

Fighting Over Fish: How Climate Change Could Influence Violent Conflict

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Abstract

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Despite rising concerns in policy circles, the academic community has yet to reach a consensus on the implications of climate change for possible outbreaks of violent conflict. Some quantitative and qualitative studies have suggested that climate change will have impacts that increase the risk of violent conflict, while other studies have not found a correlation between climate change variables and violent conflict. Moreover, few studies have looked specifically at climate-driven conflict over marine resources, particularly fisheries upon which millions of people worldwide depend for food and livelihood. The question is not only whether climate change can be expected to lead to violent conflict, but what are the pathways by which climate change could lead to violent conflict? This latter question is explored in this thesis, focusing specifically on climate change in the marine environment and its effect on fisheries. Using Analysis of Competing Hypotheses, a technique developed for intelligence analysts, findings from scientific literature are analyzed to identify the level of scientific support for five hypotheses related to the question: Will climate change affect fish distributions in ways that might result in instability and/or violent conflict? Over one hundred scientific publications and technical reports were reviewed for evidence supporting or rejecting these hypotheses. Findings showed strong support for some hypotheses, with weaker or equivocal support for others, but overall, the evidence suggests a potential causal pathway from climate change to violent conflict with climate change affecting fish availability, leading to economic decline in vulnerable places, and increasing the risk of violent conflict.

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1. Introduction

Climate change as a security issue – discussed in this article as a situation in which the impacts of a changing climate potentially lead to instability and violent conflict – has raised concern in policy circles, with retired senior military officials and national security policy experts among those warning of the dangers of a changing climate (CNA Corporation, 2007; Campbell et al., 2007). At the same, the academic community has not reached a consensus on the links between climate change and conflict, with some scholars more reticent to support the climate-conflict nexus (Gleditsch, 2012; Salehyan, 2008), and others identifying clear connections between environmental and climate change and conflict (Homer-Dixon, 1994; Hsiang, Meng, & Cane, 2011). The academic debate largely centers on the likelihood that climate change will lead to instability and conflict, with some discussion of the mechanisms by which conflict could occur. Some studies support links from climate change to violent conflict (Barnett & Adger, 2007; Burke, Miguel, Satyanath, Dykema, & Lobell, 2009; C.S. Hendrix & Salehyan, 2012; Hsiang et al., 2011); others find little support for the link (Gartzke, 2012; Gleditsch, 2012; Raleigh & Urdal, 2007). Even reviews of existing research arrive at conflicting conclusions, with Scheffran, Brzoska, Kominek, Link, & Schilling (2012) concluding that current literature supports the argument that climate change has an influence on violent conflict in at least some parts of the world, while Theisen, Gleditsch, & Buhaug (2013) conclude that the literature on climate change as a driver of conflict is inconclusive. Both articles cite the limitations with current research, offering critiques of the methodologies used and recommendations for future research.

While it is important to seek to understand the likelihood that climate change will influence violent conflict, it is equally important to explore the *potential* for climate change to influence violent conflict, even if the possibility appeared unlikely. Even one case of climate-driven changes contributing to instability or war, especially in a country of strategic importance (e.g., a nuclear-armed nation, a potential base for international terrorists, or a key oil exporting nation), would be of critical importance to policy makers, who must consider the implications of the conflict and prepare responses.

Moving forward, research is needed to investigate the mechanisms by which climate change might contribute to conflict and violence. Given the complex and far-reaching impacts of climate on

natural systems, the evolving understanding of ecological responses to climate change, and the even less well-understood social responses to climate-induced environmental changes, teasing out the links from climate change to violent conflict is inherently challenging. Current research has largely focused on terrestrial processes and systems, such as the effect of rainfall anomalies on agricultural systems and conflict (C.S. Hendrix & Salehyan, 2012). There is very little research into how the effects of climate change on marine environments could influence instability and violent conflict, yet 10-12% of the world's population, between 660-820 million people, are supported directly or indirectly through fisheries and globally fish provide about three billion people with 20% of their animal protein needs (FAO, 2012). Fish are crucial to millions of livelihoods around the world, and understanding how those livelihoods will be impacted by climate change effects on fish may offer important insights into pathways by which climate change may influence conflict in the future.

In 2007, Barnett and Adger suggested that a key aim of research to enhance understanding of climate insecurity should be to assess the vulnerability of people's livelihoods to climate change. This article explores the effects of climate change on fish distribution, human vulnerability to changes in fishery resources from climate change, resulting socioeconomic effects, and the potential for instability and violent conflict as a result. The objective of this effort is to contribute to the broader body of literature on climate change and conflict by exploring how climate-driven changes in the marine environment, specifically the effects of climate change on fish distribution, could influence the outbreak of instability or violent conflict, and to identify a pathway by which such a conflict might occur.

2. Background

Studies have looked at many elements of environmental degradation as they relate to conflict, including land degradation, deforestation, droughts, floods, storms, and water scarcity (Barnaby, 2009; Hauge & Ellingsen, 1998; C.S. Hendrix & Salehyan, 2012; Reuveny, 2007), but degradation of the marine environment, with climate change as a contributing factor, has received limited attention with respect to conflict, although millions of livelihoods depend on it. Many pathways exist by which climate affects marine populations, which makes linkages between climate and ecological responses difficult to establish with certainty (Ottersen, Kim, Huse, Polovina, & Stenseth, 2010). This challenge, in turn, makes it difficult

for researchers to establish with certainty the linkages between climate change and ecological responses in the marine environment. Although uncertainty remains about the direct and indirect impacts of climate change on fish stocks, mounting evidence shows that dramatic changes are occurring with the potential to significantly impact both marine ecosystems and humans who are dependent on the marine environment for their livelihoods (Allison et al., 2009; Cheung et al., 2010, 2012a; Cochrane, De Young, Soto, & Bahri, 2009; Hoegh-Guldberg & Bruno, 2010; Sumaila et al., 2011).

This work focuses specifically on the effects of climate change on fish distribution. By altering ocean conditions such as water temperature, ocean currents, and coastal upwelling, climate change will affect primary productivity, species distribution, community structure, and foodweb structure, having direct and indirect impacts on the distribution and productivity of marine organisms (Cheung et al., 2010). Models have predicted wide-scale redistribution of fish catch potential resulting from climate change, with significant gains in northern latitude regions and substantial losses in others, largely in the tropics (Cheung et al., 2010), as well as decreased fish size resulting from climate change (Cheung et al., 2012a), although other research suggests that using more comprehensive models, incorporating a broad range of life history factors may yield more nuanced results (Hollowed, Planque, & Loeng, 2013).

Concurrent with research into the effects of climate change on marine resources is research into the potential social and economic effects of changes to fish resources, including the possibility for instability and conflict. Vulnerability analyses have assessed the vulnerability of national economies to the impacts of climate change on fisheries (Allison et al., 2009), or have ranked the vulnerability of nations to the effects of climate change and ocean acidification (Huelsenbeck & Vorpahl, 2012). As climate change continues to affect fish resources, often compounding the effects of other pressures such as overfishing, it is important to integrate knowledge from natural and social sciences to build a stronger understanding of how factors will interact to threaten human well-being, and to consider the potential for the often devastating effects of violent conflict.

2.1 Climate Change Impacts on Fish and Fisheries

Research on the effects of climate change on fish suggests that fish stocks will be affected by increasing temperatures and other climate effects worldwide. Anticipated changes include shifting fish stocks, reduced size of fish, increased susceptibility to disease, changes in biodiversity, and impacts to populations and communities (Cheung et al., 2010, 2012a; Harvell, Altizer, Cattadori, Harrington, & Weil, 2009; Hoegh-Guldberg & Bruno, 2010; Wernberg, T. et al., 2012). Changes that have already been observed include ecosystem changes, distributional shifts, and regime shift (Grebmeier, 2006; Kortsch et al., 2012; Möllmann et al., 2009; Sumaila & Cheung, 2010). The impacts of climate-driven changes to fisheries must also be considered with respect to other factors such as fishing pressures and pollution, and the complex interaction of these factors increases the challenge of understanding exactly how climate change will affect fisheries.

Models have predicted that climate change may lead to large-scale regional redistribution of global catch potential, with an average 30–70% increase in high-latitude regions, and up to 40% decrease in tropics (Cheung et al., 2010). This could increase the availability of fish to many developed countries with high adaptive capacity and decrease the availability to many less developed tropical countries with low adaptive capacity. Among the tropical countries with national economies vulnerable to climate change-driven impacts to fisheries are many African countries, Peru, Bangladesh, Yemen, and Pakistan (Allison et al., 2009). Countries vulnerable to food security threats due to climate change impacts on fisheries include the Maldives, Togo, Comoros, Libya, Singapore, Kuwait, Guyana, Indonesia, and the United Arab Emirates (Huelsenbeck & Vorpahl, 2012). Not all vulnerable countries are included here, but this list demonstrates the potentially far-reaching effects of climate change on fisheries.

Climate change is also predicted to lead to a decrease in individual fish size. Over 75% of the populations included in a study of demersal fish are expected to experience a 5-39% reduction in asymptotic weight, with a median of 10%, in all ocean basins resulting from climate and ocean changes in marine ecosystems (Cheung et al., 2012a). Both the tropics and temperate regions will be impacted by reductions in body size, with large implications for trophic interactions, ecosystem functions, fisheries and global protein supply (Cheung et al., 2012a). Caveats to this study are that the model used in the study

did not account for other human stressors such as overfishing and pollution, and assumptions and simplifications made by researchers lend uncertainty to the model; however, evidence of shrinking fish mean weight due to climate change presents another potentially significant impact to fisheries.

Climate-driven changes in temperature affect a variety of processes that impact fish. Rising temperatures increase metabolic rates, determining life history traits, population growth, and ecosystem processes, and while organisms can adapt to variation around their optimal temperature range, acclimatization eventually fails, leading to increased mortality risk, reduced fitness, and population decline or local extinctions (Hoegh-Guldberg & Bruno, 2010). Indirect effects of climate on fish include climate shifts that lead to shifts in ocean circulation patterns that then induce changes in prey abundance, affecting fish communities (as cited in Ottersen et al., 2010).

Sea surface warming in the Northeast Atlantic over the past 50 years has affected the abundance of phytoplankton, with increasing phytoplankton abundance in cooler regions, and decreasing phytoplankton abundance in warmer regions (Richardson & Shoeman, 2004). Changing phytoplankton abundance may propagate up the food web, potentially altering the spatial distribution of primary and secondary pelagic production as future warming occurs (Richardson & Shoeman, 2004). However, other studies have concluded that linkages in the marine plankton community are weak or inconsistent across trophic levels (as cited in Ottersen et al., 2010). Nonetheless, Richardson and Shoeman's (2004) results suggest that changes in phytoplankton abundance could impact food webs in ways that could affect migration patterns, influencing fish distribution.

Distributions of both exploited and nonexploited North Sea fishes have responded markedly to recent increases in sea surface temperature, with nearly two-thirds of species studied showing distributional responses to climatic warming over 25 years, and temporal trends in distribution suggesting that fishing alone could not explain the climate-related shifts (Perry, Low, Ellis, & Reynolds, 2005). Additionally, fish that are sensitive to temperature-driven distribution shifts may include key prey species of non-shifting predators (Perry et al., 2005), increasing the unpredictability of the responses of fish and ecosystems to climate changes.

Climate change has affected the prevalence and severity of disease outbreaks in marine ecosystems (Harvell et al., 2009) and changes to biodiversity patterns of marine species have been observed following extreme climatic events, which are anticipated to increase with climate change (Wernberg et al., 2012). An increased prevalence of disease and shifts in biodiversity patterns could have detrimental effects on fish populations, decreasing their availability and impacting those who are dependent on fish for livelihoods.

While uncertainty remains about the distributional effects of climate change on fish, including questions as to where constraints may exist due to population dependence on essential habitat features (Hollowed et al., 2013) and how components of marine ecosystems may interact to affect fish, evidence from current studies suggests that climate change impacts fish distribution. Through distributional shifts and changes in catch potential, shrinking fish, ecosystem changes and changes in biodiversity, increased susceptibility to disease, and impacts to populations and communities, climate change is likely to affect fish availability, whether by increasing availability in some areas, or decreasing it in others.

2.2 Climate Change and Conflict

As climate change affects the availability of fish resources, impacts to fisheries and thus to livelihoods and economies dependent on fish should be expected. If communities or nations experience significant impacts to livelihoods and economies, a result could be social and political instability, leading in some instances to violent conflict. However, the academic community has not reached a consensus on the links between climate change and violent conflict, and many avenues of research into the problem remain to be explored. While some researchers remain skeptical of the potential for climate-driven conflict (Nordås & Gleditsch, 2007), others have found support for the hypothesis that the effects of climate change influence violent conflict (Homer-Dixon, 1994; Hsiang et al., 2011; Stalley, 2003).

The extent of the lack of consensus in the literature is evident in two meta-analyses of the literature studying the links between climate change and conflict, with one concluding that empirical evidence is limited to support the view of climate change as a driver of armed conflict (Gleditsch, 2012), while the other concludes that a significant part of the current literature supports the argument that

climate change has an influence on conflict in at least some parts of the world (Scheffran et al., 2012). The conflicting conclusions reflect the multitude of challenges involved in analyzing this problem, including data limitations, insufficient indicators, and a lack of comparability and generalization for different regional contexts and intermediate pathways (Scheffran et al., 2012). Both quantitative and qualitative studies have been used to examine the question of environmental and climate changes and conflict, but each has limitations. Quantitative studies can identify correlations between climate change and violent conflict, but cannot adequately explain causal pathways, while qualitative studies can explain complex factors but are reliant on case-specific data, making generalization of results difficult (Scheffran et al., 2012). Given the limited explanatory power of quantitative studies, and the multitude of complex factors typically involved in social instability and violent conflict, qualitative research has played and will continue to play a critical role in establishing a better understanding of the relationship between climate change and conflict. At the same time, further quantitative studies that incorporate additional variables and better data as it becomes available will be vital to continuing to identify correlations where they exist between climate change and conflict.

One of the theoretical pathways by which climate change is anticipated to lead to conflict is by increasing resource scarcity which is assumed to lead to loss of livelihood, economic decline, and increased insecurity, and when combined with other factors such as poor governance and societal inequalities, these factors may promote political and economic instability, social fragmentation, migration, and inappropriate governmental responses (Theisen et al., 2013). Through direct effects on livelihoods and indirect effects on state functions, climate change may in certain circumstances increase the risk of violent conflict; however, it will not undermine human security or increase the risk of violent conflict in isolation from other important social factors (such as poverty, weak states, migration, vulnerable livelihoods) (Barnett & Adger, 2007). Case study research has found that environmental scarcity leads to violent conflict by causing social impacts resulting in population movements, economic decline and weakening of states (Homer-Dixon, 1994). Environmental processes alone cannot explain why, where, and when violent conflict will occur; rather, it is the interaction between environmental and political systems that is critical to understanding organized armed violence (Salehyan, 2008).

A 2011 study found that the probability of new civil conflicts arising throughout the tropics doubles during El Niño years relative to La Niña years, demonstrating a relationship between global climate and the stability of modern societies (Hsiang et al., 2011). Although the authors caution that their results might not generalize to gradual trends in average temperature or particular characteristics of anthropogenic climate change (Hsiang et al., 2011), the study provides compelling evidence for the potential impact of climate change on violent conflict. Other studies have used local proxies to identify correlations between random local temperature or rainfall shocks and local civil conflicts (Burke et al., 2009; C.S. Hendrix & Salehyan, 2012), but these may be inadequate analogues for the broader scale economic, geopolitical, and social impacts of global climate changes (Hsiang et al., 2011).

Increasing food prices in weak governmental regimes have been associated with an increase in protests and riots (Hendrix & Haggard, 2012), and decreased rainfall decreasing economic growth has been shown to increase the risk of sectoral riots in India (Bohlken & Sergenti, 2010). The preceding examples demonstrate the potential for violent conflict from increasing food prices or decreased economic growth, both of which could be affected by a loss of fish resources, especially in places already experiencing or vulnerable to social instability.

Economic welfare is consistently associated with conflict incidence in a variety of studies, with economic decline and poverty linked to conflict and war (Blattman & Miguel, 2010; Burke et al., 2009; Koubi, Bernauer, Kalbhenn, & Spilker, 2012; Nordås & Gleditsch, 2007). The environmental effects of climate change are likely to negatively affect economic welfare through problems such as increased droughts, heavy precipitation events, and increased storm intensity, affecting livelihoods in many areas including areas already suffering from poverty. If economic decline and poverty are risk factors for conflict, and the effects of climate change lead to economic decline and poverty, then conflict arising from climate-induced changes is a logical possibility. The key then is to better understand how environmental, political, social, and economic systems interact, particularly within the context of a particular culture or society, to explain and possibly predict, the occurrence of violent conflict.

Climate change will affect human systems in many ways, with significant uncertainty regarding how humans will adapt and whether and how abrupt ecological changes might transpire (IPCC, 2007).

Conflict can be interstate, intrastate, or one-sided (Gleditsch, 2012), and can be influenced by a range of factors. It is no wonder, then, that there is much uncertainty and little agreement on the links between climate change and violent conflict. According to Gleditsch the one area that currently has a fair number of studies is on how changes in precipitation may influence internal conflict (2012), and Hendrix and Salehyan note that much of the debate about the security implications of climate change revolves around whether changing weather patterns will lead to future conflict (2012). Changing patterns of precipitation, and even changing weather patterns in general, are only part of the much larger suite of changes potentially arising from climate change, and future research needs to address the full scope of climate-induced changes and their potential impacts on violent conflict. The limited scope of existing studies indicates the need for further research into the area of climate change and violent conflict.

Future research must expand to include the many effects of climate change, and seek to explore the complex causal pathways that may exist between climate-induced changes and violent conflict. The potential for conflict related to climate impacts on the marine environment is largely unexplored, yet both climate change and ocean acidification are expected to increase the vulnerability of national economies (Allison et al., 2009), threatening the food security of many countries (Huelsenbeck & Vorpahl, 2012). Given that economic decline and food insecurity have been identified as factors that may contribute to conflict, it is important that climate change impacts on the marine environment and resulting social impacts be included in the larger body of research on climate change and conflict.

2.2.1 Fishery Conflict

Disagreement and uncertainty persist about the links from climate change to conflict, but conflict related to fisheries has a long history. Conflict is endemic to most fisheries, with internal disputes driven by allocation of scarce resources, division of fishery benefits, and management arrangements, and external conflicts amongst competing users (Charles, 1988). In Southeast Asia, declining and overfished small-scale nearshore fisheries are leading to increased conflicts and social tensions among user groups, resulting in coastal “fish wars” (Pomeroy et al., 2007), and in Mexico there is unrest between small communities over illegal sea cucumber fishing (Zabludovsky, 2013). These are but two examples of conflict at the local scale over fisheries.

At the international level, the current conflict over mackerel in the Northeast Atlantic provides an example of a potentially climate-driven change in a fish stock that has led to international diplomatic conflict between Iceland, Norway, the European Union, and the Faroe Islands over catch allocation (Hotvedt, 2011; ICES, 2013; Jansen & Gislason, 2011; Popescu & Poulsen, 2012). The “cod wars” of the 20th century offer another example of international conflict over fish. Through a series of unilateral declarations in 1952, 1958, 1972, and 1975, Iceland expanded its fishing jurisdictions, starting from 3 to 4 nautical miles (nm) in 1952 and ending with 50 to 200 nm in 1975. The extensions locked British trawlers out of traditional fishing grounds, impacting Britain’s fishing industry. Britain deployed Royal Navy ships to escort its fishing vessels and Iceland used its Coast Guard Service to harass British vessels off its coast. Iceland also used trawlwire cutters to sever the trawl from the trawlers in an effort to make fishing unprofitable to the British (and later West Germans). The Third Cod War increased hostility with continued use of trawlwire cutters, mutual ramming of ships, and shots fired. Iceland broke diplomatic relations with Britain, and threatened to withdraw from the North Atlantic Treaty Organization (NATO) before the conflict was resolved in Iceland’s favor in 1976 (Glantz, 1990). The mackerel and cod conflicts demonstrate the potential for conflict over fish, even between countries that are normally allies. With precedent for fishery-related conflict at both the local and international scales, it is not unlikely that climate-driven changes to fisheries will precede and possibly contribute to future conflicts over fish.

3. Methods

Many existing empirical studies on climate change and conflict attempt to answer the question “will climate change cause conflict?” examining a variety of variables to correlate climate-related environmental change and violent conflict. However, correlation cannot always explain causation and seeking to answer the question of whether climate change causes conflict by identifying the likelihood for this to occur through statistical analysis may overlook the complex interaction of factors that drive violent conflict. If climate-driven conflict is dismissed as unlikely due to statistical analysis of variables, then future analysis of potential conflict might ignore climate-related factors that, while unlikely, might still be present in some cases. Even one case of violent conflict caused or triggered by climate change could be significant, especially if it resulted in many casualties, triggered broader conflict, or occurred in a country

of strategic global importance. In studying climate change and conflict, it is as important to understand *how* climate change might cause or influence violent conflict as it is to understand the likelihood of this occurring. The methodology for this study was driven by the need to identify the causal pathways by which climate change can lead to violent conflict.

The principal question addressed by this study is *how might climate-driven environmental changes to the marine environment affect human societies and activities in ways that could lead to violent conflict*. This question falls within the broader question of how climate change might lead to violent conflict, but focuses on a part of the environment that has been relatively unexplored in climate change-conflict literature – oceans and the marine environment. A literature review led to the development of the general hypothesis: *climate change will alter fish abundances and distributions in ways that will affect livelihoods and economic well-being, potentially leading to instability and/or violent conflict*. In order to effectively analyze each component of this broad hypothesis, it was further broken down into five sub-hypotheses.

The sub-hypotheses were analyzed using Analysis of Competing Hypotheses (ACH), an analytic technique developed by Richards Heuer for intelligence analysts that involves developing a matrix to systematically analyze a set of hypotheses (Heuer, 1999). The steps of the ACH process are:

- 1) Identify hypotheses related to a problem or question,
- 2) List evidence related to each hypothesis,
- 3) Identify the evidence that is most useful in judging the relative likelihood of the hypotheses,
- 4) Draw conclusions about the relative likelihood of each hypothesis (Heuer, 1999).

The ACH technique is typically used to analyze problems of policy relevance to produce reports for government decision makers. Using the technique to analyze the scientific literature on climate change and conflict allowed for the application of a typically policy-oriented tool to examine scientific evidence about a problem.

The literature review included over 100 published studies related to climate change effects on fish (over 35 studies) and climate change and conflict (over 65 studies). Studies included in the literature

review were identified using the snowball method, with appropriate references from each study identified and reviewed. The climate change effects on fish portion of the review was concluded when new studies identified to review became less relevant to the topic. The climate change and conflict portion of the review was concluded when the same studies began to appear in references and further inquiry was not closely related to the hypotheses being analyzed. Although some relevant studies and findings may have been overlooked by using this approach, this method of identifying literature was most practical given time constraints and was appropriate to an exploratory study, which is seeking to develop methods and tentative findings to use for future studies.

Research findings from the literature review were used as evidence to analyze the competing hypotheses. Studies with findings that were not specifically relevant to the hypotheses were excluded. Findings were analyzed to determine whether they supported or refuted each hypothesis. If a finding was consistent with a hypothesis, it was assigned a “C.” Findings that were inconsistent with a hypothesis were assigned an “I,” and findings that were neither consistent nor inconsistent were neutral and assigned an “N.” The number of C’s and I’s were counted for each hypothesis and an assessment was made about which was most likely based on the evidence that was consistent and inconsistent with that hypothesis. This exercise was repeated for each of the five hypotheses, leading to an assessment of the overall hypothesis and a potential causal chain from climate change effects on fish distributions to violent conflict.

For this study, an ACH matrix was created for each hypothesis, with a competing hypothesis in each. The competing hypotheses were:

Primary	Competing
H1: Climate change will alter the availability of fish resources. (See Appendix A)	H1C: Climate change will not alter the availability of fish resources.
H2: The effects of climate change on fisheries will negatively impact livelihoods and economic stability. (See Appendix B)	H2C: Climate change effects on fisheries will not have a significant negative impact on livelihoods and economic stability.

H3: Sensitivity, resource dependency, and lack of adaptive capacity to changes in fisheries increase the likelihood of negative socioeconomic effects from climate change impacts to fisheries. (See <i>Appendix C</i>)	H3C: Sensitivity, resource dependency, and lack of adaptive capacity to changes in fisheries are unlikely to drive negative socioeconomic effects associated with climate change.
H4: Economic decline resulting from environmental/climate changes increases the risk of instability and violent conflict. (See <i>Appendix D</i>)	H4C: Economic decline resulting from environmental/climate changes does not affect the risk of instability and violent conflict.
H5: Changes in the availability of a key environmental resource (possibly caused by climate change) increases the risk of instability and/or violent conflict. (See <i>Appendix E</i>)	H5C: Changes in environmental resource availability (possibly caused by climate change) does not affect the risk of instability and/or violent conflict.

Often with relatively new areas of study, such as this investigation into the effects of climate change on fish and potential implications for violent conflict, a dearth of available material makes it difficult to grasp the preponderance of evidence (Heaney & Rafferty, 2009). In addition, information that is available is often uncertain, with qualified results or implications that remain in dispute. While this review includes a large number of studies in total, the studies used to analyze some of the hypotheses were quite limited, reflecting the limited availability of information about the specific topic. The method described here was used in order to contribute to a growing body of literature on a developing topic.

The methodology used for this study avoids asking the general question “does climate change cause conflict?” choosing instead to focus upon the effects of climate change in a certain part of the environment and to the mechanisms by which changes to resources within that part of the environment can affect human systems. This study explores the components of a broad hypothesis using published literature to illustrate a possible causal pathway from climate change to violence.

4. Results and Discussion

The results of the ACH exercise reveal strong support for three of the hypotheses, weak support for one, and support but insufficient evidence for one. None of the competing hypotheses received strong enough support from the evidence to reject the primary hypothesis. The results suggest a potential path of climate-induced environmental changes to conflict that might look like the following:

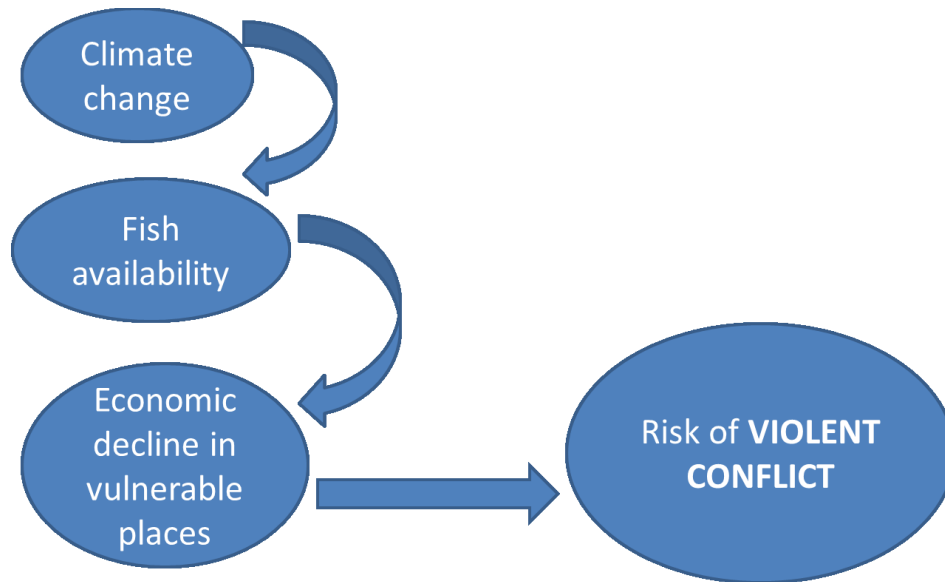


Figure 1. Possible pathway from climate change to violent conflict related to fisheries.

Such a pathway is by no means pre-ordained, but the evidence analyzed for this study supports the possibility for climate-induced environmental changes affecting fish to lead to economic decline that increases the risk of violent conflict.

The primary hypothesis for Hypothesis 1 stated that *climate change will alter the availability of fish resources*. The competing hypothesis was: *climate change will not alter the availability of fish resources*. Fourteen peer-reviewed studies published between 2004 and 2013 were analyzed, with seventeen findings identified from the studies. Fifteen of the seventeen findings were consistent

H1 Primary: Climate change will alter the availability of fish resources.	H1 Competing: Climate change will not alter the availability of fish resources.
Consistent: 15/17 Inconsistent: 0/17 Neutral: 2/17	Consistent: 1/17 Inconsistent: 14/17 Neutral: 2/17
Assessment: Climate change is likely to alter the availability of fish resources.	

with the primary hypothesis and two were neutral. None of the findings were inconsistent with the primary hypothesis; that is none of the findings conclusively found that climate change will not affect the availability of fish resources. The two neutral findings discussed or anticipated changes in future fisheries production or ecosystem changes that would affect fish, but did not link the changes definitively to climate change. In one case the authors suggested that ecosystem changes could be due to climate change, but could also be influenced by other natural or anthropogenic fluctuations such as weather or fishing (Beare et al., 2004). The other neutral finding stated that due to uncertainty over future global aquatic net primary production and the transfer of production through the food chain to human consumption, there was low confidence in predictions of future fisheries production (Brander, 2007). The fifteen findings supporting the hypothesis that climate change will alter the availability of fish resources included observational studies of climate-driven ecosystem changes (Grebmeier, 2006; Kortsch et al., 2012), effects of temperature warming on fish size (Baudron, Needle, & Marshall, 2011; Cheung et al., 2012b), climate change effects on fish productivity and biodiversity (Brander, 2007; Harley et al., 2006; Hazen et al., 2012; Hoegh-Guldberg & Bruno, 2010; Wernberg et al., 2012), regime shift (Möllmann et al., 2009), and climate-driven shifts in fish distribution (Cheung et al., 2010, 2012b; Perry et al., 2005; Ussif Rashid Sumaila & Cheung, 2010). All of these impacts should be expected to affect the availability of fish resources, which is why studies investigating a diversity of impacts were included in the review. The many ways in which climate change is expected to affect fish will also affect the availability of fish, linking these climate-driven changes to effects on human systems.

The review conducted for Hypothesis 2, with the primary hypothesis: *climate change effects on fisheries will negatively impact livelihoods and economic stability*, included only six studies but sixteen findings. The results of the analysis for H2 find somewhat more evidence that is consistent with the primary hypothesis (nine findings) than inconsistent (five findings), with two neutral findings. The competing hypothesis: *climate change effects on*

H2 Primary: Climate change effects on fisheries will negatively impact livelihoods and economic stability.	H2 Competing: Climate change effects on fisheries will not have a significant negative impact on livelihoods and economic stability.
Consistent: 9/16 Inconsistent: 5/16 Neutral: 2/16	Consistent: 7/16 Inconsistent: 7/16 Neutral: 2/16
Assessment: Uncertainty, but climate impacts on fisheries likely to negatively affect socioeconomically vulnerable.	

fisheries will not have a significant negative impact on livelihoods and economic stability has an equal number of findings that are consistent and inconsistent (seven each), and two neutral findings. The findings from this part of the literature review suggest that there is still significant uncertainty regarding the economic impacts of climate change, most likely due to the differential impacts of shifting fish distribution. Many places that are expected to lose resources, particularly in the tropics, are also more socioeconomically vulnerable to the losses (Cheung et al., 2010). So, despite the lack of consensus in the findings, it is reasonable to assess that climate impacts on fisheries will negatively affect some who are socioeconomically vulnerable.

Hypothesis 3 continues to explore the human impacts of climate-driven changes to fisheries with the primary hypothesis: *Sensitivity, resource dependency, and lack of adaptive capacity (together comprising “vulnerability”) to changes in fisheries increase the likelihood of negative socioeconomic effects from climate change impacts to fisheries.* The competing hypothesis states that *sensitivity, dependence, and lack of adaptive capacity (vulnerability) to changes in fisheries are unlikely to drive negative socioeconomic effects associated with*

climate change. The analysis of these hypotheses included the fewest number of studies, with only four studies and findings included. The limited number of studies found for this set of competing hypotheses may be due in part to the specificity of the hypotheses, which link vulnerability, defined as sensitivity, dependence, and lack of adaptive capacity, as it relates to fisheries and negative socioeconomic effects. Of the four findings reviewed,

three were consistent with the primary hypothesis, and one was inconsistent, while one was consistent with the competing hypothesis and three were inconsistent. Evidence from these few studies suggests that vulnerability to changes in fisheries increases the likelihood of negative socioeconomic effects from climate change impacts to fisheries, but given the limited number of sources available, this assessment is uncertain and a balance of evidence so

H3 Primary: Sensitivity, dependence, & lack of adaptive capacity (vulnerability) to changes in fisheries increase the likelihood of negative socioeconomic effects from climate change impacts to fisheries.	H3 Competing: Sensitivity, dependence, and lack of adaptive capacity (vulnerability) to changes in fisheries are unlikely to drive negative socioeconomic effects associated with climate change.
Consistent: 3/4 Inconsistent: 1/4	Consistent: 1/4 Inconsistent: 3/4
Assessment: Very limited studies, high uncertainty; more evidence supports that vulnerability to fisheries changes increases the likelihood of negative socioeconomic effects.	

close to 50-50 should be considered equivocal. Additional findings could sway the results toward a different assessment. Adger (2006) notes that there is evidence that communities and countries have a greater capacity to adapt than might be expected, despite their level of vulnerability. However, it is important to acknowledge the risk of negative socioeconomic effects posed by higher levels of vulnerability, consistent with the findings from three of the four studies included in this portion of the review.

Both H2 and H3 focus on the socioeconomic effects of climate change on fisheries, and include six and four studies respectively. These hypotheses address an area of study that appears to be growing – that of research integrating climate change effects, fisheries and the marine environment, and impacts to human systems – but peer reviewed, published studies remain limited.

Hypothesis 4 moves from a fisheries-specific focus to analyzing economic decline, climate and environmental change, and instability and conflict more broadly. The primary hypothesis states: *economic decline resulting from environmental/climate changes increases the risk of instability and violent conflict*, with the competing hypothesis: *economic decline*

resulting from environmental/climate changes does not affect the risk of instability and violent conflict. This portion of the review included seven findings from six studies. As with H2 and H3, the limited number of studies reviewed for this hypothesis may not warrant a definitive assessment; however, the evidence strongly supported the primary hypothesis over the

competing hypothesis. Six out of seven findings were consistent with the hypothesis that economic decline resulting from environmental or climate changes increases the risk of instability and conflict, while only one finding was inconsistent; none were neutral. Only one finding was consistent with the competing hypothesis, and six findings were inconsistent. Although the total number of studies was limited, the findings from those studies strongly

H4 Primary: Economic decline resulting from environmental/climate changes increases the risk of instability and violent conflict.	H4 Competing: Economic decline resulting from environmental/climate changes does not affect the risk of instability and violent conflict.
Consistent: 6/7 Inconsistent: 1/7	Consistent: 1/7 Inconsistent: 6/7
Assessment: Limited studies, some uncertainty; evidence supports that economic decline increases risk of violent conflict.	

suggest that environmental or climate changes that lead to economic decline or decreased economic growth can increase the risk of instability and conflict. Some studies have demonstrated that climate-induced effects negatively impact economic growth and increase the risk of instability and conflict, while others have not identified such a link. However, the variables used to assess climate variability have been limited (e.g., to rainfall or temperature variability), and climate change has the potential to affect economic growth much more broadly. Therefore, the most telling findings are those confirming that low economic growth or economic decline is a factor that increases the risk of instability or violent conflict.

The final hypothesis included in this exercise was that: *Changes in environmental resource availability (possibly caused by climate change) increase the risk of instability and/or violent conflict.* The competing hypothesis was: *changes in environmental resource availability (possibly caused by climate change) do not affect the risk of instability and/or*

violent conflict. The analysis conducted for these hypotheses included sixteen studies and sixteen findings. Again, the evidence was more consistent with the primary hypothesis than the competing hypothesis. Eleven findings were consistent with the primary hypothesis, four were inconsistent, and one was neutral. The competing hypothesis had five consistent findings, ten inconsistent, and one neutral. The studies

H5 Primary: Changes in environmental resource availability increase risk of instability and/or violent conflict	H5 Competing: Changes in environmental resource availability do not affect risk of instability and/or violent conflict.
Consistent: 11/16 Inconsistent: 4/16 Neutral: 1/16	Consistent: 5/16 Inconsistent: 10/16 Neutral: 1/16
Assessment: Changes in environmental resources, possibly from climate change, increase risk of violent conflict.	

reflect the multitude of ways to measure environmental changes and climate-driven changes, and the different ways such changes might interact to influence violent conflict. Many studies emphasize the role of environmental and climate changes as stressors, interacting with other factors such as economic factors (Burke et al., 2009; Esty et al., 1998), poor governance (Butzer, 2012; Salehyan, 2008), or ethnic strife (Homer-Dixon, 2007) to increase the risk of violent conflict. Environmental or climate-induced changes alone do not drive conflict, but rather interact with existing stressors to increase the risk of instability or violence. The findings for this portion of the analysis offer evidence that is consistent with the hypothesis that changes in the availability of environmental resources, possibly resulting from climate change, increase the risk of instability or violent conflict. While some studies have suggested that

environmental factors have minimal to no effect on the risk of instability or violent conflict, these findings strongly suggest that it is important to consider the role of environmental resource availability in the outbreak of instability and violent conflict, especially with the significant changes anticipated from global climate change.

The ACH exercise revealed more consistent evidence with each of the primary hypotheses than for any of the competing hypotheses, offering support to the overall hypothesis that *climate change will alter fish distribution in ways that will affect livelihoods and economic well-being, potentially leading to instability or conflict in some areas with limited adaptive capacity*. Many findings support that climate change is expected to alter the availability of fish. Although a limited number of studies were included, findings support the notion that those who are vulnerable to fisheries losses through exposure to changes, sensitivity to changes, and lack of adaptive capacity are likely to experience economic decline. Both economic decline and changes in the availability of environmental resources have been found to increase the risk of instability and violent conflict. The support in published literature for each of these statements suggests a potential causal chain from climate-induced changes to fish resources to violent conflict that, while certainly not imminent or unavoidable, should be carefully considered. The outbreak of instability and violent conflict can be due to a multitude of circumstances, with factors that often work in concert to influence whether or not violence occurs. Rather than continuing previous efforts to determine whether climate change will lead to conflict, the ACH exercise conducted here sought to analyze several hypotheses to identify how instability and violent conflict might occur as a result of climate-driven changes. While most studies of climate change and conflict have focused on the terrestrial environment, often using temperature and rainfall variations to measure climate changes, this exercise combined the results of such studies with the results of research into climate change effects on fish, and the socioeconomic effects of changes to fish to identify links from climate change effects in the marine environment to violent conflict.

Although violent conflict has been the focus of this article, other examples of conflict may prove useful in examining how the elements of changing availability of fish resources, vulnerability, economic impacts, and conflict may interact in the future. The ongoing conflict over mackerel in the Northeast

Atlantic presents a current case where changing fish availability has led to conflict, with likely links to climate change.

4.1 Europe's Mackerel Conflict

Over the past few years, Northeast Atlantic mackerel have become the center of an ongoing feud between Norway and the European Union on one side, and EU-aspirant Iceland and the Faroe Islands on the other. The dispute arose due to changing migration patterns of the mackerel, which have driven them in increasing numbers into Icelandic and Faroese waters (Hotvedt, 2011). These countries have significantly increased their mackerel catch, setting unilateral quotas, while the EU and Norway have made bilateral agreements on quotas (Norwegian Ministry of Fisheries and Coastal Affairs, n.d.). The lack of coordination on quotas has led to fishing that has exceeded the total allowable catch (TAC) recommendations issued by the International Council for the Exploration of the Sea (ICES) (Popescu & Poulsen, 2012).

Historically, Northeast Atlantic mackerel have been primarily caught in the northern North Sea, around the Shetland Isles, and off the west coast of Scotland and Ireland (ICES, 2013). In recent years the stock has expanded north-westward, toward Iceland and the Faroe Islands, a change attributed to increased stock size and warmer ocean temperatures (ICES, 2013). Iceland has implicated warming ocean temperatures in the shift of mackerel migrations into Icelandic waters (Ministry of Industries and Innovation, n.d.-a) and temperature-driven shifts in fish distribution have been observed in the North Sea (Perry et al., 2005), part of the mackerel's traditional range. The shift northward of mackerel toward Iceland is consistent with the predictions made by Cheung et al. (2010) of a 10-15% increase in catch potential among the northern latitude countries.

The distributional shifts in the stock resulted in the development of new fisheries and have impacted the operations of some well-established fisheries (ICES, 2013). In 2011, mackerel catches in Icelandic and Faroese waters constituted about 32% of the total reported landings, whereas prior to 2008 almost no catches were reported in these waters (ICES, 2013).

Prior to the conflict, the mackerel stock was co-managed by the EU, Norway, and the Faroe Islands in annual Coastal States consultations beginning in 1999, but the precautionary management plan agreed by the Coastal States in October 2008 has not been followed since 2009 (Popescu & Poulsen, 2012). The Coastal States rejected Iceland's initial request to participate in the management of the mackerel stock after mackerel began appearing in greater numbers in its EEZ, and in 2010 Iceland unilaterally allocated itself a quota of 23% of the TAC advised by ICES for mackerel fisheries, and the Faroe Islands awarded itself an increased quota of 15% (Popescu & Poulsen, 2012).

Iceland cites not only the availability of mackerel, but also the threat the mackerel pose to existing species and ecosystems as reasons for its substantial fishery. The significant increases in mackerel feeding in Icelandic waters may negatively impact other fish stocks, sea birds and the marine ecosystem at large. In addition, mackerel increase their weight substantially while in Icelandic waters, eating vast amounts and leaving less food for other fish. (Ministry of Industries and Innovation, n.d.-b).

The EU and Norway have historically taken the largest share of the catch and want to maintain their historical share. In Ireland and Scotland mackerel is the most important species for the local fishing fleets. In several Scottish coastal communities, mackerel represents an extremely important source of income (Hotvedt, 2011). Scottish industry and the EU claim that the stock will be ruined if overfishing continues, both blaming Iceland and the Faroe Islands (Keane, 2013). Scotland's fisheries secretary, Richard Lochhead, said, "We don't deny Iceland's right to have a share of the stock and we acknowledge that the fish have appeared in their waters; however, the main reason there is fish there in the first place is because other countries have been fishing the stock sustainably" (Keane, 2013).

The mackerel conflict stems from concern about resource scarcity – although the mackerel became abundant in Icelandic and Faroese waters, the conflict is over allocation of the fish in a way that will prevent stock depletion and scarcity of fish. Additionally, Iceland has argued that one of its reasons for fishing the mackerel aggressively is that the mackerel is endangering other commercial stocks. Economic welfare also plays a key role in the context of the mackerel conflict. Disagreement between countries about the total allowable catch stems from the importance of fishing to each country and concerns about loss of economic welfare if mackerel are overfished. The ACH exercise demonstrated

support for the notion that economic decline or poor economic growth can influence instability or violent conflict. In countries lacking adaptive capacity or well-developed institutions to manage the negative effects of economic decline, parties may resort to violence if economic resources or livelihoods are threatened. If climate change is a driver of the resource shift, and shifting resources affect economic well-being, then this case supports the argument that climate change can influence conflict.

5. Conclusions

There are a multitude of complexities involved in the outbreak of socioeconomic instability and violent conflict, and it is overly simplistic to assume direct links from environmental and climate change to conflict without understanding these complexities. But, it is also dangerous to dismiss the potential for environmental conflict due to limited empirical proof directly linking the effects of climate change to instability or violent conflict. The environmental changes resulting from climate change are unprecedented in modern times and as such, are difficult to predict. Unsupported assumptions are insufficient to support policy action, but it is imperative to critically consider the existing evidence and research across disciplines and to use multiple methods (quantitative and qualitative) to understand the potential for socioeconomic instability and violent conflict resulting from the impacts of climate change.

Counter to some conclusions that climate change will not lead to violent conflict, this analysis of studies across disciplines suggests that there are situations in which climate-driven environmental changes could lead to violent conflict. There are many mitigating factors, and most likely also additional stressors that remain to be analyzed. Concluding that climate change will inevitably lead to indiscriminate conflict is inaccurate, but it is also inaccurate to dismiss the possibility of violent conflict triggered or influenced by climate change. Evidence that climate change leads to conflict must not be incontrovertible in all cases to prove that violence related to climate change will occur. For policy makers who must respond to violent conflict, it is equally important to be aware of the likelihood for conflict as it is to understand the process by which conflict may occur in order to identify where precursors to violence may be present. The findings of this study provide guidance for how to monitor the potential for conflict in places vulnerable to both changes to fisheries resulting from climate change, and instability and violent conflict. The case of the mackerel conflict offers an example that may be indicative of future conflicts

arising as a result of climate-induced changes, with the possibility for violence if certain circumstances are present.

Many pieces of the climate-conflict puzzle remain, but evidence indicates that the potential exists for violent conflict influenced by climate change impacts to marine environments. Environmental processes alone cannot explain the occurrence of violent conflict; rather, it is the interaction between environmental and political systems that is critical to understanding organized armed violence (Salehyan, 2008). This research has demonstrated that environmental changes may be contributing factors to future violent conflict, and understanding the processes by which this can occur will be instrumental in responding to future conflicts.

References

- Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268–281. doi:10.1016/j.gloenvcha.2006.02.006
- Allison, E. H., Perry, A. L., Badjeck, M.-C., Neil Adger, W., Brown, K., Conway, D., ... Dulvy, N. K. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, 10(2), 173–196. doi:10.1111/j.1467-2979.2008.00310.x
- Barnaby, W. (2009). Do nations go to war over water? *Nature*, 458, 282–283.
- Barnett, J., & Adger, W. N. (2007). Climate change, human security and violent conflict. *Political Geography*, 26(6), 639–655. doi:10.1016/j.polgeo.2007.03.003
- Baudron, A. R., Needle, C. L., & Marshall, C. T. (2011). Implications of a warming North Sea for the growth of haddock *Melanogrammus aeglefinus*. *Journal of Fish Biology*, 78(7), 1874–1889. doi:10.1111/j.1095-8649.2011.02940.x
- Beare, D. J., Burns, F., Greig, A., Jones, E. G., Peach, K., Kienzle, M., ... Reid, D. G. (2004). Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. *Marine Ecology Progress Series*, 284, 269–278.
- Blattman, C., & Miguel, E. (2010). Civil War. *Journal of Economic Literature*, 48(1), 3–57. doi:10.1257/jel.48.1.3
- Bohlken, A. T., & Sargent, E. J. (2010). Economic growth and ethnic violence: An empirical investigation of Hindu–Muslim riots in India. *Journal of Peace Research*, 47(5), 589–600. doi:10.1177/0022343310373032
- Brander, K. M. (2007). Global fish production and climate change. *Proceedings of the National Academy of Sciences*, 104(50), 19709–19714.
- Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., & Lobell, D. B. (2009). Warming increases the risk of civil war in Africa. *Proceedings of the National Academy of Sciences*, 106(49), 20670–20674.
- Butzer, K. W. (2012). Collapse, environment, and society. *Proceedings of the National Academy of Sciences*, 109(10), 3632–3639.
- Campbell, K. M., Gullledge, J., McNeill, J. R., Podesta, J., Ogden, P., Fuerth, L., ... Weitz, R. (2007). *The age of consequences: the foreign policy and national security implications of global climate change* (p. 124). DTIC Document. Retrieved from <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA473826>
- Charles, A. T. (1988). Fishery conflicts. *Economics*, 64, 276–295.
- Cheung, W. W. L., Lam, V. W. Y., Sarmiento, J. L., Kearney, K., Watson, R., Zeller, D., & Pauly, D. (2010). Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, 16(1), 24–35. doi:10.1111/j.1365-2486.2009.01995.x
- Cheung, W. W. L., Sarmiento, J. L., Dunne, J., Frölicher, T. L., Lam, V. W. Y., Palomares, M. L. D., ... Pauly, D. (2012a). Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems. *Nature Climate Change*, 2(10), 1–5. doi:10.1038/nclimate1691
- Cheung, W. W. L., Sarmiento, J. L., Dunne, J., Frölicher, T. L., Lam, V. W. Y., Palomares, M. L. D., ... Pauly, D. (2012b). Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems. *Nature Climate Change*, 2(10), 1–5. doi:10.1038/nclimate1691
- CNA Corporation. (2007). *National Security and the Threat of Climate Change* (p. 68). Retrieved from <http://www.cna.org/reports/climate>
- Cochrane, K., De Young, C., Soto, D., & Bahri, T. (2009). Climate change implications for fisheries and aquaculture. *FAO Fisheries and aquaculture technical paper*, 530, 212.
- Esty, D., Goldstone, J., Gurr, T. R., Harff, B., Levy, M., Dalboko, G., ... Unger, A. (1998). *State Failure Task Force Report: Phase I1 Findings*. July.
- FAO. (2012). *The State of the World Fisheries and Aquaculture 2012. Part 1. World Review of Fisheries and Aquaculture*. (p. 148). Retrieved from <http://www.fao.org/docrep/016/i2727e/i2727e01.pdf>
- Gartzke, E. (2012). Could climate change precipitate peace? *Journal of Peace Research*, 49(1), 177–192. doi:10.1177/0022343311427342
- Glantz, M. H. (1990). Does History Have a Future? Forecasting Climate Change Effects on Fisheries by Analogy. *Fisheries*, 15(6), 39–44. doi:10.1577/1548-8446(1990)015<0039:DHHAFF>2.0.CO;2
- Gleditsch, N. P. (2012). Whither the weather? Climate change and conflict. *Journal of Peace Research*, 49(1), 3–9. doi:10.1177/0022343311431288

- Grebmeier, J. M. (2006). A Major Ecosystem Shift in the Northern Bering Sea. *Science*, 311(5766), 1461–1464. doi:10.1126/science.1121365
- Harley, C. D. G., Randall Hughes, A., Hultgren, K. M., Miner, B. G., Sorte, C. J. B., Thornber, C. S., ... Williams, S. L. (2006). The impacts of climate change in coastal marine systems. *Ecology Letters*, 9(2), 228–241. doi:10.1111/j.1461-0248.2005.00871.x
- Harvell, D., Altizer, S., Cattadori, I. M., Harrington, L., & Weil, E. (2009). Climate change and wildlife diseases: When does the host matter the most? *Ecology*, 90(4), 912–915.
- Hauge, W., & Ellingsen, T. (1998). Beyond environmental scarcity: causal pathways to conflict. *Journal of Peace Research*, 35(3), 299–317.
- Hazen, E. L., Jorgensen, S., Rykaczewski, R. R., Bograd, S. J., Foley, D. G., Jonsen, I. D., ... Block, B. A. (2012). Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change*, 3(3), 234–238. doi:10.1038/nclimate1686
- Heaney, R. P., & Rafferty, K. (2009). Preponderance of the evidence: an example from the issue of calcium intake and body composition. *Nutrition Reviews*, 67(1), 32–39. doi:10.1111/j.1753-4887.2008.00132.x
- Hendrix, C.S., & Salehyan, I. (2012). Climate change, rainfall, and social conflict in Africa. *Journal of Peace Research*, 39(1), 35–50.
- Hendrix, Cullen S., & Haggard, S. (2012). International food prices, regime type, and protest in the developing world. *Under journal review*. Retrieved from http://cshendrix.files.wordpress.com/2007/03/hh_foodpricesprotest_forweb.pdf
- Heuer, R. (1999). *Psychology of Intelligence Analysis*. Central Intelligence Agency: Center for the Study of Intelligence. Retrieved from <https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/psychology-of-intelligence-analysis/PsychofIntelNew.pdf>
- Hoegh-Guldberg, O., & Bruno, J. F. (2010). The impact of climate change on the world's marine ecosystems. *Science (New York, N.Y.)*, 328(5985), 1523–8. doi:10.1126/science.1189930
- Hollowed, A. B., Planque, B., & Loeng, H. (2013). Potential movement of fish and shellfish stocks from the sub-Arctic to the Arctic Ocean. *Fisheries Oceanography*, n/a–n/a. doi:10.1111/fog.12027
- Homer-Dixon, T. (1994). Environmental scarcities and violent conflict: evidence from cases. *International security*, 19(1), 5–40.
- Homer-Dixon, T. (2007, April 24). Terror in the Weather Forecast. *The New York Times*.
- Hotvedt, B. D. (2011). *The problem of sharing a common stock: an analysis of the mackerel conflict in the North East Atlantic*. University of Tromso, Tromso, Norway. Retrieved from <http://munin.uit.no/handle/10037/3528>
- Hsiang, S. M., Meng, K. C., & Cane, M. A. (2011). Civil conflicts are associated with the global climate. *Nature*, 476(7361), 438–441. doi:10.1038/nature10311
- Huelsenbeck, M., & Vorpahl, A. (2012). Ocean-Based Food Security Threatened in a High CO₂ World, (September).
- ICES. (2013). Advice September 2012 Widely distributed and migratory stocks Mackerel in the Northeast Atlantic (combined Southern , Western , and North Sea spawning components), (September 2012), 1–20.
- IPCC. (2007). *Climate Change 2007: Synthesis Report* (p. 52). Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- Jansen, T., & Gislason, H. (2011). Temperature affects the timing of spawning and migration of North Sea mackerel. *Continental Shelf Research*, 31(1), 64–72. doi:10.1016/j.csr.2010.11.003
- Keane, K. (2013, February 13). Iceland sets new unilateral mackerel quota as stalemate with EU continues. *SeafoodNews.com*. Retrieved from <http://seafoodnews.com/sub/news.asp?key=882985>
- Kortsch, S., Primicerio, R., Beuchel, F., Renaud, P. E., Rodrigues, J., Lonne, O. J., & Gulliksen, B. (2012). Climate-driven regime shifts in Arctic marine benthos. *Proceedings of the National Academy of Sciences*, 109(35), 14052–14057. doi:10.1073/pnas.1207509109
- Koubi, V., Bernauer, T., Kalbhenn, A., & Spilker, G. (2012). Climate variability, economic growth, and civil conflict. *Journal of Peace Research*, 49(1), 113–127.
- Ministry of Industries and Innovation. (n.d.-a). Iceland's Commitment to Sustainable Mackerel Fishing. *Mackerel Fishing Dispute*. Retrieved March 5, 2013, from http://eng.atvinnuvegaraduneyti.is/subjects/mackerel-fishing-dispute/nr/6902#_ftn1

- Ministry of Industries and Innovation. (n.d.-b). Mackerel Q&A. *Mackerel Fishing Dispute*. Retrieved February 26, 2013, from <http://eng.atvinnuvegaraduneyti.is/subjects/mackerel-fishing-dispute/nr/6903>
- MöLlmann, C., Diekmann, R., MüLler-Karulis, B., Kornilovs, G., Plikshs, M., & Axe, P. (2009). Reorganization of a large marine ecosystem due to atmospheric and anthropogenic pressure: a discontinuous regime shift in the Central Baltic Sea. *Global Change Biology*, *15*(6), 1377–1393. doi:10.1111/j.1365-2486.2008.01814.x
- Nordås, R., & Gleditsch, N. P. (2007). Climate change and conflict. *Political Geography*, *26*(6), 627–638. doi:10.1016/j.polgeo.2007.06.003
- Norwegian Ministry of Fisheries and Coastal Affairs. (n.d.). Atlantic mackerel (*Scomber scombrus*). *fisheries.no*. Retrieved March 16, 2013, from http://www.fisheries.no/ecosystems-and-stocks/marine_stocks/fish_stocks/atlantic_mackerel/
- Ottersen, G., Kim, S., Huse, G., Polovina, J. J., & Stenseth, N. C. (2010). Major pathways by which climate may force marine fish populations. *Journal of Marine Systems*, *79*(3-4), 343–360. doi:10.1016/j.jmarsys.2008.12.013
- Perry, A. L., Low, P. J., Ellis, J. R., & Reynolds, J. D. (2005). Climate Change and Distribution Shifts in Marine Fishes, *308*, 1912–1915. doi:10.1126/science.1111322
- Pomeroy, R., Parks, J., Pollnac, R., Campson, T., Genio, E., Marlessy, C., ... Thu Hue, N. (2007). Fish wars: Conflict and collaboration in fisheries management in Southeast Asia. *Marine Policy*, *31*(6), 645–656. doi:10.1016/j.marpol.2007.03.012
- Popescu, I., & Poulsen, K. (2012). *Icelandic fisheries: a review*. Brussels: European Parliament, Committee on Fisheries. Retrieved from <http://www.europarl.europa.eu/studies>
- Raleigh, C., & Urdal, H. (2007). Climate change, environmental degradation and armed conflict. *Political Geography*, *26*(6), 674–694. doi:10.1016/j.polgeo.2007.06.005
- Reuveny, R. (2007). Climate change-induced migration and violent conflict. *Political Geography*, *26*(6), 656–673. doi:10.1016/j.polgeo.2007.05.001
- Richardson, A. J., & Shoeman, D. S. (2004). Climate Impact on Plankton Ecosystems in the Northeast Atlantic. *Science*, *305*(5690), 1609–1612. doi:10.1126/science.1100958
- Salehyan, I. (2008). From Climate Change to Conflict? No Consensus Yet. *Journal of Peace Research*, *45*(3), 315–326. doi:10.1177/0022343308088812
- Scheffran, J., Brzoska, M., Kominek, J., Link, P. M., & Schilling, J. (2012). Disentangling the Climate-conflict Nexus: Empirical and Theoretical Assessment of Vulnerabilities and Pathways. *Review of European Studies*, *4*(5). doi:10.5539/res.v4n5p1
- Stalley, P. (2003). Environmental Scarcity and International Conflict. *Conflict Management and Peace Science*, *20*(2), 33–58.
- Sumaila, U. Rashid, Cheung, W. W. L., Lam, V. W. Y., Pauly, D., & Herrick, S. (2011). Climate change impacts on the biophysics and economics of world fisheries. *Nature Climate Change*, *1*(9), 449–456. doi:10.1038/nclimate1301
- Sumaila, Ussif Rashid, & Cheung, W. W. (2010). Cost of adapting fisheries to climate change. *World Bank Discussion Paper*, 5. Retrieved from <http://climatechange.worldbank.org/sites/default/files/documents/CostofAdaptingFisheries.pdf>
- Theisen, O. M., Gleditsch, N. P., & Buhaug, H. (2013). Is climate change a driver of armed conflict? *Climatic Change*, *117*(3), 613–625. doi:10.1007/s10584-012-0649-4
- Wernberg, T., Smale, D. A., Tuya, F., Thomsen, M. S., Langlois, T. J., de Bettignies, T., ... Rousseaux, C. S. (2012). An extreme climatic event alters marine ecosystem structure in a global biodiversity hotspot. *Nature Climate Change*. doi:doi:10.1038/nclimate1627
- Zabludovsky, K. (2013, March 19). Quest for Illegal Gain at the Sea Bottom Divides Fishing Communities - NYTimes.com. *The New York Times*. Retrieved April 2, 2013, from http://www.nytimes.com/2013/03/20/world/americas/quest-for-illegal-gain-at-the-sea-bottom-divides-fishing-communities.html?_r=1&

Appendix A: Matrix 1

Assumption/Hypothesis 1: Climate change will alter the availability of fish resources in some places.			
Key: C = Consistent, I = Inconsistent, N = Neutral, NA = Not Applicable			
		H1: Climate change will alter the availability of fish resources.	H2: Climate change will not alter the availability of fish resources.
<u>Evidence</u>	<u>Other factors (weighting)</u>		
Observations support a continued trend toward more subarctic ecosystem conditions in the northern Bering Sea, which may have profound impacts on Arctic diving seabirds, marine mammals, and subsistence and commercial fisheries (Grebmeier, et al., 2006).		C	I
Increasing sea bottom temperature is linked with haddock (<i>M. Aeglefinus</i>) experiencing faster growth in early life and reaching a lower asymptotic total length at a younger age. The possibility of a confounded effect of fisheries induced evolution operating in addition to temperature cannot be excluded entirely. The warming trend in N Sea is associated with a decrease in mass at age of <i>M. aeglefinus</i> at older ages. This constitutes potential loss of yield in a major Scottish fishery irrespective of concomitant changes in stock abundance. (Baudron, Needle, and Marshall, 2011).		C	I
Climate warming can trigger abrupt ecosystem changes in the Arctic, observed in the rocky bottom communities of two Arctic fjords (Kortsch, et al., 2012).		C	I
We have low confidence in predictions of future fisheries production because of uncertainty over future global aquatic net primary production and the transfer of this production through the food chain to human consumption (Brander, 2007).		N	N
Fisheries production is likely to be affected by loss or reduced structural complexity of coral communities, resulting in reduced species richness, local extinctions, and loss of species within key functional groups of reef fish. (Brander, 2007).	(Loss of biodiversity / reductions in demographic and geographic structure due to fishing result in greater sensitivity of fish stocks and marine ecosystems to climate change.)	C	I

Climate change can reduce (in some cases enhance) productivity of stocks through effects on net primary production, reproductive output, growth, and survival (Brander, 2007).		C	I
Most (>75%) of studied pops are expected to experience a reduction of asymptotic weight of 5-39%, median of 10% in all ocean basins due to warming and reduced oxygen content (Cheung et al., 2012).	Many assumptions/ simplifications lend uncertainty to models.	C	I
Model projects that distribution of most fish populations expected to shift poleward at median rate of ~ 27.5-36.4 km decade by 2050 relative to 2000 under the SRES A2 scenario. (Cheung, et al., 2012)	Many assumption/ simplifications lend uncertainty to the models used.	C	I
Climate change may lead to large-scale redistribution of global catch potential (CP), with a 30-70% increase in high latitude regions, and drop up to 40% in tropics (Cheung, et al., 2010)	Models linked ocean conditions with geographic ranges to predict changes in potential catch under low & high GHG emissions scenarios.	C	I
Ecological responses to climate change include changes at the individual (physiology, morphology, behavior), population (dispersal, recruitment), and community level (abundance, interaction) lead to alterations in species distributions, biodiversity, productivity and microevolutionary processes (Harley et al., 2006).	From a review/ synthesis article on implications of anthropogenic climate change on coastal marine ecosystems.	C	I
Moderate increases in temperature increase metabolic rates, ultimately determining life history traits, population growth, and ecosystem processes. Organisms tend to adapt to local environmental temperatures, with optimal physiological responses matching temperatures close to the environmental average. Organisms can acclimatize to temperature ranges around these optimal values, but beyond this range acclimatization fails, mortality risk increases, fitness is reduced, and populations decline or are driven to local extinction (Hoegh-Guldberg and Bruno, 2010).	Review article: "the Impact of Climate Change on the World's Marine Ecosystems."	C	I

<p>Biodiversity patterns changed after extreme warming event in 2011 off west coast of Australia, leading to reduced abundance of habitat-forming seaweeds, shift in community structure, and tropicalization of fish communities. Conclusion: extreme climatic events are key drivers of biodiversity patterns; frequency and intensity of such episodes have major implications for predictive models of species distribution and ecosystem structure, which are largely based on gradual warming trends (Wernberg, et al., 2012).</p>		C	I
<p>Centers of distribution (measured by mean latitudes) shifted in relation to warming for 15 of 36 species, including commercially exploited species (e.g., Atlantic cod, common sole). Distances moved ranged from 48-403 km. Nearly two-thirds of species (21 of 36) showed distributional responses to climatic warming. Boundaries of half fish species studied moved significantly with warming, from 119 to 816 km. Temporal trends in distribution suggest fishing alone could not explain climate-related shifts. (Perry, Low, Ellis & Reynolds, 2005).</p>	<p>Tested for large-scale, long-term, climate-related changes in marine fish distributions.</p>	C	C
<p>Climate model showed physical changes that will drive a substantial northward shift in biodiversity across the North Pacific for species with both commercial and conservation value. Predict increased species overlap and a potential for niche compression under IPCC A2 scenario. Some species gained habitat, some lost. (Hazen, et al., 2013)</p>		C	I
<p>Climate-induced shifts in distributions of major commercial fish stocks have been observed in last few decades (Sumaila and Cheung, 2010). However, projections of changes in potential catch, and their effects on fishing sectors, are considered uncertain (Cheung et al. in press; as cited in Sumaila and Cheung, 2010).</p>		C	I
<p>Changes in marine conditions caused by atmospheric forcing were primary agents in abiotic environment triggering the Baltic regime shift, although it is likely that a number of confounding factors contribute to ecosystem regime shifts; a resulting change was altered food web of the Central Baltic ecosystem, such as decline in cod and <i>P. acuspes</i>; sprat, copepods, and dinoflagellates benefitted. (Möllmann, C. et al., 2009)</p>		C	I

<p>Profound changes are occurring in the northern North Sea ecosystem, with most species classified in this paper as having southern biogeographic affinities showing sudden, almost exponential, increases in abundance since the mid-1990s. The changes appear to be part of a systematic long-term trend, perhaps in response to climate change, but cannot relate directly to temperature since the changes observed are complex and also likely to be influenced by associated changes in other components of the marine fauna caused by either natural (weather) or anthropogenic (fishing) fluctuations. (Beare, et al., 2004).</p>		N	N
	H1: Consistent	15/17	
	H1: Inconsistent	0/17	
	H1: Neutral	2/17	
	H2: Consistent	1/17	
	H2: Inconsistent	14/17	
	H2: Neutral	2/17	
<p>Assessment: Based on the literature reviewed, the findings are consistent with the hypothesis that climate change will alter the availability of fish resources.</p>			

Appendix B: Matrix 2

Assumption/Hypothesis 2: The effects of climate change on fisheries will negatively impact livelihoods and economic stability.			
Key: C = Consistent, I = Inconsistent, N = Neutral, NA = Not Applicable			
		H1: Climate change effects on fisheries will negatively impact livelihoods and economic stability.	H2: Climate change effects on fisheries will not have a significant negative impact on livelihoods and economic stability.
<u>Evidence</u>	<u>Other factors (weighting)</u>		
Further research is needed on the macroeconomic effects of climate change on fisheries (Sumaila, Cheung, Lam, Pauly, and Herrick, 2011).		N	N
Climate change will affect the economics of fishing because both the quantity and quality of marine fish catch and its distribution within and between nations' exclusive economic zones will be impacted. Economic consequences of climate change on fisheries might be changes in the price and value of catches, fishing costs, fishers' incomes, earnings to fishing companies, discount rates and economic rent (the surplus after all costs, including 'normal' profits, have been covered), as well as throughout the global economy (Sumaila, Cheung, Lam, Pauly, and Herrick, 2011).		C	C
Some countries may see economic benefit in the short term (e.g., Iceland) (Sumaila, Cheung, Lam, Pauly, and Herrick, 2011).		I	C
Climate change may cause large-scale redistribution of catch potential, with considerable reduction in the tropics (up to 40%), and increases in northern latitudes (30-70%). Many highly impacted regions, especially in the tropics, are socioeconomically vulnerable to these changes (Cheung, Lam, Sarmiento, Kearney, Watson, Zeller, & Pauly, 2010).		C	C

<p>Globally, the fishing sector may have an annual loss in landed values or gross revenues of between \$17 to \$41 billion in constant 2005 dollars as a result of climate change, with the loss is distributed unevenly across different continents. Developing countries likely to suffer 2-3 times larger loss in landed value or gross revenue under more intensive and less intensive scenarios, respectively. In terms of World Bank regions, East Asia and the Pacific is predicted to suffer the largest loss in landed value (\$7–\$16 billion). (Sumaila and Cheung, 2010).</p>	<p>From report for World Bank, includes their own and others' data</p>	<p>C</p>	<p>I</p>
<p>In socioeconomic terms, the potential response of seafood markets to climate change or changes in seafood demand and supply are unclear. These add uncertainty to our understanding of the potential impacts of climate change on the fishing sector. (Sumaila and Cheung, 2010)</p>		<p>N</p>	<p>N</p>
<p>In many countries, climate change will result in a significant reduction in revenues from fishing. This will mean that the public sector will need to find ways that not only help fishers replace their lost incomes, but also compensate for the lost tax revenues that this will entail (Sumaila and Cheung, 2010).</p>		<p>C</p>	<p>I</p>
<p>Global loss in household income may be between \$6–\$14 billion per year depending on the climate change scenario. Households in developing countries may suffer a bigger loss of \$3.9–\$8.4 billion relative to those in developed countries (\$1.6–\$4.2 billion) as a result of decreased landed value from their EEZs. Under the severe climate change scenario, the East Asia and the Pacific region suffers the biggest loss of up to \$6 billion per year. This is followed by Latin America and the Caribbean and Sub-Saharan Africa. (Sumaila and Cheung, 2010)</p>		<p>C</p>	<p>I</p>
<p>Notwithstanding the uncertainty, global warming will most likely boost the fisheries off Iceland and Greenland and thus contribute positively to their GDP. (Arnason, 2007)</p>		<p>I</p>	<p>C</p>
<p>If the trend of rising sea surface temperature (SST) continues in the Iberian-Atlantic fishing grounds, sardine biomass and expected profits will decrease. Further decreases will occur if the immediate effects of global warming on SST become more significant. (Garza-Gil,</p>		<p>C</p>	<p>I</p>

Torralba-Cano & Varela-Lafuente, 2010)			
It is estimated that climate change may cause a 35 percent reduction in the overall economic value of Australian fisheries by 2070. (as cited in Sumaila and Cheung, 2010).		C	I
In the UK and Ireland, medium confidence that in short-to-medium term (<20 - 50 yrs>) fishing grounds for cod could become more remote, increasing fuel costs to those who remain in the fishery. (MCCIP, 2012).		C	I
In the UK and Ireland, medium confidence that in short to medium term (<20 - 50 yrs>) red mullet and plaice become more accessible to local fleets, thus reducing fishing costs. (MCCIP, 2012).		I	C
In the UK and Ireland, high confidence that scallop productivity increases in short term (<20 years). (MCCIP, 2012).	Assume that increased productivity is economically beneficial.	I	C
In the UK and Ireland, high confidence in continued increase in sea bass and anchovy populations in short term (<20 years). Anchovy are now being specifically targeted in the UK with about 500 tonnes of anchovy being caught in the south-west in 2011. The movement of anchovy north will provide new opportunities for EU fishermen but detailed negotiations will be needed to establish how much can be fished by each interested party. (MCCIP, 2012).	Assume that increased productivity is economically beneficial.	I	C
The overall cost of adaptation of the fisheries sector worldwide in response to climate change is predicted to be large and could lead to losses in gross fisheries revenues of \$10-31 billion by 2050. (MCCIP, 2012).		C	I
	H1: Consistent	9/16	
	H1: Inconsistent	5/16	
	H1: Neutral	2/16	
	H2: Consistent	7/16	
	H2: Inconsistent	7/16	
	H2: Neutral	2/16	

Assessment: Findings from this literature review suggest that there is still significant uncertainty regarding the economic impacts of climate change, most likely due to the differential impacts of shifting fish distribution. Because many fish species, including commercially exploited species, are expected to shift with climate change, some places may lose fish resources, while others will gain resources. Many places that are expected to lose resources, particularly in the tropics, are also more socioeconomically vulnerable to the losses. So, despite the lack of consensus in the findings, it is reasonable to assess that climate impacts on fisheries will affect some who are socioeconomically vulnerable in negative ways.

Appendix C: Matrix 3

Assumption/Hypothesis 3: Vulnerability to changes in fisheries increases the likelihood of negative socioeconomic effects from climate change impacts to fisheries.			
Key: C = Consistent, I = Inconsistent, N = Neutral, NA = Not Applicable			
Vulnerability = sensitivity + dependence + adaptive capacity			
		H1: Vulnerability to changes in fisheries increases likelihood of negative socioeconomic effects from climate change impacts to fisheries.	H2: Vulnerability to changes in fisheries is not a significant factor influencing negative socioeconomic effects.
<u>Evidence</u>	<u>Other factors (weighting)</u>		
The disruption of fisheries by climate change is likely to... reduce the options for future economic growth in those countries for which fisheries are important sources of food, employment and export revenues. ...Vulnerability of the economies of some of the world's fishing countries to climate change impacts could affect their food security and levels of poverty by elevating stress on fisheries production. ...The large-scale climate-related changes in fisheries are likely to bring either increased economic hardship or missed opportunities for countries that depend upon them but lack capacity to adapt. (Allison, et al., 2009)		C	I
A large body of literature suggests that the impact of climate change on human beings and societies is shaped by the vulnerabilities specific to each region (e.g. IPCC, 2007; Füssel, 2011; Samson et al., 2011). (as cited in Scheffran, et al., 2012)		C	I
The least developed nations where residents eat large quantities of fish may suffer the worst hardships from climate change because they have fewer socioeconomic resources to obtain more food to replace what is lost from the sea (Huelsenbeck and Vorpahl, 2012).		C	I
While developing countries are portrayed as 'most vulnerable' there is, at the same time, much evidence, suggesting that communities and countries themselves have significant capacity to adapt latent in local knowledge and experience of coping with variability. Richness and diversity of findings on causes and consequences of vulnerability to climate change and climate risks (Adger, 2006).		I	C

	H1: Consistent	3/4	
	H1: Inconsistent	1/4	
	H2: Consistent	1/4	
	H2: Inconsistent	3/4	

Assessment: Given the limited number of sources included in this portion of the review, it is inappropriate to make a broad generalization regarding a definitive link from vulnerability to negative socioeconomic effects. Adger notes that there is evidence that communities and countries have a greater capacity to adapt than might be expected, despite their level of vulnerability. At the same time, however, it is important to acknowledge the risk of negative socioeconomic effects posed by higher levels of vulnerability.

Appendix D: Matrix 4

Assumption/Hypothesis 4: Economic decline resulting from environmental/climate changes increases the risk of instability and conflict.			
Key: C = Consistent, I = Inconsistent, N = Neutral, NA = Not Applicable			
		H1: Economic decline resulting from environmental/climate changes increases the risk of instability and conflict.	H2: Economic decline resulting from environmental/climate changes does not affect the risk of instability and conflict.
<u>Evidence</u>	<u>Other factors (weighting)</u>		
Decreased economic growth linked to changes in rainfall increases the occurrence of Hindu-Muslim riots in India (Bohlke and Sergenti, 2010).		C	I
Climate variability, (measured as deviations in temperature and precipitation from their past, long-run levels), does not affect violent intrastate conflict through economic growth. This finding is important because the causal pathway leading from climate variability via (deteriorating) economic growth to conflict is a key part of most theoretical models of the climate–conflict nexus. (Kouby, Bernauer, Kalbhenn, and Spilker, 2012).		I	C
We find some, weak support for the hypothesis that economic growth has a negative effect on civil conflict in autocratic countries only, although this finding is fragile with regard to model specification. (Kouby, Bernauer, Kalbhenn, and Spilker, 2012).		C	I
In Africa, rainfall shocks negatively impacting economic growth increases the likelihood of civil war (Miguel, Satyanath, & Sergenti, 2004).		C	I
Environmental decline can cause economic decline which can increase the risk of political instability (Mathews, 1989)		C	I
Multiple studies support that poor economic performance—either temporary or persistent—breeds violent conflict; if environmental changes, such as temperature increases or decreases, strong deviations in precipitation patterns, or increased water scarcity reduce economic welfare, then conflict could become more likely. (Bernauer,		C	I

Bohmelt, and Koubi, 2012).			
Low economic growth is confirmed using sensitivity analysis as a factor that increases the risk of civil war (Hegre, Sambanis, 2006), so if environmental or climate changes decrease economic growth, civil war becomes more likely.		C	I
	H1: Consistent	6/7	
	H1: Inconsistent	1/7	
	H2: Consistent	1/7	
	H2: Inconsistent	6/7	
<p>Assessment: As with the hypothesis on vulnerability, the limited number of studies reviewed for this hypothesis do not warrant a definitive assessment. Some studies have demonstrated that climate-induced effects negatively impact economic growth and increase the risk of instability and conflict, while others have not identified such a link. However, the variables used to assess climate variability have been limited (e.g., to rainfall or temperature variability), and climate change has the potential to affect economic growth much more broadly. Therefore, the most telling findings are those confirming that low economic growth or economic decline is a factor that increases the risk of instability and/or conflict.</p>			

Appendix E: Matrix 5

Assumption/Hypothesis 5: Changes in the availability of a key environmental resource increases the risk of instability and/or violent conflict.			
Key: C = Consistent, I = Inconsistent, N = Neutral, NA = Not Applicable			
		H1: Changes in environmental resource availability (possibly caused by climate change) increases the risk of instability and/or violent conflict.	H2: Changes in environmental resource availability (possibly caused by climate change) does not affect the risk of instability and/or violent conflict.
<u>Evidence</u>	<u>Other (e.g., weighting)</u>		
Environmental scarcity causes social impacts that result in population movements, economic decline, and weakening of states, which contribute to violence that is usually sub-national, persistent, and diffuse. (Homer-Dixon, 1994)		C	I
Previous research in the 1990s showed that severe environmental stress multiplied the pain caused by problems like ethnic strife and poverty in places including Haiti, Pakistan, the Philippines, and South Africa. (Homer-Dixon, 2007).		C	I
Based on five Old World case studies, the process of societal breakdown typically begins with economic or fiscal decline caused by external and internal inputs, some of which are long-term and precondition a system to suboptimal performance or weakened social-ecological response. Poor leadership, administrative dysfunction, and ideological ambivalence appear to be endemic to the processes of collapse. War or climatic perturbations possibly served as triggering mechanisms, but environmental degradation does not appear as a universal variable. (Butzer, 2012)		C	C
Warfare is an inefficient and costly way to resolve conflict over resources (as cited in Salehyan, 2008). Fighting stems from a failure to reach a bargain, and a failed political process, not from the absolute level of resources. State governments play a key role in containing/aggravating violence. (Salehyan, 2008).		I	C

Through direct effects on livelihoods and indirect effects on state functions, climate change may in certain circumstances increase the risk of violent conflict, (but connection betw climate change, human security, the state, and violent conflict are not empirically proven). (Barnett and Adger, 2007)		C	I
Drought and environmental degradation caused migration and livelihood changes in Darfur, creating actual and latent disputes that later became the focus of armed conflict; however, significant violent conflict erupted because of political factors, particularly the propensity of the Sudan government to respond to local problems by supporting militia groups as proxies to suppress any signs of resistance. Drought, famine and resulting social disruptions made it easier for the government to pursue this strategy. (de Waal, 2007)		N	N
Rainfall shocks have a significant effect on both large-scale and smaller-scale instances of political conflict in Africa, possible sensitivity to rainfall shocks due to dependence of many African economies on agriculture. Rainfall correlates with civil conflict and insurgency; wetter years more likely to suffer violent events. Low adaptive capacity across continent, climate change effects likely to be pronounced in Africa. (Hendrix and Salehyan, 2012).	Rainfall affects agricultural resource availability.	C	I
The general finding is that states suffering from greater levels of environmental scarcity are more likely to be involved in a militarized international dispute (MID). Population density and soil degradation are associated with an increase in MIDs, while fish and water scarcity and resource 'vulnerability' have no significant impact MIDs; however, several years of environmental data was missing. (Stalley, 2003)		C	I
There is not yet much evidence (statement based on review of empirical studies, specifically in a special issue of the journal) for climate change as an important driver of conflict. (Gleditsch, 2012).		I	C
Higher annual temperatures in sub-Saharan Africa are associated with significant increases in civil conflict, consistent with a growing body of evidence demonstrating the direct negative effects of higher temperatures on agricultural productivity and the importance of these fluctuations for economic performance. (Burke, Satyanath, Dykema and Lobell, 2009)		C	I
"In five decades, there were no formal declarations of war over water." it is unlikely that nations will go to war over water (Barnaby, 2009).		I	C

<p>The likelihood of domestic armed conflict is higher in countries with higher levels of environmental degradation (measured by deforestation, land degradation, and freshwater availability), with land degradation in general seeming to have the strongest effect on the likelihood of armed conflict. However, environmental scarcity is less important than economic factors in explaining domestic armed conflict. Increasing the number of risk factors increases the risk of conflict. (Hauge and Ellingsen, 1998).</p>		C	I
<p>No direct relationship to state failure was found for environmental factors; however, such factors might have indirect effects on state failure if they influence a country's material well-being or its engagement in international trade. (Esty et al., 1998).</p>		I	C
<p>In pre-industrial Europe and China, decreased agricultural production from changing climate drove wheat prices up in Europe and China, and when prices reached a certain level, more wars erupted. (Zhang, et al., 2007)</p>		C	I
<p>Traceable, causal linkages may exist between how marine resources are managed in a nation with high dependence on coastal fisheries, and the observed level of civil conflict and peace and order within the nation (Pomeroy, et al., 2007), suggesting that changes in the availability of fish resources, if not properly managed, increase the risk of conflict.</p>		C	I
<p>Meta-analysis of the empirical studies on the links between climate change and conflict concluded that a significant part of the current literature supports the argument that climate change has an influence on violent conflict in at least some regions of the world. If major 'tipping points' of societal stability are reached, climate change may become a major driver of armed conflict in the future. (Scheffran, et al., 2012)</p>		C	I
	H1: Consistent	11/16	
	H1: Inconsistent	4/16	
	H1: Neutral	1/16	
	H2: Consistent	5/16	
	H2: Inconsistent	10/16	
	H2: Neutral	1/16	

Assessment: The literature reviewed here offers evidence that is consistent with the hypothesis that changes in the availability of environmental resources, possibly resulting from climate change, increases the risk of instability or violent conflict. While some studies have found evidence inconsistent with this hypothesis, and suggest that environmental factors have minimal to no effect on the risk of instability or violent conflict, the evidence presented here strongly suggests that it is important to seriously consider the role of environmental resource availability in the outbreak of instability and violent conflict.