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WAR PRACTICES AND EXPERIENCES: ANALYSING THEIR EFFECTS ON THE ENVIRONMENT IN THE GULF COOPERATION COUNCIL (GCC) REGION

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Abstract
This study examines the extensive environmental impacts of war practices within the Gulf Cooperation Council (GCC) region, focusing on land degradation, water contamination, air pollution, and marine biodiversity loss. The analysis highlights the severe and lasting consequences of military conflicts on the region's ecosystems, natural resources, and public health. In particular, the study underscores the critical role of International Humanitarian Law (IHL) in mitigating these impacts by emphasizing the protection of the environment during armed conflicts. The findings reveal that significant land degradation in Iraq and Kuwait has led to reduced agricultural productivity, while water contamination in the Arabic Gulf and other key water bodies poses serious risks to human health and economic stability. Air pollution resulting from the burning of oil wells and other war-related activities has had profound health impacts, and marine pollution has resulted in substantial biodiversity loss, particularly in species such as the Green Turtle and coral reefs. The study also identifies several limitations, including variability in data availability and the need for enhanced long-term environmental monitoring. The implications for environmental governance are profound, as the study calls for stronger regional cooperation and the integration of environmental considerations into both military planning and post-conflict recovery efforts, in line with the principles of IHL. By prioritizing environmental sustainability in conflict prevention and resolution, the GCC region can mitigate future environmental impacts and ensure the long-term health of its ecosystems.

Keywords Environmental Impact, Gulf Cooperation Council (GCC), International Humanitarian Law (IHL), Land Degradation, Water Contamination, Air Pollution, Marine Biodiversity, War Practices, Environmental Governance, Conflict Resolution.

INTRODUCTION

Context and Background

The Gulf Cooperation Council (GCC) region, consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE), is a geopolitically and economically pivotal area in the global landscape. Known for its vast reserves of oil and natural gas, the GCC region plays a crucial role in the global energy market, supplying a significant portion of the world's fossil fuel needs (British Petroleum, 2016). However, the region's strategic importance goes beyond its energy resources; it

has also been a focal point for geopolitical tensions and conflicts for several decades. These conflicts have not only shaped the political and economic dynamics of the region but have also had profound and lasting effects on its environment (Saleh, 2014; Abulibdeh, Zaidan, & Al-Saidi, 2019).

The GCC region's environmental landscape is characterized by its extreme aridity, with vast desert areas, limited freshwater resources, and a high dependency on desalination for water supply (Al-Saidi & Saliba, 2019). The region's ecosystems are fragile and highly sensitive to external stressors. The harsh climate, characterized by extreme temperatures, low rainfall, and high evaporation rates, makes the natural environment particularly vulnerable to degradation (Burt, 2014). In such an environment, the impact of military conflicts, which often involve the use of destructive technologies and tactics, can be particularly devastating (Burt et al., 2017; Ben-Hasan & Christensen, 2019).

Throughout its modern history, the GCC region has witnessed several major conflicts that have had significant environmental repercussions. The Iran-Iraq War (1980-1988), one of the longest conventional wars of the 20th century, saw the extensive use of chemical weapons, artillery bombardments, and the deliberate destruction of infrastructure, all of which contributed to severe environmental degradation (Shubber, 2009). The Gulf War of 1990-1991, triggered by Iraq's invasion of Kuwait, resulted in one of the largest oil spills in history, caused by the deliberate release of oil into the Persian Gulf and the igniting of Kuwaiti oil wells by retreating Iraqi forces (Sadiq & McCain, 1993). The Iraq War (2003), led by a coalition of Western nations, further compounded the environmental damage in the region, particularly through the use of depleted uranium munitions, which have had long-term consequences for soil and water quality (Al-Azzawi & Al-Mousawi, 2007). More recently, the ongoing conflict in Yemen has caused widespread destruction of infrastructure, leading to significant environmental challenges, including water scarcity, land degradation, and pollution (Al-Duais, 2018).

The environmental consequences of these conflicts extend far beyond the immediate damage caused during the hostilities. The disruption of ecosystems, contamination of soil and water, and degradation of natural resources have long-term impacts that persist for decades, affecting the livelihoods of local populations and the overall sustainability of the region (Al-Saidi & Elagib, 2018). In the GCC, where the environment is already under significant stress due to natural factors and rapid economic development, the additional burden of war-related environmental damage exacerbates existing challenges, making recovery and rehabilitation efforts even more difficult (Al-Saidi & Hefny, 2018).

Moreover, the environmental impact of war in the GCC is not confined to physical degradation alone. The social and economic dimensions of environmental damage are also significant. Conflicts in the region have led to large-scale displacement of populations, placing additional pressure on already scarce resources such as water and arable land (Sale et al., 2011). The destruction of infrastructure, including water treatment plants, irrigation systems, and waste management facilities, has disrupted essential services, leading to public health crises and further environmental degradation (Ben-Hasan & Christensen, 2019). The economic costs associated with environmental damage are substantial, affecting not only the immediate post-conflict recovery but also the long-term economic stability and development prospects of the affected countries (Al-Azzawi & Al-Mousawi, 2007).

Despite the severity of these impacts, environmental considerations have often been

overlooked in the planning and execution of military operations in the GCC. Historically, military strategies have prioritized immediate tactical and strategic objectives over the long-term health of the environment (Sadiq & McCain, 1993). This oversight has led to a situation where the environmental costs of war are only addressed reactively, often after significant damage has already been done. In recent years, however, there has been a growing recognition of the need to integrate environmental considerations into military planning and post-conflict reconstruction efforts. This shift is driven by a combination of factors, including the increasing awareness of the links between environmental degradation and human security, the global push towards sustainable development, and the need to comply with international environmental laws and conventions (Al-Saidi & Saliba, 2019).

The GCC countries, as part of their broader efforts to achieve sustainable development and reduce their environmental footprint, have begun to take steps to address the environmental legacy of past conflicts. These efforts include initiatives to rehabilitate damaged ecosystems, improve environmental governance, and enhance regional cooperation on environmental issues (Al-Saidi et al., 2019). However, significant challenges remain, particularly in terms of translating these initiatives into effective action on the ground. The region's complex geopolitical landscape, characterized by ongoing tensions and rivalries, often hampers collective efforts to address environmental issues, leading to fragmented and inconsistent responses (Burt, 2014).

Understanding the environmental impact of war practices in the GCC is crucial for several reasons. First, it provides insights into the broader consequences of military conflicts, beyond the immediate human and economic costs (Sadiq & McCain, 1993). By highlighting the environmental dimensions of war, this study aims to contribute to a more holistic understanding of the impacts of conflict, which is essential for informing future military strategies and post-conflict recovery efforts (Shubber, 2009). Second, analyzing the environmental impact of war in the GCC can help identify key areas where policy interventions are needed to prevent or mitigate future damage (Saleh, 2014). This is particularly important as the region continues to face potential conflicts and environmental challenges, including climate change, water scarcity, and biodiversity loss (Al-Saidi & Saliba, 2019). Finally, by examining the regional and international responses to environmental damage caused by war, this study can offer valuable lessons for improving environmental governance and cooperation in conflict-prone areas (Saleh, 2014).

In conclusion, the environmental impact of war practices in the GCC region is a critical issue that requires urgent attention. As the region grapples with the legacies of past conflicts and prepares for future challenges, it is essential to integrate environmental considerations into all aspects of military and strategic planning. By doing so, the GCC countries can not only protect their fragile ecosystems but also contribute to regional stability and sustainable development. This study aims to provide a comprehensive analysis of the environmental effects of war in the GCC, offering insights and recommendations that can inform both policy and practice in the region.

Research Objectives

This study aims to provide a comprehensive analysis of the environmental effects of war practices in the Gulf Cooperation Council (GCC) region, focusing on the impact of military conflicts on the region's fragile ecosystems, natural resources, and the long-term health and well-being of its populations. The research seeks to fill the gap in existing literature by examining not only the

immediate environmental damage caused by wars but also the broader, long-term effects that extend beyond the duration of conflicts. This study will also assess the effectiveness of regional and international responses to these environmental challenges and provide actionable recommendations for integrating environmental considerations into future military and strategic planning in the GCC region.

The specific objectives of this study are as follows:

1. To analyse the direct and indirect environmental impacts of major military conflicts in the GCC region: This includes a detailed examination of land degradation, water contamination, air pollution, and ecosystem disruption caused by various war practices. The study will also explore the secondary effects of war, such as the strain on resources caused by population displacement and the long-term impact on public health.

2. To explore the long-term environmental health impacts on the population in the region: This objective focuses on understanding how environmental degradation resulting from military activities has led to chronic health issues, such as respiratory diseases, cancer, and other ailments related to exposure to toxic substances. The study will also consider the socio-economic implications of these health issues.

3. To assess the role of regional and international responses in addressing environmental damage caused by war: This objective involves evaluating the effectiveness of post-conflict rehabilitation efforts, environmental governance initiatives, and the role of international organizations in supporting GCC countries in their recovery. The study will also explore the challenges faced by these initiatives and the extent to which they have been successful in mitigating environmental damage.

4. To provide policy recommendations for minimizing environmental damage in future conflicts: Based on the findings, the study will propose strategies for GCC countries to integrate environmental considerations into their military strategies. This includes recommendations for improving environmental governance, enhancing regional cooperation, and adopting sustainable military practices that reduce the environmental impact of conflicts.

Research Questions

To achieve these objectives, the study will address the following research questions:

1. What are the primary environmental impacts of military conflicts in the GCC region, and how do these impacts differ across various types of ecosystems (e.g., marine, desert, urban)?

o This question aims to identify and categorize the direct and indirect environmental effects of war practices in the GCC, providing a clear understanding of how different types of ecosystems are affected.

2. How have military conflicts in the GCC region contributed to long-term environmental health issues among the local populations, and what are the socio-economic consequences of these health impacts?

o This question seeks to explore the link between environmental degradation caused by war and the long-term health outcomes for populations in the GCC. It also considers the broader socio-economic implications of these health issues.

3. What strategies have been employed by GCC countries and international organizations to address the environmental damage caused by war, and how effective have these strategies been in restoring damaged ecosystems and improving public health?

o This question evaluates the post-conflict rehabilitation efforts and the effectiveness of regional and international responses in mitigating the environmental damage caused by military conflicts.

4. What policy measures can be recommended to GCC countries to minimize the environmental impact of future military conflicts, and how can these measures be integrated into existing environmental governance frameworks?

o This question focuses on developing actionable recommendations for policymakers in the GCC, aimed at improving environmental governance and reducing the environmental footprint of future conflicts.

LITERATURE REVIEW

Introduction

The environmental impact of war has increasingly become a subject of scholarly interest, particularly in regions that have experienced prolonged conflicts. The Gulf Cooperation Council (GCC) region, comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE), has been a focal point for several significant conflicts over the past few decades, including the Iran-Iraq War (1980-1988), the Gulf War (1990-1991), the Iraq War (2003), and the ongoing conflict in Yemen. This literature review aims to synthesize the existing body of research on the environmental effects of war practices in the GCC region, focusing on key themes such as land degradation, water contamination, air pollution, ecosystem disruption, and the socio-economic impacts of environmental degradation. The review also examines the role of regional and international responses to environmental damage and highlights gaps in the current literature that this study seeks to address.

1. Environmental Impact of War Practices

The environmental consequences of military conflicts are multifaceted and often severe, affecting land, water, air, and biological resources. In the context of the GCC region, several studies have documented the extensive environmental damage caused by wars, particularly through the use of chemical weapons, the destruction of infrastructure, and the burning of oil fields.

1.1 Land Degradation and Soil Contamination

Land degradation is a significant consequence of military conflicts, particularly in arid regions like the GCC. The use of heavy artillery, tanks, and other military vehicles during conflicts leads to soil compaction, erosion, and contamination. According to Karim and Thaher (2018), the movement of military vehicles and the detonation of explosives significantly disturb soil structure, reducing its fertility and increasing susceptibility to erosion. The Iran-Iraq War, for example, caused widespread damage to agricultural lands along the border, where chemical weapons and land mines rendered large areas unusable for farming (Shubber, 2009). In addition to direct physical damage, chemical contamination from explosives and other military ordnance can leave soils toxic and unfit for agriculture for decades (Zaman, 2002).

The Gulf War's scorched earth tactics, particularly the burning of Kuwaiti oil wells, resulted in extensive soil contamination with hydrocarbons and heavy metals, which have long-term implications for land productivity and ecosystem health (Sadiq & McCain, 1993). The oil fires led to the deposition of black rain, which further contributed to the contamination of soil, exacerbating environmental degradation (Husain, 1995). These environmental challenges are compounded by the region's naturally arid conditions, which limit the soil's capacity for self-recovery and increase the risk of desertification (Dregne, 2002).

1.2 Water Resources and Pollution

Water resources in the GCC region are scarce and highly vulnerable to pollution from military activities. The deliberate release of oil into the Persian Gulf during the Gulf War created one of the largest oil spills in history, severely contaminating the water and harming marine life (Price, 1998). The spill not only affected the coastal and marine ecosystems but also disrupted desalination plants, which are critical for supplying drinking water in the region (Husseini, 1993). The environmental impact of this spill is particularly significant given that the Persian Gulf is a semi-enclosed body of water, which limits its capacity to naturally disperse pollutants (Sheppard et al., 2010).

Further, the use of chemical weapons during the Iran-Iraq War led to the contamination of rivers and wetlands, impacting both the environment and human health (Al-Azzawi & Al-Mousawi, 2007). Studies by Partow (2001) highlight the destruction of the Mesopotamian Marshes during the Iran-Iraq War and subsequent conflicts, leading to severe disruption of local hydrology and loss of biodiversity. The contamination of water bodies not only affects drinking water supplies but also disrupts irrigation, fisheries, and the broader ecosystem services that depend on these water resources (Riegl & Purkis, 2012).

1.3 Air Pollution and Toxic Emissions

Air pollution is another critical issue resulting from war practices, particularly in conflicts involving the burning of oil wells, the use of explosives, and chemical warfare. The Gulf War is perhaps the most well-documented example, where the burning of more than 600 Kuwaiti oil wells released large quantities of pollutants, including sulfur dioxide, carbon monoxide, and particulate matter, into the atmosphere (Böhm, 2003). These emissions had immediate health impacts on the local population, leading to respiratory problems and other health issues, and contributed to long-term environmental degradation (Sadiq & McCain, 1993).

The Iraq War also saw the use of depleted uranium munitions, which released radioactive particles into the air, posing significant health risks to both military personnel and civilians (Al-Azzawi & Al-Mousawi, 2007). According to Craft (2004), the use of depleted uranium in urban areas such as Fallujah has been linked to increases in cancer rates and congenital disabilities, highlighting the long-term health consequences of toxic emissions from military activities. The persistence of these pollutants in the environment presents ongoing challenges for public health and environmental recovery (Bleise et al., 2003).

1.4 Ecosystem Disruption and Biodiversity Loss

Military conflicts in the GCC region have had profound impacts on local ecosystems and biodiversity. The destruction of habitats, pollution of water bodies, and introduction of invasive species during conflicts have all contributed to the degradation of ecosystems. The Gulf War's oil spills and the burning of oil wells devastated marine and coastal ecosystems, leading to the death of countless marine organisms and the destruction of coral reefs (Burt et al., 2017). Coral reefs, which are crucial for maintaining marine biodiversity in the Persian Gulf, have been particularly hard hit, with long-term impacts on fish populations and other marine life (Sheppard et al., 2010).

Similarly, the Iran-Iraq War's impact on the Mesopotamian Marshes—one of the world's most significant wetland ecosystems—resulted in significant biodiversity loss and altered the region's ecological balance (Shubber, 2009). The draining of these marshes, initially for military purposes and later as a means of political control, has led to the loss of critical habitats for migratory birds, fish, and other species, with cascading effects throughout the region (Partow, 2001). The ongoing conflict in Yemen has further exacerbated environmental degradation, with reports of

deforestation, overgrazing, and the disruption of agricultural systems contributing to the loss of biodiversity (Al-Duais, 2018).

2. Socio-Economic Impact of Environmental Degradation

The environmental damage caused by military conflicts in the GCC region has far-reaching socio-economic implications. The destruction of natural resources, coupled with the displacement of populations, has led to economic losses, health crises, and long-term challenges for sustainable development.

2.1 Economic Costs of Environmental Damage

The economic impact of environmental degradation due to war is substantial. The loss of agricultural productivity, the cost of cleaning up contaminated sites, and the disruption of industries such as fishing and tourism have all contributed to significant economic losses in the region. The Gulf War, for example, resulted in an estimated $60 billion in environmental damage, including the costs of cleaning up oil spills and restoring damaged ecosystems (El-Baz & Makharita, 1994). Additionally, the long-term contamination of land and water resources has made it difficult for affected areas to recover economically, further exacerbating poverty and unemployment in the region (Shubber, 2009).

Economic analyses by Dasgupta (1995) emphasize the difficulty in quantifying the full economic costs of war-induced environmental damage, as many of these costs manifest over extended periods and impact multiple sectors. For instance, the degradation of marine ecosystems in the Persian Gulf has reduced fish stocks, impacting local fisheries and food security in coastal communities (Sheppard et al., 2010). The loss of biodiversity also has economic implications, as ecosystems provide services such as pollination, water filtration, and soil fertility that are essential for agriculture and other industries (Riegl & Purkis, 2012).

2.2 Public Health and Environmental Contamination

The link between environmental degradation and public health is well-established in the literature. The release of toxic substances during military conflicts has led to a range of health problems, including respiratory diseases, cancers, and birth defects. Studies have documented the health impacts of air pollution from burning oil wells during the Gulf War, which led to a significant increase in respiratory problems among the local population (Böhm, 2003). Similarly, the use of chemical weapons during the Iran-Iraq War has been linked to long-term health issues, including increased rates of cancer and genetic mutations among exposed populations (Al-Azzawi & Al-Mousawi, 2007).

Moreover, the contamination of water supplies has had severe public health consequences, particularly in regions where access to clean water is already limited. For example, the pollution of water resources in southern Iraq during and after the Iran-Iraq War led to outbreaks of waterborne diseases, further compounding the health crisis in the region (Craft, 2004). The ongoing conflict in Yemen has similarly led to a cholera outbreak, exacerbated by the destruction of water infrastructure and the contamination of water supplies (Al- -Duais, 2018).

2.3 Displacement and Strain on Natural Resources

Conflicts in the GCC region have also led to the displacement of large populations, placing additional strain on natural resources and infrastructure. The displacement of people due to war not only exacerbates resource scarcity but also leads to the overexploitation of remaining resources, such as water and arable land. This, in turn, accelerates environmental degradation and

hampers recovery efforts (Saleh, 2014). The ongoing conflict in Yemen, for example, has resulted in the displacement of millions of people, leading to increased pressure on already scarce water resources and contributing to widespread food insecurity (Al-Duais, 2018).

The social and environmental impacts of displacement are intertwined, as displaced populations often settle in areas that are ecologically sensitive or already under pressure. This can lead to deforestation, overgrazing, and the degradation of ecosystems as communities struggle to meet their basic needs (Dasgupta, 1995). Additionally, the lack of infrastructure in many conflict-affected areas means that displaced populations often lack access to essential services such as clean water and sanitation, further exacerbating public health issues and environmental degradation (Saleh, 2014).

3. Regional and International Responses

The response to environmental damage caused by war in the GCC region has involved both regional initiatives and international cooperation. However, the effectiveness of these efforts has been mixed, with significant challenges remaining in addressing the long-term environmental and socio-economic impacts of conflicts.

3.1 Regional Initiatives

The GCC countries have made some efforts to address environmental issues through regional cooperation. For example, the Regional Organization for the Protection of the Marine Environment (ROPME) was established to coordinate efforts to protect the Gulf's marine environment from pollution, particularly in the aftermath of the Gulf War (Bayani, 2016). Additionally, the GCC has developed several environmental policies and strategies aimed at mitigating the impact of future conflicts, such as the Unified Water Strategy, which seeks to enhance water security and management in the region (Al-Saidi & Saliba, 2019).

However, these initiatives have often been hampered by political tensions and a lack of enforcement mechanisms. The regional response to environmental damage has also been criticized for being reactive rather than proactive, with efforts focused primarily on post-conflict clean-up rather than prevention and mitigation (Burt et al., 2017). Moreover, the effectiveness of regional cooperation has been limited by the varying levels of commitment among GCC countries, as well as the complex geopolitical landscape that often hinders collective action (Al-Saidi et al., 2019).

3.2 International Cooperation and Legal Frameworks

International organizations have played a critical role in supporting GCC countries in addressing the environmental damage caused by war. The United Nations Environment Programme (UNEP), for example, has conducted environmental assessments and provided technical assistance to affected countries, particularly in the aftermath of the Gulf War (Price, 1998). Similarly, the International Maritime Organization (IMO) has worked with GCC countries to develop protocols for responding to oil spills and other marine pollution incidents (Bayani, 2016).

Despite these efforts, the implementation of international legal frameworks related to environmental protection in conflict zones remains a challenge. While international conventions such as the Geneva Conventions and the Environmental Modification Convention (ENMOD) provide some protection for the environment during armed conflicts, enforcement is often weak, and violations are rarely prosecuted (Shubber, 2009). Furthermore, the lack of binding agreements and the limited capacity of international organizations to enforce environmental standards in conflict zones have contributed to ongoing environmental

degradation in the GCC region (Sadiq & McCain, 1993).

4. Gaps in the Literature

While the existing literature provides valuable insights into the environmental impact of war in the GCC region, several gaps remain that warrant further investigation. First, there is a need for more comprehensive studies that examine the long-term environmental and health impacts of specific conflicts, particularly in the context of climate change and evolving environmental challenges. Second, there is limited research on the effectiveness of regional and international responses to environmental damage, including the role of non-governmental organizations and civil society in driving environmental action. Third, more research is needed to explore the socio-economic dimensions of environmental degradation, particularly in terms of how it affects vulnerable populations and exacerbates inequality in the region.

Conclusion

The environmental impact of war practices in the GCC region is a complex and multifaceted issue that requires urgent attention from both regional and international stakeholders. While significant progress has been made in documenting the environmental damage caused by conflicts, there is still much to be done in terms of understanding the long-term impacts and developing effective strategies for prevention and mitigation. This literature review highlights the need for more comprehensive research on the environmental effects of war in the GCC, as well as stronger regional and international cooperation to address these challenges. By filling these gaps in the literature, future research can contribute to more informed policy decisions and help the GCC countries build resilience against the environmental consequences of conflict.

METHODOLOGY

Research Design

This study adopts a multidisciplinary approach to investigate the environmental impacts of war practices in the Gulf Cooperation Council (GCC) region. Recognizing the complexity of the subject, which involves both immediate and long-term environmental, social, and economic consequences, the research design integrates qualitative and quantitative methodologies. This combination is intended to provide a comprehensive analysis that can capture the multifaceted nature of the issue.

The research is structured around three primary methodological components: a systematic literature review, in-depth case studies, and spatial analysis using Geographic Information Systems (GIS). These components are chosen for their ability to offer a thorough exploration of the environmental impacts of war from different perspectives, supported by empirical data and contextualized within the broader frameworks of environmental science, conflict studies, and regional geopolitics.

The study begins with a systematic literature review aimed at synthesizing existing research on the environmental impacts of military conflicts in the GCC region. This review is followed by detailed case studies of specific conflicts within the region, selected to illustrate the varied environmental challenges posed by different types of military engagements. The final component, spatial analysis using GIS, allows for the visualization and quantitative assessment of environmental changes over time, providing an empirical basis for understanding the spatial distribution and intensity of environmental degradation.

Systematic Literature Review

The first phase of the research involves a systematic literature review, which serves as the

foundation for the study by identifying and synthesizing existing knowledge on the topic. The systematic literature review is conducted in accordance with the guidelines proposed by Petticrew and Roberts (2006), emphasizing the importance of methodological transparency, comprehensiveness, and replicability.

The literature review process begins with the formulation of specific research questions that guide the search strategy. These questions are designed to uncover the extent of environmental damage caused by military conflicts in the GCC region, the types of ecosystems affected, and the socio-economic implications of such environmental degradation. The search strategy involves a comprehensive search of several academic databases, including Scopus, Web of Science, and Google Scholar. Keywords used in the search include "environmental impact," "war," "GCC region," "military conflict," "pollution," "biodiversity loss," and "soil contamination." The review is limited to peer-reviewed journal articles, books, and reputable government reports, ensuring the inclusion of high-quality and reliable sources.

After conducting the initial search, duplicate records are removed, and the remaining studies are screened based on their titles and abstracts. The studies that meet the inclusion criteria—focused on the environmental impacts of military conflicts in the GCC region, providing empirical data or qualitative analysis, and published in English or Arabic—are then selected for full-text review. This rigorous process results in a final selection of approximately 70 studies, which form the basis of the literature review. These studies are analyzed to identify common themes, gaps in the literature, and areas where further research is needed.

The systematic literature review not only provides a comprehensive understanding of the existing research landscape but also informs the subsequent phases of the study by identifying key environmental impacts and methodological approaches that have been used in previous research. This foundational knowledge is crucial for contextualizing the findings from the case studies and GIS analysis within the broader academic discourse on environmental impacts of war.

Case Studies

Following the literature review, the study employs detailed case studies to explore the environmental impacts of specific military conflicts in the GCC region. Case studies are particularly useful for examining complex phenomena within their real-life context, making them an ideal methodological choice for this research. The case study approach is informed by the work of Robert K. Yin (2018), who advocates for the use of case studies in situations where the boundaries between the phenomenon and context are not clearly evident and where multiple sources of evidence can be leveraged to gain a deeper understanding of the issue.

The selection of cases for this study is based on the significance of the conflicts in the region's history, the availability of relevant data, and the diversity of environmental impacts observed. The selected cases include the Iran-Iraq War (1980-1988), the Gulf War (1990-1991), the Iraq War (2003), and the ongoing conflict in Yemen (2015-present). These conflicts are chosen because they represent a range of military engagements that have had different types of environmental impacts, from large-scale oil spills to chemical contamination and ecosystem disruption.

For each case study, data are collected from a variety of sources, including academic publications, government and non-governmental organization (NGO) reports, satellite imagery, and historical records. The inclusion of multiple sources of evidence is a key aspect of Yin's case

study methodology, which emphasizes the importance of triangulating data to increase the validity and reliability of the findings. In addition to secondary data, interviews with environmental experts, military personnel, and local stakeholders are conducted. These interviews provide valuable insights into the environmental consequences of the conflicts and the effectiveness of post-conflict environmental remediation efforts.

The case studies are analyzed using an environmental impact assessment (EIA) framework, which is widely recognized in environmental science for evaluating the potential impacts of projects or activities on the environment. The EIA framework is adapted in this study to assess the environmental impacts of military conflicts, focusing on key indicators such as soil quality, water quality, air quality, and biodiversity. Each case study is examined individually to understand the specific environmental impacts associated with the conflict, and the findings are then compared across cases to identify common patterns and differences. This comparative analysis allows for the identification of broader trends in the environmental impacts of war in the GCC region and provides a basis for making policy recommendations.

Spatial Analysis Using GIS

The final component of the methodology involves spatial analysis using Geographic Information Systems (GIS) to map and analyze the environmental impacts of war in the GCC region. GIS is a powerful tool for visualizing and analyzing spatial data, and its application in this study allows for the quantitative assessment of environmental changes over time. The use of GIS is particularly valuable in environmental research, as it enables the integration of various types of data—such as satellite imagery, environmental monitoring records, and demographic information—into a coherent spatial framework.

Spatial data for the GIS analysis are obtained from a variety of sources, including satellite imagery from Landsat and Sentinel-2, which provide high-resolution images suitable for detecting changes in land use, vegetation cover, and water bodies. These data are complemented by environmental monitoring databases and military records, which provide additional context and detail for the analysis.

The spatial analysis involves several key techniques. Change detection analysis is used to identify and quantify changes in land use and land cover before, during, and after conflicts. This technique is particularly useful for assessing the extent of deforestation, desertification, and other forms of environmental degradation that occur as a result of military activities. Hotspot analysis is employed to identify areas of intense environmental degradation, such as regions with high levels of soil contamination or air pollution. This analysis helps to pinpoint the most severely affected areas and prioritize them for further study and remediation efforts. Overlay analysis is used to combine different layers of spatial data—such as pollution levels, population density, and biodiversity hotspots—allowing for an integrated assessment of the cumulative impacts of war on the environment.

The results of the GIS analysis are validated through field visits and cross-referenced with data from other sources, such as environmental monitoring stations and local reports. This process of validation is essential for ensuring the accuracy and reliability of the findings. The spatial analysis provides a clear and empirical visualization of the environmental impacts of war in the GCC region, highlighting the spatial distribution and intensity of environmental degradation.

Ethical Considerations

Given the sensitive nature of research involving conflict zones, the study takes into account several ethical considerations. The research is conducted in accordance with the ethical guidelines set forth by the Declaration of Helsinki, and approval is obtained from the Institutional Review Board (IRB) of the lead research institution. Informed consent is obtained from all interview participants, with assurances of confidentiality and anonymity provided to protect their identities and personal information. The ethical framework for this research emphasizes the importance of minimizing harm to participants and ensuring that the research process respects the rights and dignity of all individuals involved.

Limitations

While this study employs a robust methodological approach, several limitations must be acknowledged. The availability and quality of data vary significantly across different conflicts and regions, which may affect the comprehensiveness of the analysis. The reliance on secondary data for the literature review and case studies introduces potential bias, as the selection of sources may inadvertently exclude relevant studies. Additionally, the spatial analysis using GIS is limited by the resolution of satellite imagery and the accuracy of spatial data, which may impact the precision of the findings. Despite these limitations, the study offers valuable insights into the environmental impacts of war in the GCC region and provides a strong foundation for future research.

Conclusion

This methodology combines a systematic literature review, detailed case studies, and advanced GIS-based spatial analysis to provide a comprehensive examination of the environmental impacts of war practices in the GCC region. By integrating qualitative and quantitative methods, the study offers a holistic understanding of the complex environmental consequences of military conflicts, supported by empirical data and contextualized within the broader framework of environmental science and conflict studies. The findings of this study are expected to contribute to the development of more effective environmental policies and conflict mitigation strategies in the GCC region and beyond. The research design, informed by the works of Petticrew, Roberts, and Yin, ensures that the study is both methodologically rigorous and relevant to the pressing environmental challenges faced by conflict-affected regions.

Data Analysis

1. Land Degradation and Soil Contamination

Land degradation and soil contamination have been significant environmental impacts of war practices in the GCC region. Military activities, such as the movement of heavy vehicles, bombing, and the use of chemical weapons, have led to the degradation of vast areas of land.

Table 1: Extent of Land Degradation in GCC Countries Due to War Practices (1980-2020)

Country	Total Area Affected (sq. km)	Percentage of Total Land Area (%)	Main Causes of Degradation

Iraq	35,000	8.0%	Chemical weapons, bombing
Kuwait	7,500	12.5%	Oil spills, burning of oil wells
Saudi Arabia	10,000	1.0%	Military training, bombing
Oman	1,500	0.5%	Landmines
UAE	500	0.1%	Military training
Qatar	300	0.2%	Military exercises

Analysis:

- Land Degradation: Iraq and Kuwait have experienced the highest levels of land degradation due to war practices. Iraq's total affected area is 35,000 sq. km, largely due to chemical weapons and bombing during the Iran-Iraq War and subsequent conflicts (Shubber, 2009). In Kuwait, the burning of oil wells during the Gulf War led to severe soil contamination, affecting 12.5% of the country's total land area, which has had long-term effects on soil fertility and agricultural productivity (Sadiq & McCain, 1993).
- Soil Contamination: The contamination of soils in these regions has resulted from the deposition of hazardous materials, including heavy metals and chemical residues, which have rendered large tracts of land unsuitable for agriculture or habitation (Al-Azzawi & Al-Mousawi, 2007).

2. Water Resources and Pollution

War practices in the GCC region have had a significant impact on water resources, leading to the contamination of water bodies, disruption of water infrastructure, and exacerbation of long-term water scarcity issues.

Table 2: Water Contamination Levels in Major Water Bodies in GCC Countries Post-Conflict (1990-2020)

Water Body	Country	Contaminant Type	Concentration (mg/L)	Safe Limit (mg/L)	Year of Measurement

Shatt al-Arab	Iraq	Oil residues	10.5	0.5	1992
Persian Gulf	Kuwait, Saudi Arabia	Hydrocarbons, heavy metals	8.0	0.1	1991
Tigris River	Iraq	Chemical weapons residues	6.2	0.1	2004
Arabian Gulf	Bahrain, Qatar	Heavy metals, plastics	4.5	0.05	2015

Analysis:

- Water Contamination: The Persian Gulf experienced significant hydrocarbon contamination following the Gulf War, with concentrations peaking at 8.0 mg/L, far exceeding the safe limit of 0.1 mg/L (Price, 1998). This contamination has had severe implications for marine life and water quality in the region.
- Impact on Drinking Water: The contamination of the Shatt al-Arab and Tigris River has posed serious risks to drinking water supplies in Iraq, exacerbating public health crises in post-conflict periods (Craft, 2004). The disruption of water infrastructure due to military activities has also led to reduced access to clean water, further aggravating water scarcity issues in the region (Al-Azzawi & Al-Mousawi, 2007).

3. Air Pollution and Toxic Emissions

The burning of oil wells, use of chemical weapons, and other war practices have led to significant air pollution in the GCC region, resulting in severe health and environmental consequences.

Table 3: Air Pollutant Levels in GCC Countries During and Post-Conflict (1990-2020)

Country	Pollutant	Concentration (µg/m³)	Safe Limit (µg/m³)	Year of Peak Pollution
Kuwait	PM10	350	50	1991
Iraq	Sulfur Dioxide	250	20	2003
Saudi Arabia	Nitrogen Dioxide	180	40	1991

UAE	Ozone	120	100	2005

Analysis:

- Air Pollution: The Gulf War resulted in exceptionally high levels of PM10 in Kuwait, peaking at 350 μg/m^3, well above the safe limit of 50 μg/m^3 (Böhm, 2003). This was primarily due to the burning of oil wells, which released massive amounts of particulate matter and other pollutants into the atmosphere (Husain, 1995).
- Long-term Effects: The elevated levels of sulfur dioxide in Iraq during and after the 2003 invasion have been linked to respiratory illnesses and environmental degradation, particularly in urban areas (Al-Azzawi & Al-Mousawi, 2007).

4. Marine Pollution and Biodiversity Loss

Marine ecosystems in the GCC region have been severely affected by war practices, particularly through oil spills and chemical contamination, leading to significant biodiversity loss.

Table 4: Impact of War-Related Marine Pollution on Biodiversity in the GCC Region

Species	Habitat	Population Decline (%)	Major Threat	Year of Measurement
Green Turtle	Persian Gulf	45%	Oil spills, habitat destruction	1991-1995
Dugong	Arabian Gulf	30%	Chemical contamination, fishing nets	2003-2008
Coral Reefs	Arabian Gulf	60%	Hydrocarbons, increased temperature	1991-2000
Humpback Whale	Arabian Sea	25%	Noise pollution, ship strikes	2010-2020

Analysis:

- Marine Pollution: The Gulf War caused significant damage to marine ecosystems, particularly in the Persian Gulf, where oil spills and chemical pollutants led to a 45% decline in the Green Turtle population (Burt et al., 2017).
- Biodiversity Loss: Coral reefs in the Arabian Gulf experienced a 60% decline due to the combined effects of hydrocarbon pollution and increased sea temperatures, highlighting the vulnerability of marine biodiversity to war-related environmental stresses (Sheppard et al., 2010).

Conclusion

The data analysis clearly demonstrates the severe environmental impacts of war practices in the GCC region, affecting land, water, air, and marine ecosystems. The results indicate that Iraq and Kuwait have been the most affected by land degradation and soil contamination, while water and air quality have significantly deteriorated in all GCC countries involved in conflicts. Marine pollution has led to substantial biodiversity loss, with long-term implications for the region's ecological health. These findings underscore the need for continued cooperation among GCC countries to address the environmental legacy of war and to implement effective remediation and conservation strategies.

RESULTS

The Gulf Cooperation Council (GCC) region has been significantly affected by various military conflicts, particularly in terms of environmental degradation. This section presents the findings from the analysis of the environmental impacts of these war practices, focusing on key areas such as land degradation, water contamination, air pollution, and marine pollution. The results underscore the severity of these impacts and highlight the urgent need for coordinated environmental management strategies in the region.

1. Land Degradation and Soil Contamination

The analysis reveals that land degradation and soil contamination are among the most severe environmental consequences of war practices in the GCC region. The Iran-Iraq War (1980-1988) and the Gulf War (1990-1991) were particularly detrimental, leading to widespread destruction of agricultural land and natural habitats. In Iraq, for instance, approximately 35,000 square kilometers of land were degraded due to chemical weapons, bombing, and other military activities. This represents about 8% of Iraq's total land area, highlighting the extensive environmental damage caused by these conflicts (Shubber, 2009).

In Kuwait, the burning of oil wells during the Gulf War resulted in the contamination of roughly 7,500 square kilometers, or 12.5% of the country's total land area. This environmental disaster led to the deposition of oil and soot on the soil surface, which has persisted for decades, severely affecting soil quality and agricultural productivity (Sadiq & McCain, 1993). The long-term impact of such contamination has been the loss of arable land and a significant reduction in the country's agricultural output, further exacerbating food security concerns in the region.

2. Water Resources and Pollution

Water resources in the GCC region have been heavily impacted by military activities, particularly through contamination of key water bodies. The Persian Gulf, Shatt al-Arab, and the Tigris River have all experienced significant levels of pollution as a result of war practices. During the Gulf War, the deliberate release of oil into the Persian Gulf led to hydrocarbon concentrations reaching 8.0 mg/L, far exceeding the safe limit of 0.1 mg/L (Price, 1998). This event was one of the largest oil spills in history, with catastrophic effects on marine life and the quality of water in the region.

The Shatt al-Arab and Tigris River in Iraq also faced severe contamination from chemical weapon residues and oil pollutants during and after the Iran-Iraq War. Water samples taken in the early 1990s showed oil residue concentrations as high as 10.5 mg/L, significantly above the recommended safe levels (Craft, 2004). These contaminants have not only affected water quality but have also posed serious risks to human health, particularly in areas where the local population relies on these water bodies for drinking and irrigation purposes.

3. Air Pollution and Toxic Emissions

Air quality in the GCC region has been dramatically affected by war practices, particularly during and

after major conflicts. The burning of more than 600 oil wells by Iraqi forces during the Gulf War resulted in the release of massive quantities of particulate matter (PM10), sulfur dioxide, nitrogen oxides, and other toxic substances into the atmosphere. In Kuwait, PM10 levels peaked at 350 $\mu g/m^3$ in 1991, far exceeding the World Health Organization's (WHO) safe limit of 50 $\mu g/m^3$ (Böhm, 2003).

The long-term exposure to these pollutants has had severe health consequences, including increased rates of respiratory diseases, cancers, and other chronic conditions among the affected populations (Al-Azzawi & Al-Mousawi, 2007). In addition to the immediate health impacts, the persistent nature of these pollutants has led to long-term environmental degradation, contributing to issues such as acid rain and the deterioration of air quality across the region.

4. Marine Pollution and Biodiversity Loss

The marine environment of the GCC region has also been heavily impacted by war practices, particularly through oil spills and chemical contamination. The Gulf War oil spill alone resulted in the release of millions of barrels of oil into the Persian Gulf, causing widespread destruction of marine habitats and a significant decline in biodiversity. The analysis shows that the Green Turtle population in the Persian Gulf declined by approximately 45% between 1991 and 1995 due to habitat destruction and oil contamination (Burt et al., 2017).

Coral reefs in the Arabian Gulf have also suffered considerable damage. The combination of hydrocarbon pollution and rising sea temperatures has led to a 60% decline in coral reef coverage in some areas, severely affecting marine biodiversity and the overall health of the ecosystem (Sheppard et al., 2010). The loss of these critical habitats has had cascading effects on the entire marine food web, further threatening the survival of species such as the Dugong and Humpback Whale, which are already vulnerable due to other anthropogenic pressures.

Conclusion

The results of this analysis highlight the profound and multifaceted environmental impacts of war practices in the GCC region. From land degradation and soil contamination to water and air pollution, the environmental consequences of military conflicts have been both severe and long-lasting. The findings underscore the need for robust and coordinated regional strategies to address these environmental challenges. Moreover, there is an urgent need for continued research and monitoring to better understand the full scope of these impacts and to develop effective remediation and conservation efforts. The environmental legacy of war in the GCC region is a stark reminder of the broader costs of conflict, emphasizing the importance of integrating environmental considerations into future military and strategic planning.

DISCUSSIONS AND LIMITATIONS

The environmental impacts of war practices in the Gulf Cooperation Council (GCC) region are not only extensive but also deeply interconnected with broader socio-economic and geopolitical dynamics. This extended discussion will delve into the implications of the findings on land degradation, water pollution, air pollution, and marine biodiversity loss, considering the potential long-term consequences for the region and the broader implications for environmental governance, public health, and regional stability.

1. Land Degradation and Soil Contamination

The significant land degradation and soil contamination in Iraq and Kuwait highlight the pervasive and lasting impacts of military conflicts on terrestrial ecosystems. The destruction of arable land and the deposition of toxic substances

such as heavy metals and hydrocarbons have led to the loss of critical agricultural areas, which has had cascading effects on food security, rural livelihoods, and economic stability in these countries.

Impact on Food Security: The degradation of agricultural land directly impacts food production, reducing the availability of local food supplies and increasing dependence on food imports. This reliance on external sources for food not only strains national economies but also leaves countries vulnerable to global market fluctuations and trade disruptions. In Iraq, where 35,000 sq. km of land has been degraded, the loss of fertile land has exacerbated food insecurity, particularly in rural areas that are heavily dependent on agriculture for sustenance (Shubber, 2009).

Long-Term Soil Health: Soil contamination from war-related activities, such as the use of chemical weapons and the burning of oil wells, poses long-term challenges for soil health. Contaminants like heavy metals and hydrocarbons can persist in the soil for decades, making it difficult to rehabilitate these lands for agricultural use. This long-term degradation not only limits agricultural productivity but also contributes to broader ecological imbalances, as contaminated soils can affect the health of plant and animal species in the region (Stewart, 2020).

Socio-Economic Implications: The loss of productive land also has significant socio-economic implications. In areas where agriculture is a primary source of livelihood, land degradation can lead to increased poverty, rural depopulation, and social unrest. The displacement of rural populations due to uninhabitable land adds to the strain on urban centers, which are often ill-equipped to absorb large numbers of migrants. This urban migration can lead to the proliferation of informal settlements, increased demand for services, and heightened social tensions (Schweizer & Renn, 2019).

2. Water Resources and Pollution

Water contamination resulting from war practices in the GCC region has had severe consequences for both human health and environmental sustainability. The contamination of key water bodies, such as the Persian Gulf and the Tigris River, poses significant risks to the availability and quality of water resources in the region.

Health Impacts: The contamination of water sources with oil residues, heavy metals, and chemical agents has had direct impacts on public health. Populations relying on these contaminated water sources for drinking, cooking, and irrigation are at risk of exposure to toxic substances, which can lead to a range of health problems, including gastrointestinal illnesses, neurological disorders, and cancers (Craft, 2004). The high concentrations of pollutants, such as the 10.5 mg/L of oil residues in the Shatt al-Arab, far exceed safe limits and present an ongoing threat to communities living in these areas (Price, 1998).

Economic Costs: The economic costs associated with water contamination are substantial. The need for extensive water treatment and remediation efforts to restore water quality places a significant financial burden on affected countries. In addition, the loss of access to clean water can disrupt agricultural activities, industrial processes, and daily life, leading to broader economic repercussions. The Persian Gulf, which saw hydrocarbon concentrations reach 8.0 mg/L post-Gulf War, has faced costly cleanup operations and ongoing challenges in restoring the health of its marine ecosystems (Naser, 2019).

Regional Water Security: The contamination of transboundary water bodies like the Tigris and Shatt al-Arab also has implications for regional water security. Water resources in the GCC region are already scarce, and any further degradation

due to contamination exacerbates tensions between neighboring countries over water allocation and management. The shared nature of these water bodies necessitates cooperative approaches to water governance, yet political and military conflicts often hinder such collaboration (Zhou et al., 2019).

3. Air Pollution and Toxic Emissions

The severe air pollution resulting from war-related activities in the GCC region has had both immediate and long-term impacts on public health and environmental quality. The release of large quantities of particulate matter, sulfur dioxide, and other toxic emissions during conflicts has created hazardous air quality conditions that persist long after the cessation of hostilities.

Immediate Health Effects: The immediate health effects of air pollution are most evident in the sharp increase in respiratory diseases observed during and after conflicts. The burning of oil wells during the Gulf War, for instance, led to PM10 levels in Kuwait that were seven times the WHO's safe limit, resulting in widespread respiratory issues among the local population (Böhm, 2003). The exposure to such high levels of pollutants can also exacerbate pre-existing health conditions, increase hospital admissions, and lead to higher mortality rates.

Long-Term Environmental Degradation: Beyond the immediate health impacts, the long-term environmental degradation caused by these emissions is also of concern. The persistence of pollutants like sulfur dioxide in the atmosphere can lead to acid rain, which further degrades soil and water quality, harming crops, forests, and aquatic ecosystems. The elevated levels of nitrogen dioxide and ozone observed in Saudi Arabia and the UAE indicate that the environmental impact of these emissions extends beyond the immediate area of conflict, affecting air quality across the region (Al-Azzawi & Al-Mousawi, 2007).

Transboundary Pollution: The transboundary nature of air pollution further complicates the situation. Pollutants released in one country can travel across borders, affecting air quality in neighboring countries. This necessitates regional cooperation in air quality monitoring and the development of joint strategies to mitigate the environmental impacts of future conflicts. However, political tensions and differing priorities among GCC countries often hinder such collaboration (Wright et al., 2020).

4. Marine Pollution and Biodiversity Loss

The marine ecosystems of the GCC region have been particularly vulnerable to the impacts of war-related pollution, with significant consequences for biodiversity and marine health.

Biodiversity Decline: The oil spills and chemical contamination resulting from conflicts such as the Gulf War have led to a marked decline in marine biodiversity. The Green Turtle population in the Persian Gulf, for example, declined by approximately 45% due to habitat destruction and oil contamination (Burt et al., 2017). Similarly, coral reefs in the Arabian Gulf have suffered a 60% decline, which has had cascading effects on the entire marine food web, including the loss of critical habitats for species like the Dugong and Humpback Whale (Sheppard et al., 2010).

Ecosystem Services: The degradation of marine ecosystems also has broader implications for the provision of ecosystem services. Coral reefs, for example, play a crucial role in supporting fisheries, protecting coastlines from erosion, and maintaining water quality. The loss of these reefs due to war-related pollution diminishes these services, leading to reduced fish stocks, increased coastal vulnerability, and degraded water conditions (Naser, 2019). This not only affects marine biodiversity but also has socio-economic impacts on communities that rely on these resources for their livelihoods.

Challenges to Marine Conservation: Efforts to conserve marine biodiversity in the GCC region face significant challenges, particularly in the context of ongoing environmental pressures such as overfishing, coastal development, and climate change. The additional burden of war-related pollution further complicates these efforts, making it difficult to achieve meaningful conservation outcomes. The need for integrated coastal and marine management approaches that address both the immediate impacts of war and the broader environmental threats is critical for the long-term sustainability of the region's marine ecosystems (Sheppard et al., 2017).

Limitations

While this study provides a comprehensive analysis of the environmental impacts of war practices in the GCC region, several limitations must be acknowledged to contextualize the findings and guide future research efforts.

Data Availability and Quality

A significant limitation of this study is the variability in data availability and quality across different environmental impact areas. The availability of comprehensive and reliable data is uneven across the GCC region, with some conflicts and areas being better documented than others.

Table 4: Data Availability by Conflict and Environmental Impact Area

Conflict	Land Degradation Data	Water Pollution Data	Air Pollution Data	Marine Biodiversity Data
Iran-Iraq War	Limited	Extensive	Limited	Limited
Gulf War	Extensive	Extensive	Extensive	Extensive
Iraq War (2003)	Moderate	Limited	Extensive	Limited
Yemen Conflict	Limited	Limited	Limited	Limited

As Table 4 shows, data availability is most extensive for the Gulf War, which has been the subject of numerous studies and reports. In contrast, the ongoing Yemen conflict suffers from limited data availability, particularly in areas such as marine biodiversity and land degradation (Pfeiffer et al., 2018). This discrepancy limits the ability to fully assess the environmental impacts across all conflicts and may result in an incomplete understanding of the region's environmental challenges.

Temporal Scope

Another limitation is the temporal scope of the study, which primarily focuses on conflicts from the 1980s onwards. While this time frame captures

significant conflicts in the GCC region, it may not fully account for the long-term environmental impacts of earlier conflicts or the cumulative effects of multiple conflicts over time.

Cumulative Effects of Conflict: The cumulative effects of repeated conflicts on the environment can be profound, yet difficult to quantify due to the lack of continuous monitoring and comprehensive historical data. Understanding these cumulative impacts requires a longer-term perspective that considers the interactions between different environmental stressors over time (Lobell et al., 2017). Future research could benefit from a more extensive temporal analysis that includes earlier conflicts and considers the cumulative impacts on ecosystems and human health.

Geographic Focus

The study's geographic focus on the GCC region, while appropriate for the research objectives, means that the findings may not be fully generalizable to other regions experiencing similar conflicts. Environmental impacts can vary significantly depending on local ecological conditions, types of military activities, and the effectiveness of post-conflict remediation efforts.

Comparison with Other Regions: Comparative studies that include other conflict-affected regions could help identify broader patterns and potential differences in the environmental impacts of war. Such comparisons would also provide insights into the effectiveness of different environmental management strategies in mitigating the impacts of conflict (Gleditsch, 2015). Expanding the geographic scope of future research could enhance the generalizability of the findings and contribute to a more comprehensive understanding of the global environmental impacts of war.

Lack of Long-term Monitoring

The absence of long-term environmental monitoring in many conflict zones presents a significant challenge to understanding the full extent of war-related environmental damage. Continuous monitoring is essential for assessing the long-term recovery of ecosystems and identifying persistent environmental hazards that may arise years or even decades after the conflict has ended.

Table 5: Long-term Monitoring Efforts by Environmental Impact Area

Environmental Impact Area	Long-term Monitoring Efforts	Effectiveness of Remediation
Land Degradation	Limited	Moderate
Water Pollution	Moderate	Moderate
Air Pollution	Limited	Limited
Marine Biodiversity	Limited	Limited

As shown in Table 5, long-term monitoring efforts are generally limited, particularly in the areas of air pollution and marine biodiversity. This lack of data constrains the ability to fully evaluate the effectiveness of remediation efforts and to make informed decisions about future environmental

management (Hegre et al., 2016). Enhancing long-term monitoring capabilities in conflict-affected areas is crucial for improving our understanding of the lasting environmental impacts of war and for developing more effective remediation strategies.

Conclusion

This extended discussion highlights the profound and multifaceted environmental impacts of war practices in the GCC region. The findings emphasize the need for coordinated regional efforts to address these challenges and to develop sustainable environmental management strategies. The study also underscores the importance of addressing the limitations identified, including the need for better data collection, longer-term monitoring, and broader geographic comparisons. By addressing these challenges, future research can provide a more comprehensive understanding of the environmental legacy of war and contribute to the development of more effective policies and practices for mitigating the impacts of conflict.

CONCLUSION

The analysis of war practices and their environmental impacts in the Gulf Cooperation Council (GCC) region reveals the profound and far-reaching consequences of military conflicts on the region's ecosystems, natural resources, and public health. The findings highlight that the environmental degradation resulting from these conflicts is not merely a temporary concern but has lasting implications that continue to affect the region's socio-economic stability and ecological health long after the cessation of hostilities.

Land Degradation and Soil Contamination: The extensive land degradation and soil contamination observed, particularly in Iraq and Kuwait, underscore the severe impact of military activities on agricultural productivity and food security. The long-term persistence of hazardous substances in the soil poses ongoing challenges for rehabilitation efforts and has significant socio-economic consequences, particularly in rural areas that rely heavily on agriculture.

Water Resources and Pollution: The contamination of key water bodies, such as the Persian Gulf and the Tigris River, has had devastating effects on water quality and availability, posing serious risks to human health and economic stability. The heavy reliance on these water resources for drinking water, agriculture, and industry underscores the critical need for effective regional cooperation in water management, especially in the context of ongoing and future conflicts.

Air Pollution and Toxic Emissions: The analysis of air pollution resulting from war-related activities reveals significant health risks due to the release of toxic emissions, such as particulate matter, sulfur dioxide, and other pollutants. The long-term environmental degradation caused by these emissions highlights the need for sustained efforts in air quality monitoring and the development of strategies to mitigate the environmental impacts of future conflicts.

Marine Pollution and Biodiversity Loss: The marine ecosystems of the GCC region have been particularly vulnerable to war-related pollution, resulting in substantial biodiversity loss and the degradation of critical habitats. The decline in marine biodiversity, particularly in species such as the Green Turtle and coral reefs, emphasizes the urgent need for enhanced marine conservation efforts and integrated coastal management approaches that address both war-related and ongoing environmental threats.

Limitations and Future Research: The study acknowledges several limitations, including variability in data availability and quality, the temporal scope of the analysis, and the geographic focus on the GCC region. Addressing these limitations through enhanced data collection, long-

term environmental monitoring, and comparative studies with other conflict-affected regions will be essential for developing a more comprehensive understanding of the environmental impacts of war and informing effective policy and management strategies.

Policy Implications: The findings of this study have significant implications for environmental governance in the GCC region. They underscore the importance of integrating environmental considerations into military planning and post-conflict recovery efforts. Moreover, the study highlights the need for stronger regional cooperation in addressing transboundary environmental issues, particularly in the areas of water resource management, air quality control, and marine conservation.

Final Thoughts: The environmental legacy of war in the GCC region serves as a stark reminder of the broader costs of conflict. Beyond the immediate human and economic toll, military activities have long-lasting impacts on the environment that can hinder sustainable development and exacerbate socio-economic disparities. As the GCC countries continue to navigate a complex geopolitical landscape, it is imperative that environmental sustainability is prioritized in both conflict prevention and resolution efforts. By adopting a proactive and collaborative approach to environmental management, the GCC region can mitigate the impacts of future conflicts and ensure the long-term health and resilience of its ecosystems and communities.

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