Chapter 1
Exploring the Linkages Between Ecosystems and Human Health

Contents

1.1 Introduction

The linkages between human health and ecosystems are complex, dynamic, and political. For millennia ecosystems have provided humans with essential services such as food, water, shelter and medicine. At the same time, they have mediated the transmission of many diseases and posed a number of health risks. The vitality of ecosystem services for human health and well-being is well captured by Bernard Abraham, President of Weskit-Chi Aboriginal Trappers Association, when he commented on the importance of forest ecosystems to Aboriginal people. He observed that many Aboriginal people consider the forest as: "their food bank, drugstore, meat market, bakery, fruit and vegetable stand, building material centre, beverage supply, and the habitat for all of the creator's creatures."[1] Many Indigenous people across the world consider the health of the "country" to be intricately linked to human health and community health and well-being. This sentiment is not only

[1] A quote by Bernard Abraham, President of Weskit-Chi Aboriginal Trappers Association. http://www.envirowatch.org/gndvst.htm. Accessed May 01, 2010.

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true for Indigenous people, but for society as a whole. In addition, the intricate links between ecosystems and human health is expressed through aspects of the Indigenous culture, including views and notions of holistic health and well-being, and ecosystem-based cultural rites, and overall close proximity to nature. The World Health Organization captures this notion of holistic well-being when it defines health as *a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity* (World Health Organization 1948). However, it is the Ottawa Charter for Health Promotion that makes explicit the connection between human health and ecosystem health through its identification of "stable ecosystems" and the "sustainable use of natural resources" as essential components for health improvement (WHO 1986).

Despite this close association between human health and ecosystem health, recent evidence from the Millennium Ecosystem Assessment (MA 2005) suggests that global ecosystems are failing in their ability to continue to provide the services that are essential for human health and well-being, because of increasing human pressure on ecosystems worldwide. The report indicates that, over the past half century, human activities have altered the natural ecosystem more rapidly and extensively than in any comparable time in history. This increased pressure has resulted in close to 60 per cent of the world's ecosystem services being degraded or used unsustainably (ibid). This trend will likely continue to the extent that human beings continue to depend on ecosystems for both the necessities of life such as food and water, as well as the luxuries of diamond and caviar. What is required is recognition of the conjoint nature of society and ecosystems and how each cannot be managed separately. Human beings are integral to ecosystems, and for sometime now, the environmental sector has made use of integrated approaches to ecosystem management that have tried to balance community, economic, and environmental needs. However, the question that still exists is to what extent are these balanced? In addition, what has eluded many concerned with understanding and responding to the underlying causes of human-induced ecosystem degradation is their political and illusive nature. How we apportion blame to the causal factors responsible for ecosystem degradation, and poor health, must be subjected to rigourous analytical interpretations.

The factors that have commonly been identified as responsible for ecosystem degradation focus on rapid population growth, abject poverty and poor land use practices in the global South, and over consumerism in the North. However, as has been demonstrated throughout this book, such factors are the outcome of underlying problems that are not readily apparent, and hence are insufficient to explain the causal basis of environmental problems. The causal basis of ecosystem degradation must be examined from the basis of the structural inequalities surrounding the use of and control of ecosystem services, and how such inequalities drive various land use practices that degrade ecosystems. For example, it is important to examine how states, corporate giants, mining and logging companies, and Northern interests monopolize the environments of weaker actors (e.g. local farmers, peasants, global South), forcing them to till and live on marginal lands. In an attempt to eke out a living, displaced or marginalized communities encroach on fragile and

protected lands to "illegally" access natural resources, sometimes making use of "inappropriate" land use practices (Bryant and Bailey 1997; Bryant 1998). Also, in an attempt to increase productivity and maximize the potential of marginal lands, weaker actors may resort to intensive production systems, making use of fertilizers, pesticides, and intensive farming practices which not only adversely impact ecosystems, but consequently human health. In such contexts, then, the identification of "inappropriate land use practices" as one driving factor of ecosystem degradation completely misses the underlying reason for the use of inappropriate land use practices, and any attempt by "experts" or professionals to develop interventions or policies to correct this will be ineffective and may not prevent/correct ecosystem degradation. The causal basis of human-induced ecosystem degradation is complex and not readily apparent to external scientific experts. It is important that any perceived causal factor be examined from an historical, socio-political, and economic perspective, and examined through the lens of unequal power relations surrounding human-environment relationships. In addition, ecosystem degradation should be linked to broader processes such as unfair trade agreements, global prioritization of environmental problems and the desire for the purest gems, chocolate, coffee and caviars have contributed to destroying vast ecosystems, especially in tropical and developing regions of the world. The unfair trade agreements between the global South and the North, the re-colonization of Africa by China, and the lax environmental regulatory environment in poorer regions have all resulted in a monopoly of Southern ecosystems by multinational companies, resulting in the use of unsustainable methods of resource extraction and ecosystem degradation.

One other dimension of examining the causal explanations of environmental problems that is of interest to critical scholars is how environmental problems such as ecosystem degradation comes to be identified, defined, and labeled. How do we come to understand ecosystems as "extensively degraded", or describe other environmental problems as "global crisis"? Critical scholars argue that the identification and causal explanation of environmental problems is not value-free nor is it ever politically neutral. They argue that the framings of environmental problems and their causal explanations are shaped by the social and political contexts within which they emerge, and so are never partial, but can be located. Critical environmental scholars caution against accepting scientific environmental knowledge claims as "fact", "accurate" and a true representation of reality, without re-evaluating these claims within the socio-political and historical contexts within which they are framed (Bryant 1998; Forsyth 2003; Peet and Watts 1996).

With the exception of phenomena such as climate change, although this has come under scrutiny recently, critical scholars are concerned that by representing many environmental problems as "global" in scope and "crisis" in nature, we gloss over the particularities of environmental problems in specific localities, and fail to pay particular attention to the varying experiences and coping abilities of different population groups. We also fail to capture the micro-politics and power struggles surrounding access to, and use of natural resources at varying scales, and how such struggles shape people's interactions and experiences with the biophysical

environment. Also, given that most scientific environmental knowledge serves as the basis for policy formulation, there are concerns that environmental policies and interventions that are based on "unreconstructed" scientific knowledge could fail to uncover the "real" causes of ecosystem degradation and end up proposing wrong interventions that could further augment existing inequities surrounding the use and control of those resources (Forsyth 2003). For example, in many parts of Africa, some natural resource management policies are still based on colonial policies, without reevaluating these policies within the current challenges and needs of today's communities.

Within the circles of public health, similar critical perspectives have been used to interrogate public health knowledge claims, the constructions and explanations of certain public health problems, and how subject positions are constructed and labelled. Just like critical environmental scholars, critical public health scholars seek to illustrate that the emergence and social patterning of specific public health problems, especially those associated directly and indirectly with the environment, lie in the unequal power relations surrounding the use of, and control of environmental resources and the uneven distribution of the associated costs (e.g. pollution) of environmental activities. The concern here is to broaden the causal basis of the emergence of specific ecosystem-mediated health problems beyond exposure to disease vectors and microbes, to incorporating people-environment power dynamics and how such dynamics result in the exposure of weaker actors to environmental health risks. Explaining health problems from the basis of exposure to microbes and pathogens alone is equivalent to blaming the victim, while relieving important social and political factors that constrain the individual from freely making the decisions to avoid risk in the first place. Similarly, the uneven distribution of the costs of ecological activities and the resulting social patterning of poor health should be examined from the context of how unequal power relations allow powerful actors to displace their environmental costs to weaker actors through such acts as dumping toxic waste in other communities. These communities also are those with limited coping capabilities and have little resources to mitigate the adverse effects of these environmental pollutants.

The above concerns illustrate the complex dynamics surrounding people-environment relationships, illustrating that such issues cannot be understood through uni-lateral analytical procedures, but instead must be contextualized to reflect the temporal and spatial dimensions of such phenomena. Ecosystem degradation, the causal explanations, and the associated health problems are equally complex and should not be explained simplistically and uni-dimensionally. After all, ecosystems and society are conjoined and the activities within each sphere must be seen as constituted by, and from the other. Such inter-dependencies (political, social, economic, ecological dimensions) must always constitute the core of ecosystem-society-health investigations. The theoretical frameworks used to analyze human-environment interactions from such political, ecological, and social perspective fall outside the purview of pure ecological and health sciences disciplines, instead residing more with transdisciplinary fields such as health geography,

environmental sociology, medical anthropology, and other related fields. Similarly critical perspectives have been applied to environmental issues in the form of post-structuralist or critical political ecology and to public health field in the form of critical public health. However, the extent to which the two fields have been brought together to examine issues at the interface of public health and environmental conditions is very limited.

It is the goal of this book to draw on a variety of critical theoretical perspectives from the social, natural and health sciences to develop a rigourous theoretical framework that will allow for a critical examination of problems at the interface of environment and health, or simply referred to as ecohealth concerns. Most of the ecohealth literature has not engaged with such theoretical perspectives and hence lacks critical theoretical rigour in its analyses of environment and health phenomena. This book draws on critical social theory, including political ecology, feminist theories, and postcolonial and poststructuralist perspectives to examine environment and health issues from a critical perspective. In so doing, a new analytical framework called *critical ecohealth* is developed through the fusion of two theoretical perspectives: *critical political ecology* and *critical public health*. Critical ecohealth locates ecohealth problems, their causal explanations, the proposed interventions within a broader analytical framework, examining how they are framed, and drawing attention to their socio-political, economic, and historical antecedents. Prior to examining these theoretical frameworks in subsequent chapters, it is important to review some of the common associations between human activities, ecosystem change and how this influences human health and well-being.

1.2 Ecosystem Services and Human Health

The Millennium Ecosystem Assessment report (MA 2005) describes an ecosystem as *a dynamic complex of plant, animal, and micro-organism communities and the nonliving environment interacting as a functional unit.* Ecosystems including, farmlands, water bodies, woodlands, rangelands, and forests, produce services that are essential for human health and well-being. These services are usually classified into four categories: provisioning services, regulating services, cultural services, and supporting services (MA 2005). *Provisioning services* refer to the benefits derived from ecosystems such as food, freshwater, fibre, shelter, medicine, and fuel. These basic necessities underlie the sustenance of many communities. Many developing country nationals rely on the natural environment for medicinal plants, wildlife and other non-timber forest products. The second category, *regulating services*, refer to ability of ecosystems to regulate climate, purify freshwater, and regulate pest and diseases. The regulation of ecosystem processes can modify ecosystems in ways that influence the proliferation and transmission of disease vectors, such as mosquitoes or snails. *Cultural services* are those non-material benefits obtained from ecosystems, and include aesthetic, spiritual, educational, and recreational qualities. Cultural services provide a wide spectrum of benefits, since different cultures

associate and interact with the environment in myriad ways. For example, for some, the natural landscape serves as an ideal space for healing, meditation, recreation and the performance of cultural rites. The close bond between many Indigenous communities and other local people, and the biophysical environment endows them with unique knowledge systems about the structure and functioning of these ecosystems. This local knowledge is an essential complement to scientific understanding of the environment. Lastly, *supporting services* are those that contribute to ecosystem processes such as primary production, soil formation, and nutrient recycling. Compared to other services, the benefits of supporting services are indirect and occur over a longer-time frame.

The growing need to meet societal demand for food, shelter, livelihood and profits has resulted in increased pressure on ecosystems, and compromising their ability to continue to provide ecosystem services at an optimal level. Land use activities such as deforestation, clearance of virgin lands for agriculture and human settlement, irrigation, dam construction, road building, mining, wetland modification, and urbanization, have been identified as some of the key modifiers of ecosystems around the world. The modification of various ecosystems has resulted in the emergence and spread of a number of infectious diseases, and modified the transmission of endemic diseases (Patz et al. 2000). For example, the clearance of forests for agricultural purposes can disrupt the structure and functioning of ecosystems and lead to the emergence of infectious diseases. In Central Africa, the outbreak of Ebola, which killed hundreds of people and thousands of apes was linked to human migration into forested ecosystems where people came into contact with new microbes and animal reservoirs (Leroy et al. 2004). In Malaysia, agricultural activities have been linked with the emergence of Nipah virus (Lam and Chua 2002), while increased risk to Lyme disease in the northeastern United States has been associated with forest fragmentation, biodiversity loss, followed by suburban housing development (Schmidt and Ostfeld 2001). Also, with the relative ease of travel and transportation of goods and services around the globe, it does not take long for infectious diseases to spread from one corner of the globe to the other, as seen with the recent case of Severe Acute Respiratory Syndrome (SARS) and Swine Flu.

Infectious diseases continue to be of grave concern, both in the developed and developing world. Within the past few years alone, the world has seen the emergence of new infectious diseases such as SARS, H1N1, and HIV/AIDS. Not only did the emergence and quick spread of these diseases cause global pandemonium and drain the health budgets of many regions, but also has raised concerns about the state of global public health security and the readiness of public health authorities to respond and contain the spread of these pandemics in a quick and effective manner. Factors such as rural-urban migration, globalization, North-South migration, trade, and the fast pace of travel all contribute to making this task a challenging, yet important one. According to a recent report, not only are infectious diseases spreading faster geographically than any period in history, but they also seem to be emerging at a quicker pace than before (WHO 2007). The report indicates that since

1970, new diseases have been emerging at an unprecedented rate of one or more per year, resulting in about 40 new diseases that were unknown about a generation ago. Also, within a 5-year period leading up to 2007, the World Health Organization had confirmed over 1100 epidemics events worldwide.

This trend does not seem to be abating any time soon and re-iterates the need for a comprehensive understanding of the mechanisms through which human-induced ecosystem change adversely impacts human health. It is important to understand the clear linkages between our activities, what drives these activities, how these activities transform the ecosystem into a disease environment or a health-promoting environment, and how we are differentially impacted by such transformations. Such understanding must be informed by the social, political, and historical contexts within which ecosystem change occurs, so as to allow for the development of socially and biophysically relevant interventions. The sections below explore the linkages between some land use activities and how they shape human health outcomes.

1.3 Land Fragmentation and Health

Activities such as deforestation, clearance of virgin lands for agricultural purposes and human settlement, and road construction for mining and logging are some activities that have led to increased fragmentation of many terrestrial ecosystems. These land use activities disturb ecosystem balance and pre-existing conditions that serve to modulate the emergence and interaction of disease pathogens. This disturbed equilibrium brings humans into contact with new pathogens that can infect humans, livestock or wildlife (Wolfe et al. 2000). The emergence and re-emergence of many infectious diseases such as Chagas disease, trypanosomiasis, leishmaniasis, and onchocerciasis has been associated with land use changes (Molyneux 1998). Habitat changes also favor the emergence of zoonotic diseases and many mosquitoe-borne diseases (Gubler 2002).

Recently, there have been increasing concern about the public health threat posed by zoonotic diseases. Zoonotic pathogens – that is, those pathogens that can be transmitted between wild or domesticated animals and humans – have been identified as the most significant cause of emerging infectious diseases (Taylor et al. 2001). Taylor and colleagues observed that out of 1415 species of infectious organisms that have been identified to be pathogenic to human beings, 61% are zoonotic pathogens. Emerging infectious diseases such as Severe Acute Respiratory Symptoms (SARS), avian influenza, West Nile and HIV/AIDS, Nipah virus, Ebola, and hantavirus pulmonary syndrome are all associated with zoonotic pathogens. In general, zoonotic diseases are usually severe, with high fatality rates, and have no readily available cure, treatment or vaccine. Because zoonotic pathogens complete part of their natural life cycle in animal hosts, any human-induced activity that disturbs the equilibrium of wildlife habitats, such as encroachment into forested

areas, is likely to facilitate the transmission of zoonotic pathogens between humans, wildlife, domestic animals, and plants (Daszak et al. 2001).

Land use activities such as tropical deforestation and the processes leading to it have also been associated with the emergence and proliferation of diseases such as malaria, especially in Africa, Asia, and Latin America (Coluzzi 1994; Tadei et al. 1998). The clearance of forested areas for agriculture, rangelands and settlement allows people to inhabit previously uninhabited spaces, thus exposing them to new disease pathogens (Kalliola and Flores Paitán 1998). The construction of forest roads, the creation of culverts and other dugouts collect rainwater and serve as breeding grounds for mosquitoes (Patz et al. 2004). Also mercury is naturally embedded in the soils of most rainforests. Hence soil erosion that occurs following downpours wash mercury residue into rivers and other water bodies, contaminating water bodies. Such scenarios have led to contaminated fish in places like the Amazon (Fostier et al. 2000).

Another example of the health implications of deforestation is noteworthy. In northeastern United States, partial deforestation, followed by subsequent land use changes and human settlement patterns led to the emergence of Lyme disease (Glass et al. 1995). Lyme disease is a bacterial disease that is transmitted by the bite of a deer tick. Rodents are the major reservoir hosts for the bacteria, while deer serves as the host for the tick vectors (Steere et al. 2004). Lyme disease was first named in 1977, but discovered earlier. Incidence has been reported in North America, Asia, and Europe (ibid).

Finally, in addition to logging, mining is one extractive activity that causes a number of health problems. In many regions in Africa, lax environmental regulations prevent mining companies from taking the necessary steps to ensure their activities cause minimal impacts to both human and ecosystem health. In tropical rainforests, the use of mercury to extract gold from riverbeds has contaminated fish in many rivers, rendering them toxic (Lebel et al. 1998). Also the land degrading activities associated with mining has caused some communities to lose farmlands and livelihood options. Dugouts, culverts and mining pits create favourable breeding grounds for mosquitoes.

1.4 Water Resource Development and Health

Human interventions in watersheds, rivers, and lake systems take many forms including: irrigation, aquaculture, river damming and other watershed activities. Most of these activities interfere with the natural functioning of aquatic ecosystems, and may inhibit their ability to provide ecosystem services, such as regulation of the hydrological cycle and filtration of freshwater. Some of these activities also alter watersheds in ways that create conducive environments for the proliferation and transmission of disease vectors such as snails and mosquitoes. Some commonly identified diseases emerging from human-induced transformation of watersheds

include malaria, dengue and Japanese encephalitis, shistosomiasis, onchocerciasis, and trypanosomiasis.

Crop irrigation and the construction of dams are two land use activities that alter aquatic habitats and affect the proliferation, survival, and distribution of disease vectors. For example, irrigated rice fields provide good breeding grounds for mosquitoes, and have resulted in increased incidence and transmission of malaria in Africa, and Japanese encephalitis in Asia (Keiser et al. 2005). Also, culverts, ditches, canals and ponds associated with irrigation provide ideal conditions for the proliferation of mosquito species such as the *Culex tarsalis*. *Culex tarsalis* is a mosquito species that bites both humans and animals, and as such a major bridge vector for diseases that are constantly present in animal populations, such as the encephalitis that occurred in St. Louis in western United States (Mahmood et al. 2004). Also, irrigation activities in the Nile Delta following the construction of the Aswan High Dam resulted in the proliferation of another mosquito species, the *Culex pipiens,* which is associated with increased soil moisture levels. The *Culex pipiens* is associated with the arthropod-borne disease Bancroftian filariasis or elephantiasis, which mostly occurs in Africa and other tropical regions (Harb et al. 1993; Thompson et al. 1996).

Microbial contamination of water as a result of inappropriate sanitation and hygiene is still pertinent, especially in developing countries. A recent report from the World Health Organization estimates the burden of disease from inadequate water, sanitation and hygiene to amount to 1.7 million deaths annually, with over 54 million healthy life years lost. Also, water-associated infectious diseases claim up to 3.2 million lives each year, approximately 6% of all deaths globally (Prüss-Üstün and Corvalán 2006). The contamination of drinking water sources is not only pertinent to the developing world, but also the developed. For example, intensive farming practices and poor food processing in industrialized countries can lead to the contamination of public water sources, as was seen in the Walkerton case in Canada. In 2000, Canada experienced its worst ever water contamination, when a small town in Ontario, Walkerton, got its public water supply infested with *Escherichia coli (E. coli)* bacteria from farm runoff. The incident resulted in the death of seven people, with as many as 2,300 falling sick.[2]

Aquatic ecosystems serve as natural reservoirs for the cholera bacterium (*vibrio cholerae O1*), where it remains dormant in phytoplankton and zooplankton (Colwell 1996). Environmental conditions that cause algal blooms, such as climate-induced warming of waterways and eutrophication by agriculture and domestic nitrate and phosphate runoff, may increase the proliferation of zooplankton leading to increased dissemination of cholera into human populations (Levins et al. 1994). Also, there is increasing evidence suggesting that the seasonality of cholera epidemics may be linked to the seasonality of algal blooms, and the food chain in marine ecosystems (Colwell 1996). It is recommended that monitoring algae and other microscopic marine organisms for vibrio, especially using remote sensing satellites, may help

[2] http://www.cbc.ca/news/background/walkerton/ Accessed May, 10th, 2010.

establish an early warning system for detecting emergence of the pathogen (Levins et al. 1994).

Water bodies that are contaminated through the use of pesticides and other toxic chemicals can also pose serious health risks to people, and adversely affect various organ systems. For example, exposure to low concentrations of chemicals such as PCBs, dioxins and DDT may interfere with normal hormone-mediated physiology, impair reproduction, or cause endocrine disruption (Prüss-Üstün and Corvalán 2006).

1.5 Urbanization and Health

On April 7th each year, the World Health Organization (WHO) celebrates World Health Day. It selects a key global health issue as the theme for the day and generates awareness of the problem globally, nationally and locally. For 2010, the theme for World Health Day was "Urbanization and Health". The WHO identifies urbanization as one of the biggest health challenges of the twenty-first century (World Health Report 2008). This is based on the realization that urbanization is proceeding faster than cities can build the necessary infrastructure to contain the increasing numbers. In 2007, for the first time in history, the world's urban population surpassed 50%, with the projection that this number could exceed 70% by 2050 (UN-Habitat 2006). By 2030, it is expected that six out of every 10 people will be living in the city, and by 2050 this figure is expected to increase to 7 out of every 10 people (ibid).

Rapid and unplanned urbanization has numerous health implications, not just for the urban poor, but also for all city dwellers. It is true that the urban poor will bear the disproportionate burden of urban health problems. However, lack of social services, employment opportunities, education and other services engender despair, violence, and increased vulnerability. These problems are usually not constrained to only urban slums, but permeate to the suburbs and affect the entire society. It is therefore important that urbanization health-related concerns be viewed from a broad perspective, and their solutions be incorporated into broader public policies. The public health challenges facing urban ecosystems span beyond the health sector and must addressed from an integrated and intersectoral perspective, with partnerships among all relevant sectors.

In addition, it is important not to lose sight of the health conditions specific to urban slums. Currently, over 1 billion people – about one third of the urban population – live in slums, with this figure is expected to increase to 1.4 billion by 2020 (UN-Habitat 2006). Inequitable access to most social services, poor housing and sanitation, and inadequate water supply characterize the conditions in many urban slums. These conditions make urban slums fertile grounds for the proliferation and transmission of communicable diseases. Common health problems of the urban poor include tuberculosis, HIV/AIDS, and chronic diseases such as diabetes, heart disease, mental disorders, and road traffic accidents, and drug-related deaths.

With such clear trends of increasing urbanization, perhaps what is required is to refocus efforts on preventive health, improving living conditions in urban centres by

investing in infrastructure for sanitation, water supply, and supportive housing. It is also important for public health authorities to prepare for the onslaught and complex urban health problems that could arise with such increasing trend. Also, urban planning must ensure that urban centres become welcoming and inclusive communities with all the necessary amenities to cater to the wide spectrum of cultural diversity that immigrates to urban areas. Without such readiness, urban health problems could be a time bomb waiting to explode with the onset of any pandemic.

Finally, meeting the needs and wants of city dwellers takes a great toll on suburban and rural ecosystems, which leaves behind bigger ecological footprints. Similarly, the demands in the North for coffee, cocoa, burgers, quality furniture, and minerals take a toll on Southern peripheral ecosystems. The extraction and processing of resources such as timber and minerals fragments ecosystems and increases the opportunity for the emergence of new diseases. Also, aquaculture, shrimp farming, and deforestation for agriculture and ranching all destroy ecosystems. In most cases, the ecosystems drawn on to satisfy the needs of urban dwellers are usually not within the immediate vicinity but in remote, rural areas or in developing countries and tropical regions. In this case, the immediate and direct impacts of ecosystem destruction are displaced to inhabitants of these ecosystems, not the city dwellers. Due to their poor status and limited resources, these communities are unable to cope with or take adequate steps to mitigate the adverse impacts of ecosystem destruction on human health.

1.6 Modern Food Production Systems and Health

The increasing demand for livestock products, especially pigs and chickens, has led to the use of intensive, industrial, and landless production systems (Delgado et al. 1999). These intensive production systems, in association with ecological and other factors, have been linked to the emergence of diseases such as bovine spongiform encephalopathy (BSE), Severe Acute Respiratory Syndrome (SARS), Nipah virus, and avian influenza (World Health Report 2007). Modern production systems are characterized by activities such as increased livestock trade between regions, especially poultry and wild animals (bushmeat), overcrowding and mixing of livestock breeds, and cohabitation of livestock and people, especially in rural communities (Graham et al. 2008). Such production practices create fertile grounds for interspecies host transfer of disease agents, resulting in the emergence of novel strains of diseases or human pathogens such as SARS and influenza.

While modern production and processing systems have led to increased availability of food and livestock products, they have also increased pressures on ecosystems: fragmenting habitats, polluting environments and posing serious human health risks. For example, intensive production systems usually require large quantities of livestock feed and increase the pressure on cultivated ecosystems. They also make use of large quantities of fertilizers, pesticides and water to enhance productivity. Intensive farming practices also generate large amounts of waste, which sometimes

is not adequately disposed off. Waste is mostly flushed into waterways, which end up polluting freshwater bodies, contaminating public water supplies, and affecting marine plants and animals. In addition, some intensive livestock management practices routinely use sub-therapeutic antibiotics, which have resulted in the occasional emergence of antibiotic-resistant strains such as Salmonella, Campylobacter and *E. coli* bacteria (Garofalo et al. 2007).

The recent outbreak of Nipah virus in Malaysia is a typical example of a disease that occurred as a result of animal husbandry in association with other factors. Nipah virus is an emerging viral pathogen that causes encephalitis, an inflammation of the brain. It is fatal in up to 75% of the people it infects (WHO 2007). Between 1998 and 1999, the first outbreak of Nipah virus was reported in the Malaysian Peninsular, where 265 human cases including 105 deaths were reported (FAO/WHO 2002). The emergence of the virus is attributed to the interaction of various factors including expanding human population, climate change, poor governance, illegal land clearing, forest fires and intensive animal husbandry (ibid). The path of contagion is traced back to the human cases coming into direct contact with sick or dying pigs or fresh pig products. These pigs became sick after coming into contact with a flock of bats that were infected with a previously unknown virus. The bats migrated from neigbouring Indonesia, following an intense El Niño dry spell and forest fires in the region. In Malaysia, the bats came into contact with intensively, commercially raised pigs that were located near fruit orchards. The pigs acted as the intermediate hosts of the new virus, and developed respiratory illnesses. It is believed that transmission among pigs occurred through the aerosol route, with transmission from pigs to humans taking place following contact with throat or nasal secretions of pigs by humans. Nipah virus later occurred in Singapore, where it infected 11 human cases resulting in one death. In Malaysia, the outbreak ended with the mass culling of more than 1 million pigs (WHO 2007).

Recent findings suggest that the virus may have become more pathogenic for humans following the outbreaks in Malaysia and Singapore. This means that the virus can spread to humans without an intermediate host such as the pig, and the transmission from human to human can occur with casual contact. For example, evidence suggests that, in the most recent outbreaks in Bangladesh and India, the consumption of contaminated food such as fruits contaminated with the urine or saliva of fruit bats could likely constitute the route of exposure for several new human infections. Also human-to-human transmission could occur through close contact with people's secretions and excretions. In Siliguri, India, it was observed that transmission of Nipah virus occurred in health care setting, where close to 75% of the cases occurred among hospital staff and visitors (WHO Fact Sheet on Nipah Virus 2009).

1.7 Climate Change and Health

Leading up to the United Nations Summit on climate change in Copenhagen, there have been a number of discussions and media coverage on the potential health effects of climate change. For example, the journal *Lancet* dedicated an entire series

to *climate change and health*. The increased attention and wide coverage of climate change generated both awareness and skeptism, leading some to question the accuracy of climate change data, and to assess whether or not climate change has become one of those phenomena, whose scientific explanations and claims are politically and self-interest driven. While, this dialogue is on-going, there are also discussions about the health and potential health implications of climate change.

Climate change is expected to have both direct and indirect impacts on human health and well-being. Extreme weather events, sea level rises, and temperature changes are expected to adversely impact ecosystems, and inhibit their ability to continue to provide the essential services needed for good health, including the provision of clean air, safe drinking water, adequate food supply, shelter, and medicinal plants. Ecosystems play a vital role in regulating climatic conditions through cooling and warming mechanisms, preserving the balance among species, and acting as sinks for greenhouse gases and other pollutants. Climate-induced changes will likely disrupt the ability of ecosystems to continue to fulfill these functions.

For the most part, climate change is expected to increase the incidence and impacts of some of the world's leading killer diseases, such as malaria, diarrhoea, dengue, and malnutrition. These health problems and the pathways leading to their occurrence are highly sensitivity to climatic conditions. For example, climate-induced change can affect the proliferation, distribution and transmission of disease vectors and can also influence the length of transmission seasons for vector-borne diseases. Extreme weather events, such as floods and windstorms may contaminate fresh water supplies, facilitate the dispersal of microbes, and affect the breeding, survival, and abundance of disease vectors. Outbreaks of diseases such as cholera and leptospirosis have followed flooding in Central America (Wilson 2000). Heavy precipitation may pollute water sources with increased quantities of chemical and biological pollutants that are washed into rivers and from overloading sewers and waste storage facilities. Temperature increases may also affect water quality by increasing the growth of microorganisms and decrease dissolved oxygen (McMichael et al. 2006).

Temperature-related impacts are varied. Rising temperatures may cause drought, increase demand for irrigation, and negatively affect crop production, leading to increased malnutrition, especially in developing countries (McMicheal 1997). Changes in temperature and humidity may affect the breeding and survival of insect vectors such as mosquitoes. Recent studies suggest that climate change could increase the proliferation of the *aedes* mosquito (vector for dengue), exposing an additional 2 billion people to dengue transmission by the 2080s (Hales et al. 2002). Direct effects from heat waves can cause skin cancer, cataracts, sunstroke and reduced efficiency of the immune system (McMichael et al. 2006).

While climate change tends to be discussed from a global perspective, the health effects are regional, local, and population-specific, and are usually not evenly distributed. There are some communities and population groups that are particularly vulnerable. For example, the United Nations Intergovernmental Panel on Climate Change identified Indigenous groups and coastal communities as two groups that are most vulnerable to climate change. As has been discussed in the chapter on Indigenous health, the close affiliation between most Indigenous people and the

natural environment, together with poor socio-economic conditions, predispose them to severe impacts resulting from climate change. Similarly, people living in coastal areas and floodplains are extremely vulnerable to extreme weather events, which can destroy infrastructure and displace entire communities. Temporary relocation of displaced people can lead to increased incidence of communicable diseases due to overcrowding, limited health services, lack of clean water and sanitary facilities, poor mental health and poor nutrition.

1.8 Wars, Conflicts and Health

The unfortunate circumstances of armed conflict and war adversely impacts surrounding ecosystems and affect human health. The settings in which conflicts take place fragment ecosystems, disrupt ecosystem functioning and predispose people to new disease pathogens and new infectious diseases. In addition, the mass fleeing and displacement of people from their communities, force them to live in crowded spaces and under unhygienic conditions, which provide ideal conditions for the onset of infectious and communicable diseases. The limited health care services in refugee camps are usually not adequate to address the myriad health concerns presented, and sometimes these living conditions result in the outbreak of epidemics. Two examples that are noteworthy relate to the emergence of Marburg haemorrhagic fever in Angola, which affected over 200 people, and killed over 90 of the victims (WHO 2007), and the cholera epidemic in the Democratic Republic of the Congo, which killed over 50,000 people.

Marburg haemorrhagic fever, which is related to Ebola, occurred between 2004 and 2005, following a 27-year civil war (1975–2002) in Angola and is reported as the largest epidemic on record (WHO 2007). The disease proliferates in overcrowded areas and settings with inefficient health care services. On the other hand, the cholera epidemic in the Democratic Republic of the Congo, occurred following the Rwandan conflict in 1994. Between 500,000 and 800,000 people fled to seek refuge in the neighboring Congolese city of Goma, when the epidemic struck. The epidemic, which is said to have resulted from a combination of cholera and shigella dysentery, was very fatal, recording a high crude mortality rate of 20–35 per 10, 000 per day (ibid).

1.9 Conclusion

This chapter illustrates the various ways in which human activities impact and, in turn, are impacted by ecosystem dynamics. Ecosystems provide services that are essential for life. These services are continuously under pressure given the growing demand for food and other societal needs. In an attempt to increase productivity, human activities transform ecosystems in ways that compromise their ability to continue to provide ecosystem services. They also transform ecosystems in ways

that engender disease and adversely impact both ecosystem and human health. The causal pathways between human activities, their driving forces, and how they transform ecosystems to adversely impact health are complex and not amenable to linear processes. In addition to biophysical processes, social, political, economic and cultural factors further confound these interactions. Hence, given the increasing realization that over the next few decades, the most important determinant of human health will be ecological factors, it is probably prudent for researchers to begin to unravel these intricate connections between society, health, and environment, and ensure that power relations, and social and political considerations are incorporated into people-environment-health analysis. Such understanding will help develop appropriate interventions that will be socio-politically acceptable and also biophysically relevant.

The role of ecological factors as important determinants of human health is not new, but dates back to the 19th century. Interests in ecological factors were superseded by modern medical techniques such as the discovery of microbes, viruses, DNA and the increasing focus on individual lifestyle factors. With issues such as climate change and the rapid emergence of new diseases with mediated by ecological factors, there is, once again, growing interests in the use of ecological approaches to public health, with particular emphasis on ecosystem-human dynamics. For the past few decades there have been growing efforts to integrate health and environment concerns and to develop more ecological and holistic approaches to public health improvement, and sustainable natural resources management. This trend has given rise to new approaches such as the ecosystem approaches to human health, also known as the Ecohealth approach. Before discussing some of the key elements of this approach, it is important to trace the evolution of events leading to a renewed interest in ecological approaches to health, and in particular, the ecosystem approach to human health (Forget and Lebel 2001).

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