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UNU/IAS Report

Urban Ecosystem Analysis

Identifying Tools and Methods

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Foreword

The Institute of Advanced Studies of the United Nations University (UNU/IAS) aspires to lead global research on strategic approaches to sustainable development. Currently, the UNU/IAS is collaborating with the World Health Organization (WHO) and the United Nations Educational Scientific and Cultural Organization–Man and the Biosphere Programme (UNESCO/MAB) on an urban ecosystems initiative. We are convinced that, given the current level of urban environmental complexity, a holistic and comprehensive approach is the way forward, and we believe the urban ecosystems analysis (UEA) embodies this approach. UEA can be interpreted, organized and applied in new ways to suit the information needs of urban policy makers. This report is an effort to advance thinking on how to apply the approach.

Part of the motivation to work on an urban ecosystems approach came from the Millennium Ecosystems Assessment (MA). The MA was launched in the year 2001 as a four–year international assessment of the current and future ability of the world's ecosystems to meet human needs for goods and services. UNU/IAS and its collaborators are using the MA as a source of inspiration, but are also directing our agenda to a larger audience, particularly those scholars and practitioners not yet aware of or involved in ecosystem analysis.

A number of research meetings and workshops have been conducted with our partners to develop the approach. The first step in that direction was a joint UNU/IAS–WHO–UNESCO/MAB workshop on "Urban Ecosystems: Overcoming Definition, Scale and Methods Challenges" that took place in Tokyo in September 2001. In January 2002, a brief meeting was held, also in Tokyo, to discuss "Urban Ecosystems Analysis and Health Issues". A third meeting on the topic took place in March 2002 at the UNESCO headquarters in Paris. The findings from this meeting were presented to an MA Assessment Panel meeting that was also taking place in Paris at that time. These findings have been included in this paper's Appendix. A consultative meeting on the urban ecosystems approach then took place with Japanese scholars and policymakers in March 2002, and in June 2002 the UNU/IAS Director and urban researchers presented the Urban Ecosystems concept to the First ASEAN WHO–Healthy Cities Conference in Kuching, Malaysia.

We would like to thank a number of people for their help in our project. The compilation of this report could have not been possible without the contributions of a number of individuals to whom we are greatly indebted. We are extremely grateful to Ian Douglas of the University of Manchester, who was instrumental in the compilation of a concept paper that was presented to the MA Assessment Panel meeting in Paris in March 2002. Gordon McGranahan, the Covening Lead Author for the urban chapter of the Trends and Conditions volume for the MA and also Director of Human Settlements at the International Institute for Environment and Development (IIED) has been a key resource person. We also appreciate the time and effort put into this project by Carlos Corvalan and Hisashi Ogawa from WHO, and Peter Bridgewater, Peter Dogsé, Thomas Schaaf, and Arico Salvatore of UNESCO/MAB.

A H Zakri
Director, UNU/IAS

Executive Summary

Environmental challenges faced by cities around the world are more complex now than at any other time in history. In many parts of the world, and notably in the Asia Pacific, rapid economic growth, decentralization, privatization, and related socio–cultural changes are leading to the emergence of a complex decision making environment. New concepts and approaches are needed to find constructive solutions to environmental issues. This paper focuses on the emerging urban ecosystems analysis (UEA) to highlight its merits and to point out new tools and methods in which UEA can be applied to provide useful information to decision makers.

We believe that crucial information for policy makers includes the geographic scale of impacts from urban environmental activities and linkages between socio–economic, cultural and bio–physical factors. UEA can help in both instances.

It is unlikely that UEA would have a single methodology. Instead, we envision a comprehensive array of guiding methods, tools and techniques to choose from, so that unique situations can be dealt with appropriately. Further, new combinations of techniques are needed to assess the environmental impacts of proposed policies, plans, and programmes.

In recent years, the availability of data and tools in the environmental field has increased dramatically. This means it is now feasible to conduct the holistic analyses, which previously were difficult to accomplish. Apart from a general increase in interest in environmental protection, there are three factors behind this availability. First, modeling and simulation computer tools are becoming highly developed and relatively easily available. Second, in recent years Geographic Information Systems (GIS) have emerged as a powerful tool for conducting spatial analysis; GIS is at the heart of environmental modeling. Third, the availability of environmental data has increased over the years. Substantial amounts of environmental data, including GIS maps, are now available on the Internet.

We would like to point out that this paper is not meant to be policy–prescriptive; it has been written to be policy–relevant. While the contents of the paper have been compiled in such a way that their relevance to policy makers becomes clear, no direct recommendations or policy prescriptions have been made.

1 Introduction

We are living in an increasingly urbanized world. At the turn of the twenty–first century, about half of the world's population (roughly three billion people) live in urban areas. It is estimated that in the next twenty–five years, almost two billion more people will move to cities. Essentially all of these dramatic changes will occur in developing countries, both in terms of the total global urban population as well as increased percentage of the individual country's population living in urban areas. For many developing countries in the Asia Pacific region, the urban population is already large. Further increases in size and rates of growth will no doubt stress already impacted environments.

While urbanization is an important driver to environmental change, it is not the only urban–related influence. The conversion of land to urban uses, the extraction and depletion of natural resources, and the disposal of urban wastes cities as well as urbanization in general are having global impacts (World Resources Institute, 1997).

All cities, however, are not impacting the environment in similar ways. While developed world cities have largely overcome their traditional environmental problems (waste water removal, sanitation, water supply, indoor air pollution, etc), attention has turned to their impacts on ecosystems further away as well as those larger in scale (see for example Low, Gleeson, Elander and Lidskog, 2000). Cities in the developing world are more concerned with other issues. Urban environmental challenges in developing countries have been divided into two categories: inefficient modes of resource use, such as in the water supply, housing, or energy, and limited absorptive capacity of pollution and flooding (Sham, 1993; White, 1992). Brandon and Ramankutty (1993) classify the key urban environmental challenges in the Asian region as: water pollution; air pollution; solid waste management; and inappropriate land use. Studies of the consequences of urban activities suggest ever–increasing challenges to cities at all levels of development.

A number of factors have added to this complexity. First, the impacts of contemporary industrial processes and the toxicity of many materials used are unknown. Sometimes, what was previously seen as an environmental benefit ended up as an ecological disaster. Second, cities within fast–growing economies are going through a socio–economic and cultural transition, and as such, are facing the environmental challenges of low, middle, and high–income societies simultaneously (Marcotullio, forthcoming). Third, while the drive for decentralization is leading to the transfer of responsibilities for the urban environment from central agencies to local governments, in many cases decentralization has not been accompanied with greater financial empowerment of local governments. This situation has forced cash–starved local governments to look for other partners, such as those in the private sector, to address environmental issues. International development organizations have also become more active in the urban scene, relentlessly pushing for privatization of urban utilities. Fourth, more players are involved in, or desire to be involved in urban environmental decision making creating increasingly complex political situations. This includes, for example, both local voices and international utility companies offering their services in provision of urban environmental infrastructure and services.

In these increasingly complex circumstances, new concepts and approaches are needed to tackle environmental challenges. This paper highlights the merits of the urban ecosystems analysis (UEA) as one such approach, and identifies new tools and methods in which UEA can be applied.

The report has been divided into four sections. The next section presents background to and key elements of ecosystem analysis presenting the basis for various tools and methods, which are outlined in the third section. The fourth section presents conclusions and the appendix outlines a concept paper developed at a recent meeting that outlines some of the details of understanding dynamics of urban ecosystems analysis.

2 Background and Key Elements

Key elements to understanding what tools and methods are needed in UEA include the scale of urban activities and the inter–relationships between social and bio–physical factors. This section will outline these issues.

2.1 Urban Ecosystems in the Context of Geographical Scale

Incorporating geographic scale into UEA suggests that urban activities have impacts that vary. While some activities have dominant environmental impacts within small sections of cities, some urban activities impact ecosystems that are planetary in size. In order to understand how to contend with the scalar impacts of urban activities, we first explore the urban environmental transition theory that has incorporated the increasing scale of environmental impact into a model of urban development (see for example, McGranahan, et al 2001).

2.1.1 The Urban Environment Transition

Urban environmental transition theory suggests that wealth, in terms of GDP, can be used to distinguish the environmental performance of cities (see for example, McGranahan et al. 1994). According to McGranahan, et al (1996, p. 105), "affluence is neither unambiguously harmful nor unambiguously beneficial to the physical environment". Their claims are that urban environmental burdens tend to be more dispersed and delayed in more affluent settings. Dividing cities into three income categories, they argue that the dominant environmental problems in low–income cities are localized, immediate, and health–threatening. The environmental challenges in middle–income cities are city–wide or regional, somewhat more delayed, and a threat to both health and ecological sustainability. Finally, affluent cities must meet the challenges of global, inter–generational, and environmental threats to ecological sustainability.

An simplified typology of the shifting burdens that are described above include three categories; "brown", "gray", and "green" environmental agenda issues for cities. Historically, western cities have first encountered the so–called "brown agenda", which encompasses the conventional environmental health agenda and includes a concern for poor quality, overcrowded housing, a lack of basic services, hazardous pollutants in urban air and waterways, and accumulation of solid waste. Once cities have overcome "brown" issues they have struggled with those of the "gray agenda", including industrialization and motorization impacts (eg. chemical pollutants). As cities became highly developed, activities within their borders prompted the emergence of "green agenda" issues, which followed increases in consumption and waste generation that disrupted ecosystems and has lead to resource depletion and global climate change. This is not a description of a predisposed trajectory, however. Indeed, examples can be found of cities with different dominant environmental concerns at different levels of development than those described. Rather, empirical evidence suggests that the model holds historically and its power lies in the ability to define a reasonable relationship between development and the urban environment that includes the issue of scales of impact.

2.1.2 Framework for Applying Scale in Urban Ecosystems Analysis

From this discussion, it is possible to identify how scale might be applied to UEA. It calls for an investigation into the impacts associated with increasing wealth on urban environmental burdens and the implications of these complex relationships for urban governance. Drawing upon the urban environmental transition theory we have identified three general categories in which to discuss the geographic scale of urban environmental burdens including: ecosystems within cities; the city as an ecosystem; and cities within regional/global ecosystems.

Ecosystems within Cities: One extremely important goods and service–related issue for urban ecosystems is their ability to provide "healthy" environments both for the natural ecosystem, as well as for their citizens (Fitzpatrick and LaGory 2000; McMichael 2000). Those exploring the issues of health and cities are increasingly turning to an ecological or ecosystems approach. This is one case where the scale of ecosystems lies within the cities.

In the least developed cities and the poor neighborhoods in cities of the developing world, health, water, and sanitation (which we also term the "brown agenda") are priority issues. Indeed, for cities in the developed world as well, these are the dominant ecosystem challenges. Household sanitation and access to water are the most important environmental issues in these poorer cities and neighborhoods, as pollution of water with human excreta and other wastes is a major problem. Further, while primarily a rural issue, indoor air pollution may also affect tens of millions of people in Third World cities (Satterthwaite 1995).

In addition to what has been described above, examples of analysis of ecosystems within cities consist of focuses on city parks, wildlife in those parks, and urban agriculture. In this perspective, urban ecologists have explored the city as a natural environment (Hough 1990; Beatley 2000). Urban ecology includes the study of the interaction between living things and their environment in the city, a profoundly altered ecosystem (Gilbert, 1989; Douglas 1981). This contrasts with the Chicago School's sociological approach to studying the social and spatial organization of the city. This perspective offers ecologists the opportunity to address the practical problems related to the anthropogenic impact on ecological systems, and also provides opportunities to examine fundamental ecological questions concerning the structure, function, and organization of ecosystems in general (McDonnell and Pickett 1991).

City as an Ecosystem: Understanding the city as an ecosystem began with two different, but related, types of studies. Urban metabolism research generated a holistic view of the city as a consumer and digester of resources and a creator of waste products.

This perspective started as viewing the city as an organism with its own metabolic processes. Abe Wolman (1965) suggested that in order to overcome shortages of water and pollution of water and air, the city should be viewed as an organic body with metabolic processes. As such, inputs and outputs could be measured, and this information could help to form public economic policies.

The UNESCO/MAB programme began their extensive effort to understand urban metabolism and cities with a seminal study of Hong Kong (Boyden and Celecia 1981; Boyden, et al, 1981). Their approach was to examine the complex interactions that take place within cities, rather than studying specific problems in isolation. This technique is illustrated by the flow of important materials through Hong Kong. Studies along these lines include those that explore the energy, water, and nutrient balances of cities, along with the flows of waste materials, among others (Douglas 1983).

Cities within Regional and Global Ecosystems: The "global" city literature that emerged in the mid–1980s (Friedmann and Wolff 1982; Sassen 1991) suggests that cities are increasingly linked to each other through flows of goods, services, investment, finance, people, and knowledge. At the same time, global cities are also linked with and are increasingly impacting ecosystems elsewhere and at a larger scale. Folke et al. (1997) found in their study of northern European cities that the largest 744 cities accounted for the consumption of 25 per cent of the world's annual sea catch. This finding prompted these scholars to warn, "the web of connections linking one ecosystem and one country with the next is escalating across all scales in both space and time. Everyone is now in everyone else's backyard".

Since cities, particularly those of the developed world, cannot be self–contained "sustainable" units, they should know what their ecological footprints are and therefore contribute to reducing them. Cities are key to the promotion of global sustainability, yet we are only beginning to understand the ways in which their activities impact the local, regional, and global ecosystems.

The classification of urban ecosystems described above is the cornerstone of a framework for analysis

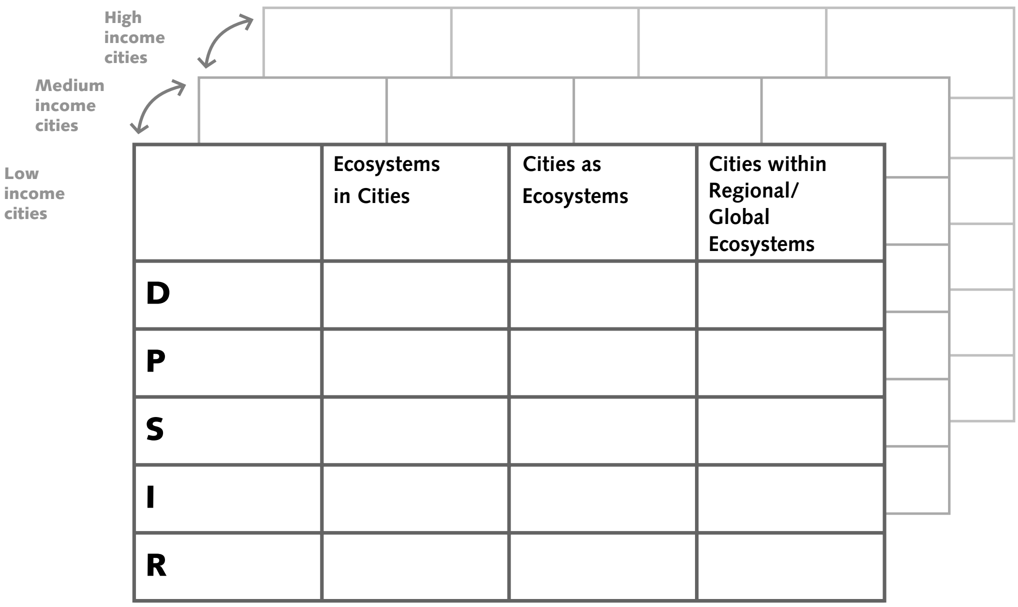

Figure 1: A framework for studying the scale of urban environmental burdens. D = Driving Forces, such as industry and transport; P = Pressures of the environment, such as pollution; S = State of the Environment is the quality of air, water and soil; I = Impacts are those of pollution on human health and eco–systems; R = Responses are various policy measures such as regulations, information and taxes designed to mitigate the above impacts.

of urban environmental issues, presented later in this paper. From this discussion, Figure 1 was developed to help frame one important aspect of how urban ecosystem research might be implemented. It defines parameters that form the basis of the assessment by dividing the various impact scales of urban activities at different socio–economic levels. Further, the figure makes use of the "Driving–Force–Pressure–State–Impact–Response" (DPSIR) framewok, which provides an overall mechanism for analysing environmental problems, and helps in organizing data and selecting indicators.

2.2 Blending Socio–Economic and Bio–Physical Factors in Urban Ecosystems Analysis

William Burch, Gary Machlis, Morgan Grove, Steward Pickett and Timothy Foresman, have all promoted the human ecosystems framework for understanding urban dynamics (see for example, Pickett, et al, 1997). The strength of this perspective is the integration of social and bio–physical components in an understandable yet simplified model of urban growth. Their framework addresses the dynamics of spatial heterogeneity as well as the influences of various social and environmental factors on the spatial patterns on cycles and fluxes of critical resources, both physical and social, eg. energy, materials, nutrients, genetic and nongenetic information, population, labor, capital, organization, beliefs and myths (Grove 1997). This work is schematically presented in Figure 2. Burch and his students have followed this approach for the last two decades with the central aim of measuring, classifying, and analysing the interactions among socio–cultural and biophysical influences on the development of urban areas. In the process they have highlighted that watersheds, as units of analysis, can be adapted for the purpose of UEA. Their model has been adapted for use in the US National Science Foundation's Long Term Ecological Research (LTER) effort.

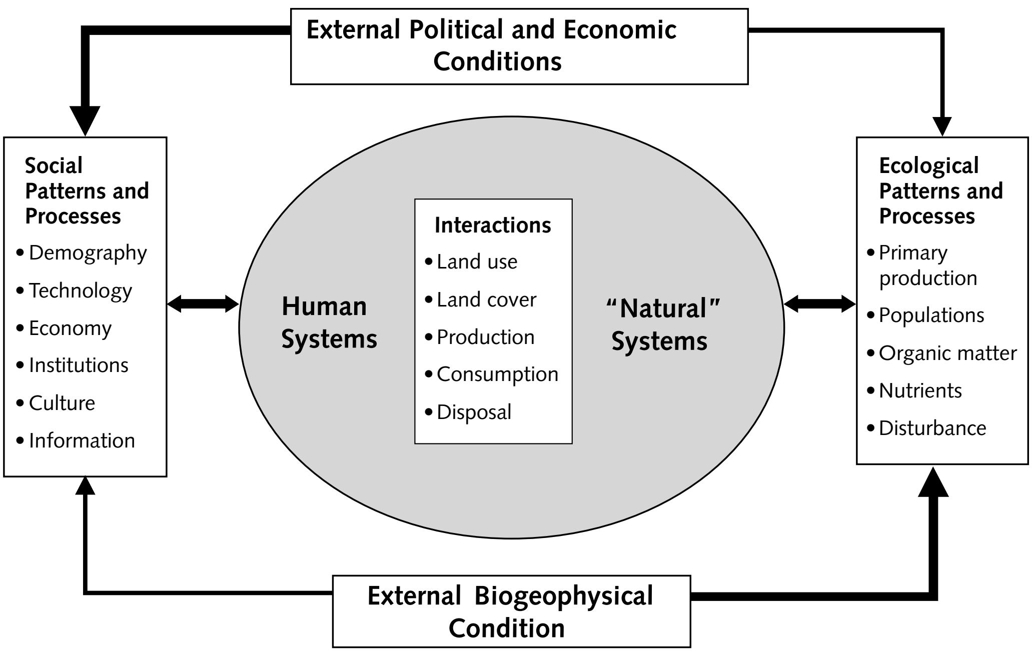

Figure 2: Conceptual framework for investigating the integrated human ecosystem

Source: The U.S. Long–Term Ecological Research Network (2000), "Toward a Unified Understanding of Human Ecosystems: Integrating Social Science into Long–Term Ecological Research" http://lternet.edu/documents/Publications/sosciwhtppr/

3 Key Tools and Methods for Urban Ecosystem Analysis

Policy makers are interested in knowing how to resolve the environmental challenges that have arise due to urban activities within their cities. Further, they need to assess the environmental impacts their proposed policies, plans and programmes. In order to be incorporate these concerns and the key elements discussed in the previous section, UEA must include a compilation of methods, techniques and tools tailor–made to suit the unique issues of each city.

3.1 Tools for Urban Ecosystems Analysis

In recent years the availability of data and tools in the environmental field has increased dramatically making it possible to conduct the kind of complex and holistic analysis that an ecosystem approach requires. Apart from a general increase in interest in environmental protection, there are three factors behind this availability. First, computer modeling and simulation tools are becoming highly developed and more readily available. This is partly due to availability of faster and cheaper computers, and an exponential interest in and development of computer applications, including modelling tools. Second, in recent years geographic information systems (GIS) have emerged as a powerful tool for conducting spatial analysis. GIS is the basis of environmental modeling. Third, the availability of environmental data has increased over the years, which is partly due to the ubiquity of the Internet. Substantial amounts of environmental data, including GIS layers, are now available on the Internet.

Popular GIS packages such as ARCINFO and ARCView from ESRI (Environment Systems Research Institute) are now available in powerful and relatively inexpensive desktop versions. Moreover, they now include modelling capabilities and several specialized planning–related modules that can be added to basic software. ArcView now comes with an easy–to–use programming language called "Avenue", which can be used to build models with a desktop GIS. A number of third–party models have been developed using Avenue. Also, the new software packages are easier to integrate or link with one another, as nearly all of them use Microsoft Visual Basic as their macro language. Not only Microsoft software has this capability; other developers (including ESRI) now also include this feature in their products. In short, better software products (easy to use and with more modeling capabilities) are now available, and they are easier to integrate. So the hurdles of using computer tools to solve complex urban ecosystem problems have been reduced considerably, so much so that there is considerable choice when building innovative "blends" of computer tools for practical application.

An additional reason that favors the urban ecosystem approach is the availability of resources on the Internet. A surprisingly large range of data and models is now available on the Internet, at nominal cost or even free of charge. The resources available on the Web are expanding on a logarithmic scale. At this point in time, the Internet offers access to more potential individual components of an urban ecosystem methodology than has ever been available before.

Professionals conducting UEA will benefit from understanding new tools for social and natural/environment analyses. These new tools are computer based demanding a certain level of computer literacy: experience with spreadsheets, database management, basic GIS functioning and the basics of modelling will also come in handy. In addition, knowledge of a number of other computer tools, like field–specific substantive applications (related to the environment, or transportation, etc.) is ideal, as is some degree of knowledge in GIS–based modelling and remote sensing methods. With the profusion of tools and data available on the Internet, professionals involved in urban ecosystems analysis will be increasingly easy to undertaken.

An ecosystems approach employing the above–mentioned points can work well in tandem with the environmental assessment tools such as strategic environmental assessment (SEA). SEA is often quoted as the way to evaluate environmental implications of proposed policies, plans, and programmes. Currently, however, SEA is still in the developmental stage. Quite often the methods used for environmental impact assessments (EIA) are also used for conducting SEA. However, current methods are not suitable for evaluating policies, plans, or programmes. SEA, therefore, remains deficient in this regard. UEA could provide the necessary structure for conducting these and other types of assessments.

3.2 Methods for Urban Ecosystems Analysis

New methods for analysing urban environmental problems have been presented by a number of researchers. Exline et al. (1982) stressed their importance, Grove (1997) pointed to particular ones, and Vasishth (2002) has indirectly described some by describing a city as layered, overlapped, and nested arrangements of subsystems, systems, and supra–systems organized in scale hierarchical arrangements. However, a comprehensive compilation of such entities does not yet exist. By and large they remain scattered throughout the vast literature of related professional fields. The general principles found in each approach described in the following paragraphs.

Systems Approach: The systems approach is helpful in examining the linkages between particular environmental phenomena and the social and natural systems. The systems approach offers a hierarchical method of clarifying the relationship of each part to the whole.

Biological Analysis: Some of the principles in this approach are balance, competition, and the ecological processes of invasion, succession, and dominance. Hierarchies, patchiness, and perturbation are some other underlying principles of ecology. Others include resilience, resistance, persistence, and variability.

Spatial Analysis: Principles such as spatial heterogeneity and scale differentiation, methods such as landscape, watershed analyses and urban land–cover models, and tools such as GIS and Remote Sensing fall under this category.

Material Flow Analyses: These include flows of materials and energy, metabolism studies and ecological footprint studies.

Social Analysis: This approach is based upon principles such as social differentiation or morphology, social identity, sociocultural hierarchy, access and allocation of resources such as wealth, power, status, and knowledge; methods like rapid rural appraisal, surveys, etc; and tools such as transects, flow diagrams, decision trees, venn diagrams, etc.

The above list is indicative of the kinds of methods that can be applied in UEA. It is our objective in this initiative to bring together scientists in various related fields, and compile an elaborate array of the concepts, principles, methods, techniques, and tools that can help in formulating urban ecosystems methodologies. There have been some initiatives in the past that could be built upon (Lattif and Omar, 1983) but much remains to be done.

4 Conclusion

To analyse the rapidly escalating and increasingly complex urban environmental challenges around the world requires the development of comprehensive approaches. Urban ecosystems analysis is the holistic approach that can fulfil this need. However, in order to be truly useful, UEA will have to satisfy the needs of policy makers. The research initiative at UNU/IAS has been undertaken with the goal of developing UEA. This report has outlined the foundations of our approach and identified a number of tools and methods that could be useful in its implementation.

Specifically, an urban ecosystems methodology is envisioned as an innovative compilation of guiding principles, methods, and tools selected from a comprehensive array of these entities. This compilation needs take place in light of the environmental challenge being analysed.

In order to put UEA in the proper context of scale and city income levels, a three–dimensional framework has been proposed. This framework has its underpinning in urban environmental transition theory, and helps in determining the sets of relevant environmental issues for a particular scale at a given location.

Appendix: Concept Document on Urban Ecosystems [1]

Cities are human creations, and they have always been centers of hope and inspiration: they are where the products of nature are used to create better qualities of life, and to facilitate cultural and intellectual achievements. Their cultural diversity is part of their vitality and dynamism. It stems from many sources and is reflected in many ways in urban areas, particularly determining people's priorities and values for the environment and ecological resources. This cultural diversity must always be taken into account when analysing urban ecosystems.

The great cities of the world have a balance of fine architecture and open space that in ecological terms offer not only a good human habitat, but also opportunities for biodiversity. This pro–active role of people in the urban environment continues to produce habitat improvements and to beneficially manage ecosystems, as the best urban wildlife reserves indicate. Nevertheless, huge challenges are posed by many cities, with high concentrations of poverty found juxtaposed to wealth in many urban areas.

Urban ecosystems may be viewed in three ways:

View 1

- As the built–up areas that are the habitat of urban people, their pets, their garden plants, the adapted animals and organisms (birds, moulds, etc) and pests (rats, weeds, parasites. etc).

- The survival of these areas depends on outside (external) support in the form of energy, water, and materials inputs.

View 2

- As the immediate urban life–support system of the urban area and its surroundings (the peri–urban area), providing such ecological services as water supplies, sources of aggregates, areas for landfill, recreation zones, watershed protection, greenhouse gas uptake, and biodiversity.

View 3

- As the areas affected by urban activities as a driving force, through provision of life–support services to urban areas, including supplies of food, energy, water, and materials. Also those areas affected by the emissions and waste flow from urban areas.

- For any individual city these may have a global outreach, with energy (coal, natural gas or oil) and food (exotic fruits, fish, meat, grain, soya, etc.) drawn from distant countries or seas. As urban populations and purchasing power grows, this outreach and impacts on other ecosystems expand.

Views of Urban Ecosystem Characteristics: Built–Up Areas and their Peri–Urban Zones (Types 1 and 2)

- In considering urban and peri–urban areas, it must be remembered that some two– thirds of the world's urban people live in urban areas with a population of 500,000 or less. Despite their prominence, size, and volume of scientific literature, megacities are not characteristic of all aspects of all urban and peri–urban areas.

- Both built–up areas and the peri–urban transition zones surrounding it share a similar mosaic of land use and land cover. While buildings tend to dominate the built–up area, open spaces are more prominent in the peri–urban zone.

- Nevertheless, even within the built–up area, there may be patches of land used for food production, remnant woodlands, river valleys or hill–top ridges with semi–natural vegetation, and rivers, lakes, ponds, or floodplain wetlands.

- Such green areas and water bodies frequently extend peri–urban characteristics towards the center of built–up areas. Such corridors are often vital for the movement of wildlife, but are also targets for the installation of transportation and utility lines. Through time, these green areas and water bodies may become more and more fragmented and segregated, making the movement, or even survival, of wildlife difficult.

- Biodiversity may be high in urban and peri–urban areas because of the variety of land cover. Protected areas of natural or spontaneous vegetation may enable some rare species to survive, but the high rate of land cover change means rapid local shifts in biodiversity.

- Many individuals, civil society organizations and local, regional, and national governments work to restore degraded areas in cities, improve habitats, create new opportunities for wildlife and give urban people the opportunity to experience nature close to their homes. At the same time, urban development can also create temporarily vacant land that is invaded by plants and animals.

1 This document was developed at a UNU/IAS–UNESCO/MAB–WHO Urban Ecosystem Meeting held in Paris in March 2002. It is based upon the proposed outline of the urban chapter in the MA. Professor Ian Douglas, University of Manchester, was instrumental in guiding the discussion at that time and in swriting this report.

- Urban and peri–urban agriculture is a major food provider, particularly in and around poorer cities. It is threatened by insecurity of land tenure, high levels of pollutants, and excessive applications of agricultural chemicals.

- Often the diversity of urban and peri–urban activities produces serious impacts on the human food chain and health, such as the effects of air and water pollution on food crops.

- Urban and peri–urban ecosystems can have a significant turnover of nutrients, but the natural biogeochemical cycles are heavily modified by human activity.

- The poverty of many urban and peri–urban areas often creates opportunities for disease vectors and lack of sanitation in many informal settlements heightens problems of disease vector control.

- Lack of waste collection in many parts of urban and peri–urban areas sometimes leads to leachates escaping into soils and substrates. Often these are broken down and dispersed, but in others they create serious groundwater contamination problems.

- Built–up areas modify the local climate, often creating a heat island effect, with which is associated an urban dust–dome in which, fine particles and gases are trapped. The dust and contaminants may be carried downwind from the urban area into adjacent peri–urban regions and the nearby countryside.

- Within built–up areas and parts of adjacent peri–urban areas noise levels are high, affecting both human beings and other organisms, although little is known about the effects of noise on animals in the urban ecosystem.

- Urban areas create light pollution that affects other living things and may disrupt some of the periodicity and diurnal rhythms of plants and animals.

- Many urban activities, particularly infrastructure for services and transportation, profoundly disrupt the urban and peri–urban subsurface, often involving pumping to keep subsurface features free of water. The implications of this for urban hydrology and ecosystems are often not fully understood.

- Modification of river channels, especially for flood control in urban areas, may lead to floodwaters being carried quickly through the urban area, only to spread out across the floodplain in unprotected peri–urban areas downstream.

Views of Urban Ecosystem Characteristics: Built–Up Areas

Human Shelter: Quality and Consequences

- Human beings create a diversity of urban shelter: the majority of urban people may be in crowded, inadequate housing, but many wealthy cities have high–quality housing with full services for nearly all their citizens.

- Inadequate housing (lacking water supplies, sanitation and safe access) is often located in hazardous areas, on potentially unstable slopes, floodplains, or excessively close to factories using toxic substances. An intra–urban ecology of health thus results.

- Production, release and migration of contaminants within urban areas, their diversion by impermeable surfaces and drainage, together with their storage (in buildings, in the ground and, particularly, in landfills) creates spatial and temporal risks.

Habitat and Biodiversity

- Cities house and create immense human cultural diversity with modern migration processes accelerating that diversity.

- Built–up areas are far from completely impervious, paved and roofed areas. The green spaces offer great opportunities for persistence of native species and invasion or importation of exotics.

- The structures themselves provide opportunities for organisms, from the rats in the sewers, to the birds nesting under the eaves of buildings. Spillages in factories, retail outlets, transport depots and homes create abundant food sources.

- This variety of niche habitats and land uses within the urban ecosystem increases the opportunity for biodiversity. Add to this the diversity of introduced and exotic invasive plants and species in gardens and abandoned neglected green spaces, and the opportunities for biodiversity are again increased.

- Compared with relatively simple temperate forest ecosystems, temperate industrialized agro–ecosystems or tropical plantations, urban areas may be relatively high in biodiversity.

- Urban habitats are often fragmented and disrupted, forming a complex mosaic which hampers movement, and even survival, of some species.

Cultural Features and the Built Heritage

- In addition to shelter, cities have many cultural perspectives and artifacts and house a huge range of significant human social, cultural and economic activities. As well as significant buildings and urban landscapes, the built heritage includes socially important gardens and parklands.

Ecosystem Services in Urban Ecosystems: Built–Up Areas

- Green spaces in cities modify the urban heat island, absorb some of the emitted greenhouse gases, provide recreation, add diversity to human life, may be of cultural value, may be part of flood control systems, and can contribute to wildlife corridors. Many are used for food production.

- The diversity of biogeochemical situations within urban green spaces creates a series of opportunities for biodiversity.

Peri–Urban Areas

Views of Urban Ecosystem Characteristics: Peri–Urban Areas

- The peri–urban areas include the transition zone where primary production activities—such as agriculture and forestry—associated with the countryside are interspersed with such land uses as urban residences, urban recreation, urban waste disposal sites, urban transportation facilities and mineral and aggregate extraction for urban construction.

- In some cases, e.g., Barcelona, Sao Paulo and Sydney, protected biosphere reserves or national parks containing forests may dominate the peri–urban area.

- Peri–urban transition zones often lie outside urban administrations, or straddle the boundaries of two administrations. Often authorities whose prime concerns are with either primarily urban or primarily rural affairs partially neglect these peri–urban areas.

- Growth of peri–urban residential zones—whether the informal settlements of the poor, or the widely separated residences of the rich—often places stresses on soils and groundwater.

- Peri–urban changes and activities alter the pattern of wildfire in many situations, often increasing risks to people and other species.

- The changing location of the peri–urban transition zone often results in pockets of rural, semi–rural or peri–urban activities and land uses being surrounded by the expanding city.

Ecosystem Dervices in Urban Ecosystems: Peri–Urban Areas

- Many peri–urban areas contain surface water reservoirs, flowing rivers from which water supplies are abstracted. These are also often the recharge zones for aquifers from which urban water supplies are extracted.

- Intensification of land use and release of agricultural and industrial chemicals in peri–urban zones are major threats to the quality of such freshwater resources.

- Sometimes potentially polluting industries are relocated to peri–urban zones, aggravating release of chemicals to the environment. Foreign direct investment industrial processing zones are also often located in such areas.

- Traffic and the transportation of goods and people produce high concentrations of emissions, noise and eventually waste, especially around shopping centers, during commuting hours and at times of festivals and sporting events. This may produce exceptionally heavy pollutant loads and noise in and around some of the linear green and river valley areas penetrated by highways and transit routes.

- Waste dumping in peri–urban areas (in regulated landfills, uncontrolled waste dumps and informally and illegally) leads to leaching of substances to aquifers, harmful impacts on groundwater drawn from nearby wells, and risks on the escape of toxic substances into the environment and the human food chain.

- Peri–urban areas can be important providers of fiber, timber, and fuel, especially in the form of managed coppiced woodlands for cooking fuel, but often the fuel wood resources of the immediate urban periphery have been over–exploited and fuel wood and charcoal are brought in from over 50 km away.

- Wise land cover protection and careful land use in upstream peri–urban areas can help reduce flooding in urban areas.

- Peri–urban areas are usually important recreation areas for urban people and can contain important sporting and leisure facilities as well as natural areas, bathing places and high–quality scenery to be enjoyed by people. Important temples, castles and amusement parks are often located in peri–urban areas.

- Forests in peri–urban areas may be sources of medicinal plants, clearly contribute to greenhouse gas absorption, help to modify urban heat islands by reducing the extent of contiguous built–up areas (e.g. Epping Forest in London), be sources for pollination, act as wildlife refugia and corridors and provide partial rings around cities.

- Water bodies and related wetlands, including those in former gravel workings, may similarly provide linear corridors and refuges for water birds. The demands of industry, settlement, and transportation can bisect and disrupt such natural corridors and rings, emphasizing that peri–urban areas have a critical juxtaposition of activities that are often not compatible with one another.

- Strategies for managing peri–urban areas require detailed analysis of all those activities and forecasting of future pressures on peri–urban land. At present information on peri–urban areas extending beyond municipal boundaries is difficult to acquire or even unavailable, making such areas a key target for new forms of data collection and status evaluation.

- In the long term, unless protected by nature conservation or green belt legislation, peri–urban areas tend to move outwards as built–up areas expand, with today's farmland and forest becoming tomorrow's peri–urban land.

Urban Activity as the Key Driver of Ecosystem Modification

Human Activities as the Primary Driver of Global Ecosystem Change

- The third view of urban ecosystems is that, in terms of the earth's land cover, the 3 billion people (50 per cent of the world's population) currently living, usually at high densities, in urban and peri–urban areas occupy only 1 to 2 per cent of the land. But the support of those people requires the transformation of some 20 per cent or more of the terrestrial surface into agro–ecosystems, grazing land or other forms of production.

- Many of these densely settled urban areas are along, or within 30 km of, the coastline, producing serious implications for coastal zone and shallow sea ecosystems. Tourist activities, both local and international, are aggravating these coastal pressures.

- The deliberate harvesting of forest products, minerals and fisheries and the indirect consequences of waste emissions, modify both the remaining terrestrial ecosystems and many of the coastal and marine ecosystems.

- Emissions and disposal of pollutants produce local, regional and global effects on ecosystems, from roadside lead pollution, to regional acid rain and global climate change.

- As the world's urban population expands, and as the size and purchasing power of the world's urban middle class expands more rapidly (consider the growth of the urban middle class in Asia's newly industrializing countries), these urban–driven ecosystem transformations will proceed more rapidly.

- Cultural diversity, social characteristics, global trade and business, political priorities and demographic characteristics influence the direction and nature of these transformations on local, regional, national, continental and global scales.

Incorporating the Urbanization Driver into Analyses of Global Ecosystem Dynamics, including the Millennium Ecosystem Assessment

- The analysis of all terrestrial ecosystems will inevitably identify urban–driven transformations.

- However, another approach might be to analyse the ecological consequences of urban metabolism (sometimes crudely assessed as the ecological footprint of cities) and to apply principles of materials flow accounting or industrial ecology to develop ways of identifying future rates of ecosystem modification for urban life support and ways of reducing those rates by modifying urban consumption patterns and materials–use patterns.

- Scale considerations will be important. The intense transformations of surrounding areas by urban forces overlap for most urban settlements (e.g. in Europe, the Indo–Gangetic Plain, eastern China). Perhaps studies of isolated cities, such as Urumchi or Manaus, may help understand the locally intense transformations stemming from a single urban center.

- The impacts of global urban demands, such as fuel, energy, and food supplies, are probably best analysed in terms of cumulative impacts on other ecosystems. Strategic environmental assessments should be used for such analysis.

- In all analyses it must be recalled that, despite their individual sizes, million+ cities house less than a third of the world's urban people: two–thirds live in urban centers of half a million or less. Even cities where the actual population in urban areas is not growing, new household formation is driving continued urban expansion. The process is generally not reversible.

- Urban management faces great challenges, but there are enough examples to show that urban living standards and the urban and peri–urban environment can be improved and managed more sustainability and with greater opportunities for people and biodiversity.

- The development of urban monitoring tools and harmonized data sets for comparison between urban areas will greatly facilitate and accelerate the process of urban environmental management.

- Urban growth and its associated economic functions with the capacity to create jobs and opportunities and to provide better services (education, health care, and social welfare) can offer a solution to some of the pressures on land use and human well–being in rural areas.

- Technological innovation has been the key to improved urban quality of life and economic opportunities. Assessment of ecosystem trends and prospects requires consideration of how technical innovation may change and/or enhance ecosystem status and trends.

- Inequality of income distribution and poverty, both within and between cities, remains a major cause of difficulties in urban management and in provision of adequate services. It also has major implications for the sources of pressures on other ecosystems caused by urban activities.

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