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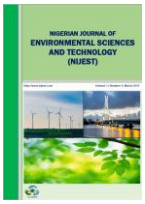

Warfare Disaster Ecology: Connecting Warfare Ecology and Disaster Risk Management Curricula

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ABSTRACT

This paper examines the topics of ecological change induced by war and the interactions between environment and warfare which though have received major attention from warfare ecology but not yet conceptualized as an area of enquiry in disaster risk management studies. This paper therefore compares warfare ecology and disaster risk management in order to bring out some of their more general characteristics with the purpose of greater conversation and collaboration across the two fields. The aim is to develop a new curriculum of 'warfare disaster ecology' (WDE) in disaster risk management studies. The objective is to better identify their potential linkages and synergies. This paper is based on desktop review of extant literature on disaster ecology. Criteria for inclusion of the reviewed articles were based on (1) the article's relevance to the proposed curriculum, and (2) the article's applicability to disaster risk management. The paper provides justifications for the development and domiciliation of warfare disaster ecology in disaster risk management studies, pointing to research themes and scales at which warfare disaster ecology can be studied. It suggests greater opportunities for interdisciplinary approach and closer connections between warfare ecology and disaster risk management, thereby expanding the curriculum and areas of specialization for graduate students in disaster risk management studies. It proposes a research direction for academics and policy implications of WDE to guide military policy-making and planning, peace-building and conflict resolution, and environmental protection for all the concerned bodies.

Keywords: Armed conflict**,** Coupled system, Curriculum, Environment, Military

1.0. Introduction

Disaster is at the core of warfare ecology and disaster risk management studies. Yet there has been limited engagement between the two disciplines. The lack of connection reflects, in part, the broader disciplinary context of disaster risk management and the infancy of warfare ecology. Whereas disaster risk management research embraces environmental determinism, warfare ecology eschews it. Yet both are concerned with the wellbeing of coupled biophysical and socio-economic systems. Greater connections can be found, notably in light of disaster risk management renewed engagement with the materiality of the environment (Agheyisi, 2020), and warfare ecology increasingly nuanced mixed-methods research on resource-related violent conflicts. Both fields encompass diverse conceptual perspectives and broadened methodological approaches, making them amenable to greater connections and mutual improvements. The emphasis of disaster risk management on human agencies in pursuit of environmental justice resonates with the structural violence approaches and social justice agenda of warfare ecology.

Amongst all human activities, war has been proven to be one of the greatest causal agents of environmental change with devastating ecological impacts (Majeed, 2004; Harbom and Wallensteen, 2007). War not only leads to loss of lives but also causes severe environmental disaster in terms of land degradation, consumption of fossil fuel, and emissions of a high level of carbon as modern warfare increasingly becomes motorized since the World War II (Bidlack, 1996; Biswas, 2000; Majeed, 2004). Norris and Kaniasty (2004) argued that large-scale war, in which harm is intentionally perpetrated, should be added to the long list of disaster types adding that war and technological disasters are more harmful psychologically than are natural disasters. Despite these realities, research

related to environmental impacts of warfare is limited in depth and fragmented by disciplines (Machlis and Hanson, 2008). Across disciplines there is little integration of theory, methods, empirical studies, and policy implications of warfare disaster. Yet, a review of empirical studies suggests complex relationships between warfare and ecosystem change.

The aversion to bringing war disaster into disaster risk management studies stems, in part, from the tradition of environmental determinism within geography and the tradition of treating human societal response to environmental hazards in a mechanistic fashion within disaster risk management (Watts 1983; Le Billon, 2012). Therefore, this paper is a preliminary comparison between warfare ecology and disaster risk management, and an initial but focused incursion of disaster risk management studies into warfare ecology with the potential of greater conversation and collaboration across the two fields. The aim of this proposal is to contribute to the curriculum development of disaster risk management, and explore possible avenues for cross pollination of disaster risk management and conflict studies. I recognize that these two fields are diverse and characterized by multi-disciplinary approaches and theoretical pluralism. In this respect, the portrayal of these two fields of study in this paper is somewhat reductionist. But a recurring theme in both fields of study is disaster.

This paper draws largely from the work of Machlis and Hanson (2008) in which they proposed the new and emerging field of applied ecology named 'warfare ecology'. Borrowing from their work, this paper presents the following: (i) a proposed course called 'warfare disaster ecology' to be domiciled in disaster risk management curriculum, (ii) a taxonomy of warfare themes useful for organizing and teaching the coursework, (iii) research needs and policy implications that emerged from the review of available empirical studies on disaster ecology. The discussion that follows is organized around these sub-themes. Conceptually, warfare disaster ecology (WDE) is the study of ecological changes in coupled biophysical and socio-economic systems induced by war. WDE can make specific and original contributions to our understandings of disaster risk of war and the impacts of warfare on the environment and ecosystems. But it can also gain from a more systematic engagement with warfare ecology as a discipline.

The paper is organized into six main parts. The next section contrasts warfare ecology and disaster management studies in terms of their conceptual and methodological approaches, highlighting some of their key focuses with regard to human and environment interactions. The following section discusses the evolution of disaster ecology as a field of study, highlighting its various dimensions which are directly related to the scope of disaster risk management. The section that follows presents the method of the paper. Next comes the section that discusses the development of WDE and justifies the domiciliation of warfare ecology in disaster management programme, identifying the potential linkages and synergies between warfare ecology and disaster risk management. The concluding section highlights some policy implications of this proposal on the development of disaster risk management studies.

2.0. Contrasting Warfare Ecology and Disaster Management Studies

Warfare ecology and disaster management studies are both interdisciplinary fields, with a broad diversity of research focuses, theoretical and methodological approaches. The aim of this section is to bring out some of their more general characteristics without exhaustive description of each field. The objective is to contrast them in broad terms to better identify potential linkages and synergies.

2.1. Warfare ecology

The term 'war' is broadly understood as collective killing for some political, strategic and tactical purposes (Smith, 2007). The importance of modern warfare lies in the frequency, scale and complexity of ecological impacts typically associated with different kinds of war (Machlis and Hanson, 2008). War ranges from large-scale interstate war to national revolutionary or guerrilla war which involves armed non-state actors against the state, and local non-state wars such as armed conflicts between tribal, sectarian, or religious factions.

Machlis and Hanson (2008) suggested that the broader taxonomy of warfare includes three stages namely; (i) war preparations, (ii) war execution (fighting), and (iii) post-war activities (reconstruction, resettlement and rehabilitation). Each stage has the potential of dovetailing into one another. Each

stage also includes several key elements such as military personnel, infrastructure and governance that influence both warfare outcomes and ecological impacts. All three stages of warfare generate ecological consequences. For instance, modern war preparations require significant fuel consumption, stockpiling of strategic arsenals, testing of weapons, and training. Active war and post-war often leads to residual unexploded ordnances (UXOs), chemical contamination, landscape cratering, vegetation removal and its attendant soil erosion, and socio-economic disruption. War can also lead to habitat destruction, looting and plundering of natural resources to finance the execution of war (Collier, 2000; Machlis and Hanson, 2008) and collateral damages.

The necessities of war impact the ecology of conflict environment in far-reaching ways. For instance, military garrisons, track ways and muster points used by both warring factions can result in losses of biodiversity, land degradation, destruction of crops and arable land, soil compaction and alteration in plant cover. Long term military operations can greatly alter land-use patterns as a result of population displacement. Bush can be deliberately set on fire during military operations as a war tactic. Fire suppresses as well as stimulates certain species of plants. Fire ecology often produces hybrid plant species which in turn affects local animal life that depends on them. Similarly, repeated air raids have a tremendous impact on flora and fauna in the environment.

Studies have shown that there is a complex relationship between warfare and changes in the ecosystem. This relationship has been aptly termed 'Warfare Ecology' (Machlis and Hanson, 2008). Although ecologists have long been concerned about the impacts of war-related activities on the biophysical environment (Keegan, 1993; Townshend, 2005), such concern was not conceptualized as a new field of study until recently. Warfare Ecology, as a new field of inquiry, is context specific. It can be investigated at different scales: local, regional and global. Central to the study of ecology is the interaction between and among organisms and their environment at different scales. Therefore, the ecosystem remains the unifying theory of warfare ecology.

Machlis and Hanson (2008) proposed that Warfare Ecology would apply ecological theory, methods, and empirical studies to war-related conditions. With its emphasis on interactions among organisms, and between organisms and their environment at multiple scales, ecology is well suited to helping understand the complex relationships between warfare and natural systems. The embeddedness of disaster in warfare bridges the gap between the inter-disciplinary fields of disaster management and warfare ecology as both aimed to inform policies to reduce, mitigate, or prevent disaster.

2.2. Disaster management

Disaster refers to an emergency situation caused by natural or human-induced hazard resulting in sudden and often large scale loss of human lives and properties over a relatively short period of time (Otero and Marti, 1995). The concept of disaster centres on human population and their livelihoods. Disparate groups are often at the frontline due to their precarious living conditions. This is why Shultz *et al*. (2007) defined disaster as an encounter between hazard and human population. Disasters have been described as extreme event(s) at the interface of natural and human systems (Sarewitz and Pielke, 2001). The ecological context under which disaster occurs determines the coping capacity of the affected community (Quarantelli, 1985, 1995, 1998; Noji, 1997; World Health Organization, 1999; Landesman, 2001; Somasundaram *et al*., 2003; Shultz *et al*., 2006). Daura (2014) defines disaster as a natural or human-induced catastrophic event occurring with or without warning, causing widespread human, material, economic, or environmental losses which exceed the ability of the affected community to cope with its impacts. Besides deaths and destruction of properties, disaster also causes population displacement, epidemics, damage to critical infrastructure, and disruption of economic and social activities (Olorunfemi and Adebimpe, 2006). Disaster is a function of natural or man-made hazards that impacts on vulnerable communities. Disaster is a measure of the impact or magnitude of hazard on the society or environment. The scale of hazard impact is exacerbated or ameliorated by how people live and use the environment.

Disaster occurs when environmental or natural processes and the living condition of a people result in the exposure to natural hazards. The intensity of disaster often depends on the intersection of the negative outcome of human activities and the underlying physical, social and governance factors that shape peoples' lives and how they respond to these factors (Agheyisi, 2020). The likelihood that a

particular type of hazard event will occur in a specific location is called risk (Daura, 2014) and the presence of human population in that specific location will influence the possibility of human exposure (vulnerability) to that hazard event. Without the presence of human population in a specific hazard-prone location, there would be no hazard. Thus, hazard is a measure of human or material loss in any environmental extreme. Disaster is the product of hazard and vulnerability (Shultz *et al*., 2007). Disaster management is the systematic process of using administrative decisions, organization skills and capacities to implement policies, strategies and coping capacities of societies and communities to lessen the impacts of natural and related environmental and technological disasters (NEMA, 2011). Disaster risk management (DRM) therefore comprises of all forms of structural and non-structural measures to prevent or limit adverse effects of hazards (Daura, 2014). Disaster risk reduction (DRR) is the new paradigm in DRM. Disaster risk reduction is a body of policies, strategies and practices aimed at curtailing vulnerabilities and exposures in a society through appropriate prevention, mitigation, preparedness and early warning programmes (Daura, 2014). Disaster risk reduction is a multi-stakeholders approach geared towards the inclusion and motivation of public authorities, civil societies and people at risk to be more involved in the conscious management of their environment. It also involves mainstreaming DRR in public planning, policies and programmes as well as decision-making processes at the community level (ISDR, 2002). Disaster risk reduction therefore aims to reduce the damage caused by hazards through an ethics of prevention. The concept and practice of DRR involve the systematic efforts to analyze and reduce the causal factors of disaster. Examples of these efforts include reducing exposure to hazards, lessening vulnerability of people and properties, sound management techniques of land and the built environment, disaster preparedness and early warning system against hazard events (Agheyisi, 2020).

Like every other forms of disaster, war-related disasters have some characteristics which can be studied over time and space. Shultz *et al*. (2007) identified the following five characteristics which are directly related to war-related disaster.

2.3. Magnitude

Multiple measures have been used to estimate the cumulative impacts of disaster globally. The public health consequences of disasters can be measured in terms of mortality, morbidity and disruption of health care infrastructure (Shultz *et al*., 2007). For human-generated disaster such as war, quantity measures are often used to denote magnitude of exposure. Case studies could provide in-depth environmental accounting and ecological analysis of an individual war through its three stages of preparations, the war itself and post-war recovery activities (Royle, 1994; Machlis and Hanson, 2008). Population analyses can be used to measure the magnitude of warfare impacts on biodiversity, using a sample biodiversity hotspots, and socio-political regions (Machlis and Hanson, 2008). The greater the magnitude of hazard, the greater is the potential for causing disaster. But as defined above, the hazard must impact vulnerable human populations to precipitate disaster.

2.4. Time dimension

Disaster impacts generally increase with frequency and duration of disaster events. Multiple disaster events tend to have more impacts than a single event. Similarly, an event of higher magnitude will have more serious impact and even slows recovery process than an event of lesser magnitude. Ecological impacts of military training involving heavy-vehicle exercises have long-term effects. Military trucks and tanks can lead to greater soil compaction and could altered vegetation cover in tank tracks over time. Live-fire training often leads to the accumulation of pollutants such as white phosphorus (a poisonous substance). Weapons-related toxins found in groundwater, vegetation and onshore marine animals have been linked to mercury contamination resulting in high rates of cancer in the local human population (Ortiz-Roque and López-Rivera, 2004; Massol-Deya *et al*., 2005; Porter, 2005). Radioactive particles discharged from nuclear weapon testing have been found to contaminate plants, animals and even human population several kilometres away from the testing sites (Stevens *et al*., 1990; Gerber, 1992).

2.5. Frequency and trends

The frequency of disasters has led to the development of enhanced capacity to record and report disaster events globally. For example, the international disaster registry located at CRED in Brussels, Belgium records natural and human-generated “technological” disaster every hour (CRED, 2005).

CRED maintains the EM-DAT Emergency Disasters Data Base as the mechanism for compiling and sharing information on disasters worldwide (CRED, 2005). A disaster event must meet at least one of the following four criteria to be recorded as a disaster in the EM-DAT Data Base: (i) 10 or more people reported killed, (ii) 100 or more people reported affected, (iii) declaration of a state of emergency, or (iv) a request for international assistance. EM-DAT does not track terrorist events which produces a gap in disaster reporting. This hiatus has been filled by the recently established U.S. Department of Homeland Security's Counter-Terrorism Center which compiles such incidents.
Furthermore, a significant increase in small and medium armed conflicts across the globe has increased the numbers of disaster records. Shultz *et al*. (2007) maintained that greater attention to the frequency of disasters and an increasing sophistication in our ability to detect and report them has produced the perception of an exponential increase in disasters globally. Kirschenbaum (2003) opined that the largely 'artifactual' upsurge in numbers of disaster events, particularly from the 1960s onward, coincides with the emergence of the field of disaster management.

2.6. Duration of impact

Disasters of all forms have their different duration of impact. By duration, it means the time of disaster occurrence. Warfare disaster impact could last for seconds (e.g. bomb blasts); minutes (e.g. terrorist strikes); hours and days (e.g. weapons testing, military assaults and associated fires); weeks and months (e.g. military preparations and combat missions); years (e.g. war, unexploded ordnances (UXOs), chemical contamination, landscape cratering, damaged and destroyed infrastructure, degraded landscapes and ecosystem services, socio-economic disruption and population displacement); decades and centuries (e.g. radioactive contamination from nuclear weapons and long-term illnesses). Duration also covers other aspects such as the period of disruption of vital services and critical infrastructure, duration in which schools and businesses were closed due to damage, and population displaced (Shultz *et al*., 2007). In terms of warfare disaster, repetitive assaults by the military over time and multiplicity of war-related activities can deepen the duration of impact.

2.7. The place dimension

The geospatial dimension of warfare disaster makes war-related disaster to be studied like every other forms of disaster. Disaster is space bound and place specific. Place may prescribe where disasters may or may not occur. It also determines which populations may be impacted. Geographical boundaries mark areas of risk for certain types of disasters. Due to the geographical spread of armed conflicts and war-related disasters, disaster hotspots can be mark out just as it is done for natural disasters. Increasingly, wars and armed conflicts are raging in different parts of the world, particularly in most developing countries. Wars and armed conflicts exacerbate population displacement forcing refugees to take residences in hyper-permeable houses and informal settlements that are vulnerable to the ravages of natural hazards (Agheyisi, 2020). This can help us to interrogate the nexus between armed conflicts and natural disaster.

Similarly, Agheyisi (2017) argues that acts of terrorism are space bound and place specific, having geographic foci. Whereas most places in the world are spared from such human atrocities, certain areas remain hotspots for frequent acts of terror. Shultz *et al*. (2007) added that within states threatened by terrorism, risk of attack varies remarkably by locale which is also a function of terrorist tactics, target selection, and population concentration. Regarding acts of terrorism, terrain, topography and ungoverned spaces (remote and inaccessible places) are all relevant factors in determining safe haven for terrorists and concealment of weapons (Shultz *et al*., 2007; Agheyisi, 2017).

3.0. Evolution of Disaster Ecology: A Review of Literature

Disaster ecological studies related to warfare started in the 1930s and when the British botanists began to document plant invasions in London's rubbles during the 1940 Battle of Britain (Davis, 2002). Two years after the first atomic explosion, studies of what would later become known as "radiation ecology" began at the Trinity site in 1947 (Machlis and Hanson, 2008). The ecosystems and ecological impacts of World War II were carefully documented 55 years after the war (Prose and Wilshire, 2000). Ecologists have focused on the environmental consequences of specific war-related activities such as nuclear testing, operational military training, battlefield contamination, and post-war reconstruction (Homer-Dixon, 2001). Research has shown that in the coming years, resource conflicts

will exacerbate modern interstate warfare (Westing, 1986; Klare, 2002; UNEP, 2007). Scientists have even considered climate change as a "threat multiplier" for states' security and ecosystem services (CNA, 2007).

More recent researches have documented large scale immediate battlefield effects as well as indirect impacts of war across landscapes. For example, research found that the Rwandan civil war and genocide led to increased poaching and large-scale deforestation near refugee camps in the neighbouring Democratic Republic of Congo (Biswas and Tortajada-Quiroz, 1996; McNeely, 2003). A recent study by the United Nations Environment Programme (UNEP) found a strong relationship between land degradation, desertification and conflict in Darfur, Sudan (UNEP 2007). At the height of the Libyan Civil War in 2019, the dust storms raised in the Sahara Desert were felt in far-away North America turning their skyline into pinkish colour. Most post-war ecological researches have focused on cleanup methods, impact assessment, remediation of military sites, forest conservation, and the potential for converting military sites to other uses. Many of such studies represent the evolution of disaster ecology and also demonstrate its potential scope.

Disaster ecology as a discipline emerged to examine the inter-relationships and interdependence of social and environmental risk factors in different contexts as they affect public health (Kaplan, 1999). Disaster ecology utilizes ecological framework to portray the impacts of disasters on human populations (Shultz *et al*., 2007). Research emphasis on ecological context is gaining momentum as increasing numbers of investigations and analyses are conducted from the ecological perspectives culminating in various ecological sub-fields such as disaster ecology and warfare ecology. Shultz *et al*. (2007) used an ecological frame of reference to propose a field of study called disaster psychiatry to consider the interplay, inter-relationship and inter-dependence of factors of disaster, namely; exposure, loss, and change on human mental health.

Disaster ecology examines the inter-relationships and interdependence of the social, psychological, anthropological, cultural, geographic, economic, and human contexts surrounding public health and disaster events such as severe storms, earthquakes, war, acts of terrorism, industrial accidents, and disease epidemics and pandemics (Kaplan, 1999). Shultz *et al*. (2007) emphasized that context largely determines the extent of disaster impact, extent of natural supports and community resources that can be tapped in times of disaster. They further posited that the disaster ecology perspective offers the prospect of disaster-specific research focus and concepts in addition with an appreciation for the importance of the ecological context dimension. Disasters ecology of war reflects the progressive or precipitous effects of human-induced destruction of the environment through an act of war or armed conflicts. Unlike many other forms of disaster, disaster of war is harm and destruction that are intentionally perpetrated by human agents. The distinctive characteristics of disaster in the context of warfare emerge from their deliberateness, destructiveness, and intensity of ecological and socio-economic changes brought about by acts of war.

4.0. Method

This paper is based on desk review of downloaded articles on disaster ecology. The articles were located by performing key word searches using the Google Search Engine. Key words and phrases used in the search include "disaster risk", "disaster ecology", "warfare disaster" and "disaster management". Results were not limited to articles published within any specified period. Once downloaded, the articles were reviewed. Those deemed relevant for this article were retained and utilized in the sub-themes of the article. The selection of articles for inclusion in the study was based on two criteria namely; (1) the article's relevance to the proposed curriculum, (2) the article's applicability to disaster risk management (Agheyisi, 2020). The reviewed articles have citations and references of authoritative scholars in disaster ecology. Textual data utilized in the paper were derived from Machlis and Hanson (2008). All the reviewed articles are included in the reference list.

5.0. Developing Warfare Disaster Ecology Curriculum for Disaster Risk Management

The development and domiciliation of warfare disaster ecology in DRM studies is both a scientific and pedagogical necessities. It has been predicted that environmental change such as climate change will precipitate disaster risks and resource war in the near future, particularly in Africa (UNEP, 2007).

The necessity of disaster ecology emerges from the deliberateness, destructiveness and intensity of ecological and socio-economic disturbances brought about by warfare. There is also the reason of the widespread ecological consequences of warfare, the complexity of warfare's interactions with coupled natural and social systems. Warfare ecology validates the hypotheses concerning the occurrence, type, and magnitude of warfare impacts on biodiversity, and coupled natural and socio-economic systems using samples of wars (Machlis and Hanson, 2008). Warfare disaster ecology has the potential to unravel the cascading effects of warfare and small scale armed conflicts such as the effect of weapon testing on ecosystem restructuring, intensification of urbanization due to warfare (Büscher, 2018), urban reconstruction due to destruction of cities, and alteration of land-use patterns in the countryside. Table 1 provides illustrations of war disaster risk factors that populate warfare ecology subfield. Warfare and armed conflicts are relatively proximal to disaster. Warfare disaster ecology (aggregate and cumulative effects of war) can be interrogated at the local, regional and global scales.

Table 1: Themes of warfare impacts by war stages and scales relevant to disaster management studies

Scale	Stages of War		
	War Preparations	War	Post-war Activities
Local Risks, Hazards/Disaster	Landscape cratering, Soil compaction, Soil erosion, Soil contamination, Habitat and biodiversity disturbance, Compromised human, plant/animal health	Landscape cratering, Soil compaction and contamination from weapons deployment, Destruction of crops and arable land, Habitat destruction, Disturbed habitat, Biodiversity loss, Increased human mortality and morbidity, Increased poaching and deforestation, Damaged infrastructure, Encroachment on protected-areas	Long-term alterations in land use and settlement patterns, Soil contamination resulting to health risks, Groundwater pollution, Biodiversity/habitat conservation in buffer zones, Conversion of military sites to productive uses ("Swords to plowshares" conservation programmes), Restoration/cleanup of battlefields,
Regional Risks, Hazards/Disaster	Presence of war pollutants in regional plants/animals, soils/water; Compromised human health	Increased extraction (looting) of mineral resources, Creation of war economy, Disruption of socio-economic activities, Widespread forest mortality from tactical defoliants and bush fires	Long-term health effects from weapons deployment, Degraded ecosystem services, Large-scale contamination from unexploded ordinances, Lingering socio-economic disruption, Disruption of resource management, Proliferation of light arms and ammunitions, Introduction of exotic plant and animal species, Large- scale conservation programmes
Global Risks, Hazards/Disaster	Nuclear fallout measured in tree rings, ice cores and ocean sediments; War-related carbon emissions	Increased demand for natural resources, Occurrence of nuclear winter, Biological weapons fallout, Increased carbon emissions	Transfer of military technologies to civilian use (e.g. Remote sensing & GIS), disruption of world economy/trade, Large- scale post-war reconstruction activities

Source: Adapted from Machlis and Hanson (2008)

Warfare disaster ecology would not only study when and where armed conflicts take place, but also at what scales such armed conflict processes unfold. By diagnosing the cascading and multi-scalar characters of many environmental and ecological impacts of warfare, WDE helps expose the structural dimensions of many armed conflicts and their more hidden impacts.

At the local scale, firing and bombing ranges used in military exercises, combat training facilities, munitions-making plants, weapons storage facilities, and nuclear testing sites are all military and strategic sites with disaster management significance. Such areas usually preclude human settlements. They also have other ecological impacts such as pollutants, soil compaction and altered settlement patterns. Table 1 illustrates the focus areas of WDE study in DRM programme. While impacts are usually caused in the preparations and war stages, the post-war stage involves the management of the impacts of war.

The study of warfare disaster ecology provides the necessary opportunity for interdisciplinary approach in disaster risk management. It offers us the opportunity to develop theories and models to

predict the relationships between warfare and environmental hazards such as biodiversity loss and decline in ecosystem services; develop mitigation, rehabilitation, and restoration strategies for war-related disasters; and formulate impact assessments of war and other protracted armed conflicts as well as the use of high-grade military weapons. Crucially, WDE in disaster risk management would expand the curriculum and areas of specialization for graduate students. Graduate courses in DRM should reflect specialized topics such as environmental security, environmental accounting, ecological analysis, post-conflict rehabilitation, remediation of military sites, disaster risks accounting, disaster risks auditing, ecological risk assessment, disaster risk governance, etc.

6.0. Policy Implications

Several policy implications emerged from the proposed domiciliation of warfare disaster ecology (WDE) in disaster risk management. These policy outcomes are most relevant to guide military operations and conflict resolution. Machlis and Hanson (2008) suggested two broad policy directions for the application of warfare ecology. The first is the application of warfare ecology to further encourage the incorporation of ecological science into military policy-making and planning. This application could provide, among other things, improved policies to mitigate war preparation impacts; refinement of war policies and tactical plans that incorporate protection of critical ecosystem services to ensure post-war capacities; enforcement and strengthening of existing international conventions relevant to the environment, and establishment of new conventions covering war remnants and post-war restoration. An example is the Convention on the Prohibition of Military Use of Environmental Modification Techniques (ENMOD) which prohibits environmental modification tactics such as weather manipulation, forest defoliation, and crop destruction as tools of war.

The second is the use of warfare ecology to encourage policies that promote the conversion of decommissioned military sites such as bombing ranges, combat training facilities, munitions plants, weapons storage facilities, military airfields and ports, and nuclear testing sites to conservation purposes. Similarly, the application of the science of warfare disaster ecology (WDE) will help develop ecosystem and environmental monitoring policies and decision-making tools by the network of concerned bodies that includes governments, armed forces, academia, security boardrooms, United Nations agencies, the International Committee of the Red Cross, and other aid organizations.

7.0. Conclusions

This paper is a novel proposition on the curriculum development of 'Warfare Disaster Ecology' (WDE) as a pedagogical addendum to disaster risk management (DRM) curriculum. Armed conflict, despite the disastrous catastrophes it engenders, has yet to make significant inroads into DRM studies. This paper discusses opportunities for connecting war-related hazards and disasters with the mainstream DRM through the three stages of war. Connecting the two fields with each other would undoubtedly develop and strengthen the ways that DRM research addresses the interplay between armed conflict dynamics and global environmental change, and thus develop ways disaster researchers define conflict. This interconnection would be particularly useful for peace and conflict studies, and for military and academic engagements to take up these issues further in order to help develop disaster ecology approaches to understanding the nature and impacts of armed conflicts.

Interpreting armed conflict through the lens of disaster would thus grant armed conflict a central theme in DRM. This implies that a new curriculum of warfare disaster ecology (WDE) seeks radical transformation of the existing structure of DRM. This could also assist DRM to develop fresh approaches to understanding the interplay between global environmental change and armed conflicts and thereby moving away from the current simplistic focus on environmental safety. However, to be effective, contributions from disaster risk managers need to be reflective of their professionalism and as such engage in fine-grained analyses attuned to the nuances of power relations in conflict management, but also prospective reflections on the direct and indirect effects that such scholarly interventions and participatory action research will likely produce. A new curriculum starts by paradigm shift and winning allies.

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