15th OSCE Economic and Environmental Forum

Session I - Environmental Security and Specific Challenges
of Land Degradation and Soil Contamination

EF.DEL/1/07
17 January 2007

ENGLISH only

Concepts of Strategic Environmental Security

A paper presented to the 15th OSCE Economic and Environmental Forum

Vienna, Austria, January 21-22, 2006

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INTRODUCTION

I am honored to speak at this important venue and share my ideas on the important topic of environmental security. Environmental security is particularly relevant at this forum because as my results will show, land degradation is an important variable in environmental security analysis. More about that idea later, but the more important concept I want to discuss today is how environmental issues can be directly related to security, which then allows environmental issues to receive fuller consideration in national and international security policy considerations. Scientists understand the significance of many of the critical environmental issues associated with sustainable development, but have not been convincing in presenting these ideas in the context that is needed to compete with more recognizable security interests such as political or military programs. Science has to present environmental issues in the context of preventive defense and stability creating programs to be understood. This paper presents a conceptual analytical model which allows the environmental security discussion to move forward as a security/defense issue.

In my view, the Organization for Security and Co-operation in Europe is the perfect venue for a discussion of environmental security from a security analysis perspective. As my thesis will propose, regional environmental stresses are primary threats to security and peace in the world in general, and in areas of this region, specifically.

The impetus the research being presented today originated with a growing personal sense that there are dramatic human-induced changes occurring in our environment. These changes are adversely affecting the Earth today and if, left unabated, they will seriously impact the safety and security of our world in the future. A burgeoning population and its demands for natural resources, renewable and non-renewable, are leading this assault on the environment. Some consider technology a co-conspirator in the degradation of the environment. Certainly, technology has evolved to the point that it can do great harm; conversely, technology can also heal and mitigate. Within this context, the overarching theme for this paper becomes,

> *Environmental degradation and environmental resource scarcity are of such a magnitude that they can become, if they are not already, an issue of regional security (military and non-military) for many regions of the world.*

Conceptually, threats to peace and security associated with environmental issues have been collected under the term ***environmental security***.

The concept of environmental security is not new, particularly for the academic community where the environmental movement began. Many of the eminent scientists who advanced our understanding of the earth's environment were also the "doomsayers" (as they were characterized at the time) who predicted catastrophic environmental consequences as a result of uncontrolled human activity. Norman Myers (1986), an early environmental security scholar, expressed the relationship between the environment and world stability well when he wrote,

> *Hence national security is not just about fighting forces and weaponry. It relates to watersheds, croplands, forests, genetic resources, climate and other factors that rarely figure in the minds of military experts and political leaders, but increasingly deserve, in their collectivity, to rank alongside military approaches as crucial in a nation's security.*

Definition of Environmental Security

This paper uses the term "environmental security" in a much more restrictive manner than do many existing definitions found for environmental security in the literature. Here the term is applied specifically to strategic security issues. The definition presented below sets the boundary conditions for this paper, but is not purported to be a final, inclusive definition of "environmental security."

> *Environmental security is a process for effectively responding to changing environmental conditions that have the potential to reduce peace and stability in the world. Environmental security involves identifying the critical issues and accomplishing environmentally related actions to prevent and/or mitigate anthropogenically induced adverse changes in the environment and minimize the impacts of the range of environmental disasters that could occur* (King, 2000)**.**

I believe that many in this room share my frustration that many environmental protection issues are not receiving the attention from governments that the science justifies. There is a great divide between the physical scientists that study the Earth's processes and the political and social scientists that direct public policies and decisions. Scientists often come to meetings such as this and bemoan that we are not listened to. The truth is that we do not speak the same language. Watch in a meeting where an atmospheric scientist is giving her best boundary layer mixing theory lecture to a group of political leaders who just want to find an affordable method to reduce toxic air pollution. What we have is a failure to communicate. Scientists simply have not been convincing in their arguments to attract the support needed to address many of our problems. Without an imminent health hazard, governments fail to invest in long-term environmental protection projects, particularly regional and multi-national programs.

Environmental security as a process is an approach that can help bridge the gap between the knowledge of science and the public policy decision making process. Environmental security analysis provides us the opportunity to demonstrate how security and the environment relate. Strategic environmental security analysis as will be developed herein is a science-based method to conduct security impact analysis of key environmental issues. Evidence is emerging that substantiates that investing in environmental protection and restoration is a cost effective approach to stabilizing and bringing enduring peace to a region of conflict.

Land degradation and water as a scarce resource are two of the critically important issues and are what brings us here today, but there are many more issues such as deforestation, air pollution, hazardous wastes, and others that I will introduce shortly.

The Law of Environmental Security

To understand the basic principles of environmental security one must understand the relationship between humans and the environment. This is not constructed on the basis of science, but on the social dimension of human activity. Consider the following view from the history of America, before there was a United States of America. I offer this only because I believe it expresses values common to all people and remains as valid today as it was in 1776 when a collection of immigrants from many lands professed that (American Declaration of Independence)

All men are created equal ……… ***that they are endowed by their creator with certain unalienable rights, among these are, life, liberty, and the pursuit of happiness.***

These words very simply state a common set of human values, and I believe they are presented in order of human need (similar in concept to Maslow's classic 'Hierarchy of

Human Needs'). People first seek life sustaining elements from their environment. Once people have secured life sustaining conditions, they strive for the higher level values such as personal liberties and other pursuits of the human spirit. Only with those needs satisfied do people then move up to the highest level of human existence, which is described as the pursuit of happiness. For this presentation, we will focus on the life sustaining component of this hierarchy of human existence. It is at this basic level that security interests coincide with environmental protection issues.

Life sustaining conditions are provided by our environment – the land, water, and air that we depend on for existence. It begins with clean air to breath. Today, air pollution has reached levels in or near many urban areas to where acute and chronic illnesses threaten millions of people. Less clear but of monumental concern is the impact of increases in carbon dioxide levels in the atmosphere and its potential to cause harmful global climate change. Next in the hierarchy of threats is pollution of fresh water supplies critical for human consumption and irrigation of crops. Water pollution and regional stressing of limited resources are issues in many parts of the world today. Land pollution (loss of arable lands) is an equally important concern for basic human existence. The land available is fixed at the upper limited, but can be greatly reduced by human disturbance such as overuse, contamination, or conversion to urban terrain.

The important conceptual linkage between the environmental conditions and security can be seen by focusing on the possible human responses to the loss of sustaining environmental conditions. Consider the case of a family that lacks enough food, or clean water, or wood to heat in the cold winter because their land lacks the environmental carrying capacity to support them. What would most parents do? They could try to move their family to a place that can better support their needs. The United Nations has identified emigration as a growing problem and has termed 'environmental refugees' as people displaced by the combined effects of population growth, resource scarcity and disease (White, 1993). The military and security repercussions of refugee problems are amply documented in reports from Rwanda, Somalia, Ethiopia, and the Sudan, just to name a few. A second option is for people to try to get resources from others who possess what they need. James Lee (1999) identified 70 separate modern era conflicts rooted in environmental issues. Further, the historical records show that, dating back to 2500 BC, water has truly been something people will fight over. Today, this trend continues. Peter Gleick (1998) identified 17 distinct incidents of armed conflict directly over access to water for human use in the period from 1945 to 1997. Clearly, the absence of sustaining environmental conditions is a destabilizing factor for a region or a country. Putting this in human terms, parents who cannot feed their children or keep them warm will do everything in their power to take care of their family, we all would. In this ever crowding world, there aren't places to move or excess resources to share and the trends are for worsening conditions, without a more positive response to environmental sustainment.

Today, the environmental security debate flourishes among social and political science scholars who work to redefine security, define environmental security, and predict the political and social responses to environmental scarcities. Within the forum developed at the Woodrow Wilson International Center for Scholars, organized as the Environmental Change and Security Project, debate and discussion continue. Thomas Homer-Dixon (1993), Marc Levy (1995), and others have helped develop and focus the early work of Norman Myers (1993) and other scholars into a better understanding of how environmental issues can/will impact security in the future. Debates have centered primarily on defining environmental security and applying political science approaches to analyze how developing countries will respond to environmental stress factors. Although these debates and discussions raise many challenging social issues, it is not a goal here to enter into that fray.

As the magnitude and extent of problems such as deforestation and loss of arable land increase in the future, it is certainly plausible that these too could give rise to conflicts in many regions of the world, conflicts as serious as those documented by Gleick for water scarcity problems or the conflicts identified by Lee. But how should responsible nations respond? They have to employ environmental security analysis to analyze the issues and develop options to mitigate harm and produce sustainable, stable conditions. Environmental scientists already recognize that the cost of cleaning up a mess is always higher than the cost of prevention. Trying to rebuild denuded forest or restore contaminated or depleted water supplies are costly activities compared to educating people on sustainable development or on measures that preserve water supplies. And at the far end of the spectrum, the cost of war resulting from environmental scarcity and degradation will be greater than many of the actions that can be undertaken to prevent these type conflicts.

GLOBAL ENVIRONMENTAL SECURITY ISSUES

This section provides a review of the critical environmental issues and presents a summary of the impacts each could have on world stability and security. This discussion serves as a basis for the strategic analysis of the security implications of these issues presented as the conclusion to the discussion.

The term “critical environmental issues” reflects two realities:

1. There are more environmental issues than can be covered effectively in this short paper, and more fundamentally,

2. Not all environmental issues are strategic security concerns.

The latter reality is simple enough, but actually deciding which environmental issues relate to national security is a challenging task. Conflict over scarce resources, water for example, is easily defined as a problem area. There is, however, a thread of logic (or paranoia) that can perceive a threat in nearly every environmental issue, if not as a primary effect, certainly as a secondary or tertiary impact influencing national security. The issues selected for this analysis are a compilation of environmental stresses identified in works published by the U.S. Environmental Protection Agency (USEPA, 1999). The goal is to employ well established environmental parameters which have historical records and well defined trend rates.

Because population trends are an important variable in nearly all environmental security issues, this analysis begins by discussing population trends on a regional scale. It then proceeds to consider three major environmental areas:

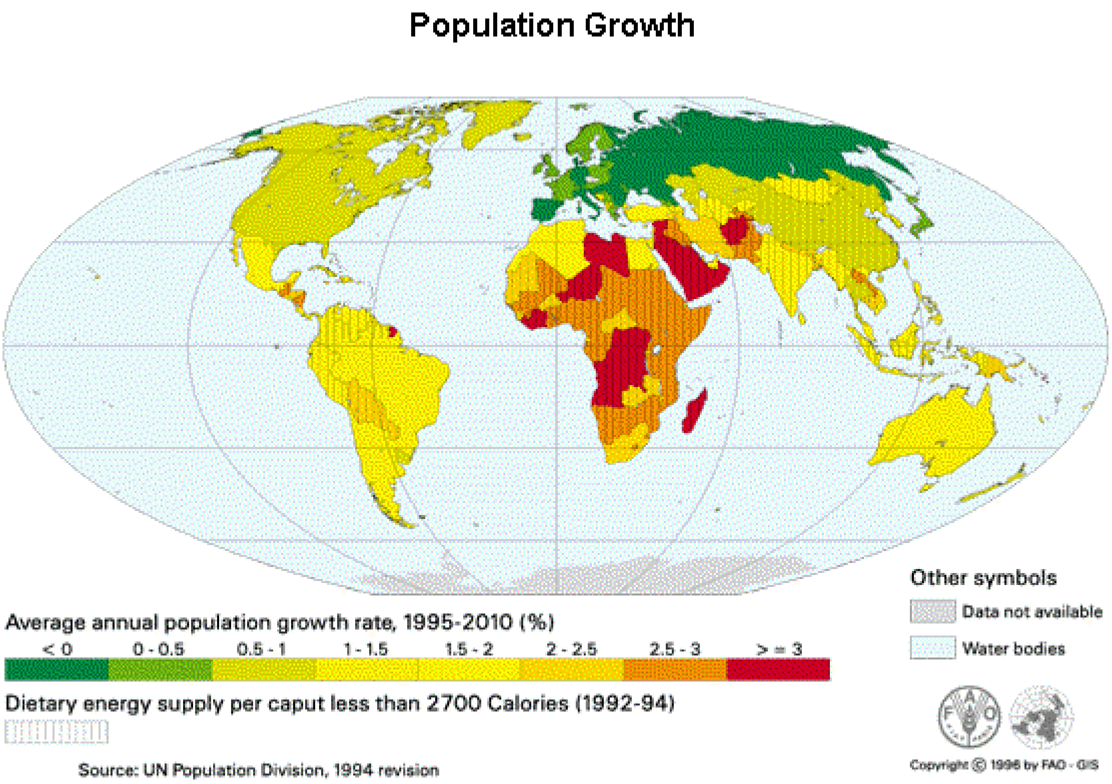
- Global Climate Change
- Land Use issues of loss of arable lands, deforestation and desertification
- Water as a scarce resource

Issues of Population Growth

Many estimates exist, with considerable variability in the upper bounds and predicted rates of growth. One well acceptable model predicts the world population asymptotically approaching 12 billion after 2100 (Getis, 1998). Figure 1 is an illustration of one projection of population growth. No matter the accuracy of the predictions, we will have growth and, assuredly, an increasing population will yield environmental impacts. We can use the concept of "carrying capacity" to help focus our understanding of the fundamental interrelationship between overpopulation and environmental security. Ecology and environmental geography share the concept of carrying capacity, which, defined in general terms, is the total population that the resources of an area can support over an indefinite period of time.

From a human perspective, the carrying capacity principle is equally valid—even with the marvelous products of human ingenuity. Technology can change the relative value of human carrying capacity by enabling us to resource one region at the expense of another, by changing efficiency of use, and by providing solutions to many other specific problems. However, there are finite limits to the number of people any region can support and, by extension, the total population the entire world can support (Brown, 1994). Some of the more optimistic philosophies of human activity espouse the belief that technology can overcome the fundamentals of carrying capacity; to date this belief has not proven valid. The critical

FIGURE 1



resources of water, land, and energy (fuel and food) are renewable at finite rates, which humankind can impact only in minor percentages of total use. In the final analysis, humans remain one of the more fragile organisms on the planet, bound to a relatively constrained set of environmental conditions of landscape, temperature, oxygen, moisture, and available energy sources.

When one considers the concept of carrying capacity in the context of human population increases, one question immediately arises: what is the total carrying capacity of the Earth?

Will the Earth be able to sustain the predicted steady-state world population of over 11 billion people after 2100, nearly double the current world population?

It is not possible to even attempt to answer the questions without first considering the spatial distribution of both people and resources. Where will these 11 or so billion people be located and how well aligned will the people be with essential resources? Another issue that complicates any analysis of regional or world carrying capacity is the ability to share or transfer resources effectively. All great modern cities now operate through a worldwide supply network. Countries such as Japan and the United Kingdom thrive at a very high standard of living, while obtaining only a small portion of consumed natural resources from within their geographic boundaries. Further, there is no assurance that this transfer process can be sustained over time.

Whether it is 8 billion, 11-12 billion, or 50 billion people, no one truly knows how many people the Earth can sustain. Many scientists studying the issue are quite concerned about the currently predicted human population increases and are acutely fearful about several rapidly growing regions with limited resources. In this situation, people first mine the natural resources, consuming water, wood, and other renewable resources at rates faster than they can be regenerated. Next, people may migrate to regions where they can be better supported, but such opportunities drastically decrease as population increases. In natural systems, the final stage of this process is the die-back phase. The human response is much more difficult to predict because more variables come into play. Humanitarian relief to stressed regions is one example of such a variable, while human conflict or war is another. In any event, the population ultimately must align with the sustainable level of resources, and this can mean reduction of the population. Often die-off is precipitated by some environmental event such as a drought, flood, or disease. The net impact is that the population suffers a significant reduction over a short period of time. Obviously, each level of this hopeless cycle will increase the insecurity in a region until complete chaos exists.

The term “hopeless” is employed in the sense that the basic principle of carrying capacity cannot be violated over the long term; thus, it is hopeless to expect a region to long support more than its natural capacity for people. Worse, the first phase, the mining of renewable resources can actually reduce the existing carrying capacity of a land for some period, and this can be a very long period for a fragile environment such as a desert or a cold region. To illustrate this concept, consider the example of agricultural crop rotation, which involves cultivating the land for a period and then allowing a fallow time for the soil to recover. It has been proven that without this recovery period the land produces less and less until it becomes unusable. As will be discussed in the section on desertification, human activity can critically damage the entire ecosystem of an area.

Many authors continue to suggest that it is the resource side of the problem that must be addressed. Former U.S. Senator Paul Simon's (1998) excellent book on water, *Tapped Out—The Coming World Crisis in Water and What We Can Do About It,* takes this general approach, i.e., fix the water supply problems and we can avoid the crisis. While his concern with water and his solutions are valid, the underlying principle of carrying capacity remains inviolable. In the water context, the climate provides a watershed with only a fixed amount of water. There is a minimum amount of water required per person each day for survival. The equation then becomes straightforward:

$$\text{Human carrying capacity} = \frac{\text{Gallons of water available per year}}{\text{Gallons per person per year demand}}$$

Conservation and other management tools can to some degree change the values in both the numerator and denominator, but cannot change the reality that a given hydrologic setting can support only a certain number of people.

Global Climate Change

Understanding global climate change is technically complex because of the many dependent variables associated with the carbon cycle, the greenhouse effect, and natural variability of weather and climate, even before factoring in anthropogenically induced change. Breaking the impasse on the science of global climate change has required considerable international cooperation, and in a sense can be considered as progress in security because of the many fruitful and cooperative relationships that have evolved. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed. Over time the IPCC has produced several significant studies on this subject and has contributed to building consensus and reducing uncertainty. The IPCC results will be the basis for discussion at several points in this review, particularly in areas where a wide diversity of opinion exists.

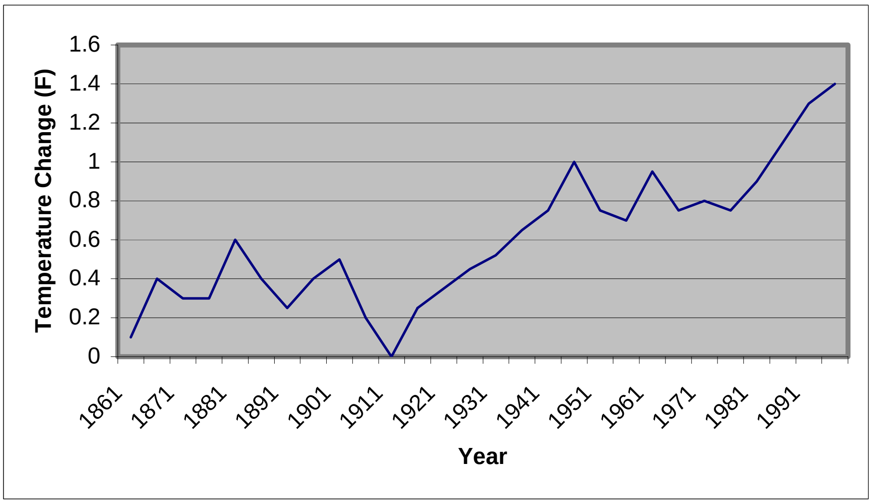
Many scientists now believe that global climate change in the form of global warming caused by anthropogenic activity is occurring. Figure 2 shows changes in world temperature over the past 140 years, the period for which accurate measured data are available. Driving global climate change is a series of interwoven phenomena including, but not limited to, deforestation, burning of fossil fuels, and industrial pollution. Assessing each of these factors independently in a static model is within our scientific capability today, but does not yield realistic results. Each activity occurs independently at different rates and concurrently with the natural variability in weather.

Many look at these data and conclude that global warming is an acute issue brought on by human abuse of the environment (White, 1993). Others, however, point out that this change over such a minute period in the history of the Earth is well within the statistical bounds of natural fluctuations (Horel, 1997). Logically, the change illustrated in Figure 2 must be the result of both, i.e., the forced changes caused by human inputs, but imbedded in the natural variability for that period. Unfortunately, there is insufficient scientific understanding to precisely separate the two components at this time.

The consensus of scientists today is that increases in carbon dioxide (CO_2) will have a direct impact on temperature. Specifically, increases in CO_2 will produce increases in global

FIGURE 2

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated.

temperatures. Data have confirmed the increase in atmospheric CO_2 by about 50 parts per million by volume over the last 40 years (Houghton, 1994). There is little argument that this increase is directly related to carbon emissions from burning of fossil fuels.

The striking similarity in the shape of the curves depicting increasing temperature and increasing CO_2 since 1960 certainly suggests a relationship, but this is not conclusive scientific evidence. Rate of temperature change within the dynamics of greenhouse gas behavior and natural climate processes is a key area of uncertainty in the global warming debate. Several complex computer models have been developed and are being continually updated, but each has proven to have strengths and weaknesses in describing actual conditions or predicting changes. A wide range of temperature predictions exists, but they generally fall in the 0.5 – 5.0 ^oC range. The Intergovernmental Panel on Climate Change (IPCC), supported by the USEPA, predicts a 1 to 3.5 ^oC temperature increase by 2100 (USEPA, April 2000). These figures represent the consensus values of scientists worldwide and have received the most scrutiny. Despite this work, there is no evidence of efforts by the international community to respond to the looming issues.

This introduces another area of uncertainty into the global warming debate, and arguably the one of greatest contention in the scientific community. Complex interactions between systems, actions, and counteractions of the carbon cycle and other processes make it difficult to determine exactly how atmospheric warming will affect the Earth's ecosystem. Based on our current understanding of climate and weather, a rise in temperatures worldwide and changes in temperature distribution, spatially and temporally, will change weather and climate over large areas of the Earth. Weather is primarily driven by the sun's energy being unequally distributed over space and time. Higher temperatures will produce more evaporation from the oceans and this will increase rains, somewhere. Higher temperatures over land will increase evaporation of soil moisture, raise dry soil temperatures, and melt ice. All of these factors will combine to change the weather patterns of a particular region, in both frequency and intensity of events. These can, over time, sum to changes in regional climates in many parts of the world. Grasslands, forests, and deserts may shift due to evolving climates.

Sea level rise as a direct response to global warming has been an issue that has captured considerable public attention, although there are many other equally important possibilities that must be assessed, particularly in considering environmental security. Based on scientific analysis to date, the range of sea level rise is predicted to be between -1 and +6 meters, not a particularly informative range to use in assessing impacts. However, the factors that enter into this calculation are fairly well defined.

First, warm water occupies a larger volume than cold water, so as ocean surface temperatures warm because of contact with the warmer air, the volume of the ocean will increase, resulting in a rise in sea level. The more difficult factor to calculate is the depth change attributable to warmer air temperatures occurring in regions with snow and ice cover. Uncertainty about whether and how much ice will melt under different warming predictions accounts for the wide range in the sea level rise estimates. Using the IPCC (1992) warming estimate as a basis for temperature rise, Houghton (1994) predicts a 50-centimeter (1.65 feet) sea level rise by the year 2100. The most detailed statistical analysis of sea rise predicts a 35 cm rise by 2100 as the most likely result, with a 10 percent chance of sea rise reaching 65 centimeters, and a 1 percent chance of a 1 meter rise (Titus, 1995). This rise, coupled with natural land subsidence in some lowland regions, could have large impacts in several critical areas of the world, such as Bangladesh and Egypt (Houghton, 1994).

There is scientific certainty that changes in weather will impact water resources, food production, human health, weather events such as floods and other "natural disasters," and coastal processes, all of which have peace and security implications. In this researcher's view, these are more difficult impacts to predict than sea level rise. In order to realistically predict the impacts of global climate change it will be necessary to input the variables with the accumulated uncertainties mentioned above into the same weather and climate models that are now employed to predict the weather.

Table 1 presents a synthesis of predicted worldwide impacts from regional climate change based upon IPCC Global Climate Change studies, as summarized by the USEPA (2000). As indicated in the table, regions relying on single-crop agriculture and subsistence farming, such as tropical Asia and Africa, are particularly vulnerable to changes in weather patterns. Vector and water-borne disease is expected to rise in the developing regions of the world and areas where more extremes in weather will increase the frequency of weather-driven disasters.

Many of the environmental issues discussed later in this chapter are inexorably linked to global climate change—water as a scarce resource, desertification, and deforestation being prime examples. While the data are not specific in terms of exactly where impacts will be seen, they do suggest that the basic carrying capacities of many regions will change, which implies that populations will need to shift in response. Overall, the impacts of global warming as predicted by this review will be a major destabilizing influence on the security of the world and will constitute a major causative factor in population migration.

Land Use – Loss of arable land

The availability of sufficient land to provide food for the supported population is a most basic issue in environmental security. Today, this is an issue that is becoming acute as loss of farm and pasture land collides with a burgeoning population. The loss of arable land has both natural and human induced components with the latter causing the most significant adverse impact. Human activities that reduce the amount of land available to grow food include urbanization of arable lands, overuse for agriculture that reduces the carrying capacity, and human activities that pollute the land making it unusable for agricultural purposes. Figure 3 depicts the basic nature of soil degradation (UNEP, 2003). Loss of arable land crosses the bounds of other land use issues including deforestation and desertification, both of which are discussed in sections to follow. The impact of loss of arable lands generates an immediate security threat because it creates an imminent threat to human life, as seen in the recent famine in the Sahel Region of Africa. Further, it constitutes an irreversible or at least extremely slowly recovering environmental change to human carrying capacity.

Later in this paper a method will be proposed to analyze the impacts of critical environmental factors on security/stability in a geographic region. Loss of arable lands will be one of the important issues proposed for environmental security analysis for the following two reasons, 1) Arable land is a fundamental critical element to sustain human ecosystem, and 2) It is a part of the environment being most drastically altered by today's activities. Looking ahead,

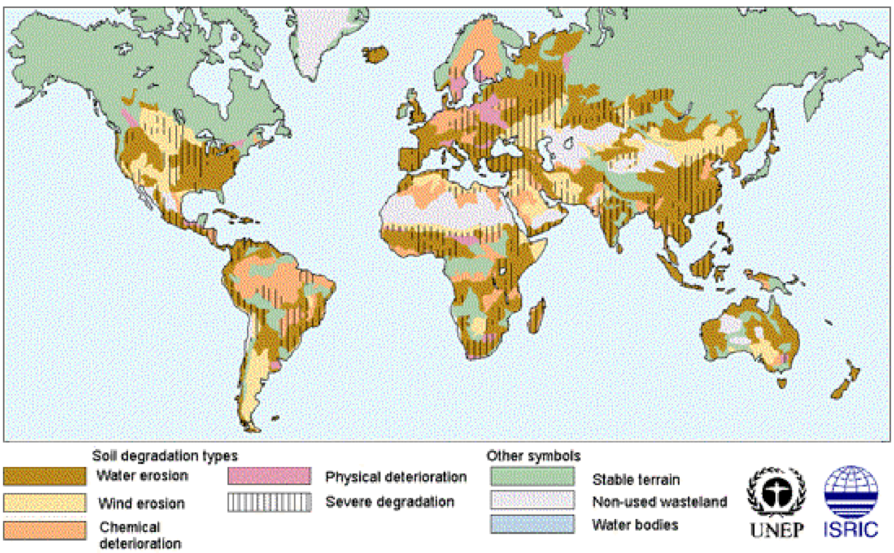
TABLE 1
Regional Impacts of Enhanced Greenhouse Effects on Climate

IMPACTS	North America	Tropical Asia	Temperate Asia	Arid Western Asia	Europe	Africa	Australasia
Geographic Area	Canada, US, and Arctic Circle	India, Pakistan, Bangladesh, Vietnam, Malaysia, and inclusive counties.	Japan, Koreas, Mongolia, most of China, and Russian Siberia	Turkey in the west to Kazakstan in the east.	West of Ural Mountains	The continent	Australia, New Zealand, and islands
Ecosystem	Shifts in location of forests and croplands; change of vegetation types; loss of waterfowl habitat	Changes in distribution of rainforest; drying of wetlands.	Reduction in the boreal forests, expanded grasslands, decrease in the tundra zone.	No large changes.	Mostly disturbed environment now. Alter wetlands through lower ground water levels	Desertification in north, loss of forests in SubSahara; deterioration of land cover. Major impacts expected throughout.	Alterations of soils and vegetation could be large.
Hydrology and Water Resources	Increased Spring and Winter runoff; decreased rain and soil moisture in summer.	Glaciers recede in Himalayas; more seasonal impacts,	Net decrease in water supply; glacier melt; North China water supplies vulnerable.	Continued water shortages in the region.	Increased precipitation in high latitudes and reduced in lower; loss of glaciers with water storage processes.	Reduction in supplies in Sahel and southern Africa. Acute concern in many already water scarce countries of the region.	Reduce water could be critical in drought prone areas; loss of snow and glaciers in New Zealand; flooding.
Food and Fiber Production	Small changes, plus and minus inputs	Vulnerable to natural disasters. Changes in production and yield very difficult to predict, but crops are sensitive to temperature and moisture.	Not agreement in predicted change;	No large net change.	Shift of growing seasons and patterns. Possible increased production.	Water shortages could be acute to farming in the North. Winter wheat growing in north hurt. Could have moderate increases in the south.	Early increased production predicted, but uncertain long-term impacts.
Human settlements	Changes in energy use; increased natural hazards.	Inundation of lowland cities,; salt water intrusion into water supplies in lowlands	Land subsidence in lowlands, slat water intrusion in water supplies	No large impacts	Flooding of more inhabited areas. Cooling demands higher, heating demands lower.	Increased exposure to natural disasters; urban water supplies threatened. Sanitation and waste disposal problems expand.	No large impacts expected
Coastal Systems	Up to 19,000 km^2 inundated; 23,000km^2 added to floodplain	Large and productive lowlands flooded; more natural hazards impacts; millions displaced by 1 m sea rise.	Japanese industry in coastal zones; large areas inundated	No large issues.	Risk of storm surges in lowland coasts of Holland, Germany Russia, and Ukraine.	Coastal erosion in central coastal areas, particularly in storm impacted west Africa. Flooding of Nile delta of concern.	Highly vulnerable to flooding and inundation
Human Health	None predicted	Increase in vector and water borne disease, malaria, dengue, and schistosomiasis	Increased transmission of vector borne disease.	Small increases in disease and heat induced health problems	No major changes	All types of disease exacerbated by malnutrition would further damage the overall health of the people of Africa.	Small increases in disease and heat induced health problems.

SOURCE: USEPA, website: www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html data will show that there is an irrefutable correlation between loss of arable land and security/stability. However, measurement and quantification of these impacts is scientifically challenging. The challenge relates back to the carrying capacity theory. Each area of land has a unique value for the population it can support in a sustainable manner, based on its location and use patterns. One can make general assumptions for this value based on geographic biomes such as those developed by Bailey (1998) or other systems that group the influence of landform, climate, and vegetation into a system of land classifications. However, this work has yet to produce a variable that usefully defines the relationship between a loss of arable land per unit of population supported. Work will be presented later showing how loss of arable land can be correlated to security, by region.

FIGURE 3

Human-induced soil degradation



Deforestation

There is a strong relationship between the reduction in the amount of forest area in the world and environmental security. On a global scale, forests are important for the uptake of carbon dioxide as part of the global carbon cycle, which then serves to regulate the greenhouse effect. This alone would be sufficient reason to consider the security implications of deforestation, but there are more direct issues that result from the widespread loss of forest areas in a region. Before discussing the impacts of deforestation, it is necessary to look at exactly what deforestation is and where and why it is occurring.

Tropical forests, located in the wet, always warm mid-latitude belt centered around the equator, occupied 1.8 billion hectares in 1990 (FAO, 1990). Nearly all tropical forests in the world today exist in the developing countries. These forests include both the rainforests with constant leaf cover and monsoon forests that lose their leaves in a dry season. Rainforests, which have literally thousands of species per hectare, are the most biologically diverse biome on Earth. Because of the thickness of the vegetation and the perennial biological activity, tropical forests are the world's most productive regions for removing carbon dioxide from the atmosphere.

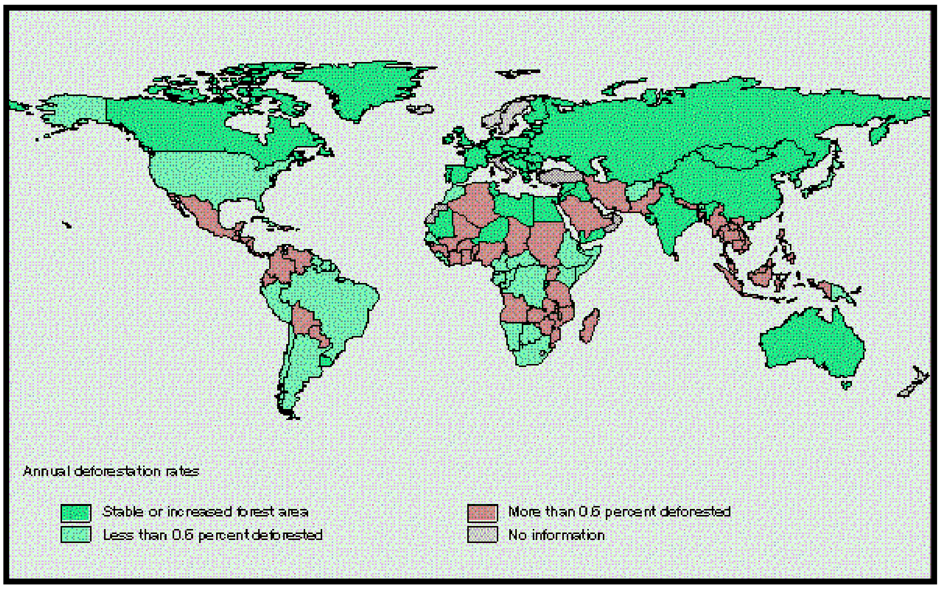
Temperate forests contain a much wider variety of both deciduous and evergreen forest types and cover a much larger area of the world, 2.4 million hectares as reported in the FAO 1990 study. Temperate forests contain both deciduous and evergreen species of trees capable of survival in all but the coldest and/or highest altitudes in the world. Though not as productive in carbon cycling or as diverse in species as tropical forests, temperate forests have the ability to propagate over large areas of the world, thus making them a critically important worldwide resource.

Deforestation, throughout time, has been the most fundamental and ongoing action of human modification of the environment. Trees are removed to clear land for agriculture, to provide lumber for building, to burn for heating and cooking, and many economic activities. In a sense, a primary difference between developed and developing countries is that developed countries have reached equilibrium with respect to their renewable forest resources, while developing countries continue to reduce forest areas.

Deforestation is defined by the FAO as the loss of tree cover to below 10 or 20 percent crown coverage (see Figure 4). On the basis of this definition, FAO has estimated worldwide deforestation for 1980–1990, is occurring at the highest rates in the developing countries and within the tropical forests. In contrast, over the period 1990–1995, developed countries showed a net growth in forest area of 0.12 percent per year. Some caution must be taken when considering this number, because it hides a loss in natural forest. In the FAO data calculations, losses in natural forest can be compensated for by increases in plantation acreage. This same source reports the total annual deforestation percentage in the tropics as 0.8 percent or 15.4 million hectares lost per year from 1980 to 1990.

The impacts of deforestation range from the very subtle changes in climate that loss of forest areas may induce to the dire life-threatening issues that the absence of fuel wood can cause. In the context of environmental security, consider the examples of Ethiopia and Haiti. In 1900 Ethiopia was 45 percent forested (FAO, 1990), while today only 2.5 percent of the country remains forest and woodland (World Resources, 1997). Likewise, Haiti has

FIGURE 4
Estimated Deforestation Rates 1980 -1990



SOURCE: FAO, 1995

gone from a mostly tree covered to a nearly barren landscape. The strategic discussion of linkages between security and environment are presented later, but it is reasonable to surmise that there is a correlation between the unrest in these countries and these drastic changes in their environments.

Deforestation is not a completely anthropogenic process. Natural changes in climate, forest fires and forest disease all occur at natural rates, producing changes in the types and locations of the world's forests. By observing natural changes, a better understanding of how human-induced deforestation will impact an area is developed. There is no question that numerous serious consequences will result from deforestation. In relation to environmental security, the most critical concerns are:

- Reduced carrying capacity of the land,
- Fewer forests as a component of the carbon cycle, resulting in loss of CO_2 removal capacity,
- Loss of biodiversity with all of its known and unknown implications,
- Increased flooding and loss of soils, with resultant mudslides and waterway siltation, and
- Reduced economic benefits from loss of forests as renewable resources.

In many parts of the world, forests are the only appropriate use for the land because of shallow soils and high rainfall rates. Removing the trees destroys the root structure that holds soil, thus increasing the intensity of the runoff and causing the soil to be quickly eroded and washed away. In addition to affecting rates of storage of rainfall, deforestation has other detrimental effects on regional hydrologic cycles, with a net effect of less available water over time. Thus, the clearing of former forestlands for grazing and farming can have effects opposite to those intended. Clearing of the Amazon forests for pastures is a classic example of this issue as described by Serrao and Toledo (1990). These pasture lands quickly degraded into unproductive lands, which has caused people to cut more forest to replace the lost grazing capacity.

What is evident in the available data and predictive modeling is that the impacts from deforestation will be most severe in the tropical regions, not unexpectedly because these are the regions of highest deforestation rates. It appears the tropical regions are trading short-term economic benefits for an unknown future. Most deforestation is being caused by land use changes, changing from forests into some agricultural or grazing use.

When considering security issues in the developing temperate forest countries, impacts on carrying capacity have the most direct and dire effects. In the developing world, the land must provide water, food, and energy for heating and cooking. Loss of fuel wood reduces the ability to properly process food, and this could lead to both malnutrition and disease.

Land Use -- Desertification

Today, some 40 percent or 60 million square kilometers of the world’s land area is classified as having a dry climate, with some 10 million square kilometers of this land being considered desert (Houghton, 1994). Desertification occurs when a vegetated area such as a steppe, through natural or human induced processes, loses vegetative cover allowing for increased soil erosion, primarily by wind. This process typically further reduces the carrying capacity of an already fragile environment. Natural fluctuations in rainfall can change the shape of a desert, usually working around the margins of an existing desert. Overgrazing, mining of groundwater, and overuse in farming are primary human activities that produce desertification of an area.

The African Sahel is the most striking example of desertification or land degradation seen in modern times. The Sahel is the belt that extends across Africa at about 15 degrees north latitude and forms the southern extent of the Sahara desert. An increase in the nomadic herding population of the region in combination with a drought lasting from 1968 to 1991 has produced desertification in the area (Strahler, 2000). Desertification has resulted in a drastic reduction of regional grazing capacity until conditions and time allow regeneration of the vegetative cover, if erosion and the other impacts of desertification have not been so severe as to irreversibly damage the land.

Global warming can produce desertification in the same way that natural climate change does. A major challenge today involves distinguishing natural desertization from human-induced desertification; even more difficult is predicting the changes resulting from the enhanced greenhouse effect. Based on experience to date and the best modeling, it can be expected that changes will occur within existing dry climates and on the margins of existing deserts. In some places the result may be a receding of the existing desert because of increased rainfall, while in others the result is likely to be desertification.

The ultimate direct impact of desertification is the complete loss of carrying capacity of an already fragile biome, and the primary indirect effect is the migration of people previously supported by that area. The ability to predict desertification is limited by the inability to predict long-term natural regional climate patterns. Adding to the problem is our lack of understanding of the impacts of anthropogenically induced global climate change, primarily from the enhanced greenhouse effect.

Expansion of the world’s deserts will be at the expense of steppe-type environments, which have grass and scrub vegetation and most commonly support sparsely populated herding cultures. Variations in migration and settlement patterns for these people make it difficult to determine the impacts of desertification on humans. More human pressure in these regions could accelerate the desertification process because of increased grazing and fuel wood gathering. Overall, the spiraling impact of desertification displacing people has been seen in the Sahara regions already and it has the potential to affect other parts of the world as a result of global warming.

Water as a Scarce Resource

Water is a critical resource for life and essential for economic success in a modern developed society. Water is required for domestic consumption, sanitary use, industrial use, electric power generating cooling water, hydroelectric generation, and agricultural irrigation. Water quantity can be measured in terms of total demand, but is better represented in terms of the quantity per person over some period of time (daily or yearly). Over the past century, there was an eight-fold increase in total water demand driven primarily by population increases, but demand per person also doubled (Gleick, 1998).

An example of the impact that development has on water use can be seen by comparing water use in the U.S. with world water use. In 1900, world demand was approximately 300 cubic meters per person per year (M^3/p/yr), while in the same units U.S. demand was 700. In 1980, world consumption had grown to 700 M^3/p/yr, while in the U.S. demand had reached 2,700 M^3/p/yr. In terms of these units which factor population growth out of the equation, water demand in the U.S. had grown by a factor of four, while world demand had increased by a factor of only two (Gleick, 1998). The important point here is that transforming from a developing to a developed society has greatly increased the demand for water.

The water problem is one of trying to reconcile supply with demand in a spatial context with the population. Supplies are fixed, while demand continues to grow rapidly, and not always in the best locations. There has been progress in improving management practices, but these have reduced the rate of growth in demand per person, not total consumption. In this context, the U.S. can be considered a recent good news story. By 1995, demand in the U.S. had dropped from 2,700 to 2,200 cubic meters per person per year, resulting in a flattening of total demand over the past 20 years. This was achievable only in concert with a small population growth rate over the same period.

The bottom-line for water as a resource is:

- Demand will continue to increase steadily and in direct proportion to population growth,
- Modernization (development) will increase demand, not reduce it, and
- It can be expected that, in areas experiencing water shortages now, conditions will worsen, while many more areas of the world will reach their limits of available water resources.

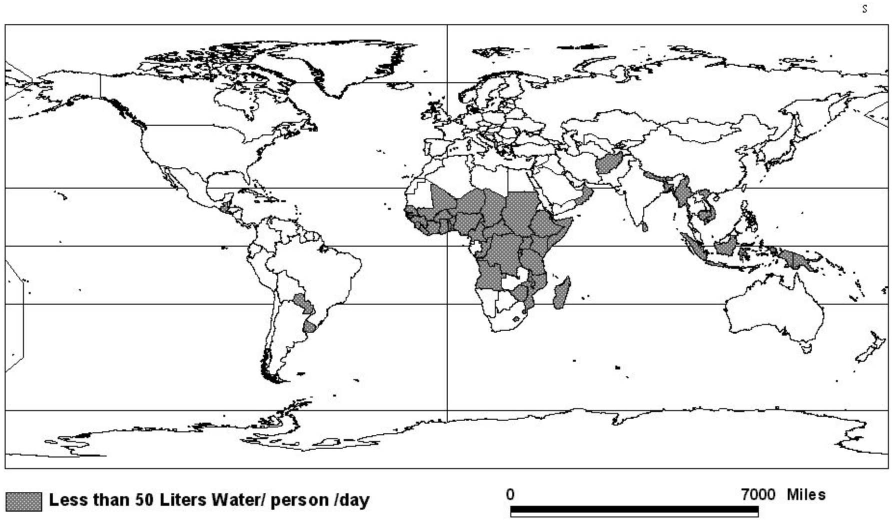
In terms of environmental security analysis, an important question is: what is the basic water requirement for a person to sustain life? This value must include water for drinking, cooking, and basic sanitation requirements such as personal hygiene and cleaning. One widely accepted estimate is 50 liters per day per person (Gleick, 1998). Figure 5 shows the countries of the world that fail to meet this standard. Figure 6 shows areas of projected water shortages by 2025 (IWMI, 2000).

Quality is an often-overlooked issue that must be addressed in any discussion relating water supplies to security. The World Health Organization (1995) estimated that 1 billion people a year contract a water-borne diarrheal disease and that 3.3 million of these people die, every year! This does not account for many other water-borne diseases that inflict pain and suffering pandemically throughout the world. A primary quality concern in the developing world is human waste being disposed of in surface waters, which contaminate drinking water supplies and this water then being consumed without adequate treatment. Clean water is a critical issue for parts of South and Central America, most of Africa, and much of Asia.

Salinity in water is another major quality issue of concern in agriculture and industry. Salts present in irrigation water are retained and concentrated in the upper layers of the soil as water naturally evaporates. Over time, without adequate rain to dissolve these salts back into

FIGURE 5

Countries with Extreme Water Scarcity



SOURCE: Data derived from Peter Gleick, *The World's Water*, (Washington, D.C.: Island Press, 1998).

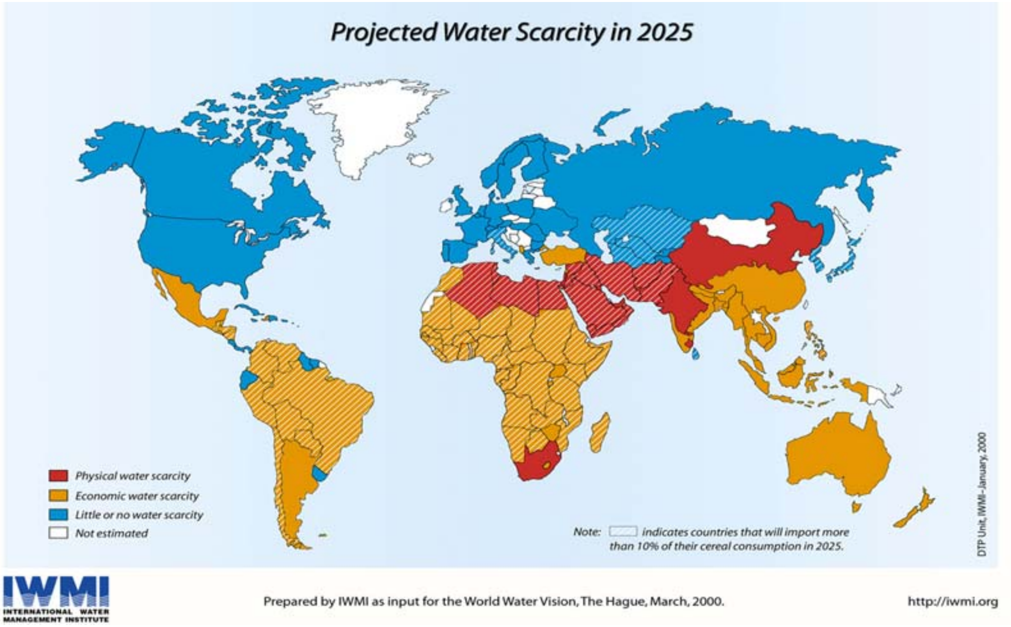
the water for transport away, salt levels in irrigated soil build up to concentrations toxic to many plants. These lands are then lost to production or must be used for crops more tolerant of salt. Such crop choices are quite limited. Salination is reducing food production rates in many parts of the world today, mostly in arid regions where lack of rainfall makes soil recovery periods very long. The U.S. is experiencing this problem in isolated parts of the arid West and Southwest.

Overall, water is a problem affecting basic survival in at least one third of the world and a limiting factor in development for most of the world. As an anonymous American sage once said, "People argue over politics; they fight over water."

STRATEGIC ENVIRONMENTAL SECURITY ANALYSIS

Obviously, achieving environmental security as a physical condition in the world is a daunting task that exists today and expected to worsen in the future, without significant change in human activity. This is compounded by the fact that environmental security is very much a contextual issue. For example, assume that two disputes over water rights exist between the U.S. and Mexico on one border, and the U.S. and Canada on the other. If the technical details of these two problems are similar, will the nature of the discussions be the same? Experience supported by numerous examples suggests that scarcity of water in the south would make that dispute much more contentious. Further, the prevailing political

FIGURE 6



environment could make the technical details of the issue secondary to the political policy considerations.

To begin, Table 2, "Impacts of Environmental Change," presents a summary of possible impacts over a range environmental security issues, including those detailed in this work (King, 2000). Considered together, these data offer several summary conclusions to be made about the impacts of environmental degradation and change, including, in order of importance:

1. Humans are threatened by loss of water and food and increased incidence of disease. This is a summary finding based on the human and farmland columns of Table 2.

2. The greatest overall impacts from cumulative environmental change will occur in the tropical countries, which are all economically developing countries.

3. Global warming with its linkages to deforestation is the issue with the potential to produce the most damage. Table 1 predicts large-scale impacts from global warming and Table 2 lists the devastating effects that reduced carrying capacity could have in some regions.

4. Climate change is likely to produce an increase in the incidence of natural hazards as increased evaporation is counterbalanced by new, more intense weather cycles. Because of environmental degradation, many more people will be at risk.

5. Issues related to water are major stress factors on human subsistence and economic development (Armitage, 2000).

Using these summary data, this discussion can move from “What” onto conduct a geographic information systems (GIS) analysis to determine generally “Where” environmental security problems and conflicts may occur. GIS is a powerful tool for employing spatial data to identify trends and cumulative factors. GIS begins by thematically mapping environmental data at a constant scale, recognizing that edge errors may exist because most data are constructed following political boundaries while the actual issues spill across borders. Different types of spatially represented data are then overlaid or stacked to identify points of conformity between features or values.

For example, a GIS analysis takes the water scarcity data from Figure 5 and overlays or stacks it with population growth rates data to create Figure 7. The result shows the correlation between countries with high population growth rates and the countries with drinking water shortage issues-- *41 of the 50 water-scarce countries also have population growth rates above 2 percent per year.*

Figure 8 shows how several issues can be correlated, in this case: population, deforestation, and water scarcity. Figure 8 is based on historical data and is therefore not truly predictive. The key to anticipating issues and preventing problems will be in attaining reasonable estimates of such factors as deforestation rates, water scarcities, loss of arable land, and population change rates.

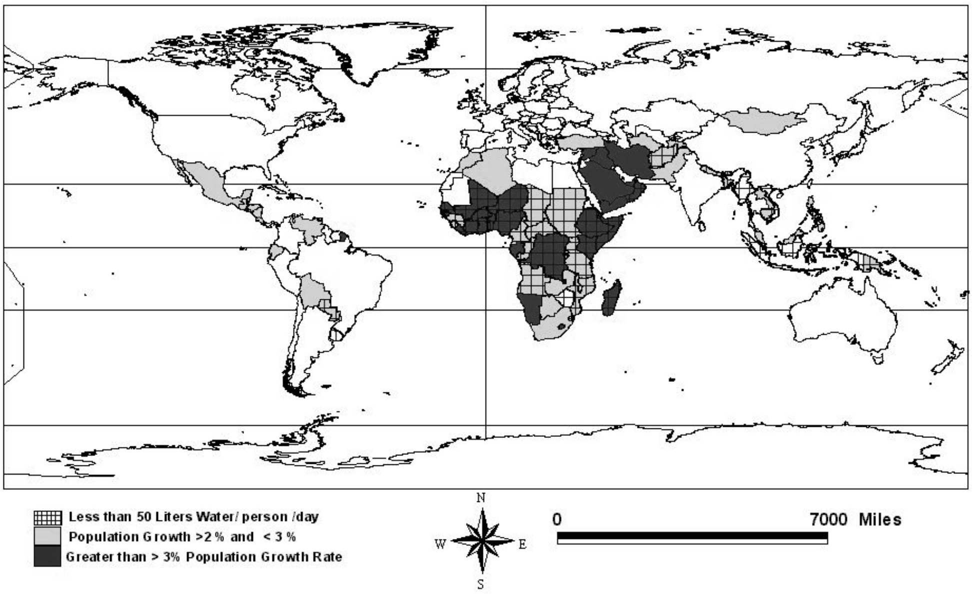
TABLE 2

Impacts of Environmental Change

	Global Environmental Concerns				Regional Environmental Concerns			
Environmental Issue	Farmland	Forest	Water / Fish	Human	Farmland	Forest	Water / Fish	Human
Global Climate								
- Warming	Inundation of arable lands, drier soils in summer, loss of farmlands	Change in shape of temperate and tropical forests	Weather changes impact the hydrologic cycle	Natural hazards, property loss, heating & cooling costs	Wetter wet seasons, drier soils in dry season	Shifts in size and location of temperate and tropical forests	Changes in rain patterns, change in temporal and spatial distribution	Increased disease in developing countries
- El Niño	---	----	---	---	Increased erosion	Change in water distribution	Increased winter rains, loss of fish in Pacific	Flooding and other natural hazards
- Ozone depletion	UV damage to many species of plants & animals	UV damage to many species of plants & animals	---	Cancer	UV damage to many species of plants & animals	UV damage to many species of plants & animals		Cancer in Southern Hemisphere
Land Issues								
- Deforestation	Loss of arable lands	Greenhouse gases produced, less CO_2 recycled, loss of biodiversity	Reduction of groundwater recharge, siltation of streams	Indigenous tribes endangered, biodiversity lost	Temporary increase in cropland	Net loss, particularly in tropical forests, Biodiversity loss	Decreased groundwater recharge, increased runoff rates	Loss of Indian habitat in rainforest, loss of beneficial species
- Desertification	Loss of arable lands	---	---	Displacement herding populace	Loss of productive lands	Encroachment on fragile forests	Reduced soil moisture, can increase runoff & reduce recharge	Migration of African nomads
- Waste disposal	Loss of arable lands	---	Contamination of surface & ground water and fish	Toxic exposure	---	---	Poisoning of water supplies & fish	Toxic exposures; contamination of water resources and food chain
Water								
- Quantity	Loss of arable lands	---	Freshwater fish lost, reduced productivity in estuaries	Increased migration	Reduced irrigation and grazing	Highly variable impacts by regions	Freshwater fish lost, reduced productivity in estuaries	Increased migration
- Quality	Salinization of arable lands, toxic levels in soil	---	Toxicity and bioaccumulation of toxics	Increased rates of disease	Salinity reduces productivity	Acid rain damage	Toxicity and bioaccumulation of toxins	Disease increases in developing countries
- Oceans	---	---	Overfishing is endangering stocks	Loss of fish, disease exposure	---	---	Overfishing is endangering stocks	Loss of fish protein; disease

FIGURE 7

Correlation of Population Growth Rates with Water Scarcity



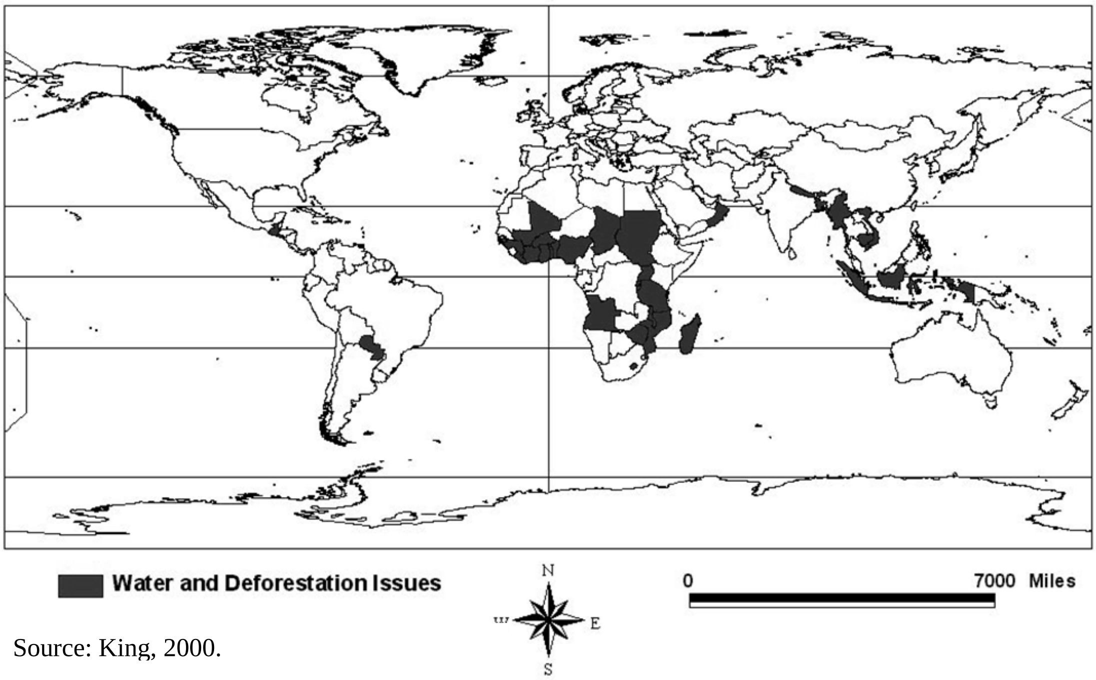
The final step in environmental security analysis is selecting the critical environmental variables that best predict social stability and security for a region. This is done by using comparative statistical method that examines the correlations between two sets of data. One set of data is environmental security data grouped by countries or regions. The second data set needed is some accepted social/political stability analysis of the same country. In words, the process is accomplished by following this process:

- A set of environmental parameters are cross correlated for all variables. The overlays presented above are constructed for every possible combination of the environmental variables. Generally this would be done in at least three gradients, such as – sustainable environment, degraded environment, severely damaged environment.

- A data set that depicts the current stability/security condition of the same region of study covered by the environmental data. This may be from published literature or may be a set of expert opinions. Again, three gradients depicting levels of stability are employed in the analysis.

FIGURE 8

Countries with High Population Growth Rate, Water Scarcity, Deforestation



Source: King, 2000.

- The two data sets are compared to obtain the highest degree of correlation between the environmental security data and the social/ political data. What we are looking for is the grouping of environmental parameters that most closely predicts the actual stability conditions of an area. For example, Figure 8 shows the countries that are environmental security risks because of a combination of high population growth rates, water scarcity, and high deforestation rates. These data would be positively correlated with stability if a world map of socially unstable countries showed many of the same countries. If all countries matched of both maps, the correlation would be 1.0, and if none of the countries matched the correlation would be 0. The set of environmental parameters that give the highest correlation factor identifies the critical environmental security factors. This author has conducted three sets of experiments, one for world scale and two for specific regions (sub-Saharan Africa and South America); It was found that the highest correlating variables change slightly by geographic region, but that very strong correlations are available for all regions, ranging from 0.85 to 0.95. Water resources was a variable applied in all regions studied, while loss of arable land was applied in a study of South America. Each of these studies produced high correlations between security and these environmental parameters. Further work is needed to refine the appropriate variables for arable land analysis because of the variability of carrying capacity per area across the range of geographic domains. This issue is mitigated by conducting analysis only within a geographic domain such as a tropical, savannah, or other ecologically consistent biome.

CONCLUSIONS

International environmental security, as defined in this paper, is fundamentally concerned with avoiding environmentally induced conflict or in a more positive view, establishing conditions that promote peace through sustainable environmental management. Most who study the causes of conflict agree that conflict requires a set of conditions where people lack or perceive a lack of fundamental requirements to sustain their way of life. In the most basic form, this may be a lack of water, food, shelter, health, or a sense of security. Only after such basic life sustaining requirements are in place can cultural and political factors come into play to affect security. Environmental security analysis completes the spectrum of assessment to assure that appropriate actions are taken to best preserve or restore peace. This paper focused on introducing a process to analyze environmental issues in a security context and presented a predictive model for conducting this analysis. Science fails if it cannot help us anticipate problems and plan and execute programs that proactively address these issues rather than reactively responding after the damage has been done. The model presented is not yet complete, particularly in refining the environmental variables to be included in the analysis. However, the results obtained prove the concept and provide a framework for the work to follow.

In summary, common sense, natural science, and political science rarely align as they do in the conclusion that environmental security is a topic of critical importance to establishing a more stable and secure world.

<u>BIBLIOGRAPHY</u>

Armitage, Ambassador Richard. Lecture at the Naval War College, May 2000.

Bailey, Robert. *Ecoregions: The Ecosystem Geography of the Oceans and Continents, Springer-Verlag*, New York, 176 p, 1998.

Brown, Lester, and Hal Kane. *Full House: Reassessing the Earth's Carrying Capacity*. New York: Norton, 1994.

Food and Agriculture Organization of the United Nations (FAO). *Forest Resources Assessment 1990: Global Synthesis.* As reported at: www.igc.apc.org/wri/wr-96-97/lc_ttxt2.html, April 2000.

Getis, Arthur, and others. *Introduction to Geography.* Boston: McGraw-Hill, 1998.

Gleick, Peter. *The World's Water.* Washington, D.C.: Island Press, 1998.

Goode's World Atlas. Edited by Edward Espenshade and others. New York: Rand McNally, 1995.

Hansen, Andrew, and others. *Global Change in Forests: Responses of Species, Communities, and Biomes.* Bioscience, September, 2001.

Horel, John, and Jack Geisler. *Global Environmental Change: An Atmospheric Perspective.* New York: John Wiley, 1997.

Homer-Dixon, Thomas. *Environmental Scarcity and Global Security.* New York: Foreign Policy Association, 1993.

Houghton, John. *Global Warming: The Complete Briefing.* Oxford, England: Lion Publ., 1994.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 1992: The Supplemental Report to the IPCC Scientific Assessment.* Geneva: United Nations, 1992.

King, Wendell , *Understanding International Environmental Security: A Strategic Military Perspective* Atlanta, AEPI, 2000,43.

Lee, James. *Inventory of Conflict and Environment.* Atlanta, Ga.: AEPI, April 1999.

Levy, Marc, A. "Is the Environment A National Security Issue," International Security, 20:2, 1995, 35-63.

MacKenzie, Fred T. *Our Changing Planet.* New Jersey: Prentice Hall, 1998.

Myers, Norman. "The Environmental Dimension to Security Issues." *The Environmentalist* (1986): 251-57.

Myers, Norman. *Ultimate Security: The Environmental Basis of Political Stability.* New York: Norton, 1993.
Schwartz, Daniel, and Ashbindu Singh. *Environmental Conditions, Resources, and Conflicts.* United Nations Environment Programme, 1999.

Serrao, Emanuel, and Toledo, J. Chapter 13 – *The Search for Sustainability in Amazonian Pastures.* Alternatives to Deforestation: Steps Toward Sustainable Use of the Amazon Rain Forest, New York, 1990.

Simon, Paul. *Tapped Out—The Coming World Crisis in Water and What We Can Do about It.* Champaign, Ill.: Welcome Rain Publishing, 1998.

Strahler, Alan, and Arthur Strahler. *Introducing Physical Geography.* New York: John Wiley, 2000.

Titus, James, and Vijay Narayanan. *The Probability of Sea Level Rise.* Washington, D.C.: USEPA, 1995.

U.S. Environmental Protection Agency . *Environmental Security* (USEPA 160-F99-001). Washington, D.C., 1999.

U.S. Environmental Protection Agency Website: www.epa.gov/globalwarming/emissions/international/inventories.html, April 2000.

U.S. Environmental Protection Agency Website: www.epa.gov/globalwarming/publications/reference/ipcc/summary/page4.html, April 2000.

White, Rodney. *North, South, and the Environmental Crisis.* Toronto: University of Toronto Press, 1993.

World Health Organization (WHO). *Community Water Supply and Sanitation: Needs, Challenges and Health Objectives* (A48/EOS/96.15). Geneva: 48th World Health Assembly, 1995.

World Resources 1996-1997. Website: www.igc.apc.org/wri/wr-96-97, April 2000.