

DEFENCE AND SECURITY JOURNAL



Defence Services Command and Staff College Sri Lanka
2024



DEFENCE SERVICES COMMAND AND STAFF COLLEGE (DSCSC)

SRI LANKA

ABOUT US

In the beginning, the Army Command and Staff College (ACSC) was established by the Sri Lanka Army on 16 March 1998 with the first course consisting of 26 Course Participants including few selected Course Participants from the Sri Lanka Navy and Sri Lanka Air Force, and with the aim of developing the professional knowledge and understanding, both in Command and Staff aspects.

The change from ACSC to DSCSC on 22 January 2007 could be perceived as an indication shown from the very inception on the importance of a Joint Services atmosphere. Moreover, the effort of all military arms was felt imperative to be joint, in order to combat very own adversary thus setting greater emphasis on 'Joint Environment'. The DSCSC Course No 1 commenced with 36 Course Participants from the Army, 8 Course Participants from the Navy and 10 Course Participants from the Air Force with respective Services function under three wings namely Army, Navy and Air.

At present, the DSCSC set out to train middle grade officers of the armed forces, both local and foreign, in command and staff techniques, but just as important, it aims at helping them to develop the intellectual attributes to cope with their future appointments and the challenges that are inevitable in the years ahead. By this process, DSCSC seek to develop their breadth of understanding and the ability to analyse and evaluate different issues in logical ways to derive possible solutions in the contemporary security environment.

VISSION

To be the premier centre of excellence in preparing emerging leaders of the three services and selected public officials to meet evolving defence and security challenges.

AIM

To develop the professional knowledge and understanding of selected Course Participants from the Three-services, Sri Lanka Police, friendly foreign countries and other public institutions in order to prepare them for appointments on Command and Staff, whilst imparting knowledge on government procedures and public sectors.

DEFENCE AND SECURITY JOURNAL

December 2024

Volume 9

Defence Services Command and Staff College
Sri Lanka

EDITORIAL BOARD

Editors-in-Chief

Major General DKSK Dolage USP psc - Commandant

Dr George IH Cooke

Editors:

Colonel NPA Mendis psc - Head of the Training Team, Army Wing

Captain (ASW) SK Vidanage USP psc - Head of the Training Team, Navy Wing

Group Captain WUS De Silva USP psc - Head of the Training Team, Air Wing

Colonel WHMCK Wijekoon WWV RWP RSP USP psc - Directing Staff

Commander (C) KJP Rohana psc - Directing Staff

Wing Commander MADCK Wijethunga psc - Directing Staff

Associate Editors:

Lieutenant Colonel GKGPS Gannoruwa RWP RSP USP SLLI - GSO I (Training Support)

Major ADB Attanayake VIR - GSO II (Production / Publication)

Major GLA Geeganage SLAGSC - English Instructor

Design & Print: White Hackle Publication - Sri Lanka Light Infantry

Defence and Security Journal, Volume 9, 2024

© Defence Services Command and Staff College, Sri Lanka 2024

All Rights Reserved. No material in this publication may be reproduced without the written permission of the publisher.

ISSN 2536-8745

Disclaimer: The views expressed and the information contained in the papers included in this publications are the sole responsibility of the author, and do not bear any liability on the Defence Services Command and Staff College, Sri Lanka.

FOREWORD



As the Commandant of Defence Services Command and Staff College (DSCSC), it is both privilege and honour for me to introduce the latest volume of 'Defence and Security Journal – 2024' of DSCSC. This annual academic journal is 9th of the series reflecting our collective commitment to foster intellectual discourse and advancing the knowledge landscape in defence and strategic studies.

In an era marked by dynamics of volatility, uncertainty, complexity and ambiguity in challenges to global, regional and national security, continuing intellectual advancement in the strategic studies discipline is essential. Therefore, contribution of military officers and scholars to explore the dynamics of contemporary and future challenges deem necessary for strategic development of our nation. This journal serves as a platform for our Faculty, Course Participants and distinguished scholars to present their wealth of knowledge and views on different issues ranging from traditional military threats to emerging domains such as cyber security, hybrid conflicts etc. It is through this intellectual rigour that we ensure our Defence Services remain adaptive, informed and prepared for to face the uncertainties of the contemporary strategic environment.

The articles featured in this edition represent a rich tapestry of perspectives, encompassing operational insights, strategic evaluations, and explorations of present and future trends. Such diversity underscores the multidisciplinary approach that is fundamental to address contemporary challenges to national defence sector. These contributions not only enhance our understanding but also strengthen the professional acumen of our officers, enabling them to excel as leaders and decision-makers.

I extend my heartfelt gratitude to the authors for their invaluable contributions and the Editorial Board for their unwavering commitment to produce this scholarly journal. Together, we continue to uphold the ethos of excellence that defines the purpose of DSCSC to produce competent and confident middle-grade leaders ready to face challenges of 21st Century.

As you explore the pages of this journal, I invite you to reflect on the ideas presented and to engage with them critically. Let us harness this opportunity to advance collective knowledge to ensure national security environment conducive for future prosperity of Sri Lanka.

Major General DKSK Dolage USP psc

Commandant

Defence Services Command and Staff College, Sri Lanka

CONTENTS

THE DOUBLE-EDGED SWORD: ARTIFICIAL INTELLIGENCE AND NATIONAL SECURITY IN SRI LANKA	01
Brigadier KVP Dhammika USP ptsc MPhil MSc BSc	
HEATING THE BATTLE SPACE: CONSEQUENCES OF CLIMATE CHANGE ON AIR OPERATIONS	10
Wing Commander HWN Wanasinghe psc and Wing Commander MADCK Wijetunge psc	
SRI LANKA’S STRATEGIC RE-EMERGENCE AS SEA POWER NATION IN THE INDIAN OCEAN THROUGH MAHAN’S PRINCIPLES	27
Commander (C) AGMPK Wijenayaka RSP psc MSc (D & SS) MAIR (UoP) PG Dip in CPS BNavalSt (Maritime Warfare) Hons	
ADVANCING MARITIME SECURITY: INTEGRATING BIG DATA ANALYSIS FOR SURVEILLANCE AND CLASSIFICATION IN SRI LANKA	46
Commodore N Ranasinghe RSP USP psc MSc Dip in WA&DS Dip in Strat and Def Studies	
THE NEXT GENERATION OF WARFARE: HARNESSING ARTIFICIAL INTELLIGENCE	63
Asela Waidyalankara, Cybersecurity Analyst	
A COMPARATIVE ANALYSIS OF CLAUSEWITZ AND CAPTAIN LIDDELL HART’S MILITARY THEORIES AND THEIR APPLICABILITY IN THE MODERN WARFARE: INSIGHTS FROM SRI LANKA AND UKRAINE	72
Dr Punsara Amarasinghe PhD and Prof Rohan Gunaratna PhD	
Note on Contributors	84

THE DOUBLE-EDGED SWORD: ARTIFICIAL INTELLIGENCE AND NATIONAL SECURITY IN SRI LANKA

Brigadier KVP Dhammika USP ptsc MPhil MSc BSc

ABSTRACT

The national security landscape of Sri Lanka faces a double-edged sword with the rise of Artificial Intelligence (AI). While AI offers significant advantages in threat detection, cybersecurity, and intelligence gathering, its effectiveness hinges on unbiased training data and algorithms. Biases in AI systems can lead to misinterpretations, missed threats, and ultimately, a weakened national security posture. This paper explores the two main types of AI bias - data bias and algorithmic bias, and their potential consequences for Sri Lanka. It further delves into the decision-making processes of AI systems, including the role of Fuzzy Logic and Neural Networks, and how these techniques can introduce biases.

The pervasive digital news environment, spanning television and online platforms, has a dual role. While it keeps the public informed, it often disproportionately highlights negative events such as crimes, robberies, and assaults. This continuous influx of negative information feeds AI models, including Large Language Models (LLMs) and future image and video recognition systems, potentially skewing their output. The unchecked nature of this data dissemination can adversely affect Sri Lanka's image and national security. This paper suggests a balanced approach to harness AI's benefits while safeguarding the national narrative. Finally, the paper proposes mitigation strategies to ensure responsible AI development and deployment, safeguarding Sri Lanka's national security.

Key Words: AI Biases, Neural Networks, Fuzzy Logic, Data Biases and Algorithmic Biases.

1. INTRODUCTION

The national security of Sri Lanka is undergoing a critical transformation with the integration of AI systems. While AI promises faster and more accurate threat detection, cyber defence fortification, and improved intelligence gathering, its success hinges on unbiased data and algorithms. Biased AI systems can lead to misinterpretations of data, missed threats, and ultimately, a false sense of security. For instance, an AI system trained on biased data might disproportionately flag individuals from certain ethnicities as potential threats, leading to wasted resources and eroded public trust. This paper examines the two primary sources of AI bias - data bias and algorithmic bias, and their potential consequences for Sri Lanka's national security.

The media landscape has transformed with the advent of digital platforms, shifting news dissemination from scheduled broadcasts and print to a constant flow of information. Although this democratizes access to news, it also prioritizes sensationalized, often negative content. This exposure creates extensive datasets for AI training, particularly for LLMs and future image and video recognition systems. However, without control over the nature of this information, the result can be a distorted perception of reality. For Sri Lanka, this could mean a global image dominated by crime and instability, potentially impacting tourism, foreign investment, and national security.

2. THE TWO FACES OF AI BIAS: DATA AND ALGORITHMS

AI systems rely on massive datasets to learn and make decisions. However, these datasets can be inherently biased, leading to biased outcomes. This is known as data bias. Sri Lanka's diverse population with various ethnicities, religions, and socioeconomic backgrounds necessitates representative training data for AI systems. If the data primarily reflects a specific demographic, the AI might develop biases against others, leading to false positives and a distorted understanding of potential threats. Furthermore, historical biases embedded in data, such as skewed arrest records, can perpetuate unfair profiling of certain communities.

The design of the AI algorithms themselves can also introduce bias, known as algorithmic bias. For instance, AI systems designed for language processing might struggle with languages like Tamil or Sinhala due to limitations in their training data. This could lead to the misinterpretation of social media posts or communications, potentially suppressing legitimate dissent and hindering security efforts. Another example is the use of Fuzzy Logic in AI decision-making. Fuzzy Logic, unlike traditional digital logic with clear 0s and 1s, allows for degrees of truth between these values. While helpful in dealing with imprecise data, Fuzzy Logic introduces bias during the definition of membership functions and rules. These functions can unconsciously reflect the biases of the developers, impacting the AI's decision-making process.

3. UNDERSTANDING AI DECISION-MAKING: FUZZY LOGIC AND NEURAL NETWORKS

Many AI systems, particularly those used for image and video recognition, rely on Neural Networks. A neural network consists of interconnected 'neurons' organized into layers. The three main types of layers are:

- a. **Input Layer:** Receives the initial data (features) and passes it to the next layer.
- b. **Hidden Layers:** Intermediate layers between the input and output layers. They learn complex representations.
- c. **Output Layer:** Produces the final prediction or output.

(INTENTIONALLY KEPT BLANK)

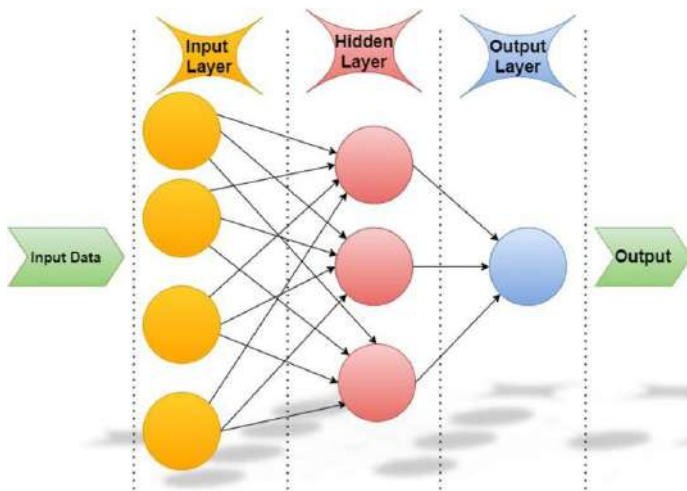


Figure 1: Three Main Layers of Neural Network

Each connection between neurons has an associated weight, and neurons apply an activation function to the weighted sum of their inputs to produce an output. Common activation functions² include:

- a. **ReLU (Rectified Linear Unit):** $f(x) = \max(0, x)$
- b. **Sigmoid:** $f(x) = 1 / (1 + e^{-x})$
- c. **Tanh (Hyperbolic Tangent):**
 $f(x) = (e^x - e^{-x}) / (e^x + e^{-x})$

These functions enable the network to model complex, non-linear relationships within the data.

During training, data flows through the network in a forward direction from input to output, with each layer computing its output based on the weighted inputs and an activation function. The final output is compared to the ground truth to compute the loss. Back-propagation is then used to adjust the weights based on this loss, with the goal of minimizing the loss through optimization algorithms like gradient descent. Neural networks with multiple hidden layers, referred to as deep neural networks, leverage these deep architectures to learn complex features and representations, a process known as deep learning.

These complex mathematical models mimic the structure of the human brain, learning from vast amounts of data. However, neural networks can inherit biases from the data they are trained on. Let's consider a simplified example:

Imagine an AI system trained to identify suspicious activity in images. The training data primarily consists of images depicting individuals with a specific clothing style as potential threats. The neural network, based on this biased data, might incorrectly flag anyone wearing similar clothing as a threat, regardless of their actual behavior.

3.1 Mitigating AI Bias for a Secure Sri Lanka

To ensure responsible AI development and mitigate potential biases, Sri Lanka can implement several strategies:

a. Data Diversity: Collaborate across government, academia, and civil society to ensure AI training data reflects the country's diverse population. Data diversity, like a well-balanced recipe, is all about having a variety of ingredients. In the world of AI, this translates to using a broad range of information to train AI models. Here's how data diversity benefits society and future AI:

(1) Positive Impacts on Society:

(a) **Better Decision-Making:** Imagine a self-driving car trained mostly on data from highways. It might struggle in narrow city streets. Diverse data, including urban environments, helps AI models adapt to real-world complexities, leading to fairer and more accurate decisions.

(b) **Reduced Bias:** AI models are only as good as the data they're trained on. Biased data can lead to biased AI. Data diversity helps mitigate this by ensuring a wider range of perspectives are included, leading to fairer outcomes for everyone.

(c) **Innovation and Creativity:** When AI encounters a wider range of information, it can spark new connections and ideas. This can fuel innovation in various fields, from medicine to art, by helping AI identify patterns humans might miss.

(2) **Importance for Future AI Systems:** As AI becomes more integrated into our lives, data diversity becomes even more critical. Here's why:

(a) **Robustness:** Imagine a healthcare AI trained primarily on data from healthy individuals. It might struggle to diagnose illnesses effectively. Diverse data, including patient information with various health conditions, helps AI models handle unexpected situations.

(b) **Scalability:** As AI takes on more complex tasks, it will need to process massive amounts of information. Diverse data helps AI models generalize their knowledge and apply it to new situations, making them more scalable.

(c) **Transparency / Trust:** When people understand the data used to train AI, they are more likely to trust its decision-making. Data diversity helps build trust by demonstrating that AI considers a wide range of viewpoints.

b. Human Oversight: Maintain human involvement in AI-driven decision-making processes to interpret results, address potential biases, and ensure accountability. Human oversight in AI is like having a final edit before hitting publish. Imagine an AI writing news articles. It can crank out tons of content, but it might miss something crucial, like factual errors or offensive language. A human editor can review the AI's work, ensuring accuracy and avoiding bias. This keeps the AI efficient and keeps humans in control.

c. **Algorithmic Transparency:** Invest in Explainable AI (XAI) technologies to understand how AI algorithms reach their decisions, allowing for bias detection and correction. Artificial intelligence (AI) has become a powerful tool, but sometimes these powerful models can be like black boxes - they give you an answer, but you don't understand how they arrived at that answer. This is where Explainable AI (XAI) comes in.

XAI is all about making AI models more understandable to humans. It is a set of techniques that can help you understand the reasoning behind an AI's decisions. There are a few reasons why XAI is important:

(1) **Trust:** If you do not understand how an AI system works, it's hard to trust its decisions. XAI can help build trust in AI systems by making their decision-making processes more transparent.

(2) **Fairness:** AI systems can sometimes be biased, reflecting the biases in the data they are trained on. XAI can help to identify and mitigate these biases.

(3) **Improvement:** By understanding how an AI system works, you can identify ways to improve its performance.

d. **There are a number of different XAI techniques, including:**

(1) **Feature Attribution:** This technique helps to identify which features of an input were most important in the AI's decision.

(2) **Model Inspection Techniques:** These techniques allow you to see how the AI model is making its decisions, step by step.

(3) **Counterfactual Explanations:** This technique allows you to see how the AI's decision would have changed if the input had been different.

XAI is a rapidly developing field, and there is still a lot of research to be done. But it is an important area of research, as it will help to ensure that AI systems are trustworthy, fair, and effective.

4. RECOMMENDATIONS

a. **Controlled Data Landscape for Mitigating AI Bias.**

Sri Lanka's national security hinges on responsible AI development, which requires addressing data bias in AI systems. The current media landscape, lacking a management system and dominated by adverse and negative news cycles, creates a major challenge. Here's a crucial recommendation:

b. **Implement a National Policy for a Controlled Data Manipulation in the Media, with a Specific Focus on Minimizing Repetitive Negative News.**

The absence of a media management system necessitates proactive measures. Sri Lanka can encourage media outlets to prioritize balanced reporting and factual information. This fosters a more nuanced national narrative and prevents the creation of biased datasets that can be harnessed by global AI systems.

c. **Fostering Collaboration for Responsible AI Development.**

To fully harness AI's potential for national security while mitigating bias, Sri Lanka needs a collaborative approach.

d. **Establish a National AI Task Force Comprising Government Agencies, Academia, the Private Sector, and Civil Society.**

This collaborative body can spearhead initiatives for:

- (1) **Developing a National AI Strategy:** A comprehensive strategy outlining ethical guidelines for AI development, data governance, and responsible use in national security applications.

(2) Promoting Research and Development: Necessarily Support research initiatives to explore bias mitigation techniques specific to Sri Lanka's diverse context. This could involve exploring alternative.

(3) Data sources beyond traditional media and developing culturally-sensitive AI algorithms.

5. CONCLUSION

By implementing these recommendations, Sri Lanka can proactively manage its data landscape and foster responsible AI development. These efforts will ensure that AI becomes a force for good, strengthening national security and fostering a secure future for its citizens.

AI offers significant potential to enhance national security in Sri Lanka. However, its effectiveness hinges on responsible development and deployment. By addressing data and algorithmic biases, Sri Lanka can leverage AI's strengths while safeguarding national security, upholding human rights, and maintaining public trust. A balanced approach that acknowledges both AI's capabilities and limitations is crucial for navigating the complex security challenges of the future. Sri Lanka's proactive approach to data and AI development will ensure it benefits from this powerful technology without compromising national security or public trust.

REFERENCES

Fernando, M. (2022). The Role of Explainable AI in Mitigating Algorithmic Bias. *Journal of Artificial Intelligence Applications*, 8(3), 245-262.

Lipton, Z. C. (2018). The flipside of fairness: A conversation about bias in the context of algorithmic decision-making. *Big Data & Society*, 1(1), 1-14.

Nair, V., & Hinton, G. E. (2010). Rectified linear units improve neural network acoustic models. *Proceedings of the 30th international conference on machine learning* (pp. 807-814). ACM

Smith, J. (2023). Understanding AI Bias and Its Implications for National Security. *International Journal of Security Studies*, 15(1), 112-129.

HEATING THE BATTLE SPACE: CONSEQUENCES OF CLIMATE CHANGE ON AIR OPERATIONS

Wing Commander HWN Wanasinghe psc and
Wing Commander MADCK Wijetunge psc

ABSTRACT

Climate change is not a prediction, it is a present-day ground reality. It has been accelerated by man-made reasons primarily by the emission of greenhouse gases and deforestation. This study is focused on the consequences of global warming specifically on air operations. Objectives of the study are to find out the consequences of global warming, particularly on air operations, to identify the measures taken by different stakeholders to address the issues due to global warming, to determine the level of commitment of aviators in adopting the measures to address global warming and potential inputs of technology to mitigate adverse effects of global warming on air operations. The methodology of the study adopted an inductive approach to this exploratory qualitative study and pragmatism was the philosophy. Grounded theory was the strategy and the time horizon was cross-sectional. Data collection and analysis happened to be the technique. Primary data were collected through a sample of aviators operating in tropical regions, selected through purposive sampling. The findings of the study revealed that, disrupted weather patterns, effects on aircraft performance, effects on human performance, sustainability of aircraft and associated equipment, risk of fire hazard and rise of sea level are the most pressing phenomena on air operations due to climatic change. There were two recommendations based on the research outcome namely, to encourage global-level discussions for seeking long-term solutions, continue research on sustainable solutions and develop a combined strategy. Human kind have already joined the vicious cycle of climate change and accelerated it through a variety of activities, essential for modern-day living. Yet there are ways and means to slow down the process of global warming, which require short-term and long-term solutions. Collective effort through genuine collaboration could yield better results than working in isolation.

Keywords: Air Operations, Global Warming, Climate Change, Sustainable Solutions

1. INTRODUCTION

Climate change is a novel notion. It is not a prediction but a ground reality today. It has been there at the outset. Then the question arises, why the world has paid more attention to climate change in the latter decades? It has been identified that man-made reasons have accelerated the rate of climate change significantly and in turn, there will be a dramatic change to the livelihood on planet Earth (Zandalinas, Fritschi and Mittler, 2021). Despite the way too different contributions to climate change by different stakeholders, the price for the same would have to be paid collectively. Nonetheless, certain states, regions, and entities would have more impact than others such as coastal regions and islands. Air space could be considered one of the most affected due to climate change. Thus, the study is focused on the inevitable consequences of one specific segment of climate change namely the global warming on air operations by military elements, which predominantly behaves across the atmosphere.

2. METHODOLOGY

Researchers adopted an inductive approach to explore the research gap between the expected effectiveness of the measures taken for addressing global warming and the actual effectiveness of those measurements. During the exploratory qualitative study, pragmatism has been the philosophy whilst adopting grounded theory as the strategy. The time horizon was cross-sectional. The collection of primary data was through interviews with aviators of the Sri Lanka Air Force, Royal Omani Air Force, Indian Air Force and Pakistan Air Force selected purposively. The study population was aviators operating in tropical regions, where atmospheric temperatures are relatively higher. The theoretical population is all aviators operating under a heated-up atmosphere as of now and in the future. Secondary data were collected through literature and related conference proceedings. Data collection and analysis was the technique adopted.

2.1 Conceptualization.

The conceptual framework has been formulated based on the theoretical framework as follows:

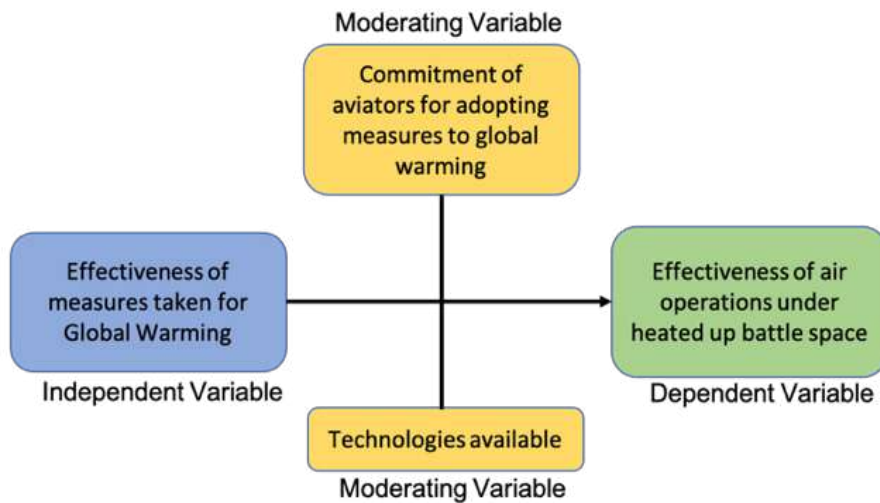


Figure 1: Conceptual Framework
Source: (Authors, 2023)

3. CLIMATE CHANGE AND GLOBAL WARMING

Climate change and global warming have emerged as two of the most pressing and inseparable environmental challenges today (Zandalinas, Fritschi and Mittler, 2021). The scientific consensus is clear: natural and man-made reasons. As far as human activities are concerned, particularly the burning of fossil fuels, emission of greenhouse gases and deforestation, are the primary drivers of these phenomena. The consequences of climate change and global warming are far-reaching and pose significant threats to global ecosystems, economies, industries and future generations.

One of the most evident impacts of climate change is the rise in global temperatures. Over the past century, the Earth's average temperature has increased by approximately 1 degree Celsius (Kerr, 2007). One degree may seem like a small change, but it has profound implications. Rising temperatures lead to the melting of polar ice caps and glaciers, causing sea levels to rise. Coastal regions are already experiencing more frequent and severe flooding, displacing communities and threatening infrastructure (Masson-Delmotte et al., 2018).

This paper intends to discuss the consequences of global warming rather than the reasons behind it. Even though the consequences of global warming

are multifaceted, this paper will limit its focus on the impacts particularly upon air operations as follows:

- a. Disrupted weather patterns.
- b. Effects on aircraft performance.
- c. Effects on human performance.
- d. Sustainability of aircraft and associated equipment.
- e. Risk of fire hazard.
- f. Rise of sea level.

Several organizations are monitoring and studying climate change and global warming. United Nations (UN), National Aeronautics Space Administration (NASA), Climatic Research Unit of the United States of America (USA), and National Oceanic and Atmospheric Administration of the USA...etc are among key such organizations. The statistics analyzed by these organizations unanimously represent a continual and sharp rise in global temperature. Two following indexes are depicting the rise of global surface temperature as well as the ocean temperature.

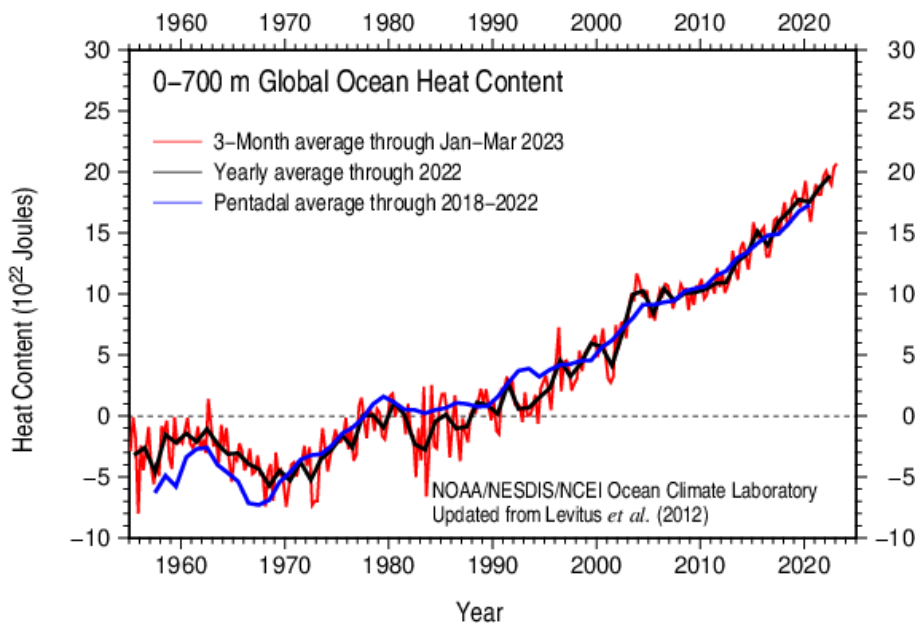


Figure 2: Global Average Surface Temperature Index
Source: www.climate.gov

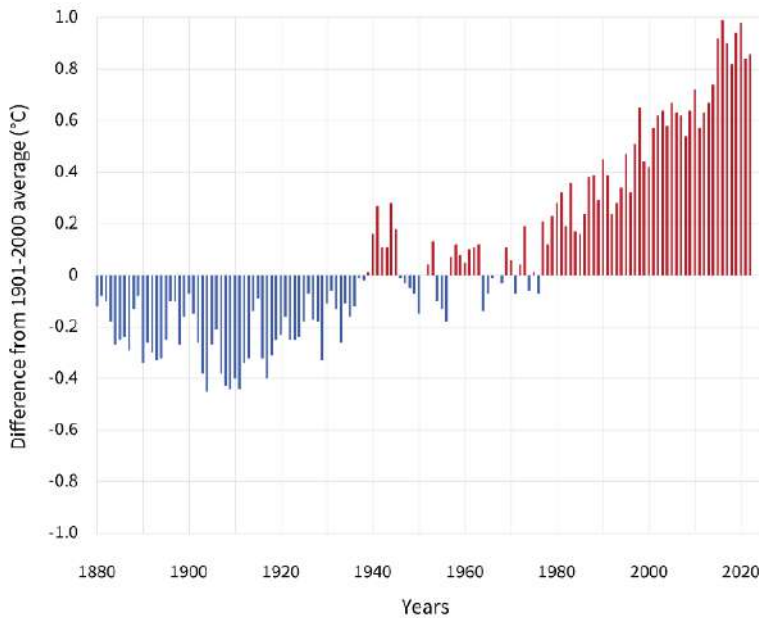


Figure 3: Global Average Ocean Heat Content
 Source: www.ncei.noaa.gov

The empirical data reveal that the hottest years as far as the average global temperature is concerned are 2016 and 2020. Nonetheless, 7-11 Jun 2023 had been recorded as the highest ever average global temperature recorded trussing previous data by a substantial margin as highlighted by European Union’s Climate Monitoring Unit.

“The world has just experienced its warmest early June on record”

- Samatha Burgess, Deputy Director of the Copernicus Climate Change Service.

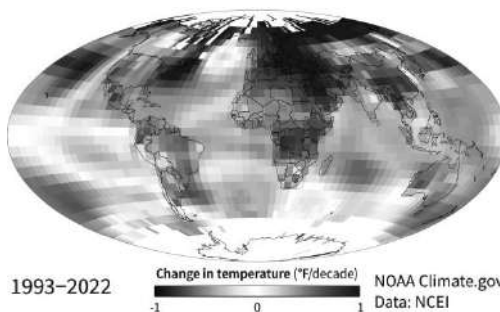


Figure 4: Recent Temperature Trends (1993-2022)
 Source: www.ncei.noaa.gov

It is more than 1.5 degrees Celsius than the pre-industrial era for the first time in history. These events have culminating effects on intense and long-lasting climatic changes in the future.

4. FINDINGS AND DISCUSSION

4.1 Disrupted Weather Patterns.

The atmosphere is the medium for air operations. Thus, at the outset, favorable weather conditions have been a decisive factor for the safety and success of air operations. Weather Radars, autopilot systems, and many other systems are been developed through modern technology to conduct air operations amid adverse weather (Beckwith, 1971). Nevertheless, extreme weather conditions such as storms, hurricanes, volcanic eruptions, heat waves, different forms of heavy precipitation...etc are still posing significant disruptions for air operations (Gultepe et al., 2019).

One of the most striking manifestations of disrupted weather patterns is the increasing frequency and intensity of extreme weather events. Rising global temperatures create favorable conditions for the formation and intensification of hurricanes and tropical storms. Warmer ocean waters provide the energy necessary for these systems to grow stronger, resulting in more destructive storms with higher wind speeds and heavier rainfall (Wuebbles et al., 2014).

Global warming further leads to the exacerbation of heat waves. Heatwaves are becoming more prolonged and intense, posing severe threats to humans, natural ecosystems and even man-made infrastructure. The combination of high temperatures and increased humidity creates a dangerous heat index, pushing the limits of human tolerance beyond the red line (Delworth, Mahlman and Knutson, 1999). The impact on human performance, aircraft and associated equipment due to higher temperatures is discussed subsequently.

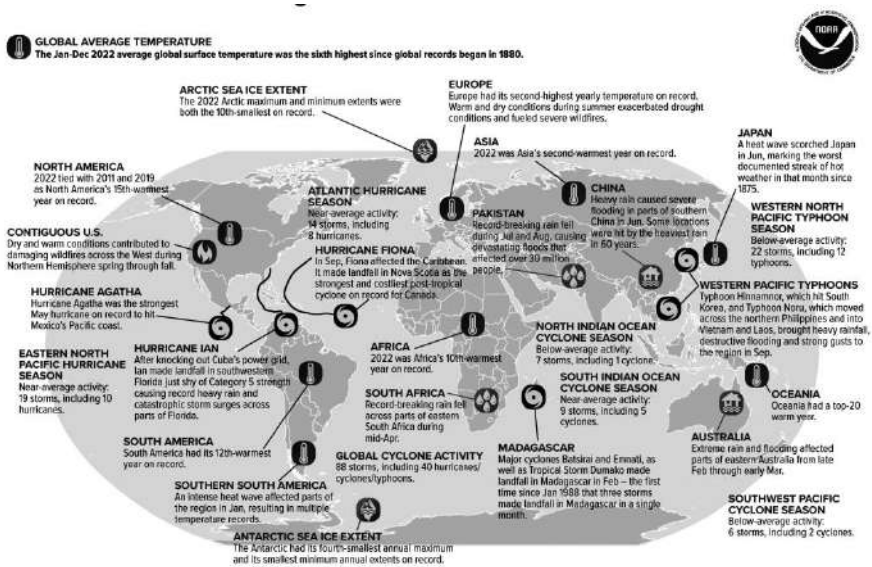


Figure 5: Selected Significant Climate Anomalies and Events in 2022

Source: www.ncei.noaa.gov

4.2 Effects on Aircraft Performance.

Global warming results in heating air than usual, which makes the air less dense causing numerous challenges to air operations. Mainly the effects of less dense air are twofold. On one hand, it affects the propulsion system. Air-breathing engine performance heavily depends on the quality of air it consumes (Wei et al., 2022). As per the gas laws, the density is proportional to pressure. Low pressure at the inlet results in low-pressure air at the combustion. With a drop in density and pressure, the partial pressure of oxygen also drops, which affects the fuel-air mixer adversely. All these phenomena are contributing to less efficient propulsion output (Whalley and Ebrahimi, 2002).

On the other hand, less dense air affects the aircraft's aerodynamic performance. Heavier than air machines are flown according to the laws of physics (Webster, 1920). There are several theories in combination that describes the principles of flight such as Bernoullies' theorem, Newtons' laws, Circulation theory, Magnus effect, Momentum theory...etc. Qualities of air and aerodynamics form the cornerstone of almost all these theories. Less dense air creates low pressures than expected by the aerodynamics at respective places of the aircraft, thus adversely affecting the creation of lift

(Grauer and Morelli, 2015). Pilots experience a significant drop in aircraft performance in terms of payload, maneuverability, rate of climb...etc as the atmospheric temperature rises.

In combination, under higher atmospheric temperatures the engine performance and aircraft performance allows lesser payload, demand longer runway for take-off and landing (Coffel, Thompson and Horton, 2017; Zhou et al., 2018), truncate the operational range and endurance of the flight, restrict the maneuverability way below the full potential...etc (Sun et al., 2016). Even an increment of one degree of Celsius can significantly affect the aircraft performance as per the aircraft performance charts provided in flight/performance manuals.

During the gulf war, American aviators experienced a significant drop in their aircraft performance due to comparatively higher temperatures they were used to and as a result, they had to conduct more sorties than usual for airlift and strike. This is contributing to the vicious cycle of climate change speeding up by emitting more carbon and consuming more fossil fuels (Khordagui and Al-Ajmi, 1993). For usage in Africa and the Gulf region, the aircraft is specially designed to operate under higher atmospheric temperatures. What-so-ever done, their operational efficiency and performances are comparatively lesser than in colder regions.

4.3 Effects on Human Performance.

Human performance is greatly influenced by environmental factors, and one such factor that has a significant impact is temperature. Hyperthermia has adverse effects on human physiology, cognitive function, and physical performance (Turner, 2020). In general, the rise of the human body's core temperature beyond 38 degrees Celsius, forces the individual into hyperthermia region and if the core temperature rises beyond 41 degrees Celsius the probability of death due to hyperthermia sets in (Desforges and Simon, 1993). Of course, different individuals have different tolerances for these environmental factors. Usually, the aviators' ground working environment is tarmac, which is having higher temperatures compared to other ordinary working environments. The rise of temperature is, therefore, more phenomenal on-air operators than that of other professions.

Elevated temperatures affect various physiological processes in the human body. One of the most critical mechanisms is thermoregulation, which allows the body to maintain its core temperature within a narrow range. As ambient temperatures rise, the body must work harder to dissipate heat and prevent overheating (González-Alonso, 2012). This increased strain can lead to dehydration, heat exhaustion, and even heatstroke.

Dehydration negatively affects cognitive function and physical performance. When the body loses water through sweating, blood volume decreases, which reduces the delivery of oxygen and nutrients to the brain and muscles, consequently, cognitive abilities such as memory, attention, and decision-making are impaired, leading to reduced productivity and increased errors (Cheuvront and Kenefick, 2014; Pross, 2017).

Furthermore, higher temperatures can affect sleep patterns, resulting in sleep deprivation. Sleep is essential for cognitive restoration and consolidation of memory. Sleep deprivation caused by excessive heat can further impair cognitive function and alertness, leading to decreased productivity and increased accidents. (Pross, 2017)

In addition, hyperthermia has a detrimental effect on cognitive function. Heat stress can impair short-term memory, attention, and problem-solving abilities. In an environment with increased temperatures, individuals may experience difficulty in concentrating, reduced information processing speed, and diminished decision-making capabilities (Cheuvront and Kenefick, 2014). Such cognitive impairments can have significant consequences in various settings, including work, learning, and other cognitive-demanding activities.

Higher temperatures also impact physical performance. Heat stress increases the perceived effort during physical tasks, leading to decreased endurance and reduced strength and power output (Pontiggia et al., 1990). The body's natural response to heat is to divert blood flow to the skin for cooling purposes, which can compromise muscle perfusion and oxygen delivery. Exercise in hot environments can also lead to muscle fatigue and an increased risk of heat-related injuries, such as cramps, heat exhaustion, and heatstroke (Loeschke and Sørensen, 2005). These conditions can be debilitating and, in severe cases, life-threatening.

All these conditions limit the full potential of a human being physically and psychologically. These conditions could be detrimental during a high-intensity air operational demand. Ground troops in far distances could be deprived of critical aerial support.

4.4 Sustainability of Aircraft and Associated Equipment.

Aircraft and the associated equipment in air operations are delicate unless otherwise developed for specific robust conditions. Air assets and related ground equipment are usually stationed on the tarmac or inside a shelter (hangar/soft shelter/hardened shelter). All these places except the shelters with air conditioning will be subjected to a rise in temperature. The aircraft are usually designed to operate for decades than years. Avionics packages of modern aircraft are comparatively complex and mission-critical. These systems contain electronic circuits, crystal liquid displays, and materials such as rubber, plastic fabrics...etc. When exposed to higher heat, these parts and materials start deforming more than usual (Kitto and Robertson, 1989). A higher number of avionics-related unserviceability in hotter regions are commonplace. In Furtherance, deforming of materials such as rubber, plastic, and fabric due to higher heat could seriously truncate the usable life. For example, the life of a drag chute, in terms of the number of deployments, used to maximize aerodynamic braking in fighter platforms drastically reduces, when exposed to high heat during deployments. Wearing of tires would be pronounced under heated-up conditions. When the environment is more humid the conditions start to exacerbate. All the solutions other than parking/placing in an air-conditioned environment have not yielded effective results.

4.5 Risk of Fire Hazards.

The fire triangle is fundamental in fire science, explaining three essential components for a fire to ignite and sustain. Namely, they are fuel, oxygen and heat. It is understood that there is a significant difference between flashpoints and auto ignition points. Nevertheless, fire hazards increase with the rise of atmospheric temperature. However, the possibility of escalating a started fire under higher temperatures rises exponentially (Carnicer et al., 2022). The aviation environment itself is fire-prone, thus more emphasis to fire cover is given. The effectiveness of these fire extinguishing and control

measures would be undermined by a significant rise in atmospheric temperatures.

4.6 Rise of Sea Levels.

The rise of sea levels due to global warming is a critical consequence that poses significant threats to coastal regions and low-lying areas around the world. As the Earth's average temperature continues to increase, the polar ice caps and glaciers are melting at an accelerated rate, leading to the ingress of significant amounts of water into the oceans (Raper and Braithwaite, 2006). The primary cause of rising sea levels is the expansion of seawater as it warms. This thermal expansion alone contributes to a portion of the sea level rise. However, the melting of land-based ice, particularly in Greenland and Antarctica, is the primary driver of the drastic increase in sea levels. These ice masses have been stable for centuries, but with global temperatures on the rise, they are melting at an alarming rate. The sheer volume of water released into the ocean exacerbates the problem, causing sea levels to steadily rise year after year (Raper and Braithwaite, 2006; Shukla, Verma and Misra, 2017).

Despite the serious consequences on the population living in coastal regions and coastal ecosystems in general, aviation has particular issues from this phenomenon. There are many airfields located in coastal areas, with marginal airfield elevation. The current rate of sea level rise is approximately 3.4 ± 0.4 millimeters per year. Further, the rate itself has accelerated from 2.5 millimeters to 3.4 millimeters within the past three decades.

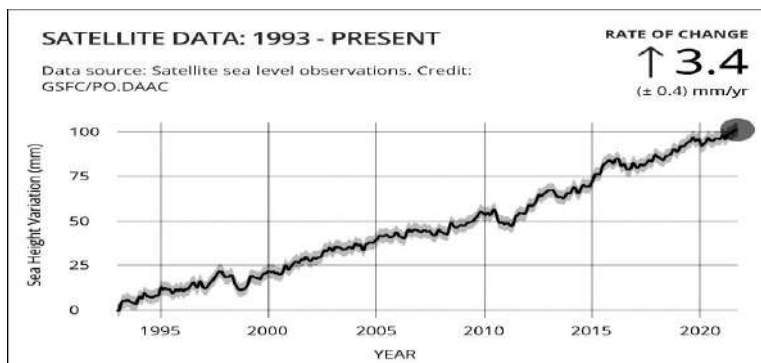


Figure 6: Rate of Sea Level Rise
Source: www.sealevel.nasa.gov

For example, in an island like Sri Lanka, 07 airfields including three out of four primary international airfields will be affected due to the rise of sea levels soon if the sea levels continue to rise. Loss of available infrastructure would seriously undermine the operational capacity. Relocating/rebuilding this infrastructure would incur exponential costs for the relevant authorities as well as consume a significant amount of time and effort to regain the operational status.

4.7 Solutions in Aviation for Global Warming.

As one of the most affected industries by climate change, air operators are compelled to find solutions for effective and efficient air operations amidst global warming. These solutions could be categorized as long-term and short-term. Short-term solutions are predominantly focused on how to retain efficiency and effectiveness under existing conditions with existing assets, while long-term solutions focus on how to reduce contribution to global warming in aviation as well as to design future temperature level compatible air assets.

4.8 Short-term Solutions.

The changes in aviation demand a significant amount of time, effort, and money. As far as the aircraft performance is concerned, except for mission-critical operations, routine operations, training, and non-mission critical air operations could be planned during the time of favorable temperature slots in diurnal temperature variation forecast reports. This practice has been already implemented by many air forces located in tropical and heated-up areas, especially during summer. The humidity levels are also to be a concern since the higher levels of humidity could produce the feel of a higher temperature than the actual. This step has been taken predominantly considering the human factor, which has more delicate and serious limitations than the machines. Keeping the people hydrated and continuous education regarding the adverse effects of higher temperatures would be beneficial to keep the physical and mental health of the air/ground crew in unfavorable conditions for safe and efficient air operations. Heat acclimatization programs, where individuals gradually expose themselves to higher temperatures over time, can also improve tolerance and performance in hot conditions.

Aviation accounts for 1.9 % of total greenhouse gas emissions as an industry. The movement towards renewable energies such as solar power could reduce the carbon footprint of the aviation industry.

Further, respective authorities could plan for the relocation of endangered airfields due to the sea level rising to viable locations. Gradual transition would permit controlled effort and cost, rather than sudden shifts.

5. RECOMMENDATIONS

Based on the findings of the study following recommendations could be put forward to face the adverse consequences of climate change in general and global warming in particular on-air operations.

5.1 Encourage Global Level Discussions for Seeking Long-term Solutions.

As the consequences of climate change become more prominent, global leaders have taken the initiative to open up forums to discuss the future cause of actions to address climate change. Global Air Forces Climate Change Collaboration was held in London in line with a two days event of Global Air and Space Chief's Conference 2022, where they pledged to commit to innovative solutions to reduce dependency on fossil fuels and carbon footprint, thus moving to sustainable and alternative sources of energy through sharing of expertise, best practices, resources and research capacities. This is the first of this kind of agreement among global-level military aviators. The forum could be expanded to accommodate the voices of developing and affected nations to have more productive sessions. Nevertheless, the forum is to be opened to developing and affected nations to accommodate their experience and concerns.

5.2 Continue Research on Sustainable Solutions.

As agreed upon by the air chiefs of global air and space forces, research effort in finding solutions to this issue is of paramount importance. The seriousness of the issue demands serious attention for research. The technology could provide better solutions to reduce the dependency on fossil fuels and find sustainable alternatives. Already there are some studies,

which have gone a reasonable distance in finding solar and battery-powered solutions. Additionally, improving aircraft designs and aerodynamics, optimizing flight routes, and implementing air traffic management systems can further enhance fuel efficiency and reduce carbon emissions. All these are time-consuming and resource-intensive efforts, where rich air forces could take the lead.

5.3 Develop a Combined Strategy.

As the impact of global warming is common to all stakeholders in varying degrees, the participation of all parties is required. Steps taken in isolation would not yield much results. Hence, a combined strategy could be developed to take a collective effort in battling the common cause. This strategy could include how each stakeholder can contribute within their capacities to optimize the output. Humankind has speedup the vicious cycle of climate change in isolation, seeking development. Now it's time to get together and slow down the process to ensure livable conditions for the future.

6. CONCLUSION

Climate change has been accelerated due to man-made reasons collectively. Nevertheless, certain states, industries and regions have to pay more to the consequences of the same despite their degree of contribution. Conducting a post-mortem to find out who is responsible more would not provide the answer to the existing issues. In contrast, a collective and collaborative effort would yield better results than working in isolation in this regard. Humans have already entered into the vicious cycle of climate change and inadequate measures to slow down would result in detrimental impacts on future generations. Dialogues for discussing the issues and finding solutions have already started, which is a very positive sign for future generations and particularly for the future sustainability of the aviation industry. The steps taken today would decide the fate of the aviation in future as well as it would slow down the global warming process and climate change.

REFERENCES

- Beckwith, W. B., 1971: the effect of weather on the operations and economics of air transportation today. *Bull. Amer. Meteor. Soc.*, 52, 863–869, [https://doi.org/10.1175/1520-0477\(1971\)052<0863:TEOWOT>2.0.CO;2](https://doi.org/10.1175/1520-0477(1971)052<0863:TEOWOT>2.0.CO;2).
- Carnicer, J. et al. (2022) ‘Global warming is shifting the relationships between fire weather and realized fire-induced CO₂ emissions in Europe’, *Scientific Reports*, 12(1), p. 10365. Available at: <https://doi.org/10.1038/s41598-022-14480-8>.
- Cheuvront, S.N. and Kenefick, R.W. (2014) ‘Dehydration: Physiology, Assessment, and Performance Effects’, in *Comprehensive Physiology*. Wiley, pp. 257–285. Available at: <https://doi.org/10.1002/cphy.c130017>.
- Coffel, E.D., Thompson, T.R. and Horton, R.M. (2017) ‘The impacts of rising temperatures on aircraft takeoff performance’, *Climatic Change*, 144(2), pp. 381–388. Available at: <https://doi.org/10.1007/s10584-017-2018-9>.
- Delworth, T.L., Mahlman, J.D. and Knutson, T.R. (1999) ‘Changes in Heat Index Associated with CO₂-Induced Global Warming’, *Climatic Change*, 43(2), pp. 369–386. Available at: <https://doi.org/10.1023/A:1005463917086>.
- Desforges, J.F. and Simon, H.B. (1993) ‘Hyperthermia’, *New England Journal of Medicine*, 329(7), pp. 483–487. Available at: <https://doi.org/10.1056/NEJM199308123290708>.
- González-Alonso, J. (2012) ‘Human thermoregulation and the cardiovascular system’, *Experimental Physiology*, 97(3), pp. 340–346. Available at: <https://doi.org/10.1113/expphysiol.2011.058701>.
- Grauer, J.A. and Morelli, E.A. (2015) ‘Generic Global Aerodynamic Model for Aircraft’, *Journal of Aircraft*, 52(1), pp. 13–20. Available at: <https://doi.org/10.2514/1.C032888>.
- Gultepe, I. et al. (2019) ‘A Review of High Impact Weather for Aviation Meteorology’, *Pure and Applied Geophysics*, 176(5), pp. 1869–1921. Available at: <https://doi.org/10.1007/s00024-019-02168-6>.
- Kerr, R.A. (2007) ‘Global Warming Is Changing the World’, *Science*, 316(5822), pp. 188–190. Available at: <https://doi.org/10.1126/science.316.5822.188>.
- Khordagui, H. and Al-Ajmi, D. (1993) ‘Environmental impact of the Gulf War: An integrated preliminary assessment’, *Environmental Management*, 17(4), pp. 557–562. Available at: <https://doi.org/10.1007/BF02394670>.
- Kitto, J.B. and Robertson, J.M. (1989) ‘Effects of Maldistribution of Flow on Heat Transfer Equipment Performance’, *Heat Transfer Engineering*, 10(1), pp. 18–25. Available at: <https://doi.org/10.1080/01457638908939688>.

Loeschcke, V. and Sørensen, J.G. (2005) 'Acclimation, heat shock and hardening—a response from evolutionary biology', *Journal of Thermal Biology*, 30(3), pp. 255–257. Available at: <https://doi.org/10.1016/j.jtherbio.2004.12.005>.

Masson-Delmotte, V., Zhai, P., Pörtner, H.O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R. and Connors, S., 2018. Global warming of 1.5 C. An IPCC Special Report on the impacts of global warming of, 1(5), pp.43-50.

Pontiggia, P. et al. (1990) 'The Biological Responses to Heat', in, pp. 271–291. Available at: https://doi.org/10.1007/978-1-4684-5766-7_26.

Pross, N. (2017) 'Effects of Dehydration on Brain Functioning: A Life-Span Perspective', *Annals of Nutrition and Metabolism*, 70(Suppl. 1), pp. 30–36. Available at: <https://doi.org/10.1159/000463060>.

Raper, S.C.B. and Braithwaite, R.J. (2006) 'Low sea level rise projections from mountain glaciers and icecaps under global warming', *Nature*, 439(7074), pp. 311–313. Available at: <https://doi.org/10.1038/nature04448>.

Shukla, J.B., Verma, M. and Misra, A.K. (2017) 'Effect of global warming on sea level rise: A modeling study', *Ecological Complexity*, 32, pp. 99–110. Available at: <https://doi.org/10.1016/j.ecocom.2017.10.007>.

SLAF (no date) Sri Lanka Air Force : Guardians of the Skies, www.airforce.lk. Available at: https://www.airforce.lk/image_gallery.php (Accessed: 2 July 2022).

Sun, Y.-F. et al. (2016) 'Flying high: Limits to flight performance by sparrows on the Qinghai-Tibet Plateau', *Journal of Experimental Biology* [Preprint]. Available at: <https://doi.org/10.1242/jeb.142216>.

Turner, J.M. (2020) 'Facultative hyperthermia during a heatwave delays injurious dehydration of an arboreal marsupial', *Journal of Experimental Biology* [Preprint]. Available at: <https://doi.org/10.1242/jeb.219378>.

Webster, D.L. (1920) 'THE PHYSICS OF FLIGHT', *Journal The Franklin Institute Devoted to Science and the Mechanic Arts*, 189(5), pp. 553–580.

Wei, X. et al. (2022) 'Thermodynamic analysis of key parameters on the performance of air breathing pre-cooled engine', *Applied Thermal Engineering*, 201, p. 117733. Available at: <https://doi.org/10.1016/j.applthermaleng.2021.117733>.

Whalley, R. and Ebrahimi, M. (2002) 'Gas Turbine Propulsion Plant Control', *Naval Engineers Journal*, 114(4), pp. 77–94. Available at: <https://doi.org/10.1111/j.1559-3584.2002.tb00173.x>.

Wuebbles, D.J. et al. (2014) 'Severe Weather in United States Under a Changing Climate', *Eos, Transactions American Geophysical Union*, 95(18), pp. 149–150. Available at: <https://doi.org/10.1002/2014EO180001>.

SRI LANKA'S STRATEGIC RE-EMERGENCE AS SEA POWER NATION IN THE INDIAN OCEAN THROUGH MAHAN'S PRINCIPLES

Commander (C) AGMPK Wijenayaka RSP psc MSc (D & SS) MAIR (UoP)
PG Dip in CPS BNavalSt (Maritime Warfare) Hons

ABSTRACT

Sea power, as explained by Admiral Alfred Thayer Mahan, holds critical significance in shaping the destiny of nations, particularly in the Indian Ocean region where Sri Lanka is situated. This paper delves into Mahan's principles of sea power within the context of Sri Lanka, emphasizing the pivotal role of naval capabilities and governmental initiatives. Through an analysis of existing literature and an examination of Sri Lanka's unique maritime challenges and opportunities, this research elucidates the ways in which modern technology, strategic harbour development, engagement with fishing communities, and regional agreements contribute to enhancing Sri Lanka's Sea power. Finally, recommendations are offered based on the insights gained from this analysis.

Keywords: Sea Power, Naval Strategy, Sri Lanka, Maritime Security, Alfred Thayer Mahan, Indian Ocean Region

“Whoever controls the Indian Ocean dominates Asia. This Ocean is key to seven seas. In the twenty-first century, the destiny of the world will be decided on its waters.”

- Admiral Alfred Thayer Mahan

1. INTRODUCTION

The ocean, often regarded as the cornerstone of state affairs, holds immense significance for nations worldwide, profoundly influencing their geopolitical standing and global influence. For island nations such as Sri Lanka, gifted with expansive maritime domains dwarfing their landmass, the mastery of maritime affairs, commonly referred to as sea power, becomes paramount for asserting dominance and ensuring security. Central to sea power is the concept of maintaining Command of the Sea, denoting control and

supremacy over maritime territories, a responsibility chiefly entrusted to a nation's naval and coast guard forces. However, small power nations like Sri Lanka face unique challenges in asserting their sea power, relying on geographical factors and internal capabilities while remaining vulnerable to external pressures and influences. Despite its strategic position in the Indian Ocean, Sri Lanka has grappled with neglecting or abended due to many reasons which includes absences or weak foreign policy, changing of government etc. Hence, its sea power, leading to significant challenges such as terrorist threats from groups like the Liberation Tigers of Tamil Eelam (LTTE), whose maritime activities have posed a considerable challenge to Sri Lanka's naval dominance. This paper aims to explore the feasibility of Admiral Alfred Thayer Mahan's theory of sea power in enhancing Sri Lanka's maritime capabilities. By examining past challenges, current shortcomings, and potential strategies, this research seeks to offer insights and recommendations to bolster Sri Lanka's Sea power and attain Command of the Sea in the Indian Ocean region.

2. INDIAN OCEAN

The Indian Ocean, with its unique geographical structure and strategic significance, holds a pivotal role in shaping global affairs. Unlike the Pacific and Atlantic Oceans, the Indian Ocean is bordered by land on three sides, with the Indian subcontinent protruding deeply into its waters, fundamentally altering its dynamics. This geographic feature not only defines the ocean's boundaries but also influences its currents, trade routes, and geopolitical significance.

2.1 Geo-strategic Environment of the Indian Ocean Region.

The Indian Ocean emerges as a focal point of global interest due to its strategic importance. Positioned strategically within this vast expanse, Sri Lanka enjoys a distinct advantage over neighbouring nations. Scholars have highlighted the critical role of the Indian Ocean in global affairs, driven by the economic growth of Asian economies and their increasing demand for essential resources, especially crude oil. Admiral Mahan's assertion that "Whoever controls the Indian Ocean will dominate Asia, and the destiny of

the world will be decided on its waters" resonates profoundly as powerful nations compete for maritime dominance.

2.2 Sea-borne Trade and Resource Wealth.

As the third-largest ocean covering 20% of the Earth's surface, the Indian Ocean harbours significant natural resources and serves as a crucial artery for global trade. With 38 littoral states and 17 landlocked nations, many of which are still developing, the region holds vast potential. It boasts two-thirds of the world's proven oil reserves, one-third of natural gas, and substantial reserves of diamonds, uranium, and gold. Additionally, it facilitates the transportation of half of the world's crude oil shipments and a significant portion of bulk and containerized cargo.

2.3 Importance of Critical Maritime Chokepoints.

Critical maritime chokepoints like Bab-el Mandab, the Strait of Malacca, and the Strait of Hormuz underscore the significance of the Indian Ocean. These passages are essential for tanker and cargo vessel access, making them vulnerable to disruption. Consequently, both regional and extra-regional powers maintain a keen interest in the region, necessitating expanded maritime domain awareness to safeguard national interests while fostering cooperation to address maritime crimes.

3. SRI LANKA'S STRATEGIC IMPORTANCE AND POWER RIVALRIES

Sri Lanka's strategic position in the Indian Ocean has increasingly drawn attention from global powers, leading to the formulation of foreign policies and power rivalries. Navigating these dynamics requires a nuanced approach that balances national security interests with international cooperation and diplomacy to ensure stability and prosperity in the region.

4. LITERATURE ON SEA POWER OF SRI LANKA

Once known as 'Ceylon,' the tiny maritime nation nestled in the heart of the Indian Ocean has historically held a position of strategic importance.

Referred to as 'Serendip' or the 'Island of Jewels' by medieval Arab seafarers (Kaplan, 2019, p.198), its Sinhala name 'Sri Lanka' took precedence in 1972. Sri Lanka, though often overlooked, has been a significant player in Indian Ocean geopolitics, as highlighted in Panikkar's 'The Strategic Problem of the Indian Ocean,' where he asserted that "Ceylon is for all defence purposes an integral part of India." Additionally, Panikkar identified Sri Lanka as the main island, providing a vital cover from the South, and emphasized the strategic importance of its two harbours, Colombo and Trincomalee, which have been recognized as crucial maritime assets since ancient times. Centrally located in the Indian Ocean, Sri Lanka shares no physical borders with any other country in the region. However, its history reveals a series of foreign invasions and occupations by powers such as China, Portugal, the Netherlands, and Britain (Kaplan, 2019, p.195). This tumultuous past underscores the vulnerability of Sri Lankan waters to foreign encroachment and underscores the inherent risks associated with external powers dropping anchor in and around its territory.

The presence of foreign vessels in Sri Lankan waters represents a tangible threat to the country's maritime sovereignty and underscores the imperative for Sri Lanka to assert its sea power. The nation must be vigilant against encroachments by foreign powers and take proactive measures to safeguard its territorial integrity and maritime interests. As mentioned in the 'Monsoon', Kaplan indicated that:

"In the world of late antiquity, Ceylon - strategically located at the hinge between the Bay of Bengal and the Arabian Sea - was the entry pot between China and the Middle East. As George Hourani writes, Chinese ships used to sail as far as west as Ceylon, and from Ceylon westward trade was in the hands of the Persians and Axumites (present Ethiopia). Chinese Admiral Zheng He broke the pattern by using Ceylon as a base for sailing as far as west as the Horn of Africa making two trips to the island".

Panikkar mentioned in the 'Indian and the Indian Ocean' that British has a line of defence stretching from Aden to Singapore via Trincomalee which give her effective control of Indian seas.

Moreover, 'The Strategic problem of the Indian ocean' Panikkar mentioned that:

"The position of Ceylon in the Indian Ocean gives it a special importance. Till the 16th century as no oceanic power had attempted to control the destinies of India, Ceylon's importance to the mainland remained unrecognised. The Portuguese, though they controlled Ceylon, did not make it a base as Goa was more important for their purpose. The Dutch having their main interest in the East Indies, appreciated to a greater extent the strategic value of Ceylon, but as they had no continental ambitions, their possession of the island did not materially affect Indian history. But in the struggle for naval supremacy between the French and the English, Ceylon came into its own in oceanic strategy. Trincomalee is the only harbour, which afford sheltered accommodation for a fleet of all seasons. In the fight against the French, Admiral Hughes recognizing its importance, captured it and made it his base. The first action of the French fleet under Suffern were for wresting this vital port from the English and when the French Admiral obtained this prize (31st August 1782) the whole balance of sea power in the Bay of Bengal was shifted at one stroke. The present war which brought the Bay of Bengal into the naval picture has once again emphasized the importance of Trincomalee".

The Japanese attack on Trincomalee harbour in April 1942 vividly illustrated the pivotal role of Sri Lanka, then known as Ceylon, in the defence of India's western seas. Following the fall of Singapore, Ceylon emerged as a stronghold of naval defence, with future offensive actions hinging on bases at Trincomalee and Colombo (Panikkar, 1944, p.15). This underscored Ceylon's integral role in regional defence strategies. Sri Lanka's bid for United Nations membership faced repeated rejections, with the USSR exercising its veto power thrice until Sri Lanka finally gained membership in 1955. The presence of British naval and air force installations in Trincomalee and Katunayake, respectively, played a significant role in these rejections. Even after British departure, their reluctance to relinquish control over Trincomalee underscored its strategic importance. However, Sri Lanka eventually removed both camps from its soil in 1957.

Sri Lanka shares historical waters with India in its northern region, with a narrow distance of less than 20 miles between the two nations. This proximity facilitated Liberation Tigers of Tamil Eelam (LTTE) activities, as they frequently crossed the International Maritime Boundary Line (IMBL) for combat training and replenishment. Through various maritime agreements with countries like Britain (1947), China (1963), and the USSR (1962), Sri Lanka has underscored its strategic significance in the Indian Ocean. These agreements, including those with India concerning maritime boundaries, highlight Sri Lanka's importance on the global maritime stage.

Despite its rich maritime history, including shipbuilding and naval invasions, Sri Lanka's maritime capabilities have dwindled over time due to foreign invasions. The absence of Command of the Sea in Sri Lankan waters has been a key factor behind these setbacks. In Mahan's words, sea power is crucial to a nation's success, with control of the sea equating to control of the world. Unfortunately, Sri Lanka has yet to establish this control due to various reasons. Government initiative is essential to develop Sri Lanka's sea power. Sri Lanka's geographic location in the Indian Ocean lies at the centre of significant historical events and development trajectories. However, this aspect has often been overlooked in discussions. Questions regarding Japanese bombings in 1942, the British fleet's presence, and the lack of foreign investment in Sri Lanka's maritime capabilities underscore the importance of Sri Lanka's geographic location and its impact on global affairs.

5. COMMAND OF THE SEA AND SEA POWER

The concept of 'Command of the Sea' as articulated by Julian Corbett, encapsulates a nation's naval power, emphasizing control over maritime communication for both commercial and military purposes. Corbett distinguishes naval warfare from land warfare by highlighting its focus on controlling communications rather than conquering territory. He underscores the dual nature of the sea, acknowledging its role as both a vital means of communication and a barrier. By achieving command of the sea, a nation not only removes this barrier but also gains the ability to exert direct military pressure on adversaries while strengthening its own defences against enemy incursions. Sri Lanka, often categorized as a small power

nation, particularly due to factors such as population size, geography, economy, and military capabilities, underscores the significance of its geographical location for national security. The Imperial Japanese Kamikaze squadron's Easter attack in 1942 highlighted Sri Lanka's vulnerability as an island nation, reinforcing its status as a small power despite its strategic importance in the Indian Ocean.

According to Britannica, sea power refers to the means by which a nation extends its military influence onto the seas. It is measured by a nation's ability to utilize the seas in defiance of rivals and competitors and includes diverse elements such as combat craft and weapons, auxiliary craft, commercial shipping, bases, and trained personnel. The U.S. strategy broadens the concept of sea power beyond military might, encompassing a nation's capacity to safeguard its political, economic, and military interests through control of the sea. The principal components of sea power are naval power, ocean science, ocean industry, and ocean commerce. Therefore, a nation's sea power can be defined as its ability to project military power onto the sea, relying on various factors. Identifying and analysing these factors is crucial for maintaining and enhancing sea power within a nation's waters.

6. WHAT IS A SMALL STATE?

The definition of a small state varies across academic literature, but common characteristics can be identified. According to the Montevideo Convention, a state, as a person of international law, should possess permanent populations, a defined territory, a government, and the capacity to enter into relations with other states. However, specific characteristics commonly associated with small states include limited economic resources, a smaller variety of agricultural products, a smaller population, high transportation costs, small administration, vulnerability to external pressure, limited influence on events outside their borders, limited room for manoeuvre in the international decision-making process, insufficient control over domestic security and defence, less military power, and international prestige. The Commonwealth defines small states as particularly vulnerable due to geographic positioning, strong trade dependence, limited access to development finance, and the disproportionate impact of natural disasters and climate change. Politically, the power and capability of a state can vary

significantly, with small states often surviving in hierarchical international relations structures by serving various functions such as buffer states, barriers, outposts, geopolitical gateways, resource-rich peripheries, or diplomatic mediators. However, they may struggle to interact effectively with the outside world due to limited resources and influence, prioritizing short-term considerations over long-term planning.

7. CONCEPTUALIZING THE EXISTING LITERATURE

The study of sea power traditionally focuses on powerful states, leaving a gap in scholarly works concerning small nations' sea power. Analysing the sea power of small states requires a blend of traditional and non-traditional approaches due to the lack of tailored methodologies.

Sea power, a critical component of national power, necessitates government involvement in establishing armed naval forces to safeguard maritime interests and deny adversaries access to maritime domains. However, the dominance of powerful nations often overshadows the sea power aspirations of smaller states like Sri Lanka, leading to power rivalries among superpowers in the region.

8. FACTORS INFLUENCING SMALL STATES' NAVAL EFFICACY

The efficacy of a small state's navy depends on various interrelated factors, including financial resources, central administration capacity, maritime assets' quality and quantity, maritime infrastructure, and political and naval decision-making effectiveness. State behaviour, geographic location, geopolitics, and public sentiment also shape a state's sea power, encompassing its capacity to influence events both at sea and on land, including the management, control, and utilization of maritime resources.

9. GAP IN LITERATURE ON SRI LANKA'S SEA POWER

Despite the critical importance of sea power for Sri Lanka, there is a notable shortage of literature on the subject. Existing literature often focuses on non-traditional security threats, such as maritime piracy, power struggles, port security, illegal fishing, human trafficking, and drug trafficking, within the

context of superpower rivalry in the Indian Ocean Region during the Cold War era. This emphasis on security-related issues sidelines the discussions on fundamental theories and concepts of sea power. In conclusion, while the sea power of small states like Sri Lanka is crucial for national security and development, it remains underexplored in academic literature. There is a pressing need for greater scholarly attention to understanding and analysing the sea power dynamics of small nations, particularly within the context of evolving geopolitical challenges in the maritime domain.

10. THEORETICAL BACKGROUND

When examining existing literature, it becomes apparent that coastal states leverage their naval power to safeguard national interests. Sea power, a multifaceted concept, encompasses political influence, national security, control of sea lanes of communication, and geographic space. Scholars like Mahan and Corbett assert that sea power is integral to a nation's power and security, holding contemporary significance for superpowers, great powers, regional powers, and small states like Sri Lanka.

11. RESEARCH DESIGN

This study employs a qualitative approach (triangulation), utilizing methods for gathering secondary data to comprehend by island nations' in executing sea power.

12. DATA COLLECTION METHOD

Secondary data for this study encompass academic texts, interviews, journal reviews, recent research reports, websites, and data collected by other researchers. Additionally, information from publications, websites, research studies, speeches, recordings, videos, and audios hold significant importance for the research.

13. DATA ANALYSIS

The project relies on qualitative data, and textual analysis and triangulation methods are employed to identify key elements of the data. These elements

are then utilized to formulate arguments and recommendations. Moreover, truthful arguments play a crucial role in the data analysis, ultimately contributing to the formulation of recommendations.

14. INFLUENCE OF SEA POWER ON WEALTH ACCUMULATION

In works such as 'Why Nations Failed' by Daron Acemoglu and James A. Robinson, the role of sea power in wealth accumulation is explored. Acemoglu and Robinson illustrate how present wealthy nations accumulated their wealth through looting and maritime trade. Mahan extensively discusses how the United Kingdom became a global powerhouse by leveraging its naval fleet to colonize territories worldwide. Mahan's strategies, including overseas bases and power projection capabilities, were successfully adopted by the United States. The importance of maintaining sea lanes of communication for sovereignty and economic prosperity is highlighted by Sri Lanka's experiences with threats from groups like the LTTE.

15. KEY FACTORS CONTRIBUTING TO SEA POWER

Mahan identifies key factors contributing to a nation's sea power, including geographical position, physical conformation, extent of territory, population size, character of the people, and character of the government. He emphasizes three interlocking factors shipping (both unarmed and armed), production, and colonies as foundational to sea power. These factors, combined with six principles, shape a nation's maritime capabilities.

Mahan argues that effective utilization of maritime resources is essential for a nation to dominate the world stage, viewing sea power as a "great highway" for cheap transportation and a prerequisite for global influence. From the Sri Lankan perspective, Mahan's Theory: for global influence. From the Sri Lankan perspective, Mahan's principles and factors hold significance in understanding the nation's contemporary maritime challenges and opportunities. In conclusion, Mahan's theory provides valuable insights into the dynamics of sea power, which remain relevant for small states like Sri Lanka navigating the complexities of modern geopolitics and maritime security.

16. ANALYSING THE SIX PRINCIPLES FROM SRI LANKAN PERSPECTIVE

16.1 Geographical Position.

Mahan emphasized the strategic advantage of nations whose focus is directed primarily towards the sea, particularly those not compelled to defend their territory by land or expand through continental means. He noted that such nations possess inherent advantages over those with continental boundaries, with their geographic positioning influencing the concentration or dispersion of naval forces (p. 29). Additionally, Mahan highlighted the significance of various geographic features such as ports, expansive coastlines, ridges, and rivers in amplifying the strategic importance of a state.

Mahan's emphasis on the strategic advantage of nations primarily focused on the sea holds significant relevance for Sri Lanka, situated in the Indian Ocean. As an island nation, Sri Lanka's control over its maritime domain is crucial, particularly given its central location as a gateway from West to East. The country's expansive coastline and vital sea lanes of communication contribute to its aspiration to transition to a blue-water economy. However, recent developments, such as foreign investments and agreements, indicate a relinquishment of control over strategic locations to foreign interests. Sri Lanka must reassess its approach to maritime affairs to maximize its strategic advantages and positively contribute to regional and international affairs.

16.2 Physical Confrontation.

As the second principle, Mahan had discussed countries physical confrontation highlighting most strategic and salient feature of the geography of the countries impact on enriching or preventing its capacity to interact with other states (Mahan, 1890, p.35-42). This is the external factor of any nation that must consider when formulating foreign policy of the country.

For Mahan, numerous and deep harbours are a source of strength and wealth, and doubly so if they are the outlets of navigable streams, which facilitate in them the concentration of a country's internal trade (Mahan, 1890, p.36). Moreover, some physical conditions which separate a country into two or more parts, depending wholly upon external sources and unique borders, either give birth and strength to sea power, or makes the country powerless (Mahan, 1890, p.40). The physical features of Sri Lanka, including deep harbours and geographic barriers, play a crucial role in shaping its maritime capabilities. While these features foster rich maritime relations, they also pose security risks if left undefended. Historical examples, such as foreign exploitation of Trincomalee harbour and the development of Hambantota deep water harbour, underscore the complex interplay between national sovereignty and foreign influence. Understanding and effectively managing these challenges are essential for Sri Lanka to leverage its geographic advantages and enhance its maritime capabilities.

16.3 Extent of Territory.

The last of the conditions affecting the development of a nation as a sea power and touching the country itself as distinguished from the people who dwell there, is Extent of Territory. Further, Mahan also mentioned that the regards the development of sea power, it is not the total number of square miles which a country contains, but the length of its coastline and the character of its harbours that are to be considered (Mahan p 43-44).

According to the Mahan is to be said that the geographical and physical conditions being the same, extent of seacoast is a source of strength or weakness according as the population is large or small (Mahan, 1890, p.43-44). A country is in this like a fortress; the garrison must be proportioned to the enceinte.

A recent familiar instance is found in the American War of Secession. Had the South had a people as numerous as it was warlike, and a navy commensurate to its other resources as a sea power, the great extent of its seacoast and its numerous inlets would have been elements of great strength.

Mahan's emphasis on the extent of territory underscores the significance of Sri Lanka's coastline and harbours in assessing its maritime capabilities. With its extensive coastal belt and strategic harbours like Colombo and Trincomalee, Sri Lanka plays a crucial role in both economic and military affairs. Despite challenges, such as damage from natural disasters, these harbours remain integral to domestic and international trade, contributing to Sri Lanka's maritime significance on commercial and strategic fronts.

16.4 Number of Population.

Mahan analyses the how 'number of populations' affect the sea power of the country in fourth conditions. He argues that in respect of dimensions it is not merely the number of square miles, but the extent and character of the seacoast that is to be considered with reference to sea power; and so, in point of population it is not only the grand total but the number following the sea or at least readily available for employment on ship-board and for the creation of naval material (Mahan, 1890, p.45). Further, he emphasised that differences in what is called staying power, or reserve force, which is even greater than appears on the surface; for a grate shipping afloat necessary employs, besides the crews, a large number of people engaged in the various handcrafts which facilitate the making and repairing of naval materials, or following other calling more or less closely connected with the water and with craft of all kinds (Mahan, 1890, p.46).

Sri Lanka's maritime population, including fishermen and retired naval personnel, forms a crucial reserve force that enhances the country's maritime strength. Leveraging the expertise of these individuals and integrating them into reserve programs can bolster Sri Lanka's maritime capabilities and preparedness for emergencies. Additionally, civilian populations residing in coastal areas play a significant role in supporting maritime activities and industries, contributing to Sri Lanka's maritime resilience and readiness.

16.5 National Character.

If sea power be really based upon a peaceful and extensive commerce, aptitude for commercial pursuits must be a distinguishing feature of the nations that have at one time or another been great upon the sea (Mahan,

1890, p.50). As per the theoretical context of Mahan, the tendency towards trade, involving necessity or the production of something to trade with, is the national characteristic most important for the development of sea power (Mahan, 1890, p.54). Therefore, Mahan explains the national character as the collective term referring to the attitude and aptitude of a nation's peoples towards economic development through industrial and agricultural processes, which is inseparable from the sea.

Mahan's framework emphasizes a nation's inclination towards trade and economic development as crucial factors in the development of sea power. Sri Lanka's historical economic trajectory, influenced by various policy approaches, has hindered the development of its maritime commerce. To realize its maritime potential, Sri Lanka must prioritize stable governance, transparent economic policies, and strategic investments in maritime infrastructure and trade facilitation.

16.6 Character of the Government.

According to Mahan discussing the effects upon the development of a nation's sea power exerted by its government and institutions, it will be necessary to avoid a tendency to over-philosophizing, to confine attention to obvious and immediate causes and their plain results, without prying too far beneath the surface for remote and ultimate influences (P-58). It defines the government direct involvement over the development of sea power of the country. When it comes to the Sri Lankan context, being an island small power nation, it all depends on the sea. Unfortunately, none of the government has identified this. Mahan also highlighted that England having undoubtedly reached the greatest height of sea power of any modern nation, the action of her government first claims attention. In general direction this action has been consistent, though often far from praiseworthy. It has aimed steadily at the control of the sea (p-59).

Effective government action is paramount for the development of Sri Lanka's Sea power. However, a lack of cohesive policies and strategic vision has hindered progress in harnessing the nation's maritime potential. Strategic investments in maritime infrastructure, modernization of naval capabilities, and robust policy frameworks are essential for Sri Lanka to

realize its maritime potential and assert its influence in the global maritime domain.

16.7 Failure of Sri Lanka Foreign Policy.

Sri Lanka's foreign policy landscape has been influenced by various challenges, including civil unrest, terrorism, and external interventions. Shifts in governmental administrations have led to changes in foreign policy priorities, impacting the country's international standing. Despite maintaining a non-aligned foreign policy, challenges such as the COVID-19 pandemic and rising nationalism require careful navigation to maintain balanced relations with major powers like China and India.

17. CONCLUSION

In conclusion, a nation's maritime prowess, often epitomized as sea power, stands as a pivotal determinant of its global stature. For Sri Lanka, strategically positioned in the Indian Ocean, effective management of maritime affairs and the cultivation of sea power are imperative. Historically, the neglect of sea power has left Sri Lanka vulnerable to external influences and challenges, exemplified by past terrorist activities, notably perpetrated by the LTTE. The geostrategic significance of the Indian Ocean further underscores the critical importance of sea power for Sri Lanka. As a small nation with a distinctive geographic location, Sri Lanka finds itself at the crossroads of global power dynamics.

The region's economic vitality, the demand for essential resources, and the strategic transshipment of oil all contribute to the Indian Ocean's centrality in global affairs. Alfred Mahan's assertion that control of the Indian Ocean equates to dominance in Asia and influences the world's destiny resonates strongly in the contemporary geopolitical landscape.

This study, drawing from diverse secondary sources and employing qualitative research methods, seeks to evaluate the feasibility of Mahan's sea power theory for enhancing Sri Lanka's maritime capabilities. By identifying challenges encountered by small powers like Sri Lanka, the research aims to offer recommendations to bolster the nation's sea power and establish

command of the sea in the Indian Ocean. Given the study's objectives and geopolitical realities, it is imperative for Sri Lanka to reassess its approach to sea power. Developing a modern navy, enhancing maritime domain awareness, and formulating comprehensive strategies are crucial steps for Sri Lanka to assert itself in the Indian Ocean. Recognizing the Indian Ocean as a vital geopolitical asset should prompt Sri Lanka to actively cultivate its sea power, collaborating with regional and extra-regional powers while safeguarding its national interests. Ultimately, Sri Lanka's success in navigating the complex waters of the Indian Ocean will hinge on its commitment to strengthening its sea power, leveraging its unique geographic position, and actively engaging in cooperative efforts that ensure stability and security in this vital maritime region.

18. RECOMMENDATIONS FOR ENHANCING MARITIME SECURITY AND SUSTAINABILITY

18.1 Conduct Comprehensive Security Analysis in IOR.

Conducting a comprehensive security study on the Indian Ocean Region (IOR) is crucial given the dynamic global security landscape. Analysing geopolitical dynamics, emerging security challenges, and maritime crime trends will inform effective security policies and deployment strategies.

18.2 Modernize Naval Capabilities.

Strategic investment in modernizing and expanding the Sri Lanka Navy is essential for enhancing maritime surveillance and response capabilities. Upgrading existing naval fleet with modern equipment ensures operational efficiency and effectiveness while maintaining a cost-effective approach.

18.3 Enhance Maritime Domain Awareness through Affordable Technology.

Developing advanced surveillance capabilities through strategic investments in affordable technologies like satellite systems and UAVs. Establishing seamless coordination with Air Surveillance to augment MDA capabilities, either through maritime UAVs or integration of SLAF units.

18.4 Formulate Comprehensive Maritime Strategies.

Develop comprehensive maritime strategies addressing naval operations, security, disaster response, and international cooperation. Initiate inclusive formulation process involving stakeholders from government, academia, and maritime industries to ensure effectiveness.

18.5 Collaborate with Regional and Extra-Regional Partners.

Foster strategic collaborations with regional and extra-regional powers through joint exercises and information-sharing agreements. Establish bilateral agreements for harbour utilization and seek assistance from neighbouring nations like the Maldives to strengthen Maritime Domain Awareness.

18.6 Invest in Coastal Infrastructure.

Upgrade coastal infrastructure including ports and shipyards to foster efficient maritime transportation and trade. Encourage shipbuilding endeavours through governmental support and promote exports to target countries to revitalize the maritime industry.

18.7 Capacity Building and Training.

Prioritize capacity building and training programs for naval personnel and coast guard forces to ensure a highly skilled maritime force. Create a continuous learning environment to stay abreast of modern naval tactics and evolving threats, including search and rescue operations and disaster response.

18.8 Ensure Compliance with International Law and United Nations Convention on the Law of the Sea (UNCLOS).

Uphold international laws, particularly UNCLOS, to contribute to regional stability and promote freedom of navigation. Collaborate with international partners to engage in joint exercises and information-sharing mechanisms, fostering mutual understanding and trust.

18.9 Invest in Research and Development Initiatives.

Invest strategically in research and development initiatives to stay at the forefront of evolving maritime technologies and security threats. Foster collaborative partnerships with academic institutions and private enterprises to drive innovation in maritime defence and surveillance.

18.10 Promote Public Awareness and Engagement.

Elevate public awareness regarding the significance of maritime security through comprehensive outreach programs. Implement educational initiatives and collaborate with media outlets to engage the public in discussions about the nation's maritime strategy and the importance of sea power.

18.11 Ensure Environmental Sustainability.

Incorporate environmental sustainability practices into maritime activities to safeguard oceans and marine ecosystems. Enforce stringent regulations to prevent pollution, promote sustainable fisheries, and minimize the ecological footprint of maritime operations.

REFERENCES

Britannica (2024). 'Sea Power'. Available at <https://www.britannica.com/topic/sea-power> Access on 17 May 2024.

Commonwealth Library, Characteristics of small states. Online. Available at <https://www.thecommonwealth-library.org/index.php/comsec/catalog/download/713/713/5356?inline=1>. Access on 17 May 2014.

Giok, K.K. 'Sea Power as a Strategic Domain'. Online journal. Vol 41 no 3. Available at https://www.mindef.gov.sg/oms/content/dam/imindef_media_library/graphics/pointer/PDF/2015/Vol.41%20No.3/Sea%20Power%20As%20A%20Strategic%20Domain.pdf. Access on 20 May 2024.

Kaplan, R. D. (2019). 'Monsoon: The Indian Ocean and the Future of American Power'. p 195, p 198.

Kumara S. J. (2021). 'The Sea Power of Small States: A Case Study of Sri Lanka'. *European Scientific Journal, ESJ*, 17(2), 151. <https://doi.org/10.19044/esj.2021.v17n2p151>

Mahan, A. T. (1890). 'The Influence of Sea Power on History'. p 25 (chapter 1).

Montevideo Convention on Rights and Duties of a state (1933). Online. Available at http://www.hudok.info/files/1114/3526/0588/Evi-Doc_12_Montevideo.pdf. Access on 20 May 2024.

Panikkar, K. M. (1945). 'Indian and the Indian Ocean'. Access on 10 May 2024.

Robinson, James A, and Daron Acemoglu. (2012). 'Why Nations Fail: The Origins of Power, Prosperity, and Poverty'. Random House. at <http://www.tinyurl.com/y57yqpy8>

Sea Power, Global Security Organization. 'Sea Power'. Available at https://www.globalsecurity.org/military/library/policy/navy/nrtc/12018_ch20.pdf. Access on 17 May 2014.

Wijegunaratne, R.C. 'Maritime security concerns in the Indian ocean: Sri Lanka's perception of overcoming challenges'. Defence article. Online. Available at <https://www.defence.lk/upload/ebooks/Rear%20Admiral%20Rc%20Wijegunaratne.pdf>. Access on 20 May 2024.

ADVANCING MARITIME SECURITY: INTEGRATING BIG DATA ANALYSIS FOR SURVEILLANCE AND CLASSIFICATION IN SRI LANKA

Commodore Nimal Ranasinghe RSP USP psc MSc Dip in WA&DS
Dip in Strat and Def Studies

ABSTRACT

Human affairs today have become more complex; globalization has compelled to exploit every inch of the world for markets and resources. The seas become the most vital and economical space in supply chain. The Indian Ocean has become one of the most important sea areas as Asia slowly dominates the main stage of the world. Peace and undisturbed movements in the Indian Ocean are indispensable; hitherto, maritime threats have also evolved to remain relevant and to have their share. Sri Lanka has a huge sea area to protect, but merely in possession of sufficient assets, owing to various restrictions. To address these maritime security threats, the ultimate goal is to identify maritime threats as earliest as possible for appropriate action at an earlier stage.

Having a robust maritime surveillance is indispensable for Sri Lanka, Present maritime surveillance generates a huge amount of information, however most of them are abandoned in the place where those are generated, except a very few, are transmitted to command canthers. However, these data can be further managed to derive superior outcomes to acquire better decisions, predictions, recordings, and training systems for better integrated maritime surveillance.

This paper seeks to investigate, how information gathered by maritime surveillance can be processed using emerging technologies considering the future trends of threats and affordability of Sri Lanka, the study extends to investigate the nexus between managing information and effective maritime surveillance, therefore a problem statement designed as: Incorporating big data analysis into maritime security will lead to significant improvements in maritime surveillance and classification capabilities, thereby enabling enhancing maritime security in the maritime domain of Sri Lanka.

Keywords: Maritime Surveillance, Maritime Security, Emerging Technologies, Big Data Analytics, Maritime Domain Awareness

1. INTRODUCTION

The economic developments and geopolitical upheavals in the world, over the last few decades have made the Indian Ocean Region (IOR) an area that drawn international concern. Indisputably, Sri Lanka is located in one of the most geopolitically important places. Therefore, Sri Lanka is obliged to protect territorial waters, seas extend up to 22 km from the shore (area 21,500 km²), and the Exclusive Economic Zone (EEZ) extends outward 370 km (area 510,000km²) including the Search and Rescue Area (SAR) (<https://marineregions.org>, 2023).

In the same way that world maritime commerce and trade find the IOR as a focal point, so do all maritime threats. Presently, in many security and defence forums in the world, amply discuss about the non-traditional maritime threats. These include irregular migration, drug trafficking, Illegal Unregulated and Unreported (IUU) fishing, arms smuggling, maritime piracy, natural disasters, maritime pollution and climate change. All the above threats have very significant implications on the national security of Sri Lanka, ultimately international peace and trade as well. If Sri Lanka fails or falls short of maintaining peace and security in these sea areas, there is a strong probability that other states, who have enormous stakes in the region will seek to employ a military presence in the area, which will eventually prejudice the sovereignty of Sri Lanka as a nation.

Sri Lanka is presently making all efforts to deny maritime threats, particularly in recent years. Referring to the records of apprehensions of drug trafficking and IUU fishing in the last decade, it is amply evident that the Sri Lanka Navy (SLN) has increased naval patrols and surveillance to dominate its territorial waters (EEZ) to monitor maritime activities and deter illicit and illegal activities (Navy, 2024). However, it is noteworthy Sri Lanka has not made major revisions to the inventory of naval assets since victories in the war in 2009, besides a few Off-Shore Patrol Vessels (OPV) accrued to the fleet. Sri Lanka has a larger area of responsibility than her assets can be committed; therefore, Sri Lanka should choose options smartly.

When considering introducing improvements to the maritime security of Sri Lanka, there are several options available, such as acquiring assets, technologies, surveillance equipment for enhancing Maritime Domain Awareness (MDA), and collaboration with neighbouring states who have stakes in IOR. Sri Lanka must weigh all the options meticulously. Improving diplomatic collaboration may, raise concerns over sovereignty owing to the power dynamics in the Indian Ocean. Therefore, improving the MDA with available assets and equipment will emerge as the best solution for Sri Lanka. With regards to MDA, Sri Lanka has a huge space that can upgrade surveillance, integration, and information fusion, along with better analysis (Meegoda, 2020). The paper intends to discuss enhancing MDA and maritime security, through affordable improvements to maritime surveillance.

2. LITERATURE REVIEW

To acquire sufficient theoretical insights into the field of study, concepts and theories related to maritime security, maritime threats, surveillance methods, big data analysis and its application were referred to develop the arguments and hypotheses. Maritime domain awareness (MDA) is defined as the effective understanding of anything and everything associated with the maritime domain that could impact the security, safety, economy, or environment of a nation (Army, 2018). Surveillance is defined as the systematic observation of aerospace, cyberspace, surface, or subsurface areas, places, persons, or things by visual, aural, electronic, photographic, or other means (Army, Joint Publication JP 3-0 Joint Operations 17, 2017). In meeting such aspirations, it is necessary to plan a way of transformation to acquire competencies such as suitable surface assets, underwater detection capabilities, surveillance capabilities, improving MDA, and improving maritime diplomatic capacity, knowledge hubs, and resilience (Meegoda, 2020).

The methods of denying and deterring threats in the maritime domain, should conform to the attributes of maritime power. Attributes of maritime power explain the employment of forces to deny maritime threats through access, mobility, lift capacity, posture, versatility, sustained reach, resilience, and leverage as described in the British maritime doctrine. These attributes are valid and relevant even against non-traditional threats (British Maritime

Doctrine, 2011). In functioning of these attributes, information is the most indispensable enabler. Therefore, surveillance is the most rudimentary, and single component, that guides all the above attributes.

The dense traffic in IOR is a storehouse of wide-ranging information. Every piece of information will not be relevant or accurate; therefore, the maritime surveillance system inevitably has to riddle through this disorder to recognise, what is normal or an anomaly. Having many different agencies and stakeholders involved in maritime security, information sharing and flow between these agencies will become a challenging in creating a shared situational awareness. Sharing intelligence with intra-state and inter-state agencies, which are components of maritime security, can be considered an extra advantage as well, as it can lessen the workload concerning maritime threats as well as national security (COL Nicholas Lim & CPT Chong De Xian, 2020). In Sri Lanka, there are several organisations working in parallel and at different levels for maritime security: the Sri Lanka Navy, Coast Guard, and Air Force, along with several civil maritime security agencies such as the Department of Fisheries, Port Authority (SLPA), Customs, Immigration and Emigration Department, and shipping agencies (Kulatunga, 2017). Several agencies are already operating in conjunction with SLN for the implementation of the International Ship and Port Facility Security Code (ISPS Code), which is mandatory for international shipping. There is a collection of vital information or data that remains only with SLN and SLPA.

In maritime surveillance efforts, the main effort is not allowing vessels passing unobserved and unmonitored. Conducting comprehensive surveillance in the maritime domain, and facilitating real-time information and intelligence sharing is an imperative function in Maritime security (Senarathna, 2021). As a direct consequence, the main components of the maritime surveillance system are passive sensors and platforms, active sensors and platforms, communication links, and data fusion stations (Bisceglia, 2024). These systems generate a huge amount of data, which extensively demands dedicated methods of handling and managing.

When referring to the present uses of emerging technologies in maritime surveillance in other parts of the world, the United States of America (USA) Argus surveillance system (strategically designed system to train and

deploy elite amphibious combat teams) it gathers more than 20 GB of data per second. The Green Line Vessel Selection System (VSS) in the USA, helps to analyse and identify targets of interest and make decisions. Incorporating Command and Control Systems (C2) with an operational analysis, VSS is a comprehensive decision-support platform, with exclusive risk methodology that presents a clearer understanding of the actors in MDA, where decisions can be taken and assets can be deployed. Possession of a vigorous information distribution mechanism permits stakeholders to selectively and securely share information, with a holistic maritime picture by feeding data from multiple sources, such as terrestrial and satellite-based ship positions and AIS data.

The present-day dilemma of overwhelmed data from various sensors can be addressed by emerging technologies, which provide ground-breaking capabilities to handle all this data, as part of the Intelligence Surveillance and Reconnaissance (ISR) grid, which can be analysed automatically. Big data analytics may play an important role in managing the data inundation and assisting analysts, in focusing their efforts (M, 2015). Considering the present applications in other parts of the world, It further envisages, the use of emerging technologies as big data analytics emerges as the most comprehensive solution when considering the above mentioned mammoth of tasks and functions in maritime surveillance.

3. ASSESSMENT OF SRI LANKA'S MARITIME SURVEILLANCE SYSTEM

The present surveillance effort in Sri Lanka can be identified in two aspects: static and mobile. Mobile surveillance includes deploying ships and air assets, and submitting attributes of maritime power such as access, mobility, posture, availability, and sustained reach. Static surveillance comprises of installed RADARs, observation posts (OPs), and intelligence, surveillance, and reconnaissance (ISR) arrangements; these cover very limited areas, merely a few miles from the coast. Therefore, it does not generate sufficient information, yet it is a very high amount. In the modern world, information and information technology are profoundly becoming dependent variables for all operations. (Sciences, 1997). The huge Area of Responsibility (AOR) of the seas around Sri Lanka has become the most difficult challenge. Acquiring sufficient assets, technology, and competencies to meet maritime

threats, is a huge challenge for Sri Lanka. When referring to the economic ability of Sri Lanka to embark on improvements, the budget allocation of Sri Lanka for the defence is around USD \$1.45 billion, from that USD \$1.29 billion has to be committed for recurrent expenditures of the defence forces.

Thus, only USD \$160 million of the budget remains for capital expenditure (Kuruwita, 2022). Acquiring platforms even merely equipped for surveillance and reconnaissance, remains well beyond the affordability of Sri Lanka. Furthermore, Sri Lanka does not have stringent defence agreements with militarily powerful nations, therefore failing to acquire even marginally equipped offensive assets. Therefore, Sri Lanka has literally hit the ceiling in acquiring the assets, yet the maritime security commitments are mounting high in all aspects. In contrast, the overall national character of Sri Lanka, does not display willingness to extend as a traditional inter-state power projection force, but required to symbolise to many of its cooperative partners, the readiness to accept a fair share of the burden, when dealing with collective maritime security threats and fulfilling obligations (Senarathna, 2021).

Owing to various difficulties and restrictions acquiring assets is beyond the economic horizon of Sri Lanka. When acquiring surveillance equipment, those are also embedded with several other expenses as infrastructure facilities, maintenance, routines and dockings, which will be always higher than the initial cost. Sri Lanka should embark on improving surveillance, collaboration with other nations, and intelligence sharing, which will be apparently most effective and economical. While considering the surveillance effort, Sri Lanka gathers quite a sufficient amount of data and information on maritime surveillance, but it seems diluted and abandoned in most of the places themselves, and those data and information alone are only a data, where all the decisions are made manually, without processing towards making decisions.

As Chris Hardwick stated "We are not in an information age; we are in an information management age". Considering Sri Lanka's ambition to advance maritime surveillance with cutting-edge improvement, smart options can be explored, thereby managing information is the most feasible and affordable option. The advantages are threefold. First, by implementing such an information management system, Sri Lanka can indulge in a wide range of

benefits available throughout the spectrum; second, it will provide enormous leverage to incorporate future developments and acquisitions; and third, it will provide a well-visible poise for all stakeholders at sea, as well as criminals. Acquiring an information management system, with suitable infrastructure to exploit emerging technologies such as big data analytics will be the most effective and apposite solution available for Sri Lanka.

4. BIG DATA ANALYTICS

Big data analytics is a complex process of examining data to uncover or derive information, such as hidden patterns, correlations, market trends and preferences, that can help make informed decisions. On a broad scale, data analytics technologies and techniques leverage the analysis of datasets and the gathering of new information. It involves queries and answers to basic questions about operations and performance. It is also a form of advanced analytics, that involves complex applications with elements such as predictive models, statistical algorithms, and ‘what-if’ analysis powered by analytics systems. These are some salient characteristics of big data which need to be considered (Scott Robinson, Alexander S. Gillis, 2024):

Volume	Scale of data generated is overwhelming, in terabytes, petabytes, and even exabytes, from various sources and sensors
Velocity	The speed of data generated and transmitted in Nanoseconds, is a remarkable characteristic of big data
Variety	Data in diverse formats, structured data, semi structured data (XML and JSON files), and unstructured data (text, images, and videos). Management and refining all these varieties of data poses an exceptional challenge
Value	Benefits, relevance and importance that can deliver big data
Veracity	Quality, accuracy, integrity and credibility of data. The data may have some missing pieces, might be inaccurate or might not be able to provide real and valuable insight

Table 1: Characteristics of Big Data (Kothari, 2023)

5. INTEGRATING BIG DATA ANALYTICS INTO MARITIME SURVEILLANCE

This requires developing and planning the concepts, designing the architecture, developing and performing quality assurance (QA), deploying the solutions, and providing support and maintenance. The following steps should be adopted when introducing big data analytics (Simplilearn, 2024):

- a. **Defining Objectives and Outcomes:** Identify the specific goals, objectives of maritime surveillance, while anticipating the specific set of data needed.
- b. **Data Collection and Integration:** The gathered data should be standardized, integrated, and stored in a centralised repository for easy access and analysis. The solutions should be able to aggregate and harmonize data from unequal sources, into a unified format by using data integration tools such as Application Programme Interfaces (API) and custom data pipelines, to transform and reconcile data. Data governance and quality assurance are mandatory to ensure the accuracy, completeness, and reliability of the gathered data.
- c. Data pre-processing and cleansing arrangements should be established to remove inconsistencies, errors, and irrelevant information in raw data. This involves data normalisation, de-duplication, and outlier detection to ensure data quality.
- d. **Big Data Analytics Techniques:** Select appropriate big data analytics techniques such as machine learning, data mining, pattern recognition, and predictive modelling, based on the defined objectives. These techniques facilitate uncovering hidden patterns, trends, and anomalies within maritime data.
- e. **Infrastructure and Tools:** Relevant infrastructure includes software tools required for analysis, scalable computing resources, storage systems, and analytics platforms to be planned. It should be with a secure cloud-based solution and distributed computing frameworks which are well-networked.

f. **Model Development and Training:** Methods to be in place, to develop and train systems to predict using historical data to detect and predict maritime activities of interest. It should also be able to refine and improve continuously, based on feedback and new sets of data to increase accuracy and consistency.

g. **Real-time Monitoring and Alerting:** A well designed mechanism must be integrated to trigger alerts, warnings, and notifications automatically.

h. **Visualization and Reporting:** The analysed data and insights are to be displayed in electronic displays, dashboards, maps, and the Action Information Organization (AIO), with facilities for extrapolating and interpolating analysis. This will provide easy interpretation for better decision-making. It may also provide interactive visualisation tools to estimate the effectiveness of the best Course of Action (COA).

i. **Evaluation, Validation, Deployment, and Training:** Systems should be incorporated to ensure the best performance and effectiveness of the solutions against predefined metrics and benchmarks. Also it is required to validate the accuracy and reliability of the insights generated against their relevance and usefulness. Personnel involved also need to be trained on, how to use systems effectively and interpret the insights generated by establishing a culture of data-driven decision-making (Simplilearn, 2024).

6. THE PRESENT USE OF BIG DATA ANALYTICS IN SRI LANKA

Sri Lanka has already made considerable headway as a nation in using emerging technologies. Application of Big Data analytics in Sri Lanka spans various sectors and industries such as agriculture, health sector, tourism, transportation and logistics, finance and banking, education, and telecommunication. Therefore, big data analytics is not naïve to Sri Lanka, and it is already in the vicinity of maritime security.

7. METHOD OF STUDY, MATERIALS, AND DATA

With the knowledge and understanding gathered from numerous assignments held during the last three decades, and after holding vital appointments in SLN, the writer always had a strong desire to propose a more comprehensive mechanism to establish maritime security for Sri Lanka, which is more affordable and effective. The study approach was planned as a systematic progression through key phases. At the outset, literature was referred to understand the existing, technologies and challenges in maritime security of Sri Lanka. Secondly, interviewed personnel from government and private agencies, to study the specific needs and requirements for maritime security and surveillance. Responses were also gathered from personnel, who are handling diverse data sources (satellite imagery, AIS, and radar), about their experiences and methods used for ensuring the quality, accuracy and integrity of the data.

The study adopted a mixed-methods approach while merging quantitative analysis and qualitative assessments. The quantitative component includes, studying the volume and velocity of data with regards to data sources, data transfer, data communication, data analysis, and data storage. The qualitative aspect includes interviews, observations, and consultations with key stakeholders. In view of obtaining an understanding of operational challenges and specific needs, it also anticipated to outline the constraints, specific challenges of the maritime environment and the ability of the present maritime security ecosystem to integrate big data analytics. This comparative approach will facilitate, identification of transferable lessons and effective strategies for the implementation of Big Data analysis in Sri Lankan maritime security. The research design will be iterative, adaptive, and collective, which demands close coordination among researchers, policymakers, users, and practitioners to develop a robust and actionable maritime surveillance system. Further study attempts to recommend actions for advancing maritime security through the integration of big data analytics.

8. PROBLEM STATEMENT AND OBJECTIVES

The maritime security of Sri Lanka is a critical concern, however traditional methods of maritime surveillance and classification often fall short.

Considering the economic capability and national character of Sri Lanka, it is apparently not fitting to pursue aggressive and expensive advancements in maritime security. Incorporating big data analytics presents a promising opportunity, to enhance maritime security by gathering and analysing vast amounts of data from diverse sources. Therefore, considering the vital parameters as efficiency, adaptability, and affordability, the problem statement is set as "Incorporating big data analysis into maritime security will achieve significant improvements in maritime surveillance and classification capabilities, thereby enhancing security in the maritime domain of Sri Lanka.". The study was conducted to explore the ability and compatibility of integrating the surveillance outcomes into big data analysis, develop a framework for integration, and propose recommendations for implementation.

9. ANALYSIS OF THE FINDINGS AND DISCUSSION

The understanding and learning acquired from surveys, interviews and referencing relevant materials have brought much insight to the study. All responses indicated that Sri Lanka has a critical responsibility in protecting IOR from maritime threats, and presently Sri Lanka is making all possible efforts in that direction. In maritime surveillance, Sri Lanka is presently obtaining a huge amount of data from RADARs, CCTV, and AIS on location, vectors, and images for maritime surveillance, with optimum coverage of approximately 12–15 nautical miles from the coast. Sea patrols are also deployed, which happen 24x7 in near harbours, along the coast and sometimes in deep sea. It generates data from numerous sources in massive volumes. Most of these data are generated at high velocity are transmitted to the Area Command Headquarters and Naval Headquarters. It is revealed in the study, these data are often abandoned at the point of generation, except for a few stations, where records are maintained physically.

These data are gathered in many data formats, such as character, numeric, graphic, Universal Character Set and etc., presently some of these important events and incidents are saved manually for future reference as evidence. The same data are used for accusations in legal proceedings and diplomatic concerns when required. Some of these data are critically important as the incidents; however, quality, accuracy, integrity, and credibility are compromised owing to the methods of generation, transmission, and

storage. Hence, they become invalid and tampered when forwarded to judicial and diplomatic proceedings.

In a highly congested maritime environment as IOR, Electro Magnetic Spectrum (EMS) based surveillance is very effective in obtaining and managing "information," which is vital in maritime security. Therefore, incorporating big data analysis into maritime surveillance is a substantial and essential step forward in improving maritime security and its efficacy. Leveraging advanced analytical techniques on bulky volumes of maritime data such as vectors of vessel movements, satellite imagery and patterns, Sri Lanka can improve its ability to monitor, detect, and respond to numerous maritime activities. The study shows, the generated data in the present maritime surveillance effort of Sri Lanka is submitting to most of the characteristics and pre-requisites of Big Data analytics such as volume, velocity, variety, value, and veracity. Therefore, in a gamut, the existing maritime surveillance appears to be almost one step behind on embarking a ground-breaking improvement as introducing Big Data Analysis.

10. BIG DATA ANALYTICS FOR MARITIME SURVEILLANCE

Big data analytics enables the processing of huge amounts of real-time data from multiple sensors and sources, which facilitates the painting of a comprehensive maritime picture, enabling quick and better-informed decision-making. When the data and information sets are made and designated, it is easy to analyse historical routes, behaviours, and patterns. Big data analytics also enable forecasting potential threats, incidents, and warnings while permitting proactive measures. It also suggests routes commonly followed by illegal vessels, and helps to establish areas susceptible to maritime threats; therefore, assets can be deployed effectively. Big data analysis will propose optimised resource allocation such as patrol vessels and aircraft, while analysing and classifying high-risk areas or times where increased surveillance is needed to maximise the effectiveness of maritime surveillance efforts.

Big data analytics can serve as a link between other maritime surveillance systems, such as the Automatic Identification System (AIS), RADAR, and satellite surveillance, which can provide a more accurate, inclusive, and coordinated approach to maritime security. Analysing a large number of

data sets and creating stacks of patterns will deliver valuable insights to understand the trends and patterns in maritime activities. Apart from supporting decision making, it also provides complete information for policy-making aimed at improving maritime security. In a nutshell, the integration of big data analysis into maritime surveillance systems will provide a cutting-edge improvement to maritime security and safety, ultimately contributing to national security as a whole.

11. RECOMMENDATIONS AND CONCLUSIONS

In light of the discussion made above, incorporating big data analytics for maritime surveillance is a ground-breaking application for maritime security, and will be able to cater to almost all the demands and obligations of Sri Lanka to ensure maritime security in terms of affordability and effectiveness. Implementation of Big Data analytics requires several infrastructure and peripheral requirements, as discussed in the literature review. A scalable and strong data storage system, a high-performance computing infrastructure to process and analyse are essential infrastructure requirements. The infrastructure should also support real-time maritime surveillance and streaming data processing to analyse incoming data streams in near real-time. This also requires low-latency processing capabilities. By installing data governance practices to ensure data quality, integrity, and compliance with existing regulations, the system will be more efficient and predictive. Additionally, it should necessitate the investment in training and capacity-building initiatives to prepare personnel with the necessary skills to harness the power of big data analytics effectively (Rahul, 2018).

(INTENTIONALLY KEPT BLANK)

Requirement	Functions	Software and Language Requirement
Data Storage and Management	Databases	MongoDB, Apache Cassandra, PostgreSQL, MySQL
	Data Lakes	Apache Hadoop HDFS, Amazon S3, Azure Data Lake
	Distributed File Systems	Hadoop Distributed File System (HDFS), Apache HBase
Data Processing and Analytics	Big Data Processing Frameworks	Apache Spark, Apache Flink, Apache Beam
	Machine Learning Libraries	TensorFlow, scikit-learn, Apache Mahout
	Geospatial Analysis Tools	GDAL, GeoPandas, PostGIS
	Data Visualization Tools	Tableau, Power BI, or Apache Superset
Streaming Data Processing	Streaming Platforms	Apache Kafka, Apache Flink, Amazon Kinesis
Security and Compliance	Encryption Tools	OpenSSL
	Access Control Systems	Apache Ranger, AWS Identity and Access Management (IAM)
	Compliance Management Software	GDPR and maritime laws
Integration and Interoperability	APIs and Middleware	Middleware solutions for integrating heterogeneous maritime data
	Data Standards	Maritime data standards: AIS data standards and international data exchange formats AIVDM, AIVDO
Monitoring and Management	Monitoring Tools	Prometheus, Grafana, Datadog
	Logging and Auditing	Elastic search, Logstash, Kibana, Splunk

Table 2: Requirements, functions, and software requirements for incorporating big data analytics into maritime surveillance in Sri Lanka

12. COSTS FOR INFRASTRUCTURE AND SOFTWARE

The cost of incorporating big data analysis for maritime surveillance may vary significantly depending on the scale of the operation. The volume of the data, velocity of the data generation, complexity of analytical tasks, selected software and infrastructure will determine the cost. The costs can be basically outlined as follows:

- a. **Infrastructure Costs:** The cost of hardware, cloud services, and networking equipment to support data storage, processing, and analysis. (approx. 100,000 USD)
- b. Costs associated with acquiring licenses for software tools (approx. 100,000 USD).
- c. **Development and Implementation Costs:** Customization, integration, and configuration of software tools and platforms. Also included hiring developers, data engineers, and system administrators (approx. 100,000 USD).
- d. **Data Acquisition Costs:** Acquiring maritime data from various sources, some of which the Sri Lanka Navy already owes (approx. 50,000 USD).
- e. **Personnel Costs:** Costs for hiring personnel for managing, analysing, and interpreting maritime data experts such as data scientists, analysts, domain experts, and IT professionals. SLN already has some experts in these fields (approx. 100,000 USD).
- f. **Security and Compliance Costs:** Costs for implementing security measures, encryption tools, access control systems, and compliance management software. SLN already has some of these to some extent (approx. 50,000 USD).
- g. **Operational Costs:** This includes costs for system monitoring tools, software updates, and troubleshooting that SLN is already in possession of to some extent (approx. USD 50,000), (Andrei Klubnikin, 2022).

The total cost is hovering around USD 550,000; allowing for a buffer, it will be USD 650,000 (approx. LKR 200 m), which is one-time investment (in phases) and will facilitate future acquisitions and improvements as well. However, it is imperative to have a meticulous planning and survey on cost analysis, considering both upfront and on-going expenses, while harmonizing with the existing systems, and stripping in to nuances of the required outcomes.

In conclusion, submitting to the critical requirements of addressing the threats in IOR, and the obligations of Sri Lanka as a nation, it is important to improve maritime security. Integrating big data analytics into maritime surveillance holds immense potential. Considering the enormous volumes of data generated by maritime activities, and obtaining those data through maritime surveillance and incorporating big data analysis, Sri Lanka can manage information effectively. Therefore, Sri Lanka can enhance its surveillance capabilities and improve its ability to deter, prevent, and deny maritime threats. In addition, the integration of big data analysis enables collaboration and information sharing among various stakeholders seamlessly. Establishing a coordinated intelligence-led approach will strengthen maritime security further by embracing emerging technologies, such as big data analytics for surveillance and classification, and will also provide several added advantages, which can bolster its maritime security posture, make full use of attributes of maritime power, protect its maritime borders, improve the visibility of the nation's presence and promote economic prosperity and stability in the region as a responsible state.

REFERENCES

- Bisceglia, L. (2024). Maritime surveillance systems and data fusion. *Maritime Systems and Technologies Journal*, 15(2), 99-114.
- British Maritime Doctrine. (2011). *British maritime doctrine: BR 1806 (4th ed.)*. The Stationery Office.
- Kothari, C. R. (2023). *Research methodology: Methods and techniques (5th ed.)*. New Age International Publishers.
- Kulatunga, A. (2017). Maritime security arrangements in Sri Lanka. *Sri Lanka Maritime Security Review*, 8(1), 22-33.
- Kuruwita, R. (2022). Defense budget allocation and maritime security: A financial perspective. *Journal of Economic Policy*, 29(4), 301-312.
- Lim, Nicholas & Chong De Xian. (2020). Maritime security in the Indian Ocean: Challenges and opportunities. *Defense Studies Journal*, 13(3), 45-60.
- M, N. (2015). The role of emerging technologies in maritime security. *Technology and Defense Review*, 7(2), 14-25.
- Meegoda, A. (2020). Enhancing maritime domain awareness: Strategies for Sri Lanka. *Maritime Affairs Journal*, 12(3), 87-101.
- Navy. (2024). *Annual report of the Sri Lanka Navy*. Sri Lanka Navy.

Rahul, K. (2018). Big data infrastructure and requirements. *Journal of Information Technology*, 20(3), 123-135.

Scott Robinson, G., & Gillis, A. S. (2024). Characteristics and implications of big data. *Data Analytics Review*, 15(1), 55-70.

Senarathna, M. (2021). Collaborative maritime security efforts in the Indian Ocean. *Defense Collaboration Journal*, 19(1), 98-109.

Simplilearn. (2024). Steps to integrate big data analytics in maritime surveillance. *Simplilearn Big Data Journal*. Retrieved from <https://www.simplilearn.com>

THE NEXT GENERATION OF WARFARE: HARNESSING ARTIFICIAL INTELLIGENCE

Asela Waidyalankara

ABSTRACT

The advent of Artificial Intelligence (AI) has revolutionized various sectors, including defence and security. This article explores the next generation of warfare, characterized by the integration of AI technologies. It examines how AI can enhance strategic decision-making, automate defensive and offensive operations, and introduce new dimensions to cyber warfare. The discussion highlights the benefits and challenges of AI in military contexts, emphasizing the need for robust ethical frameworks and international cooperation to mitigate risks. The future of warfare, powered by AI, presents both unprecedented opportunities and formidable challenges.

Key Words: Artificial Intelligence, Cyber Warfare, Next Generation Warfare, Military Technology, Strategic Decision-Making, Ethical Frameworks

1. INTRODUCTION

The landscape of warfare is undergoing a profound transformation with the advent of artificial intelligence (AI). This evolution marks the next generation of warfare, where AI technologies are integrated into military operations, enhancing capabilities, and introducing new dimensions to combat. This article delves into the implications of AI in modern warfare, exploring its potential to revolutionize defense strategies, automate operations, and reshape the global security paradigm.

The use of AI in military contexts is not entirely new. Historical precedents include early automated systems like radar and the first computer systems used for codebreaking during World War II. However, the contemporary landscape is vastly different, with AI systems now capable of learning, adapting, and performing complex tasks autonomously. This shift is driven by advancements in machine learning, neural networks, and data analytics, which collectively enable AI to process and analyze vast datasets, identify patterns, and make decisions with unprecedented speed and accuracy.

2. THE ROLE OF ARTIFICIAL INTELLIGENCE IN STRATEGIC DECISION-MAKING

AI's most significant impact on warfare lies in its ability to enhance strategic decision-making. Advanced algorithms can analyze vast amounts of data in real-time, providing military leaders with actionable insights. This capability enables more informed decisions, rapid response to threats, and efficient resource allocation. For instance, AI-driven systems can predict enemy movements, assess battlefield conditions, and suggest optimal strategies, thereby increasing the effectiveness of military operations.

One prominent example is the use of AI in intelligence analysis. Traditional intelligence gathering involves sifting through massive amounts of data from various sources, a task that is both time-consuming and prone to human error. AI can automate this process, swiftly analyzing data from satellite images, social media, intercepted communications, and other sources to provide comprehensive situational awareness. This allows commanders to make quicker and more informed decisions, potentially altering the course of engagements.

Additionally, AI enhances strategic planning through simulation and wargaming. AI-powered models can simulate various scenarios, allowing military planners to test different strategies and predict their outcomes. This capability is invaluable for both training purposes and real-world operations, as it provides insights into potential challenges and opportunities that may not be apparent through traditional planning methods.

For instance, the US Department of Defense employs Project Maven, an initiative that leverages AI to process and analyze video footage captured by drones. AI algorithms can identify patterns, recognize objects, and alert human operators to potential threats, significantly reducing the workload of analysts and enhancing situational awareness (Vincent, 2019). Another example is the UK's National Cyber Security Centre, which uses AI to monitor and analyze network traffic for signs of cyber threats. Machine learning algorithms can detect anomalies that indicate cyber-attacks, enabling rapid response and mitigation efforts (UK Government, 2021).

3. AUTOMATION OF DEFENSIVE AND OFFENSIVE OPERATIONS

AI also plays a crucial role in automating both defensive and offensive military operations. Autonomous drones, robotic soldiers, and AI-powered surveillance systems can perform tasks that are too dangerous or complex for humans. These technologies not only enhance operational efficiency but also reduce the risk to human life. For example, AI-controlled drones can conduct reconnaissance missions, identify targets, and execute strikes with high precision, while autonomous defence systems can detect and neutralize threats in real-time.

The use of autonomous systems in combat operations is already being realized in various military applications. For instance, the US military has deployed AI-powered drones capable of performing autonomous reconnaissance and surveillance missions. These drones can operate in hostile environments, providing real-time intelligence without putting human pilots at risk. Similarly, robotic ground vehicles equipped with AI are being developed to perform tasks such as explosive ordnance disposal, logistics support, and even direct combat roles.

On the offensive side, AI is revolutionizing the capabilities of precision-guided munitions. AI algorithms can analyze sensor data to improve targeting accuracy, ensuring that strikes hit their intended targets with minimal collateral damage. This precision is crucial in modern warfare, where minimizing civilian casualties and avoiding unnecessary destruction are paramount concerns. Additionally, AI can optimize the timing and coordination of attacks, enhancing the overall effectiveness of military operations.

In defensive operations, the Iron Dome, an AI-powered air defence system developed by Israel, exemplifies the integration of AI in military technology. The system uses radar and AI algorithms to detect and intercept incoming rockets and artillery shells. Since its deployment, the Iron Dome has successfully intercepted thousands of projectiles, protecting civilian populations and critical infrastructure (Defense Update, 2021).

On the offensive side, the US military has deployed AI-powered drones capable of autonomous reconnaissance and surveillance missions. These

drones, such as the MQ-9 Reaper, can operate in hostile environments, providing real-time intelligence without putting human pilots at risk. Additionally, AI is revolutionizing the capabilities of precision-guided munitions. For instance, AI algorithms can improve targeting accuracy, ensuring that strikes hit their intended targets with minimal collateral damage (US Air Force, 2020).

4. CYBER WARFARE: A NEW FRONTIER

The integration of AI into cyber warfare introduces a new frontier in military conflict. AI can be employed to develop sophisticated cyber weapons, enhance cybersecurity measures, and conduct cyber espionage. Machine learning algorithms can identify vulnerabilities in enemy systems, launch cyber-attacks, and defend against intrusions more effectively than traditional methods. However, this also raises the stakes, as adversaries can deploy AI-driven cyber-attacks, leading to a potential arms race in the cyber domain.

Cyber warfare has become an integral component of modern military strategy, with AI playing a pivotal role in both offensive and defensive operations. On the offensive side, AI can automate the discovery of vulnerabilities in enemy networks, enabling more efficient and targeted cyber-attacks. For example, AI algorithms can scan vast amounts of code to identify security flaws that human analysts might miss. Once identified, these vulnerabilities can be exploited to disrupt communications, disable critical infrastructure, or steal sensitive information.

Defensively, AI enhances cybersecurity by continuously monitoring networks for signs of intrusion or abnormal activity. Machine learning algorithms can analyze network traffic patterns, detect anomalies, and respond to threats in real-time. This proactive approach is essential for defending against sophisticated cyber threats that can bypass traditional security measures. Additionally, AI can help in the development of resilient systems that can quickly recover from cyber-attacks, ensuring continuity of operations in the face of persistent threats.

The potential for AI-driven cyber warfare also raises significant concerns about the escalation of conflicts. The speed and precision of AI-enabled attacks could lead to rapid escalation, making it difficult to control the pace

and scale of cyber engagements. This necessitates the development of norms and agreements to govern the use of AI in cyber warfare, similar to existing treaties on conventional and nuclear weapons. The International Bar Association has noted the increasing relevance of cyberattacks as potential war crimes. For instance, Russian cyberattacks on Ukraine's infrastructure, including power grids and satellite communications, have raised significant concerns. These attacks highlight how cyber operations can cause widespread disruption and harm, similar to traditional kinetic warfare.

A notable example of AI in cyber warfare is the Stuxnet worm, which targeted Iran's nuclear facilities. Although not entirely AI-driven, Stuxnet employed advanced algorithms to exploit vulnerabilities in industrial control systems, causing significant damage to Iran's nuclear program (Zetter, 2014). This incident highlights the potential of AI-driven cyberattacks to disrupt critical infrastructure.

Defensively, AI enhances cybersecurity by continuously monitoring networks for signs of intrusion or abnormal activity. The cybersecurity firm Darktrace uses AI to protect organizations from cyber threats. Its AI system, known as the "Enterprise Immune System," can detect and respond to cyberattacks in real-time, mirroring the human immune system's ability to identify and neutralize pathogens (Darktrace, 2020).

5. ETHICAL AND LEGAL CONSIDERATIONS

The deployment of AI in warfare brings forth significant ethical and legal challenges. The potential for autonomous weapons to make life-and-death decisions without human intervention raises moral concerns. It is imperative to establish robust ethical frameworks and international regulations to govern the use of AI in military contexts. Ensuring accountability, transparency, and compliance with international humanitarian law is crucial to prevent misuse and mitigate risks.

One of the primary ethical concerns is the delegation of lethal decision-making to autonomous systems. The prospect of machines making decisions to use lethal force without human oversight raises questions about accountability and the value of human life. There is an ongoing debate about the moral and legal implications of such systems, with some arguing that

they could potentially reduce human error and minimize casualties, while others contend that they could lead to indiscriminate violence and loss of control.

To address these concerns, it is essential to develop clear guidelines and regulations that define the roles and responsibilities of AI systems in military operations. This includes establishing protocols for human oversight, ensuring that autonomous systems are used in compliance with international humanitarian law, and creating mechanisms for accountability in case of misuse or unintended consequences. Additionally, fostering a culture of ethical AI development within the military and defense industry is crucial to ensure that ethical considerations are integrated into the design and deployment of AI technologies.

Recent developments in international law highlight the importance of regulating AI in warfare. For example, the Human Rights Watch has advocated for a treaty to ban fully autonomous weapons, emphasizing the need for human control over life-and-death decisions. Similarly, the United Nations has been actively discussing the ethical and legal implications of AI in military contexts, underscoring the need for global cooperation and regulation. The book 'Killer Robots: Legality and Ethicality of Autonomous Weapons' by Krishnan provides a comprehensive analysis of the legal and ethical challenges posed by autonomous weapons. It discusses the potential for these weapons to violate international humanitarian law and the ethical dilemmas of allowing machines to make life-and-death decisions.

6. INTERNATIONAL COOPERATION AND GOVERNANCE

The global nature of AI technology necessitates international cooperation and governance. Countries must collaborate to develop common standards and protocols for the use of AI in warfare. Establishing treaties and agreements can help manage the risks associated with AI-driven military technologies. Additionally, fostering dialogue between military leaders, policymakers, and technologists is essential to address the challenges and opportunities presented by AI in warfare.

International cooperation is vital to prevent the proliferation of AI-driven weapons and ensure that their use is governed by agreed-upon norms and

standards. This includes the establishment of international treaties that regulate the development, deployment, and use of autonomous weapons, similar to existing arms control agreements. Such treaties could include provisions for transparency, verification, and enforcement to ensure compliance and build trust among nations.

Furthermore, fostering dialogue between military leaders, policymakers, and technologists is essential to address the multifaceted challenges posed by AI in warfare. This includes understanding the technical capabilities and limitations of AI, assessing the strategic implications of AI-driven military technologies, and developing policies that balance security concerns with ethical considerations. Collaborative efforts can also help identify best practices and share knowledge on the safe and responsible use of AI in military contexts. The European Parliament's recent report on the military implications of AI underscores the need for a comprehensive regulatory framework. The report highlights the potential benefits and risks of AI.

7. CONCLUSION

The next generation of warfare, characterized by the integration of AI, presents both unprecedented opportunities and formidable challenges. AI has the potential to revolutionize strategic decision-making, automate operations, and transform cyber warfare. The next generation of warfare, characterized by the integration of AI, presents both unprecedented opportunities and formidable challenges. AI has the potential to revolutionize strategic decision-making, automate operations, and transform cyber warfare. Real-world examples, such as Project Maven, the Iron Dome, and AI-powered drones, demonstrate the transformative potential of AI in enhancing strategic decision-making, automating operations, and advancing cyber warfare capabilities. However, the ethical, legal, and security implications of AI in military contexts must be carefully managed. As we navigate this new era, international cooperation and robust governance will be key to harnessing the benefits of AI while mitigating its risks. The future of warfare, powered by AI, will undoubtedly reshape the global security landscape, demanding innovative approaches and vigilant oversight.

As AI continues to advance, it is crucial for military and defence organizations to stay ahead of the curve, leveraging AI to enhance their

capabilities while addressing the associated challenges. By fostering a culture of innovation, adhering to ethical principles, and engaging in international cooperation, we can ensure that the next generation of warfare is characterized not only by technological superiority but also by a commitment to peace, security, and human dignity.

REFERENCES

Allen, G., & Chan, T. (2017). *Artificial Intelligence and National Security*. Harvard Kennedy School, Belfer Center for Science and International Affairs.

Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., ... & Amodei, D. (2018). *The Malicious Use of Artificial Intelligence: Forecasting, Prevention, and Mitigation*. ArXiv preprint arXiv:1802.07228.

Crootof, R. (2016). The killer robots are here: Legal and policy implications. *Cardozo Law Review*, 37(5), 1837-1915.

Darktrace. (2020). *The Enterprise Immune System*. Retrieved from <https://www.darktrace.com>

Defense Update. (2021). *Iron Dome: Israel's Defense Shield*. Retrieved from <https://www.defense-update.com>

European Parliament. (2021). *Report on the Military Implications of AI*. Retrieved from <https://www.europarl.europa.eu>

Geisler, K. (2019). *Autonomous Systems: Implications for Military Operations*. *Journal of Strategic Studies*, 42(6), 760-782. doi:10.1080/01402390.2019.1631810

Horowitz, M. C. (2018). The ethics & morality of robotic warfare: Assessing the debate over autonomous weapons. *Daedalus*, 145(4), 25-36. doi:10.1162/DAED_a_00437

Human Rights Watch. (2020). *Campaign to Stop Killer Robots*. Retrieved from <https://www.hrw.org>

International Bar Association. (2023). *Cyberattacks as War Crimes*. Retrieved from <https://www.ibanet.org/Cyberattacks-as-war-crimes>

Johnson, D. D. P. (2020). *Artificial Intelligence in Military Decision-Making*. *Parameters*, 50(1), 5-20.

Krishnan, A. (2009). *Killer Robots: Legality and Ethicality of Autonomous Weapons*. Retrieved

from <http://www.coep.ufrj.br/~ramon/COE-841/autonomous/book%202009%20-%20Killer%20Rob>

Payne, K. (2021). *I, Warbot: The Dawn of Artificially Intelligent Conflict*. Oxford University Press.

Russell, S., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.

Scharre, P. (2018). *Army of None: Autonomous Weapons and the Future of War*. W. W. Norton & Company.

Taddeo, M., & Floridi, L. (2018). How AI can be a force for good. *Science*, 361(6404), 751-752. doi:10.1126/science.aat5991

US Air Force. (2020). MQ-9 Reaper. Retrieved from <https://www.af.mil>

Zetter, K. (2014). *Countdown to Zero Day: Stuxnet and the Launch of the World's First Digital Weapon*. Crown.

**A COMPARATIVE ANALYSIS OF CLAUSEWITZ AND CAPTAIN
LIDDELL HART'S MILITARY THEORIES AND THEIR APPLICABILITY
IN THE MODERN WARFARE: INSIGHTS FROM
SRI LANKA AND UKRAINE**

Dr Punsara Amarasinghe PhD and Prof Rohan Gunaratna PhD

ABSTRACT

The celebrated idea of Prussian war strategist Clausewitz regarding the conventional warfare played a dominant role up to the First World War in the West. In his seminal work 'On War', Clausewitz posits "If you want to overcome your enemy, you must match your efforts against the power of resistance". In a way his idea was akin to annihilating the enemy's army in major battles. However, this idea was challenged by British military strategist Captain Basil Liddell Hart in his book titled 'The Strategy' by proposing a different military theory called 'Indirect Approach'. The objective of this paper is to undertake a comparative analysis between Clausewitz and Liddell Hart regarding the utility of their military theories in modern warfare. While taking a methodology based on a comparative analysis of the utility of the two doctrines, this paper explores the effectiveness of those military strategies against the current asymmetries in modern warfare. In order to buttress the reliability of this research, the examples from Ukrainian war and the Sri Lankan civil war between 1990-2009 would be examined. The main objectivity of this paper lies in creating a novel discussion on the merits and demerits of Clausewitz and Captain Basil Liddell Hart's theories of war in the contemporary warfare. The results emerging from this research will demonstrate the relevance of re-reading both Clausewitz and Liddell Hart in an era, where the orthodox idea of warfare is at stake.

Key Words: Strategy, Military, War, Sri Lanka, Ukraine

1. INTRODUCTION

The dominant refrain of the present age is that we are in the 'post-Cold War era'. Beyond that, we are not sure. We may be living amidst the triumph of liberal capitalist democracy and the end of history, or a period of civilizational conflict, or – as the current worldwide turbulence would encourage us to conclude – the age of terrorism or AI. Whatever we choose to believe, we tend to think of the Cold War as a unique event, which is now the memory of a bygone age. However, the catastrophic events that took place owing to Russia's invasion of Ukraine suddenly ended the slumber of those who dwelled on the romanticizing vision of liberalism and Cold War nostalgia. The Russian invasion of Ukraine did sabotage Fukuyama's thesis along with Huntington, who assumed that a military conflict between Russia and Ukraine is an impossibility by virtue of their shared Orthodox values (Huntington, 89). Given such a turbulent time, the importance of tracing the military strategies come to the fore. It is in this context that this paper intends to make a comparative analysis between the strategic moves of two great military thinkers of human history. It is by no means an exaggeration to state that the military doctrines propounded by Clausewitz and Captain Liddell Hart are antithetical to each other as their philosophical approaches to the battlefield took different bends. Thus, any attempt in comparing both of them in light of modern warfare can become a complexity, yet this study determines to take a nuanced approach in revisiting Clausewitz and Liddell Hart.

The celebrated idea of conventional warfare of Clausewitz arose in a time when European powers engaged in complex geopolitical encounters in search of a hegemony, and against the backdrop of European history of the 19th century. Captain Basil Liddell Hart emerged as a champion of a different military theory called 'Indirect Approach' in an era, where conventional warfare failed in achieving the objectivity of war. The military failures that Liddell Hart witnessed as a captain of the Yorkshire light infantry regiment in the Western front or in the battle of Somme compelled him to look for an alternate military theory to intensify favorable military outcomes. It appears that both military strategists have molded their theories parallel to the historical incidents, which contained an empirical basis.

Based on a comparative analysis of both Clausewitz and Liddell Hart, this paper explores the validity of their theories to the modern warfare. The certainty of challenges that encompassed the modern warfare ranging from military asymmetries to the development of AI are obvious issues that may refute the theories of Clausewitz and Liddell Hart, but the task of this paper remains twofold. First, it examines the differences between two military doctrines separately while astutely examining their applicability in the modern battlefield. In doing this task, this study looks into Sri Lankan Civil War (1983-2009), which was by all means an unconventional war within a state and Russia-Ukraine military conflict. Secondly, this paper would assess how both military doctrines can become effective regardless of their orthodoxy in the 21st century warfare.

2. ANALYSIS FROM 'ON WAR'

Carl von Clausewitz stands in a prominent position in the small pantheon of Western military theorists as his magnum opus 'Vom Kriege' contains remarkable ideas, which are useful for modern warfare in the 21st century. Prussian General Clausewitz completed his celebrated thesis in accordance with the contemporary needs of the European giants. In fact, Clausewitz' own state, Prussia was sandwiched between the Austro-Hungarian empire and France, thus creating a hostile environment for Prussian existence, which fervently impacted upon Clausewitz understanding of war as the continuity of politics by the other means. Nonetheless, today Clausewitz is often quoted than read, more venerated than understood (Shephard, 1991).

First time readers of Clausewitz certainly find his style to be obtuse and confusing, as it is filled with philosophical aphorisms rather than providing astute analysis of military theory. For instance, in the opening chapter of 'On War', Clausewitz describes war as nothing but a duel on a larger scale, an act of force to compel the enemy to do our will or else he reiterates his most popular dictum "War is a continuation of politics by other means" (Kennedy, 1988). Despite the aphorism filled with his text that tries to describe war as a dialect, one needs to understand Clausewitz as a military thinker than a soldier. The objective of writing his thesis 'On War' was rooted in capturing the observation that are universal to all the wars regardless of the geopolitical locations. After having studied the Napoleonic wars in his time, in which he himself served as a General, he uses a

dialectical method of reasoning in exploring the nature of war. Perhaps, this usage of dialectical method of critical examination by using a dialogue of contrary views seemed to have risen from the 19th century German philosophical tradition, which frequently dealt with the dialect (Mc Neil, 1982).

In his explanation of war, Clausewitz describes war as a social phenomenon that is aimed at imposing one's will on one's opponent through the use of force. Based on his state centric interpretation, written in an era, where European powers were interested in consolidating the state power, Clausewitz acknowledged the fact that war can embody different ends depending on the actors, purpose and even means available at the time. He further understands man's inherent thirst for war as a part of human existence which can only be resolved through a bloodshed. In continuing his lengthy analysis of war, Clausewitz describes war as a riddle which constitutes no logical limit to its application of force. Each side will compel its opponents to follow suit: A reciprocal action that must lead, in theory to extremes (Clausewitz, 76).

The paradoxical trinity is the phase initiated by Clausewitz in describing the three main pillars of the war: the government, the army and the people. The first factor to be constrained is the government as Clausewitz emphasizes the central role politics plays in war, he posits that war is not an end unto itself, but rather a tool in realizing the political objectives. Although, he was a trained military general, Clausewitz was not a military exclusivist to rely only on military solutions as he regarded war as the last resort. Second pillar in his trinity is the people and Clausewitz believed that people should be zealous in war efforts for its successful need. He states "passions that are to blaze up in war must already be inherent in the people as war is not an action of living force upon a lifeless mass but always the collision of two living forces" (Clausewitz, p.18). He understood that risk awaits the people in war and duly explained the only way to reduce the human casualties in the war front was based on mutual coordination among the states, that distinguished civilized form of warfare from savages. The third and final factor that Clausewitz highlighted was the army, and he states "The political object is the goal, war is the means of reaching it, and means can never be considered in isolation of their purpose" (Clausewitz, p.25). Clausewitz's paradoxical trinity comprised of the tendencies of the government, people

and armies, in which the effects and contrasts among them produce outcomes which are difficult to predict.

The major military philosophy that Clausewitz developed was a combination of many distinct engagements, which consisted of defensive principals he emulated from Napoleon and Frederick the Great. The cardinal approach he developed in his strategic thinking in war essentially focused on the directness of the troops and launching attacks to the enemy from the front and the flanks. Clausewitz states:

“A fundamental principle is never to remain completely passive, but to attack the enemy frontally and from the flanks, even while he is attacking us. We should, therefore defend ourselves on a given front merely to induce the enemy to deploy his forces in an attack on the front” (Clausewitz, p.45)

It should be noted that the geopolitical trajectories that encompassed Clausewitz military upbringing decisively shaped his military philosophy in favour of major battles. He was truly fascinated with the Napoleonic way of overthrowing the enemy to render him politically helpless and militarily impotent, thus forcing him sign whatever the conditions that Napoleon determined. Clausewitz was also an admirer of the subtle military technics used by Frederick the Great of Prussia. Frederick the Great often looked for an alternative objective in occupying the territories that would enable them to annex them or use them in a fair deal. These two characters inspired Clausewitz in constructing his strategic approach in the battle field based on launching massive attacks. (Langston, 1963) He proposed that the goal of any solid army was to annihilate the enemy completely. He states “We must pursue this goal with the greatest energy and with the last ounce of our strength” (Clausewitz, p.56).

His faith in major battles in the warfare can be further seen in his analysis of the strategic principles for the offence which illustrates his stances in the offensive lines of war. He states “We must select for our attacks one point of the enemy’s position and attack it with great superiority”.

Clausewitz was more conventional in using the infantry forces in the battle field with a greater confidence, which may had derived from his admiration of the French legion. Regarding the consistency of the use of force, he states

“Even though we are strong, we should still direct our main attack against one point only. In that way we shall gain more strength at this point. For to surround an army completely is possible only in rare cases and requires tremendous physical or moral superiority” (Clausewitz, p.67).

Notwithstanding the grandeur held by Clausewitz in the field of military theory, his strategies reached the ebb in the Great War by virtue of their operational failures in the ground level. Amidst the Franco-Russian alliance, Germany opted for Clausewitz’s admonition of attaining a quick victory against the foe, which was carried under General Moltke who desired to capture French capital. In fact, this was a detrimental move made by Germans as their intensity in the battlefield finally exhausted them by paving the path to the complete military annihilation. (Liddell Hart, 1939) Although Clausewitz had seen greater European wars in his life time, he was not aware of what awaited him in the following century. The First World War made unprecedented demands upon the people of the warring nations both on the battlefield and the home front which were not possible to be addressed by Clausewitzian approach (Keegan, 2003).

3. LIDDELL HART’S BIG IDEA

Captain Basil Liddell Hart entered the annals of military history with his most celebrated idea called ‘Indirect Approach’, but it is important to observe that his military doctrine arose as an answer to the catastrophic military failures from the Great War. In particular, Liddell Hart understood extensive misreading of Clausewitz and adherence to large scale battles caused the havoc in the war machinery of both allies and the central forces in the First World War. Captain Liddell Hart witnessed the brutality of major war failures in Western Front by deploying more soldiers which led the troops to slaughter. Liddell Hart described this as a result that stemmed from Clausewitz’s emphasis on great superiority of the warfare, who held that “Only a great battle can produce a major decision” (Lewin, 1971).

Inspired by Chinese strategist Sun Tzu, Liddell Hart developed a new military theory in the 1920’s. He realized how political dimensions, sea power, air crafts and public uprising altered the face of war, which fundamentally distinguished from how Clausewitz viewed warfare. In his seminal work entitled ‘Strategy’, Liddell Hart analyzes the war as a concept

from the ancient time to the Great War and he juxtaposes himself against Clausewitz in the way he interprets the strategy. In his criticism of Clausewitz, Liddell Hart states that old Prussian General looked at war from a parochial perspective, which unnecessarily stressed the importance of the engaging the enemy as the only means to achieve a strategic end. On the contrary, Liddell Hart describes strategy as “The art of disturbing and applying military means to fulfill the ends of policy” (Liddell Hart, 1967, 335).

The indirect approach remains the monumental contribution made by Basil Liddell Hart to the military theory. It appears Liddell Hart coined this indirect approach after a careful examination of the history, in which he realized that wars are won when the means of war are applied in a manner that an opponent is unprepared to meet, that is, employed in an indirect fashion. He looked at how Hannibal marched across the Alps to strike Rome as a palpable example from history manifesting the indirect approach. In his theory of ‘Indirect Approach’, strategy does not need to overcome resistance, but rather exploit the elements of movements and astonish to achieve victory by throwing the enemy off balance before a potential strike. He states “Direct attacks against an enemy firmly in position almost never works and should never be attempted” (Liddell Hart, 89).

This statement came from him through a set of historical illustrations he presented, where attacks on formidable targets ended in unmitigated military disasters. He uses the word “dislocation” as a key word of the indirect approach as dislocating the enemy stands more paramount than seeking an instant victory. The subsequent results arising from dislocating the enemy opens greater opportunities to military generals to exploit the chances. He discusses the chances that any military leader can accomplish in discussing his second principle of the indirect approach. “To defeat an enemy, a commander must first upset his enemy’s equilibrium; which is not accomplished by the main attack, but instead-must be realized before the main attack can succeed”.

Unlike Clausewitz, who was fascinated with major battles and massive attacks, Liddell Hart never endorsed the direct success in war. He explained that a commander should never employ a rigid strategy revolving around powerful direct attacks nor fixed defensive positions. The Infantry was his

favourite mode of war, which needs to be buttressed by the combined air and artillery forces and it was obvious that this mechanism generated the German military doctrine '*Blitzkrieg*' in the Second World War against British, French and Soviet troops. However, he was mindful in the political apparatus in achieving the military objectives (Waltz, 1959). Liddell Hart believed if wars are waged to attain political objectives, then those objectives should not go beyond the accessible military means to achieve them. Generally, the task of war is what he calls a better state of peace, or the realization of a policy of goal that makes peaceful existence better for at least one of the combatants. He argues that military victory does not spontaneously ensure attaining the object unless it is aligned with the political object.

4. SHADOWS OF CLAUSEWITZ AND LIDDELL HART IN MODERN WARFARE

The 21st century warfare is an enterprise epitomizing the changing dimensions in war blended with the use of modern technology, which is entirely different from the orthodox continental warfare during the time of Clausewitz. Nonetheless, the roots of the very genesis of war which emanates from the human mind remains consistent throughout the ages regardless of the influx of technology. Warlike element is such a timeless concept that Clausewitz elaborated in '*On War*', which highlights Man's inherent enthusiasm for fighting driven by 19th century German romanticism over battlefield (Aron, 1983). The spirit that Clausewitz revered is visible today as a key factor in setting the trajectories of war and those sentiments can be easily seen in examining some of the modern wars in different contexts.

The Ukraine-Russian armed conflict is ongoing war, which can be used as an ideal case study in assessing the relevance of Clausewitz's warlike element in the ground level. After Russia launched the military invasion of Ukraine in February 2022, the public morale among the Russia people seemed to have divided as some eagerly engage in the war towards its end and some openly hesitate, whether Moscow can reach a favourable outcome. However, in the case of Ukraine, the people's zeal in defending Kiev was high and the armed forces were combined with the volunteers who appeared to defend the capital. Early reports indicate most of the Ukrainian

citizens came forward with most basic weapons from Kalashnikovs to Molotov cocktails for the sake of defending the capital.

To be sure, the strong Ukrainian resistance that Russian forces faced from the Ukrainian people stands as a microcosm of the warlike element of Clausewitz in action. While looking at how warlike element propounded by Clausewitz came into the picture in armed conflict within a state, the Sri Lankan civil war becomes the clearer example. Unlike the conventional interstate wars that Clausewitz went on to discuss, the Sri Lankan example is a war within a state that lasted for 30 years between the government and a terrorist organization called the Liberation Tigers of Tamil Eelam (LTTE). Therefore, applying a western military theorist in analyzing the nature of a civil war in an island seems to be an absurd task, but such an assumption is likely to be false as the nature of war remains same regardless of the geopolitical distinctions. In his paradoxical trinity, Clausewitz looks at primordial violence, hatred and enmity; influenced by the play of chance and probability; and rationally subordinated to politics.

The primordial violence, hatred and enmity are linked fundamentally to the people; luck and chance, to the armed forces and their commander; and rationality to the government. (Pereira, 2014) In the 4th Eelam War, the public sentiment which stood in favour of the government war effort was akin to the manifestation of warlike element by Clausewitz. In fact, the government mechanism intensified people's participation in the war by various means such as establishing civil security committees across the country, also the media projection depicting the warrior image of 'Sri Lankan soldier' effected the development of people's faith in the victory, which lasted until the elimination of LTTE in 2009 (Chandra Prema, 2012).

It is by no means an exaggeration to describe Captain Basil Liddell Hart as the most cited and well received military theorist, whose military tactics have vanquished the conventional open war strategy of Clausewitz. The 'Indirect Approach' that Liddell Hart coined in 'The Strategy' become the main mode of resistance embraced by Ukrainians in their efforts in defending Kiev. When the war broke out on 22nd February 2022, Russians mounted an armoured and air assault on Kiev with the benign expectation that Kiev would easily surrender before the mighty Russian air power along with the artilleries. The Russian way of initiating massive attacks denote the

typical Clausewitzian manifestation of war. However, the Russian war machinery was stunned by the unexpected resistance of Ukraine. Rather than using massive armed tanks, Ukrainians used hand held missiles such as the javelin to carry out sudden attacks on Russian supply chains.

In August 2022, the Russian airbase in Crimea was targeted by some Ukrainian fighters who bombed eight aircrafts. When the fully fledged war was going on in the Ukrainian front, the Ukrainian resistance fighters seemed to have taken it to Russia's heart Moscow itself. It has been reported that two Russian Generals were killed on the war front while Russian military facilities were often targeted by Ukrainian rockets. Last summer Russia suffered heavy casualties as Ukrainian forces intensified counterattacks based on the 'indirect approach' that included the attacks launched on the Russian garrison in Kherson and the destruction of the major bridges across the Dnieper River, which sabotaged the Russian supply line. Meanwhile, in Moscow, Russia's prime ideologist Alexander Dugin's daughter was assassinated in August. Last September was a rather catastrophic month for Russians as Ukraine killed nearly 465 soldiers within a week which was followed by another surprise rocket attack on Russian troops on the New Year's Eve in Makiivka. Both the attacks manifested Liddell Hart's two principles in the indirect approach, which states direct attacks on firm defensive positions seldom work and should never be attempted and to defeat the enemy one must first disrupt his equilibrium, which must take place before the main attack is commenced.

The utility of 'Indirect Approach' in Sri Lankan military apparatus dates back to the early 1990s and it mainly sprang as a result of the massive failures suffered by Sri Lankan armed forces from their conventional combat strategies against the LTTE. Since the outbreak of Eelam War in 1983, the LTTE achieved an extraordinary combating capacity due to various factors and the morale of the Sri Lankan armed forces reached its nadir in the early 1990s. By the time General Cecil Waidyaratna became the Commander of Sri Lankan Army in 1991, the array of military defeats of Sri Lankan Army was catastrophic, which included LTTE's capture of Mankulam, retreat from the Jaffna fort and daily attacks on military vehicles.

Even though General Waidyaratna was not a field officer or a great combatant, he was a genuine military theorist. In a work titled "Gota's War"

veteran journalist C.A. Chandraprema states “Waidyaratna was the first army officer, who began to think of a comprehensive mechanism to annihilate LTTE terrorism completely through a prism of military theory” (Chandraprema, 218).

Based on the previous operational failures in Sri Lankan Army, General Waidyaratna recommended that Sri Lankan Army should launch its operations separately. He acknowledged the inability of combating in both the Northern and Eastern provinces together as the Sri Lankan Army did not possess such advanced power. Hence, he suggested that Army should focus on the Eastern province where the LTTE remained relatively weaker. In his further analysis, Waidyaratne believed after capturing the weakest province of the enemy, Sri Lankan Army should use its fullest strength in defeating LTTE in the Northern Province. This was what exactly Captain Liddell Hart explained as indirect approach. Also, he suggested to take intensive actions in increasing the capacity of Sri Lankan Navy to combat the supply network of the LTTE.

None of those recommendations were implemented during his tenure and General Waidyaratna passed away in 2001 as a retired general, but surprisingly the operational style adopted by Sri Lankan Army under then General Sarath Fonseka resembled what Waidyaratna recommended. Between 2007 and 2009, Sri Lankan Armed Forces relied on the indirect approach than the direct approach. The capture of Toppigala and the subsequent military success in the Eastern province paved the path for Sri Lankan Army to consolidate their whole energy in liberating the whole Northern Province in 2009.

5. CONCLUSION

Both Clausewitz and Liddell Hart were products of their time. The historical antecedents, the events they witnessed, political ideologies they revered simply carved the military philosophies that both of them produced. None of those theories in war are highly unlikely to be the most appropriate ones in an era, where the asymmetries of wars have come to the fore. Even the Ukrainian war efforts harboured by the indirect approach would be challenged by the growing massiveness of Russian attacks. Celebrated wisdom of Liddell Hart has clearly saved the Ukrainian military resistance

from a complete collapse. But the bitter reality that looms before the war front is that Ukraine will need to face significant battles for decisive results. In particular, the recent shift of Russian war strategy in Ukraine has embraced a more rigorous path consisting of unleashing heavy attacks by a new wave of missile strikes. The overarching analysis arising from this comparative analysis of both Clausewitz and Liddell Hart based on their utility in modern warfare proves the impossibility of adopting a single military strategy. Therefore, the future of the war is likely to be blended between both Clausewitz and Liddell Hart by opting for a middle path.

REFERENCES

Aron, Raymond 1983. Clausewitz: The Philosopher of War, London: Routledge.

Clausewitz, Carl Von 1832. On War, London: Penguin Books.

Chandraprema, C.A. 2012. Gota's War: Historical Defeat of Tamil Terrorism, Colombo: Vijitha Yapa.

Huntington, Samuel 1996. The Clash of the Civilizations, London: Penguin Books.

Keegan, John 2000. The First World War, London: Penguin Books.

Kennedy, Paul 1986. The Rise and Fall of Great Powers, New York: Vintage.

Lewin, R 1972. The Captain who taught Generals, *International Affairs*, Vol.47, No.1

Liddell Hart, Basil 1929 Strategy, New York: Oxford University Press.

Liddell Hart, Basil. 1967 Why don't we learn from history? London: Oxford University Press.

McNeill, William. 1982. The Pursuit of Power: technology, armed force and society since AD 1000. Chicago: Chicago University Press.

Pereira, Lucas. 2014. Innovation and the Warlike Phenomenon, *Brazilian Journal of Strategy and International Relations*, Vol.4, No.6.

Shephard, John E, 1991. Is Clausewitz still relevant?, *US Army War Quarterly*, Vol.2, No.1

Waltz, Kenneth. 1959. Man, State and War: A Theoretical Analysis, New York: Columbia University Press.

NOTES ON CONTRIBUTORS



Brigadier KVP Dhammika, serves as the Director of Defence Cyber Command and Information Warfare Centre at the Ministry of Defence, Sri Lanka. Being an alumnus of Isipathana College, he joined General Sir John Kothelawala Defence University as a Service Cadet in 1993, and earned a Bachelor's Degree in Defence Electronic Engineering. Commissioned as a Second Lieutenant in 1997, Brigadier Dhammika has held key positions in the Sri Lanka Signal Corps. He is a Chartered Engineer of India and a member of the College of Military Engineering, Sri Lanka (CMETSL). He also served as a Senior Lecturer at General Sir John Kotelawala Defence University and headed the Electronic Wing of the Centre for Research and Development (CRD) at the Ministry of Defence, where he was a founding member. His academic credentials include an MPhil in Electronic and Telecommunication Engineering from the University of Moratuwa, and MSc in Military Technology from Savitribai Phule Pune University, obtained at the completion of the Defence Services Technical Staff Course in India.



Wing Commander HWN Wanasinghe is an operationally qualified Fighter Pilot, fighter leader and an A2 graded Flying Instructor. He completed his Master's Degree in Human Resource Management in 2020 at University of Colombo. He graduated from Defence Services Command and Staff College, Sri Lanka securing First in Order of Merit in Air Wing (Golden Owl) and Commandants' Honours in 2022, concurrently completing Master's Degree in Defence and Strategic Studies at KDU. He has published 12 conference papers and journal articles. At present he serves as a Chief Casualty Evacuation Operations in United Nations Multidimensional Integrated Stabilisation Mission in Central African Republic.



Wing Commander MADCK Wijetunge is an operationally qualified Fighter Controller. He held the appointments of Officer Commanding Operations in No 05 and 06 Air Defence Radar Squadrons and Officer Commanding Training at the Air Defence Command and Control Centre. He also held the positions of Directing Staff and Senior Instructor appointments at the Junior Command and Staff College, Sri Lanka Air Force Academy. He is an alumnus of the Defence Services Command and Staff College, Sapugaskanda, Course No DSCSC 14, securing Second in Order of Merit in Air Wing and simultaneously completing the Master's Degree in Defence and Strategic Studies at KDU while becoming the First in Order of Merit. He has also earned a Postgraduate Diploma in Defence Management, a Diploma in International Relations, and a Higher Diploma in Applied Statistics with distinction. He has published and presented several research papers in international and local research journals/ conferences. Presently he is serving as a Directing Staff at the Defence Services Command and Staff College, Sri Lanka.



Commander (C) AGMPK Wijenayaka is a Communication Specialist Officer in Sri Lanka Navy and he has successfully completed his basic degree at University of Kelaniya with Second Class lower division in year 2005. He has earned a Post Graduate Diploma in Conflict and Peace Studies at University of Colombo in year 2014. Further, he completed his Staff Course from the prestigious institute of Defence Services Command and Staff College, Sri Lanka in year 2018 and acquired both psc and Masters of Defence and Strategic Studies from General Sir John Kotelawala Defence University. Moreover, he holds Masters of International Relations from the University of Peradeniya in year 2021 and Masters in Military Technology from Defence Services Technical Staff Course at Military Institute of Technology Pune, India in year 2024. Presently he is serving as a Directing Staff at the Defence Services Command and Staff College, Sri Lanka.



Commodore Nimal Ranasinghe was born in 05th June 1973 and studied in Ananda College, Colombo. He has joined Sri Lanka Navy as an Officer Cadet in 1994, and was commissioned as an Acting Sub Lieutenant on 22nd October 1996. He has completed his Sub Lieutenant Technical Course in Bangladesh and specialized in Navigation in India. He has a Bachelor's Degree in Technical Management Sciences, and has a Master's Degree in Management. In year 2010, has completed the Staff Course in Malaysia. He also has a Diploma in Defence and Strategic Studies from University of Malaya, and completed Programme on Terrorism and Security Studies in Germany. He has held key appointments of Commodore Sea Training, Deputy Director Naval Policy & Plan at Naval Headquarters, Captain Operations Department, Directing Staff at Staff College, Directing Staff at Naval and Maritime Academy, Training Captain, Senior Staff Officer Local Training, Senior Staff Officer Naval Examination and Curriculum, and also he was appointed as Deputy Area Commander, Northern Naval Area. Presently he is following the National Defence Course at the National Defence College in India.



Asela Waidyalankara is a renowned expert in Cybersecurity and Digital Transformation. With over a decade of experience in the field, he has contributed significantly to enhancing cyber defence mechanisms and promoting digital innovation. Asela holds degrees in Business & Technology, Law and Master of Law and is a frequent speaker at international conferences. He is currently serves as the Course Director for Cybersecurity and Emerging Technology Policy at the Bandaranaike Academy for Leadership and Public Policy and Visiting Lecture for MSc in Digital Transformation Leadership at NEXT Campus the Sri Lankan affiliate for London Metropolitan University UK. His work focuses on the intersection of technology, security, and policy, with a particular interest in Artificial Intelligence (AI) and its applications.



Dr Punsara Amarasinghe is a Lecturer at the Department of International Law, Faculty of Law, General Sir John Kotelawala Defence University, Sri Lanka. He is a PhD holder Public International Law from the Institute of Law, Politics and Development at (Sant Anna School for Advanced Studies)Scuola Superiore Sant Anna in Pisa, Italy. He holds LL.M from South Asian University, New Delhi and completed his undergraduate studies in law at the Faculty of Law, University of Colombo, Sri Lanka.

He completed another Masters degree in International Relations from the HSE, Moscow. He worked as a Research Assistant at the Department of Public and Private International Law at Higher School of Economics in Moscow in 2018 for a project on Russian legal realism. He has held two visiting research fellowships at Global Legal Studies Centre in University of Wisconsin Madison and Sciences PO, Paris. Also, he was affiliated to Minerva Center for Strategic Studies at Hebrew University, Jerusalem in Israel for a brief period in 2019. His research interests deal with the Military Strategies, Asymmetric Warfare, Russian Foreign Policy and theories of international relations. He is a life member of Indian Society of International law and the current joint secretary of the Royal Asiatic Society of Sri Lanka.



Prof Rohan Gunaratna is a global expert on terrorism and security, serving as Professor of Security Studies at the S. Rajaratnam School of International Studies, Nanyang Technological University. He holds a Master's from the University of Notre Dame and a PhD from the University of St Andrews. A former Senior Fellow at West Point and the Fletcher School, he has advised security agencies worldwide and testified before the 9/11 Commission. Author of 16 books, including Inside Al Qaeda, his work

is based on extensive field research in conflict zones. In 2014, he received the Major General Ralph H. Van Deman Award for advancing international security cooperation.



CORE VALUES OF DSCSC

LEARNING

HONOUR

RESPECT

DECORUM

EXCELLENCE

INNOVATION

PUNCTUALITY

MISSION COMMAND

PRISTINE ENVIRONMENT

DRIVING TENET: COMMON SENSE

Published by
Defence Services Command and staff College
Sapugaskanda, Makola South 11640,
Sri Lanka
Tel: +94-112964218/ +94-112963792
Fax: +94-112962151
Email: dsccsl@gmail.com / dscc@army.lk

