UVA

FRANK BATTEN SCHOOL
of LEADERSHIP and PUBLIC POLICY

TREADING MURKY WATERS

Combating Overfishing in Vietnam

ASIA MARITIME TRANSPARENCY INITIATIVE

DISCLAIMER

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

Samadani, Kayvon Lee

I. Table of Contents

II. Honor Statement 2
III. Acknowledgments 2
IV. Acronyms and Abbreviations 2
V. Executive Summary 3
VI. Introduction 4
VII. Problem Statement 4
VIII. Client Overview 4
IX. Background on Problem 5
X. Consequences of Problem 8
XI. Evaluative Criteria 9
XII. Methodology 11
XIII. Evidence of Potential Solutions 14
XIV. Evaluation and Analysis 18
XV. Recommendation 24
XVI. Implementation 25
XVII. Conclusions 26
XVIII. Supporting Material 28

II. Honor Statement

On my Honor as a student, I have neither given nor received unauthorized aid on this assignment.

KLS

III. Acknowledgments

I would like to express my gratitude to the following individuals and organizations who have helped make this thesis possible:

The Sigma Phi Educational Foundation and the Sigma Phi Society: for financially supporting my research; for inspiring within me a "capacity for sympathetic understanding of [my] fellow men and for genuine interest in them".

The Frank Batten School of Leadership and Public Policy, and especially my advisors Prof. Andrew Pennock and Prof. Noah Myung: for encouraging me to pursue my passions; for motivating me to push the boundaries of my analytical skills.

Prof. John Robinson: for being a source of knowledge and inspiration; for being an excellent educator and mentor.

Prof. Spencer Phillips and Prof. Huong Ngo: for introducing me to Vietnam; for helping to guide my thesis through its infancy.

The Center for Strategic and International Studies and Mr. Gregory Poling of the Asia Maritime Transparency Initiative: for giving me a chance to write this thesis for you.

Margaret Sparling and Lindsay Dickinson: for your thoughtful feedback and generous support; Maggie, I owe you one.

Anonymous friends: for your inspiring generosity.

Connor Wallace: for 17 years of unfailing friendship; for being a source of inspiration; for being a source of joy.

Mom and Dad: for raising me to be curious; for raising me to be thoughtful; for your constant support in all my endeavors; for all the sacrifices you have made to make my education possible.

IV. Acronyms and Abbreviations

CBA – Cost Benefit Analysis.

EEZ – Exclusive economic zone. The area of maritime domain extending 200 miles out from the continental shelf.

EU – European Union.

ITQ – Individual Transferable Quotas.

IUU – Illegal, Unreported, Unregulated Fishing.

IPMDA – Indo-Pacific Partnership for Maritime Domain Awareness

MARD – Ministry for Agriculture and Rural Development

MDA – Maritime domain awareness.

NGO – Non-governmental Organization.

NPV – Net present value.

SCS – South China Sea.

TAC – Total allowable catch.

TC – Total catch.

VNSC – Vietnam National Space Center

V. Executive Summary

The Center for Strategic and International Studies has requested an analysis of possible ways for Vietnam to cut down on overfishing. Vietnam is the third largest seafood exporter by value and is a major stakeholder in the South China Sea and south Pacific generally (Nguyen, 2024). Despite Vietnamese government efforts to prioritize fishing regulation, progress remains limited. Consequently, fish stocks in the SCS are severely depleted, and the EU has issued Vietnam a yellow card warning, putting Vietnam's access to a $1 billion USD market under threat (FishFocus, n.d.). In the absence of policy intervention, Vietnam will lose access to the European market, face massive unemployment, and immanent ecological disaster. This analysis used cost-benefit analyses, simulations, qualitative reasoning, and an analytical hierarchy process to identify policy alternatives, define policy goals, and measure the policies outcomes. Three policy alternatives were evaluated: implementing Individual Transferable Quotas, creating a Co-Management System, and increasing Maritime Domain Awareness. Of the three policies, the author recommends Vietnam institute a system of Individual Transferable Quotas. This alternative delivers maximum impact and high net present value relative to the other alternatives. To implement the alternative, the Vietnamese government must identify catch targets, evaluate historic catch distribution, and allocate catch quotas. The Ministry of Fisheries and Ministry for Agriculture and Rural Development should spearhead these efforts.

VI. Introduction

There are 4.1 million operational fishing vessels on Earth (FOA, n.d.). This fleet is larger than the populations of over half the countries on Earth (Worldometer, 2023). 3.1 million of these vessels, 76% of the global fleet, cannot be tracked publicly (Paolo, et. al., 2024). At any given time, on any given day, at least 30,000 vessels are operating as phantoms, completely invisible to the world and any mechanism of accountability. It's as if the entire student, faculty, and staff of the University of Virginia were to suddenly and inexplicably vanish.

Roughly 1.98 million vessels in this phantom fleet are in Asia, where most of the world's seafood comes from (Ritchie & Roser, 2024). It should come as no surprise that many countries struggle to hold members of this phantom fleet accountable for its actions. For Vietnam in particular, inability to hold vessels accountable for maritime laws within their EEZ threatens to completely upend their massive fishing industry. Even though Vietnam has publicly made addressing IUU fishing a priority, little progress has been made (Nguyen, 2024).

The following analysis will review the recent history of Vietnamese IUU fishing activity in the SCS, the most widely accepted fishing regulation schemes, establish clear goals and outcomes for policymakers in Vietnam, use analytical and qualitative tools to evaluate potential policy alternatives, and provide an informed, data driven solution to address the problem of overfishing in Vietnam. This analysis considers three distinct alternatives to managing Vietnam's fisheries:

- Alternative 1: Implementing a System of Individual Transferable Quotas (ITQ)
- Alternative 2: Creating a Co-Management System
- Alternative 3: Increasing Maritime Domain Awareness (MDA)

To assess the impact these three policy alternatives would have on the situation in Vietnam, the following criteria were be used:

- Cost
- Effectiveness
- Equity
- Feasibility

To synthesize the information gathered and analyze the alternatives in terms of the above criteria, the analysis employs CBAs, an AHP, and Monte Carlo simulations.

VII. Problem Statement

Vietnam is one of the world's worst perpetrators of illegal overfishing and has taken great strides to reign in its commercial fleet. Despite significant efforts on the part of the Vietnamese government, little has improved (Nguyen, 2024). <u>Too many of Vietnam's commercial fishing vessels can operate outside the rule of law, resulting in a yellow card from the European Union and deteriorating fish stock health. This directly threatens Vietnam's ability to integrate into the world market, and the livelihoods of 10% of the Vietnamese population (Ngyuen, 2011).</u>

VIII. Client Overview

The Center for Strategic and International Studies is a world premier defense think tank. Its Asia Maritime Transparency Initiative (AMTI) works to de-escalate tense and potentially deadly situations in the SCS by providing stakeholders with accurate assessments about claimant states actions and capabilities. The AMTI is a team of leading experts in southeast Asia who can provide unique insights for policymakers regarding disputes within the South China Sea. It is directly in the AMTI's interest to evaluate Vietnam's fishing practices and efforts to regulate fishing more generally. The AMTI is uniquely positioned to make policy recommendations because of the expertise of their researchers, objectivity, and track record of excellence.

IX. Background on Problem

The fishing industry is a vital component of the world's food supply. Millions rely on fish for vital protein and nutrients, and global demand for seafood is projected to grow by over 6% annually for the next decade (Fish & Seafood, n.d.). This industry is highly lucrative, generating an expected revenue of $675 billion USD in 2024 (Fish & Seafood, n.d.) While many countries engage in large scale commercial fishing, Vietnam occupies a massive portion of the global seafood production (Nguyen, 2024).

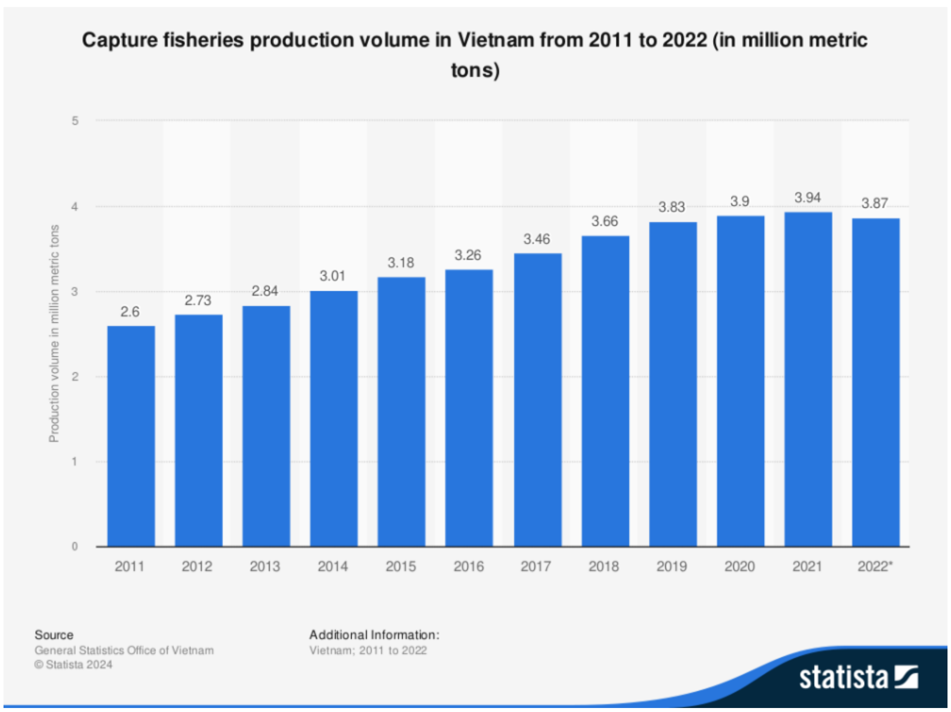

Figure 1. Fig. 1 shows the production of Vietnam's capture fisheries from the year 2011 to 2022. The volume has steadily risen over the past decade, showing no signs of slowing down.

Vietnam is the world's third largest exporter of seafood by value (Nguyen, 2024), exporting nearly 4 million tons in 2022, worth nearly $11 billion dollars (Nguyen, 2023). Vietnam's massive coastline and maritime domain make fishing a dominant industry in the nation, creating over 600,000 Vietnamese jobs (Nguyen, 2022). Vietnam's capacity for seafood export has dramatically outpaced the Vietnamese government's ability to regulate its commercial fishing fleet. The existence of this gap means IUU fishing activity goes largely unpunished.

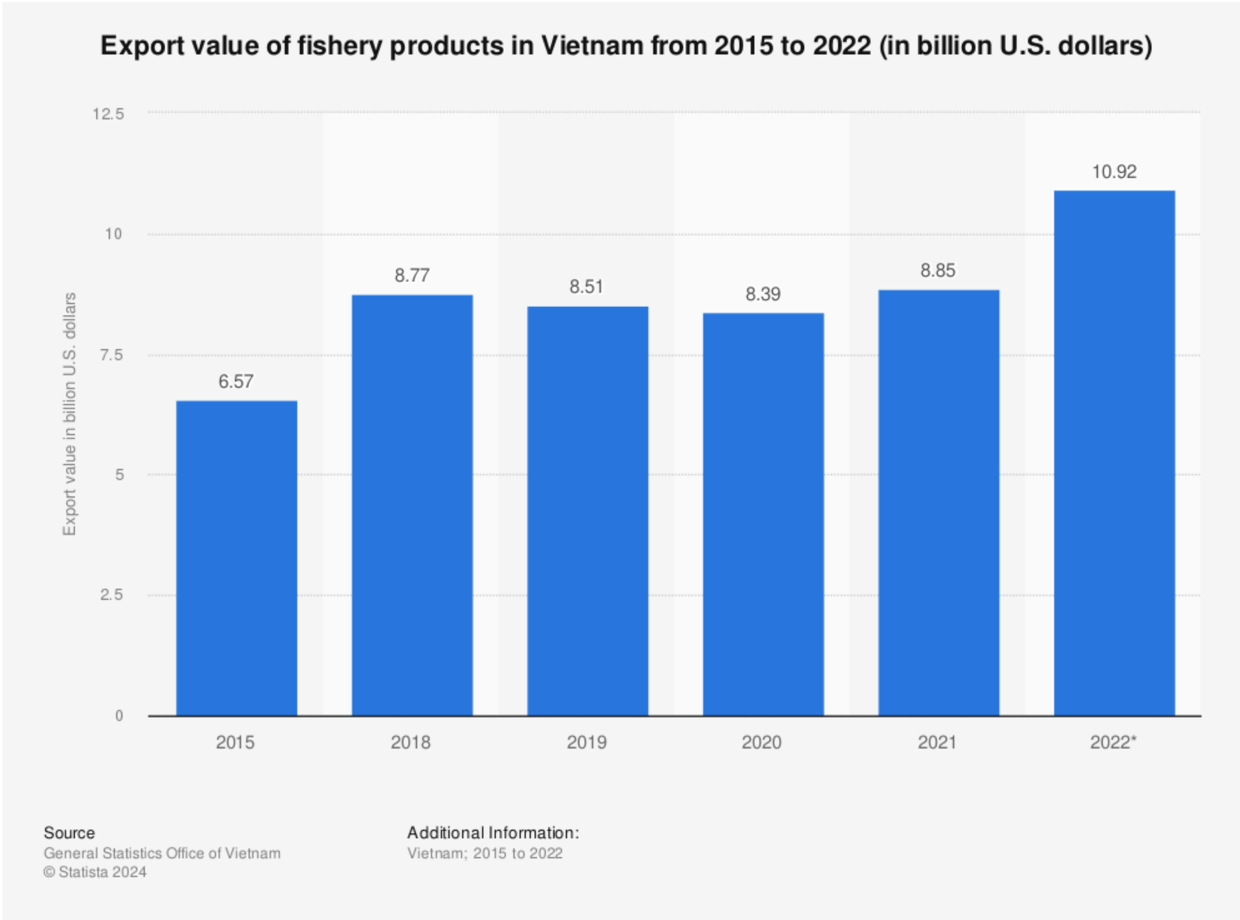

Figure 2. Fig. 2 shows the export value of Vietnamese fishery products in billions of USD from 2015 through 2022. 2021 to 2022 saw a massive increase in the value of Vietnamese exports. As demand increase, it is likely that Vietnam will continue to make massive profits from fisheries exports. 10% of the export value, or $1 billion, is directly from the EU market.

Indeed, Vietnamese fishing vessels are notorious for illegally operating far outside of the Vietnamese EEZ. This practice has caused tension between their neighbors, especially Malaysia and Thailand (Jia & Wang, 2023). In just three years from 2013 to 2016, Vietnamese authorities report that 726 vessels and 5,752 fishers were arrested for engaging in IUU fishing activities (Nguyen, 2014). The situation is so dire that Vietnamese fishermen have been caught illegally fishing as far south as Australia (Nguyen, 2024). From 2013 to 2017, 20 Vietnamese vessels were caught fishing in Australia's EEZ.

Figure 3. Fig. 3 shows a map of the South China Sea. The map highlights the EEZs each state is entitled to in blue. In red, the figure shows China's infamous "9-dashed line" which China illegally uses to claim control over approximately 90% of the South China Sea. The map also highlights several island chains under dispute.

The reality of rampant Vietnamese IUU fishing was largely ignored by Vietnamese authorities, and no strong measures had been taken to stop the problem (Nguyen, 2024). Willful ignorance remained the status quo of the Vietnamese government until 2017, when the EU issued Vietnam a yellow card. Since 2017, Vietnam has made addressing IUU fishing a major priority, and taken strides to reign in its commercial fleet (Nguyen, 2024). Despite the shift in priorities, very little progress can be shown for Vietnam's efforts. Vietnam still struggles to control fishing in its waters (Anh, 2022).

Causes of Inaction

Several explanations exist as to why the problem went unaddressed. Chief among them are a lack of surveillance capacity, a lack of enforcement capability, and the use of fishing fleets as part of strategic competition for sovereignty in the SCS play a large part as to why Vietnam has largely been unable to reduce overfishing (Nguyen, 2024).

Vietnam lacks the technology necessary to effectively monitor its maritime domain (Nguyen, 2024; Tran, 2023). Upgrading Vietnam's technical capacity would require partnership with multinational organizations that aim to improve MDA (Tran, 2023). This is not easier said than done, and many western lead MDA organizations can be considered anti-Chinese. While leaders deny such explicit motivations, reigning in Chinese gray zone activity is a major policy priority for several claimant states and their allies.

Further contributing to Vietnam's lack of progress is their lack of enforcement capabilities. The governance structure in Vietnam is highly compartmentalized, with minimal interdepartmental interaction and significant redundancy. Major government decisions require individual approval from the President, resulting in painfully slow policy responses. (An IMF official once noted to the author that if Vietnam was serious about achieving its development goals, it would need to abandon its current system of government). Further, Vietnam does not have a robust coast guard to enforce maritime law at sea, nor does the government have the capacity to monitor the offloading of vessel catch (Tran, 2023). Widespread inefficiencies further hinder Vietnam's ability to enforce their fishing regulations.

The current regulatory framework in use involves a haphazard mix of enforcement strategies, with unclear and often overlapping jurisdictional responsibilities (Socialist Republic of Vietnam, 2001). Without a clear and unified enforcement strategy, Vietnam cannot make necessary changes to effectively enforce their maritime law.

Finally, the complex geopolitical environment of the SCS influenced and continues to influence Vietnamese decision making. Vietnam and China are fiercely competing for sovereignty and influence. For both states, their commercial fishing vessels have become key pieces in their bids for control over contested and lucrative waters. Operating commercial fishing vessels within the SCS allows Vietnam to enforce their claimed maritime domain without the use of military vessels and other aggressive means. In the absence of major changes, it is unlikely that the situation in Vietnam will change.

X. Consequences of Problem

Economic consequences

Should Vietnam fail to improve its regulation of its fishing industry, the EU will issue it a red card, cutting it off from the European maker. Should Vietnam get cut out of the European market, Vietnam would lose access to an over $1 billion dollar market (fishfocus, n.d.). The EU represents over 10% of the value of Vietnam's exports by dollar amount (statista, n.d.). The impact on the Vietnamese economy would be devastating, and likely completely upend the livelihoods of hundreds of thousands of people.

Ecological collapse and its economic consequences

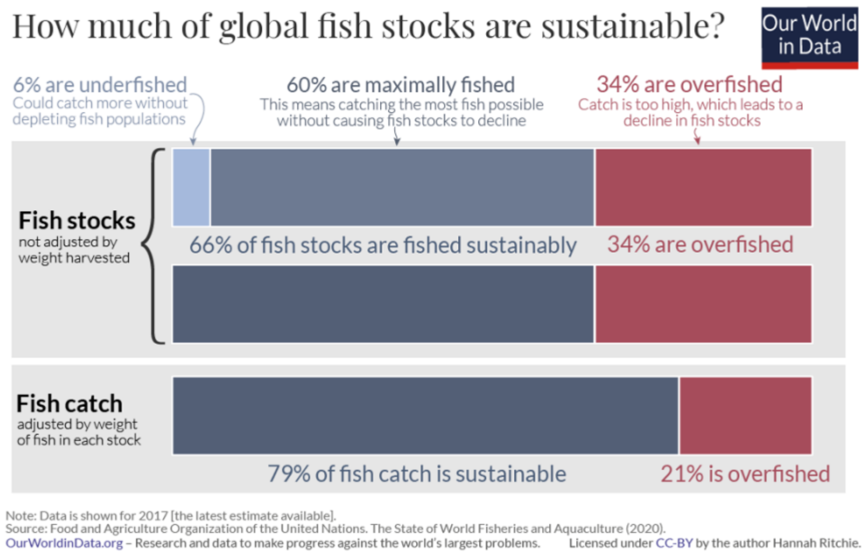

Figure 4. Fig. 4 shows a breakdown of the world's fisheries, classifying stocks as either sustainable or unsustainable (with 6% classified as underfished). The figure is not specific to any region but gives a general overview as to global stock health. It is likely an underestimate of the current situation facing fisheries.

The SCS is being fished to its limits. 25% of the SCS fish stocks have completely collapsed, with another 25% being over-exploited and near collapse (Greer, 2016). Should current trends continue, it is highly likely there would be mass extinctions beyond the heightened extinction rates the world is already seeing (Jamail, 2016). When this happens, half of the world's population will lose access to their primary source of protein and other vital nutrients (WWF, n.d.). This effect would be particularly devastating to southeast Asia, as the region is more reliant on fish protein than any other in the world (Pomeroy, et. al., 2015).

In addition to food security, a collapse of the fishing industry would have profound impacts on employment. 10% of the Vietnamese population is directly employed by the fishing industry, and would stand to lose their livelihoods (Nguyen, 2011). This effect would be most concentrated in rural fishing communities that rely solely on fishing for income (WWF, n.d.).

XI. Evaluative Criteria

Effectiveness

Any policy proposed must be able to address illegal fishing in Vietnamese waters. Effectiveness will refer to how many tons of overfishing in Vietnam's EEZ a policy abates relative to the status quo. Abatement will be tallied as metric tons. The effectiveness of a policy is important because it is the primary desired outcome of this analysis. This classification of effectiveness aligns with both the goals of the CSIS and of the Vietnamese government (Socialist Republic of Vietnam, 2001). If a policy fails to abate overfishing, it should not be considered.

Effectiveness will be measured using Monte Carlo simulation. To simulate an alternative, year to year differences in catch using catch data from Vietnam, Cambodia, or Iceland. Using that data, the Monte Carlo simulation will project outcomes of instances of overfishing in Vietnam across a ten-year span (eleven "years" counting 2025 as year 1). The outcomes will be compared to a projection of the status quo. Each policy option will be scored from 1-5 individually and 1-9 scale comparatively, with a low number indicating no effect, and higher numbers indicating a massive effect (See appendix A for a description of each score value).

Cost

A goal of any policy addressing illegal fishing should be to minimize the cost of enforcement and maximize the impact. Cost will refer to the net present value of a policy alternative. A solution that costs more to implement than it saves in impact on illegal fishing is both economically unsound and practically unviable. The government of Vietnam has limited resources at their disposal, and maximizing their efforts in the form of costs is of vital importance.

Cost will be measured using a CBA. The CBA will run ten years into the future (eleven "years" counting 2025 as year one). Costs and benefits will be listed, values, and projected. For the purposes of this CBA, costs and benefits will include those specific to the government of Vietnam, fishers, and society at large. Given the uncertainty associated with CBA and Vietnamese government action, a sensitivity analysis will be included in the CBA. Using 5%, 7%, and 9% discount rates will serve as liberal, moderate, and conservative NPV estimates. Each policy option will be scored from 1-5 individually and 1-9 comparatively, with a low number indicating no effect, and higher numbers indicating a massive effect (See appendix A for a description of each score value).

Equity

The fishing industry in Vietnam is dominated by small to medium sized vessels operated independently. Any policy that cracks down on illegal fishing should take care not to create adverse effects on the poorest fishermen and push control of the fishing industry to massive firms, depriving more remote fishing villages income and job opportunities. Equity will refer to a qualitative assessment of how a policy alternative will impact poor fishers.

To measure this criterion, I will examine previous case studies to determine the impact various interventions have on the makeup of the fishing industry after their implementation and compare them to Vietnam. Impact itself can be measured using a few different proxies, including share of TAC by fishing village/province and number of licensed boats and firms. Policy alternatives will be scored from 1-5 individually and 1-9 comparatively, with a low number indicating no effect, and higher numbers indicating a massive effect (See appendix A for a description of each score value).

Feasibility

Any policy aimed at addressing fishing regulation must be feasible given the limited capabilities of the Vietnamese government and the unique culture of Vietnam and Southeast Asia generally. Vietnam has clearly articulated its desire to improve its fishing regulations and enforcement (Phuong, 2022), so feasibility is not a question of political will, but one of how the policy alternative fits within the Vietnamese context.

Specifically, feasibility will refer to how likely the policy alternative is to be implemented by the Vietnamese government if adopted. The following three sub criteria will be used to assess the feasibility of an alternative more accurately.

Managerial Feasibility

This will refer to a policy alternative's capacity requirements, buy in from authorities, and complexity. An alternative that is feasible in this category will have lower capacity requirements, high buy in, and not be overly complex.

Enforcement Feasibility

This will refer to a policy alternative's resource needs and monitoring challenges. A policy alternative that is feasible will have low resource needs and few monitoring challenges.

Policy alternatives will be scored from 1-5 individually and 1-9 comparatively, with a low number indicating no effect, and higher numbers indicating a massive positive effect (See appendix A for a description of each score value).

XII. Methodology

To score the alternatives performance in each criterion, the author used the scoring rubric from figure 5. The rubric ranges from one to five. One signifying the alternative has no effect on the criteria, and five signifying the alternative has a massively positive effect on the criteria. The language of the rubric is borrowed from the AHP scoring language (appendix A) and follows best practices from public opinion polling as taught to the author. Using a rubric ensures consistency throughout the different measures and analytical processes. While the rubric only shows whole numbers, alternatives were able to be assigned scores of +/- .5 to allow for greater specificity. The scoring outcomes can be found in figure 7.

Rubric for scoring alternatives using qualitative analysis

1	2	3	4	5
The option has little to no impacts the criterion	The option marginally impacts the criterion	The option has a positive impact on the criterion	The option has a major positive impact on the criterion	The option massively positive impacts the criterion

Figure 5. Fig. 5 shows the rubric used to guide scoring of the alternatives in the analysis. The scores run from 1 to 5. The scores correspond to the impact an alternative would have on the criteria. Importantly, none of the scores represent a negative impact. This is borrowed from public opinion data polling when the evaluation being made does not include an equal range from negative to positive, but from low effect/feeling to high effect/feeling.

Qualitative and quantitative analytical methods were used to score each alternative. The qualitative methods involved using the recommendations and outcomes of meta-analyses and other papers to inform judgments on the impact an alternative might have on a criterion. The quantitative methods used to conduct the analysis included Monte Carlo simulations and CBAs.

Quantitative Methods Employed

Monte Carlo simulation is a computational technique that utilizes historic data and random sampling to model outcomes. By running simulations hundreds of times, Monte Carlo simulations rely on computational analysis and the law of large numbers to produce outcomes with high fidelity to the assumptions included in the initial simulation formula. Key benefits of this approach are the ability to use historic data to reduce uncertainty and traceability of outcomes. Additionally, given the flexibility of these simulations, inputs and assumptions can easily be included or changed, and outcomes are visible and traceable. Given the availability of fishing data from different regulatory contexts, Monte Carlo simulations offer a well-respected means to predict outcomes from various regulatory schemes. (See appendix B through D for a full list of the assumptions and outputs of the Monte Carlo simulation.)

The Monte Carlo simulation was used to create accurate assessments of the impact each policy alternative would have on overfishing. This included an average year to year catch difference and average total catch for all 100 ten year runs. These data points were directly factored into the AHP ranking each alternative received in the effectiveness section.

The CBA was used to understand the NPV of each policy alternative. The CBA also included a sensitivity analysis, using a range of discount rates, to allow for a more nuanced interpretation of the NPV. The primary outcome, the dollar NPV, was averaged, and presented relative to the other alternatives and the status quo. (See appendix E through H for a full list of assumptions and outputs of the Monte Carlo simulation.)

Framework for Analysis: Analytical Hierarchy Process

Given the diverse set of criteria and their different ways alternatives were measured, it was necessary to use a central analytical process to incorporate the various assumptions, quantitative and qualitative inputs, and assessments of the alternative’s performance within each criterion. To accomplish these goals, this analysis employed an AHP.

An AHP is a reasonable and effective approach for evaluating alternatives for managing overfishing in Vietnam for several reasons. Firstly, overfishing is a complex issue influenced by multiple interrelated factors such as economic, social, environmental, and regulatory aspects (Global Initiative, 2019). AHP allows for the systematic structuring of these factors into a hierarchical framework, enabling a comprehensive analysis. Secondly, AHP facilitates the incorporation of stakeholder preferences and expert opinions by assigning weights to criteria based on their relative importance. This ensures a more inclusive decision-making process and considers the diverse perspectives of stakeholders involved. Finally, AHP provides a transparent and quantifiable method for evaluating alternatives, which aids in identifying the most effective strategies for mitigating overfishing while balancing conflicting objectives. Through utilizing AHP the one can provide robust recommendations for sustainable fisheries management in Vietnam that account for the complex and multifaceted nature of the problem.

Major inputs to the AHP came from three broad categories: literature, CBA, and the Monte Carlo simulation. The results of meta-analyses and other findings from prominent researchers motivated and informed the rankings and scoring in the AHP (Appendix I). In addition, the outcome of the CBAs (appendix E, F, G, and H) directly informed AHP rankings by giving dollar amounts to compare. Finally, the outcome of the Monte Carlo simulation was used to give direct catch/enforcement outcomes for comparison and ranking in the AHP (appendix I).

Description of Criteria Weights

Priortization Matrix	Effectiveness	Cost	Equity	Feasibility	Average for Criteria in Rows
Effectiveness	1.00	7.00	5.00	1.00	3.500
Cost	0.14	1.00	0.33	0.20	0.419
Equity	0.20	3.00	1.00	0.14	1.086
Feasibility	1.00	5.00	7.00	1.00	3.500
	2.343	16.000	13.333	2.343	8.505

Figure 6. Fig. 6 shows the weighting scores of each alternative. The score is assigned by comparing the row against the column and assigning a value of either 1-9 or 1-1/9. Whole numbers indicate the row is higher weighted than the column, and integers indicate the column is higher weighted than the row.

The various criteria used to evaluate the policy options presented in this analysis are not considered equally important. Therefore, a unique weight has been assigned to each criterion within the AHP which allows high levels of flexibility and accuracy in understanding how well the policy options meet the needs of the client. This was done by making pairwise comparisons between each criterion to the another, and ranking them 1-9 based on the language in appendix A.

1. Feasibility

Feasibility is weighted 0.423, highest among the policy alternatives. If an alternative is not likely to be implemented, it should be discarded for alternatives with a chance of uptake. This must be balanced with the understanding that some of the most effective interventions are difficult to implement or may not be readily taken up by stakeholders.

2. Effectiveness

Effectiveness is the second most important criteria to this analysis and was scored 0.417. It is vitally important to the economic and ecological health of the fisheries in Vietnam that any policy implemented is effective at curtailing overfishing. However, it is more important that a new policy be feasible and likely to be adopted rather than be completely effective. Therefore, effectiveness is ranked slightly behind feasibility.

3. Equity

Equity is an important consideration because fishing employs many low-income individuals in small vessels across Vietnam (Ngyuen, 2011), but was weighted relatively low, scoring 0.102. Any regulation implemented should take care not to have an oversized negative impact on low-income small boat fishermen in Vietnam. However, a policy that is highly effective and/or highly feasible is more valuable, and so equity is not weighed heavily in this analysis.

4. BCA

Finally, BCA is the lowest weighted criteria, scoring 0.058. While BCA is important, the scope of this analysis is limited, and does not include many other benefits of allowing the fish stocks in Vietnam to recover. However, the BCA in this analysis does provide a relatively accurate picture of the costs and benefits associated with each policy and gives key indications for the relative performance of each alternative.

XIII. Evidence of Potential Solutions

Alternative 1: ITQ

Description

To combat overfishing in the Vietnamese East Sea, the Ministry of Fisheries should restructure their licensing procedure to create an ITQ system. This alternative entails assigning property rights to fishermen and creating a marketplace for the exchange of those rights, or ITQs.

Under this recommendation, the Ministry of Fisheries, in conjunction with the Provincial/City People's Committee of each coastal province, should establish TAC amounts and allocate ITQs to each province based on catch history. The Provincial/City People's Committee would then determine the ITQ amount per vessel. This kind of dual management has been critical to the success of ITQs in Iceland (Gissurarson, 2000), and would fit into the existing Vietnamese framework of regulation (Socialist Republic of Vietnam, 2001).

To initiate this process, the Ministry of Fisheries should combine their current research priorities with historic catch data for each coastal province to establish TAC and ITQ amounts. In addition, an ITQ 'conversion' rate should be established between the various fish species. Once the initial ITQ allocation is made, the Ministry of Fisheries should create a forum for vessels to buy and sell ITQs. A digital forum would allow for vessels across Vietnam to actively and in real time participate, reflecting the willingness to pay and except for each vessel.

After the ITQs has been initially implemented and established, continued management will be split between the Ministry of Fisheries and the Provincial/City People's Committee. The Ministry of Fisheries, mirroring the system of Iceland (Gissurarson, 2000), should cover higher level concerns such as producing relevant research on fishing stocks and issuing TAC updates. The Provincial/City People's Committee would handle daily operations of the ITQ system, including the monitoring and documentation of harvest offloads.

Maritime enforcement of the ITQ system will be spearheaded by the Fisheries inspection force, but the Provincial/City People's Committee should take steps to employ civilian observers, as well as observers from NGOs such as GreenPeace (oceans, n.d.). The Ministry of Fisheries should actively recruit observers from NGOs who focus on neutral enforcement of fishing regulations and protecting vulnerable fish species (oceans, n.d.).

To fund the ITQ system, the government of Vietnam will need to utilize multiple streams of capital. In Iceland and Canada, much of the funding for ITQ systems came from the government and revenues raised by service fees during harvesting offloads (Gissurarson, 2000; Weimer & Vining, 2017). The Ministry of Fisheries should impose similar taxes or fees on harvesting offloads. In the Icelandic case, the fee represented no more than 0.4% of the total catch value and raised $11 million dollars annually, just under half of the funds needed to manage the ITQ system, which was $30 million (Gissurarson, 2000). The Ministry of Fisheries could also impose a small tax on the sale of an ITQ, which would add additional funds for the program.

Outside of the fee structure, the government of Vietnam could turn to the World Bank or United Nations to make up additional initial investments needed to train and organize individuals within the Ministry of Fisheries and the local Provincial/City People's Committee (Ye & Gutierrez, 2017). From the initial investment, as was the case in Iceland, revenue from catch will more than exceed the cost of management, giving the Ministry of Fisheries an opportunity to tax revenue from sales to further close the gap in funding.

Supporting Evidence

ITQs are a relatively novel way to manage fisheries (Gissurarson, 2000; Merayo, et. al., 2018). In 2000, only Iceland and New Zealand had comprehensive ITQ systems, but just eight years later, roughly 10% of the global fish population was under some form of quota system management (Gissurarson, 2000; Merayo, et. al., 2018). The rapid adoption of ITQ-like management systems can likely be attributed to the alternatives positive impact on key outcomes, including reducing TC, arriving at pareto efficient outcomes, ease of administration, and equitable economic impacts (Gissurarson, 2000; Merayo, et. al., 2018; Ovando, et. al., 2020)

ITQs have been utilized in Canada for both sea and river systems (Bardach & Petashnik, 2020) and Iceland and the pacific islands for deep sea fishing to successfully lower TC (Gissurarson, 2000; Merayo, et. al., 2018). ITQs have successfully kept fish stock at healthy and sustainable levels (Bardach & Petashnik, 2020; Gissurarson, 2000; Merayo, et. al., 2018). Moreover, stocks of fish that previously faced imminent collapse were brought to healthy and sustainable sizes (Gissurarson, 2000).

ITQs follow the Coasean theory of economics, meaning they arrive at pareto efficient outcomes without burdensome regulation or other interventions (Gissurarson, 2000; Merayo, et. al., 2018; Ovando, et. al., 2020; Phillips, 2024). In the case of fisheries management, this theory argues that parties with clear property rights, low-cost transactions, and adequate enforcement of regulations, negotiations over property rights will arrive at a pareto optimal point, regardless of the initial allocation of rights. Case studies and meta-analysis validate this theoretical conclusion (Gissurarson, 2000; Merayo, et. al., 2018; Ovando, et. al., 2020; Phillips, 2024).

ITQ systems are fairly easy to manage. With relatively low management costs at higher levels of government, an ITQ system has the potential to significantly reduce TAC through effective regulation (Gissurarson, 2000; Ovando, et. al., 2020). Enforcement costs are generally low, and employ small numbers of people (Gissurarson, 2000). In fact, firms could be incentivized to participate in ITQ systems because they have been demonstrated to dramatically increase profitability (Gissurarson, 2000). By streamlining processes and aligning the incentives of diverse stakeholders, the system could operate with minimal central government involvement while lowering TC and increasing enforcement efficiency (Gissurarson, 2000; Ovando, et. al., 2020).

Finally, ITQ systems deliver equitable outcomes across multiple different applications (Gissurarson, 2000; Merayo, et. al., 2018; Ovando, et. al., 2020). ITQ systems export quotas to small and remote fishing villages rather than concentrating quotas in the most populated ports (Gissurarson, 2000; Merayo, et. al., 2018). In the case of Iceland, rural development and economic opportunities increased after the implementation of the ITQ system (Gissurarson, 2000). In the pacific islands where ITQ systems are used, large commercial vessel activity decreased by 62%, while small vessel activity saw no such dramatic drop in fishing activity, indicating the smallest fishers were protected from job loss (Merayo, et. al., 2018).

Alternative 2: Co-Management

Description

To address the lack of compliance with fishing laws, Vietnam should implement a co-management system of governance in East Sea fisheries. Co-management of fisheries involves a bottom-up approach that combines the efforts of key stakeholders (i.e. fishers, local governments, law enforcement, and NGO's) to oversee and enforce fishing regulations (Jönsson, 2019; Obiero, et. al., 2015). Currently, Vietnam has no such provisions for management, and relies on a convoluted mixed management style combining local and national government entities (Socialist Republic of Vietnam, 2001).

To implement co-management of fisheries in Vietnam, the Ministry of Fisheries should provide materials and funding to the Provincial/City People's Committees of the coastal provinces. To successfully implement a co-management system, Provincial/City People's Committee's would need to fulfill a few key functions.

First, they must educate the local fishers on the rules and regulations surrounding fishing. Second, co-management systems must be given adequate equipment, including boats, fuel, engines, navigational systems, and communication systems to monitor and enforce the regulations. Additionally, the localities must create forums for various stakeholders to come together to periodically discuss the state of management in the locality. Given the resources to accomplish these two tasks, the co-management systems will be responsible for providing regular reports to the Ministry of Fisheries on catch amounts and violations and integrating updated regulations regarding TAC and any new regulations.

The funds for these supplies will come from the Ministry of Fishing and the Fisheries inspection force that operates in that area (Socialist Republic of Vietnam, 2001). This co-management system would require new employees to function. It would also require the Ministry of fisheries to distribute equipment to localities. However, partnership with NGOs offers a way for the central government to reduce the implementation burden placed on them. NGOs can either supply their own equipment or themselves perform monitoring functions (Phillips-Levine, et. al., 2022), potentially saving a few to hundreds of thousands of dollars. The Ministry of Fisheries should impose pigouvian taxes on the sale of the fish harvest that the co-management system would oversee, which is in line with practices in other fishery systems (Obiero, et. al., 2015). Otherwise, the Ministry of Fisheries could apply for some of the $22 billion dollars in funding available from the WTO or other international organizations (Monge & Jungwiwattanaporn, 2022; Ye & Gutierrez, 2017). Given how high of a global priority fisheries management is for the world, it is highly likely that many international groups would be willing to partner with the Vietnamese government (Monge & Jungwiwattanaporn, 2022).

Supporting Evidence

The 21st century has seen a surge in co-management as a mechanism for low- and middle-income countries to manage fisheries (Viner, et. al., 2006). African countries are increasingly relying on co-management to regulate freshwater fisheries (Obiero, et. al., 2015). In Asia, over 100 co-management programs are in effect (Evans, et. al., 2015). Co-management is largely lauded for its high feasibility (d'Armengol, et. al., 2018; Evans, et. al., 2015; Kaluma & Umar, 2021; Obiero, et. al., 2015; Viner, et. al., 2006) and equitable outcomes (Evans, et. al., 2015; Viner, et. al., 2006).

In states with more cooperative cultures and/or limited central government authority, co-management has emerged as a highly feasible means to regulate fishing (Evans, et. al., 2015; Pomeroy, et. al., n.d.). In many cases, co-managed fisheries lead to increased awareness (Obiero, et. al., 2015) and compliance with fishing regulations (Evans, et. al., 2015; Whitehouse & Fowler, 2018; Viner, et. al., 2006). Additionally, co-management schemes have effectively limited illegal fishing activities and methods (Evans, et. al., 2015). Existing forest management practices in Vietnam suggest that co-management systems resonate with current social and regulatory norms, further supporting their feasibility (Phillips, Personal Communication, 2024).

Co-managed is generally considered to be the most direct way to increase equitable outcomes in fisheries (Viner, et. al., 2006). Across many co-management schemes, stakeholder engagement, especially among fishers themselves, increased dramatically (Evans, et. al., 2015; Viner, et. al., 2006). Through co-management, local fishers have a greater say in policy making decisions, increasing the voice and power of previously disempowered stakeholders (Viner, et. al., 2006). More directly, local fishers reported having higher household incomes due to co-management systems (Evans, et. al., 2015).

Alternative 3: Maritime Domain Awareness

Description

To enhance Vietnam's MDA capabilities, the Vietnamese Communist Party should invest more funding into the Vietnam National Space Center (VNSC) to launch more observation satellites and increase the capacity to analyze information from partner satellites, as well as enter the IPMDA.

MDA is a broad term that refers to activities like using satellite imagery, GPS tracking, and multinational information sharing groups to determine the location and activities of vessels in a specific area (Bueger, 2015; Tran, 2023). The IPMDA is a US-led multinational organization aimed at providing partners with a comprehensive framework for maritime monitoring and partner capacity building (Roy, 2023). Given the goals and objectives of the IPMDA, the Vietnamese government will need to create groups within the Ministry of Fisheries and the VNSC who facilitate integration with the IPMDA system and act as point of contact for the implementation of increased MDA capabilities. These offices do not need to employ massive numbers of officials and can rely on the expertise of more advanced partners in the agreement such as India and the United States.

Assuming joining the IPMDA means the Ministry of Fisheries employs a team of 60 people to facilitate the MDA capacity upgrades and assuming relatively cheap launch prices, with a small amount of initial spending the Vietnamese government could make major improvements to its MDA.

Funding for MDA enhancement will come from both the Vietnamese Communist Party and the IPMDA. Given how much of priority MDA issues are for the government (Socialist Republic of Vietnam, 2001), it is likely limited appropriations will be made, and given the importance of MDA issues to IPMDA members, it is likely they will support the integration of new technologies in Vietnam.

Supporting Evidence

MDA is considered a crucial component of fisheries management (Bueger, 2015; DeRidder & Nindang, 2016; Ye & Gutierrez, 2017) and maritime security and law enforcement (Bueger, 2015). Most broadly, MDA includes technologies for monitoring vessels activity at sea and government to government information sharing schemes. Given the abundance of vessels and claimant states operating in and around Vietnam, MDA is especially necessary for the SCS (Bueger, 2015; Pomeroy, et. al., n.d.). Experts contend Vietnam's inability to monitor its maritime domain is a major contributing factor to Vietnam's inability to regulate their commercial fleet and China's ability to conduct gray zone operations (Hinke, et. al., 2021; Lin, et. al., 2022; Luo, 2022; Mastro, 2022; Poling, 2023).

Increasing satellite surveillance capacity and vessel monitoring will allow Vietnam to enforce its fishing regulations more readily (Tran, 2023). Enhanced MDA capacity would allow Vietnam to monitor its waters, enforce its maritime laws, and hold its commercial vessels accountable for violating the law more effectively (Ye & Gutierrez, 2017).

Engaging in multinational information sharing is a major component of international relations (The White House, 2023). Many such agreements exist and allow member states to more effectively police their maritime domains and combat overfishing (among other illegal activities) (Ye & Gutierrez, 2017). Indeed, participating in such organizations positively impacts security cooperation between participating states (Bueger, 2015). Given the precarious security environment that exists for Vietnam in the SCS, engaging with multinational information sharing groups may enhance Vietnamese sovereignty (The White House, 2023).

XIV. Evaluation and Analysis

Outcomes Matrix with scores

	Effectiveness	Cost	Equity	Feasibility	Total
ITQ	4.5 (53,920,124 metric tons)	3.5 ($11.81 million Average NPV)	3.5	2.5	14
Co-Mangement	2.5 (52,768,121 metric tons)	2.5 ($11.51 million Average NPV)	5	4	14
MDA	3 (not applicable)	2.5 ($11.52 million Average NPV)	1.5	2	9

Figure 7. Fig. 7 shows the alternatives and corresponding criteria with a 1-5 ranking. 1 indicates low performance, while a 5 indicates high performance. The colors green, yellow, and red are added to further assist the viewer in distinguishing between rankings. This matrix is unweighted. Alternative 1, ITQ, and alternative 2 Co-Management, both score 14 points. This demonstrates both alternatives relative strengths and weaknesses, and shows that, depending on what criterion is valued more, either may be suitable for the task of addressing overfishing.

Alternative 1: Individual Transferable Quotas
Cost: 3.5 (Average NPV of $11.81 billion)

Sensativity Analysis of Alternative 1 Cost Benefit Analysis

Rate	5%	7%	9%	Average
NPV	$14,358,703,792.92	$11,640,327,617.75	$9,638,438,347.18	$11,879,156,585.95

Figure 8. Fig. 8 shows the results of the CBAs for alternative 1. The three different values represent a sensitivity analysis, indicating a liberal, moderate, and conservative estimates on the NPV of the alternative. Unique to this alternative is the catch fee structure that adds massive benefit.

ITQ ranks high for cost, scoring 3.5 and an average NPV of $11.84 billion. Alternative 1 is unique in this analysis given its catch fee system and the lower management costs. The fee structure is .5% of the catch value and varies outside of the catch limits set by the government, adding value where value may be lost due to a decrease in abatement. Additionally, the costs associated with ITQ management are relatively low, at $30 million/year. Due to the high benefits of the catch fee, lower relative management costs, and the sensitivity analysis, the NPV of alternative 1 is $11.81 billion. (See appendix F for further information regarding the CBA for alternative 1.)

Given the top-down approach of ITQ systems, the government would likely bear most of the direct costs associated with this alternative (Gissurarson, 2000). The cost to fishers would be indirect, which is not necessarily captured in the CBA. However, the benefits of abatement to society are included in the CBA, which does reflect a value that fishers and the government alike would derive.

Working against the CBA ranking of alternative 1 is uncertainty associated with Vietnamese governance and effective enforcement. Because these considerations are already considered in subsequent criterion, the CBA largely assumes an effectiveness as demonstrated by the literature.

Effectiveness: 4.5 (53,920,124 metric tons of overfishing abated)

Results from Monte Carlo Simulation of Alternative 1

Measure	% Difference year to year	Total Catch (metric tons)	Government Profit ($/yr)
Average	0%	31,325,857	$ 11,988,409.33

Figure 9. Fig. 9 shows the outcome of the Monte Carlo simulation of alternative 1. The primary outcome of interest is the total catch. The total catch represents the average across 100 runs of the simulation. Each run constituted a 10-year span, and the reported value is the average total catch over the ten years.

Creating an ITQ system ranks 4.5 for effectiveness, abating 53,920,124.05 metric tons of overfishing relative to the status quo. Using the year-to-year difference in total catch from Iceland as a proxy for effective enforcement of an ITQ system in Vietnam showed an average year to year difference of 0%, meaning half of the time the total catch was reduced year to year, a massive reversal of the current fishing trends in Vietnam (fig. 2). (See appendix C for more information regarding the Monte Carlo simulation for alternative 1.)

This level of effectiveness is due to several factors outside of the simulation. The most important is that such systems have worked with great success in a wide range of fishing environments and cultures (d'Armengol et., al., 2018). Notably, ITQs have been utilized in Canada for both sea and river systems (Bardach & Petashnik, 2020) and Iceland for deep sea fishing (Gissurarson, 2000) to great effect. Additionally, ITQ systems lower the effort to catch ratio of national fleets, meaning less time is spent catching more fish, furthering efficiency (Gissurarson, 2000). In all these cases, ITQs served not only as a means of regulating a complex market, but to bring fish stocks back to healthy and sustainable levels, a key outcome for Vietnam (Phuong, 2022).

Finally, ITQs allow for the central government to directly influence catch amounts and work with research organizations and NGOs. Cross collaboration between distinct stakeholders, spearheaded by the central government, maximizes the value each group adds, while leaving key decision making power to the government, leading to quick decision making and enforcement capabilities (Gissurarson, 2000).

Equity: 3.5

Alternative 1 scores 3.5 in equity. ITQ systems distribute shares of the total allowable catch throughout areas of high and low wealth where it has been implemented (Gissurarson, 2000). In previous iterations of ITQ implementation (notably Iceland), the smallest fishery villages saw increased ITQ allocation relative to larger metropolitan areas, increasing rural development and employment opportunities (Gissurarson, 2000). Given how important fishing is as a means of employment for the Vietnamese, and the prominence of small boat fishing, protecting rural fishing villages is important (Ngyuen, 2011).

This distributional pattern is likely due to several factors, but two high level mechanisms emerge. The first is small scale fishers likely have higher willingness to pay to fish than large commercial enterprises due to the cultural significance of fishing (Phillips, Personal Interview, 2024). This higher willingness to pay could mean they would buy more rights, even if they would be better off foregoing that right to fish.

A second explanation for this pattern is that larger fishing enterprises are more efficient and can cut down production or transition to other industries or practices more readily than a small fisher. This could mean that they would be less willing to buy additional rights to fish compared to smaller operations that do not have other alternatives for making money or even getting substance. The ITQ system would tap into both forces, likely protecting the smallest fishers in the market.

Feasibility: 2.5

Managerial Feasibility

Alternative 1 scores 2.5 in feasibility. One significant positive factor in the feasibility of alternative one is the ease of administration (Gissurarson, 2000). With relatively low management costs at the higher levels, an ITQ system has the potential to significantly reduce Total Allowable Catch (TAC) through effective regulation. By streamlining processes, the system could operate with minimal central government involvement while still exerting a substantial influence on catch amounts and enforcement of rules.

Enforcement Feasibility

However, the difficulty of enforcement presents a significant challenge to feasibility. While managing the system may not be overly complex, ensuring compliance demands significant investment in resources and personnel. Historically, enforcement in ITQ systems has primarily occurred at ports during catch unloading (Gissurarson, 2000). In Vietnam's case, enforcement must extend to both port and sea operations, necessitating more comprehensive mechanisms. This heightened enforcement requirement poses a primary challenge to the feasibility of this approach, with no clear resolution in sight.

Alternative 2: Co-Management of Fisheries

Cost: 2.5 (Average NPV of $11.51 billion)

Sensativity Analysis of Alternative 2 Cost Benefit Analysis

Rate	5%	7%	9%	Average
NPV	$13,951,305,770.56	$11,335,728,842.16	$9,247,102,458.51	$11,511,379,023.74

Figure 10. Fig. 10 shows the outcomes from the CBAs conducted for alternative 2. The three different values represent a sensitivity analysis, indicating a liberal, moderate, and conservative estimates on the NPV of the alternative.

Co-management scores 2.5 in cost, with an average NPV of $11.51 billion. Alternative 2 requires the most employees by far, significantly raising the cost to the government for employing them. Additionally, the government would have to provide significant material support to the local Provincial People's Committees, further adding to the costs. However, given that there already exists a similar management system for the forests of Vietnam, administrative costs regarding training may be lower. Finally, alternative 2 has no fee structure by which the government can make profits to cover expenses associated with the alternative. (For additional information about the CBA for alternative 2 see appendix D.)

Additionally, while the CBA assumes a similar level of effectiveness across alternatives, based on the prevailing literature, the abatement levels that can be expected from this system are likely lower than the needed amount, and would decrease the benefits significantly (Obiero et. al., 2015). It is likely that the conservative CBA value of $9.25 million more accurately reflects the NPV of alternative 2.

Effectiveness: 2.5 (52,768,121 metric tons of overfishing abated)

Results from Monte Carlo Simulation of Alternative 2

Measure	% Difference year to year	Total Catch (metric tons)	Government Profit ($/yr)
Average	4%	32,477,859	$ 21,439,193.59

Figure 11. Fig. 11 shows the outcome of the Monte Carlo simulation of alternative 2. The primary outcome of interest is the total catch. The total catch represents the average across 100 runs of the simulation. Each run constituted a 10-year span, and the reported value is the average total catch over the ten years.

Co-management of fisheries scores 2.5 in effectiveness and abates 52,768,121.92 metric tons of overfishing. The outcome of the Monte Carlo simulation is based on the year-to-year change in total catch from Cambodian inland fisheries, which are managed using a co-management scheme. Indeed, meta-analyses of co-management schemes, in Southeast Asia especially, have demonstrated an ability to reduce catch amounts and increase sustainability of fisheries (Evans, et. al., 2015; Pomeroy, et. al., n.d.). Additionally, some co-management schemes have effectively limited illegal fishing activities and methods (Evans, et. al., 2015). Even so, co-management is most effective in achieving compliance with gear prohibitions rather than catch prohibitions, lowering the effectiveness ranking (Evans, et. al., 2001; Whitehouse & Fowler, 2018). (For additional information on the Monte Carlo simulation for alternative 2 see appendix D.)

Importantly, the ecological benefits of co-management are not universal, and meta-analyses of co-management systems in various fishing contexts and state contexts have demonstrated both mixed results and overtly negative (Obiero, et. al., 2015; Whitehouse & Fowler, 2018). In fact, many of these analyses rely on interviews and qualitative feedback rather than quantitative studies of fish abundance, meaning they are highly subjective, depending on how highly one values the colloquial knowledge of participants, which the author does not. This detracts from the alternatives ranking in effectiveness.

Additionally, co-management in Vietnam will face many barriers to effective implementation, one of which is seen in cases across ASEAN nations, which is the propensity of corruption to negate reforms (Pomeroy, et. al., n.d.). Given the prevalence of regulatory inefficiency in Vietnam, it is highly likely any system will have to overcome corruption or be negatively impacted by it.

Equity: 5

Co-management scores a 5 in equity. Across many other co-management schemes, stakeholder engagement, especially among fishers themselves, increases dramatically (Viner, et. al., 2006). By engaging local fishermen, they have a greater say in policy implementation and formulation, increasing the voice and power of previously disempowered stakeholders (Viner, et. al., 2006). These findings have been supported across different co-management systems in varying fishing and state contexts, demonstrating how alternative 2 massively positively impacts equity (fig. 7).

Feasibility: 4

Managerial Feasibility

Co-management of fisheries in Vietnam scores a 4 feasibility. Ease of administration is supported by empowering community fisheries to improve compliance with regulations, particularly regarding the ban on illegal gear (Evans, et. al., 2001; Obiero et. al., 2015). Collaboration with NGOs enhances this process, leveraging their expertise and resources for effective implementation of development policies and cost saving.

Additionally, the socialist history of rural cooperation in Vietnam aligns well with the concept of co-management. Indeed, existing practice of forest management in Vietnam suggests that co-management systems resonate with current social and regulatory norms, further supporting their congruence with prevailing attitudes and practices (Phillips, Personal Communication, 2024). This suggests that Co-Management will have a major positive impact on feasibility.

Enforcement Feasibility

However, the presence of misaligned incentives among participating parties complicates implementation efforts, as well as limited buy-in from community members due to the absence of direct incentives (Viner, et. al., 2006). Moreover, the scale and lack of physical boundaries in maritime areas pose challenges, as delineating authority between different co-management systems can be complicated, hindering enforcement efforts (Pomeroy, et. al., 2015). Additionally, these systems do not align with natural fish stock distributions, further complicating quota enforcement (Pomeroy, et. al., 2015).

Alternative 3: Enhanced Maritime Domain Awareness

Cost: 2.5 (Average NPV of $11.52 million)

Sensativity Analysis of Alternative 3 Cost Benefit Analysis

Rate	5%	7%	9%	Average
NPV	$ 13,954,933,746.59	$ 11,338,847,428.84	$ 9,249,507,127.05	$ 11,514,429,434.16

Figure 12. Fig. 12 shows the outcomes of the CBAs conducted for alternative 3. The three values represent a sensitivity analysis, indicating a liberal, moderate, and conservative estimates on the NPV of the alternative.

Enhancing MDA scores a 2.5 in cost, with a $11.52 million NPV. The largest cost (aside from the lost fishing revenue) is the launch costs. Incorporated in that value are the technical upgrades needed to support increased amounts of satellite imagery. Wages represent a relatively small fraction of the costs of alternative 3, as the number of staff needed to support the launch and upgrades is minimal, given the high level of expertise required. (For additional information about the CBA for alternative 3 see appendix H.)

However, the costs associated with MDA are likely overestimated given the availability of funding from states and other sources to enhance MDA capabilities and technologies (Roy, 2023). This reality was incorporated into the CBA by using the ratio of international aid to government expenses for 2022 and applied it to the MDA benefits.

In addition, MDA is not considered a main mechanism for fishing law enforcement, and instead supplements existing infrastructure (Bueger, 2015), making its effectiveness questionable, and lowering its benefit. In fact, MDA is often associated with addressing security concerns. While overfishing, especially in Vietnam, does include serious security and sovereignty concerns (Womack, Personal Communication, 2023), it is entirely likely that the positive impact on overfishing abatement that MDA could have is low. While the mean NPV of MDA is +$11.52 billion, essentially equaling co-management, the more likely NPV is closer to +$9.247 billion, reflecting the lower abatement benefits.

Effectiveness: 3 (beyond the scope of the analysis)

Increasing MDA capacity scores a 3 in effectiveness. MDA is a crucial component of fisheries management, and increasing satellite surveillance capacity and vessel monitoring will allow Vietnam to enforce its fishing regulations more readily (Tran, 2023). Therefore, an effective MDA system is likely to positively impact stock health and equip authorities to crack down on overfishing. Increased MDA capacity does not include mechanisms for accountability or address the level of fishing, meaning sustainability targets are not explicitly considered. This is the primary detractor from alternative 3's effectiveness. While this does not increase effectiveness, it does not detract from the effectiveness of alternative 3, which contributes to its medium ranking.

Because MDA is considered a supplement to fisheries management, modeling the impact of enhanced MDA on Vietnamese fisheries poses a significant challenge. Overcoming this challenge is beyond the scope of this thesis and can and should be the subject of future research on fisheries management.

Equity: 1.5

Increasing MDA capacity scores a 1.5 for equity. Without explicitly addressing stakeholder engagement, or engaging small and medium sized vessels, it is likely that the trend of small sized vessels leaving the industry will only accelerate as they are out competed by larger, more technologically advanced vessels. This puts increased pressure on poor communities and fishers, likely driving them out of the industry, working against the goals of equity.

While alternative 3 does not directly support equity, it could have indirect benefits. A more comprehensive understanding of the maritime environment where Vietnamese vessels are operating and competing can facilitate enforcement of regulations, allowing vessels of all sizes to fish in less competitive environments. This could have a trickle-down effect and allow small fishers who follow the rules to fish in a more fair and less competitive environment. With that being said, this is only a potential secondary outcome, and does not significantly impact alternative 3's performance in this criterion.

Feasibility: 2

Managerial Feasibility

MDA scores a 2 for feasibility. The issue of MDA holds significant importance for the Vietnamese government, which has made substantial investments in begging to upgrade vessel technology to bolster maritime surveillance (Tran, 2023). Vietnam has been augmenting its enforcement capabilities with investments in boats and submarines and ships, potentially enhancing its ability to utilize satellite information effectively (Tran, 2023). However, due to Vietnam's unique historical connection to China, there are serious concerns about the government's willingness to adopt alternative 3 (Womack, Personal Communication, 2023).

Vietnam's relationship with China involves delicate signaling (Womack, Personal Communication, 2023), and participation in information-sharing groups could provoke tensions with both domestic and Chinese stakeholders, potentially escalating maritime disputes. Moreover, given Vietnam's history of defending sovereignty through conflict, joining multinational information-sharing initiatives may be perceived as compromising Vietnamese autonomy and security.

Enforcement Feasibility

Further detracting from the feasibility of alternative 3 are the significant challenges of administration. Utilizing satellite imagery requires advanced technology, which is costly and demands highly specialized expertise not readily available in the country (Tran, 2023). The process of launching satellites itself is formidable and expensive, while interpreting and acting upon satellite data necessitates further technical capacity. Enforcement of maritime laws using MDA information similarly requires significant investment in satellite technology. While there is alignment in recognizing the importance of understanding the maritime environment for safeguarding fishing stocks, the primary hurdle lies in technological constraints rather than cultural discrepancies.

XV. Recommendation

Summary Scores from the Analytical Hierarchy Process

Summary	Effectiveness	Cost	Equity	Feasibility	
	Weight & Scores	Weight & Scores	Weight & Scores	Weight & Scores	Weighted Score
	0.417	0.058	0.102	0.423	
ITQ	0.724	0.600	0.216	0.283	0.478
Co-management	0.083	0.200	0.723	0.643	0.392
MDA	0.193	0.200	0.061	0.074	0.130

Figure 13. Fig. 13 shows the outcomes matrix from the AHP analysis conducted of the three alternatives. The weights for each criterion are shown in yellow. The average scores from the pairwise comparisons between each alternative within each criterion are in blue. The weighted final score is given in green. Alternative 1, ITQ, scores the highest.

Based on the policy analysis, outcomes matrix, and AHP, the author believes alternative 1, instituting a system of Individual Transferable Quotas, is the best way to reduce overfishing in Vietnam (for additional information on the AHP see appendix A and I). While alternative 1 and 2 score a 14 on the outcome's matrix (fig. 7), given the weights of the criteria, the AHP outcomes matrix clearly demonstrates alternative 1's superiority. Specifically, in the key criterion of effectiveness, alternative 1 strongly outperforms alternatives 2 and 3. In addition, alternative 1 has a much higher NPV as demonstrated by the BCA analysis, while alternatives 2 and 3 perform equally well in the BCA.

Given the results of the matrix (fig. 7) and the AHP (fig. 13), alternative 3 does not present a realistic means by which Vietnam can combat overfishing. Regardless of how another analyst may choose to value the criterion, alternative 3 fails to distinguish itself, leaving only two viable policy alternatives. Moreover, while alternative 2 does perform highly in feasibility, the highest weighted criterion, its underperformance in the criteria of cost and effectiveness contribute to its low score.

This final recommendation is heavily dependent on the weighting scheme adopted by this analysis. It explicitly trades off serious feasibility concerns with the understanding it will be massively more effective than the other two alternatives. Because alternative 1 and 2 scored equally high on the outcome's matrix, a shift in criterion weight could dramatically change the outcome of this analysis.

Additionally, if one values equity and feasibility above effectiveness, then alternative 2 would strongly outperform alternative 1. The choice not to value equity above other alternatives was deliberate. Equity as an outcome is highly dependent on the effectiveness of an alternative. Considering the potential massively negative impacts on equity of the status quo, any alternative that avoids the status quo necessarily promotes equity, at least to a marginal extent. By making the opposite trade off, and valuing effectiveness and cost, alternative 1 presents itself as the clear best performing alternative.

XVI. Implementation

Stakeholders and Their Roles

Government agencies, particularly and the Ministry of Fisheries, are integral to the successful implementation of ITQs in Vietnam. Their roles encompass policy formulation, regulation, and enforcement, ensuring that the ITQ system aligns with broader national objectives while effectively managing fishing activities (Socialist Republic of Vietnam, 2001). Without their backing, no fishing regulation can move forward.

Fishing communities and Provincial People's Committee's, composed of fishers and fishing cooperatives, represent key stakeholders directly impacted by ITQs (Gissurarson, 2000). Their active involvement in the design phase of the ITQ system is crucial for ensuring the legitimacy and practicality of the quota allocation process, as well as fostering community buy-in and compliance (Gissurarson, 2000).

NGOs and environmental groups possess valuable expertise and resources that can contribute to the development and implementation of sustainable fishing practices under the ITQ regime. Their engagement can enhance the ecological effectiveness, social equity, and enforcement effectiveness of ITQ management strategies.

Steps for Implementation

The successful implementation of ITQs in Vietnam necessitates a comprehensive approach encompassing several key steps. Once legislation is passed, capacity building initiatives are essential, with training programs designed to educate fishers, government officials, and relevant stakeholders on the intricacies of ITQs and their implications for sustainable fisheries management. MARD should partner with NGO organizations to develop and implement this training at the Provincial level.

Concurrent with education efforts, Vietnam should task Provincial authorities with establishing historic catch data to inform the allocation of initial ITQs. The establishment of a fair and transparent ITQ allocation mechanism is vital and requires careful consideration of factors such as historical fishing records, stock health, and geographic wealth distributions to inform initial allocations (Gissurarson, 2000). Once these processes are in motion, the Ministry of Fisheries should begin enforcing a catch fee, which will help fund additional enforcement mechanisms needed to prevent quota violations and uphold compliance with ITQ regulations.

Lastly, ongoing evaluation and adaptation processes are necessary, with regular assessments conducted to gauge the effectiveness of ITQs in achieving conservation goals and address any emerging challenges or changing environmental conditions through adaptive management strategies. This should be the responsibility of the Ministry of Fisheries to lead, providing annual updates to the MARD, and working with Provincial authorities to disseminate updated quota information before each new season. Perspectives and Mitigation of Resistance

While some stakeholders may support ITQs for their potential to restore fish stocks and ensure long-term sustainability, others, particularly small-scale fishers, may perceive them as a threat to their livelihoods. To mitigate resistance, the government should engage in extensive consultation with Provincial authorities and other stakeholders, provide compensation or alternative livelihood options for affected communities, and emphasize the long-term benefits of sustainable fishing practices.

Not only might external resistance threaten implementation, but internal mechanisms may hamper uptake. The siloed nature of Vietnam's government poses a significant challenge to creating national policy, particularly regarding complex issues such as fisheries management. With various ministries and agencies operating within their own distinct spheres of influence and priorities, coordination and collaboration can be difficult, leading to fragmented approaches to policy making. In the case of implementing ITQs for fisheries management, the coordinated involvement of multiple governmental bodies such as MARD and the Ministry of Fisheries are crucial for comprehensive government policy.

However, entrenched bureaucratic structures and departmental rivalries may impede effective communication and cooperation, resulting in delays or inconsistencies in policy formulation and implementation. Overcoming these silos requires concerted efforts to foster interagency dialogue, streamline decision-making processes, and promote a shared understanding of overarching national goals, ultimately facilitating the development of integrated and sustainable policies to address pressing challenges like overfishing in Vietnam.

XVII. Conclusions

Vietnam is well known to be a prolific perpetrator of IUU fishing in the SCS and beyond (Nguyen, 2024). After years of largely ignoring the problem, the Vietnamese government was forced to act after the EU issued Vietnam a yellow card warning, prompting a dramatic shift in priorities within the government of Vietnam. Despite changes in rhetoric and modest advances in monitoring and enforcement capabilities, Vietnam still lacks the capabilities to fundamentally hold their commercial fishing fleet accountable to Vietnamese maritime law (Nguyen, 2024). Should the status quo continue, Vietnam stands to lose access to the European seafood market, as well as the imminent collapse of major fish stocks in their EEZ (Jia & Wang, 2023). These would have devastating consequences for the people of Vietnam, including massive unemployment, civil unrest, and ecological disaster. Given the magnitude of the problem and the potential consequences, the Vietnamese government must act with urgency to improve fisheries regulation in their EEZ.

To do this, Vietnam should adopt a system of Individual Transferable Quotas for their deep-sea fisheries. Successfully implementing an ITQ system presents a low cost and effective means for the government of Vietnam to regulate their fisheries and arrive at a socially optimal distribution of fishing effort, all while reducing total catch to sustainable levels. While implementing such a system faces significant implementation challenges, the promise of success, low costs, and high cost of failure necessitate bold action.

Limitations

The above analysis is not without limitations. While addressing many of these limitations is beyond the scope of a master's thesis, they are worth noting, nonetheless. Given how important the CBA and Monte Carlo simulations were to the analysis, an understanding of where they may be limited allows for a more complete understanding of the applicability of its findings.

The CBA in this analysis is subject to several limitations that each impact the accuracy of its findings. Firstly, the CBA does not quantify all the costs and benefits involved in the alternatives proposed. Particularly, intangible costs and benefits, such as environmental impacts and social welfare improvements, may be inadequately measured or monetized. Moreover, the CBA does not fully account for the distributional impacts on different stakeholders of each alternative. Additionally, the CBA fails to adequately account for serious risk and uncertainty inherent in future projections, especially for a still developing nation such as Vietnam. The resulting NPVs may be overly optimistic estimates. Finally, the CBA is limited in its ability to incorporate non-market values, such as health or quality of life improvements gained from ecosystem services, into the analysis.

The Monte Carlo simulation employed in this analysis has two major limitations, specifically assumption sensitivity and incomplete modeling assumptions. The simulation's outcomes heavily rely on the underlying assumptions and input parameters. Small changes in these assumptions may lead to substantial variations in the simulated outcomes, potentially impacting the reliability and robustness of the findings. This analysis relied heavily on the major assumption that Icelandic and Cambodian fishing outcomes were applicable to Vietnam. Indeed, not enough information was known about alternative 3 to even attempt a Monte Carlo simulation. For the first two alternatives, it is possible the underlying assumptions of applicability may not hold, which would significantly alter the results. Moreover, the simulation's simplifications and assumptions may not fully capture the complexities of the real-world deep sea fishing system in Vietnam. The modeling assumptions in this analysis may overlook critical factors at play, such as the relatively peaceful interaction between Vietnamese and Chinese fishers, or the control that Chinese influence has over Vietnamese politics. Excluding these realities may bias the results and limit the simulation's ability to accurately represent the true outcomes of the alternatives.

Future Research

Given the massive scale and severity of overfishing, the limitations of this analysis, and the potentially massive negative consequences of inaction, future research is needed to better understand how states can successfully regulate their commercial fishing fleet and promote sustainable fishing practices. Future research in the field should prioritize a deeper understanding of the true impact of increased MDA on the efficacy of fishing regulations. While there is broad recognition of the necessity of MDA for regulatory enforcement and resource management, further empirical studies can determine precise effects on compliance rates, fish stock sustainability, and overall ecosystem health. Additionally, future research efforts should aim to better understand the distributional consequences of different regulatory schemes within the fishing industry. By examining how regulatory interventions affect various stakeholders differently, researchers can provide policymakers with insights into the equity implications of different policy approaches and identify strategies to mitigate adverse distributional effects. Finally, future research should focus on more accurately quantifying the non-market costs and benefits associated with fishing regulations. These include environmental degradation, loss of ocean biodiversity, as well as the non-market benefits, such as the recreational and cultural values associated with sustainable fisheries. By addressing these research priorities, future research can provide valuable insights and inform evidence-based policymaking to promote more effective and equitable fisheries management practices.

XVIII. Supporting Material

Bibliography

Anh, T. (2022). What Vietnam Can Learn From Thailand's Fight Against Illegal Fishing. *The Lowy Institute*. https://www.lowyinstitute.org/the-interpreter/what-vietnam-can-learn-thailand-s-fight-against-il egal-fishing.

Bacchi, U. (2017). An end to overfishing could reap billions of dollars in global profits, study says. Reuters. https://www.reuters.com/article/us-global-food-overfishing-idUSKBN15T30P/#:~:text=Overfishing%20costs%20more%20than%20%2480,study%20by%20the%20World%20Bank.

Bardach, E. & Patashnik, E. (2020). A Practical Guide for Policy Analysis. *CQ Press*.

BBC. (2023, July 7). What is the South China Sea dispute? *BBC.* https://www.bbc.com/news/world-asia-pacific-13748349.

Boat Driving. (n.d.). How Much Does a Boat Cost? Price Chart. *BoatDriving.org.* https://www.boatdriving.org/average-boat-price/.

Bueger, C. (2015). From Dusk to Dawn? Maritime Domain Awareness in Southeast Asia. *Contemporary Southeast Asia*, 37(2), 157–182. http://www.jstor.org/stable/24916578.

Cardinale, M., Dorner, H., Abella, A., Andersen, J., Casey, J., Doring, R., Kirkegaard, E., Motova, A., Anderson, J., Simmonds, E., Stransky, C. (2013). Rebuilding EU fish stocks and fisheries, a process underway?. *Marine Policy*. https://www.sciencedirect.com/science/article/abs/pii/S0308597X1200200X.

Davenport, C. (2021). The revolution is satellite technology means there are swarms of spacecraft no bigger than a loaf of bread in orbit. *The Washington Post*. https://www.washingtonpost.com/technology/2021/04/06/small-satellites-growth-space/.

Earth. (2021) Overfishing in South China Sea Could Cost $10 bn a Year in Lost Revenues. (2021). *Earth.org*. Retrieved February 6, 2024, from https://earth.org/overfishing-in-south-china-sea-could-cost-10-bn-a-year-in-lost-revenue.

ePropulsion. (2023). How Much Does a Boat Motor Cost: Outboard Motor Price by Brand and HP in 2023. *ePropulsion. https://www.epropulsion.com/post/outboard-motor-price/.*

Evans, L., Charrett, N., & Pemsl, D. (2011). Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. *Journal of Environmental Management*. https://doi.org/10.1016/j.jenvman.2011.03.010.

FishFocus. (n.d). Retrieved April 3, 2024, from https://fishfocus.co.uk/vietnam-seafood-exports-to-eu-increase/#:~:text=Vietnam%20seafood%20exports%20to%20EU%20increase.,most%20EU%20member%20countries%20increased.

Fish & Seafood - Worldwide. (n.d.). Retrieved March 18, 2024, from https://www.statista.com/outlook/cmo/food/fish-seafood/worldwide.

FOA. (n.d.). Retrieved April 3, 2024, from https://www.fao.org/3/cc0461en/online/sofia/2022/fishing-fleet.html#:~:text=The%20world%20had%20an%20estimated,revision%20of%20FAO%20fleet%20data.

FOA. (2021). Global Capture Production/Quantity (1950-2021), Fishery and Aquaculture Statistics. *FOA Fisheries Division. http://www.fao.org/fishery/statistics/software/fishstatj/en.*

Gissurarson, H. (2000). Overfishing: The Icelandic Solution. *Institute of Economic Affairs*. http://www.iea.org.uk/sites/default/files/publications/files/upldbook16pdf.pdf.

Global Initiative. (2019). IUU Fishing Index 2019. *Global Initiative*.

Goh, E. (2008). Great Powers and Hierarchical Order in Southeast Asia: Analyzing Regional Security Strategies. *International Security, 32(3), 113–157*. https://doi.org/10.1162/isec.2008.32.3.113.

Greer, A. (2016). The South China Sea Is Really a Fishery Dispute. *The Diplomat*. https://thediplomat.com/2016/07/the-south-china-sea-is-really-a-fishery-dispute/#:~:text=Although%20the%20SCS%20covers%20only,the%20total%20global%20fish%20catch.

Guillot, W. M. (2019). Why De-escalation Is Bad Policy. *Strategic Studies Quarterly*, *13*(3), 3-6. https://www.jstor.org/stable/10.2307/26760125.

https://globalinitiative.net/analysis/iuu-fishing-index/.

Jamail, D. (2016). Global Fisheries are Collapsing – What happens when there are no fish left? *All Creatures.* https://www.all-creatures.org/articles/ar-fish-global-fisheries-collapsing.html.

Jia, Y., & Wang, Z. (2023). Vietnam's illegal fishing in South China Sea unabated in 2022. *The East is Read*. https://www.eastisread.com/p/vietnams-illegal-fishing-in-south.

Jönsson, J. (2019). Overfishing, social problems, and ecosocial sustainability in Senegalese fishing communities. *Journal of Community Practice*, 27. https://doi.org/10.1080/10705422.2019.1660290.

Lin, B., Garafola, C. L., McClintock, B., Blank, J., Hornung, J. W., Schwindt, K., Moroney, J. D. P., Orner, P., Borrman, D., Denton, S. W., & Chambers, J. (2022). A New Framework for Understanding and Countering China's Gray Zone Tactics. *RAND Corporation*. https://www.rand.org/pubs/research_briefs/RBA594-1.html.

Luo, S. (2022). Provocation without escalation: Coping with a darker gray zone. *The Brookings Institute.* https://www.brookings.edu/articles/provocation-without-escalation-coping-with-a-darker- gray-zone/.

Mastro, O.S. (2022). Deterrence in the Indo-Pacific. *Asia Policy 29(4), 8-18*. https://doi.org/10.1353/asp.2022.0066.

Ministry of Industry and Trade (Vietnam). (2023). *Báo cáo Xuất nhập khẩu Việt Nam năm 2022* [Vietnam Import - Export Report 2022] (PDF). *Hong Duc Publishing House* (Vietnam).

Hà Nội. pp. 248-251. Archived (PDF) from the original on 2023-07-01. Retrieved 2023-12-03.

Monge, E., & Jungwiwattanaporn, M. (2022). Global Deal Will Help Reduce Overfishing and Improve Ocean Health. *PewTrusts*. Retrieved February 6, 2024, from https://www.pewtrusts.org/en/research-and-analysis/articles/2022/.09/20/global-deal-will-help-reduce-overfishing-and-improve-ocean-health.

Nguyen, K. (2024). Assessing Vietnam's Challenges in Fighting IUU Fishing. *Yusof Ishak Institute.* https://www.iseas.edu.sg/wp-content/uploads/2024/01/ISEAS_Perspective_2024_18.pdf.

Nguyen, M.-N. (2022, September 2). Number of people working in fisheries Vietnam 2019-2020, by quarter. *Statista.* https://www.statista.com/statistics/1330161/vietnam-quarterly-number-of-people-employ ed-in-fishing/#:~:text=In%20the%20fourth%20quarter%20of,valuable%20exports%20in%20recent%20years.

Nguyen, M. (2023). Fisheries & Aquaculture - statistics & facts. *Statista*. https://www.statista.com/topics/9875/fishery-and-aquaculture-in-vietnam/#topicOverview.

Ngyuen, M. (2011). Value Chain Analysis. *Nong Lam University*.

Obiero, K., Abila, R., Njiru, M., Raburu, P., Achieng, A., Kundu, R., Ogello, E., Munguti, J., & Lawrence, T. (2015). The Challenges of Management: Recent Experiences in Implementing Fisheries CoManagement in Lake Victoria, Kenya. *University of Michigan Library*. https://doi.org/10.1111/lre.12095.

Oceans. (n.d.). GreenPeace.org. Retrieved February 6, 2024, from https://www.greenpeace.org/international/tag/oceans/.

Ovando, D., Libecap, G., Millage, K., & Thomas, L. (2020). Coasean Approaches to Address Overfishing: Bigeye Tuna Conservation in the Western and Central Pacific Ocean. *Marine Resource Economics*. https://doi.org/10.1086/711853.

Paolo, F.S., Kroodsma, D., Raynor, J. et al. Satellite mapping reveals extensive industrial activity at sea. Nature 625, 85–91 (2024). https://doi.org/10.1038/s41586-023-06825-8.

Phillips-Levine, T., Phillips-Levine, D., & Mills, W. (2022). How NGOs Can Help Keep Tabs on China's Illegal Fishing Activity. *Maritime Executive*. Retrieved February 6, 2024, from https://maritime-executive.com/editorials/How-ngos-can-help-keep-tabs-on-china-s-illeg al-fishing-activity.

Phuong, Van. (2022). Vietnam's illegal fishing could earn it an EU ban. *Eco-Buisness*. Retrieved February 6, 2024, from https://www.eco-business.com/opinion/vietnams-illegal-fishing-could-earn-it-an-eu-ban.

Pomeroy, R., Parks, J., Courtney, K., & Mattich, N. (2015). Improving Marine Fisheries Management in Southeast Asia: Results of a Regional Fisheries Stakeholder Analysis. *Elsevier.* https://repository.library.noaa.gov/view/noaa/33078/noaa_33078_DS1.pdf.

Pomeroy, R., Katon, B., & Harkens, I. (n.d.). Fisheries Co-management: Key Conditions and Principles Drawn from Asian Experiences. *International Center for Living Aquatic Resources Management*. https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/1220/pomeroy.pdf?sequence=1&isAllowed=y.

Ritchie, H., & Roser, M. (2024). Fish and Overfishing. *Our World Data.* https://ourworldindata.org/fish-and-overfishing.

Roy, A. (2023). A work in progress: The Indo-Pacific partnership for maritime domain awareness. *Pacific Forum*. Retrieved February 6, 2024, from https://pacforum.org/publication/pacnet-48-a-work-in-progress-the-indo-pacific-partnership-for-maritime-domain-awareness.

SEAFDEC. (2022). Fisheries Country Profile: Cambodia. http://www.seafdec.org/fisheries-country-profile-cambodia/.

Socialist Republic of Vietnam. (2001). Fisheries Law. *United Nations Office on Drugs and Crime.* https://sherloc.unodc.org/cld/uploads/res/document/fisheries-law_html/Fisheries_Law.

Statista. (2021). "China: outward FDI flows to Vietnam 2021." *Statista.* https://www.statista.com/statistics/720408/china-outward-fdi-flows-to-vietnam/.

Sumaila, U,R., Cheung, W., Dyck, A., Gueye, K., Huang, L., et al. (2012) Benefits of Rebuilding Global Marine Fisheries Outweigh Costs. *PLoS ONE* 7(7): e40542. doi:10.1371/journal.pone.0040542.

The Global Economy. (2024). Vietnam: Foreing Aid. *Theglobaleconomy.com*. https://www.theglobaleconomy.com/Vietnam/foreign_aid/#:~:text=Foreign%20aid%20and%20official%20development%20assistance%20received&text=The%20average%20value%20for%20Vietnam,is%20516.07%20million%20U.S.%20dollars.

The White House. (2023). FACT SHEET: President Joseph R. Biden and General Secretary Nguyen Phu Trong Announce the U.S.-Vietnam Comprehensive Strategic Partnership. *The White House*. https://www.whitehouse.gov/briefing-room/statements-releases/2023/09/10/fact-sheet-president-joseph-r-biden-and-general-secretary-nguyen-phu-trong-announce-the-u-s-vietnam-comprehensive-strategic-partnership/#:~:text=Biden%20and%20General%20Secretary%20Nguyen%20Phu%20Trong%20elevated%20U.S.%E2%80%90Vietnam,%2C%20prosperity%2C%20and%20sustainable%20development.

Tran, B. (2023). Vietnam’s Quest for Enhanced Maritime Domain Awareness. *Yusof Ishack Institute*. https://www.iseas.edu.sg/wp-content/uploads/2024/01/ISEAS_Perspective_2023_96.pdf.

Weimer, D., & Vining, A. (2017). Policy Analysis; Concepts and Practice (6th ed.). *Routledge.*

Whitehouse, L., & Fowler, M. (2018). Meta-analysis reveals that fisheries co-management alters socio-economic outcomes and resource well-being. *MARINE ECOLOGY PROGRESS SERIES*, 600. https://doi.org/10.3354/meps12681.

Worldometer. (2023). Retrieved April 3, 2024, from https://www.worldometers.info/world-population/population-by-country/.

Viner, K., Ahmed, M., Bjørndal, T., Lorenzen, K. (2006). Development of Fisheries Co-management in Cambodia: A case study and its implications. *WorldFish Center*. https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/1789/WF_670.pdf?sequence=1&isAllowed=y.

WWF. (n.d.). Overfishing. *World Wildlife Fund*. https://www.worldwildlife.org/threats/overfishing.

Xinhua. (2024). Vietnam’s state budget collection down 5.4 pct in 2023. *Xinhua Net.* https://english.news.cn/20240104/fcf941dc604a4c7eacd207886b39ed13/c.html#:~:text=Vietnam's%20budget%20spending%20in%202023,3.2%20percent%20year%20on%20year.

Ye, Y., & Gutierrez, N. (2017). Ending fishery overexploitation by expanding from local success to localized solutions. Nature. https://doi.org/10.1038/s41559-017-0179.

Appendix

Appendix A: AHP scoring language

Relative Importance Scale and Scoring			
Relative Importance	**Value if Row is Better than Column**	**Value if Column is better than Row**	
Equal importance/quality	1	1.000	The two options contribute equally to the criterion
Somewhat more important/better	3	0.333	Experience and judgment favor one option over the other
Definitely more important/better	5	0.200	Experience and judgment strongly favor one option over the other
Much more important/better	7	0.143	One option is strongly favored and its dominance has been demonstrated in practice
Very much more important/better	9	0.111	Evidence favoring one option over the other is of the highest possible order of affirmation
Intermediate Values	*2,4,6,8*	*1/2, 1/4, etc.*	
In each cell, you are comparing the criterion/option in the ROW to the criterion/option in the COLUMN.			

Appendix B: Monte Carlo simulations general assumptions

Generally, the monte Carlo simulations in this analysis rely on repeated iterations of a simulation to arrive at the most likely outcome based on the input assumptions. The propensity for increasingly large random samples to cluster around a number is generally known as the law of large numbers. I assumed that after 100 runs (1000 years), the law of large numbers will be in effect.

Secondly, the Monte Carlo simulations in this analysis assume the value of 1 metric ton of abated overfishing is $10,989.01. Given that estimates suggest the value to society of increasing the mean sustainable yield (putting off catch so that it can be harvested in the future) of fisheries by 9.1 million metric tons/year is equivalent to $100 billion dollars/year (Sumaila, et. al., 2012), it follows that each increased abated metric ton of fish would provide $10,989.01 in benefits to society.

Third, I assume perfect enforcement of the three alternatives. This assumption is not supported by catch data from ITQ systems. However, I assume this to attempt to isolate the impact the alternatives would have on cost, and not blend two separate alternatives (cost and effectiveness).

Fourth, I set reduction targets based on a compilation of different recommendations from the literature and my understanding of what could be reasonable expected. This is a major assumption that I made largely on a judgment call, as any specific number would require intense species-specific analysis. Those analysis are done by major government organization, think tanks, and teams in universities. Doing one for this paper goes well beyond the scope of my analytical competencies.

Finally, the values for profits associated with each simulation were calculated assuming the value of one metric ton of fish is assumed to be $2,821.71. This amount is based on the value of Vietnamese fish from 2022 (Nguyen, 2023). It was derived by dividing total value in dollars by total production in metric tons.

Appendix C: Alternative 1 Monte Carlo simulation assumptions

To conduct the simulation for alternative 1, I assumed that the year-to-year variation in TC for Iceland will be applicable to Vietnam if they were to adopt the same policy. Countries that have adopted ITQ systems in the past have reported massive success, and the author assumes that Vietnam will enjoy similar outcomes. Even if these outcomes do not hold, this base assumption gives the analysis a starting point with which to compare the alternative to others.

Additionally, the simulation of alternative 1 assumes that year to year differences in TC are randomly distributed. Graphing the differences over time and using a quadratic line of best fit yielded an R squared value of only .54, indicating it does not explain the variation. This assumption directly influences the simulation by determining how catch variation is generated. In this case, it is generated using a random number generator in Excel.

Appendix D: Alternative 2 Monte Carlo simulation assumptions

To conduct the simulation for alternative 2, I assumed that the year-to-year difference in TC for Cambodia's inland fisheries (FOA, 2021) will hold for Vietnam. Cambodia uses co-management to manage its inland fisheries, and using historical data from Cambodia, the author simulated how a co-management system might impact Vietnam.

The simulation assumes that historic catch data and the probability of any given year to year difference is random. An analytical analysis of the catch data with a line of best fit resulted in an R squared value of .1, indicating the variation is not explained with a non-random distribution.

Appendix E: Cost-Benefit Analysis general assumptions

For the CBAs in this analysis, I assumed that the value of 1 metric ton of abated overfishing was $10,989.01. Given that estimates suggest the value to society of increasing the mean sustainable yield (putting off catch so that it can be harvested in the future) of fisheries by 9.1 million metric tons/year is equivalent to $100 billion dollars/year (Sumaila, et. al., 2012), it follows that each increased abated metric ton of fish would provide $10,989.01 in benefits to society.

Secondly, the value of one metric ton of fish is assumed to be $2,821.71. This amount is based on the value of Vietnamese fish from 2022 (Nguyen, 2023). It was derived by dividing total value in dollars by total production in metric tons.

Third, I assumed that the average wage of a Vietnamese worker is $4,000/year. While there are no official government sources backing up this data, it is reported by a number of blogs and corroborated by expert’s opinions and the authors' understanding of the context.

Finally, I assumed perfect enforcement of the three alternatives. This assumption is not supported by catch data from ITQ systems. However, the author assumes this to attempt to isolate the impact the alternatives would have on cost, and not blend two separate alternatives (cost and effectiveness).

To find the NPV, I used the formula “(present value) = (future value)/(1+(discount rate))^year”. This is common practice.

Appendix F: Alternative 1 Cost-Benefit Analysis assumptions and outcomes

I assumed that the management costs for the ITQ system in Iceland will be the same for Vietnam. This assumption simplifies the analysis, brining it in the scope of what can be expected for a thesis of this kind. I assumed that collection of the TC fee will be perfect and match the actual unloaded catch amount. This assumption simplifies the analysis, brining it in the scope of what can be expected for a thesis of this kind.

Alternative 1 Full Cost-Benefit Analysis

Cost	Value	Benefit	Value (year)	Rate	PV Costs	PV Benefits	
Wages	$ 1,520,000.00	Abatement	$24,516,481,310.00	7%	$ (722,141.05)	$ 52,742,242.99	
Management	$ 30,000,000.00	catch fee total	209766331.4		$ (14,252,783.89)	$ 46,445,213.51	
lost revanue	$651,813,953.49	catch fee 1	$ 56,434,200.00		$(309,672,113.89)	$ 40,746,365.56	
		catch fee 2	$ 53,175,124.95			$ 35,594,382.72	
		catch fee 3	$ 49,916,049.90			$ 30,942,102.78	
		catch fee 4	$ 46,656,974.85			$ 26,746,193.75	
		catch fee 5	$ 43,397,899.80			$ 22,966,854.61	
		catch fee 6	$ 40,138,824.75			$ 19,567,538.75	
		catch fee 7	$ 36,879,749.70			$ 16,514,698.50	
		catch fee 8	$ 33,620,674.65			$ 13,777,549.17	
		catch fee 9	$ 30,361,599.60			$ 11,327,851.10	
		catch fee 10	$ 27,102,524.55			$11,647,603,663.15	
		catch fee 11	$ 23,843,449.50		Sum PV Cost	Sum PV Benefits	NPV
					$(324,647,038.83)	$11,964,974,656.58	$11,640,327,617.75
Cost	Value	Benefit	Value (year)	Rate	PV Costs	PV Benefits	
Wages	$ 1,520,000.00	Abatement	$24,516,481,310.00	5%	$ (722,141.05)	$ 53,746,857.14	
Management	$ 30,000,000.00	catch fee total	258151734.7		$ (14,252,783.89)	$ 50,642,976.14	
lost revanue	$651,813,953.49	catch fee 1	$ 56,434,200.00		$(381,102,118.94)	$ 47,539,095.14	
		catch fee 2	$ 53,175,124.95			$ 44,435,214.14	
		catch fee 3	$ 49,916,049.90			$ 41,331,333.14	
		catch fee 4	$ 46,656,974.85			$ 38,227,452.14	
		catch fee 5	$ 43,397,899.80			$ 35,123,571.14	
		catch fee 6	$ 40,138,824.75			$ 32,019,690.14	
		catch fee 7	$ 36,879,749.70			$ 28,915,809.14	
		catch fee 8	$ 33,620,674.65			$ 25,811,928.14	
		catch fee 9	$ 30,361,599.60			$ 22,708,047.14	
		catch fee 10	$ 27,102,524.55			$14,334,278,863.23	
		catch fee 11	$ 23,843,449.50		Sum PV Cost	Sum PV Benefits	NPV
					$(396,077,043.88)	$14,754,780,836.80	$14,358,703,792.92
Cost	Value	Benefit	Value (year)	Rate	PV Costs	PV Benefits	
Wages	$ 1,520,000.00	Abatement	$24,516,481,310.00	9%	$ (722,141.05)	$ 51,774,495.41	
Management	$ 30,000,000.00	catch fee total	1139328116		$ (14,252,783.89)	$ 48,784,518.30	
lost revanue	$651,813,953.49	catch fee 1	$ 56,434,200.00		$(252,599,319.30)	$ 45,794,541.19	
		catch fee 2	$ 53,175,124.95			$ 42,804,564.08	
		catch fee 3	$ 49,916,049.90			$ 39,814,586.97	
		catch fee 4	$ 46,656,974.85			$ 36,824,609.86	
		catch fee 5	$ 43,397,899.80			$ 33,834,632.75	
		catch fee 6	$ 40,138,824.75			$ 30,844,655.64	
		catch fee 7	$ 36,879,749.70			$ 27,854,678.53	
		catch fee 8	$ 33,620,674.65			$ 24,864,701.42	
		catch fee 9	$ 30,361,599.60			$ 21,874,724.31	
		catch fee 10	$ 27,102,524.55			$ 9,500,941,882.94	
		catch fee 11	$ 23,843,449.50		Sum PV Cost	Sum PV Benefits	NPV
					$(267,574,244.24)	$ 9,906,012,591.42	$ 9,638,438,347.18

Appendix G: Alternative 2 Cost-Benefit Analysis assumptions and outcomes

I assumed this alternative will employ 300 people. This assumption is based upon my understanding of the context in Vietnam and discussions from the literature.

Additionally, I assumed the equipment costs would be $2,000,000/year. I assumed one vessel and engine are worth a combined $20,000 (Boat Driving, n.d.; ePropulsion, 2023). I additionally assumed that the alternative would require 100 boats per year. The CBA further assumes that the bulk of the equipment costs will be paid over the first three years of the alternative. The cost of additional equipment is marginal for the rest of the alternative's life.

Alternative 2 Full Cost-Benefit Analysis

Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefit		
Wages	$ (1,200,000.00)	Abatement	$ 24,516,481,310.00	7%	-570111.3557	11647603663		
Equipment	$ (2,000,000.00)				-1632595.754			
Lost Revanue	$ (651,813,953.49)				-309672113.9			
					Sum NP Costs	Sum NP Benefits	NPV	
					-311874821	11647603663	$	11,335,728,842.16
Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefit		
Wages	$ (1,200,000.00)	Abatement	$ 24,516,481,310.00	5%	-701615.1469	14334278863		
Equipment	$ (2,000,000.00)				-1169358.578			
Lost Revanue	$ (651,813,953.49)				-381102118.9			
					Sum NP Costs	Sum NP Benefits	NPV	
					-382973092.7	14334278863	$	13,951,305,770.56
Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefit		
Wages	$ (1,200,000.00)	Abatement	$ 24,516,481,310.00	9%	-465039.4204	9500941883		
Equipment	$ (2,000,000.00)				-775065.7007			
Lost Revanue	$ (651,813,953.49)				-252599319.3			
					Sum NP Costs	Sum NP Benefits	NPV	
					-253839424.4	9500941883	$	9,247,102,458.51

Appendix H: Alternative 3 Cost-Benefit Analysis assumptions and outcomes

Alternative 3 Full Cost-Benefit Analysis

Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefits	
Wages	$ (240,000.00)	Abatement	$ 24,516,481,310.00	7%	-114022.2711	11647603663	
Launch	$ (1,500,000.00)	International subsidies	$ 4,745,070.19		-1224446.815	2254348.663	
Lost Revanue	$(651,813,953.49)				-309672113.9		
					Sum NP Costs	Sum NP Benefit	NPV
					-311010583	11649858012	$11,338,847,428.84
Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefits	
Wages	$ (240,000.00)	Abatement	$ 24,516,481,310.00	5%	-140323.0294	14334278863	
Launch	$ (1,500,000.00)	International subsidies	$ 4,745,070.19		-877018.9336	2774344.263	
Lost Revanue	$(651,813,953.49)				-381102118.9		
					Sum NP Costs	Sum NP Benefit	NPV
					-382119460.9	14337053207	$13,954,933,746.59
Cost	Value	Benefit	Value	Rate	PV Cost	PV Benefits	
Wages	$ (240,000.00)	Abatement	$ 24,516,481,310.00	9%	-93007.88409	9500941883	
Launch	$ (1,500,000.00)	International subsidies	$ 4,745,070.19		-581299.2755	1838870.574	
Lost Revanue	$(651,813,953.49)				-252599319.3		
					Sum NP Costs	Sum NP Benefit	NPV
					-253273626.5	9502780754	$ 9,249,507,127.05

I assumed that the value of subsidies from NGO sources will be the same as the ratio of NGO subsidies for Vietnamese government spending generally. Vietnam received $516.07 million in aid for the year 2021 and spent $71.08 billion in the year 2023. Therefore, the proportion of aid that would be spent on the expenses incurred in alternative 3 is .726% of the costs.

Further, I assumed that launching a satellite will cost $1.5 million. Reporting estimates the cost of launching a small satellite at $1 million (Davenport, 2021), and an extra $500,000 was added to account for development costs. As satellite technology continues to improve, and rental space on rockets continues to become available, I assumed the cost of launch will not be as burdensome in the future, thus the low-cost projection.

Appendix I: AHP Scoring

Effectiveness	ITQ	Co-management	MDA
ITQ	1.00	7.00	5.00
Co-management	0.14	1.00	0.33
MDA	0.20	3.00	1.00
	1.343	11.000	6.333

Cost	ITQ	Co-management	MDA
ITQ	1.00	3.00	3.00
Co-management	0.33	1.00	1.00
MDA	0.33	1.00	1.00
	1.667	5.000	5.000

Equity	ITQ	Co-management	MDA
ITQ	1.00	0.20	5.00
Co-management	5.00	1.00	9.00
MDA	0.20	0.11	1.00
	6.200	1.311	15.000

Feasibility	ITQ	Co-management	MDA
ITQ	1.00	0.33	5.00
Co-management	3.00	1.00	7.00
MDA	0.20	0.14	1.00
	4.200	1.476	13.000

The above images show the scores given to each alternative within the four criteria laid on in this analysis. Each alternative is considered against the others within the context of the criterion specified. The alternative in the row is considered against the alternative in the column.

While quantitative and qualitative methods were used to evaluate each alternative, ultimately the assignment of a number involved making judgment calls based on my own understanding of the context and alternative. These judgment calls were not random. They were based on the outcomes of a thorough literature review and two robust analytical tools. Even so, I have made every attempt to stay true to the scoring scheme laid out in appendix A.

To ensure my scoring was consistent, I used a coded consistency ratio indicator in Excel. Speaking frankly, I am not entirely sure how the code in Excel works. However, the AHP template used was given to me by a professor at the University, and I am differing to their expertise in this matter.

The scoring outcomes for alternatives within criteria are considered consistent when the "consistency ratio" is < .1. All my scoring decisions were within the consistency ratios acceptable parameters except the scores for equity, which was .103. I cannot understand why this is happening and given that this is for a graduation requirement and not actual policy implementation, I would ask the reader to accept my scoring decisions for that criterion with only slight reservations.