Chapter VII: Vector-borne Diseases

A. Overview

A disease vector is an organism, such as a mosquito, tick, or leech, which carries disease parasites from one host (person carrying disease) to another. Vectors carrying parasitic diseases have been in existence for centuries. In fact, recently uncovered archeological evidence provides evidence of malaria's impact on civilization since the time of the ancient Egyptians. Today, human activities contributing to changes in the natural environment have led to a resurgence of this and other vector-borne disease on a worldwide scale.

Vector-borne disease species vary considerably in feeding, mating, and incubation habits. For instance, some mosquitoes are active only during the day, and rely on vision and movement to locate their next meal. Other mosquitoes are known to be night-active mosquitoes, and tend to rely on odor to navigate, although such odor preferences vary from species to species. Different mosquito breeds are able to coexist by concentrating on different hosts; by broadening their preferences in host consumption when necessary; and by being active during other times of the day. Some mosquitoes can read the bacterial signals in the water where they lay their larvae to tell whether the pool is temporary or permanent—a crucial determinant regarding the eggs' fate. One type of female, An. funestus, only lays eggs in highly vegetated areas that make them difficult to capture. Thus, whenever a shadow crosses over the larvae, they can dive to the bottom of the pool and remain hidden there for up to thirty minutes![22] Yet one factor shared by all mosquitoes alike is their production of larvae. Larvae development generally lasts only one to two weeks, and hatching usually occurs in less than a minute. However, the most important common requirement for most larvae to survive is the availability of water resources.

B. Human Behavior and Transmission of Vector-Borne Diseases

Transmission and proliferation of vector-borne diseases results from changes in human behavior and natural habitat alterations, as much as it does from mutations in the pathogen itself. Examples of human behavior that affect the environment of disease vectors are: (a) mass migration and sudden population movement, (b) international travel and commerce, (c) changes in land use, (d) microbial adaptation and resistance, (e) lack of reliable public infrastructure; and (f) global climate change. [23]

- ***Population migrations.*** Sudden population change due to war, environmental degradation, and other regional conflicts has enabled disease vectors to spread rapidly, with those in flight often being the most affected. Refugee camps in sub-Saharan Africa and the Middle East, for example, possess a particularly high transmission rate of infectious diseases. Rapid unchecked urbanization has provided some disease vectors with access to numerous habitats, such as open sewers and water storage containers, while increases in human population density have resulted in many mosquitoes developing a preference for feeding solely on humans, as their previous food sources of assorted mammalian and bird species became increasingly scarce.
- ***International travel and commerce.*** The combination of today's international trade, air travel and tourism ensures the continual spread of disease vectors. Each day, some two million people are engaged in cross-border movement. Areas such as seaports, airports, and cemeteries are especially vulnerable in this regard. The effects of global trade in food result in un-hygienic food production, handling, and preparation in originating countries that introduce microbial disease pathogens into foreign countries, such as E. coli, and Salmonella.
- ***Land use change.*** Changes in land and water use patterns are major factors contributing to the spread of vector-borne disease. Deforestation has altered the habitats of disease vectors, often forcing them to adapt to urban living conditions while also bringing humans into closer contact with the insects and animals carrying disease. Water management practices, such as dam building, open irrigation canals and flooded rice fields, and open sewer pits, have encouraged the spread of water-breeding vectors by providing them with an area in which to survive and pro-create.

22 Sharakhov, I. V., Serazin, A. C., Grushko, O. G., Dana, A., Lobo, N., Hillenmeyer, M. E., Westerman, R., Romero-Severson, J., Costantini, C., Sagnon, N.'F., Collins, F. H., and Besansky, N. J. (2002) *Inversions and gene order shuffling in Anopheles gambiae and A. funestus*. Science, 298:182-185.

23 *National Intelligence Estimate: The Global Infectious Disease Threat and Its Implications for the United States, National Intelligence Council*. Woodrow Wilson Environmental Change and Security Project Report 6 (2000)

- ***Microbial adaptation and resistance.*** Technological breakthroughs and use of medicinal antibiotics, both in developed and developing countries, where they are used extensively today, has continually resulted in development of microbial drug resistance. The ability of disease microbes to constantly evolve resistance to antibiotics renders them particularly difficult to treat, especially in poorer areas where there is little hope of acquiring recently introduced drug products that have greater efficacy in treating diseases.
- ***Lack of reliable public infrastructure services.*** The dearth of funds for sanitation facilities, effective water management systems, and basic public health care in many developing countries has led to a re-emergence of vaccine preventable deaths, especially apparent in areas vulnerable to war, natural disaster, or economic collapse.
- ***Climate change.*** Disease associated with mosquitoes is likely to expand its geographic reach as more and more regions around the world experience warmer climates and increased rainfall as a result of global climate change.

C. Major Types of Vector-Borne Diseases

Throughout their existence, mosquitoes have evolved numerous traits to ensure the survival of their breed. Those who have been victim to mosquito bites are not unfamiliar with the itch that follows; an effect of mosquitoes' special saliva, which they inject into human, or animal bloodstreams while feeding. The injection of saliva serves two purposes; first to anaesthetize the host against immediate pain or sensations, and second, to disrupt the blood clotting process that allows the parasite to feed on the host. Unfortunately, the injection of the vector's saliva also serves a third purpose: the transmission of disease to the host organism.

(i) Dengue Fever: The mosquito responsible for transmitting the dengue virus, Aedes aegypti, is a small, black and white insect with stripes on its legs and back which generally bites during the early morning and late afternoon hours. The dengue mosquito rests indoors in dark places or outside where it is cool and shaded. The principal vector of the disease tends to breed in human-made containers that collect rainwater, or any other stagnant pool of water. It is estimated that about 50-100 million people worldwide are infected with Dengue-related diseases each year.

The Dengue virus exists mainly in two forms: dengue fever and dengue hemorrhagic fever, the latter being the more deadly. Dengue hemorrhagic fever (DHF) is a life threatening form of dengue fever with at least four different strains. While infection from one vector will create immunity to that specific strain, it will also exacerbate infection and death when exposed to other remaining strains. There is no vaccine or medical treatment for dengue fever. Thus the only way to prevent the disease is by eliminating the chance of human exposure.[24]

Before the Second World War, it was unusual for more than one Dengue strain to exist in the same area, and most individuals were immune to the strain existing in their communities. However, with the onset of war, new strains of DHF were introduced into many areas, causing mass infection and the spread of DHF. Additionally, cities in developing countries experienced a surge of urban growth, which led not only to a decline of cover vegetation where predators of the Dengue mosquitoes thrived, but also provided Aedis agypti with a multitude of breeding spots in form of open water containers in human settlements. In this way Aedes aegypti evolved from an isolated rural tree-hole breeding disease vector into an urban scourge, as a result of significant change in the urban environment of developing regions. [25]

(ii) Malaria: Anopheles gambiae, otherwise known as "mass murderer" to researchers in the field, is the mosquito species responsible for transmitting malaria. Originating in forested areas of Africa, malaria is one of the oldest diseases of humankind, with one of the most numerically intimidating of death tolls. Although today the geographic range of malaria has decreased, being confined mainly to the tropical regions of Africa, Asia and Latin America, about forty percent of the world's population still lives in risk of contracting malaria. Sub-Saharan Africa alone accounts for an estimated ninety percent of the global malaria burden (WHO, 1999). Although the disease is preventable and even curable, at least 300 million people suffer from infection annually, while over 2 million people die as a result from exposure each year; most of them young children.[26]

There are about 380 different species of the Anopheline mosquito, of which 60 are able to transmit four types of the plasmodium parasites that cause the disease. The disease is spread through the feeding habits of the female mosquito,

24 Marten, G. 2001. *Human Ecology: Basic Concepts for Sustainable Development*. London: Earthscan.

25 *Ibid*.

26 See *History of Malaria*: http://www.unicef.org/media/historymalaria.htm

which requires nutrients from the blood in order to reproduce (the males feed only on plants). Malaria will not display the first signs of infection until 7-20 days after the initial bite. Because malaria can share disease symptoms common to other illnesses, such as headache and fever, many patients consequently receive improper treatment initially. If left untreated, the parasite can infect red blood cells, which results in depleting oxygen in brain tissues and other organs of the body. This leads to severe anemia, permanent organ damage, convulsions, coma and death.[27]

Of the four different species of malarial parasite, the most deadly organism is found in tropical regions of Africa, which accounts for the high incidence of malaria in sub-Saharan Africa. The other factor contributing to the incidence of malarial infection in Africa can be traced to the 1955–1969 worldwide campaign to eradicate malaria. This public health campaign, led by the newly formed World Health Organization, encouraged the use of DDT and chloroquine (a relatively inexpensive drug product) to achieve dramatic results in Europe, North America and the Soviet Union, as well as some areas of Asia and Latin America. However, most areas in Africa did not receive the benefits of this initial campaign, since many countries in the region lacked adequate infrastructure and access to medical resources that were vital to the worldwide campaign's success. In the meantime, the disease vector mosquito had acquired insecticide resistance to DDT, while the disease-bearing parasite had similarly developed drug resistance to chloroquine, a relatively inexpensive pharmaceutical product. Since then, the worldwide quest to eradicate malaria has been abandoned, as more developed countries no longer see themselves at risk. [28]

In many ways, the global campaign to eradicate malaria of the 1960s has only succeeded in making present-day malaria far more lethal by increasing vector resistance to pesticide use and treatment. At present, it is re-emerging in areas once thought to have permanently eradicated the deadly disease. Deterioration of healthcare and sanitation infrastructures, increased human migration, climate change, and faulty land use and urban planning has also been responsible for the resurgence of the malarial mosquitoes in recent years. As a response to the growing urgency of malaria spreading worldwide, WHO and other international bodies have launched the Roll Back Malaria campaign in 1997. [29]

(iii) Schistosomiasis: A major water-borne communicable disease caused by parasitic worms that annually infects 200 million people worldwide. Infection occurs upon human contact with certain types of water snails that carry the parasitic worms known as schistosoma. Disease infection is indicated either by the presence of blood in the urine, which leads eventually to bladder cancer or kidney problems, or bloody diarrhea, which leads eventually to serious complications of the liver and spleen. [30]

Human fecal wastes dumped into freshwater sources are the main factor in the proliferation of the disease. This is because the excreta of an infected person contain eggs that hatch on contact with freshwater. Once the eggs are hatched, they release larvae that seek out snail hosts in which to produce parasites. The new parasites produced by the snail host are then excreted into the surrounding water where they can penetrate human skin within a few seconds. People therefore become infected with schistosomiasis by contact with contaminated water through swimming, fishing or irrigation activities, among others. [31] Schistosomiasis prevention can be achieved by drinking properly boiled water, avoiding swimming in contaminated lakes and streams, and by bathing in water heated to 66 degrees C (150 degrees F) for 5 minutes. [32]

D. Vector-Borne Disease Control

It is virtually impossible to completely block transmission to vector-borne disease, yet there are many ways to reduce transmission. Practices aimed at limiting risk to exposure are known as vector control. Vector control policies are aimed at modifying human behavior as well as human environments, with pesticide application used only as a last resort. This is because insecticides, in addition to being environmentally harmful, are very costly. Even when there are adequate funds to support pesticide use, the mosquito will eventually develop resistance to the chemical, often evolving into an even more pernicious vector to control.

27 McGinn, Anne Platt. (2003). *Combating Malaria, in State of the World 2003*. Washington, DC: Worldwatch

28 See *History of Malaria* http://www.unicef.org/media/historymalaria.htm

29 See *Roll back to Malaria Partnership* to: http://www.rbm.who.int

30 WHO Infectious Disease Homepage http://www.who.int/ctd/schisto/disease.htm

31 *Ibid.*

32 Ahmed, A. Karim. *op. cit.*

Risk of exposure to vector-borne disease is, in general, directly related to environmental conditions. Environmental management, which includes planning, organization, and modification of environmental factors that accelerate disease transmission, can be an effective means of vector control. Management strategies are often site-specific, depending on what type of habitats the mosquito in question prefers, and should therefore focus on destruction and alteration of natural as well as manmade containers responsible for providing larval habitats that produce the greatest number of mosquitoes in each community.

In order to manage environmental conditions to successfully decrease vector disease incidence, it is crucial to understand the breeding habits of the target mosquito, because it is the reduction in larvae production and not the elimination of individual mosquitoes that will produce the most dramatic effects. Ae. aegypti, for example, breeds primarily in human-made containers in Asia and the Americas, while in Africa it breeds both in synthetic containers as well as natural ones, such as leaves, tree holes, etc. [33]

In 1980, the WHO Expert Committee on Vector Biology and Control defined environmental management as a component of three parts: (a) environmental modification, (b) environmental manipulation, and (c) changes in human habitat or behavior. [34]

(i) Environmental Modification:

Long-lasting physical transformations of disease-bearing vector habitats include:

- **Improvement of Water Supply and Storage:** Having a reliable source of water that does not enable mosquitoes to breed can make a great difference in any community. Water piped to households is preferable to wells, communal standpipes, rooftop catchments and other open delivery systems. Of equal, if not more importance, is how water is stored. If water is stored using tanks, drums, jars, or other similar devices, openings should be sealed using tight fitting lids or screens. It is important that the covered containers be routinely inspected to ensure that they have not deteriorated, while at the same time allow users to withdraw water easily.
- **Solid Waste Management:** Many open containers can be found at the sites of garbage dumps, and thus all vector control policies should promote environmentally sound waste management, especially focusing on such aspects as “reduce, reuse, recycle.” Used tires provide a favorite hatching area for mosquitoes, and thus special efforts should be made to reduce their vector-breeding potential, such as cutting, shredding or chipping them into smaller fragments.
- **Sanitation Systems:** Every effort should be made to ensure that sanitation facilities do not promote an increased population of disease-bearing vectors.

(ii) Environmental Manipulation:

Temporary changes to disease-bearing vector habitat as a result of planned activity to produce conditions unfavorable to vector breeding include:

- **Chemical Application:** Although the use of insecticides for prevention and control of vector borne disease is strongly discouraged, since it ultimately results in vector resistance, in severe cases of malarial proliferation it may be necessary to use them in combination with more preventative and sustainable measures.

(iii) Changes in Human Habitation or Behavior:

Efforts to reduce human/vector pathogen contact through education include:

- **Habitat:** Human beings can make many simple changes in their immediate habitat to discourage disease vector production. For example, fences and fence posts made of hollow stems, such as bamboo, may be cut to the node; containers capable of collecting water outside should be covered or stored upside down; ornamental pools and fountains can be chlorinated or populated with larvivorous fish; rice paddies can be drained intermittently to kill mosquito larvae; roof gutters could be periodically drained; and housing evaluated to make sure there are no unscreened openings where vectors can get indoors. In Indonesia for example, malaria transmission rates were drastically reduced when farmers allowed rice paddies to dry out completely during certain periods. Similarly, in Sri Lanka, the breeding of malaria-

33 See Chapter 5: *Vector Surveillance and Control*. Available online at: http://www.who.int/emc/disease/ebola/Denguepublication/048-59.pdf

34 World Health Organization. 1980. *Environmental management for vector control, in Fourth report of the WHO Expert Committee on Vector Biology and Control*. Geneva: WHO.

transmitting mosquitoes was significantly suppressed in small rivers and irrigation canals by regularly flushing them out. [35]

- **Behavior:** Sleeping under bednets can reduce the number of mosquito bites considerably. On the other hand, it was found in India that women who wear long shawls about their bodies were unwittingly storing disease vectors.

E. Recommended Environmental Health Indicators and Benchmarks for Vector-Borne Diseases

Basis for selection:

The primary recommended environmental health indicators and benchmarks assess the incidence of vector-borne diseases in a selected population and among children below the ages of five. Such environmental health indicators provide an overview or snapshot of the severity of different types of vector-borne diseases in a community, especially among vulnerable young children. In addition, three specific vector-borne diseases are selected for priority concern—dengue fever, malaria and schistosomiasis. Such indicators or benchmarks can be developed by obtaining the morbidity and mortality rates of these vector-borne diseases from official public health records of a selected region.

For secondary indicators, emphasis is placed in determining the amount of public health educational and prevention programs that is available in a community. Also, equally important are indicators that assess the availability of vector-borne disease prevention program, such as the number of household use of bednets, and access to preventative public health facilities in a community.

Among tertiary indicators for vector-borne diseases that needs considerable further development is to link them to significant land use changes in a region, such a deforestation rates and wetland management programs, and other infrastructural factors as agricultural irrigation practices and large dam construction projects.

Note: Although environmental factors such as global warming can have a significant impact on spreading the geographic reach of vector-borne diseases, it is ultimately changes in human behavior influenced through widespread public health educational and prevention programs that will make the greatest contributions in halting transmission of vector-borne diseases, since mosquitoes and other parasitic organisms already exist in tropical regions and have proven capable of adapting to new habitats at higher latitudes.

Summary of Recommended Indicators and Benchmarks:

(i) Primary Indicators

- Percent of Population with Vector-Borne Diseases
- Percent of Children below five years with Vector-Borne Diseases
- Dengue Fever: Morbidity and Mortality Rates
- Malaria: Morbidity and Mortality Rates
- Schistosomiasis: Morbidity and Mortality Rates

(ii) Secondary Indicators

- Educational Indicators: e.g., Number of Public Health Educational Programs
- Prevention Indicators: e.g., Number of Programs to Limit Potential Breeding Habitats
- Percent of Household with Bednets in a Region
- Percent of Population with Access to Preventive Public Health Facilities

(iii) Tertiary Indicators

- Land Use Changes: Deforestation Rates, Wetland Management, Irrigation Practices, Dam Constructions.

(iv) Modifying Factors

- Population Density: Rate of Urban Growth
- Climate Type: Rainfall Patterns, Temperature Ranges

35 UNEP, UNICEF, WHO. 2002. *Children in the New Millenium: Environmental Impact on Health*. New York: United Nations Environment Program (UNEP), United Nations Children's Fund (UNICEF), World Health Organization (WHO).

Chapter VIII: Food Security and Safety

A. Overview

Having secure access to safe, affordable, and nutritious food is one of the most fundamental requirements of survival of a community, and thus constitutes a basic human right. It is the responsibility of governmental institutions to ensure that all people have access to adequate food. The right to food consists of two primary aspects: first, ensuring all inhabitants have enough food to meet their basic daily needs, commonly referred to as food security; and second, ensuring that all inhabitants are protected from harmful and unsafe food, referred to as food safety.

B. Food Security: Causes of Food Scarcity

Food security can be defined as access to ample and nutritious food at all times which provides enough nourishment for an active and healthy life. [36] Food security is primarily an issue of distribution. Today some 800 million of the world's population—about 200 million of them young children—suffer from hunger and chronic malnutrition. [37] In many developing regions, it is estimated that over half of all child mortality is caused by malnutrition. [38] The cycle of hunger and infection that leads to vulnerable immune systems is often responsible for this. In these instances, even if children are adequately fed they may not be able to absorb nutrients adequately due to water-borne diseases like diarrhea and other parasitic infections such as hookworm, roundworm, and whipworm. In this way, issues of food security like malnutrition are inseparable from water safety and sanitation concerns.

In the past, when more food was needed, more land was simply cleared away to allow the development of new farming areas. In many areas throughout the world today, this is no longer an option. A large majority of the world's most suitable agricultural land is already in use, and even if remaining forests, wetlands or grasslands were converted to farmland, the net gain from the marginal quality of these cleared areas would not match the productive loss of such natural ecosystems.

Food insecurity is a problem not so much of the quantity of food available but of its patterns of distribution – there is sufficient food available to feed to world's population, it is simply not distributed among those that need it most. Lack of food can generally be related to combination of three factors: (a) lack of adequate resources; (b) lack of proper land management strategies; and (c) lack of adequate distribution. While lack of adequate resources and lack of proper land management are problems confronted locally, lack of adequate distribution is most commonly experienced at the global scale.

(i) Lack of Resources: Lack of adequate resources essential for agriculture is a problem experienced by more and more communities. Many areas simply are not endowed with the natural resources necessary to farm successfully, with minimal availability of arable land and/or water. Some areas have used resources they originally possessed to the point of near depletion. In the case of water use, this is especially true – water availability is one of the single, most important factors associated with food security issues. If an area has no water, it will have no food. Yet it is also difficult for most areas of the world to acquire water from outside sources. Many regions of the world have resorted to farming in areas where nature never intended the use of a plow or a cultivator. For instance, mountainous farm plots, besides having characteristically rocky, infertile soils, are often prone to mass amounts of severe erosion once trees and shrubberies are removed that formerly provided soil stabilization in hilly areas. Air pollutants, such as acid aerosols and photochemical oxidants, can also adversely affect crop yields, in addition to other atmospheric factors related to local weather and climate variability.

(ii) Poor Management Strategies: Land and irrigation water in agricultural regions are often managed in highly unsustainable manners with a focus on short term production, which inevitably leads to dangerously low crop yields in the long run. Throughout the 1960s and 70s, the easiest and fastest way to increase crop yields was by increasing irrigation and through excessive use of pesticides and fertilizers. Yet such procedures have already been practiced to exhaustion, leaving many areas drained of nutrients and unable produce a healthy crop yield. Faulty water management can lead to waterlogged soils, depriving crops of much needed oxygen that results in salinization, as well as soil erosion. About two-thirds of soil erosion is caused by water washing away fertile topsoil; the remaining

36 Please refer to: http://www.childstats.gov/ac2000/ccontxt.asp

37 WRI, UNEP, UNDP, World Bank. 1998-99. *World Resources: A Guide to the Global Environment, Environmental Change and Human Health*. New York: World Resources Institute (WRI), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and World Bank.

38 Bartlett, Hart, Satterthwaite, de la Barra, and Missair. 1999. *Cities for Children: Children's Rights, Poverty, and Urban Management*. London: Earthscan Publications Ltd.

one third is attributed to wind erosion. [39] Farmland can also be degraded in other ways, such as through mechanical tilling, repeated cropping without sufficient fallow periods, and the replacement of nutrients with manure or fertilizer, which actually ends up depleting soil nutrients. Meanwhile, the over-application of pesticides kills beneficial organisms, not to mention being toxic to humans and other biological species.

(iii) Distributional Inequities: More commonly, food scarcity results not from limited food supply, but from lack of access to the available food supply, and often is a logistical or market-driven problem of inequitable food distribution. The International Fund for Agricultural Development (IFAD) observes in its mission statement that the causes of food insecurity and famine were "…not so much from failures in production, but structural problems relating to poverty and the fact that a majority of the developing world's poor population was concentrated in rural areas." [40] Global markets and increasingly internationalized systems of trade render the food distribution problem much more complex. The present global market is dominated by a few large national economies, which makes it difficult for smaller developing nations to compete in already highly specialized markets. Thus, developing countries' requirements to integrate into the global economy is acquired by devoting their arable lands to high-value export products, (i.e. "cash crops"), rather than cultivating basic food crops needed for local populations. [41] In addition, many cash crops, such as cotton and tobacco, require large amounts of water. Moreover, such agricultural uses, using large quantities of synthetic fertilizers and pesticides, significantly degrade the environment, while providing no nutritious food value to the general public.

Quite often, national governments involved in such export trade practices find that they lack sufficient capital to import basic food crops to feed their own people. Thus, it is possible for a net surplus of food to exist on a global scale while millions of people at the regional or local scale may experience famine-like conditions, unable to obtain basic foodstuffs. Such "market failure" in food commodities occurs when little or no food is available within a market system to feed hungry people in dire need. For example, food may be produced for export-market only or is out of the price range of most poor people in rural areas. Thus, food access should be examined at the market-level, i.e. access to land and food, and not simply in terms of crop failure or increasing population because all agricultural activities (except subsistence agriculture) occur through an exchange of cash or labor. Large-scale famines can no longer be seen as lack of food but the result of complex interaction of societal forces pitted against the need to conserve natural resources and to maintain a clean and sustainable environment. Thus, during times of agricultural crisis, no social or economic basis exists to expect market-driven systems to provide sufficient food for people—if people can't afford to pay for food, the current market system will not be able to provide it, no matter how dire the circumstances. [42]

Health Impacts of Pesticides and Agricultural Chemicals [43]

Although there are many different pesticide products available in today's marketplace, their major uses generally fall under the following categories: insecticides, rodenticides, herbicides, fungicides and antimicrobials that are employed to control insects, rodents, weeds, fungi, and bacteria/viruses, respectively. Other minor categories of uses include chemical agents that control algae, mites, nematodes, insect eggs, or those that disrupt insect mating behavior (pheromones), or inhibit insect or plant growth. Chemical substances that are active ingredients of pesticide products are divided into the following categories: (a) organo-chlorine compounds, such as DDT, aldrin, endrin, and lindane, which have relatively low acute toxicity, but are often found to be cancer-causing substances that bioaccumulate in the environment (as persistent organic pollutants), (b) organophosphate compounds, such as malathion, parathion, methylparathion, which generally possess high acute toxicity as nerve agents (as chemical inhibitors of nerve transmissions), but do not appear to pose cancer risks and are much more biodegradable, (c) carbamate compounds, such as carbaryl, carbofuran, thiodicarb, which generally have high acute toxicity and may pose cancer risks, but do not as a rule bioaccumulate in the environment, (d) metal-based compounds, such as arsenic, copper, zinc, mercury, lead oxides and their salts, that have the acute and chronic toxicological profiles associated with heavy metals.

39 WRI, UNEP, UNDP, World Bank. 1998-99. *World Resources: A Guide to the Global Environment, Environmental Change and Human Health*. New York: World Resources Institute (WRI), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), and World Bank.

40 Please refer to International Fund for Agricultural Development's missions statement: http://www.ifad.org/sf/mission.htm

41 International Institute for Sustainable Development http://iisd1.iisd.ca/pcdf/1996/81quizon.htm

42 Vogel, C. and J. Smith, 2002. *Politics of Scarcity. South African Journal of Science* 98: 7-8 p.315

43 Excerpted from: Ahmed, A. Karim. *op. cit.*

At present, large volumes of chemical pesticides are produced and sold globally for agricultural production, forest management and household use. It is estimated that worldwide industrial sales of pesticides were about $33 billion in 1996, while the export of pesticide products from developed to developing countries continues to increase substantially each year. However, the volume of discarded and obsolete pesticide products in many developing regions has skyrocketed in recent years. These include such non-biodegradable organo-chlorine pesticides (such as aldrin, dieldrin, DDT, endrin, HCH, lindane) and the acutely toxic organophosphate pesticides (such as malathion and parathion). The UN's Food and Agriculture Organization has likened the current situation to a "time bomb" and has urgently called upon industry and governments to increase the pace of clean-up of contaminated storage sites. Several hundred thousand metric tons of banned or unwanted pesticides are now stockpiled in waste storage sites around the world awaiting proper treatment and disposal.

Throughout the 1970s and 1980s, while industrialized countries in North America and Europe began to impose stricter controls on their domestic production, use and disposal of toxic substances, pesticides and hazardous wastes, there was a dramatic increase in the export of banned and severely restricted products from developed to developing regions of the world. This led the international community to adopt a series of agreements and conventions that provided voluntary guidelines and regulatory procedures to control the global shipment of toxic substances and hazardous wastes. In 1995, the International Code of Conduct on the Distribution and Use of Pesticides was adopted by the Food and Agriculture Organization (FAO), followed in 1987 by the enactment of the London Guidelines for the Exchange of Information on Chemicals in International Trade by the United Nations Environment Programme (UNEP).

In 1989, an international regulatory procedure, called the Prior Informed Consent (PIC) was adopted to help control the importation of banned or severely restricted products into developing countries, to be jointly implemented by UNEP and FAO. Under PIC, officials in importing countries are required to be informed by the exporter about the toxicological characteristics and regulatory status of potentially hazardous chemicals before shipment of the product to their region. In 1998, the Rotterdam Convention was adopted, extending the PIC regulatory procedure to hazardous pesticide products on the list of toxic substances requiring prior informed consent. The Rotterdam Convention provides legally binding assurances that all shipments of dangerous chemicals and pesticides be subject to authorization by importing countries, including provisions for obtaining adequate product labeling and toxicological information on imported goods

In recent years, a considerable amount of regulatory attention in developed countries has been placed in preventing and controlling health risks associated with carcinogenic or mutagenic (i.e., genetic or developmental) impacts of toxic substances, since their chronic effects are not immediately manifested because of their long latency periods or over a multi-generational time frame. This includes assessing health risks from trace amounts of cancer-causing substances found in air, water, soil, food and other consumer products. Thus, regulatory agencies in many developed countries have established fairly stringent health safety standards for potentially carcinogenic substances. Many of these toxic chemicals are persistent organic pollutants (POPs), such as those found in a number of widely used pesticides and chlorinated hydrocarbons. The major characteristic of POPs is their long-term chemical stability, i.e., they do not break down to form less toxic chemical substances in the environment. Moreover, POPs as a class of compounds do not readily dissolve in water. Thus, they tend to bioconcentrate in the food chain, especially in the fatty tissues of fish and livestocks, posing serious health risks to human populations. Under the recently signed international agreement, the Stockholm Convention on Persistent Organic Pollutants (POPs Treaty), which was adopted in December 2000 in Johannesburg, the following 12 chemicals are to be phased out and eliminated: polychlorinated biphenyls (PCBs), dioxins and furans, aldrin, dieldrin, DDT, endrin, chlordane, hexachlorobenzene, mirex, toxaphene and heptaclor.

More recently, another class of toxic substances, known as endocrine disrupters, has been brought to the attention of regulatory agencies in developed countries for its potentially severe long-term impact on both animals and human populations. These toxic substances contain organo-chlorine pesticides, polychlorinated biphenyls, dioxins and furans, and a number of plant-based and synthetic estrogens. By interfering with the endocrine system, these estrogen-mimicking compounds have been associated with developmental disorders and reproductive failures in wildlife animal and fish species, stunting their normal growth and their ability to produce healthy offspring. While the toxicological impact of endocrine disruptors on human populations has not been thoroughly determined, preliminary studies have shown significant declines in the male sperm production in the past few decades. In addition, some researchers believe that recent increases in breast, testicular and prostate cancer, along with increased behavioral disorders in children in many developed countries, may be associated with long-term, chronic exposure to endocrine disruptors, which are found in trace amounts in many fresh water sources and food products. At present, a number of multilateral agencies (for example. WHO, Organization for Economic Cooperation and Development (OECD)), and national regulatory agencies (including U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and Environment Canada) have embarked on a concerted effort to assess the potentially serious harmful effects of endocrine disruptors on human populations.

C. Food Safety Guidelines

The enormous volume of the world food trade is valued at between US$300 billion and $400 billion. A common concern of many national governments is that food imported from other countries should be safe and not jeopardize the health of consumers or pose a threat to the health and safety of their animal and plant populations. Reliable access to nutritious food can mean nothing if the food itself is unsuitable for consumption or dangerous to human health. It is generally assumed that most causes of food safety are a result of environmental contaminants or chemical residues found on the food, such as pesticides and other synthetic agents. In many regions of the world, however, the impacts of improper food handling and lack of hygiene, which results in harmful bacteria and other microbial agents such as protozoa, parasites, viruses, and fungi or their toxins, that is the most frequent cause behind food borne diseases. Other factors affecting food safety include antibiotic resistance to certain pathogens; the use of genetically modified organism (GMO) that could potentially transfer human allergens and lead to antibiotic resistance; and organically-raised foods that contain no chemical preservatives and may be more perishable. [44]

International legal instruments, such as a set of codes, have been developed for protecting the health of consumers against food-borne hazards. The Codex Alimentarius is the international food guideline that has been in place since 1963 to ensure food safety worldwide. Jointly administered by the FAO and WHO, the Codex's mission is to provide internationally accepted, scientifically based food safety guidelines in order to maintain and protect public health. The Codex Alimentarius serves as the basis for many national food standards around the world, since it has set global standards for pesticide and veterinary drug residues, additives, food imports, inspections, and food sampling methods, among other items. [45] The Codex guidelines are considered scientifically justified and is accepted as the benchmarks against which national measures and regulations are generally taken. [46]

D. Recommended Environmental Health Indicators and Benchmarks for Food Security and Safety

Basis for Selection:

For primary environmental health indicators, emphasis is placed on determining the extent of malnourished individuals in the general population and among young children in a community, such as the incidence of caloric and protein deficiencies, and the incidence of nutritionally insufficient intake of essential minerals and vitamins. As an important corollary to these primary indicators and benchmarks, efforts should be made to assess the availability in a community with high incidence of malnutrition of key low-cost mineral and vitamin supplements, which may differ from region to region due to geographical factors, such as iodine deficient soil, and other socio-economic considerations. Another important environmental health indicator is the determination of the percent of food commodities, such as raw fruits and vegetables that have detectable levels of toxic pesticide residues or have bacterial and/or fungal contamination.

Among the secondary environmental health indicators recommended are developing a quantitative inventory of the types and amounts (per hectare) of acutely or chronically toxic pesticides used in food production in a farming community, including determining the per capita use of highly toxic pesticides, such as chlorinated hydrocarbons, organic phosphates and carbamates, in a given agricultural region. These secondary indicators and benchmarks provide an indirect measure of potential health-related problems in many agricultural areas of developing regions, such as those linked to acute poisonings and accidental deaths in adults and young children, enhanced rates of teenage suicides (from self-induced abuse) and other chronic diseases, such as increased incidence of developmental diseases, respiratory disorders and different forms of cancer. A more direct measure of agricultural chemical impacts on the health and welfare of infants and young children is determining the prevalence of blue-baby syndrome in a

44 FAO Food Quality and Safety http://www.fao.org

45 Guidelines can be found at: http://www.codexalimentarius.net/standard_list.asp

46 *Understanding the Codex Alimentarius* http://www.fao.org/docrep/w9114e/W9114e01.htm#TopOfPage

farming community, which is caused by ingesting contaminated drinking water that results from excessive nitrate (e.g., animal manure) and commercial fertilizer runoffs into surface and groundwater sources.

Finally, it is important to determine the extent of sustainable agricultural practices that are being carried out in a region. For these purposes, tertiary indicators and benchmarks should be developed that assesses the percent of food crops grown in a farming community that do not use pesticides, synthetic fertilizers or other types of agricultural chemicals. Another environmental health indicator or benchmark would be determining the percent of farmers that use integrated pest management (IPM) techniques on their land, in which pesticides and other agricultural chemicals are only used as a last resort, while biological means of control and non-chemical methods are the principal mode of suppressing harmful insect and weed populations.

Summary of Recommended Indicators and Benchmarks:

(i) Primary Indicators

- Incidence of Malnutrition in Population/Children: Calorie/Protein Deficiencies
- Incidence of Malnutrition in Population/Children: Essential Mineral/Other Nutrient Deficiencies
- Incidence of Malnutrition in Population/Children: Vitamin Deficiencies
- Percent of Population with Access to Key Low-Cost Mineral and Vitamin Supplements
- Percent of Food Products with Detectable Levels of Toxic Pesticide Residues
- Percent of Bacterial and Fugally Infected Food Products

(ii) Secondary Indicators

- Types and Amounts of Acutely/Chronically Toxic Pesticides Used on Farm Land Under Cultivation—
- Per Capita Use of Highly Toxic Pesticides in Agricultural Production in a Region—Chlorinated Hydrocarbons, Organophosphates and Carbamates
- Nitrate and Commercial Fertilizer Contamination in Drinking Water: Incidence of Blue-Baby Syndrome in a Region

(iii) Tertiary Indicators

Implementation of Sustainable Agricultural Methods:

- Percent of Crops Not Using Chemical Pesticides
- Percent of Crops Not Using Synthetic Fertilizers
- Percent of Crops Using Integrated Pest Management (IPM)

(iii) Modifying Factors

- Geographic Location
- Climate Type: Rainfall Patterns and Temperature