Special Reports

The Linkages Between Population and Water: Forthcoming Articles from ECSP

By Shanda Leather

Population growth as well as the demand for and scarcity of clean water are all dynamics that stress the capacity of governments and societies to (a) provide basic services and (b) maintain a healthy human and natural environment. Neither population growth nor water supply, however, can be considered in isolation. Human usage puts the most consistent stress on water resources; in turn, the scarcity or misallocation of water resources greatly affects the well-being of human populations and natural ecosystems. In collaboration with the University of Michigan Population Fellows Program, the Environmental Change and Security Project (ECSP) commissioned in fall 2000 a series of articles to examine global and regional linkages between population and water. The interplay among these issues is at the heart of this project.

Each of the three articles (summarized below) has been jointly written by a pair of authors, representing both a Northern and Southern perspective. Each article also draws on regional case-study material. Rather than revisit the widely-researched area of water shortages and potential conflict in the water-scarce Middle East, we chose to expand the population-water discussion by focusing on Southern and East Africa, India, and the Philippines. It was also our goal in commissioning these articles to promote cooperation between the authors—allowing them to work collaboratively, to share concepts and experiences, and to bring that collaboration to a wide audience through the ECSP network. Since the opinions and work of Southern authors are not widely featured in North American publications, we also wanted to raise the profile and exposure of those with direct experience of these issues in developing countries.

The Coming Fresh Water Crisis is Already Here
by Don Hinrichsen and Henrylito D. Tacio

Don Hinrichsen *is a writer/media consultant and fundraiser for the Untied Nations Population Fund in New York. He has written five books over the past decade on topics ranging from coastal resources to an atlas of the environment.* **Henrylito D. Tacio** *is a Filipino journalist who specializes in science and the environment.*

In "The Coming Freshwater Crisis," Hinrichsen and Tacio assert that demand for fresh water is outstripping the ability of many governments to supply it. The authors look broadly at global trends in population growth and fresh water availability, highlighting areas that are already at crisis stage and looking toward those areas that will soon present difficulties. Their discussion sets the stage for some of the more in-depth topical discussions in the subsequent articles.

Hinrichsen and Tacio outline the global dynamics of (a) population and fresh water, (b) fresh water availability, and (c) fresh water use before moving on to a lengthy discussion of what they term "a future of scarcity"—an accelerating demand for fresh water accompanied by its declining per-capita availability:

> "...[Global] demand for water is rising not only because of population growth but also because of urbanization, economic development, and improved living standards. Between 1900 and 1995, for example, global water withdrawals increased by over six times, more than double the rate of population growth.
>
> "Since 1940, annual global water withdrawals have risen by an average of 2.5 to 3 percent a year while average annual population has grown 1.5 to 2 percent. In developing countries, water withdrawals are rising more rapidly—by 4 to 8 percent a year for the past decade—because of population growth and increasing demand per capita.
>
> "Moreover, the supply of fresh water available to humanity is in effect shrinking because many fresh water resources have become increasingly polluted. In many countries, lakes and rivers are used as receptacles for a vile assortment of wastes—including untreated or partially treated municipal sewage, industrial poisons, and harmful chemicals

leached into surface and ground waters from agricultural activities…"

Hinrichsen and Tacio emphasize how developed countries have a much higher per-capita water usage (and thus greater demand) than developing countries. Low household use in developing countries also reflects the difficulty many people have in obtaining clean water. However, the authors are quick to point out that this pattern is changing dramatically, as countries become predominantly urban and demand for piped water increases. Through this, Hinrichsen and Tacio lay the groundwork for a discussion of intersectoral competition that is more thoroughly dealt with in the second article.

Finally, Hinrichsen and Tacio examine the degradation of water supplies and the effect such degradation has on increased demand and consumption. Pollution (both agricultural and industrial) is a problem faced by developed and developing countries alike. As pollution continues, current sources of clean water either will become unusable or will require clean up at great cost to either governments or consumers. All of these issues are vividly highlighted in the article's case study from the Philippines. Authoring the case study, Tacio details examples from throughout the archipelago to illustrate the trends of inadequate supply, polluted sources, and lack of access—all in a country that, as one of the wettest in Southeast Asia, is commonly perceived as water-rich.

Water Crisis: The Case of the Philippines

"…The country's water is supplied by rainfall as well as rivers, lakes, springs, and groundwater. With changing weather patterns worldwide, rainfall is growing scarcer. The little that comes from the heavens is collected, or wasted, in watersheds with balding forests. As a result, there has been a dramatic drop of from 30 to 50 percent in the country's available stable water resources in the past three decades.

"A recent report released by the Philippines Department of Environment and Natural Resources (DENR) said that 90 percent of 99 watershed areas in the country are "hydrologically critical" due to their degraded physical condition. Massive destruction of the once-productive forested watersheds by illegal loggers and uncontrolled land use from mining, overgrazing, agricultural expansion, and industrialization have contributed to water depletion.[1]

"Worse, excessive soil erosion is hastening the destruction of watershed areas. The DENR report stated that 36 of the country's 75 provinces in the country are severely affected by soil erosion. Two provinces—Cebu and Batangas—have lost more than 80 percent of their topsoil to erosion. In Luzon, the four major basins—Bicol, Magat, Pampanga and Agno—are in critical condition due to acute soil erosion and sedimentation.

"River pollution also contributes to the country's current water problem. Out of 418 rivers in the Philippines, 37 have been classified as polluted, while the rest are seriously polluted. The DENR's Environmental Management Bureau listed 11 rivers that are considered "biologically dead." Water pollution is mainly caused by domestic wastes, which account for 52 percent of the pollution load. Industry accounts for 48 percent.

"There is more bad news. Water levels in the country's major sources have been dropping at the rate of 50 percent over the past 20 years. Excessive pumping of groundwater has caused water depletion and consequent decline in water levels.[2] In less than 20 years, water levels in wells have dropped from an average of 20 meters below land surface to more than 120 meters in some areas, particularly in the industrialized areas of Paranaque and Taguig, both in Metro Manila…"

Urbanization and Intersectoral Competition for Water by Ruth Meinzen-Dick and Paul P. Appasamy

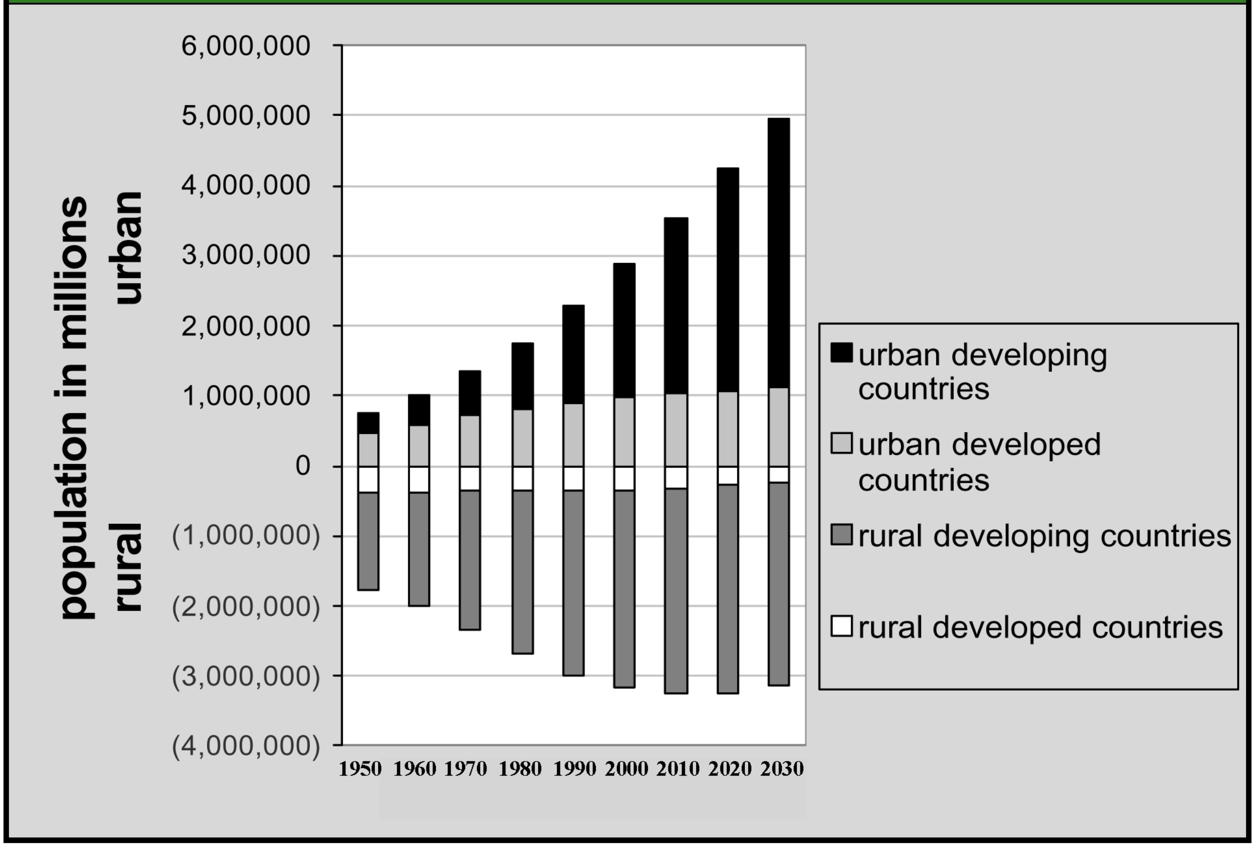
Ruth Meinzen-Dick *is a Senior Research Fellow at the International Food Policy Research Institute. She has conducted extensive research on a wide range of issues related to water management, property rights, collective action, and gender analysis, especially in South Asia and Southern Africa.*

Paul P. Appasamy *is Director, Madras School of Economics, Chennai, India. He has spent the last three decades studying and working in the areas of water resources and urban development.*

While human populations 100 years ago were primarily rural and agriculturally-based, humans are rapidly

Shanda Leather is the former deputy director of the Environmental Change and Security Project.

Figure 1. Urban and Rural Population in Millions, 1950-2030



Source: Data from FAO STAT (2000).

becoming a predominantly urban species. More than half of humanity now resides in urban areas. This trend brings with it a shift in demand for and use of water resources. While agriculture still accounts for the largest volume of fresh water use, the percentage of fresh water now used to supply activities in urban areas has vastly increased. These rising urban demands means that water must be reallocated from agricultural activities to industrial and urban household usage. Authors Ruth Meinzen-Dick and Paul Appasamy take up this issue of this allocational intersectoral competition by exploring the dramatic demographic trend toward global urbanization and its effect on the distribution of and competition over water resources.

Worldwide, urban populations have grown by more than 2 billion since 1950, and are anticipated to grow by that much again in the next 25 years. (See Figure 1.) Two of the largest challenges to supporting this urban-based population are (1) the provision of water, and (2) the treatment and disposal of water-born waste. Meinzen-Dick and Appasamy point out that such provision is not a problem at an aggregate level: urban water use still makes up a fraction of that used for agriculture. However, highlighting a theme seen over and over in these articles, the authors argue that it is (a) the provision of water *when and where it is needed* as well as (b) *the quality of what is supplied* that pose the greatest problem. Meinzen-Dick and Appasamy probe not only the technical and economic implications of urbanization and intersectoral competition, but also the social and political implications of this trend:

- "…Domestic water demand is not simply a multiple of the population size. Per-capita demands increase with urbanization and rising incomes. Rural water supply systems in India, for example, use a norm of 40 liters/capita/day for domestic use without household piped connections (where it is assumed that other water sources can be used for bathing and washing clothes). This rises to 70 liters/capita/day for urban areas with piped water supply but no underground sewerage, and then to 125 liters/capita/day for urban areas with underground sewerage (as in most major cities).[3] These norms refer to basic levels; water demand can rise even further with rising incomes. Residential use in Europe averages around 200 liters/capita/day, and in the United States, 400 liters/capita/day [4]…

- "…Even in cities that have high average domestic water consumption, many people are not adequately served by municipal supplies, especially in slums and peri-urban areas. A study in nine East African cities found that, from the late 1960s to the late 1990s, the proportion of households with piped water at their homes and the availability of water in the municipal systems both decreased…
- "…Beyond domestic water needs, water is an input into the economic development process. Industrial production requires water, although the exact amount varies, depending on the industry and the technology used…Agriculture is the largest water consumption sector worldwide—and especially in developing countries. Irrigation has been and will continue to be critical to achieving food security. Worldwide, irrigated agriculture contributes nearly 40 percent of total food production on 17 percent of the cultivated area. Irrigated production contributes over 60 percent of the food in India, and nearly 70 percent of the grain in China (Rosegrant and Ringler 1998)…[5]
- "…Stereotypical images of 'thirsty cities' that equate urban demand with 'drinking water' or factories and rural water supply with irrigation do not adequately represent the water uses in each area. Domestic water supply is also needed in rural areas. With rural industrialization, factories increasingly draw water (and discharge wastes) in rural areas. Nor should the water uses of urban agriculture be overlooked."

Meinzen-Dick and Appasamy go on to discuss thoroughly the different economic values of water and to examine the various ways water resources are allocated among these demanding sectors. Research indicates that all users—even poor domestic consumers—are willing to pay for water in one way or another, as long as they are guaranteed a reliable and safe supply. Meinzen-Dick and Appasamy argue that, since water is vital to life and livelihoods, the provision of water is critical to the social stability and political legitimacy of governments. Understanding the power relations of the stakeholders is essential to understanding intersectoral competition and water allocation in any given situation.

Finally, the authors move through a well-structured explanation of the various users within a water system (and their relative positions of power) before outlining various options for meeting urban water needs. Many of these options require either (a) transfer of supply and power from one sector to another, or (b) compromise on the part of several sectors. These are political decisions, influenced by the power and legitimacy of governing bodies. However, as Meinzen-Dick and Appasamy detail, there are also possibilities for mutual gain:

> "…A closer look at water *uses* shows that domestic, agricultural, and industrial water uses are all found in both rural and urban areas (though in different concentrations). A closer look at water *users* indicates that households may have interests in many different water-using activities. Appropriating water from existing rural uses for transfer to cities and industries may cause resentment. Negotiated approaches that allow farmers (a) to voluntarily reduce water use, and (b) profit from transferring water to cities are likely to cause less resistance and less loss of livelihoods in rural areas.
>
> "Both economic progress and the stability of governments depend on meeting the water needs of rural and urban as well as peri-urban areas. This will require substantial investments in urban infrastructure for water supply, treatment, and disposal. At the same time, very few places will be able to meet unchecked urban water demands. Therefore, demand management will also be necessary. Pricing, which has received considerable attention as a means of demand management, is only one tool and may not be very effective without complementary education campaigns, leak detection, retrofitting, recycling, and other technical improvements.

Negotiated approaches that allow farmers to (a) voluntarily reduce water use, and (b) profit from transferring water to cities are likely to cause less resistance and less loss of livelihoods in rural areas.

"Providing water in an efficient, equitable, and sustainable manner to both urban and rural areas in the 21st century poses as much an institutional as a technical challenge. The ad hoc and sectoral approaches of the past are not adequate for the interrelated nature of urban water use. To meet urban water needs, water institutions must expand their vision in at least two directions: (a) to extend services to low income communities and peri-urban areas, and (b) to protect the quality of surface and ground water…

"…Finally, dealing with the water needs of the poor (who may make up one-third of the urban population) requires far greater efforts. Meeting these needs is an effort likely to go beyond conventional engineering approaches to include a wider range of options for water supply and sanitation. It also requires rethinking institutional approaches (such as thoroughly involving community organizations in decision-making as well as implementation)…"

Exploring the Population-Water Resources Nexus in the Developing World
by Anthony R. Turton and Jeroen F. Warner

Jeroen F. Warner *is currently completing a Ph.D. on images of water security at Middlesex University, U.K. He is also the research coordinator for the International Multi-Stakeholder Platforms project at Wageningen University's Irrigation and Water Management group.*

Tony Turton *heads the African Water Issues Research Unit at Pretoria University in South Africa. A political scientist by training, he has a specific interest in water as an element of economic growth and development in Southern Africa.*

This theme of new approaches to water scarcity and water management is picked up in the final article in the series, authored by Anthony Turton and Jeroen Warner. Turton and Warner begin by defining their approach to the concepts of scarcity, resources, and legitimacy—bringing some highly useful nuances to these terms.

One of the most important and interesting discussions in this article is the development of a "resource matrix." The authors expand on previous work done by Leif Ohlsson, who termed a "first order" resource as any natural resource and a "second order" resource as a society's ability and willingness to deal with scarcities of a first order resource. Turton and Warner adapt these terms to develop their "resource matrix," which displays a variety of resource combination possibilities for countries

Figure 2. Turton and Warner's Resource Matrix

Quantitative Aspect of the Resource	Type of Resource: First-Order (Water Resources)	Type of Resource: Second-Order (Social Resources)
Relative Abundance	Position 1	Position 2
Relative Scarcity	Position 3	Position 4

according to their natural water supply and their ability to effectively use that supply (see Figure 2).

Societies that are in positions 1 and 2 have relative abundance in both first and second order resources, while those in positions 3 and 4 have scarcity in both areas. A key additional element of Turton and Warner's analysis is that the rate of population growth has a great effect on both natural and social resource availability.

Using three variables (natural resource availability, social resource availability, and population growth rates), Turton and Warner go on to develop a unique and informative discussion of the positions of various countries in their study areas of East and Southern Africa. These countries fall into three categories: (1) Structurally-Induced Relative Water Abundance (SIRWA)—*social abundance but water scarcity*; (2) Structurally-Induced Relative Water Scarcity (SIRWS)—*water abundance but social-resource scarcity*; and (3) Water Poverty (WP)—*scarcity of both water and social resources*. The reasons for the positioning are complex, but some preliminary analysis shows commonalities that have fundamental implications for water management. Table 1 presents the classification of the countries in the study area and the authors' explanatory text.

Turton and Warner detail the nuances of each country's situation:

> ". . .Southern Africa has a spread of cases from all three categories, with all results corresponding with what is known about each country. The three cases that are classified under SIRWA are known to be the most prosperous countries in the region. (Should data have been available for Seychelles, then this country would probably also fall into this category.) For these countries, the water-related problems are primarily of a first-order nature—namely, the continued search for and mobilization of alternative sources of water supply. Given the relative economic prosperity of these countries, the range of options is wide, covering: (a) supply-sided solutions (development of ever more distant water resources via International Basin Treaties and desalination where appropriate); and (b) management of demand and the importation of Virtual Water (water imported into a country in the form of grains or other foodstuff—the final products of water usage rather than the water itself) in an attempt to balance the national water budget. All three strategies are known to be taking place at present. The role of Virtual Water trade as a critical component of a strategic water management strategy for these countries is only recently becoming known (Turton et al., 2000b).
>
> "The five cases that are classified under SIRWS are all countries that ostensibly have an abundance of water but that lack the institutional, financial, or intellectual capital to translate this into economic growth and development. As such, the type of problems facing these countries is primarily of a second-order nature. Angola and the Democratic

Table 1. Classification of Various African States in terms of Proposed Typology

	First-Order Problems	Second-Order Problems	More Complex Problems
	SIRWA	**SIRWS**	**WP**
Southern Africa	Botswana Mauritius South Africa	Angola Democratic Republic of Congo Namibia Zambia	Lesotho Malawi Swaziland Tanzania
East Africa			Burundi Egypt Eritrea Ethiopia Kenya Sudan Tanzania Uganda

Republic of Congo (DRC) are politically unstable—being embroiled in seemingly endless civil war. Unfortunately, no end to this debilitating condition is in sight. Mozambique offers a glimmer of hope, as it has turned its back on civil war and is seemingly on the road to economic recovery. Institutional capacity there is extremely weak, however, and a high debt burden continues to hamper this recovery. The major floods that took place in Mozambique in early 2000 set its economic recovery back significantly and also were a manifestation of the inability to respond to crisis. Namibia is politically stable, but has become embroiled in the Angolan civil war and the DRC. This role does not bode well for its future, as Namibia is starting to hemorrhage precious financial resources that could be used in institutional development instead. Namibia also presents an interesting case in the sense that the first-order type of indicators shows the country to be relatively well-endowed with water. This impression is highly misleading, however, as the water that exists is found only on the northern and southern borders of the country, and is also difficult to exploit. The low population levels also create a false impression by presenting a relatively high per capita water availability, showing the flaws in first-order analyses. Zambia is politically stable but has a low level of economic activity, and the civil wars in both Angola and the DRC are impacting it negatively. Should Angola, the DRC, Mozambique, and Zambia manage to solve these problems, then they could conceivably become the regional breadbaskets, using their natural resource endowment to balance the regional water scarcity by becoming Virtual Water exporters within the Southern African Development Community (Turton et al., 2000b).

"The four cases that are classified under WP present a complex set of problems indeed. In these cases, there is a relative scarcity of both first and second-order resources, so dependence on external aid is likely to grow over time. Lesotho is an interesting case as it is first-order resource-poor—yet it is also the source of water for South Africa via the Lesotho Highlands Water Project (LHWP). Water is one of the few natural resources that Lesotho can exploit (the other being labor and, to a lesser extent, diamonds); so it sells water to South Africa, using the royalties to finance other development projects. Significantly, all of the East African countries fall into this category, suggesting that the development problems in East Africa are far more complex than Southern Africa in relative terms…"

> Turton and Warner enter into a philosophical, theoretical, and practical discussion that explores not only the usefulness of GIS but also the concern that it is being used to exploit existing power relations and concepts of security.

Turton and Warner also discuss the use of one of the most popular technological management tools promoted in water management today—remote sensing, or Geographical Information Systems (GIS). GIS has become a highly popular way to represent three-dimensional data. Turton and Warner enter into a philosophical, theoretical, and practical discussion that explores not only the usefulness of GIS but also the concern that it is being used to exploit existing power relations and concepts of security. According to the authors, one worrying trend here is the "securitization of water" and the use of GIS to reinforce that trend:

"…When water has been elevated to a national security concern, projects promoting water development become undebatable. The persistence of this phenomenon has given rise to a concept known as the 'sanctioned discourse,' whereby a select elite determines what may be said about water-related development projects and who may say it in the first place…

"…The relevant point here is that this practice can mean unwelcome information that goes contrary to the sanctioned discourse will be screened out by gate-keeping elites…

"…This leads us into a more sinister world, in which data is manipulated for political rather than scientific ends, establishing a link with the notion of legitimacy that was raised at the start of this article...Also, as the output of GIS depends on the input and the questions underlying it, GIS represents the world in a way that reflects those interests. Depending on what gate-keeping elites want to show, they can manipulate their computer images to highlight and represent their preconceived image of reality. But what for? And for whom? Critical geographers have worried about who is empowered by GIS technology. The question 'what do you want to know and why do you want to know this?' is all the more apt in light of the potential for surveillance. Knowledge is power, and GIS could easily be used as a technology of power to reinforce the control of citizens by states."

In the final section of their article, Turton and Warner turn to examine four critical questions in the water debate: (1) Will there be enough water to support regional populations in the future? (2) Can GIS technology be used to map water resources and future population growth? (3) Has the question now become one of managing demand rather than supply? (4) How will demand management be achieved? Through a discussion of these questions, Turton and Warner present us with the beginnings of policy issues and recommendations aimed at getting at the underlying issue of second-order resources (again, which represent society's ability and willingness to deal with scarcities of a first-order resource). If this distinction between first- and second-order resources is not made and understood, they argue, hydropolitical policies are likely to fail.

Each of the papers in this series successfully delves under the surface of the population-water discussion—going beyond simple comparisons of population size, per-capita use and water availability. By looking at the nuances of definition, interpretation, and analysis, each paper examines the interplay between population and water issues globally and in their respective regions of study.

All three papers will be published by the Environmental Change and Security Project in fall 2001. Please write to Robert Lalasz at lalaszrl@wwic.si.edu *if you would like to receive copies when they are available.*

Endnotes

[1] Environmental Management Bureau. (1996). *Philippine Environmental Quality Report (1990-1995)*. Department of Environment and Natural Resources, Manila, Philippines.

[2] Tacio, Elena. (1994, March 27). "The great thirst." *Manila Chronicle*, A1.

[3] See MIDS (Madras Institute of Development Studies). (1995). *Policies for urban water supply: A strategy paper* (draft final report). Madras, India: MIDS.

[4] See Cosgrove, William J. & Rijsberman, Frank R. (2000). *World water vision: Making water everybody's business.* London: Earthscan Publications.

[5] Rosegrant, Mark & Ringler, Claudia. (1998). "Impact on food security and rural development of transferring water out of agriculture." *Water Policy 1*, 567-586.

Environmental Mission Recommendations for the U.S. Intelligence Community

By Captain Steve Kiser, USAF

Abstract

This article gives a concrete list of simple yet effective ways in which U.S. intelligence satellites can significantly boost the country's emerging environmental security mission. These recommendations (a) highlight a nexus of traditional national security issues and environmental security issues, and (b) largely promote synergistic cooperation between the traditional and the progressive. The article then analyzes both the direct and the associated costs of the proposed programs.

One important legacy of the Cold War is that the United States possesses a very well-functioning intelligence community with the capacity to collect once-unimaginable amounts of information and data. But strategists now rightly ask how or even if the current U.S. security posture—inarguably still defined by the Cold War—fits the chaos of the post-Cold War era. A new debate has opened regarding the place of non-state and non-military threats for national security planning, and many non-traditional areas (including food, water, and energy) are now being considered as essential "security" issues. Perhaps the most broadly discussed of these areas is the role and priority of environmental problems.

Environmental threats to both the United States and its interests abroad are clearly growing and will continue to grow in importance. And as environmental issues become more germane to U.S. security, the national security apparatus must be used to address them. While a considerable body of literature already addresses the significant emerging field of environmental security and its role in the U.S. national security paradigm, this article gives concrete recommendations to policymakers on how to use the U.S. intelligence community in an environmental role. It then broadly assesses the costs—both direct and associated—of these kinds of applications.

Recommendations

There are many specific areas where the application of U.S. strategic overhead systems could significantly aid the environmental security mission. While many private, nongovernmental satellite programs and businesses already exist that could undertake some of the missions detailed below, it is important to note that U.S. intelligence community assets can do them better, quicker, more accurately, and at less cost.

Treaty Verification

Treaty verification is perhaps the most compelling case for an expanded environmental monitoring mission by the U.S. intelligence community. The spate of environmentally-related treaties and protocols in recent years highlights a relative void in the United States' ability to monitor treaty progress and adherence. Indeed, the United States is signatory (although the U.S. Senate has not ratified all of them) to nine major international environmental conventions. These include: the recently signed Stockholm Treaty on Persistent Organic Pollutants (the so-called "dirty dozen" treaty, with approximately 50 signatories); the Montreal Protocol on Substances that Deplete the Ozone Layer of 1992 (136 signatories); and the Basel Convention on Transboundary Movements of Hazardous Waste (136 signatories) (U.S. Department of State, 1998(a); "US to sign," 2001). Literally hundreds of smaller agreements, treaties, and protocols also exist. While absolute verification and compliance with every single environmental treaty is an unrealistic goal, having at least a robust verification mechanism for these treaties is a highly desirable goal for the United States.

While the United States has officially disavowed it, the Kyoto Protocol to the United Nations Framework Convention on Climate Change serves as a good example of the ratification burden required by the new generation

Captain Stephen Kiser is a graduate of the USAF Academy and the University of Hawaii and is pursuing a Ph.D. in policy studies at the RAND Graduate School, where he is exploring ways mutual environmental concerns can and should be used as confidence-building measures between potential adversaries. He was previously an assistant professor of political science at the US Air Force Academy, where he taught a variety of courses on international security and Asian affairs.

of environmental treaties. Kyoto requires significant reductions in six greenhouse gases, including carbon dioxide, methane, nitrous oxide, and various substitutes for ozone-depleting chlorofluorocarbons (CFCs). The Kyoto Protocol has been criticized for (among other things) lacking concrete verification procedures. Indeed, even the U.S. Department of State admits that this is one of the unresolved portions of the treaty (U.S. Department of State, 1998(b)). Critics charge that the protocol contains no provision for answering even basic informational questions such as: How much carbon is in the air now? How much did each individual country emit in 1990—the treaty's baseline year? How much of each kind of greenhouse gas is each country emitting today? And how will we confirm a government's claims that it is (for example) planting carbon sinks? In addition, no openly-available carbon baselines exist for many of the nations who are signatories to the protocol. With no baseline, how does one measure progress?

Such treaty verification is a specific mission for which intelligence community satellite systems can help a great deal. While commercially available satellites could perform some treaty verification, intelligence satellites could do the job more quickly, more thoroughly, and with a substantially higher resolution (and thus higher accuracy) than other organizations. Additionally, with a quicker revisit time over various targets, monitoring potential violations or efforts to return to treaty standards could be more thoroughly monitored. An excellent example of this capability was demonstrated when the Director of the Central Intelligence Agency's Environmental and Societal Center (DESC) used Medea to report that a vast boreal forest in Russia might not be the huge carbon sink the Russians hoped it to be (National Intelligence Council, 1999).

The U.S. intelligence community's vast databases could also easily be mined to assess a country's total and types of economic activity, its total forested area, and other pertinent data to establish environmental baselines with more accuracy. While these imagery databases would not have all the necessary data for such a task, they can supply important pieces to the puzzle—pieces that will not be found elsewhere. Other environmental treaties pose similar problems and would similarly benefit from the intelligence community's involvement.

With environmental treaties and protocols increasing in both number and importance on the international stage, the United States would be wise (a) to use all its resources to establish accurate baselines for these treaties, and (b) then use its vast information-gathering resources to ensure other signatory parties are fulfilling their ends of the bargain. While the primary purpose of this use of intelligence community satellite assets is first and foremost protection of U.S. interests and treaty obligations, the goal of the treaties is environmental protection—a true nexus of national and environmental interests.

Warning for Potential Conflict or Humanitarian Disasters

One traditional mission of the U.S. intelligence community is to provide warning of impending conflict. Through a fairly complicated system of specific indicators that in theory are observable by the intelligence community, intelligence analysts are able to give warning of looming violence to military commanders and policymakers. A similar system of environmental indications and warnings is currently being developed at the Central Intelligence Agency's DESC—using food production, water supply, and demand for food and water as the key variables. Currently, this prototype system covers only Africa. Not only should this system be fully developed, it should have more complete data for at least other environmentally-stressed areas such as Russia, Central Asia, India, Indonesia, and portions of China.

Intelligence satellites should be used as the primary source of data for this groundbreaking computerized system. The prototype system uses exclusively open-source data that comes from a patchwork of sources (N. Kahn, personal communication, July 22, 2000).[1] By having a single, reliable, U.S.-tasked data source: (a) variations between data sources can be eliminated; (b) a steady stream of data will exist; and (c) U.S. intelligence analysts will be given the flexibility to update the database on their timetable according to national need rather than relying on whenever data is produced by an open source.

This system graphically represents geographic areas (again, at the moment, only the African continent). It uses Geographic Information Systems technology to generate a display of population density, water supply and demand, food supply and demand, poverty indices, transportation network densities, distributed wealth, and a variety of other environmental factors. After selecting two of these variables—for example, water supply and demand—an analyst can then generate two color-coded maps depicting each variable. The system then gives the option of overlaying the two maps to produce a third map, highlighting where surpluses and gaps in supply exist. Other variables (such as carrying capacity, societal capacity, and susceptibility to natural disasters) are also being developed for the database.

While no one claims this system will accurately predict conflict itself, the value added to other types of analysis (political, economic, and military, for example) is significant. A lack of food and water can be an early indicator of a failing state, as was the case in Somalia. Additionally, when U.S. troops are deployed to areas where access to water does not exist, this system can quickly be used to assess both how much water is available and how much stress the addition of U.S. personnel in the area will add to water supplies. Thus, the benefit of the system is twofold: while increasing the value and accuracy of the intelligence community's larger indications-and-warning system, it can also be used for more efficient military mission planning.

In addition, such a robust system could be a testing tool. By going back decades and collecting data from intelligence imagery archives, it could enable analysts to conduct retrospective analysis on a variety of conflicts as well as to develop theories and models of conflict causality with greater accuracy and precision. Analysts could also use the system to analyze thoroughly actual conflicts to determine better what role environmental factors might have played in them. Such testing would add empirical data to the now largely-theoretical debate about the role of environmental factors in conflict.

From a disease-prevention perspective, the higher-resolution imagery provided only by intelligence satellites can be very beneficial as well. The potential spread of vector-borne diseases (especially malaria) can be more thoroughly tracked with high-resolution infrared or optical satellite imagery. Such imagery can better identify and characterize standing water areas, vegetation types, and other variables that promote such diseases. With that data, governments and relief workers can then help track and control such diseases by contributing to estimates of spatial and temporal distributions of disease risk (Kilston, 1997, page 642). As malaria holds the dual distinction of being a top killer around the world and becoming increasingly resistant to antibiotics, this mission could be a powerful tool in fighting the disease.

Another recent application of satellite imagery to world health centers on the mysterious and deadly Ebola virus. A recent study of NASA-generated satellite data shows that Ebola seems to infect humans most readily during rainy seasons that follow periods of extensive drought. This finding is one of the few clues researchers have about how and why this stealthy disease flares up (Salopek, 2000). Other satellite-derived applications to human health at least ought to be explored.

Setting Environmental Baselines and Continuums

The U.S. government could also create a program with the singular purpose of creating year-by-year baselines of environmental conditions of the world, starting with the 1960s. As of about 1990, non-intelligence community satellites were able to collect enough data to measure the larger aspects of environmental change. In February 1995, President Clinton issued Executive Order 12951, authorizing the CIA to make public more than 800,000 photos taken between 1960 and 1972 by two of the earliest U.S. intelligence satellite platforms—Corona and Discoverer (Klass, 1995). If the U.S. government were also to release enough data from images archived from 1972 to 1990, analysts could build an unprecedented and invaluable 40-year global environmental continuum.

If the U.S. government were also to release enough data from images archived from 1972 to 1990, analysts could build an unprecedented and invaluable 40-year global environmental continuum.

Such a continuum would allow for retrospective trend analysis that could help confirm or disprove current theories of environmental degradation, the impact of humans on the environment, and the role environment plays in conflict. The continuum would provide better perspective and a larger dataset for testing these theories. It would also furnish a series of baselines for measuring how rapidly the Earth's environment is changing, possibly also providing more clues than are currently available as to the causes of such change. This capability directly impacts aggregate security concerns. If the Earth's environment is changing significantly slower or faster than currently assessed, our national priorities will also change. As Vice-Admiral William O. Studeman, then the Acting Director of Central Intelligence, stated in 1995: "[t]he final lesson from the CORONA program is that these intelligence systems are valuable assets that belong to the American people. We should declassify them when their secrets are no longer critical to national security. Film from these early broad-area-search systems still contains a wealth of information" (Studeman, 1995).

Sensor Calibration and Ground-Truthing

Military technology is already being used to aid several other non-military sensors (such as the NASA Earth Observing System constellation of satellites) to calibrate the sensors on these platforms (Trevedi, 2000). With minimal impact to national security concerns, this cooperation could continue to extend to other environmental monitoring and assessment efforts both inside and outside the U.S. government. Data collected from all types of environmental sensors—ground-based, airborne, or space-borne—could be compared with environmental data collected from the highly-sensitive and fully-calibrated intelligence satellite platforms.

This comparison would accomplish two things. First, it would calibrate and validate other valuable sensors, using previously-cleared personnel to conduct such tests. This practice would be economical for both the U.S. government and nongovernmental environmental organizations (NGOs); it would cost NASA or an NGO far less to ground-truth its sensors using data from another government organization than it would to contract that work out or develop its own tests independently. Second, such calibration could also be used to adjust previously collected data, thus standardizing more and more environmental information. Such a synergistic combination of environmental analyses was illustrated with the introduction of the LANDSAT program. There is no reason to believe such efficiencies will not be accomplished through an expanded data-sharing program.

Cooperation between the Intelligence Community and Other Organizations

The U.S. intelligence community has developed a tremendous pool of expertise when dealing with remote sensing and satellite imagery. Two generations of analysts have come and nearly gone since the U.S. launched CORONA, its first imagery satellite, in 1960. Since then, imagery intelligence has become an integral part of the U.S. intelligence community's activity.

This expertise can be shared, and already is in some ways. For example, one of the most significant developments in Earth observations in 2000 was the launch of the Interferometric Synthetic Aperture Radar (IFSAR) on the space shuttle's space topography mission. This mission's purpose was to map approximately 80 percent of the globe's land surface using radar to collect elevation data at exceptionally accurate levels. Currently, NASA has elevation data at 100-meter samplings. ISFAR will provide that data at 30-meter samplings—over a three-fold increase in resolution (Kirsten Thompson, personal communication, July 20, 2000). This project is a joint project between the National Imagery and Mapping Agency (NIMA, the organization which primarily interprets satellite data for the intelligence community) and NASA (FAS, 2000).

The collected information is expected to be highly valuable to a wide audience. The environmental community can use it for such activities as improving hydrological models, assessing erosion risk, achieving higher accuracy in delineation of watersheds, monitoring volcanic activity, and researching earthquakes (Kirsten Thompson, personal communication, July 20, 2000). Military personnel can use the information to develop extremely accurate flight simulators, logistic planning, terrain analysis for combat and traffic purposes, and improved battlefield management. Civilian applications exist as well: land use planning; communication considerations (such as line-of-sight microwave); or enhanced ground warning systems for civil aircraft (FAS, 2000).

IFSAR is but one example of the nexuses of environmental and traditional national security expertise that exist within the U.S. government. By using NIMA's expertise, environmental and other types of human security can be significantly enhanced.

Other Applications

The above recommendations are simply the largest areas in which the U.S. intelligence community's expertise, knowledge, and capabilities in satellites can and should be used to augment environmental monitoring and assessments. Below are a few examples of the dozens of other potential applications:

- Infrared satellites can not only aid firefighters combat forest fires, but they can also be used as an investigative tool to find out where and possibly how fires begin.
- A global, comprehensive coral reef assessment has not been conducted and (because of the sheer volume of imagery needed) is probably too expensive to undertake without the intelligence community's archive of images of coastlines around the world.
- The extent of global deforestation, desertification, and habitat destruction—all issues of concern for international treaties to which the United States is signatory—can be easily culled from images already being taken.
- Higher-resolution satellites in the infrared spectrum could give a much more accurate assessment of the health of forests around the world.
- Satellite imagery could give an extremely accurate

assessment of where and to what extent human development in sensitive environmental areas is occurring.

· Continuous monitoring of the polar caps (an indicator of global climate change), improved monitoring of ice flows and icebergs within international shipping lanes, and other Arctic phenomenon could also be gleaned from the intelligence community's data. An excellent example of such cooperation is the data released in the early 1990s by the U.S. Navy. The Arctic ice data (especially polar cap thickness) that U.S. submarines collected during the Cold War has now become a very valuable dataset for environmental scientists.

Costs

Assuming new responsibilities always carries costs, both direct and in opportunity. The proposals made in this article are no different: each carry a different kind of cost to be paid in different ways. While simply encouraging cooperation between the intelligence community and other federally-funded organizations and non-governmental organizations is relatively cost-free, funding for treaty verification would probably be rather high. And the creation of an environmental continuum would entail different sets of costs, both direct and indirect.

While a precise breakdown of costs for each of these proposals is beyond the scope of this article, it is possible to set up a framework of costs and analyze such concerns indirectly. The expenses associated with some of these recommendations fall into two broad categories—direct costs and associated costs.

The direct costs of these proposals are nearly impossible to calculate for a variety of reasons—the intelligence community's classified budget being the greatest barrier. Regardless, the direct costs of adding an environmental security mission to U.S. intelligence gathering activity are not in data collection but in adding the necessary personnel to conduct environmental analysis. For example, enormous amounts of archived U.S. intelligence information contain environmental data. The costs of putting these data to use for an environmental security mission lie in training and paying analysts to sift through these records and to glean the data needed, not in collecting additional data.

This same framework applies to intelligence collected both now and in the future. The U.S. intelligence community collects massive quantities of information every day; and there is more than enough collateral environmental data in this collection to keep analysts busy without necessarily tasking intelligence assets to collect specifically environmental data. In addition, future improvements in the capabilities of U.S. intelligence community satellites will be able to eliminate any potential competition between traditional and environmental security analysis needs. For example, U.S. Representative Larry Combest (R-TX) has strongly advocated the deployment of a series of 24 different small satellites, which could produce images of 40- by 50- square mile swaths with approximately three-foot resolution. Within a single hour, such a constellation of satellites could image 17,980 square miles—an enormous quantity of data (Fulgham & Anselmo, 1998; "NRO Opens Up," 1997; and "DARPA Eyes," 1997).

Still, the costs of analyzing such data would not be prohibitive. Should the U.S. government decide it will be the main purveyor of analysts to this mission, direct costs for analysts, space, equipment, and other related assets should be less than U.S. $2 million annually.[2] However, a different approach could also be used. Instead of the U.S. government being the exclusive purveyor of environmental analysts, it could simply serve as a clearinghouse—releasing data to environmental scientists and certain environmental NGOs that are already conducting extensive analysis of environmental security issues. Such a "cooperative engagement" policy would allow a far larger number of environmental experts to look at more data and allow many of the above proposals (such as creating an environmental continuum or assessing coral reefs worldwide) to be conducted essentially free-of-charge to the government.

The downside of this proposal is the substantial increase in associated costs and the greater challenge included with such costs. Again, the majority of the proposals of this article deal largely with handling and releasing archival or collateral data. Because of how this information is collected and distributed, associated costs would probably exceed direct costs. First, the release of classified information requires human eyes to review (or "scrub") the data to ensure vital national secrets are not also being released. Additionally, simply moving classified material around requires a certain amount of paperwork and tracking. And providing and maintaining the necessary security clearances to the additional number of persons who would become "environmental security analysts" is no small task: just the background investigation to provide such clearances can take months. In sum, the acts of finding and analyzing environmental data itself cost little; the increased requirements on the infrastructure and bureaucracy necessary to release classified data would be substantial. Estimating the necessary funds for this set of indirect costs is also very difficult, as it would necessarily be spread throughout the entire intelligence community.

Any discussion of costs, however, must also include a discussion of benefits. How much would the United States gain by adopting some or all of the above policy proposals? The synergies and advances resulting from a mingling of the intelligence community and the environmental security mission are difficult to predict. But the outlines of benefits can be glimpsed from examining the kinds of intelligence gains and savings the United States will glean from the more precise data produced by the previously-mentioned IFSAR mission. For example, IFSAR will enable insurance companies to save hundreds of millions of dollars as insured structures are built in less natural-disaster-prone areas. In addition, the better aviation and communication structures resulting from the IFSAR data will save hundreds and perhaps thousands of lives each year. And medical and humanitarian disasters will be minimized because of IFSAR's better watershed data. While the projections are estimates, they are also reasonable. Thus, while there is no debate regarding the question of increased costs to the intelligence community, this question must be posed with an eye towards benefits earned.

Endnotes

[1] Dr. Norm Kahn is a former senior analyst with the DESC. He gave an interview and briefing to the author at which sample datasets were demonstrated.

[2] This estimate is based off having 10 analysts, each paid an average of $50,000 annually, plus an infrastructure budget of $1.5 million—both, in the author's opinion, generous estimates

References

"DARPA eyes low-cost radar satellite constellation." (1997, June 2). *Aerospace Daily*, 341-2.

Federation of American Scientists (FAS). (2000). Interferometric Synthetic Aperture Radar /Shuttle Radar Topography Mission (IFSAR/SRTM). (2000). [On-line]. Available: www.fas.org/irp/program/collect/isfar.htm

Fulgham, D.A. & Anselmo, J.C. (1998, March). "DARPA pitches small sats for tactical reconnaissance." *Aviation Week and Space Technology*, 24.

Kilston, Steven. (1997, April). "High resolution commercial remote sensing satellites: Their value for environmental monitoring." *Proceedings of the 1997 American Congress on Surveying and Mapping/American Society for Photogrammetry and Remote Sensing Conference (Technical Papers, Volume 4: Resource Technology).* Author.

Klass, Phillip J. (1995, June 12). "CIA reveals details of early spy satellites." *Aviation Week and Space Technology*, 167.

National Intelligence Council and DCI Environmental Center. (1999). *The environmental outlook in Russia*. Washington, DC: Government Printing Office.

"NRO opens up to new satellite system ideas." (1997, July 30). *Jane's Defence Weekly*, 23.

Salopek, Paul. (2000, January 11). "Ghastly ebola unlikely to be last of its kind." *Chicago Tribune*, A1. [On-line]. Available: http://chicagotribune.com/news/nationworld/article/0,2669,2-40413,FF.html

Studeman, William O. (1995, February 24). Remarks at the signing of Executive Order declassifying early satellite imagery. [On-line]. Available: www.fas.org/spp/military/program/imint/dci_speech_22495.htm

Trevedi, B. (2000, July). "The truth is down here." *Smithsonian Air & Space 15*, 32.

U.S. Department of State. (1998a). "The Kyoto Protocol on Climate Change." Fact sheet released by the Bureau of Oceans and International Environmental and Scientific Affairs. [On-line]. Available: http://www.state.gov/www/global/oes/envir_agreements.html

U.S. Department of State. (1998b). Fact sheet on international environmental agreements. [On-line]. Available: http://www.state.gov/www/global/oesfs_kyoto_climate_980115.html

US to sign global ban on "dirty dozen" toxins. (2001, April 16). CNN. [On-line]. Available: http://www.cnn.com/2001/ALLPOLITICS/04/19/bush.environment.02/index.html