10-31-2021

Natural resource damage assessment for oil spills in Sri Lanka: the application of Habitat Equivalency Analysis

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NATURAL RESOURCE DAMAGE ASSESSMENT FOR OIL SPILLS IN SRI LANKA: THE APPLICATION OF HABITAT EQUIVALENCY ANALYSIS

By

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the reward of the degree of

MASTER OF SCIENCE
in
MARITIME AFFAIRS

(OCEAN SUSTAINABILITY GOVERNANCE AND MANAGEMENT)

2021

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): ....

(Date): 21 September 2021

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Acknowledgements

At the outset, I would be grateful and profound to express my sincere gratitude towards Dr. Yohei Sasakawa, Chairman of the Nippon Foundation, for awarding me the Sasakawa Fellowship and to the World Maritime University (WMU) for giving me this immense opportunity to complete my MSc program at Sweden amidst the COVID 19 pandemic.

It is a radiant sentiment to express special gratitude to my research supervisor Prof. Johan Hollander for his expert guidance and for sharpening my skills to make this academic work a success. I humbly appreciate your selfless effort throughout the research. I would like to express my special thanks to Prof. Francis C. Neat, Head of Specialization Ocean Sustainability, Governance and Management (OSGM), and all the academic staff of OSGM for sharing such an outstanding knowledge and experience during the whole course.

I would take this opportunity to acknowledge all respondents who participated in the survey for their valuable time and generous support. Without their contribution, this effort would not have been possible. I would also extend my sincere thanks to the library staff of WMU for their prompt assistance.

This journey might not be accomplished without the recommendation of Prof. Terney Pradeep Kumara, former Chief Executive Officer of Marine Environment Protection Authority (MEPA) of Sri Lanka, and the kind support of Mr. Jagath Gunasekara, General Manager (Overseeing) of MEPA and the management of MEPA including Ms. Thalatha Ranasinghe. I sincerely appreciate all the concerns you have shown me.

I register my heartfelt thanks to all my wonderful friends in OSGM family and WMU for turning this period into a memorable chapter in my life.

Last but not least, I am highly indebted to my loving parents, to my husband Dimuthu for their encouragement and patience and to my little daughter Riyana for her great sacrifice. You all were the continued moral throughout my works.

Abstract

Title of Dissertation: **Natural Resource Damage Assessment for Oil Spills in Sri Lanka: The Application of Habitat Equivalency Analysis**

Degree: **Master of Science**

The high risk of oil spills increases the potential to cause severe environmental, economic and social impacts to Sri Lanka as a coastal nation. Protection of the marine and coastal environment from oil pollution is therefore of high priority. Thirty-nine oil spills occurred in Sri Lanka between 1999 and 2021, including the X-Press Pearl pollution disaster in 2021. Yet compensations for environmental damages caused by oil spills have never been claimed for any accidents under the national or international legal regime though Sri Lanka is a party to the 1992 CLC and 1992 IOPC Funds. The objectives of the study are to find the constraints in the national legal regime; Marine Pollution Prevention Act Number 35 of 2008 (MPPA) on environmental damage claim, to find challenges in existing Natural Resource Damage Assessment (NRDA) procedure and to suggest solutions and recommendations to overcome these shortcomings while proposing Habitat Equivalency Analysis (HEA) as a scaling method in quantifying the ecological losses during NRDA procedure. The qualitative research approach was applied by employing both primary and secondary data. Primary data was collected via interviews and questionnaire surveys and secondary data was collected from peer-reviewed scholarly articles through desk research. Thematic analysis, supplementary analysis and Chi-square test were used for analyzing data. The study found no internationally permissible environmental damage quantification method and a restoration based environmental damage claim provision in the MPPA. The existing damage assessment process for oil spills is rudimentary and not following any standard protocol.

Moreover, the issues in baseline data sharing, lack of knowledge and skills on NRDA and absence of a NRDA Response Fund are several key issues identified during the study. Accordingly, it is emphasized the importance of reformations to statutory provisions of MPPA to address existing loopholes and limitations. Finally, the study suggests developing an internationally admissible and compensable NRDA procedure for oil spills and with feasibility analysis it is proposed to apply HEA as the scaling technique in NRDA procedure for oil spills in Sri Lanka.

Key words: Natural Resource Damage Assessment, oil spills, Habitat Equivalency Analysis

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List of Abbreviations

CCD	Coast Conservation and Coastal Resource Management
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CLC	International Convention on Civil Liability for Oil Pollution Damage
CWA	Clean Water Act of 1972
DSAY	Discounted-Service-Acre-Year
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
GDP	Gross Domestic Production
HEA	Habitat Equivalency Analysis
IMO	International Maritime Organization
IOPC Fund	International Oil Pollution Compensation Fund
MEPA	Marine Environment Protection Authority
MOA	Memorandum of Agreements
MPPA	Marine Pollution Prevention Act Number 35 of 2008
NARA	National Aquatic Resources Research and Development Agency
NOAA	National Oceanographic and Atmospheric Administration
NOSCOP	National Oil Spill Contingency Plan
NRDA	Natural Resource Damage Assessment
NRDA&R	Natural Resource Damage Assessment and Restoration
OPA	Oil Pollution Act of 1990
REA	Resource Equivalency Analysis
SARC	South Asian Association for Regional Cooperation
SOP	Standard Operating Procedures
WMU	World Maritime University

Chapter 1
INTRODUCTION

1.1 Background of the study

The pollution of coastal and marine habitats due to oil spills is a major environmental concern. It adversely affects on marine wildlife, habitats, fisheries and human activities due to its chemical pollutants (e.g. heavy metals, polyaromatic hydrocarbons) (Ifelebuegu et al., 2017). These adverse effects may last a long time duration in the environment, causing detrimental effects to human health (Bhattacharya et al., 2016). Particular coastal nations with diverse coastal ecosystems and dense human populations pose a high risk of being polluted by oil spills, with large negative environmental and socio-economic consequences (Martínez et al., 2007).

Being a small island nation, Sri Lanka possesses various coastal landforms with diverse ecosystems rich in biodiversity (Balasuriya, 2018; Satyanarayana, 2017; Climate Change Secretariat, 2013). Hence oil spills cause detrimental damages to these sensitive coastal ecosystems and their ecological services. Further, it causes severe consequences to the socio-economical status of the country due to high population density, a significant amount of Gross Domestic Production (GDP) derived from marine fisheries (CBSL, 2020), tourism and other employment opportunities associated with coastal zone (The World Bank, 2017).

In history, eight major accidental oil spills have occurred in Sri Lankan waters between 1994 and 2015 with considerable environmental and socio-economic impacts (Kularatne, 2020). The oil spill incidents of MT New Diamond oil tanker (2020) and the environmental disaster from X-Press Pearl container ship (2021), which caused incalculable damage are two incidents happened recently in Sri Lanka (BBC, 2021). The threat of oil pollution in Sri Lankan waters is high due to several reasons. The geostrategic location of Sri Lanka closed to the Middle East to Far East trade route

(ITOPF, 2005), high probability for accidents due to a high number of ship arrivals to Colombo port (Gunasekara, 2011), oil unloading activities, bunker services (Gunasekara 2011; MEPA, 2009), offshore oil exploration related activities (Piyadasa, 2014) are key factors increasing the risk of oil pollution.

When an oil spill occurs in a particular environment, a Natural Resource Damage Assessment (NRDA) is conducted to assess the appropriate type and amount of restoration required to offset the adverse impacts caused to the natural environment and its ecological services (NOAA, 2021). The service lost is calculated and restoration alternatives will be developed to yield a similar service amount to the public (NOAA, 2021). Habitat Equivalency Analysis (HEA) is a commonly used method for service-to-service scaling which does not involve quantification of the lost ecosystem services in a monetary value (NOAA, 2021; Desvousges et., 2017). The International Maritime Organization (IMO) has adopted a three-tiered regime that provides compensation for oil pollution damages. The 1992 International Convention on Civil Liability for Oil Pollution Damage (CLC), the 1992 International Oil Pollution Compensation Fund (IOPC Fund) and the Supplementary Fund 2003 pertain to liability and compensation for oil pollution damages to the coastal and marine environment and its natural resources (Kim et al., 2017; Steiner, 2004). One of the rationales to conduct a NRDA process for oil spill damage is to assess the loss and damages to the natural environment within its jurisdiction and claim damages under the domestic law and international conventions to which they are a party (Steiner, 2004).

1.2 Problem statement

Sri Lanka has ratified the 1992 CLC and the 1992 IOPC Fund (MPPA, 2008). According to the informal discussions conducted with officers in Marine Environment Protection Authority (MEPA) and legal officers in Sri Lanka, no proper compensation for environmental damages has been claimed under these international legal instruments, mainly due to the absence of permissible NRDA procedure for oil spills and some loopholes in the spill liability regime set forth in Sri Lanka by the national legislation of Marine Pollution Prevention Act Number 35 of 2008 (MPPA). Hence it is a timely need for Sri Lanka to overcome the challenges of natural resource damage assessment for oil spills by studying the existing systems comprehensively. Habitat Equivalency Analysis (HEA) is a method created by National Oceanographic and Atmospheric Administration (NOAA) to measure compensation for habitat damages caused by oil spills and other contaminant-related effects as a service-to-service scaling method (NOAA, 2021). Though it's a relatively new approach, it has been accepted as a basis for settlement in federal court in the US and it leads the US NRDA process (Kim et al., 2017; Ray, 2008). Thus, it should not necessitate an extensive proof-of-method before its application (Ray, 2008). Hence the HEA method will be proposed as a NRDA process for oil spills in Sri Lanka and it is yet to be studied about the challenges, opportunities and recommendations for the application of this method in Sri Lanka.

1.3 Research questions

1. What are the current issues in Natural Resource Damage Assessment (NRDA) processes and constraints in compensation regime for environmental damages caused by oil spills in Sri Lanka?

2. What are the challenges, opportunities for application of Habitat Equivalency Analysis (HEA) in NRDA for oil spills?

3. What are the solutions and recommendations for the application of the HEA as compensation scaling method of environmental damages due to oil spills permissible under the 1992 International Convention on Civil Liability for Oil Pollution Damage (CLC) and 1992 International Oil Pollution Compensation Fund (IOPC Fund) in Sri Lanka.?

1.4 Research objectives

1. To identify existing issues in Natural Resource Damage Assessment (NRDA) processes and constraints in compensation regime for environmental damages caused by oil spills in Sri Lanka.

2. To analyze challenges and opportunities for applying Habitat Equivalency Analysis (HEA) in NRDA for oil spills.

3. To find the solutions and recommendations for the application of the HEA as compensation scaling method of environmental damages due to oil spills permissible under the 1992 International Convention on Civil Liability for Oil Pollution Damage (CLC) and 1992 International Oil Pollution Compensation Fund (IOPC Fund) in Sri Lanka.

1.5 Structure of the dissertation

The dissertation consists of five chapters. Chapter 1 describes the background of the study and research objectives. Chapter 2 reviews the literatures on natural resource damage assessments for oil spills, legal aspects on compensation regime for oil spill damages under the 1992 CLC, 1992 IOPC Fund, 2003 Supplementary Fund and the theory behind the HEA comprehensively. Chapter 3 covers the research methods that were followed in the study. The study was based on qualitative research which consisted interviews, questionnaire surveys together with a desk study. Thematic analysis, descriptive analysis and categorical data analyses were used to examine the data. Chapter 4 presents the results and the exploration of the data. In chapter 5 the results are evaluated and discussed critically under three research objectives with recommendations presented. Finally, the summary and conclusions of the study are included in Chapter 6.

1.6 Ethical issues, key assumptions and potential limitations

The research was conducted adhering to the principles of research ethics. This mainly included privacy protection of research participants, ensuring the confidentiality of research data, honesty and transparency of interviews. Biased representation of data or any misleading data representations were avoided according to the World Maritime University (WMU) research ethic guidelines.

It was assumed that the academia and policy makers would provide their consent to provide required information within the limited time frame. Collection of data via online questionnaire surveys and interviews conducted via zoom meetings would not be as effective entirely as much as a collection of data in person. Limited time frame was another constraint for the study. Delays were caused to contact some participants due to the COVID 19 pandemic situation. Nevertheless, the study was conducted successfully to meet the research standards of WMU.

Chapter 02
LITERATURE REVIEW

2.1 Oil spills

Marine oil spills are often referred to as any releases of petroleum hydrocarbons into the coastal or marine areas due to human activities such as consumption, transport or extraction of hydrocarbons. Oil spills result from accidental leakages or blowouts from offshore oil platforms, drilling rigs and wells, spills occur at refineries, pipelines, land transport and accidents of marine vessels (Chilvers et al., 2021; Lee et al., 2015). The study conducted by Chilvers et al. (2021) considering 1702 oil spills reported globally from 1970 to 2018, revealed that the significant type of reported oil spills were heavy or crude and light fuels that have been released from different sources. Figure 2.1 illustrates the percentages of pollution sources of these oil spills where general shipping (47%) and oil tankers and oil tanker barges (23%) were the main two oil pollution sources among them (Chilvers et al., 2021).

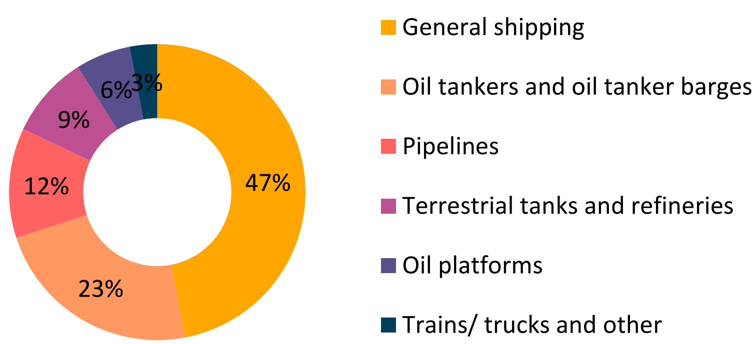

Figure 2.1 The percentages of pollution sources of a total of 1702 oil spills reported globally from 1970 to 2018 (Chilvers et al., 2021)

Exxon Valdez oil spill (1989) and Deepwater Horizon oil spill (2010) are major oil spills that caused catastrophic environmental effects and devastated economic harm in history

(Zhang et al., 2019; Fingas, 2011). Predominantly the economic impacts are associated in two ways, the immediate cost for responding and remediating to the oil spill and the prolonged cost to the reliant society by affected ecosystem resources and services (Lee et al., 2015). It will cause extensive economic losses and social ramifications when oil spills happen close to or are transported to tourism/ recreational sites, aquaculture sites, commercial fishery areas and commercial activities which rely on seawater for operations (ITOPF, 2021; Zhang et al., 2019).

2.1.2 Environmental effects of oil spills

The effects of petroleum spills can cause a wider range of impacts (ITOPF, 2021) with the highest publicized and damaging disasters to environment (NRC, 2003). The intensity of the damage depends on multiple factors including the physical properties and quantity of oil spilled, existing weather conditions during the oil spill incident, ecological significance and biological attributes of the damaged area, as well as how the oil interacts with the environment (ITOPF, 2021). When the spill occurred, the physicochemical properties of oil undergo dissolution, weathering, oxidation and volatilization ensuing diverse environmental impacts. Calm sea conditions incorporate oil slicks spreading over water surface and shorelines while waves allow oil to mix into the water column (French-McCay et al., 2021; NRC, 2003).

Oil causes chemical toxicity to marine organisms via sub-lethal or acute toxic effects (ITOPF, 2021; NRC, 2003). Thicker oil slicks do great damages to the environment. Inhalation of toxic chemicals, ingestion cause harm to respiratory, digestive and circulatory systems of marine species. It causes great risks to fish, eggs and juveniles through bioavailability (Walker, 2019). Marine mammals are threatened severely by oil slicks through oil-fouled skin (NRC, 2003). Seabirds are severely impacted by fouling feathers, poor reproductive success (Walker, 2019; NRC, 2003; Höfer, 1998) and it is estimated that up to ten times of birds may die as many as discovered or reported oil-fouled dead counts (Höfer, 1998). Due to the protective blubber, pinnipeds and cetaceans are suffering minimally long-term compared to sea otters (Höfer, 1998).

Toxic chemicals accumulated in sediments may cause substantial adverse effects rather oil slicks spread on the water surface (NRC, 2003). In this context, ecological imbalances can be caused by temporary domination of opportunistic species such as nematodes, polychaetes due to the alterations of environmental conditions by the pollution incident. Consequently, all these facts may result in total collapse of benthic communities making them as most vulnerable group (ITOPF, 2021; Höfer, 1998). Especially the intertidal coral reefs are mostly harmed by exposure to water surface oil slicks and dissolved chemical particles in the water column (Walker, 2019; NRC, 2003). Further, the habitat losses through oiling and clean-up mechanisms are another indirect effects of oil spill disasters (ITOPF, 2021).

Chilvers et al. (2021) stated that the adverse impacts on wildlife are not proportional to the size of the oil spill as significant numbers of organisms were harmed by just about any size of the oil spill where there are inadequate measures for environmental damage. Ultimately the damages to natural environment alter the products of nature, which yield human wellbeing by affecting human health (Desvousges et al., 2018; Ifelebuegu et al., 2017).

2.1.3 Oil spill risk and vulnerability of Sri Lanka

The growing oil exploration, production activities and vessel traffic against the preparedness for oil spills in Southeast Asia indicate that there is a significantly increased risk of marine oil spills. The region's capability for oil pollution preparedness is at an immature level compared to the other global regions (Varghese, 2014). A study conducted by Gunasekara (2011) reveals that the probability and risk of oil spill occurrences in South Asian countries are at a medium level while the consequences from oil spills are at a high level.

Being an island in the Indian Ocean, Sri Lanka is a highly vulnerable country to oil pollution incidents due to several key factors (Kularatne, 2020; BOBLME, 2013; Gunasekara, 2011). Apart from the unique geostrategic position in world's busiest shipping route, there is an increased risk of ship accidents leading to subsequent oil spills due to the combined effects of Indian Ocean monsoonal seasons and tropical cyclones creating extreme weather conditions (Kularatne, 2020; Gunasekara, 2011). The high number of ship callings and congessions in Colombo port (Gunasekara, 2011), which is a rapidly growing maritime hub in South Asia (SLPA, 2020), bunker services, oil import and its unloading activities (Gunasekara 2011; MEPA, 2009) are key shipping related factors increasing the risk of oil pollution in Sri Lanka. Further, the offshore oil exploration-related activities in Mannar and Cauvery basins will also intensify the risk of oil pollution in the country (Piyadasa, 2014).

As a tropical island, Sri Lanka is endowed with high biodiversity and resources-rich coastal area (Balasuriya, 2018; Satyanarayana, 2017; Climate Change Secretariat, 2013). The land area of the coastal zone represents 24 percent of the total area of Sri Lanka and comprises 33 percent of the population in the country. The coastal zone provides 40 percent of Gross Domestic Production (GDP) mainly via fisheries and tourism (The World Bank, 2017). Fisheries play an important role in food security, generating GDP (4.5 percent of country's total export revenue) and livelihood opportunities (CBSL, 2020). Approximately 90 percent of total domestic fish catch comprises marine pelagic fisheries within the Exclusive Economic Zone (EEZ) (CBSL, 2020; The World Bank, 2017). Tourism plays a major role in domestic economy and coastal tourism represents 60 percent of total tourism revenue and over 62 percent of tourist hotels are in the coastal zone (The World Bank, 2017).

According to the rich biodiversity, vast ranges of sensitive habitat niches, dense human population, and high-income generation in coastal areas of Sri Lanka, oil spill incidents cause devastating effects on the country's environmental, social, and economic status. These facts indicate that Sri Lanka is highly vulnerable to oil spills.

2.2 Compensation of oil pollution damage

Liability and compensation for damages caused by oil pollution from ships on the marine environment are administered by the 1992 International Convention on Civil Liability for Oil Pollution Damage (CLC) and the 1992 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund) (Kim et al., 2017; Jacobsson, 1994).

"The Marine Environment Protection Authority (MEPA) which is the apex body for enforcing laws and regulations under the Marine Pollution Prevention Act Number 35 of 2008 (MPPA), is responsible for prevention, controlling and managing pollution in Sri Lanka's marine environment" (MEPA, 2021). Sri Lanka has ratified the 1992 Protocol of CLC and IOPC Fund of 1992 and these conventions came into force on 22 January 2000 (IOPC Funds, 2021).

2.2.1 Civil Liability Convention of 1992

After the Torrey Canyon disaster in 1967, IMO had introduced Civil Liability Convention (CLC) covering liability and compensation for pollution damage caused by ships. The convention was adopted on 29 November 1969 and it entered into force on 19 June 1975 (IMO, 2019).

The scope of the application of CLC covers the measures taken to prevent or minimize oil pollution damages resulted from ships or laden tankers in a territory of a contracting state. However, pollution caused by non-persistent oil types such as kerosene and gasoline does not fall within the convention's scope. Further, the CLC covers neither oil spills from a tanker in a ballast voyage nor the bunker oil spills from ships other than tankers (Jacobsson, 1994). To be covered by the CLC the ships carrying more than 2,000 tons of oil are needed to maintain insurance or any other financial security arrangement. Accordingly, it covers damages caused or measures taken for incidents in which oil has been discharged or escaped when carrying oil in bulk as cargo by any seagoing vessel (IMO, 2019). If any oil spill resulted as a consequence of an incident, the ship owner has strict liability for the pollution damage and adequate compensation has to be paid to the victim (IMO, 2019). This strict liability is exempted only if the damage is caused by a war activity, sabotage by a third party, a natural disaster, and any failure of maintaining navigational aids (Bernard, 1997; Jacobsson, 1994).

In 1992, the convention was amended to set higher compensation limits and widen the scope covering pollution incidents that happened in the Exclusive Economic Zone (EEZ) or any equivalent area of a particular state party. The 1992 Protocol of CLC covers pollution damages as previously, but the compensation for environmental damage is limited to cover the expenses of reasonable measures taken for restoring the contaminated environment and the cost incurred for all preventive measures even no oil spill occurs as there would be a risk or threat for oil spill damage (IMO, 2019). Compensation for oil pollution damages such as offshore operations is not entitled to the scope of the 1992 CLC as it only covers the oil pollution incidents caused by ships. In these contexts, the compensation for pollution damages is governed by relevant domestic laws (Jacobsson, 1994).

2.2.2 International Oil Pollution Compensation Fund (IOPC Fund) of 1992

The International Fund for Compensation for Oil Pollution Damage (Fund Convention) has been elaborated as a supplementary convention to the 1969 Civil Liability Convention (CLC). It was adopted on 18 December 1971 and entry into force on 16 October 1978 (IMO, 2019). The member states of CLC can become parties to the Fund Convention. “The purpose of the Fund Convention is to pay supplementary compensation to a victim who is unable to obtain full and adequate compensation under the CLC for oil pollution damage due to the non-liability of ship owner to the CLC under any exemptions of the convention” (Jacobsson, 1994). Further, the Fund Convention has no obligation to pay compensation when the damage is caused by a spill of a warship or is an act of war. In addition, it is relieved from the obligation whenever the claimant fails to prove that the pollution damage was caused by one or more laden tankers (Jacobsson, 1994). Unlike the CLC, the Fund Convention gives relief to the ship owners from additional financial burden as it is built up from the contributions from oil importers. Hence, if certain pollution damage exceeds the available compensation limit under the CLC, the Fund will pay an additional amount while spreading the burden evenly between cargo interest and ship owner (IMO, 2019).

The Fund Convention was superseded by the 1992 Protocol adopted on 27 November 1992 known as the International Oil Pollution Compensation Fund (IOPC Fund) and was entered into force on 30 May 1996 (IMO, 2019). This IMO protocol of 1992 to amend the Fund Convention widens the scope of its application and sets higher limits for compensations (Schmitt & Spaeter, 2009; Jacobsson, 1994). According to the new resolution, the "assessment of compensation for environmental damages can be granted only if a claimant who has a legal right to claim under prevalent domestic law, has suffered quantifiable economic loss" (Jacobsson, 1994).

Jacobsson (1994) stated that the definition for "pollution damage" was not clear under both 1992 CLC and 1992 IOPC Fund. But with experiences in the past the conventions have worked well in the admissibility of compensation claims.

2.2.3 The IMO protocol of 2003; International Oil Pollution Compensation Supplementary Fund (Supplementary Fund)

The Supplementary Fund was adopted on 16 May 2003 and was entered into force on 3 March 2005. The aim is to supplement the compensation under two conventions; 1992 CLC and 1992 IOPC Fund with additional third-tier compensation. The Supplementary Fund is open to all contracting members of 1992 IOPC Fund and it is optional. Oil pollution damage caused in the territory of a state party will be covered under the scope of the Supplementary Fund (IMO, 2019). Accordingly, there should be a legally driven process that engages science to quantify the extent of the oil pollution damage to obtain the compensation claim (Peterson, 2012).

2.3 Natural Resource Damage Assessment

Natural Resource Damage Assessment (NRDA) emerged as a process under federal statutes of the United States (US) when determining the economic and ecological damages from Exxon Valdez oil spill. It was defined by the Clean Water Act (CWA) of 1972, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Oil Pollution Act (OPA) of 1990. Through the NRDA the trustee representing the public comprising state government and federal agencies and Indian tribes have recovered damages from the responsible parties (Desvousges et al., 2018; Hanson et al., 2013; Peterson, 2012; Strange, 2002). With time, the NRDA process was changed from monetary compensation to the restoration projects compensating the natural resource service losses from a particular damage incident (Desvousges et al., 2018).

The concept of habitat restoration evolved with replacing damaged physical area to replace its lost ecological services while the fragile area returns to a condition similar to before the damage occurred (NOAA, 2021[a]; NOAA, 2021[b]). To restore affected habitats, it is necessary to know about the area prior to the damage occurred. Studying the habitat types and better understanding of the relationships among systems before and after the damage occurred assists to define the best possible restoration options (NOAA, 2021[a]). The process of NRDA determines the magnitude of harm to natural resources, appropriate amount and type of restoration required to offset impacts on wildlife, ecosystems, fisheries, human uses, etc. and the best means to restore them (NOAA, 2021[b]).

The NRDA process has three distinct steps namely; preliminary assessment, damage assessment and restoration planning and restoration (NOAA, 2021[b]; Kennedy & Cheong, 2013). The preliminary assessment determines whether any impact has occurred by reviewing scientific literature, collecting data, using mathematical models and predicting the effects of pollution incidents. During damage assessment and restoration planning the trustee quantifies the damage using scientific and economic studies. The process of defining the appropriate size of restoration projects is called "restoration scaling" which involves a framework of quantifying and evaluating the losses and the benefits of alternative restoration plans (e.g. Habitat Equivalency Analysis (HEA) under service-to-service approaches, contingent valuation under the valuation approaches) (Roach & Wade, 2005; Penn, 2002; NOAA, 1997). Then possible restoration projects such as creation of oyster reefs/ other shellfish habitats, beach enhancements and species recovery monitoring programmes are identified and public feedback is obtained. In the restoration stage, the injured area is returned to its original state and compensates the general public for their lost use including the time taken to recover the resources fully (NOAA, 2021[b]).

A Restoration Plan is designed to meet two statutory goals; restoring damaged natural resources to its original state or baseline levels (Primary restoration) and compensating the public for the interim losses caused from the time of natural resources are damaged up until they return to the baseline levels (Compensatory restoration) (Kennedy & Cheong, 2013; Strange, 2002; NOAA, 1997). Baseline is the condition of the natural resources and ecosystem services which would have existed if the pollution incident has not occurred considering both natural processes and those which are resulted from human actions (Hanson et al., 2013; Kennedy & Cheong, 2013). It is a fundamental component of NRDA and is important for estimating ecological and economic damage that occurred, determining suitable restoration projects and their endpoints, establishing liability and any exogenous trends (Kennedy & Cheong, 2013). Baseline data should consist of the normal range of biological, physical and chemical status of the damaged resource or assessment area for the purpose of analysis with statistical descriptions (Hanson et al., 2013).

Natural resource trustee seeks the restoration to compensate the general public for losses of natural resources and services caused by oil spill damage (Strange, 2002; NOAA, 1997). The responsible party of the damage pays for recoverable damages including the cost of damage assessments, restorations and rehabilitations, replacements and the diminution in value of natural resources pending restoration (Kennedy & Cheong, 2013; NOAA, 1995).

2.4 Habitat Equivalency Analysis (HEA)

In Natural Resource Damage Assessment (NRDA), habitat restoration has evolved from replacing the damaged physical area to serve same amount of lost ecological services (NOAA 1997; Ray, 2008). The amount of restoration required can be determined by the service-to-service scaling process. Accordingly, the National Oceanographic and Atmospheric Administration (NOAA) in the US has developed the method of "Equivalency Analysis" particularly Resource Equivalency Analysis (REA) and Habitat Equivalency Analysis (HEA) to scale compensation for injured habitats from contaminant-related effects including oil spills (Desvousges et al., 2018; Ray, 2008; NOAA 1997). Restoration alternatives to provide same amount of services are developed after calculating the service lost from the effects. Appendix A outlines the standard formula for calculating the appropriate scale of a compensation project.

The scientific data on analyses of habitats (Bas et al., 2016; NOAA; 1995), area inhabited by faunal species, location and quantity of both oiled and unoiled areas, etc. along with expertise judgment considering previous experience are applied in estimating the interim loss of habitat (Penn, 2002). The HEA estimates the total loss by complete in-kind replacement of lost services between the times of damage until the restored habitat reaches the baseline condition or fully functional (Ray, 2008). Economic damage estimate faces difficulties due to data scarcity on ex-ante economic costs of natural resource damages, challenges when estimating off-site human uses and nonuse values (Roach & Wade, 2005). Hence over the last few years, the HEA was being used increasingly as it is a viable alternative over economic damage estimate (Bas et al., 2016; Roach & Wade, 2005; NOAA, 2000).

The HEA assumes that the equivalent habitats will provide equivalent services and years of lost ecosystem services would be compensated by restoring acres of extra habitats (NOAA, 2021[a]). Further, it is assumed that the public derives approximately equal utility values on a unit service provided by the injured site and its compensatory restored site (Roach & Wade, 2005; NOAA, 1995). It calculates the ecosystem service lost in discounted terms (Barbier, 2013). The measurement unit to quantify services is discounted-service-acre-year (DSAY) which denotes the value of total ecosystem services delivered by one acre of a particular habitat in one year. In this approach services for future are discounted by assigning lower value on services which will require extended period to accrue (NOAA, 2021[a]). Discounting assumes that resource users value services greater today than in future. The standard discount rate is assumed to be three percent thus, "for every year it requires replacing a specific amount of service or if restoration would be delayed, an amount of certain habitat capable of producing an additional three percent of the remaining lost service should also be restored." (NOAA, 2021[a]; Ray, 2008).

An important factor in HEA negotiation process is determining which specific service would be most effective for replacing and the degree to which the damaged site delivered this service prior to the damage. Further, the ecosystem service supplied by a particular parcel of habitat before the damage and the extent to which that has been damaged may be difficult to determine when it has limited evidences on original status of that habitat. These factors should be negotiated among the interested parties in HEA approach (Strange et al., 2002).

Choosing a correct indicator or metric (e.g. coral cover) is the other critical feature in the HEA to monitor whether the restoration efforts are up to the expectations (Viehman, 2009; Ray, 2008). Ray (2008) stated that selecting a metric that can represent several ecosystem services has obvious benefits. For example, shoot density of a dominant species in a wetland can represent primary production, utilization by faunal species in the area, probability of sedimentation, etc. (Ray, 2008). The conditions for choosing a common metric depend on several factors. It must represent any significant differences in the qualities and the quantities of ecosystem services provided by both the damaged and restored habitats (Ray, 2008; NOAA, 1995). The HEA can be used even though the lost and restored resources and services cannot be compared but if it has a common metric which is accounting for ecosystem service value differences of injured and replaced sites (Penn, 2002). The total amount of damage claim obtained from the responsible party of the damage is utilized to settle the costs spent for the assessments, for replacing, restoring, rehabilitating or acquiring its equivalent habitat of the damaged resources (primary restoration) and for initiating compensatory restorative activities. On some occasions, the responsible party may implement these projects by themselves based on the performance criteria defined by the trustee (NOAA, 2021[a]).

At present HEA is widely used for quantifying ecosystem services and for scaling complex, large NRDA restoration projects (Desvousges et al., 2018; Kim et al., 2017; Shaw & Wlodarz, 2013). Though it's a relatively new approach, HEA was accepted in federal court (Ray, 2008) as well as it has proven results in the negotiation of settling environmental damage claim liabilities in major oil spill occurrences including the case of Texaco oil pipeline rupture incident in 1997 (Desvousges et al., 2018; Barbier, 2013). It has been used in several countries for determining the values of compensatory mitigation for oil spill damages (Shaw & Wlodarz, 2013). Hence it is not required an extensive proof-of-method for its application (Ray, 2008).

Chapter 03
METHODOLOGY

3.1 Study area

Sri Lanka is a small island nation with 65,610 km^2 of total land area. The total population is approximately 21 million with the highest density (3438 persons per km^2) at Colombo and lowest density (38 persons per km^2) at Mullaitivu (Satyanarayana, 2017). The average temperature is 27°C with 70%- 90% of humidity level. Rainfall shows substantial monsoonal variations and it is high during Southwest monsoon (June-July) and Northeast monsoon (October-December) (Nisansala et al., 2020). Extreme weather events, including extreme rains and cyclones attributed to climate change, have become more frequent over the last decades (Satyanarayana, 2017).

3.1.1 Sensitive coastal environment of Sri Lanka

The island has a coastline of 1620 km in which there are various coastal landforms comprising lagoons, estuaries, beaches, rockyshores, sandunes with diverse ecosystems rich in biodiversity (Satyanarayana, 2017). The Exclusive Economic Zone of the country is about 517000 km^2 (Gunasekara, 2011). There are 45 estuaries and 40 lagoons with a total extent of about 1580.17 km^2 of area (Kularatne, 2020). Saltmarshes coverage extends about 238 km^2 of area providing habitats for wild species, including migratory birds and several fish species (Climate Change Secretariat, 2013). Sri Lanka possesses 183 hard coral species from 68 genera (Rajasuriya & De Silva, 1988) and the most common types of coral reefs are fringing and patch reefs (Rajasuriya & White, 1995). About 25 true mangrove species extend in approximately 88.15 km2 of area, which provide habitats, breeding, and nursery grounds for a large number of species (Climate Change Secretariat, 2013). Hence, these high biodiversities and vast ranges of sensitive habitat niches in coastal areas of Sri Lanka have low ecological resilience for oil spill damages (Gunasekara, 2011). Since five out of eight commercial ports of the country are situated in the vicinity of numerous marine protected areas (BOBLME, 2013; Perera & de Vos, 2007), they pose a great risk of detrimental effects in case of oil pollution incidents.

3.2 Research design and rationale

The qualitative research approach is applied in the whole study by employing both primary and secondary data. The purpose of conducting qualitative research is to find a detailed explanation about implementation of an event and to recognize the nuances of subjective understanding which was motivated by different members in a particular setting (Erickson, 2012).

This qualitative study involves multi-sectoral stakeholders who engage in the Natural Resource Damage Assessment (NRDA) process for oil spills in Sri Lanka. They were involved mainly under two sectors; academia and policy makers. Academia comprised of scientists and university lecturers while policy makers comprised of marine managers and legal officers. Secondary data from peer-reviewed literature was used to support primary data collected via interviews and questionnaires as well as to propose possible solutions for identified challenges in NRDA procedure of Sri Lanka.

3.3 Secondary data collection

Comprehensive desk research was conducted to review existing scientific, socio-environmental and legal aspects focusing on the research objectives. Secondary data is data that was collected for another primary purpose by somebody else other than its user. The utilization of existing data is a viable option for gathering a large extent of data with limited resources and time frames (Johnston, 2017). Different legislative documents, official government websites, peer-reviewed scholarly articles, several manuals and guidelines related to conducting NRDA process for oil spills and application of Habitat Equivalency Analysis (HEA) were reviewed as secondary data sources. Table 3.1 shows the different types of documents referred for the study and how to access them.

Table 3.1 Sources of secondary documents referred for the study

Type of document	Secondary data source	Web link
Peer-reviewed scholarly articles	Scopus database	https://www.scopus.com/search/form.uri?display=basic&zone=header&origin=#basic
	Google scholar	https://scholar.google.com
The Marine Pollution Prevention Act Number 35 of 2008	Marine Environment Protection Authority website	https://mepa.gov.lk/wp-content/uploads/2021/07/35of2008-MEPA-Act-E.pdf
Natural Resource Damage Assessment guidance manuals	National Oceanic and Atmospheric Administration website	http://www.losco.state.la.us/pdf_docs/NOAA_NRDA_Guidance_Scaling_1997.pdf
	Oil Spill Academic Task Force (OSATF) website	https://oilspill.fsu.edu/docs/Un-Natural_Resource_Damage_Assessment_and_Restoration.pdf
Habitat Equivalency Analysis (HEA) overview	National Oceanic and Atmospheric Administration website	https://casedocuments.darrp.noaa.gov/northwest/cbay/pdf/cbhy-a.pdf
The International Convention on Civil Liability for Oil Pollution Damage (CLC)	International Maritime Organization (IMO) website	https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Civil-Liability-for-Oil-Pollution-Damage-(CLC).aspx
The International Oil Pollution Compensation	International Maritime Organization (IMO)	https://www.imo.org/en/About/Conventions/Pages/International-Convention-

Funds (IOPC Funds)	website	on-the-Establishment-of-an-International-Fund-for-Compensation-for-Oil-Pollution-Damage-(FUND).aspx

As search strings (natural AND resource AND damage AND assessment AND for AND oil AND spills), (environmental AND damage AND compensation AND for AND oil AND pollution) and (habitat AND equivalency AND analysis AND for AND oil AND spills) were used for searching literature. Additionally snowballing search approach was performed. Accordingly, a total of 469 scholarly articles were found related to NRDA for oil spills (313), environmental damage compensation for oil pollution (132) and HEA for spills (24). Then considering the publishing year, the average citation number, importance to the research questions and the accessibility, 54 articles were shortlisted. Figure 3.1 illustrates the process of selecting scholarly articles during the desk research.

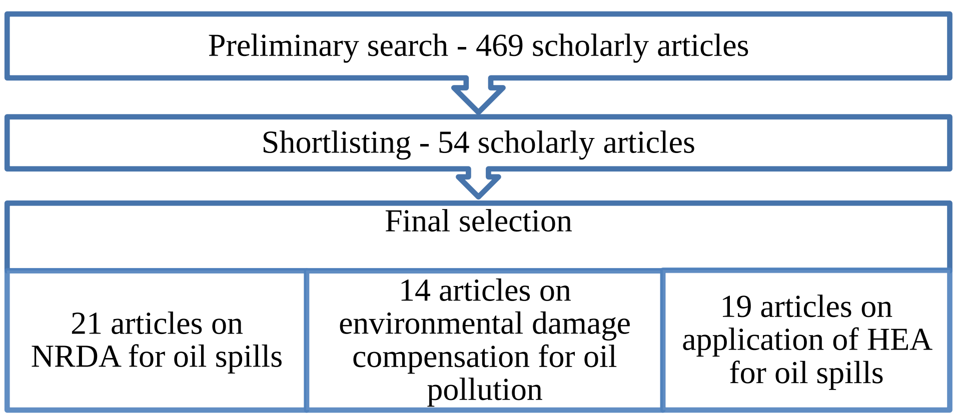

Figure 3.1 Process of selecting scholarly articles for the study

3.4 Primary data collection

Primary data is collected by the researcher (Johnston, 2017). Interviews and questionnaires are effective tools for gathering qualitative and quantitative data from a large population relatively easily and in an affordable way. The application of questionnaire surveys in scientific research provides added value to the particular study (Young et al., 2018). To collect data more efficiently, both interviews and questionnaires were adopted in the study. Figure 3.2 illustrates the process of collecting primary data. The presented questions were similar in both interviews and questionnaire surveys. To examine the background of research area, the initial literature review was conducted before developing the questionnaire as it is a crucial step in the designing process (Perrone, 2020; Ikart, 2019). A pre-test checks the reliability and validity of the questionnaire (Ikart, 2019; Roopa & Rani, 2012). Hence pretest was carried out with two volunteer participants to ascertain the questionnaire's effectiveness by fixing weaknesses.

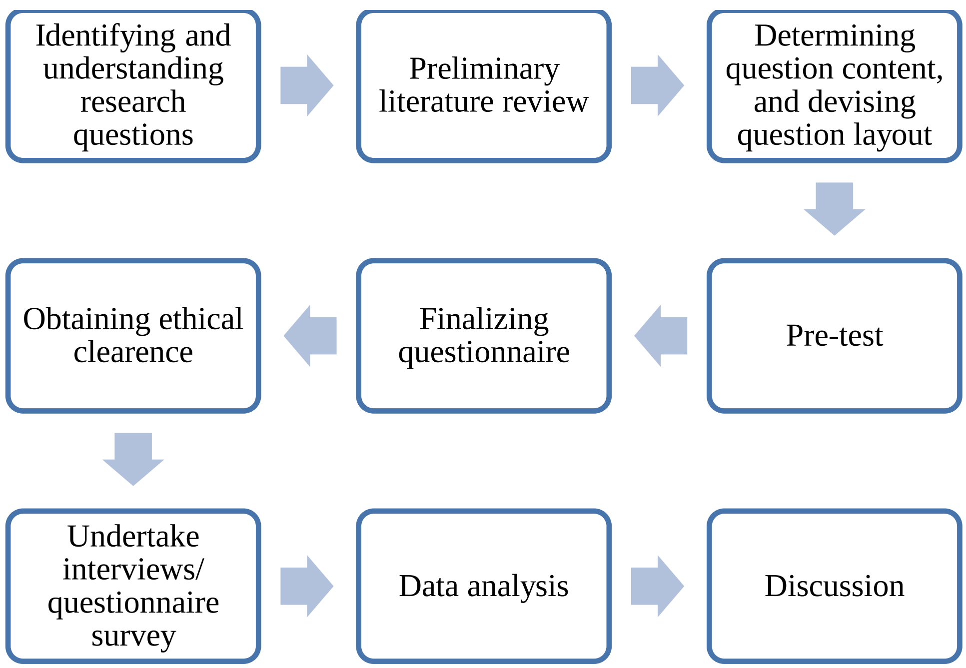

Figure 3.2 Basic stages followed in the interview/ questionnaire survey process. Adapted from Young et al., 2018; Roopa & Rani, 2012.

Two different questionnaires were designed for stakeholders under two sectors (academia and policy makers). Interviewees were reached via emails attaching the questionnaire with the participation information sheet (Appendix B) and the consent form (Appendix C). The participation information sheet included all relevant information but not limited to the purpose of study, interview procedure and request, confidentiality and contact details of the researcher and the research supervisor. Participation in the survey was entirely voluntary. If the interviewee was willing to participate in the survey, he/ she could choose one of the two options; either via a questionnaire survey or facing an interview according to his convenience. Table 3.2 shows the number of respondents from two sectors who participated in the study under two survey methods and altogether, there were 17 respondents.

Table 3.2 Number of respondents participated to the survey under two survey methods from each sector

Survey method	**Number of respondents in each sector**	
	Academia	**Policy makers**
Interviews	5	5
Questionnaires	4	3

3.4.1 Sampling

Sampling of group of people who would participate in the survey is the other important concern in the survey process. The research focus was to engage professionals responsible for conducting the Natural Resource Damage Assessment (NRDA) process for oil spills in Sri Lanka. A combination of two techniques of non-probability sampling methods; convenient sampling and snowball sampling were adopted for identifying potentially eligible interviewees as there were few professionals in the focused background. Convenient sampling allows getting responses or completing interviews in a cost-effective way and snowball sampling allows contacting a small group of participants and coordinates them to contact other eligible professionals (Rahi, 2017). Accordingly, 18 numbers of academia and 12 policy makers were identified. Altogether 17 participants (Table 3.2) responded and they were incorporated into the survey.

3.4.2 Interview process

Since face to face interviews are the best method for obtaining complex, sensitive and high-quality data though it is very labor-intensive (Mathers et al., 1998), semi-structured interviews were conducted through video conference meetings via Zoom in July and August 2021. The meetings were scheduled based on the participant's requests. The average targeted time of interviews was 20-30 minutes. Nevertheless, most of the interviews took approximately 40 minutes. The interviews were recorded via handwritten notes and the recording facility of the Zoom platform. The semi-structured one-to-one interview method allows exploring individual perceptions in-depth about a certain topic (Morcos & Dalton, 2021). However, when uncertainty or interesting point developed during the discussion, additional questions were asked for clarification and further understanding.

3.4.3 Questionnaire survey

"A questionnaire is a list of mimeographed or printed questions that is completed for or by a respondent to deliver his/ her view or opinion (Roopa & Rani, 2012). A semi-structured questionnaire survey was conducted for those who preferred to participate in a questionnaire survey rather than in an interview. Proper questions can yield high-quality answers from the questionnaire survey (Ikart, 2019). Two different questionnaires designed for academia and policy makers were included at the last of this chapter. Each questionnaire consisted of ten major questions, including contingency questions, open-ended questions, closed-ended questions and matrix questions. The selection of specific question types was depended on survey objectives and the intended answers. The average time taken for completing three multiple-choice questions is one minute and an open-ended response question would take time of about three multiple-choice questions (Ikart, 2019). The average time taken for completing the questionnaire was 20-25 minutes. Google form was used to devise the questionnaire and the link to questionnaire was distributed via email.

3.5 Data analysing

Thematic analysis analyses classifications and presents themes or patterns which related to the data (Boyatzis 1998). Thematic analysis was executed considering the deductive approach (Alhojailan, 2012) as the study aims to find more precise content for NRDA and HEA process of Sri Lanka through broader generalized theories and global practices in specific concerns. Three themes were identified according to the research questions covering constraints in damage compensation regime for oil spills in Sri Lanka, issues in NRDA process, challenges and solutions for the application of the HEA in Sri Lanka. Coding was done manually while reading transcripts to classify them into themes based on similarities (Miles & Huberman 1994). Moreover, descriptive statistics that provide summary of samples collected during the study were employed to better illustrate analysed data (Sharma, 2019).

A successful analysis of secondary data involves a systematic technique with procedural and evaluative steps (Johnston, 2017). Supplementary analysis which is a technique of secondary data analysis was utilized for the study. It investigated issues related to the NRDA process and its legal regime that were not addressed or partially addressed during the primary study and verified the results of primary data analysis (Heaton, 2008). Accordingly, the analysis results of both primary and secondary surveys were combined and discussed parallel to get firm conclusions.

Statistical analysis

The attitudes of respondents of each sector (academia, policy makers) towards existing facilities for conducting NRDA in Sri Lanka were assessed by a likert scale question included in question number ten of the questionnaire. The participants responded to each facility by rating them (e.g. very dissatisfied, least satisfied, very satisfied) and the studied facilities included technical capacity, expertise knowledge, funding capacity, adequacy of human resources, awareness building, effectiveness of national legal regime for damage claim and effectiveness of international legal instruments for damage claim.

To analyze group differences, the distributions of categorical data in two-way tables (with the variables of rating levels and sectors) were compared by performing the Chi-square test (McHugh, 2013) manually. Null hypothesis (H_0) was erected as there was no difference of responses between academia and policy makers on existing facilities for conducting NRDA in Sri Lanka, while alternative hypothesis (H_1) was erected as there was a significant difference of responses between academia and policy makers on existing facilities for conducting NRDA in Sri Lanka

3.6 Data storage

All data related to the study, including audio/ video recordings taken during Zoom interviews, was stored securely in the computer and kept until the completion of this study. After completion of each interview, it was transcribed to a word document referring to the recordings and notes taken during the interview. These word documents along with signed consent forms were also saved on the computer and the data gathered through the questionnaires was stored in a virtual google drive.

3.7 Ethical consideration

The survey to collect primary data was conducted after receiving ethics approval from the WMU Research Ethics Committee. The participant was signed to the consent when only he/she read and understood the participation information and contents in the consent form. The data protection practice in line with WMU guidelines was expressed at the beginning of the interview. It was ensured that the data collected through the survey is only accessed by the researcher and is protected from unauthorized use without consent from the participant. Every possible effort was made to keep participant’s anonymity in private and confidential. Thus, the naming system of R1, R2, R3 and so on was used to denote the respondents. However, the participants were informed that due to the small number of respondents and the specialized nature of a particular respondent, it still might be possible to identify him/ her by the nature of his/ her comments.

3.8 Questionnaires

3.8.1 Questionnaire for the Academia

01. The Natural Resource Damage Assessment (NRDA) process for oil spill damages in Sri Lanka measures; (Please select one or more options)

    a. ☐Acute effects and mortality

    b. ☐Chronic effects

    c. ☐Long-term effects

    d. ☐Ecosystem-wide / cumulative effects

    e. ☐Other (Please specify)…………………………………………………………

02. Does Sri Lanka have the baseline environmental studies in the ecosystem at-risk?

    ☐Yes ☐No

    If Yes, Does it cover; (Please select one or more options)

    a. ☐The full spectrum of ecosystem components such as primary producers, zooplankton, benthic invertebrates, forage fishes, larger fishes, birds, mammals, etc.

    b. ☐Information on background of hydrocarbon and other contaminant levels in water and sediment, as well as background contaminant levels in biological tissues etc.

    c. ☐General ecological characterization of the region including distribution and abundance, reproductive success, feeding habits, migratory behavior, growth rates and body condition etc.

    If No, If it is impractical to conduct baseline studies in every environment-at-risk, Are there baseline environmental studies at least those judged to be at greatest risk?

Other (Please specify)…...……………………………………………………….

03. Are there Pre-spill natural resource damage assessment and restoration (NRDA&R) training programmes?

☐Yes ☐No

Remarks………………………………….……………………………………

04. In a Restoration Plan for oil spill damage, what are the activities taken as **Primary restoration** to restore the damaged natural resources to baseline level? (Please select one or more options)

a. ☐Natural recovery
b. ☐Control of residual sources of contamination
c. ☐Replacement of sand or vegetation, or modifying hydrologic conditions
d. ☐Replacing essential species, habitats, or services that would facilitate the restoration of other, dependent natural resource and service components
e. ☐Other (Please specify) …………………………………………………....

05. What are the activities taken for **Compensatory restoration** (compensating the public for the interim losses from the time of natural resources are injured until they return to baseline)?

06. What are the challenges during “Restoration Planning Phase” which evaluates potential injuries to natural resources and services and use that information to determine the scale of restoration actions?

07. What is/are the most used scale of restoration alternative/s in Sri Lanka?

a. ☐Resource-to-resource approach (e.g. Resource Equivalency Analysis)
b. ☐Service-to-service approach (e.g. Habitat Equivalency Analysis)
c. ☐Valuation approaches (Travel Cost Method)
d. Remarks

08. Habitat Equivalency Analysis (HEA) is a service-to-service scaling method in NRDA process. Is the HEA used as a NRDA scaling process for oil spill damage assessments in Sri Lanka?

☐Yes ☐No

If Yes, What are the advantages of using this method?

09. What are the challenges and difficulties faced during the process of applying HEA scaling method;

When choosing a common metric (or indicator)?
When selecting annual discount rate? (e.g. 3% annual discount rate)
Other…………………………………………………………………………...

10. Challenges for Natural Resource Damage Assessment in Sri Lanka. (Please rank accordingly)

Component	Ranking				
Technical capacity	☐ Very dissatisfied	☐ Dissatisfied	☐ Least satisfied	☐ Satisfied	☐ Very satisfied
Expertise knowledge	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Funding capacity	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Adequacy of human resources	☐ Below optimum level		☐ Optimum level		☐ Above optimum level
Awareness building/ Trainings/ Workshops	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Effectiveness of national legal regime for damage claim	☐ Very ineffective	☐ Ineffective	☐ Least effective	☐ Effective	☐ Very effective
Effectiveness of international legal instrument for damage claim	☐ Very ineffective	☐ Ineffective	☐ Least effective	☐ Effective	☐ Very effective

3.8.2 Questionnaire for the Policy makers

1. Is there a **pre-spill** Natural Resource Damage Assessment plan (NRDA Plan) in National Oil Spill Contingency Plan (NOSCOP) in Sri Lanka?

   ☐Yes ☐No

   If Yes; It includes (Please select one or more options)

   a. ☐Identification of environments-at-risk from pollution events
   b. ☐Systematic analysis of vessel traffic patterns, types of vessels and cargoes, and identify traffic convergences
   c. ☐High-risk areas based on ports, terminals, high-traffic areas offshore, and traffic crossings
   d. ☐Identification of cross-border environments that may be affected in neighboring countries
   e. ☐Chemical analysis and physical analysis (specific gravity, viscosity/ pour point, solubility, volatility/ distillation characteristics) of cargoes/ pollutants most likely to be spilled
   f. ☐Other (Please specify)………………………………………………

2. Is there a **Natural Resource Damage Assessment (NRDA) plan** in National Oil Spill Contingency Plan (NOSCOP) in Sri Lanka?

   ☐Yes ☐ No

   If Yes,

   2.1 Does the NRDA Plan include a set of Standard Operating Procedures (SOPs) to guide all NRDA steps/studies?

   ☐Yes ☐No

   Remarks…………………………………..…………………………………

2.2 Does the NRDA Plan anticipate relationships with neighboring countries in the event of the cross-border spread of a pollution event from regions within its jurisdiction?

☐Yes ☐No

Remarks……………………………………….……………………………

2.3 Does the NRDA Plan have Memorandum of Agreements (MOAs) between government/ non-government agencies who collaborate to conduct NRDA process?

☐Yes ☐No

Remarks…………………………………..…………………………………….

3. Are there Pre-spill natural resource damage assessment and restoration (NRDA&R) training programmes?

☐Yes ☐No

Remarks………………………………………………………..…………………

4. Does the act have restoration-based damage claim provision (the "restoration plan")?

☐Yes ☐No

5. How is the NRDA Response Fund of Sri Lanka?

6. What are the allowable methods to estimate the damages, as interpreted in the implementing regulations?

7. Is the trustee who conducts NRDA process, limited to valuation methods specifically identified in the regulations?

☐Yes ☐No

If Yes; What is/ are the valuation method (s)?

If No, Is it allowable to use of a specific method by providing detailed standards for its application?

8. What are the reliability and validity issues which have been arisen when assessing admissibility of scientific studies on NRDA processes?

9. What are the gaps and challenges of the act when filing a lawsuit or submit a claim to the International Convention on Civil Liability for Oil Pollution Damage (CLC) or International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND convention) against the responsible party?

10. Challenges for Natural Resource Damage Assessment in Sri Lanka. (Please rank accordingly)

Component	**Ranking**				
Technical capacity	☐ Very dissatisfied	☐ Dissatisfied	☐ Least satisfied	☐ Satisfied	☐ Very satisfied
Expertise knowledge	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Funding capacity	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Adequacy of human	☐		☐		☐

resources	Below optimum level		Optimum level		Above optimum level
Awareness building/ Trainings/ Workshops	☐ Very poor	☐ Poor	☐ Fair	☐ Good	☐ Excellent
Effectiveness of national legal regime for damage claim	☐ Very ineffective	☐ Ineffective	☐ Least effective	☐ Effective	☐ Very effective
Effectiveness of international legal instrument for damage claim	☐ Very ineffective	☐ Ineffective	☐ Least effective	☐ Effective	☐ Very effective

Chapter 4
RESULTS

This chapter presents the results of interviews and questionnaire surveys. Sub topic 4.1 summarizes details of the participants in the survey. Sub topic 4.2 illustrates the past oil spill incidents happened in Sri Lanka. Sub topics 4.3 (Sector one: Academia) and 4.4 (Sector two: Policy makers) present the results and analysis of data collected during the study. All sub-topics under 4.3 and 4.4 were lined up according to the order of the questionnaire questions. Each sub-topic is related to the particular question in the questionnaire.

4.1 Interviewee analysis

Multi stakeholders who engage in Natural Resource Damage Assessment (NRDA) process for oil spills in Sri Lanka were involved in the survey under two sectors; academia and policy makers. The Academia sector represented four university lecturers and five scientists, while policy makers consisted of four marine managers, three legal officers and a navy officer.

Table 4.1 shows the details of interviewees and interviews conducted throughout the data collection. Table 4.2 provides the details of respondents and questionnaire surveys conducted for the study. The surveys were driven from the end of July to mid-August of 2021.

Table 4.1 Details of interviewees and interviews conducted for the data collection

Serial No	Interviewee	Duration of interview	Sector	Position
1	R1	35 minutes	Academia	Scientist
2	R2	30 minutes	Academia	University lecturer

3	R3	40 minutes	Academia	Scientist
4	R4	1 hour 06 minutes	Academia	University lecturer
5	R5	25 minutes	Policy maker	Legal officer
6	R6	1 hour 10 minutes	Policy maker	Marine manager
7	R7	45 minutes	Policy maker	Marine manager
8	R8	25 minutes	Policy maker	Legal officer
9	R9	40 minutes	Academia	University lecturer
10	R10	30 minutes	Policy maker	Marine manager

Table 4.2 Details of respondents and questionnaire surveys

Serial No	**Respondent**	**Sector**	**Position**
11	R11	Academia	Scientist
12	R12	Academia	Scientist
13	R13	Academia	Scientist
14	R14	Academia	University lecturer
15	R15	Policy maker	Navy officer
16	R16	Policy maker	Legal officer
17	R17	Policy maker	Marine manager

4.2 Oil spill incidents in Sri Lanka

The number of oil spill incidents occurred in Sri Lanka between 1999 and 2021 is illustrated in Figure 4.1 and there was total of 39 oil spills caused during that period

(MEPA Unpublished Report). Out of this, there were seven major pollution incidents, including MT New Diamond ship accident in 2020 and X-Press Pearl disaster in 2021.

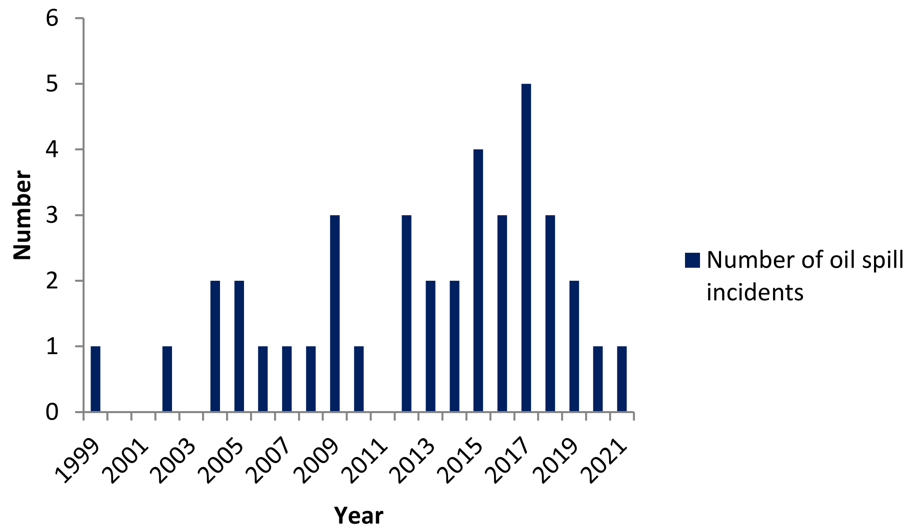

Figure 4.1 Overview of oil spill incidents from 1999 to 2021 in Sri Lanka

4.3 Sector one: Academia

4.3.1 The types of environmental assessments conducting for oil spill damages in Sri Lanka

According to the analysis of nine responses on multi-select multiple-choice questions, Figure 4.2 illustrates the Natural Resource Damage Assessment (NRDA) process for oil spills in Sri Lanka. It mostly measured the acute impacts and mortality (36.84%) followed by chronic impacts (26.32%), cumulative effects (21.05%) and long-term impacts (15.79%). Acute effects are characterized by lost productivity and species mortality over a short exposure to the pollutants. Chronic or sub-lethal effects are digestive impairment, reduced growth rates, reproductive impacts and so on. Long-term studies are continued to investigate ecosystem components where effects are suspected and it monitors ecological recovery, the effectiveness of the restoration program, etc. (Steiner, 2004). Studies on cumulative effects identify adverse effects of persistent toxic compounds, bioaccumulation, loss of ground water, soil quality and so on (Steiner, 2004). However, three respondents have expressed that there was no standard sampling procedure or standard protocol to measure the adverse effects of oil spill incidents in Sri Lanka. No proper long-term damage assessments have been conducted methodically by the responsible organizations. Two respondents expressed that the sample collected for oil spill incidents were not ensuring the chain of custody.

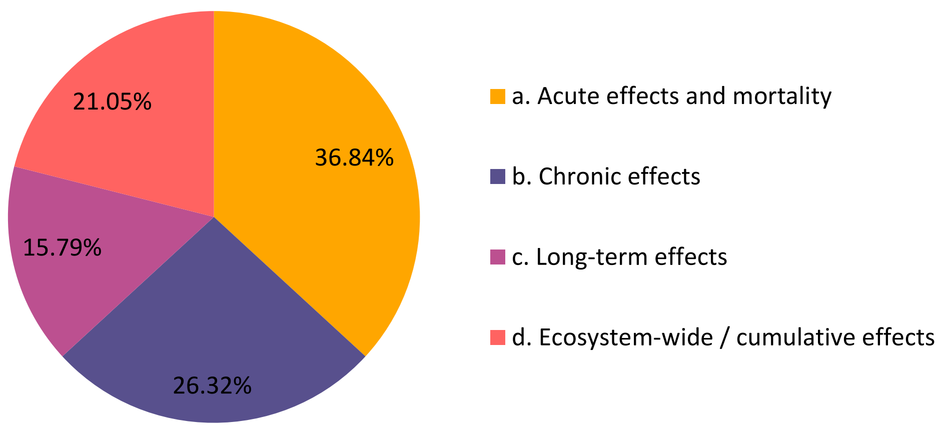

Figure 4.2 The environmental assessments conducted after oil spill incidents in Sri Lanka

4.3.2 The baseline environmental studies in the ecosystem at-risk

Four respondents responded as baseline data were available, while four respondents expressed as baseline data were not available. Six respondents explained that the availability of marine baseline data was site-specific, sporadic and not consistent. Complete data set for coastal habitats, turtles and species on continental shelf was absent. Further, R4 expressed that though there were baseline data sets, these were kept under some organizations as confidential documents. R3 explained that most of the available data of ecological characterizations of species were mostly laboratory driven and no field data were available. Accordingly, all respondents were not fully satisfied with the available baseline data due to the absence of a methodically obtained proper dataset.

Baseline environmental studies have been conducted on those judged to be at the greatest risk. R3 answered that the complete baseline data of sensitive areas at high-risk places such as commercial ports (e.g. Colombo port) was available. Five respondents indicated that this information was ad hoc and was usually collected as part of specific projects or EIAs. There were no systematic monitoring using standardized methods based on identified management criteria. R1 highlighted that there were isolated maps illustrating key species such as coral reefs, seagrass beds and mangroves that have been developed by different scientists but most of them were contradictory and all were conspecific. All respondents expressed that data was not accessible as there was no public domain or robust platform for data sharing.

4.3.3 Pre-spill Natural Resource Damage Assessment and Restoration (NRDA&R) training programmes

Four responses expressed that there were few local training programmes related to NRDA&R. R2 stated that few scientists in the National Aquatic Resources Research and Development Agency (NARA) of Sri Lanka got training opportunities abroad. R9, R12 and R13 explained that neither was in a satisfactory level nor comprehensive specific training programmes.

4.3.4 Primary restoration activities taken to restore the damaged natural resources to baseline level after an oil spill incident

The response results of nine academia on the multi-select multiple-choice question regarding primary restoration activities taken after oil spill damages in Sri Lanka (Figure 4.3) indicated that the control of residual sources of contaminants (40%) and allowing the natural recovery (45%) were the most practiced methods as primary restoration activities. R2 stated that they were handling such events case by case with the above-mentioned activities as a quick solution for the problem without having a standard protocol. Further, R9 explained that though the mangroves were restored, it was not a part of a systematic NRDA&R process. For example, when it was needed to conduct a mangrove restoration program, those kinds of damaged sites were selected as restoration sites.

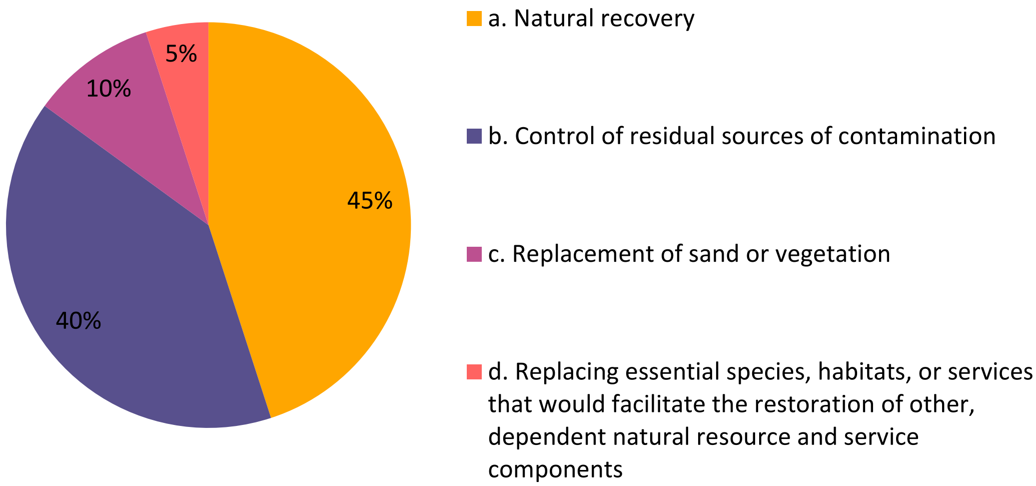

Figure 4.3 Primary restoration activities taken after oil spill incidents in Sri Lanka

4.3.5 Compensatory restoration activities taken to restore the damaged natural resources to the baseline level after an oil spill incident

Responses regarding the existing compensatory restoration activities after oil spill incidents in Sri Lanka are summarized in Table 4.3. It reveals that there was no systematic compensatory restoration approach established in Sri Lanka in order to restore the damaged natural resources to the baseline condition.

Table 4.3 Responses of academia regarding the existing compensatory restoration activities after oil spill incidents in Sri Lanka

Serial No	Responses on existing compensatory restoration activities	Respondent
01	No systematic approaches or formulas were available to compensate the public for interim losses from the time	R2, R4, R9, R11, R13, R14

	natural resources were affected until they returned to baseline.	
02	Ecological parameters have to be studied in a systematic way to decide the necessary ex-situ restoration	R1
03	Damage compensations for fisheries have been paid only for the banned period of fisheries considering the statistics from Department of Fisheries. But a claim system for the decrease of fishery production due to the damage until it became baseline levels or any compensatory restoration system has not been established in Sri Lanka yet.	R3
04	Unavailability of population dynamic studies or stock assessment data for economically important food and ornamental fish species though some fish catch data exists. Hence there are issues when using mathematical models without knowing the standing stock sizes.	R4
05	Without a proper mechanism for damage assessments, the compensation process is unclear, politically driven, or unscientific.	R11, R13
06	Until MT New Diamond oil spill incident in 2020, environmental cost or damage to the environment has not been focused in Sri Lanka.	R2, R9

4.3.6 Challenges during the restoration planning phase

The restoration planning phase determines the scale of restoration actions by evaluating the potential injuries to natural resources and services (NOAA, 1997). Table 4.4 summarizes the identified challenges of the restoration planning phase for oil spill damages in Sri Lanka.

Table 4.4 Challenges of the restoration planning phase for oil spill damages in Sri Lanka

Serial No	Identified challenges	Respondent
01	Unavailability of comprehensive baseline data	R2, R9, R11
02	Unavailability of information on ecosystem composition	R9
03	High levels of pre-event pollution and habitat degradation	R11
04	Lack of pilot-tested methodologies to determine the best restoration approaches	R2
05	Uncertainty in the success rate of the restoration project due to low survival rate of the species	R1
06	Issues with damage claiming provisions. If the claim would not be obtained fully the planned activities would not be implemented successfully.	R3
07	High cost associated with restoration technologies	R1
08	Long term committed finance mechanisms	R2, R14
09	High cost in obtaining technical knowledge from resource countries	R1
10	Unavailability of trainings on modern restoration	R9

	technologies in marine and coastal environment	
11	Technical issues	R1, R2, R14
12	Regulatory barriers arose when conducting projects (e.g. obtaining permissions to conduct restoration activities)	R1
13	Social issues arose from surrounding communities of the project area	R3
14	Extreme weather challenges and other environmental consequences	R1
15	Finding best possible areas with species-specific environmental condition	R3
16	Lack of environmental economists to scale the coastal restoration projects, limited experts for specific habitat restoration	R9, R12
17	Inadequate trained human resources (e.g. Marine scientists with sea confidence)	R1, R9, R14
18	Issues with resources mobilization	R1
19	Lack of inter-agency coordination	R2
20	Institutional issues (e.g. Department of Wild Life might not allow conducting restoration programmes in a marine sanctuary)	R3
21	Issues associated with COVID 19 pandemic (e.g. the	R4

	manpower was gradually getting reduced)	

4.3.7 Scale of restoration alternative/s used in Sri Lanka

Response results showed that both resource-to-resource approaches (six responses) and valuation approaches (five responses) were used as scales of restoration alternatives. R2 mentioned that the travel cost method and contingency valuation approaches were the most used valuation methods. But R13 stated that none of them were being used satisfactorily or regularly. R4 answered that in the X-Press Pearl pollution incident in 2021, the turtles were given value based on the number of tourists visiting the turtles every year. But there was a problem with calculation as tourists were not coming to Sri Lanka during the COVID 19 pandemic.

4.3.8 The application of Habitat Equivalency Analysis (HEA)

All nine respondents replied that the HEA was not applied as a service-to-service scaling method in NRDA process for oil spills in Sri Lanka.

4.3.9 Possible challenges and difficulties during the process of applying HEA scaling method

Several possible challenges might be arisen when HEA is applied as a scaling method of oil spill NRDA in Sri Lanka and Table 4.5 summarizes these challenges identified during the study.

Table 4.5 Possible challenges during the process of applying HEA in NRDA process for oil spills in Sri Lanka

Serial No	Identified challenges	Respondent
01	Non availability of data on comprehensive ecosystem services and valuation based on unit areas.	R11

02	Any available information is limited to key services over a broad sector and does not consider geographic variations. This is due to a sectoral approach to valuation rather than location-based analysis.	R11
03	Choosing a proper common metric or indicator is a complex task that needs more researches and more time.	R3
04	Field issues associated with chosen indicator; e.g. If shoot density is taken as an indicator for assessing biomass of seagrass meadows, there may be consequences to the habitat due to uprooting of plants. Though there are indirect or primary methods such as Braun-Blanquet method to assess biomass, these methods are not considered as accurate as calculating shoot density.	R1
05	The environmental valuation/ ecosystem valuation is very rudimentary at the moment in the country. There are only a few environmental economists in Sri Lanka	R2
06	HEA is relatively new and has not been tested in Sri Lanka.	R2
07	Issues in proving this approach in the domestic legal system	R3
08	Trained dedicated human resources	R9, R13
09	Delay in domestic legal procedures	R9
10	Lack of vision to institutionalize such approaches	R13

4.4 Sector two: Policy makers

4.4.1 Availability of pre-spill natural resource damage assessment (Pre-spill NRDA) plan

According to the results, four respondents have mentioned that there was a pre-spill natural resource damage assessment plan for oil spills in Sri Lanka, while four respondents stated that there was no such plan in Sri Lanka. R10 explained that though there was no specific report on the pre-spill natural resource damage assessment plan, data of some of the components intended to be included in the pre-spill NRDA plan were available in the country. Table 4.6 shows the responses on currently available components related to the pre-spill NRDA plan.

Table 4.6 Data availability in Sri Lanka related to the components of pre-spill NRDA plan for oil spills

Serial No	Component	Number of Responses	Remarks
01	Identification of environments-at-risk from pollution events	7	
02	Systematic analysis of vessel traffic patterns, types of vessels and cargoes, and identify traffic convergences	0	R6 and R10 stated that types of vessels and cargoes, vessel traffic patterns are available though these were not analyzed systematically
03	High-risk areas based on ports, terminals, high-traffic areas offshore, and traffic crossings	5	R7, R8 and R10 mentioned that the Port Biological Baseline Surveys at four commercial ports in Sri Lanka, project on identification of species

			invasiveness at commercial ports in Sri Lanka, Strategic EIAs have been conducted and data at high risk port areas were available. High-traffic areas offshore and traffic crossings are available at web portals
04	Identification of cross-border environments that may be affected in neighboring countries	0	
05	Chemical analysis and physical analysis of cargoes/ pollutants most likely to be spilled	2	R7 indicated that most of these data could be obtained from Ceylon Petroleum Corporation
06	Other	2	R7 and R10 explained that water quality monitoring data at sea-bathing sites, beaches, lagoons, estuaries, Environmental Sensitivity Index (ESI), coastal profile at Western and Southern provinces of Sri Lanka were available at MEPA, NARA and CCD.

4.4.2 Natural Resource Damage Assessment (NRDA) plan for oil spills in Sri Lanka

All of policy makers replied as there was no NRDA plan for oil spill damages in Sri Lanka. Accordingly, due to the absence of NRDA plan for oil spills, there was no set of

Standard Operating Procedures (SOPs) to guide all NRDA steps and no anticipated relationships with neighboring countries in the event of the cross-border spread of a pollution event. Further, no Memorandum of Agreements (MOAs) between government and non-government agencies collaborated throughout the NRDA process. R6 revealed that the existing procedure depended on case by case due to the absence of proper protocol or methodology to conduct a NRDA. Hence the government might spend a considerable amount of money for expertise, laboratory testing and other processes. R10 cited that though there was coordination within SARC region in case of oil pollution events, there was no specific plan. Further, it was mentioned that Marine Environment Protection Authority (MEPA) possessed the mandate to develop and execute NRDA plan for oil pollution incidents in Sri Lanka.

4.4.3 Training programmes for natural resource damage assessment and restoration (NRDA&R)

Two respondents have stated that there were training programmes and R16 mentioned that it was conducted based on the available Environment Damage Assessment Guideline by MEPA. But R6 revealed that the training was only a few-day workshop and more trainings were needed for the staff of MEPA. Five respondents explained that though the restoration training programmes for coral, mangroves species and pilot projects for seagrass had been conducted, these were not specifically designed as NRDA&R training programmes.

4.4.4 Restoration-based damage claim provision of the Act

Six out of eight respondents have replied as there was no restoration-based damage claim provision of the Marine Pollution Prevention Act Number 35 of 2008 (MPPA), which had the mandate for conducting NRDA process for oil spills in Sri Lanka. Two respondents have not replied to the question.

4.4.5 The NRDA Response Fund of Sri Lanka

According to the responses, there was no NRDA Response Fund in Sri Lanka. R8 and R10 explained that the annual budget allocated under the section of the National Oil Spill Contingency Plan (NOSCOP) of the MEPA action plan was utilized for the management of oil spill incidents. R7 indicated that there was a proposal to establish such a fund, but it could not be proceeded.

4.4.6 Methods to estimate the damages, as interpreted in the implementing regulation (MPPA)

R10 cited that there was no specific method interpreted in the MPPA to estimate the environmental damages caused by oil pollution incidents. R16 explained that due to the unavailability of a special legal provision in MPPA they could only use methods that were adopted in CLC and IOPC Fund, such as cost of restoration. Further, R10 mentioned that those were the improvement areas that had to be addressed.

4.4.7 Is the trustee who conducts NRDA process, limited to valuation methods specifically identified in the regulations?

R7 stated that MEPA was responsible for conducting NRDA for oil pollution incidents as the trustee organization. But there was no specific provision in the MPPA regarding the valuation method or any restoration scaling method for oil spill environmental damages. R10 explained that a methodology proposed by the appointed management team (appointed by MEPA whenever a pollution incident occurred) would be followed and these methodologies differed from case to case. Valuation methods had been used in recent two oil spill incidents (MT New Diamond oil pollution incident and X-Press Pearl environment disaster) in Sri Lanka.

4.4.8 The reliability and validity issues that have been arisen when assessing the admissibility of scientific studies on NRDA processes

Table 4.7 shows the summarized responses of policymakers on the issues that have arisen when assessing the admissibility of scientific studies of NRDA processes for oil spills in Sri Lanka.

Table 4.7 Reliability and validity issues associated with scientific studies of NRDA processes in Sri Lanka

Serial No	Issues	Respondent	Remarks
01	No clear legal provision related to NRDA for oil spill damages. Hence it was not clear which scaling method could be used.	R16	
02	Errors associated with sampling procedures due to the absence of proper guideline	R6	Lack of well-trained dedicated staff for sampling activities
03	Issues associated with advanced analytical testing, bio-specimen processing and bio storage due to limited laboratory facilities, cold storage facilities etc.	R4	Absence of a sophisticated central laboratory system
04	Challenges in finding foreign laboratory service	R4	Finding laboratory services without vested interest
05	Uncertainty with the results of	R10	Lack of confidence with

	damage assessment reports		the reports
06	Insufficient competency levels of responsible government agencies when conducting scientific activities	R7, R4, R15	Lack of knowledge and skills of officers at trustee organization(s).
07	Conflicts on applying scientific procedures among institutes	R7	
08	Political influence and lack of political will		

4.4.9 Gaps and challenges of the MPPA when filing a lawsuit or submit a claim to the 1992 International Convention on Civil Liability for Oil Pollution Damage (CLC) or 1992 International Oil Pollution Compensation Fund (IOPC Fund) against the responsible party.

R16 clarified that as per the internationally adopted system of the 1992 CLC and 1992 IOPC Fund, the environment damage based on the economic valuation method would not be accepted. Hence these were not admissible under the above two conventions as well as Protection and Indemnity (P and I club) rule for pollution covers. Thus only the reasonable costs for restoration programmes could be claimed. But the biggest issue was the unavailability of national legislation related to restoration-based damaged claim provision. Section 34 Civil liability of the MPPA was the provision that can be used to claim the direct cost such as cleaning operations, manpower cost, food and lodging, chemical cost, etc.

Under this topic, R5 explained furthermore the issues pertaining to the national legislation under damage claim provisions. Given that when a ship based pollution or another major pollution incident occurred in Sri Lanka the national legal actions were taken under the section 26, 27 (Criminal liability) in MPPA. But the provisions covered under these sections were not appropriate and admissible for pollution caused by a small amount of oil. Further, there were issues in compensation for natural resource damage under section 34 of the act. For example, the damage claim of Thaldiyawatta oil spill incident (2018) could not be compensated due to some loopholes in the MPPA. These gaps and loopholes included but were not limited to the incompleteness of section 34 of MPPA and the absence of specific court type mentioned in section 34 in order to compensate damages to the environment. R10 revealed that still no claim was filed in international courts or under CLC or FUND instruments. Even the case of MT New Diamond spill incident (2020) was progressing in the High Court of Sri Lanka.

4.5 Facilities for conducting natural resource damage assessment of oil spills in Sri Lanka

The ratings given by the respondents of each sector (academia and policymakers) on existing facilities for conducting natural resource damage assessment of oil spills in the country were analysed separately. Figures 4.4 to 4.10 illustrate the rating levels given by both sectors.

4.5.1 Technical capacity for conducting NRDA of oil spills

Responses of academia showed a wider spread regarding their satisfactory level of technical capacity, while policymakers answered that it was in between "dissatisfied" and "satisfied" levels (Figure 4.4). The majority of respondents expressed that the technical capacity for NRDA in Sri Lanka was dissatisfied with poor technical infrastructure. Unavailability of sophisticated equipment (e.g. remotely operated vehicle or submarine to go near and inside the wreck when an accident happened) and a high-quality laboratory were identified as urgent needs in the country.

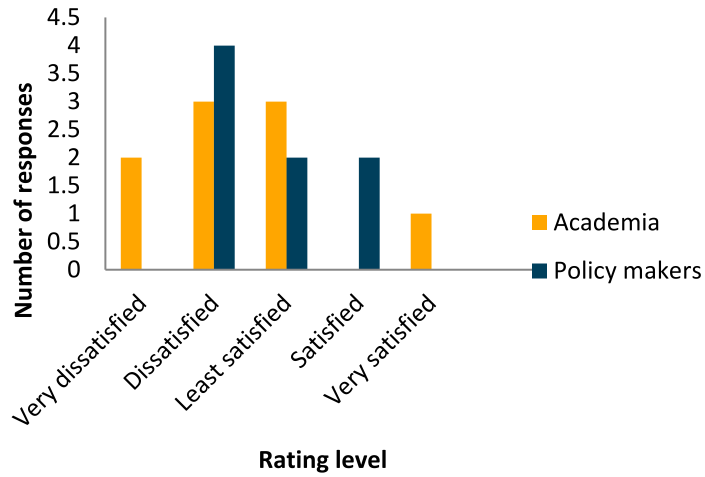

Figure 4.4 Technical capacity for conducting NRDA of oil spills in Sri Lanka

4.5.2 Expertise knowledge for conducting NRDA of oil spills

The academia seemed to have a wider spread of their result between "poor" and "excellent" rating levels while results of policymakers were confined to "fair" and "good" rating levels (Figure 4.5). Nonetheless, two academia (R2, R9) stressed that though there were experts in a broad picture in the country, there were no field experts who possessed both knowledge and skills on ecology and environmental economics for assessing environmental damages of oil spills.

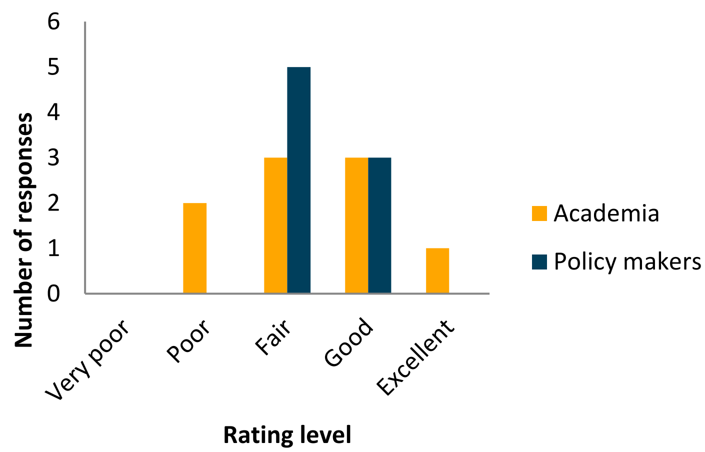

Figure 4.5 Expertise knowledge for conducting NRDA of oil spills in Sri Lanka

4.5.3 Funding capacities for conducting NRDA of oil spills

The illustration of Figure 4.6 indicates that the responses of academia regarding funding capacities lay within "poor" and "good" rating levels while policy makers' responses spread widely. Most respondents answered that the funding capacity for conducting NRDA was in a "poor" condition. Some respondents explained that the government fund available for the annual action plan of MEPA was utilized for NRDA for oil spills. But the claiming of that expenses from the responsible party was more time-consuming with slow legal procedures.

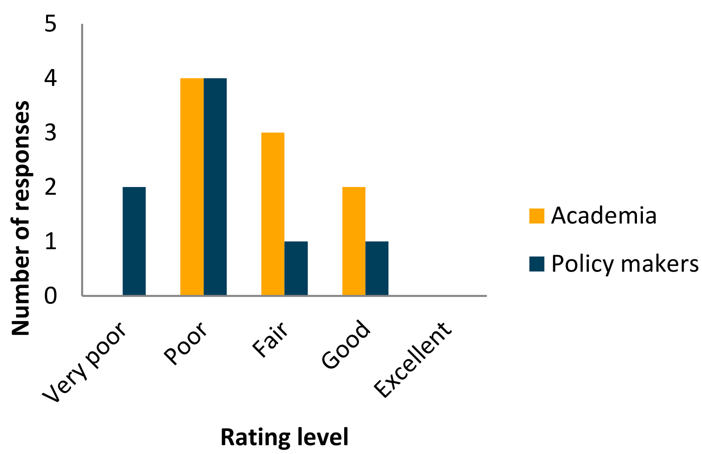

Figure 4.6 Funding capacities for conducting NRDA of oil spills in Sri Lanka

4.5.4 Adequacy of human resources for conducting NRDA of oil spills

Regarding the adequacy of human resources for conducting NRDA process, academia seemed to have a balanced spread of their result. At the same time, policymaker's responses narrowed to "below optimum level" and "optimum level" (Figure 4.7). The majority of respondents replied as the adequacy of human resources for NRDA was at an "optimum level" in Sri Lanka.

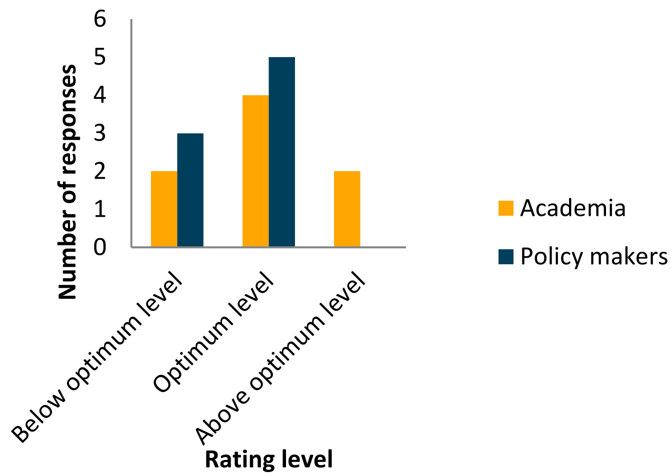

Figure 4.7 Adequacy of human resources for conducting NRDA of oil spills in Sri Lanka

4.5.5 Awareness building/ trainings/ workshops for NRDA of oil spills

Figure 4.8 illustrates the response results of awareness building for NRDA. Responses of academia showed a broader distribution pattern for rating levels and responses of policymakers restricted to “very poor” and “poor” rating levels. The majority of respondents (11 out of 17 respondents) reacted to the awareness building for NRDA as in a “poor” situation. Most policymakers mentioned that it was a timely need that should be paid special attention to by the government.

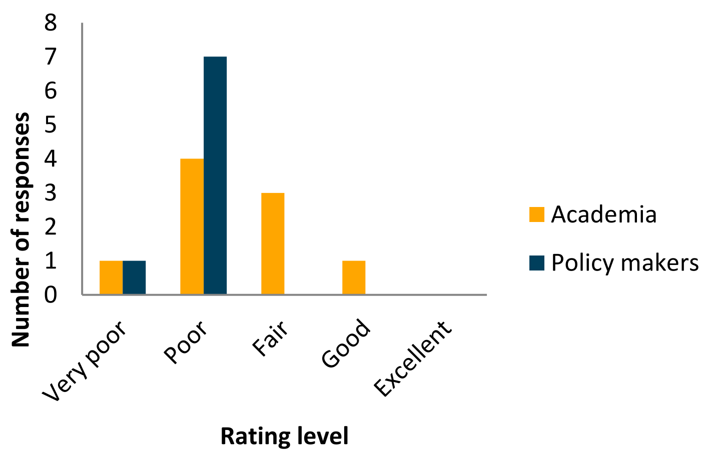

Figure 4.8 Awareness building/ trainings/ workshops for NRDA of oil spills in Sri Lanka

4.5.6 Effectiveness of national legal regime for damage claim of oil spills

When it focuses on the effectiveness of the national legal regime for damage claims of oil spills in the country (Figure 4.9), all the response results narrowed to the "very ineffective", "ineffective" and "least effective" levels. Most of the respondents including the majority of academia answered that the effectiveness of the national legal regime for oil spill damage claims was least effective. This emphasizes the need for a reformation of the MPPA.

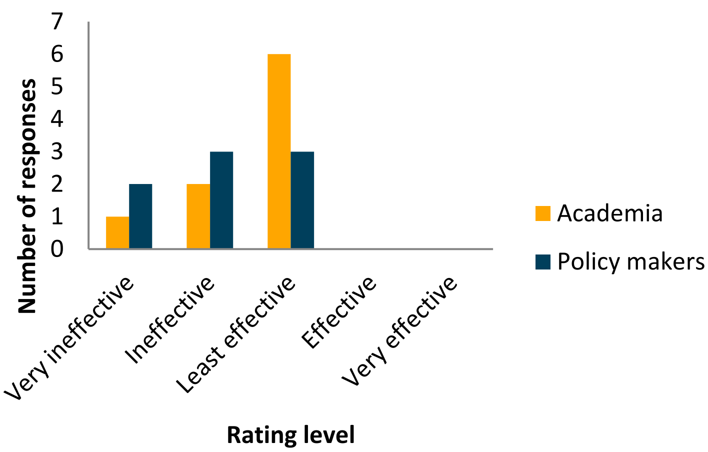

Figure 4.9 Effectiveness of national legal regime for damage claim of oil spills in Sri Lanka

4.5.7 Effectiveness of international legal instruments for damage claim of oil spills

The rating responses of both sectors regarding the effectiveness of international legal instruments for damage claims of oil spills in Sri Lanka mostly followed a similar distribution pattern (Figure 4.10). Most responses were biased towards "least effective" and "ineffective" rating levels. R4 remarked that if specific conventions had been ratified, Sri Lanka could obtain direct claims for wild life losses for X-Press Pearl oil pollution incident (2021).

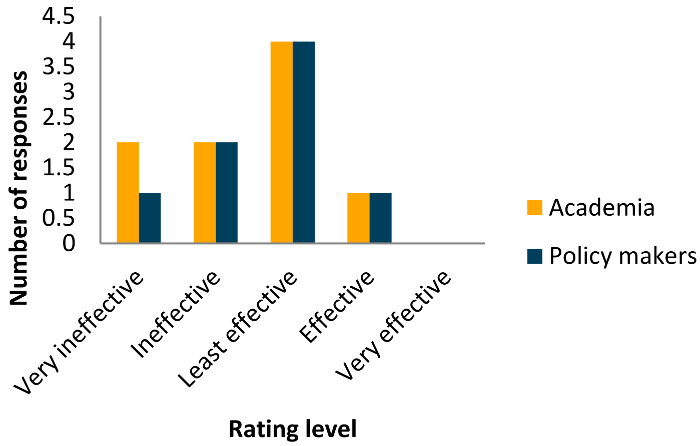

Figure 4.10 Effectiveness of international legal instruments for damage claim of oil spills in Sri Lanka

4.6 Results of statistical analysis

The results of the Chi-square test of each seven facilities are summarized in Table 4.8. Based on *P*-value approach or critical value approach, it could not reject the null hypothesis (H_0) for each seven facilities at the significance level (α) of .05 (The *P*-Value $\geq \alpha$ or $\chi^2 \leq$ cv; Table 4.8). Accordingly, there were no statistically significant differences of responses between academia and policymakers on studied facilities for conducting NRDA in Sri Lanka. It revealed that the attitudes of academia and policymakers towards the facilities for oil spill NRDA were similar, giving a solid conclusion about the existing facilities of Sri Lanka. However, the test results might be affected by the low number of respondents for each sector (nine respondents for academia and eight respondents for policymakers).

Table 4.8 Chi-square test values on responses between academia and policymakers regarding existing facilities for NRDA of oil spills in Sri Lanka

Facilities for NRDA	χ^2	**cv**	**df**	***P*-value**	**N**
Technical capacity	5.302	9.488	4	.258	17

Expertise knowledge	3.453	9.488	4	.485	17
Funding capacity	3.286	9.488	4	.511	17
Adequacy of human resources	2.311	5.991	2	.315	16
Awareness building	4.776	9.488	4	.311	17
Effectiveness of national legal regime	1.480	9.488	4	.830	17
Effectiveness of international legal regime	0.275	9.488	4	.991	17

Note: The distributions of categorical data in two-way tables with the variables of sectors and rating levels were compared by performing Chi-square test.
χ^2, Chi-square test value; cv, critical value of the Chi-square test at the significance level of .05; df, degrees of freedom; *P*-value, probability of observing the sample statistic as extreme as the test statistic; N, sample size

Chapter 05
DISCUSSION

Protection of the marine and coastal environment from oil spill pollution is of high priority in Sri Lanka as a coastal nation. As the trustee organization which has the responsibility for conducting Natural Resource Damage Assessment (NRDA) for oil pollution damages (Ward and Duffield, 1992), Marine Environment Protection Authority (MEPA) presently faces huge challenges related to the submission claim for environmental damage.

5.1 Constraints in compensation regime for environmental damages caused by oil spills

5.1.1 Limitations of the national legal regime on environmental damage claims for oil spills in Sri Lanka

Faced with a high risk of oil spill occurring in Sri Lankan coastal areas and with potentially severe impacts, it is highly required to strengthen the ability of Marine Pollution Prevention Act Number 35 of 2008 (MPPA) to claim the compensation for natural resource damages by assessing the impacts of oil on the coastal areas of Sri Lanka as well as to monitor the recovery from such impacts.

During the study, it was mentioned that when ship-based pollution or another major pollution incident occurred, the national legal actions were taken under the Criminal Liability; the section 26 (Discharging of oil or any other pollutant into Sri Lankan waters) and 27 (Dumping of oil and other pollutants, only under a permit) of MPPA (MPPA, 2008). In such a case, the responsible party is liable to a fine not less than 4 Mn Rs and not exceeding 15 Mn Rs. This provision is vague and not appropriate when considering the pollution caused by a small amount of oil. Kularatne (2020) stated that the wealthy ship owners and operators escape easily with smaller fines imposed by the High Court of Sri Lanka. Further, the study indicated that in a marine pollution event involving a ship, the MPPA has permitted to detain the ship until the compensation was paid. But the MPPA does not mandate particular ship to have a Certificate of Insurance or any equivalent except the ships carrying more than 2000 MT of oil in bulk as cargo. In such cases, the wealthy ship owners may tend to abandon the ship without paying fines due to the protracted legal process. Furthermore, there is no specific provision to deal with the pollution caused by Sri Lanka Defense Forces (BOBLME, 2013). Piyadasa (2014) stated that MPPA did not address oil spill pollution damages adequately. The term "related activity" in section 40 (1) of the MPPA is imprecise and incomplete to address the pollution caused by offshore projects, except petroleum exploration (Kularatne, 2020). Establishing an efficient mechanism for reporting a pollution activity enhances the success of environmental management (Madushika & Chandrasena, 2018; Piyadasa, 2014). But there is no specific time and frequency for reporting other than the term "as soon as possible" in the MPPA (Piyadasa, 2014). Those are the provisions that must be addressed in the act amendment processes.

Under section 34 in Civil Liability of MPPA, the responsible party would be liable for the damages caused by the oil pollution (MPPA, 2008). Nevertheless, there are issues in compensation for natural resource damages under section 34, which can only be used to claim the direct cost of cleaning operations, manpower, fisheries compensation, etc. In oil pollution incidents, the government has an obligation to assess the damage to natural resources and to recover the affected environment to the baseline condition (Steiner, 2004). Kim et al. (2017) cited that the environmental damage compensations had never been claimed under the IOPC Fund in Korea due to the absence of adequate NRDA practice and unavailability of internationally permissible economic quantification procedure. The situation is similar in Sri Lanka also as there is neither a specific method (valuation method or any restoration scaling method) interpreted to estimate the environmental damages caused by oil pollution incidents nor restoration-based damage claim provision in the MPPA. An important issue in this regard is where the legal arguments and claims for damages would take place. As R16 cited that due to the unavailability of a particular legal provision in the national regime, they could only use methods adopted within the framework of two international conventions CLC (1992) and IOPC Fund (1992).

One of the major challenges in environmental liability provisions is valuing damages caused to ecological services with passive or indirect human uses. For quantifying these services, the application of non-market valuation methods is controversial (Desvousges et al., 2018; Kim et al., 2017; NOAA, 2000). Accordingly National Oceanic and Atmospheric Administration (NOAA) of the US has reframed the interim loss of damage claim from "how much money would the public require to make them whole to how much compensatory restoration does the public require to make them whole" (Jones & DiPinto, 2018). International law offers the right to a government to claim damages against the responsible party through a methodical NRDA program (Steiner, 2004). According to the NOAA (2021), the NRDA process does not address criminal or civil liability and in order to file a legal case, the endpoints should be related to the effects of oil. To be admissible, the claim must be related to the restoration programmes which followed pre-approved protocols supported by accurate quality documentation and chain of custody (NOAA, 2021). Accordingly, Sri Lanka also should pay attention to overcome these challenges through a comprehensive NRDA system.

The review conducted by Jones et al. (2015) revealed that several tropical countries, including Nigeria, India, Mexico, Brazil, Indonesia and Philippines had enacted additional legislative provisions forming liability for injured natural resources. They have incorporated procedural modifications that increase access to courts. Sri Lanka also requires such type of reforms to statutory provisions to address the natural resource compensation provisions effectively covering both the interim losses and restoration of damaged resources or replacement by the equivalent resource to the damaged resources if a particular resource would not be restored. The identified gaps and loopholes in the MPPA reveal that the available provisions are inadequate to protect the natural resources and services from oil pollution incidents in Sri Lanka. Hence the study encourages a superficial legislative review for establishing effective policy strategies to guide the NRDA process.

5.1.2 Challenges of international legal regime on environmental damage compensations for oil spills

As a party to CLC (1992) and IOPC Fund (1992), Sri Lanka should pay special attention to these instruments' scope, requirements and limitations when filing lawsuits and presenting claims. Claims under IOPC Fund should be based on actually incurred expenses for reasonable purposes. The marine ecological damage claims for unexploited natural resources in monetary terms with sweeping assumptions are inappropriate to admit. Environmental damage compensations can be granted if only the claimant, who has a legal right to claim it under the national law, has suffered quantifiable economic loss. Accordingly, the reasonable measures of reinstatement cost undertaken or to be undertaken would be appropriate (Jacobsson, 1994).

Several limitations inherent to CLC (1992) and IOPC Fund (1992) have been revealed during several oil spill cases (Schmitt & Spaeter, 2004), including MV Hebei Spirit oil spill incident in 2007 (Soto-Onate & Caballero, 2017). Only direct losses could be claimed under the conventions. For example, only the direct losses caused to tourism but not the supportive industries would be taken into account. Neither the environmental costs nor the local economic rehabilitation was admissible. Slowness in the litigation process for payment of the indemnifications is the other issue (Soto-Onate & Caballero, 2017). Hence, in MV Hebei Spirit oil spill incident, the government of Korea has issued a special Act to cover the rest of the losses as well as to advance certain compensations which have to be covered by the Fund and ship-owner’s insurance (Kim et al., 2017; Soto-Onate & Caballero, 2017). When considering Sri Lanka, no single case has been claimed yet as compensation for pure environmental damages under the above international legal instruments. The court case of MT New Diamond oil pollution incident (2020) is continuing in the High Court of Sri Lanka and the estimated damage could not be claimed yet. The recent environmental disaster X-Press Pearl pollution event (2021) is also under investigation state. According to the results of rating responses on the effectiveness of international legal instruments for damage claims (Figure 4.10), the majority of responses laid within the “least effective” to “very ineffective” range. Hence, the study would present several suggestions including ratifying important treaties related to direct environmental damage claims, an in depth understanding of international legal regimes related to oil pollution damage claims when compiling national statutory provisions, developing a feasible and internationally acceptable NRDA system including admissible economic quantification method such as HEA.

5.2 The challenges and opportunities for establishing a NRDA process for oil spills in Sri Lanka

The high probability of oil spill occurrences in Sri Lanka is an apparent phenomenon when studying the oil spill incidents in the past (Figure 4.1) and considering other risk factors. Nevertheless, the existing order of environmental damage assessment procedure and damage claim provision is contentious in the country.

“Making the environment and the public whole for the injuries to natural resources and services” is the goal of NRDA process (NOAA, 1995). The damage assessment for oil pollution incidents is organized in three phases; rapid assessment in the first two months, mid-term assessment in the remainder of year one and long-term studies (Steiner, 2004). In Sri Lanka, it mostly measures the acute impacts, chronic impacts, cumulative effects. However, it was identified that those studies had not been conducted methodically following SOPs. Some stated that long term effects were not appropriately studied. Dunford et al. (2004) stated that it might be challenging to estimate the reductions in important ecological functions and it might need extensive field surveys. Further, it was identified that the continuous data collection on sensitive coastal habitats throughout the year was a challenging task due to the rough sea condition during monsoon seasons in

Sri Lanka. Ocean Studies Board (2013) said that the studies on long-term changes in ecological community structures under the NRDA remained undisclosed. But in order to proceed with restoration planning, the trustee should quantify the degree, spatial and temporal extent of the damage (NOAA, 1997).

The unavailability of a pre-spill NRDA plan and a NRDA plan for oil spills in Sri Lanka is the utmost reason for most of the challenges identified by the study. Developing a pre-spill NRDA plan is not an entirely new task for Sri Lanka at the moment, as information for most of the components to be included in the plan are already available (Table 4.6). Cross-border environments that may be affected in neighboring countries have to be studied. Pre identification of laboratories or resource centers, gathering data scattered at different institutions, systematic analysis of data, and updating available information are vital considerations for developing a pre-spill NRDA plan.

The development of NRDA plan would reinforce the existing chaotic system of damage assessment for oil spills. Standards of Procedures (SOPs) and Memorandum of Agreements (MOAs) are essential components in a NRDA plan. The set of SOPs will guide all the NRDA steps by establishing consistent standards, laboratory procedures, chain of custody, etc., ensuring the quality of data and credibility of results (Steiner, 2004). The MOAs between government and non-government agencies collaborating throughout the NRDA process would minimize the existing conflicts among institutes when conducting cooperative assessment programs. It is further effective in several ways, including reduced duplication of studies, sharing information and enhanced cost-effectiveness of the NRDA process (Shaw & Wlodarz, 2013). Together with clear documentation, all these practices may improve the transparency and admissibility (Baker et al., 2020) of scientific studies for court procedures while saving time and a considerable amount of government funds.

The baseline data for conducting NRDA for oil pollution incidents

The availability of baseline data is a fundamental component in NRDA process. Without having baseline information, it is impossible to assess the damage (Piyadasa, 2014). Gunawardena & Rowan (2005) said that the baseline environmental data was scientifically uncertain and limited in Sri Lanka. During the study, most academia mentioned that the availability of marine baseline data was site-specific and sporadic. For example, data of ecosystem components (e.g. primary producers, benthic invertebrates, forage fishes, birds) were available, but it was subjective to place. Some respondents answered that the data were collected ad hoc as a part of EIA projects and were kept under some organizations as confidential documents. The full spectrum of coastal ecosystem components is not available under one institution. A coastal baseline survey has been conducted in 2018 (except studies on marine mammals and turtles), but it might not be sufficient as it has been conducted only for two months. Baseline information is dynamic and it may change considerably over time (Dunford et al., 2004). Hence monitoring must be carried out regularly and the results should be compared with the baseline data (Piyadasa, 2014).

Satyanarayana (2017) stated that maps illustrating vegetation types, land use patterns, elevations could be utilized as baseline data which aids in visualizing the coastal vulnerability. Further, the studies on general ecological characterizations of species such as reproductive success, growth rates, feeding habits, etc., mainly were laboratory driven and minimal field experimental data were available in Sri Lanka. The studies have revealed highly uncertain relationships among laboratory toxicity studies and adverse effects on indigenous communities in the natural environment (Dunford et al., 2004). When conducting NRDA for oil spill incidents, if baseline data is not available at the affected place, the data of a reference site that is similar to the pre-spill condition of the damaged site can be considered (Baker et al., 2020). Furthermore, due to various human-induced stressors, the natural coastal environments are not pristine and stable. Hence the targeted restoration endpoints may diverge from pre-spill conditions. For such situations, there are guidelines for projecting baselines (NOAA, 2021).

During the survey with policymakers, it was revealed that the baseline environmental data were available at places judged to be at greatest risk, such as commercial ports in Sri Lanka. This included Port Biological Baseline Surveys conducted at Colombo, Trincomalee, Hambantota and Galle ports, water quality data at sea-bathing sites, identification of marine species invasiveness, Environmental Sensitivity Index (ESI) from Negombo to Ahangama and coastal environmental profile for the southern coast of Sri Lanka. The ESI is crucial in protecting the coastal environment from oil spills (Putra et al., 2021) by indicating vulnerable areas to establish protection priorities (NOAA, 2021). According to the responses, information on species live on the continental shelf was unavailable and future research studies must be focused on these areas.

Almost all respondents expressed that there was a huge issue in Sri Lanka regarding the limited accessibility to scientific data due to the absence of a public domain for data sharing. Some studies also stated that accessing reliable scientific data kept under government and associated research agencies is also problematic (Gunawardena & Rowan, 2005). Hence establishing a government-led baseline data-sharing platform, developing a database for storing baseline survey data and damage assessment data are essential steps for the advancement of scientific approaches in the environmental protection of Sri Lanka. Then if an incident occurs, data can be obtained from relevant institutes through an inter-agency coordination mechanism or by paying for that data.

Primary restoration activities

The traditional approach for Natural Resource Damage Assessment (NRDA) is to restore the equivalent extent of habitat, populations of affected species, or any other resources harmed (Ocean Studies Board, 2013). In the event of an oil spill in Sri Lanka, the first and foremost step of primary restoration activity taken was controlling residual sources of contaminants to control the spread of further damage. In some cases, replacement of contaminated sand and vegetation has been done. The most frequently practiced method was allowing natural recovery of harmed wild fauna and flora. In the absence of active management or intervention, the ecosystems recover by natural community succession and attenuation of pollutants leading to a steady ecosystem service state. This may or may not be similar to the pre-spill condition depending on other natural and anthropogenic influencing factors over time (Hanson et al., 2013).

The quantification of recovery from primary restorative activities and compensatory restoration activities may be achieved cost-effectively by combining with damage studies (NOAA, 1997). According to the survey results, those practices were followed as a quick solution for the pollution incident at that time, rather than conducting them according to a standard protocol. The establishment of a Natural Resource Damage Assessment and Restoration Plan (NRDA&R) is the best solution to overcome the existing weaknesses in the system.

Compensatory restoration activities

The study revealed that there was no systematic approach available to compensate the public for the interim losses from the time natural resources are affected until they return to baseline. Further, it was found that until the year 2020 (MT New Diamond pollution incident), the compensatory claims for environmental damages have not been concerned. The NRDA depends on the preexisting adequate scientific knowledge of compensatory restoration for lost resources and its human and ecosystem services (Peterson, 2012).

A respondent explained that "*we could claim for the extent of reduced fish catch if we had stock assessment data for at least commercially valuable fish species and we have not done any population dynamic studies that take a long time depending on the species. Therefore we have no idea about the standing stock*". Apart from that, the environmental damage compensation for MT New Diamond oil spill accident also faced several complications due to the unavailability of data in off-shore environments. The gaps in scientific studies of deep-sea systems jeopardize the implementation of compensatory restoration without knowing the actual extent of the damages (Bas et al., 2016). The conducting of extensive studies on the functioning of deep-sea processes is broad and takes more time than typical NRDA studies (Peterson, 2012).

Ecosystem Service Valuation (ESV) quantifies the damages caused to the community by calculating the welfare loss (Barbier, 2013; Kennedy & Cheong, 2013). Contingent valuation technique and travel cost method have been applied in some instances in Sri Lanka. But it was stated that none of them were being used satisfactorily or regularly. Kennedy & Cheong (2013) argued that it was more appropriate if baselines would be characterized in value terms to scale compensatory restoration. In Sri Lanka, only mangrove valuation has been done. But some studies showed that the mangrove valuation in Sri Lanka was underestimated as it considered only marketed services such as fishery and forestry benefits (Gunawardena & Rowan, 2005). Barbier (2013) also stated that most valuation studies had mainly focused on few ecosystem services and goods. But there were many vital services such as nutrient cycling, coastal protection, erosion control, carbon sequestration, which did not have observable marketed outputs. When considering the overall capacity of Sri Lanka, the ecosystem valuation is quite challenging with the limited technical, funding capacity and scarcity of environmental economists in the country. Further, the available literature on marine valuation is insufficient to make effective policy decisions (Barbier, 2013).

Pollution disaster of X-Press Pearl incident (2021) has faced challenges in quantifying the environmental loss using travel cost and contingency valuation techniques as reduced tourist visits to Sri Lanka due to the COVID 19 pandemic. Further, due to the unavailability of the particular legal provision in MPPA related to NRDA for oil spills, it was unclear which scaling method had to be used. Considering all the issues, this study intended to suggest a service-to-service scaling mechanism; Habitat Equivalency

Analysis (HEA), over the valuation approaches to quantify the interim loss caused to the natural resources and services.

Without having a standard scientific guide or NRDA plan, the existing compensatory process might be politically driven and unscientific. Hence this study proposes to adopt a feasible and compensable NRDA procedure (with NRDA&R Plan and Pre-spill NRDA Plan) for oil spill pollution incidents in Sri Lanka. The NRDA procedure would be gazetted under the MPPA or would be adopted as an amendment to the MPPA.

Training needs and capacity building

During the study, it was identified that awareness building and comprehensive training opportunities were essential and urgent needs in the country. Gunasekara (2018) stated that the non-availability of trained human resources was the main issue in implementing the oil spill contingency plan of Sri Lanka. It is proposed to establish a dedicated damage assessment team. It would provide a strong base for capacity building (Jones & DiPinto, 2018). The training needs highlighted during the study were field techniques, environmental valuation, and modern restoration technologies. For such training needs the coordination with other regional initiatives which conduct resource inventories will be important (Jones & DiPinto, 2018). Moreover, it is suggested that all personnel participating in oil spill damage assessment surveys should be trained and familiarized with relevant procedures and equipment and all those personnel should be updated periodically with new knowledge. It will enhance the competency level of officers in responsible organizations (Piyadasa, 2014). As the study demonstrated, establishing a sophisticated central laboratory system in Sri Lanka for analysing samples of damage assessment was a vital requirement that should be paid urgent attention.

NRDA response fund

The establishment of a NRDA response fund was the other central aspect of NRDA process. Piyadasa (2014) stated that there should be an independent and sustainable funding mechanism in the absence of adequate government fund allocation in environment protection from oil pollution incidents in Sri Lanka. The study also identified that a long-term self-sustainable funding mechanism would be fundamental in marine environment protection efforts. The money collected as fines for oil pollution incidents under civil liability and criminal liability provisions of MPPA was debited as treasury funds. Based on those funds, MEPA staff had got welfare facilities such as loan schemes. But neither of those funds has been allocated for compensatory restoration programmes for particular oil spill damage nor any other environmental protection programme. Piyadasa (2014) expressed that a marine environment protection fund could be established in Sri Lanka based on the polluter pay principle. Thus, the legal provisions have to make a statutory obligation to expend this money solely on restoring or replacing equivalent natural resources and holding the capital in reserve (Jones & DiPinto, 2018). These all facts are suggested to be considered when founding a NRDA response fund in Sri Lanka.

5.3 Recommendations for the application of Habitat Equivalency Analysis (HEA) in Sri Lanka

The HEA has become the most widely accepted method to assess ecological damages, scale restoration in NRDA (Baker et al., 2020; Desvousges et al., 2018; Kim et al., 2017) and to settle NRDA claims (Dunford et al., 2004). HEA is applied successfully in USA and EU countries (e.g. Germany, Sweden, UK, Spain, Poland, Czech Republic) (Shaw & Wlodarz, 2013). The study done by Barbier (2013) explained the pros and cons of the HEA, focusing on both economic and ecological perspectives emphasizing that HEA had more advantages over conventional monetary compensation methods.

The restoration planning phase of NRDA comprises two parallel processes, "injury assessment" and "restoration selection." During the injury assessment, the trustee quantifies the damage to natural resources while in restoration selection, restoration alternatives that meet restoration objectives are formulated (NOAA, 1997). This study identified several challenges in the restoration planning phase (Table 4.4) in Sri Lanka. The application of HEA may provide a flexible solution for most of them. It avoids costly and prolonged litigation processes and expensive economic valuation studies (Barbier, 2013) and it requires relatively simple computations (Desvousges et al., 2018). A respondent expressed that in Sri Lanka, the planned restoration activities would not be implemented successfully if the claim would not be obtained fully. But in HEA since both the responsible party and trustee have the opportunity to come to an agreement ensuring the amount of money for the proposed project (Barbier, 2013).

When considering the impacts on aquatic fauna and avifauna, which were not quantified directly into the HEA model, several projects have shown that it could be assessed by converting their biomass to equivalent plant production (salt-marsh, seagrass) considering trophic level transfers (Penn, 2002). Finding the best metric or indicator species (fauna or flora) that characterizes ecological losses and gains is the key to determining whether HEA is appropriate in a given context (NOAA, 2000; Bas et al., 2016). Hence as some respondents replied, it would need more future researches to identify possible indicators depending on the dominant ecological and geographical context in Sri Lanka. High cost associated with restoration technologies is another issue identified in the study. The HEA method produces several restoration options and allows trade-offs among proposed projects to find the best, cost-effective and efficient restoration alternative (Desvousges et al., 2018; Scemama & Levrel, 2016; Barbier, 2013; Roach & Wade, 2006). Another unavoidable challenge is more frequent extreme weather patterns in Sri Lanka attributed to monsoon seasons and climate change. As respondents answered, "*it is challenging to conduct underwater or coastal restoration* *programs due to rough sea conditions*.” Hence it should be considered during the restoration planning phase.

HEA has several assumptions and input variables as any mathematical model to derive the result (Scemama & Levrel, 2016; Dunford et al., 2004). When properly structured and applied, it will produce reliable results for oil spill incidents and other simple cases, including hazardous-substance releases (Dunford et al., 2004). Though the scientific literature regarding the theory of HEA is relatively complete, it is encouraged to observe how the complicated ecosystem services are integrated through HEA as damage assessment practices (Desvousges et al., 2018). Moreover, it is recommended that the trustees to evaluate whether the conditions of HEA are fulfilled and to evaluate the use of valuation methods as an alternative (NOAA, 2000). Ecosystem valuation might be invoked if compensatory restoration projects cannot provide ecologically similar services or resources to those lost (Kennedy & Cheong, 2013). Further, the presence of human use losses will not preclude the application of HEA. Several NRDA cases (e.g. NRDA for the 1996 North Cape oil spill) have used HEA and market-based monetary valuation methods separately to address ecological losses and human use losses (e.g. recreation), respectively (Roach & Wade, 2006). As HEA deals with service-to-service comparison, the role of environmental economists and ecologists is crucial. For this reason, it seeks joint ecological and economic research cooperation (Shaw & Wlodarz, 2013).

Chapter 06

SUMMARY AND CONCLUSIONS

This study has evaluated the existing natural resource damage assessment procedure for oil spills in Sri Lanka and the national legal regime for environmental damage claims. The analysis of results highlights the following findings and implications.

First, though a number of oil spill incidents occurred in the past, no single case has been claimed as environmental damage compensation other than direct costs under the criminal and civil liability provisions of the MPPA. Several loopholes and constraints in the MPPA were identified, including the absence of internationally permissible environmental damage quantification method and unavailability of specific legal provision for restoration-based environmental damage claims. Hence the study emphasizes the importance of reformations to statutory provisions to address those loopholes to protect the marine environment from oil pollution damages.

Second, as a party to the CLC (1992) and IOPC Fund (1992), when claiming environmental compensation, Sri Lanka must have an internationally admissible NRDA procedure with an acceptable ecological damage scaling method. This study demonstrated that the existing oil spill damage assessment procedure in Sri Lanka was rudimentary and not conducted methodically. Possible solutions and recommendations have been given for challenges including but not limited to unavailability of standard protocol to guide damage assessment process, issues in obtaining quality baseline data from different organizations, absence of a NRDA response fund, lack of specific knowledge and skills on coastal and marine environmental damage assessments and scaling techniques. To overcome most of these hindrances, it is urged to develop a feasible NRDA process in order to meet national and international compensatory requirements. The NRDA process shall be gazetted under the MPPA or shall be adopted as an amendment to the MPPA.

Third, the study proposes the Habitat Equivalency Analysis (HEA) as an alternative scaling technique over economic valuation approaches. The comprehensive qualitative analysis of challenges and opportunities during the study disclosed that to quantify the ecological losses during the NRDA process, it would be worth adopting the HEA in Sri Lanka. It appears to be a more feasible technique for making successful claims through the international legal regime. It articulates a preference for resource restoration (as primary and compensatory restoration) rather than monetary compensation for the impaired natural resources and services.

Fourth, several research needs were identified for filling the gaps in scientific knowledge within the purview of oil spill damage assessment in Sri Lanka. The studies to determine best coastal habitat restoration methods, field-level studies on the general ecological characterization of marine species (e.g. reproductive success, feeding habits), population dynamic studies for commercially valuable species, surveys on species live on the continental shelf, comprehensive research for finding indicator species important in HEA, case studies for applying HEA are some key areas as future research needs.

Finally, adhering to NRDA procedure with enhanced competence level of responsible organizations and cross-disciplinary collaboration among ecologists and economists from the onset of oil spills would result in more accurate and compensable ecological damage estimates. The success in the natural resource damage compensation regime for oil spills in Sri Lanka will ultimately protect the environment and the public as a "whole."

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Appendix A: Algebra of HEA

Standard formula for calculating the appropriate scale of a compensation project using Habitat Equivalency Analysis (HEA) (NOAA, 1995)

Appendix A: Algebra of HEA

Below, we outline the generic formula employed to calculate the appropriate scale of the compensation project. We first provide the notation for the HEA calculations.

Let t refer to time (in years), where the following events occur in the identified years:

$t=0$, the injury occurs

$t=B$, the injured habitat recovers to baseline

$t=C$, time the claim is presented (2000)

$t=I$, habitat replacement project begins to provide services

$t=M$, habitat replacement project reaches full maturity

$t=L$, habitat replacement project stops yielding services

Other variables in the analysis include:

V_j , the value per acre-year of the services provided by the injured habitat (without injury)

V_p , the value per acre-year of the services provided by the replacement habitat

x_t^j, the level of services per acre provided by the injured habitat at the end of year t

b^j , the baseline (without injury) level of services per acre of the injured habitat[16]

x_t^p, the level of services per acre provided by the replacement habitat at the end of year t

b^p, the initial level of services per acre of the replacement habitat

ρ_t , discount factor, where $\rho_t = 1/(1+r)^{t-C}$, and r is the discount rate for the time period

J, the number of injured acres

P, the size of the replacement project

We select a metric, x, for capturing overall level of habitat services, or habitat function, which could represent a single service flow from the resource or an index that represents a

[16] We simplify the representation of the baseline to be constant through time. Seasonal or inter-annual (or other) forms of variation could be incorporated, by adding time subscripts to the baseline variable b.

weighted average of multiple service flows. In the chosen metric, we define: x_t^j as the level of services per acre provided by the injured habitat at the end of year t, and b^j as the baseline level of services of the injured habitat; consequently, $(b^j - x_t^j)$ is the extent of injury in year t.[17] Analogously, we define x_t^p, as the level of services provided by the replacement habitat at the end of year t, and b^p as the initial level of services of the replacement habitat, prior to any enhancement activities; consequently, $(x_t^p - b^p)$ represents the *increment* in resource services provided by the replacement project - which is the relevant measure for our analysis. In our discussion in the text in the body of this paper, however, we referred to habitat services as a percent of the baseline level of services of the injured habitat, b^j; in this format, $(b^j - x_t^j)/b^j$ represents the percent reduction in services per acre at the injured site from the injured site baseline, and $(x_t^p - b^p)/b^j$ represents the percent increase in services per acre, relative to the injured site baseline, for the replacement site.

To translate the quantity in year t into an effective quantity in the year of the claim, C, we apply the discount factor $\rho_t = 1/(1+r)^{t-C}$, where r is the annual discount rate. Finally, the number of injured acres is J. The goal of the habitat equivalency analysis is to solve for the size of the replacement project, P.

[17] For ease of calculation all services flows are calculated from values at the end of each year. More precise estimates of the level of discounted service flows could be obtained by using smaller time periods (e.g. semi-annual or monthly). If smaller time periods are used the discount rate should be adjusted to keep the annual discount rate unchanged.

The equation equating the sum of the present discounted value of the services lost at the injured site with the sum of the present discounted value of the services provided at the replacement site becomes:

$$\left[\Sigma_{t=0}^{B} V_j * \rho_t * \left[\left(b^j - x_t^j\right)/b^j\right]\right] * J = \left[\Sigma_{t=I}^{L} V_p * \rho_t * \left[\left(x_t^P - b^P\right)/b^j\right]\right] * P$$

Under the assumption that the per unit value of replacement habitat services, V_p , is equal to the per unit value of injury habitat services, V_j , the calculation to solve for the size of the replacement project then becomes:

$$P = \frac{\left[\Sigma_{t=0}^{B} \rho_t * \left(b^j - x_t^j\right)/b^j\right] * J}{\left[\Sigma_{t=I}^{L} \rho_t * \left(x_t^p - b^p\right)/b^j\right]}$$

Note that the variables representing the per unit values of services drop out of the equation.

If the per unit values of lost and replacement services are not equal, then an alternative restoration scaling approach may be necessary. The HEA can still be applied if the value differences are known or can be estimated. In that case, the calculation to solve for the size of the replacement project is:

$$P = \frac{V_j}{V_p} * \frac{\left[\Sigma_{t=0}^{B} \rho_t * \left(b^j - x_t^j\right)/b^j\right] * J}{\left[\Sigma_{t=I}^{L} \rho_t * \left(x_t^p - b^p\right)/b^j\right]}$$

The ratio of $\frac{V_j}{V_p}$ is greater than one if the per unit value of the injured services is greater than the per unit value of the replacement services. Subsequently, more of the replacement project habitat would be needed than if the per unit values were equal. Less of the replacement project habitat would be needed if the per unit value of the injury habitat is less than the per unit value of the replacement habitat.

Appendix B: Participation information sheet

Establish under the auspices of the International Maritime Organization
a specialized agency of the United Nations

PARTICIPATION INFORMATION SHEET

Project title: Natural Resource Damage Assessment for Oil Spills in Sri Lanka: The of Habitat Equivalency Analysis
Researcher: S.M. Dinishiya Athukorala
Supervisors: Professor Johan Hollander

I am S.M.Dinishiya Athukorala. Currently, I am following Master of Science in Maritime Affairs specialized in Ocean Sustainable, Governance, and Management at World Maritime University, Malmo. You are being invited to take part in a research study about Natural Resource Damage Assessment for Oil Spills in Sri Lanka: The Application of Habitat Equivalency Analysis. We strongly believe that you can make an important contribution to this research study.

PURPOSE OF RESEARCH STUDY

Oil spills are a major threat not only to the environment but also to the human health and national economy of a country. My research study aims to assess the existing issues in natural resource damage assessment (NRDA) processes and constraints in compensation regime for environmental damages caused by oil spills in Sri Lanka. Challenges and opportunities will be analysed for application of Habitat Equivalency Analysis (HEA) as a NRDA method of oil spills in Sri Lanka. Moreover, the study is to find the solutions and recommendations for the application of the Habitat Equivalency Analysis as compensation method of environmental damages due to oil spills under the International Oil Pollution Compensation Fund (Fund Convention) and International Convention on Civil Liability for Oil Pollution Damage (CLC) in Sri Lanka.

INTERVIEW REQUEST

The aim of this interview/ questionnaire survey is to acquire your experience and perception in natural resource damage assessment (NRDA) process for oil spills in Sri Lanka. In particular, I would like to discuss the current practices of NRDA process, challenges, gaps and loopholes in legal regimes as well as your recommendations for better NRDA system for oil spills in Sri Lanka.

PROCEDURE

The questionnaire which follows a semi-structured format will require 25-30 minutes to be completed. Or if you prefer, you may have an interview over video conference meeting (Ex: Via Zoom). The interview will require 15-20 minutes and consists of same questions included in the questionnaire. As the interview proceeds, we may ask questions for clarification or further understanding. Mainly I may listen to your views, opinions, experiences, or knowledge on the matter at hand. The interview will be recorded via handwritten notes and an electronic audio recording device. However, you may opt out of the electronic audio recording.

USE OF DATA

The data collected from the research study will be used to complete the master's thesis research and the thesis's production. Data may also be used in the publication or presentation of the thesis and publications or presentations arising from the thesis. A summary of the thesis will be made available to you as a copy, which will be sent through email.

CONFIDENTIAL

The information collected from participants will be kept private with strict confidence. You are given the option to be named in research. If you do not wish to be named in the study, then your identity will be excluded from academic publications and presentations arising from this research. I will do ensure that every possible effort will be made to confirm your identity remains anonymous. However, due to the small number of participants and the specialized nature of your role, it still may be possible your identity will be identifiable by the nature of your comments.

BENEFITS

There will be no direct benefit to you if you participate in this interview. However, the possible benefits of your participation in society include the potential development & improvement of legislation, current NRDA procedure, capacity building, training needs identification and etc in Sri Lanka. It will improve the health and well-being of coastal and marine ecosystems and reduce the impacts of oil spills, therefore benefiting human health. Other benefits include a possible identification of loopholes and gaps in national legal regime when filing damage & restoration claims after an oil spill disaster. These will be timely needs for Sri Lanka as well. You will not receive any compensation for participating in the interview.

DATA STORAGE

All data relating to the study will be stored securely and kept until the completion of this study. The audio recordings taken during interviews will be kept on a computer protected by a password. Data will also be stored in virtual drive linked to the university personal email. Hard copies of data (i.e., transcript, notes) will be securely stored in a locked filing cabinet. Consent forms will be stored in a locked cabinet in the supervisor’s office on the University premises. All materials will be retained for the research period and will be either deleted or shredded as soon as the degree is awarded. The material you provide will only be used for this research project, and it will only be disclosed with your permission.

VOLUNTARY PARTICIPATION

Please read this carefully and ask any questions or more information before deciding whether or not to participate.

Your participation is voluntary in this research study. If you don’t wish to participate, you don’t have to. However, if you decide to participate in the research project, you will be asked to sign the consent form. By signing in, you are telling us that you:

- Understand what you have read
- Consent to take part in the research project

WISH TO WITHDRAW

You will be permitted to withdraw from the interview at any time without giving a reason.

Thank you very much for your time. If you wish to know more and ask a question, please feel free to contact my supervisor or me at:

CONTACT INFORMATION
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Appendix C: Consent form

WMU WORLD MARITIME UNIVERSITY

Dear Participant,

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in Maritime Affairs at the World Maritime University in Malmo, Sweden.

The Topic of the Dissertation is " **Natural Resource Damage Assessment for Oil Spills in Sri Laka: The Application of Habitat Equivalency Analysis"**

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will be published online and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymised research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

Your participation in the interview is highly appreciated.

Student's name	S M Dinishiya Athukorala
Specialization	Ocean Sustainability, Governance and Management
Email address	w1802079@wmu.se

* * *

I consent to my personal data, as outlined above, being used for this study. I understand that all personal data relating to participants is held and processed in the strictest confidence, and will be deleted at the end of the researcher's enrolment.

Name: ……………………………………………………………………………

Signature: ……………………………………………………………………………

Date: ……………………………………………………………………………