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SCIENTIFIC ASSESSMENT OF THE LONG-TERM ENVIRONMENTAL CONSEQUENCES OF WAR

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Introduction

The environmental impacts of wars are almost invariably adverse, regardless of whether they are caused by direct military actions or strategic counteractions, or collateral damages, or are the result of military support activities before or after the war. The total environmental damage caused by a specific war is the result of several factors. These include: the type of war (conventional, biological, chemical, or nuclear); the types of weapons and extent to which they are used; the duration and intensity of the war; the extent and type of terrain over which the war is fought; the strategies used during the war; and the prewar environmental conditions. These factors also affect the duration of the specific environmental impacts. It has been estimated that some 200 armed conflicts have occurred since World War II, mostly in developing countries. These wars have killed more than 20 million people and displaced several millions more, causing serious environmental and economic damages.[1]

Environmental impacts of wars

The environmental impacts of wars are often multi-dimensional. They also often have repercussions in areas long distances away from those of concentrated battle and over prolonged periods of time, long after the wars have ended. Several possible environmental impacts of war are explored below.

[1] M. A. Tolba and O. A. El-Kholy, *The World Environment 1972-1992* (London and New York: Chapman and Hall on behalf of UNEP, 1992).

IMPACTS ON LAND

Land is affected both by direct war actions and by military operations (preparations for war). Bombs and missiles contribute to the formation of craters, compaction and erosion of soil, and soil contamination by toxic and hazardous residues. Land use patterns often change over prolonged periods of time due to the continued presence of landmines and other remnants of war. Use of biological, chemical, and nuclear weapons is also likely to change land use patterns significantly by precluding any productive use of land for very long periods of time - even centuries.

There are also those activities that specifically target land resources. For example, deliberate deforestation efforts can alter the prevailing land, water, and biotic regimes, with any number of resulting adverse consequences. Another example is the degradation of soil conditions that resulted from the oil well fires in Kuwait. Deducing the appropriate methods for amelioration of such damages to soil, as well as actually carrying them through, is likely to be a costly and technologically difficult endeavor, putting off further the productive use of the affected lands.

Use of land for military operations also contributes significantly to environmental damage. Globally, it is estimated that the amount of land used for these purposes ranges between 750,000 and 1,500,000 km^2, an area that is likely larger than the total surface areas of France and United Kingdom combined (797,000 km^2).[2] This prevents the land from being used for alternative purposes, such as urbanization, agricultural production, habitat preservation, or recreation. For example, up until the 1980s the US military was the largest holder of agricultural land in the Philippines, a significant portion of which was left idle. In Kazakhstan, more land is currently reserved for the use of the military than is made available for wheat production.

IMPACTS ON WATER

Water contamination (of both surface and groundwater) is also a common result of various types of warfare. Use of chemical, biological, or nuclear weapons can contribute to long-term water pollution, with attendant health

[2] WorldBank, *World Development Report 1998-1999(1998).*

hazards for humans and the associated ecosystems. Appropriate remedial techniques for such contamination are often technologically impossible or extremely expensive, technologically complex, and require very high levels of scientific expertise. It is precisely these aspects that are not readily available in many countries in the developing world where most wars have been fought in recent decades.

Water and wastewater treatment plants and water distribution and sewer systems are often direct and/or indirect victims of war. During World War II, the British targeted German dams for destruction.[3] Similarly, the American military bombed dams in North Korea during the Korean War.[4] Immediately following World War II, productivity of the water distribution systems in Tokyo decreased by nearly 90 percent as a result of damage caused by the war and the channeling of resources (both financial and professional) away from efficient operation of the systems and into the war efforts.[5] By contrast, the current losses from the water distribution system in Tokyo are only 7 percent, the second best in the world after Singapore at 6 percent.[6] The direct costs of repairing the damages to water supply and wastewater systems caused by war are high. The indirect costs of such destruction to human health are simply unknown and mostly incalculable.

IMPACTS ON AIR QUALITY

In addition to the atmospheric emissions from the vehicles and other equipment used during routine war activities and military operations, serious air pollution often occurs as a result of the use of chemical, biological, and nuclear weapons. The aggressive act of setting fire to the Kuwaiti oilfields resulted in extensive air pollution in the region. Depending on the extent and nature of the air pollution and the prevailing topographical and atmospheric conditions around the area where it originates, airborne pollutants can travel over long distances, contribute to acid rain, and cause serious health hazards for humans and other living organisms located within the affected zone.

[3] Stockholm International Peace Research Institute/United Nations Environment Program, *Environmental Hazards of War* (London and Newbury Park: SAGE Publications, 1990).

[4] *Ibid.* [5] Tolba and El-Kholy, *The World Environment.*

[6] Juha I. Uitto and Asit K. Biswas, *Water for Urban Areas in the 21st Century* (Tokyo and New York: United Nations Univ. Press, 1999).

NOISE

Conventional weapons and low-flying jets can generate high levels of noise (140 decibels or more) which could have long-term impacts on the hear-ing of people subjected to it.

RESOURCE DEPLETION

Resource depletion is an important environmental impact of war that has generally received inadequate attention. Even during peacetime, military use of energy and non-renewable resources is substantial. It has been estimated that global petroleum consumption for military purposes is about 6 percent of the total world consumption, or almost one-half of the total consumption of all developing countries combined.[7]

Nearly 85 percent of the total energy used by the United States government is for military purposes.[8] For example, the fuel used by an F-16 training jet in less than one hour is nearly equivalent to what an average US motorist uses over a period of two years.[9] The amount of energy used to produce weapons is also high: in the US it is almost equivalent to twice that of the energy directly used by the military.[10] Further, during wartime, when high technology and sophisticated weapons are used, total energy used by the military might increase by factors of five to twenty times over the levels used during peacetime, depending on the conditions that prevail during any specific war.[11]

Military uses of other non-renewable resources are also significant. For example, global military consumption of aluminum, copper, nickel, and platinum is higher than the total consumption of these metals by all the developing countries of the world combined. It has been estimated that the military accounts for 11 percent of global copper use, 9 percent of iron, and 8 percent of lead. Overall, on a global basis, between 2 and 11 percent of fourteen important minerals is consumed for military purposes: aluminum, chromium, copper, fluorspar, iron ore, lead, manganese, mercury, nickel, platinum, silver, tin, tungsten, and zinc.[12] Global consumption of aluminum, copper, nickel, and platinum for military purposes is greater

[7] Tolbaand El-Kholy, *The World Environment.*
[8] United Nations Environment Program, *Internal Documents on Peace and Security* (1991).
[9] *Ibid.* [w] *Ibid.* " *Ibid.* [n] S.S.Kim, *The Quest for a Just World Order* (1984).

than Latin America's consumption for all purposes.[13] The environmental impacts of the mining activities associated with such high levels of extraction of resources are certainly significant.

HAZARDOUS MATERIALS

War efforts generate vast quantities of hazardous materials, the environmentally sound disposal of which is a difficult, time-consuming, and expensive task. The manufacture, maintenance, storage, and use of weapons alone generate great varieties and tremendous quantities of these wastes.

Undoubtedly, the military establishments of the United States and the countries of the former Soviet Union are two of the largest global producers of hazardous wastes. It has been estimated that the US Defense Department produces between 400,000 and 500,000 tons of toxic wastes annually.[14] This estimate does not include the hazardous wastes produced by defense contractors, or the Department of Energy, which produces nuclear weapons. Because of the secrecy invariably associated with military activities, the types and quantities of hazardous wastes generated, appropriateness of the practices currently used for their disposal, and the overall environmental and health impacts of hazardous waste management processes are virtually unknown.

Chemical warfare introduces hazardous materials to the environment. Despite this, use of such weapons has historically been widespread. Chemicals like chlorine, phosgene, diphosgene, and mustard gas were used by both sides during World War I. The British used herbicides for defoliation in Malaysia during the late 1940s and early 1950s. The United States used about 44 million litres of Agent Orange, 20 million litres of Agent White, and 8 million litres of Agent Blue over 1.7 million hectares in Vietnam from 1961 to 1971.[15] Some areas were sprayed several times. These practices contributed to serious environmental damage, such as large-scale devastation of crops, deforestation, soil loss due to reduction in vegetation, destruction of wildlife habitat, and decline in fish catch. They also had adverse impacts on human health, resulting in predisposition of

[13] *Ibid.* [u] UNEP, *Internal Documents.*

[15] Stockholm International Peace Research Institute/United Nations Environment Program, *Herbicides in War* (London and Philadelphia: Taylor & Francis, 1984).

the exposed populations to cancers, chromosomal damages, spontaneous abortions, and other conditions.[16]

The environmental and health problems associated with the safe disposal of radioactive materials and the wastes that are the result of the world's nuclear weapons programs are neither easy to quantify, nor possible to solve with the present level of technology. Accidents at nuclear facilities pose an additional problem. Up to 1995,212 such accidents with nuclear-powered vessels can be documented worldwide. Further, at least seven nuclear-powered reactors and forty-eight nuclear warheads lie on the ocean floor because of accidents.[17] Their long-term environmental impacts are basically unknown.

An additional environmental concern that has recently surfaced is that of the US military's use of depleted uranium in ammunitions during the Gulf War and the Kosovo conflict. It is not known what the long-term environmental and health impacts on ecosystems and humans from this depleted uranium will be.

Assessment of long-term environmental impacts of war

Even though the reliable assessment of the environmental consequences of war is an important topic, it historically has been a largely ignored area of study and research. Considerable general information is currently available regarding the potential environmental impacts of wars. However, a detailed, comprehensive, and authoritative study on the actual short-, medium-, and long-term environmental impacts of a single war anywhere in the world is conspicuously absent. Environmental scholars, development experts, and political scientists, for whatever reasons, have shied away from carrying out such studies, even though the importance and relevance of such studies is indisputable.

Equally, international organizations like the various United Nations agencies (UNEP, UNDP, UNESCO, etc.) have basically ignored this critical issue. Further, in spite of its importance, no major, serious, multidisciplinary international conference on this complex subject has been organized until now. It is thus to be hoped that the interest and momentum generated by the First International Conference on Addressing

16 *Ibid.;* see also Alastair Hay, "Defoliants: The Long-term Health Implications," chapter 16 in this volume.

17 Stockholm International Peace Research Institute/UNEP, *Herbicides in War.*

Environmental Consequences of War, held in Washington, D.C. in June 1998, will go a long way to interest scholars and experts to initiate major studies in this area in the foreseeable future.

There are, of course, many generalized assessments of environmental impacts of war, but their reliability and usefulness leave much to be desired. There are many reasons why we are presently facing this sad situation, in spite of the fact that the environmental impacts of wars are generally accepted to be considerable. Since the main focus of this chapter is the scientific methods of assessing ecological damages from war, only the major scientific reasons for not being able to carry out realistic environmental assessment will be analyzed herein.

METHODOLOGICAL CONSTRAINTS

There are major methodological constraints on accurate forecasting of medium- and long-term environmental impacts. The first and most far-reaching of these is the environmental impact assessment (EIA) process itself, the likeliest tool to be used in forecasting the environmental impacts of war. The first country where EIA became a formal requirement was the United States, with the passage of the National Environmental Protection Act in 1970. Soon thereafter, EIA became mandatory in Canada and certain Western European and Asian countries.[18]

The techniques and the processes that are presently used to forecast environmental impacts have undergone only minor changes, both conceptually and methodologically, since they first came into practice in the early 1970s.[19] The most notable change during the past quarter of a century in this area has been our capacity to analyze increasing numbers of parameters and data more cost-effectively, which may be attributed to the fact that computers have become more powerful and economical.

In retrospect, environmental assessment techniques were acceptable, even laudable, in the early 1970s. They constituted a significant improvement over the then-prevailing practices. Unfortunately, these techniques have

[18] P. Modak and Asit K. Biswas, *Conducting Environmental Impact Assessments for Developing Countries* (New York: McGraw-Hill, 1999); Asit K. Biswas and S. B. C. Agarwala, *Environmental Impact Assessments for Developing Countries* (Oxford and Boston: Butterworth-Heinemann, 1992).

[19] AsitK. Biswas, *Water Resources: Environmental Planning, Management and Development (New* York: McGraw-Hill, 1997).

been used continuously for more than twenty-five years on the assumption that they are reliable and effectively improve environmental management practices. Similarly, international organizations, ranging from the United Nations Environment Program to the World Bank, now utilize the same techniques without ever analyzing the extent to which they effectively predict medium- to long-term environmental impacts with any degree of certainty. Hundreds of international and national guidelines are available on EIA, but scarcely a single objective study is available on the comparative effectiveness of these guidelines in predicting and managing environmental impacts.

In fact, there do exist several fundamental problems with the current environmental assessment techniques, which have been analyzed in detail.[20] While environmental assessment has become a real growth industry globally, nearly exclusive emphasis is placed on prediction of the various impacts that will likely arise from possible interventions in a project requiring assessment. Once the assessment is completed and reviewed by an appropriate governmental or legal entity, the process is considered complete for all practical purposes.

Unfortunately, the environmental assessment process, as it is practiced at present, is still an art rather than a science. There are numerous interacting physical, technical, economic, environmental, and social factors that need to be considered, making it very difficult to assess in advance the net results of all the interactions due to any specific intervention, especially one as multi-faceted as war. In addition, many environmental impacts are site-specific, making accurate predictions extremely difficult. Factors such as the time when specific problems may surface, the magnitude of each impact, and the spatial distribution of the impacts over any area provide examples of the sorts of issues that are extremely difficult to predict with accuracy.

A major reason for this unsatisfactory state of affairs is the near-total absence of monitoring and evaluation of the actual environmental impacts caused by actual interventions. Even for standard development projects, it is highly unlikely that even 0.1 percent of them, on a global basis, are currently monitored on a medium- to long-term basis.[21] In the absence of monitored results, the hypotheses on the basis of which environmental

20 For example, see Modak and Biswas, *Conducting Environmental Impact Assessments;* Biswas, *Water Resources.*

21 Biswas, *Water Resources.*

assessments are carried out cannot be validated or further improved. Thus, the biases and errors that have been inherent in the process from the beginning are continually being perpetuated all over the world.

If the situation is bad for "normal" development projects, on which hundreds of thousands of environmental assessments have already been carried out globally, it is significantly worse when assessment of the environmental impacts of wars are considered. This is partly because predicting the environmental impacts of wars involves even more complicating factors, and partly because no such comprehensive assessment has ever been carried out. On the basis of anecdotal evidence, it is clear that there are often extensive and significant differences between the predicted and actual impacts of development projects. In the case of wars, we scarcely have even a single case study where an attempt has been made to assess the environmental impacts comprehensively, let alone to compare the differences between the actual and predicted impacts. Even for the Gulf War, several years after its completion, we do not yet have sufficient objective and reliable assessments of its potential long-term environmental impacts. It is really an indictment on our present society, which can spend billions of dollars on a war, yet fails to make comparatively minor amounts readily available to monitor and evaluate the long-term environmental consequences of those wars.

One reason for the discrepancies between real and predicted impacts of wars is the considerable risks and uncertainties that are invariably associated with any reliable analysis of non-linear complex systems. Water regimes and biological populations are notoriously variable by nature. Their normal perturbations are often so great that the collection of statistically significant data to make definitive cause-and-effect linkages is very expensive, and can even prove impossible due to political or national security reasons (such as when environmental impacts of wars are to be studied). Under such conditions, and at our present state of knowledge, it is simply not feasible to identify definitively which variations could be due to natural causes, and which are attributable to the direct and indirect consequences of a war.

Similarly, cause-and-effect relationships of the health impacts of wars are not easy to define, especially when the impacts are due to low levels of sustained exposure from biological, chemical, or radiological elements from natural, man-made, and/or war-related sources. The scientific basis for assessing such dose-response relationships, and the determination of

which impact, or even which parts of impacts, are due to war as opposed to "normal" exposures, leaves much to be desired. Currently, it is very difficult, if not impossible, to assign a chronic health impact to a specific cause or causes stemming from any war.

The difficulties in assessing such impacts are apparent in the discrepancies between estimates for impacts of specific wars and their actual outcomes. For example, during the Vietnam War, Agent Orange was considered to be harmless to human health, even though no authoritative toxicological studies were carried out prior to its use that could withstand peer review. It was used extensively for defoliation purposes before the mutagenic and teratogenic impacts of the herbicide were realized, and only then after some American scientists challenged the thinking of the US Defense Department that the herbicide had no serious health impacts. Unquestionably, the extensive use of Agent Orange has caused extensive environmental and health damages on a long-term basis in Vietnam.[22]

The 1990-91 Gulf War is a prime example of the difficulties of predicting environmental impacts of wars, and the need for assessing what is predicted as compared to what actually happens. Several environmental impacts of this war were overestimated. For example, it was widely reported in the media during and after the war that the impacts would include:

- Changes in global climate;
- A significant increase in the rate of global warming;
- Changes in monsoon patterns, especially in Southeast Asia;
- Serious air quality problems in countries as far away as India and Bangladesh;
- The possibility of a global "nuclear winter";
- Large-scale acute and chronic health impacts; and
- Catastrophic changes in coastal ecosystems.

It is now generally agreed that the actual environmental impacts are most likely significantly less than what were forecasted. It is now mostly accepted that:

- The smoke did not affect global climate because of its low altitude. The base of the smoke plume was generally at heights between 0.5 to 2 km, and its top was typically in the range of 3 to 4 km. The plume was never

[22] For a more detailed discussion of the health impacts of Agent Orange use in Vietnam, see Hay, "Defoliants."

detected above 6 km, the height necessary for large quantities of soot to enter the jet stream. In addition, its short residence time ruled out any realistic possibility of a "nuclear winter";

- Carbon dioxide emissions from the war are now estimated at 300 million metric tons, only about 1.5 percent of the current global emissions from the burning of fossil fuels and biomass;
- The impact on global warming is likely to be so small that it would be immeasurable because the extent, intensity, and duration of the fires were not significant on a global scale;
- Long-distance transport of air pollutants has not been substantiated. No impacts have been noted in India or Bangladesh in terms of day-to-day weather, or changes in monsoon patterns;
- Ground-level concentrations of nitrogen oxides, carbon monoxide, hydrogen sulfide, and ozone did not even exceed the local standards of Kuwait and Saudi Arabia. However, there were times when sulfur dioxide levels exceeded local standards;
- Anecdotal evidence indicates that many parts of Kuwait's desert ecosystem are recovering faster than initially anticipated; and
- Long-term health impacts are unlikely to be significant, and even if these do prove to be significant, they cannot be scientifically attributed to the war because detailed baseline data are not available from earlier periods to make such comparisons statistically significant.

While no reliable scientific data are presently available to indicate that the Kuwaiti oil fires had many long-range and long-term effects on the global atmosphere, no one can question their local, and even regional, impacts. There were some 610 oil fires, covering seven oilfields to the north and south of Kuwait City. The fires consumed over 6 million barrels of crude oil and 70 million cubic meters of associated gases daily.[23] The smoke plumes were 15 to 150 km wide, at distances of 0 to 1,000 km from the fires. The plumes were not generally photo chemically active until they had travelled approximately 200 km, which lessened their overall impacts. The ozone concentration occasionally exceeded 120 parts per billion inside the plume, around 1,000 km downwind from the source. Visibility, local and regional temperatures, and solar flux were also reduced under the plume.[24] The smoke particles coagulated as they were transported downwind, which

[23] Modak and Biswas, *Conducting Environmental Impact Assessments.* [u] *Ibid.*

accelerated their removal potential by cloud and rain. The medium- to long-term impacts of the resulting soot and oil deposition over much of Kuwait and northeastern Saudi Arabia on soil, water, and biota are basically unknown at present. Unquestionably, the terrestrial biosphere of Kuwait was adversely impacted by the fires.

LACK OF SCIENTIFIC INTEREST

It should be noted that nearly all the wars during the past five decades have occurred in the developing world. Not surprisingly, environmental scientists from developed countries have shown very limited interest in such wars unless their own countries were involved, as was the case for the Vietnam War and the 1990-91 Gulf War. Even then, the interest was focused only on limited aspects of the environmental consequences; for example, on implications of using defoliant herbicides in Vietnam, or the climatic impacts of the Kuwaiti oil fires. No attempt was made to conduct comprehensive monitoring and assessment of the overall environmental impacts of these wars, even though such studies are vitally necessary.

Regrettably, scientists from the developing countries where most of these wars are taking place also have shown very little interest in this area. Further, until recently, no sustained effort has been made by international organizations to encourage sufficient funding and thorough investigation of this issue. This is despite the fact that many such countries have suffered, and will continue to suffer, from major adverse environmental impacts due to these wars. A good example of this lack of commitment is seen in the international reaction to the impacts of the Gulf War. After the initial flurry of activities immediately following the termination of the war, there has been insufficient visible sustained effort by the appropriate international organizations to monitor and objectively evaluate the environmental impacts of the war. Whatever limited efforts were made highlighted the problem of inadequate coordination and insufficient communication between the various organizations involved, and then disappeared fairly quickly after an initial indication of interests.[25]

[25] See, however, Green Cross International, *An Environmental Assessment of Kuwait, Seven Years After the War* (1998).

Conclusion

Assessment of the long-term environmental consequences of war is an important issue, but it has neither received nor is receiving adequate atten-tion thus far. The scientific profession has first to realize that there is a major gap in our knowledge base in this subject that needs to be filled. Simultaneously, funding agencies need to be convinced that this is an important area of research that deserves priority financial support on a long-term basis.

Considering that reliable assessments of the environmental impacts of war are important at both the national and international levels, both for taking appropriate countermeasures and developing international policies and norms, this is an area of scientific investigation that should receive urgent attention. Without a reliable base of knowledge, it is simply not possible to develop and implement appropriate environmental mitigation measures in a timely, cost-effective manner.

On the other hand, in December 1998, Green Cross International (GCI) published the results of a multi-disciplinary study on the impacts of the 1990-91 Gulf War.[26] The study was funded by the Kuwait Foundation for the Advancement of Sciences, and provides information that is vital, as it may be compared with the initial predictions, and such a comparison could help to explain why many of the initial predictions were inaccurate. This comparison could also further improve the current state of the art in terms of methodologies available. It is of note that the Allies, who spent billions of dollars on this war, have so far shown no interest in conducting or promoting such a study, even though the benefits that would accrue from additional work are unquestionable. Utilizing the GCI case study as a mechanism for assessing the methodological constraints would benefit environmental assessments worldwide, both on a national and on an international level.

[26] *Ibid.*