee,	Yangon, Myanmar	jsycdc@mptmail.net.mm priycdc@mptmail.net.mm
11. Mr. Kang Rattanakone	Acting Director General - Urban Dev. Admin. Authority, Luang Prabang Province	Luang Praban, Lao PDR	No email
12. Mr. Thevarak Phoneko	Deputy Chief of International Cooperation Division, Science, Technology and Env. Agency	Vientiane, Lao PDR	thevarack@hotmail.com thevarack@yahoo.com

13. Mr. Pheng Douangnguen	Governor- Sayyabury District, Sayyabury Province	Sayyabury, Lao PDR	phengdng@yahoo.com.uk
14. Mr. Ang Chiek	Deputy Director, Department of Environment Phnom Penh Municipality	Phnom Penh, Cambodia	chiek_ang@yahoo.com or ang.chiek@online.com.kh
15. Mr. PHOURNG LINA	Deputy Governor of Siem Reap City	Siem Reap, Cambodia	012901234@mobitel.com.kh
16. Phan Huang	Vice Director-Dept. of Natural Resources and Environment, Quang Ning Province	Ha Long, Vietnam	phonghalong@yahoo.com
17. TRAN KIM THANH	Deputy of Analysis & Maintenance Dept. Hanoi Center for Env.& Natu.Res Monitoring & Analy	Ha Noi, Vietnam	tkthanh@cenma.com.vn
18. DINH VIET CUONG	Officer of International Cooperation Division, Vietnam Env. Protection Agency.	Ha Noi, Vietnam (Da Nang replace.)	dinhvietcuong1711@yahoo.com

UNU & USA

19. Dr. Peter J. Marcotullio	United Nation University	UNU-IAS	pjm12@columbia.edu
20. Ms. Clarice Wilson	United Nation University	UNU-IAS	wilson@ias.unu.edu
21. Dr. Niels Schulz	UNU, Postdoctoral Research Fellow	UNU-IAS	schulz@ias.unu.edu
22. Dr. Ademola Braimoh	UNU, Postdoctoral Research Fellow	UNU-IAS	braimoh@ias.unu.edu
23. Dr. Gary Machlis	USA	Idaho	gmachlis@uidaho.edu
24. Dr. Wayde Morse	USA	Idaho	mors7758@uidaho.edu

ASEAN

25. Mr. Loh Ah Tuan	DEPUTY CEO / DIRECTOR-GENERAL FOR ENVIRONMENTAL PROTECTION NATIONAL ENVIRONMENT AGENCY,SINGAPORE	ASEAN	loh_ah_tuan@nea.gov.sg
26. Mr. Chua Yew Peng	HEAD, PLANNING & DEVELOPMENT DEPARTMENT, NATIONAL ENVIRONMENT AGENCY, SINGAPORE	ASEAN	chua_yew_peng@nea.gov.sg
27. Mr. Aprianto Masjhur	Technical Officer- Environment, Bureau for Resources Development	ASEAN	aprianto@aseansec.org

Singapore workshop schedule (no field trip)

26 January 2008

Time	Activities & Learning Objectives		Presenter
8:30a – 9:00a	**Registration**		
9:00a – 9:35a (35 min.)	**Opening remarks**		
	9:00a-9:05a (5 min.)	Introduction to the project	Peter
	9:05a-9:15a (10 min.)	Welcoming remarks by CEO, NEA	Mr. Lee Yuen Hee
	9:15a-9:35a (20 min.)	Self-introductions	All
9:35 a – 10:00a (25 minutes)	**Break**	Group picture, coffee and tea	All
10:00a – 10:30a (30 min.)	**Introduction to workshop**		
	10:00a – 10:15a (15 min.)	A. Define an ecosystem approach for urban management.	Gary
	10:15a – 10:20a (5 min.)	B. Outline the workshop schedule	Gary
	10:20a – 10:30a (10 min.)	C. Explain why the human ecosystem approach is a valuable strategy for developing useable knowledge for urban ecosystem management.	Gary
10:30a – 11:15a (45 min.)	**Environmental change and urban water issues**		
	10:30a – 10:50a (20 min.)	A. Environmental change: Describe current knowledge of environmental change and its causes and consequences related to urban water issues.	Wayde
	10:50a – 11:05a (15 min.)	B. Urban water issues: Identify general categories of urban water issues across scales of impact	Peter, Niels
	11:05a – 11:15a	C. Discussion	Peter

	(10 min.)		
11:15a - 12:15p (60 min.)	**The Human Ecosystem Model (HEM): A practical introduction**		
	11:15a – 11:45a (30 min.)	F. Define the human ecosystem concept and its 6 basic elements.	Gary
	11:45a – 12:15p (30 min.)	G. Identify, describe, and explain the components of the model.	Gary
12:15p – 1:15p (60 min.)	**Lunch (Marie Room II)**		
1:15p – 2:15p (60 min.)	**The HEM: A practical introduction cont'd**		
	1:15p – 1:25p (10 min.)	H. Introduce key relationships in the model.	Gary
	1:25p – 1:40p (15 min.)	I. Suggest practical applications of the model.	Gary
	1:40p – 1:50p (10 min.)	J. An example from US watershed management: ICBR	Jean
	1:50p – 2:15p (25 min.)	K. Review HEM: Discussion	Gary
2:15p - 3:10p (55 min.)	**Exercise 1: Using the HEM for scenario building**		
	2:15p – 2:25p (10 min.)	A. Introduction to scenario building and team exercise. Form teams.	Wayde, Peter
	2:25p – 3:10p (45 min.)	B. Teams meet and identify variables related to urban water scenario.	Wayde, Gary, Peter, Niels, Jean, Tatiana
3:10p – 3:40p (30 min.)	**Break**		
3:40p – 4:45p (65 min.)	**Exercise 1: Team presentations**		
	3:40p – 3:55p (15 min.)	D. Prepare team presentations.	Wayde
	3:55p – 4:45p (50 min.)	E. Team presentations.	Wayde, Gary
4:45p – 5:00p (15 min.)	**Conclusion day 1: HEM as a tool**		Gary
7.00p – 9.00p	**Welcome Dinner @ Kintamani Indonesian Restaurant**		All

January 27, 2007

Time	Activities & Learning Objectives		Presenter
8:00a – 8:30a (30 min.)	**Review of day 1 and overview of day 2**		Peter
8:30a – 9:30a (60 min.)	**The HEM: Measurement and data collection**		
	8:30a – 8:45a (15 min.)	A. Measurement: Identify measures and indicators for the different variables.	Gary
	8:45a – 9:00a (15 min.)	B. Data collection: Identify different methods of data collection appropriate to different measures.	Gary
	9:00a – 9:15a (15 min.)	C. Analysis: An example of GIS applied to urban water issues	Jean
	9:15a – 9:30a (15 min.)	D. Discussion	Gary, Jean
9:30a – 10:15a (45 min.)	**The HEM: Case studies**		
	9:30a – 9:35a (5 min.)	A. Introduction to cascading effects across model components	Gary
	9:35a – 9:50a (15 min.)	B. Tokyo: Case Study on cascading effects	Peter
	9:50a – 10:05a (15 min.)	C. Phnom Penh: Case Study on cascading effects	Wayde
	10:05a – 10:15a (10 min.)	D. Discussion	Gary
10:15a - 10:45a (30 min.)	**Break**		
10:45a – 12:00p (75 min.)	**Exercise 2: Using the HEM to predict cascading effects in urban ecosystems**		
	10:45a – 11:00a (15 min.)	E. Introduction to Team exercise 2. Form teams.	Wayde
	11:00a – 12:00p (60 min.)	F. Teams meet and identify variables with cascading effects in an urban water scenario.	Wayde, Gary, Peter, Niels, Jean, Tatiana

12:00p – 1:00p	**Lunch (Marie Room II)**		
1:00p – 2:10p (70 min.)	**Exercise 2: Team presentations**		Wayde, Gary
2:10p – 3:15p (65 min.)	**The HEM: Applications**		
	2:10p – 2:30p (20 min.)	A. Selecting from different forms of data display to create effective tools for decision-making.	Jean
	2:30p – 2:45p (15 min.)	B. Using the model for planning (backcasting, prediction), management and decision-making on water related issues in ASEAN megacities.	Gary
	2:45p – 3:05p (20 min.)	C. General guidelines for applying the HEM for policy decision-making.	Gary
	3:05p – 3:15p (10 min.)	D. Discussion	Gary
3:15p – 3:30p (15 min.)	**Break**		
3:30p – 3:45p (15 min.)	**Conclusion** to Workshop.		
	3:30p - 3:35p (5 min)	A. Understanding the limits of modeling and the future of the HEM development	Gary
	3:35p - 3:40p (5 min)	B. Understanding the challenges of urban ecosystem management,	Gary
	3:40p - 3:45p (5 min)	C. Next steps in the project	Peter
3:45p – 4:00p (15 min.)	**Evaluation 1:** Written formal feedback on the workshop.		Wayde
4:00p – 4:30p (30 min.)	**Evaluation 2:** Form groups for structured interviews.		Gary, Peter, Wayde, Niels, Jean, Tatiana
4:30p – 5:00p (30 min.)	**Close:** Presentation of certificates.		Peter, Gary

Participants to the Singapore workshop:

Name	Title	Organization	Country	City	Gender
Dr. Awg. Hj. Muhammad Majdi Hj. Awg. Abd. Azis	Environment Officer	Department of Environment, Parks and Recreation Ministry of Development	Brunei Darussalam	Bandar Seri Begawan	M
Ms. Aida Hj. Abd. Hamid	Acting Senior Water Engineer	Department of Water Services Public Works Department, Ministry of Development	Brunei Darussalam	Bandar Seri Begawan	**F**
Mr. Ujang Solihin Sidik	Staff of Deputy for Pollution Control	Ministry of the Environment	Indonesia	Jakarta	**M**
Mr. Sarjono	Head	City Planning Board of Balikpapan	Indonesia	Balikpapan	**M**
Mr. Syahrumsyah Setia	Head	Environmental Impact Monitoring Board	Indonesia	Balikpapan	M
Mr. Harmes Joni	Head	City Planning Board of Medan	Indonesia	Medan	M
Ms. Purnama Dewi Daulay	Head	Environmental Management and Mineral Resources Agency	Indonesia	Medan	**F**
Ms. Ruhselah binti Ismail	Environmental Control Officer	Putrajaya Corporation	Malaysia	Putrajaya	F
Mr. Ahmad Hairi Bin Hussain	Director	Planning and Development Department, Kuantan Municipal Council	Malaysia	Kuantan	**M**
Mr. Isidro Galarita BORJA	Planning Officer	City Planning and Development Office	Philippines	Cagayan de Oro City	M
Mr. Simeon Josafat LICAYAN	Information Technology Officer	City Planning Development Office (GIS Division)	Philippines	Cagayan de Oro City	M
Ms. Caridad S. CONCEPCION	Deputy Head	Environmental Protection and Waste Management Department	Philippines	Quezon City	F
Mr. Ramiro S. OSORIO	Barangay Council and Environmental Consultant	Environmental Protection & Waste Management Department	Philippines	Quezon City	M
Ms. Ma Jenia LABITORIA	Head	Construction Division of the City's Engineering Department, City's Environmental and Natural Resources Office	Philippines	Ilo Ilo City	F
Mr. Brummel John D.	Planning Officer	City's Environmental and Natural	Philippines	Ilo Ilo City	M

VARGAS		Resources Office (City ENRO)			
Mr. POON Chiew Tuck	Senior Engineer	Pollution Control Department, National Environment Agency	Singapore	Singapore	M
Mr. Nick TAN	Senior Policy Executive	Policy Department, National Environment Agency	Singapore	Singapore	M

Officers who attended as observers:

Name	Title	Organization	Country	Gender
Mr. LOH Ah Tuan	Deputy Chief Executive Officer / Chairman	National Environmental Agency, Ministry of the Environment and Water Resources / ASEAN Working Group on Environmentally Sustainable Cities (AWGESC)	Singapore	M
Mr. CHUA Yew Peng	Divisional Director	Policy & Planning Division National Environmental Agency	Singapore	M
Mr. BIN Chee Kwan	Chief Engineer	Environmental Protection Division, National Environment Agency	Singapore	M

Secretariat / support staff:

Name	Title	Organization	Country	Gender
Ms. Vinca SAFRANI	Technical Officer	Environment / Disaster Management Unit Bureau for Resources Development, ASEAN Secretariat	Indonesia	F
Ms. SOH Suat Hoon	Assistant Director	International Relations Department, Policy and Planning Division, National Environment Agency	Singapore	F
Ms. KOH Mei Leng	Assistant Director	International Relations Department, Policy and Planning Division, National Environment Agency	Singapore	F
Ms. Jacin CHAN	Assistant Director	International Relations Department, Policy and Planning Division, National Environment Agency	Singapore	F
Mr. Desmond LEE	Assistant Director	International Relations Department, Policy and Planning Division, National Environment Agency	Singapore	M

Resource persons:

Name	Title	Organization	Country	Gender
Dr. Gary MACHLIS	Canon Professor of Conservation	College of Natural Resources University of Idaho	USA	M
Dr. Jean MCKENDRY	Principal Scientist and Program Coordinator	The Canon National Parks Science Scholars Program University of Idaho	USA	F

Mr. Wayde MORSE	NSF IGERT Fellow PhD Candidate	University of Idaho	USA	M
Dr. Peter J. MARCOTULLIO	Research Fellow	United Nations University Institute of Advanced Studies	UNU/USA	M
Dr. Niels SCHULZ	Research Associate	Energy Futures Lab Imperial College London	Germany	M
Ms. Clarice WILSON	Programme Associate	United Nations University Institute of Advanced Studies	UNU/Sierra Leone	F
Dr. Tatiana GADDA	JSPS-UNU-IAS Postdoctoral Fellow	United Nations University Institute of Advanced Studies	UNU/Brazil	F

Appendix C - Funding sources outside the APN

	Amount awarded
UNU-IAS*	~US$75,000
Asian Institute of Technology	~US$15,000
ASEAN Secretariat through a generous grant from Singapore.	~US$20,000

*Final amount for fiscal year 2007 not yet available.

Appendix D - Evaluation of the Singapore Capacity Building Workshop with Comparisons to the Bangkok Workshop

Wayde Morse and Gary Machlis

Introduction

The second capacity building workshop of the Application of the Human Ecosystem Model (HEM) to Urban Environmental Management in ASEAN was held in Singapore, on 26-27 of January 2007. This was the second of three workshops. The first was held in Bangkok on 28-29 of June 2006. The project uses the HEM as a basis for understanding the complex interaction of variables useful for the resolution of urban environmental problems. The HEM was introduced as a decision making tool for urban water related issues in the ASEAN region. The workshop highlighted potential water management issues related to different future scenarios of environmental change.

The workshop was attended by 17 participants representing cities and observers from sponsoring organizations.

The purpose of this report is to: 1) outline the results of the formal and informal evaluations conducted at the conclusion of the Singapore workshop, and 2) compare the results to that of the first workshop in Bangkok.

Methods

The evaluation of the workshop was conducted in two separate sessions: a formal structured evaluation questionnaire and semi-structured interviews.

Participants first evaluated the workshop using questionnaires (see Appendix 1 for a copy of the questionnaire). The questionnaires consisted of three parts including, 1) general workshop questions, 2) questions on specific elements of the workshop, and 3) recommendations for future workshops. The first two sections were rated with a standard evaluation scale with 1 representing “low” and 5 representing “high”. An average score was calculated for each question. The questionnaire included 4 open-ended evaluation questions. The open-ended questions were reviewed and results reported in order of the number of comments received.

The second evaluation session was conducted using small group semi-structured interviews (see Appendix 2 for a copy of the semi-structured interview questions). A series of 5 questions were used to guide the interviews. Each group was facilitated by one of the resource persons conducting the workshop.

Results

Sections 1 & 2 of questionnaire

Overall the scores were relatively high with no questions scoring under the second highest level of 4 (Table 1). No individuals scored any given question lower than 3. The highest score was reported for the overall effectiveness of the instructors (4.71). The usefulness of lectures/presentations and usefulness of the exercises were tied for the second highest score (4.65). The next highest rankings were reported for the overall workshop (4.53) the usefulness of the workshop for their work (4.53) and the usefulness of the case studies (4.47). Scoring slightly lower, but still very positively evaluated, were quality of arrangements (4.41) and usefulness of the manual (4.29).

The content of the workshop and its presentation and exercises were rated highly by most participants. The relevance of the workshop to participants' work and training appears strong. There was no field trip during the Singapore workshop.

Care should be taken interpreting these results as the sample size is small. Minor variations in scores may reflect small random variations rather than actual and significant differences in evaluation scores.

Singapore workshop compared to Bangkok workshop evaluation scores

Every score on the Singapore evaluation either improved or remained the same as on the Bangkok evaluation (see Table 1). Both the logistics/accommodations and the manual scored under 4 on the Bangkok evaluation but were substantially improved for Singapore. The largest improvements were for the overall quality of the arrangements (+.54), the usefulness of the case studies (+.41) and the usefulness of the presentations (+.40). The usefulness of the manual and the usefulness of the presentation for personal education also improved (+.36 and +.30 respectively). The overall effectiveness of the workshop stayed the same and remained relatively high. In summary, the workshop was evaluated higher for all areas, and in particular for those areas that were evaluated relatively lower for the earlier Bangkok workshop.

Table 1: Questionnaire evaluation scores (1=Low, 5=High), average score presented for the Bangkok workshop in 2006 and the Singapore workshop in 2007.

Question	Score Bangkok N=17	Score Singapore N=17	Score change
Section 1: General workshop questions			
Overall effectiveness of the workshop	**4.53**	**4.53**	__
Overall effectiveness of the instructors	**4.59**	**4.71**	**+.12**
Usefulness of the workshop to your personal education	**4.29**	**4.59**	**+.30**
Usefulness of the workshop to your current work/job responsibilities	**4.35**	**4.53**	**+.18**
Overall quality of arrangements for participants (travel, lodging, meals, etc)	**3.87**	**4.41**	**+.54**
Section 2: Specific elements of the workshop			
Usefulness of the lectures/presentations	**4.25**	**4.65**	**+.40**
Usefulness of the case studies	**4.06**	**4.47**	**+.41**
Usefulness of the field trip to the Bio-Solar home	**3.47**	**NA**	**NA**
Usefulness of the exercises	**4.47**	**4.65**	**+.18**
Usefulness of the manual	**3.93**	**4.29**	**+.36**

Section 3 of questionnaire

Singapore

Content analysis of the open ended questionnaire reflects the evaluations identified by the survey questions (see Table 2). When asked about the aspects of the workshop that they liked the most, the majority of responses (8 individuals) identified the exercises and how they helped provide a clear understanding of the HEM.

Three participants cited the case studies as their favorite aspect of the workshop while another three cited the lectures as their favorite. Additionally, two participants cited learning about the HEM model and the relaxed atmosphere as what they liked most in the workshop. One participant cited each of the following as their favorite aspect of the workshop: application of the HEM, measurement, the environmental change presentation and urban water issues, the six basic elements, and materials and visual aids.

When asked which aspects of the workshop they liked least, participants listed the case studies as problematic. However, it was because they wanted additional cases and more cases from their countries. It was specifically mentioned that Tokyo did not fit their circumstances. A number of other items were mentioned by individual participants as their least favorite including powerpoint slides that were difficult to read on the screen, language difficulties within the group and too much air conditioning.

When asked what could be done to improve the workshop, a number of useful ideas were presented. The most common recommendation (six participants) mentioned was for more case studies and case studies presented in greater detail. Related to the wish for more case studies was an interest in a field trip to demonstrate a real case study of how to apply the HEM. Other participants mentioned that a film of a case study where the HEM has been applied would be useful. More exercises were recommended by three participants while another two recommended the entire workshop be longer and more detailed. Another added that definitions of the variables in the model should be added to the manual.

When asked for additional comments a few new ideas emerged, while a number of the ideas previously mentioned were reiterated. Three participants made comments about the manual including the need to have larger images that were more legible and a glossary defining the variables in the model. The desire for the addition of more exercises and additional case studies was also reiterated. Two new ideas emerged. One was a request for the model to be translated into other Asian languages (two individuals) and another concerned the level of officials that should be invited. Both lower level technical officials and high level senior management were identified as individuals who should be included in these workshops. Other comments included positive reflections on the usefulness of the workshop and the sentiment that the workshop was efficient and gave them confidence to use the model in the future.

Comparison to Bangkok workshop evaluation

Comments in the Bangkok evaluation centered on positive reflection on the presentation of the HEM model, with negative comments regarding the relevance of the field trip to the Bio-solar home. In contrast, the Singapore evaluation comments focused primarily on the benefits of the case studies and exercises as primary learning tools for applying the HEM. The desire to have additional cases, and cases relevant to their specific countries, was mentioned several times in the Singapore workshop evaluation. These comments were not mentioned in the Bangkok workshop evaluation. However, similar to the Bangkok workshop recommendations, participants wanted to see the application of the HEM in the 'real world' through field trips or video. The problematic issues related to length of individual presentations and lack of diversity of presenters identified in Bangkok workshop seems to have been resolved in the Singapore workshop. Similarly, items related to accommodations and the manual were not identified as problematic in the Singapore workshop as they were in the Bangkok workshop evaluation.

Table 2: Open-ended responses on evaluation questionnaire, Singapore and Bangkok workshops. The number of times each topic was mentioned is recorded after the phrase.

Which aspects of the workshop did you like most?

Singapore
Exercises (8)
    They provided a clearer understanding
    Direct practice
    Allowed discussion of variables
    Allowed participants to share their knowledge
Case studies (3)
Lectures (3) Nice and short with many presenters
HEM model presentation (2)
Relaxed atmosphere (2)
Application of HEM (1)
Measurement (1)
Environment and urban water issues (1)
6 basic elements (1)
Materials and visual aids (1)

Bangkok
The Human Ecosystem Model itself (8)
    The first presentation of the HEM is the most effective
    Key relationships in the model
    Model is interesting and applicable to work
Case studies (2)
Cascading effects (2)
Exercises (2)
Environmental change (1)

Which aspects of the workshop did you like least?

Singapore
Case studies (3)
    Want more and in different locations from their countries (not Tokyo)
PPT slides hard to read (1)
Language difficulties in group (1)
Too much air conditioning (1)

Bangkok
Field trip to bio-solar house (2)
Environmental change and water issues in urban areas (2)

Long presentations (1)
The workshop is mostly headed by one person (1)
Would like more members in exercise groups (1)
Early schedule (1)
Classroom conditions (1)

How can the workshop be improved?

Singapore
More case studies (6)
 With more cities (ASEAN) and deeper detail
 To test and demonstrate the HEM
More exercises (3)
Longer and more detailed workshop (2)
Add film of case study where HEM used/applied (1)
Add field trip to show real life case study (1)
Definitions of variables in manual (1)

Bangkok
Share current experiences with model (7)
 Case study on cascading effects; how the HEM has been used to avoid or control for cascading effects. Then ask participants to discuss
 Present a real case study from an ASEAN city in detail and have participants compare it with their own experience
 Need both urban and rural case studies to make relevant
 The model needed to be applied in practical or pragmatic manner
More than 2 days for the workshop (5)
 It seems like a useful model, but in this time I cannot learn it enough to apply it
More information before workshop (2)
Follow up for in-country participants, then monitor by the team here (1)
Select participants for language skills (1)
Need more interaction from participants (1)
More time getting to share experiences with other countries (1)

Other comments?

Singapore
Translate to Asian language (2)
Glossary in manual (2)
Longer and legible manual (1)
Invite technical officials (1)
More exercises (1)
Case study of Philippines (1)
Improved their confidence to apply it (1)
Useful and efficient (2)
HEM course for senior officials (1)

Bangkok
N/A

Informal interviews

The small group semi-structured interviews provided more detailed evaluations on specific sections of the workshop and on how to improve future workshops. General comments are discussed first followed by sections related to specific aspects of the workshop.

General overview

Comments regarding the HEM presentation suggested it was applicable, "real" and useful. Exercises and case studies were reported to contribute to this sense of usefulness. This was particularly the case for the explanation of cascading effects. There were several comments about the visual presentation of both the projected images and the printed manual. In both cases, it was suggested that only the important details should presented and that what is presented ought to be visibly large, legible and clear.

Presentations

In general, presentations were well received. Several positive comments were made regarding their short length and topic focus. Participants stated that there was continuity between lectures, they understood the main issues, the right amount of information was presented, and that the information was presented at a good pace. It was mentioned by several groups that they liked the HEM presentation. They felt the model represented both a strategic and a holistic approach, that it was a powerful tool, and that it appeared easy to apply. One group mentioned that the HEM allowed them to structure complexity while also being pragmatic. It was also stated that the 6 basic elements presentation framed the model well.

Comments made on specific presentations were not always consistent. One group mentioned that presenting the combination of HEM and GIS was useful and thought it was a powerful tool. However, two other groups suggested that a case in Idaho was not very relevant to their situation and there were several issues with the presentation of divorce as an indicator for water issues. One group felt that the section on measurement, indicators and data collection should be shortened and time added to other sections. In contrast, another group suggested more time should be spent on data collection and management and how to do it while using the model.

There were a couple of additional presentations that participants would have liked. One group suggested a presentation on how the model could be applied within the legal framework of an Environmental Impact Assessment as that would help justify its use to senior management and make it part of their required data collection. Another suggestion regarded a desire for a presentation on working with limited data and another for more in depth analysis of scale issues.

Exercises

All groups mentioned that they liked the exercises. They mentioned that the exercises helped them to learn the HEM more deeply and in a practical way, in contrast to abstract theoretical concepts. Participants felt that the HEM came alive to them during the exercises through their discussions and working with the model. Along these lines, groups suggested that more exercises 3-4 were appropriate. They also felt that the workshop should be extended to accommodate this. One group suggested that the issue of scale should be incorporated into the exercises to address cascading effects across scales. It was also noted that the exercises were useful for learning about water issues in other countries. Forming groups by country facilitated the exercises and helped demonstrate how other countries have addressed their particular water issues.

Case studies

Each group mentioned the importance of the case studies for learning cascading effects. However, most groups also mentioned that they would like to see more case examples and, in particular, cases from their own countries. Several groups mentioned that they did not relate to the Tokyo case study. It was also mentioned that the cases were too simplistic and they could be more complex. Several groups suggested that the wanted to see case examples of how the HEM had already been used for policy and what the results were. Along these same lines, one group suggested that a video that presented a case from analysis to policy recommendations through to results would be useful. Another group suggested that each country could present actual issues from their country from which impromptu case analysis could be made and used for examples. It was also suggested that at least one case should reflect a flood, drought or sea level rise since they were used for the exercises.

Field trip

Several groups mentioned that they would have liked to go to the field in Singapore to see an example of how to do the HEM.

Manual

Though the content was largely deemed useful, the main comments regarding the manual were for improved presentation and additional information. The visual images were deemed too small and sometimes grainy and hard to read. Specifically, it was suggested that larger images of the model were necessary. It was mentioned that tables should be legible and only the relevant information included. While the tabs helped, it was also suggested that it was difficult to follow the presentations in the manual. Page numbers were suggested to address this issue.

There were several requests for additional information about the model. One group requested further reading on the HEM with case studies. Another group suggested that a history of the HEM and the workshops should be included in the manual. Several groups suggested that they wanted technical information on CD at end of workshop, in addition to a summary for the boss. Several groups mentioned that a glossary would be helpful to make specific definitions from the HEM clearer.

Logistics and course mechanics

There were a number of items that participants addressed regarding logistics. The general issue of what the appropriate level of participants to invite to the workshop was mentioned by several groups. Both lower level technicians and senior management were suggested as more appropriate for the workshop. It was also suggested that other agencies such as planning, vulnerability assessment (crisis management) and transportation groups might be appropriate. It was mentioned by one group that a “train the trainers” workshop is a good next step. Follow up workshops were also suggested, and/or that a network of trained practitioners should be established. Several groups suggested that more exercises should be included and that the workshop should be longer to accommodate this. It was recommended that a train the trainers should be a week.

Several particular logistic issues were mentioned including; food needs be religiously appropriate, that Saturday is usually a day off from work, and that there were some English language barriers.

Comparison to Bangkok workshop evaluation

Two issues that were identified in the Bangkok evaluation that needed improvements were the manual and lack of connection with the field trip and the workshop. The manual's content appears to have been improved, but recommendations for the inclusion of additional support information in the manual echo those form the Bangkok evaluation. The main issues still to be overcome with the manual can be addressed with pagination and larger images for visual clarity. Connectedness with the local context still appears to be of key importance to participants and suggestions for additional case studies from more local countries were offered. However, critiques were offered of the case studies of Idaho because it used indicators that may not have been culturally suitable in the local context (divorce). Consistent with the Bangkok evaluation participants desired an overview of a case study were the HEM has been used successfully. The main focus of the evaluations in Singapore that went beyond what was suggested in the Bangkok workshop evaluation was for additional exercises and case studies.

Conclusion

Overall, the workshop was evaluated positively by participants. This evaluation showed that this workshop provided both a positive learning experience for participants and an important opportunity to evaluate and learn how to improve the delivery of the material presented.

Questionnaire

Dear participant,

Thank you for participating in the Singapore Capacity Building Workshop, Application of the Human Ecosystem Model to Urban Environmental Management in ASEAN. We are asking you to help us with an evaluation of this workshop so that we can develop the most effective ways of presenting this information. As this is only the second workshop presenting this material, your opinions are critical to its future improvement. Your feedback is sincerely appreciated.

Thank you,

Dr. Gary Machlis

Section 1: General workshop questions

Please rate aspects of the workshop on a 1 to 5 scale. Circle your response to the items.

Overall effectiveness of the workshop.

Not effective		Neutral		Very effective
1	2	3	4	5

Overall effectiveness of the instructors.

Not effective		Neutral		Very effective
1	2	3	4	5

Usefulness of the workshop to your personal education.

Not useful		Neutral		Very useful
1	2	3	4	5

Usefulness of the workshop to your current work/job regularities.

Not useful		Neutral		Very useful
1	2	3	4	5

Overall quality of arrangements for participants (travel, lodging, meals, etc.).

Low quality		Neutral		High quality
1	2	3	4	5

Section 2: Specific elements of the workshop

Please rate the usefulness of the following elements for explaining the Human Ecosystem Model on a 1 to 5 scale. Circle your response to the items.

Usefulness of the lectures/presentations.

Not useful		Neutral		Very useful
1	2	3	4	5

Usefulness of the case studies on cascading effects.

Not useful		Neutral		Very useful

1	2	3	4	5

Usefulness of the exercises.

Not useful		Neutral		Very useful
1	2	3	4	5

Usefulness of the manual.

Not useful		Neutral		Very useful
1	2	3	4	5

Section 3: Recommendations for future workshops
Please elaborate on ways you feel the workshop could be improved.

Which aspects of the workshop did you like most?

Which aspects of the workshop did you like least?

How can the workshop be improved?

Any other comments you would like to share with us?

Thank you!

Semi-structured interview questions

Semi-Structured Interview Evaluation

1) Which aspects of the workshop did you like most? Please be specific.

2) Was the manual a useful aid for the workshop? How could it be improved?

3) Which aspects of the workshop did you like least? Please be specific.

4) How can the workshop be improved?

5) Please share any additional comments or suggestions you have.

Appendix E - General Guidelines for Applying the Human Ecosystem Model (HEM) to Policy Decision-making Related to Water Management and Climate Change

G.E. Machlis

Introduction

The Human Ecosystem Model (HEM) can be applied to policy decision-making related to water management and climate change. The HEM includes *base conditions, critical resources, and the social system*. Within the social system, there are specific variables of *social institutions, timing cycles, and social order*. Key flows include *individuals, energy, nutrients, materials, information and capital*. Combined, these components and flows make up the human ecosystem. For a more comprehensive description of the HEM, see background materials in the training manual.

Climate change is long-term (decadal or longer) alteration of climate regimes. This includes variability in temperature, precipitation, hydrological and atmospheric systems, growing seasons, ecosystem processes, and human interactions with climate. Climate change occurs locally, regionally, and globally, and includes both annual volatility and cumulative change of climate regimes. The major driver of local climate change is change in land cover as well as regional climate trends. The major driver of regional and global climate change is global warming due to increases in carbon dioxide and other greenhouse gases. This increase is driven mainly by human activities.

The HEM can assist the resource manager and policy-maker in evaluating the potential effectiveness of water management policies related to climate change. The following guidelines may be helpful. The guidelines are general statements of strategy, and not formal procedures. Where “policies” are mentioned, they are policies relevant to water management.

Guideline 1. Using the Overall HEM to evaluate policy alternatives

The overall HEM model is a useful checklist of key variables to consider in policy-making. Consider each policy alternative separately. For each variable in the HEM, evaluate the policy alternative’s impact as potentially significant or insignificant. For each variable that may be significantly impacted, evaluate the policy alternative’s impact as positive, negative, or unknown. Weight these effects as critically important, important, or not important for sustainable water management. Compare the results for each policy alternative. Use the comparison as input into the policy choice.

Guideline 2. Using the specific variables and “strands” of the HEM to evaluate policy alternatives

The individual variables and “strands” of related variables in the HEM provide a useful tool for policy-making. Consider each policy alternative separately. For key variables of interest, evaluate the policy alternative’s impact as positive, negative, or unknown. For those alternatives with positive or negative impacts, trace the cascading effects to second-order and third-order variables, noting the significance and direction (positive or negative) of effect upon each variable. Weight these effects as critically important,

important, or not important for sustainable water management. Compare the results for each policy alternative. Use the comparison as input into the policy choice.

Guideline 3. Using the HEM to evaluate the cascading effects of climate change

The HEM can be used to evaluate the cascading effects of climate change. Develop a specific climate change scenario (sea level rise, flood, drought, or other) at a specific scale (local, regional, global). Include ranges (high, medium, low) of most probable climate shifts (temperature, precipitation, hydrological and atmospheric systems, growing seasons, ecosystem processes, and human interactions with climate). Identify key variables in the HEM most likely to be impacted by the high/low shifts. Describe the likely impacts and evaluate them as positive, negative, or unknown. Identify the second-order variables most likely to be impacted by these first-order impacts, and repeat the evaluation process. Repeat the full process for third-order effects. Use the results to identify the cascading effects of climate change.

Guideline 4. Using the HEM to revise/improve existing policies

The HEM can be used to revise and improve existing policies. Identify potential policy revision, and describe its key environmental, economic and social benefits and costs. For each benefit and cost, identify those variables in the HEM that are most significantly impacted. Describe the likely impacts and evaluate them as positive, negative, or unknown. For those negative impacts, identify the range of additional policy revisions that might mitigate or reverse these negative impacts. Evaluate the policy revisions as to their potential adoption (high, medium, low). Compare the results for each potential policy revision. Use the results as input to revise and improve policies.

A Comment on the HEM and Policy Analysis

The HEM is a powerful model for evaluating policy alternatives related to water management and climate change. It includes both biophysical and socioeconomic variables that reflect ecosystem approach, and that are relevant to a wide range of human ecosystems. Like all models, it has limitations which should be considered when applying the model.

First, it is a complex model with many interactions, and comprehensive data for all variables and interactions is often not available (see Guideline 1). This can be overcome by focusing on specific variables and “strands” (see Guideline 2). Second, the ability of the model to make specific predictions with high accuracy is limited by both data and available diagnostic research on water management activities. This can be overcome by treating broad ranges (high, medium, low for example) as sufficient for preliminary policy analysis (see Guideline 3 and 4). More accurate analyses can follow if necessary. Third, no ecosystem model—especially one that includes both biophysical and socioeconomic variables—can accurately predict response to climate change if the climate change assumptions are vague or inaccurate. This can be overcome by using the most reliable and high probability climate change assumptions possible (see Guideline 3).

Conclusion

Climate change at local, regional and global scales has and will have significant implications for water management. The ability to systematically evaluate water management policy alternatives within an interdisciplinary ecosystem approach is an important skill for water managers of the 21st century. The HEM is one tool for such efforts.

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