THE IMPACT OF CLIMATE CHANGE ON CAMBODIA'S MARITIME ENVIRONMENT: THE WAY AHEAD

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A. INTRODUCTION

1. The importance of the sea

The Earth as we know it is dominated by the oceans. Roughly, 70% of its surface is covered by water. The ocean influences all aspects of life. It is the largest ecosystem on Earth. It is home to 94% of the entire planet's wildlife (SPC, 2022). It provides us with basic

life supports such as oxygen, fresh water and food. Oceans regulate our climate, absorb greenhouse gases, and contain minerals and natural resources such as sand, gravel, oil and natural gas. It also serves as the foundation for much of the world's economy, supporting sectors from tourism to fisheries to international shipping.

Humans have explored and made use of the resources found in the ocean since the beginning of their existence. The sea accounts roughly for 17% of the global production of edible meat (Costello, 2020). Food from the sea is produced from wild fisheries and mariculture (animal farming in the sea). They are a major source of food for people around the world and the demand keeps growing as the global population increases.

For many states, marine tourism comprises a significant portion of their economic activity. The sea is also seen as a place for most people to enjoy, relax, and engage in sport activities.

On the topic of climate, the seas play a very important role in regulating it. It synchronizes the heat around the globe by moving warm currents towards the Poles, circling back after cooling down, which affects the Earth's weather patterns. Moreover, the seas absorb huge amounts of CO2, which is a major cause of climate change.

From an economic standpoint, the sea enables almost 90% of global trade. This represents a whole cluster of economic activities that create jobs and businesses for millions of people around the world. In recent years, new studies and research has been conducted, and new industries have been established. These include extracting marine components for medicinal purposes, farming algae and seaweed for food and fuel and the mining of new raw materials.

Environmental aspects of the sea such as waves, tides, currents, salinity and temperature fluctuation are used in the production of renewable energy. With the evolution of technology, huge progress has been achieved in the development of marine-based energy sources. In general, the sea is used in almost all of our daily lives. It supports livelihood of people around the world and the sustenance of the Earth.

2. Climate change

Climate change is a term that refers to major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer (IPPC, 2007a). Any factor which alters the

radiation received from the sun or lost to space, or which alters the redistribution of energy within the atmosphere, and between the atmosphere, land and ocean, can cause climate change (Hougton J.T, 1990).

There are two different factors for climate change: anthropogenic climate changes and natural variations. The anthropogenic factor talks about human activities that have changed and continue to change the Earth's surface and atmospheric composition.

According to the Environmental Protection Agency (EPA) (EPA 2010), human-induced activities that cause climate change include deforestation, burning fossil fuels, emissions of greenhouse gas (GHG) and other pollutants, changes in land use such as urbanization and agricultural expansion. The natural causes of climate change are based on the sun's intensity, change in the Earth's orbit, changes in ocean current circulation, volcanic eruptions, melting of glaciers and sea-level rise.

Today, however, changes in the climate are largely the result of anthropogenic activities. It is important to note that The United Nations Framework Convention on Climate Change (UNFCCC) uses the term "Climate Change" to refer exclusively to change brought about by human activities. Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven by economic and population growth and are now higher than ever (IPCC, 2014). This has led to greenhouse gases such as CO2, CH4 and N20 to concentrate and trap heat that causes the Earth to warm. Such an effect also reduces the Earth's cooling efficiency (IPCC, 2020).

According to the United Nations (UN), the impact from climate change includes:

- Hotter temperatures
- More severe storms
- Increased drought
- A warmer, rising ocean
- Loss of species
- Not enough food
- More health risks
- Poverty and displacement

Human activities have changed, and continue to change, the Earth's surface and atmospheric composition. These activities affect the rainfall patterns across the globe with increasing floods, drought frequency and severity, heat stress, wind, sea-level rise and wave action (IPCC, 2020). A warmer climate will lead to a more vigorous hydrological cycle that causes more severe floods and droughts. Climate change creates additional stresses on land and sea, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure and food systems.

3. Background and Motivation

As shown earlier, climate change is a key concern of our. It is a real and urgent challenge that is already affecting people and the environment worldwide (Braman, 2010). It threatens to exacerbate existing environmental concerns including deforestation, serious soil erosion and loss of top soil and land degradation, which in turn has adversely affected agricultural productivity (NRC, 2011). As Cambodia is a country that relies mainly on the agriculture sector, extreme climate events such as flooding, droughts and violent storms worsen economic development and Gross Domestic Product (GDP) growth. Cambodia's agriculture plays a vital role in supporting economic growth, ensuring equity and food security, and developing the rural economy. This agricultural activity is predominantly rain fed, based on household subsistence and characterized by low input and moderate or low fertility land thus making it dependent on weather conditions and changing climate.

There is a significant amount of research on climate issues in Cambodia and this report is partly based on existing literature references. Many government and non government organization (NGO) reports also cover on these matters as well. On the other hand, research on its effects on Cambodia's maritime environment is limited and not easy to come across, which is seen to be a knowledge gap.

4. Statement of research problem

As mentioned in the above section, understanding the impact that climate change can have on the maritime environment is very crucial. This report will illustrate the impact of climate change on Cambodia's maritime environment. In doing so, it will suggest different approaches one could implement to mitigate against, and adapt to those, impacts of climate change. Finally, the challenges that Cambodia is facing regarding climate change will be discussed in this report.

In summary, the research questions this report focuses on is: "*How does climate change impact Cambodia's maritime environment and how should Cambodia mitigate or adapt to the challenge of climate change?"*

5. Objective

The main objective of this research is to illustrate how climate change influences Cambodia's maritime environment and offer policy recommendations to the Royal Government of Cambodian (RGC). The purpose is to study and be able to understand the impact of climate change on the Cambodian maritime environment. This knowledge would benefit people in general who have a connection to the maritime environment.

Furthermore, this information would also contribute to the decision-making processes of the Cambodian maritime authority. By achieving the main objective, this paper will address additional sub-objectives, such as:

- A study of Cambodia's maritime environment;
- An investigation of the impact of climate change on Cambodia's maritime environment; and
- A proposal to discuss some approaches to alleviate, mitigate and adapt to climate-related problems.

In addition, this report also focuses on a few other objectives such as finding the challenges between different stakeholders in order to work together efficiently and the development of legislation or over-arching law as well as the cooperation between states in the region.

B. CAMBODIA'S MARITIME ENVIRONMENT

1. Cambodia

Cambodia is a country, formally known as the Kingdom of Cambodia, located in the mainland of Southeast Asia with a total area of 181,035 km2. The topography of the country mainly consists of central plains surrounded by mountainous and highland regions and a coastline along the south of the country. Cambodia shares a border with Thailand to the North and West, Lao to the Northeast, Vietnam to the East and has a 443 km coastline as per Figure 1-1. Phnom Penh is the capital city of Cambodia, located in the central plain and at the convergence point of the rivers Mekong, Tonle Sap, and Bassac.

Figure 1-1: Map of Cambodia

Cambodia is a tropical country. The climate is influenced by monsoonal conditions that produce two seasons: a wet season and a dry season. The annual average temperature is 28°C, with a maximum average of 38°C in April, and a minimum standard of 17°C in January (DoM, 2013) (Heng, 2014). The average annual rainfall from 1985-2013 ranged from 1,000-1,400 mm in the central lowlands, ranged from 2,000-2,200 mm in uplands to 3,000-4,000 mm in the coastal zone. The annual rainfall distribution is shown in Figure 1-2 below.

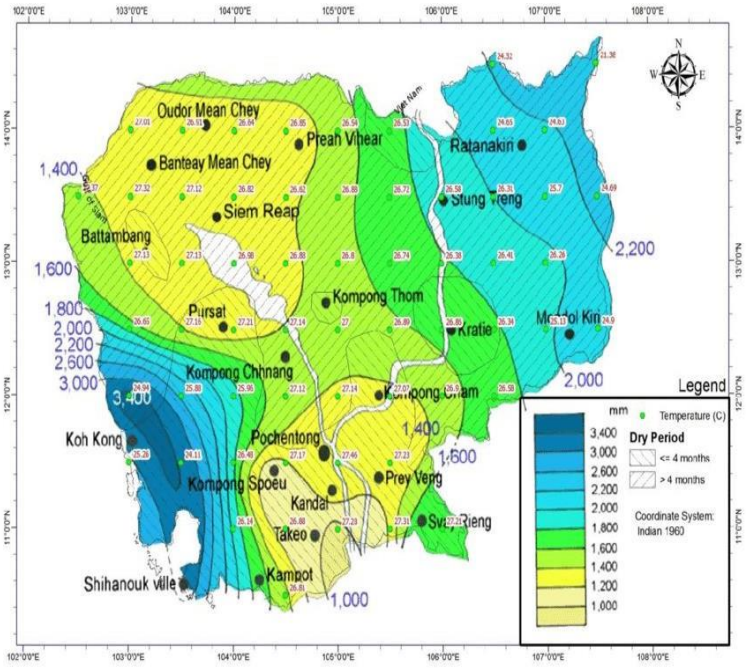

Figure 1-2: Annual Rainfall Distribution of Cambodia (Sovann, 2010)

The population in Cambodia is 15.3 million people in 2019 and is projected to reach

17.3 million by 2023, 18 million by 2028, and around 21 million by 2048 (NIS, 2019). About 80% of the population live in rural areas. The poverty in rural areas is higher than the poverty in urban area. Climate change has a big impact on poverty especially for people who live in the rural area.

From an economic standpoint, Cambodia mostly relies on four main sectors, namely agriculture, tourism, industry and construction. The annual GDP grew at an average of 8% between 2000 and 2010 and about 7% since 2011. The annual GDP and real GDP growth rate are shown in the Figure 1.3. According to (NIS, 2011), agriculture, fisheries and forestry accounted for 32% of GDP, industry 22%, services 38% and taxes on product 8%. The agriculture sector comprises rice production, livestock and rubber. On the other hand, the industry sector relies on fast-growing subsectors such as textile, apparel and footwear. The construction industry, investment in electricity, water and energy development also play important roles in this sector as well. The main export products of Cambodia are garments, minerals, and agro-based products such as paddy, rice, fish and rubber.

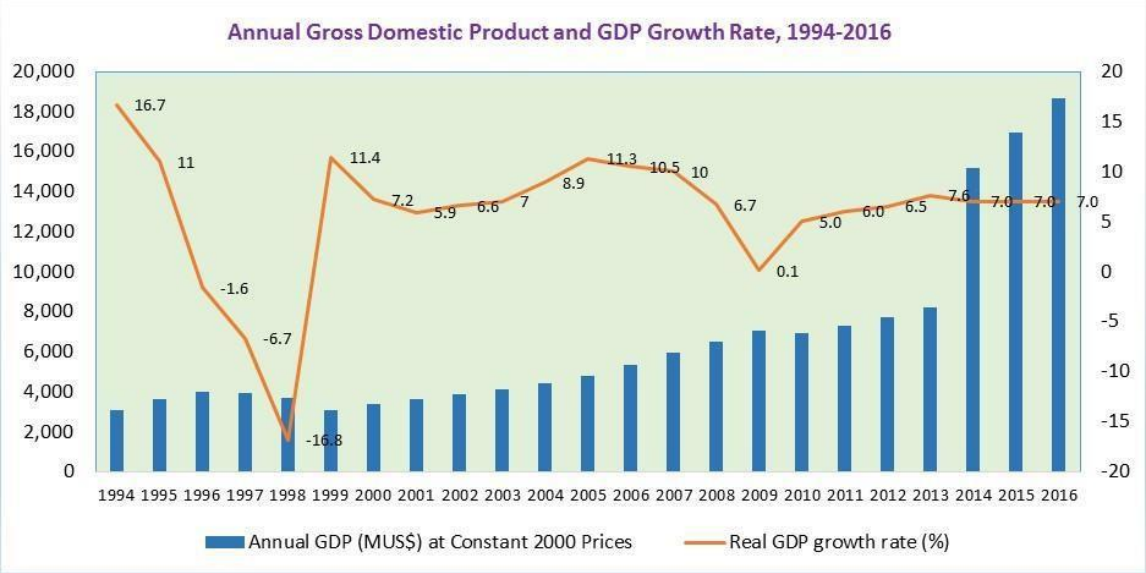

Figure 1-3: Annual GDP and Real GDP Growth Rate from 1994 to 2016 (GSSD, 2022)

The tourism sector accounts for 11.8% of GDP of the country in 2004 and certainly is the key contributor to country's economic growth. With the advantage of natural resource, geography and cultural heritage, this sector creates job opportunities and provides a livelihood to the most Cambodians by attracting tourist and helps boost the green economic development in the country.

2. Cambodia's maritime environment

Though Cambodia is located in Southeast Asia, Cambodia's coastal zone covers a land area of about 17,237 km^2 and has a 443 km coastline with an EEZ of about 55,600 km^2 (GSSD, 2015).

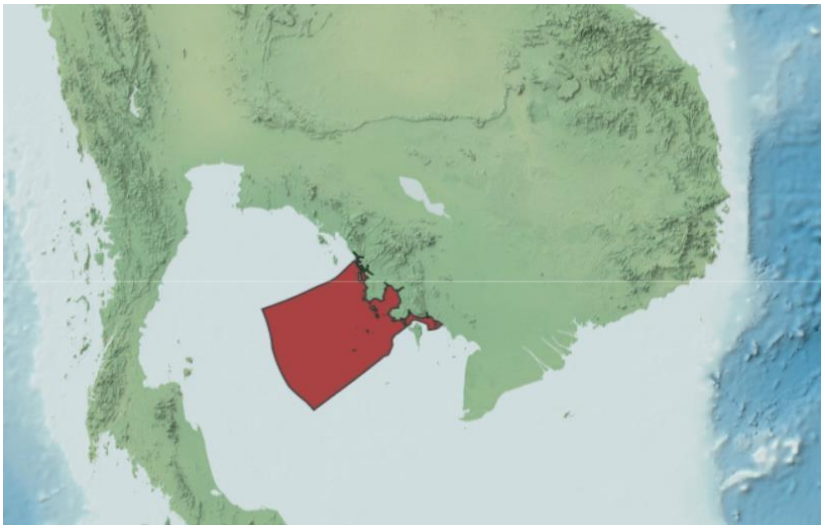

Figure 2- 1: Cambodia's EEZ (Marineregions, 2023)

Cambodia's coastal zone covers the partial territories of four provinces namely, Koh Kong, Preah Sihanouk, Kampot and Kep. According to Ministry of Planning (MoP) in Cambodia, the population growth rate in this zone has been increasing steadily with the rate of 5.7% from 673,000 in 1994 to 845,000 in 1998 (GSSD, 2015).

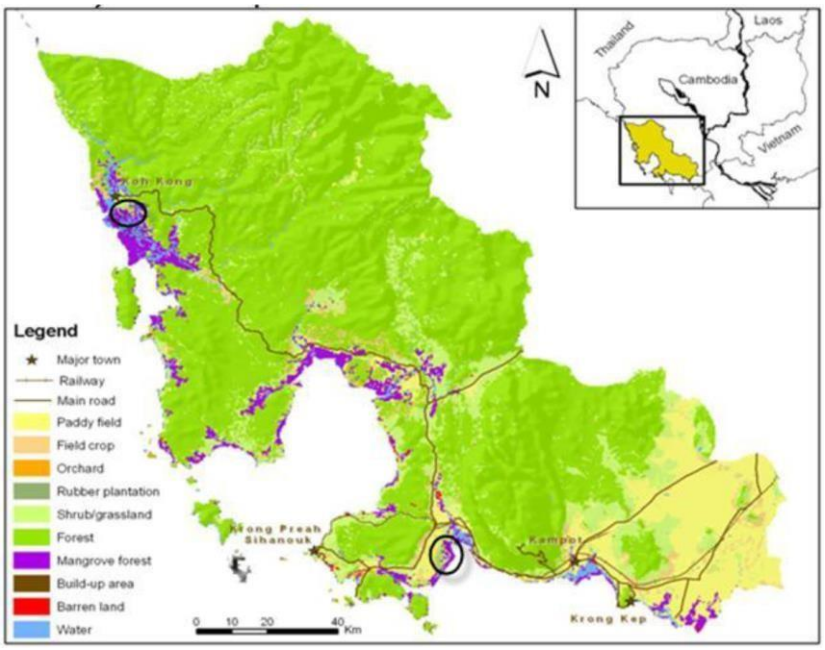

Figure 2-2: Map of the coastal area and its land-use types (CCCA, 2012)

Agriculture, forestry and fisheries are the main economic activities follow by salt production, tourism and other services. Tourism is important to Cambodia: the beaches, islands, coral reefs and sea grasses attract tourists from around the world, especially in Preah Sihanouk province and Kampot province. These regions possess highly integrated ecosystems such as beach, forest, strand vegetation, mangroves, swamp forest – specifically Melaleuca – estuarine ecosystems, sea grass, coral reef and other marine ecosystems in the shallow seabed. Figure 2-3 shows a beautiful capture of Melaleuca swamp forest in Koh Kong province. According to GSSD (2015), there are 34 known species of hard coral and 14 species of soft coral in Cambodia's coral reefs.

Mangrove forests and mudflats, which are located throughout the coastal zone, support both endangered/vulnerable wildlife and species of both commercial and livelihood importance.

Figure 2-3: Melaleuca swamp forest in Koh Kong province (Sophun, 2020)

3. Maritime challenges

Maritime security is the key to national security and economic growth. In order to have good order at sea, Cambodia needs to overcome several nontraditional challenges caused by state, non-state actors, and Mother Nature particularly climate change.

Like every other nation in the world, Cambodia is confronted with a number of maritime issues. Both traditional and nontraditional security threats, such as overlapping

maritime boundaries, illegal fishing, human and drug trafficking, terrorism, piracy, transnational crimes, environmental degradation and sea level rise pose a threat to Cambodia's sea. The ability of the Cambodian navy and coast guard to provide maritime security for its territorial and international seas is hampered by a lack of funding and key resources, including ships and rescue boats (Chheang, 2010). More crucially, Cambodia lacks the necessary legal framework, human resources and agency coordination to deal with challenges to maritime security. To carry out the responsibilities of the maritime activities, there are no relevant waterway-maritime transport and port rules and regulations. The inadequacy and inefficiency of both soft and hard infrastructures prevent Cambodia from effectively carrying out necessary measures to deal with both traditional and non-traditional security issues.

C. Climate Change: The impact on maritime environment

1. Climate Change in Cambodia

Cambodia is a tropical country and has a monsoonal climate system composed of two seasons: a rainy season and a dry season. Figure 3-1 below shows a trend of average annual temperature between the year 1901 and 2017. Due to limited available climate data, this climate trend is based on the dataset from the University of East Anglia's Climatic Research Unit Time-Series version 4.02 (CRU TS4.02). According to this figure, there is an upward trend from around 26.5°C in 1985 to around 27.5°C in 2017. This trend shows that the climate in Cambodia has become warmer and the effect climate change is apparent.

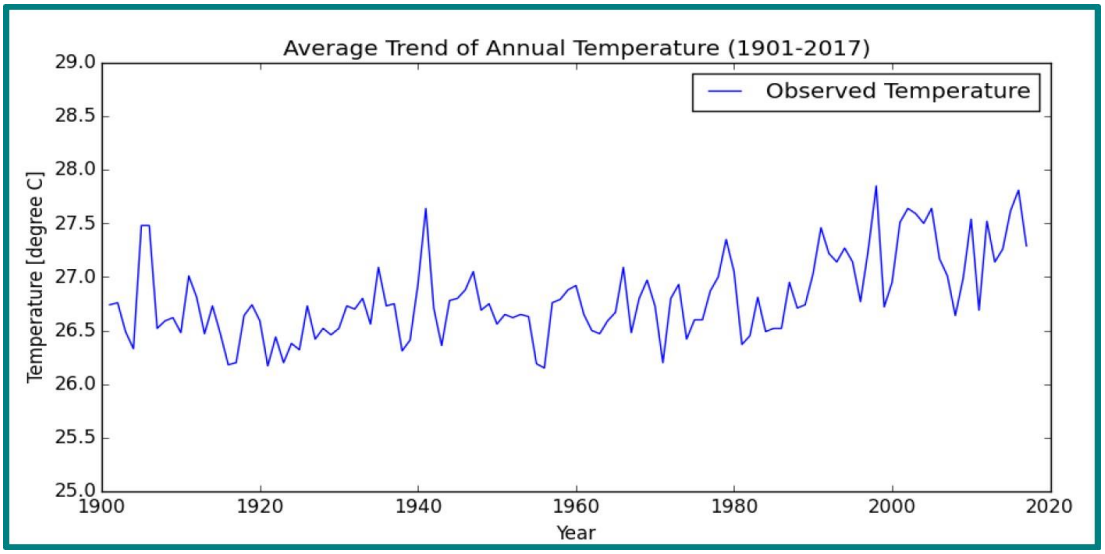

Figure 3-1: Average annual temperature of Cambodia from 1901 to 2017

Work has been done to project long-term changes to the climate out to 2100. The two scenarios of GHG pathways: Representative Concentration Pathway 4.5 (RCP4.5) and Representative Concentration Pathway 8.5 (RCP8.5) were selected to indicate the trend of the climate projection. Figure 3-2 shows this work. The observed and projected trends of changes in the average annual temperature up to year 2100 are based on the two selected scenarios, compared to the baseline period of the year 1981-2005. It appears that in both scenarios, the average annual temperature is projected to increase by 1.0°C by the year 2040. Contrastingly, by the year 2100, the projection in RCP4.5 and RCP 8.5 are expected to be increasing around 2.5°C and 4.5°C, respectively.

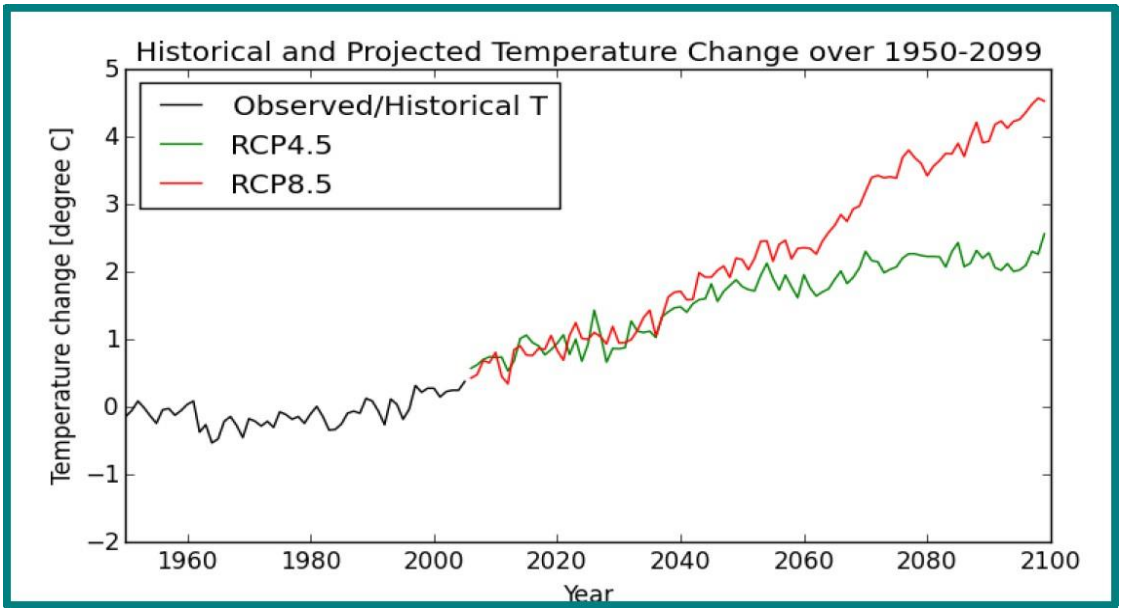

Figure 3-2: Observed and projected trends of changes in average annual temperature up to year 2100 based on RCP4.5 and RCP8.5. Dataset from CRU TS4.02 (GSSD, 2022)

2. Climate Change Vulnerability

Although not as highly exposed to the effects of climate change as other countries in the region, e.g. the Philippines and Vietnam, Cambodia is rated as one of the most vulnerable countries in the world to climate change (9^{th} rank World Risk Index 2011, 6^{th} rank Maplecroft Climate Change Vulnerability Index 2012). According to (Yusuf & Francisco, 2009), Cambodia is one of the most vulnerable countries to climate change due to its low adaptive capacity, despite its relatively low exposure to climate hazards.

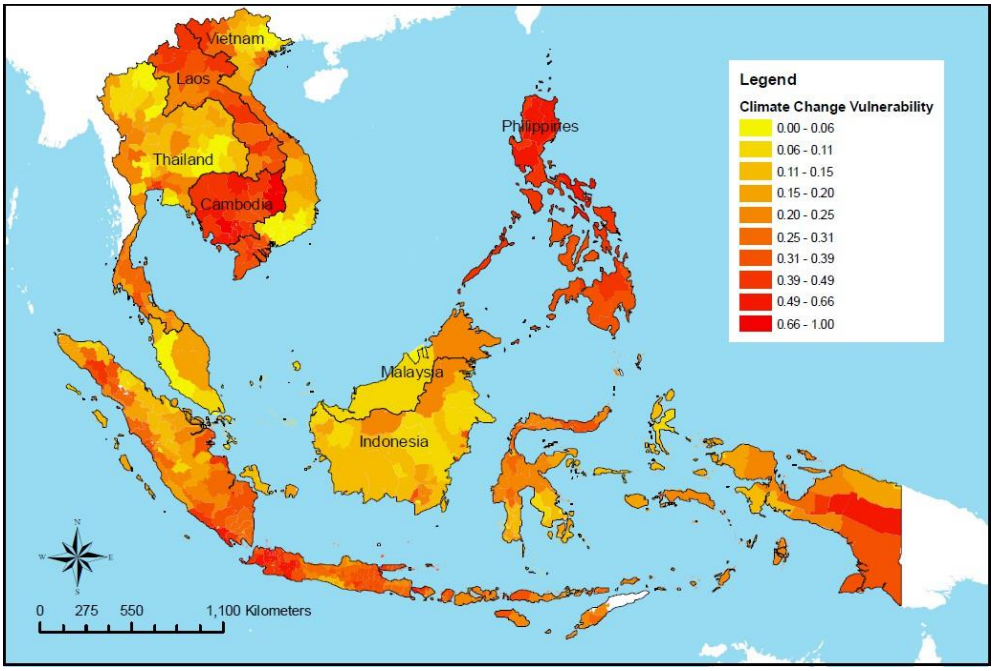

Figure 3-3: Climate change vulnerability map of Southeast Asia

As shown in the Introduction, the majority of the Cambodian people are reliant on climate sensitive sectors such as agriculture, forestry and fisheries. Almost all provinces in the country are vulnerable or highly vulnerable to climate change due to their exposure to natural disasters, high dependency on climate variability and poor coping mechanisms. The vulnerability to climate change at the community/local level was assessed using the nationwide commune statistics of 2017 combining with a synthetic review of relevant documents and expert judgment. It is also based on the UNFCCC methodological approaches and guidelines (GSSD, 2022). There are eight indicators aggregated in the assessment as below:

- Education level by age groups
- Primary occupation types
- Household assets and facilities
- Remoteness
- Source of drinking water
- Sanitation facility
- Dependency ratio
- Frequency of occurrence of climate extreme events

Figure 3-4 below shows the spatial distributions of climate change vulnerability at the commune level of Cambodia at five different level of the Vulnerability Index: very low, low, medium, high, and very high. From the dataset, there are 563 out of 1,629 communes (33.5%) categorized into the high and very high level of climate change vulnerability. While 468 communes (28.7%) are in medium level, 413 communes (25.3%) are classified as low level of vulnerability.

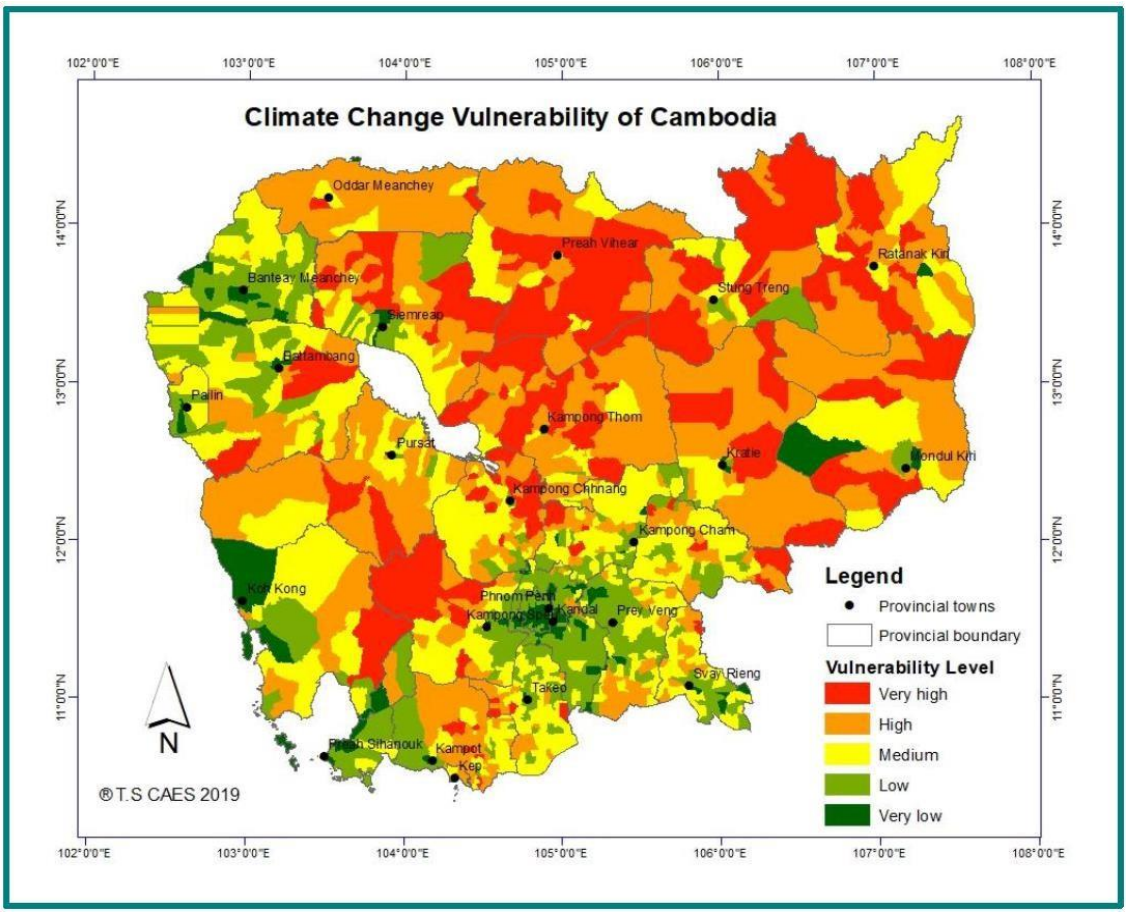

Figure 3-4: Spatial distributions of climate change vulnerability at commune level in Cambodia (GSSD, 2022)

From this map, we can see that Cambodia is especially vulnerable in the north and northeast regions of the country, while the least vulnerable are in the northwest, the capital city Phnom Penh and surrounding area and in the coastal area. On the latter, the low-level vulnerability of Cambodia's coastal areas requires further exploration due to limited data available on rising sea levels. If this factor is incorporated, these coastal areas would be fallen into higher level of the vulnerability scale.

3. Impacts on maritime environment

One of the most vulnerable areas in Cambodia to climate change are the coastal zones. The RGC has recognized this zone as pivotal in Cambodia's work to adapt to existing and upcoming impacts of climate change. It is vulnerable to sea level rising, seawater intrusion, storms, floods, pests in agriculture production and contaminated drinking water. Roughly 25,000 hectares of coastal zone would be permanently inundated due to the one-meter sea level rise that was projected for the year of 2100 (GSSD, 2015). However, the modelling projecting this sea level rise is complicated. It requires being able to process and analyse huge amounts of data. From experience, these projected figures might be significantly underestimated. To complicate matters, the development of tourism, the further industrialization of the economy and expanding land use without proper planning are exacerbating these vulnerabilities. Mangrove ecosystems and coastal erosion are especially vulnerable, and their degradation can exacerbate climate change vulnerability (GSSD, 2022).

Many coastal areas are experiencing saltwater intrusion and sea flooding. Climate change is expected to intensify and the affected areas are expected to be much greater than the total area of inundation from sea level rise. For example, during the dry season, there is little rain and the level of freshwater from rivers is low. As such, rising sea levels will push salt-water intrusion levels further into freshwater systems for longer period, reducing freshwater availability and affect the ecosystem along the coast. Moreover, salt production is one of the main economic drivers for coastal provinces in Cambodia, particularly in Kampot and Kep provinces. Base on GSSD (2015), Kampot province has about 3,334 ha of saltpans while Kep provinces has about 2,000 ha. These saltpans area could be increased and even expended to the other coastal provinces. However, due to climate change and rising sea levels, many coastal areas face potential inundation and salt-water intrusion, which causes major problem in salt production. Table 3-1 below is derived from (CCCA, 2012), and summarizes the climate change related impacts and their effects.

Type of climate change related impacts	Climate change related impacts and effects
Sea level rise/ Seawater intrusion	– Salinization of the land surface as well as the groundwater, impacting the fertility of farming areas as well as freshwater ecosystems – Threat to food security and livelihoods because most agriculture in the coastal zone is concentrated in these flood-prone, low-lying coastal areas – The infrastructure in the coastal zone also comes under pressure, which can lead to an increased vulnerability over time and lost income from tourism.
Storms surge	– The increased frequency of storms affects cultivation, fisheries and coastal erosion. – Destroying households at highly vulnerable locations – In 2011, 38 houses and 14,000 m2 of mangrove forests were destroyed, two fishing boats sank, and forest fires occurred in about 30 places.
Severe/heavy rainfall and floods	– Because of heavy rainfall, floods destroy property and productive assets, such as crops and livestock. – Flooding often leads to poor water supply and unsanitary/unhygienic conditions, causing severe health issues and disease outbreaks. – The heavy rainfall also affects salt production activity
Increased temperature	– Reduce the ability of people to work due to heat stress – It has a detrimental effect on the overall health of people, crops and livestock
Droughts	– A decline in ecosystem functions contributing to food security problems – Droughts or heat waves will ultimately cause problems – regarding water scarcity

Table 3-1: Main Experienced Climate Change Impacts in the Coastal Areas of Cambodia

D. TOWARDS A CAMBODIAN APPROACH TO CLIMATE CHANGE

Climate change is both a regional and global ecological phenomenon. Its effects are tangible and are already being felt in Cambodia (MoE & UNDP 2010). Cambodians are aware of the country's changing climate. Flood, drought and higher temperatures are the extreme weather conditions recognized by most farmers as the factors that could harm their daily activities and livelihoods. Climate change is a crosscutting issue in various national development activities. Climate change adaptation and resilience could be mainstreamed and implemented at the provincial, district, and community levels.

Meanwhile, as many people in coastal area are already affecting by the impact of climate change, suitable climate adaptation measures to help them cope with these impacts must be put in place. In the following Table 4-1, we will outline the suitable adaptation measures to each type of climate change impact for the Table 3-1.

Type of climate change related impacts	Suitable Adaptation Measures
Sea level rise/ Seawater intrusion	– Construction of saltwater protection dyke – Locating or building high grounds for human and animals to seek shelter to solve the problems in case of floods – Preparing boats for communities and households – Informing villagers about the importance of cleaning their houses during and after seawater flooding has occurred. – Awareness raising and preparation for emergency relief procedures at all the vulnerable villages – Promoting research to produce saltwater resilient crop species
Severe/heavy rainfall and floods, and storms surge	– Conserving and reforestation of mangrove forests – Locating or building high grounds for human and animals to seek shelter to solve the problems in case of floods – Increasing weather broadcasting system and improving accessibility to the vulnerable groups, for example, through social media – Encouraging local communities to keep up with weather broadcasting news

Increased temperature and droughts	– Ensuring water sources for the community by building basins to store drinking water – Preparing water sources for crops and animals – Preparing medicine for the community concerning both humans and animals – Ensuring preparedness in the case of forest fire Increasing the capacity of irrigation systems is required, and this includes restoration of existing irrigation canals and building the new ones, especially in the areas of hotspots – Constructing small-scale household-based irrigation schemes like community or household ponds for water Harvesting

Table 4-1: Climate change adaptation measures suitable for the coastal areas

Other adaptation strategies include:

- Conducting systematic research on the social and cultural aspects of co-management; identifying conflicts and potential resolution opportunities;
- Designing and implementing demonstration projects through commune-based mangrove management;
- Developing a management strategy with the participation of communities, local authorities, and other relevant agencies;
- Create campaigns to raise awareness aimed at coastal communities, local governments, the military, and provincial government officials for the preservation and sustainable management of natural resources such as mangroves, fisheries, and marine resources;
- Explore, in collaboration with mainstream development organizations, the provision of sustainable alternative livelihoods to mangrove dependent communities;
- Policy advocacy through policy briefs, workshops, and seminars; and
- Mainstreaming climate change mitigation and adaptation measures into commune investment and development plans.

E. CONCLUSIONS AND POLICY RECOMMENDATIONS

1. Conclusions

There is a variety of problems in maritime security around the world. For instance, the issue of climate change, which has long been acknowledged as a major problem for modern society, is also a significant challenge for maritime security. It exacerbates existing problems while creating new ones as well. The recommended solution to climate change is to mitigate the cause in the first place by either limiting the emission of greenhouse gas or preserving the nature. However, these mitigation approaches need to be carefully considered before implementation owing to numerous constraints such the need for economic development for each country, the livelihood of the people, the capital fund for protecting the environment and the willingness to collaborate. This study has endeavored to investigate the impact of climate change on Cambodia's maritime environment. It has also looked at ways for Cambodia to solve the problem in order to assist policy-makers, planners and the general public that use the maritime environment.

2. Recommendations

Recognizing that climate change is a global issue and requires individual and collective effort to adapt or mitigate its impacts, Cambodia's government has developed comprehensive regulations and policies aimed at addressing climate change issues.

Cambodia has continued to develop and strengthen institutional capacity in both government agencies and community organizations to understand the impact of climate change on agriculture, forestry, fisheries, livestock, animal and human health, improved the country's capacity for long-term adaptation and resilience to climate change, and integrated these considerations into sectoral planning at all levels.

The following recommendations are for the government to improve the climate change situation in Cambodia:

- Proper land-use/cover management and conservation should be taken into account to ensure that agriculture sector development is environmentally friendly, conserves forest ecosystem services, and supports the value chain of the whole agriculture system in that region.
- Mechanisms to regularly monitor, evaluate and control agro-industrial development to

maximize adaptation to climate change should be devised and implemented by government institutions and local authorities.

- Education and training on system of rice intensification and pest management should be extended to farmers to increase and diversify agricultural productivity and minimize harm to human health and ecosystems.
- Measures to ensure effective and efficient implementation of initiatives so as to meet the aims of national policies, particularly forest management policy, coastal protection policy and long term adaptation strategy for development, should be put in place.
- Water resources and irrigation services must be mainstreamed in the integrated strategic development program to mitigate environmental impacts of climate change, consistent with government's prioritization of water sector policy as one of the top four strategies towards national development efforts.
- Physical irrigation infrastructure development is urgently needed to cope with uncertainties due to climate change (irregular rainfall and water levels) and the growing frequency of natural calamities (drought, flood, and cyclone) and to extend the cultivation area to intensify agricultural production and ensure national food security.

Moreover, looking through a military lens, below are some of the recommendations for military policy to improve the situation:

- Adding climate change study to military courses, trainings, and seminars
- Strengthening military resources, training and preparedness for climate change world
- Targeting plans and processes towards a greener military: reduce emissions, research and use green energy applications, etc.
- Raising awareness via international cooperation or association such as ASEAN platform, UN platform, bilateral platform, etc.
- Driving cooperation with countries in ASEAN with regards to climate change
- Enhancing joint service understanding of climate change
- Establishing training programs at local levels to support local communities for awareness, mitigation, and adaptation of climate change.
- Researching best practices of developed nations.

The international community has helped Cambodia improve and strengthen its maritime security in recent years. However, there are still a number of challenges to overcome, including a lack of human resources and financial resources, an uncoordinated legal framework, coordination between the relevant ministries and agencies, and physical infrastructure such as battleships, combat boats, and vessels.

3. Further Study

Although there are several interesting result from the study, there are still some other parts that we can extend and further improve. First of all, this study investigated the impacts of climate change on Cambodia's maritime environment. This can allow us to propose a number of measures to each specific impact as per the stated scope of the paper. Due to the limited size of the study one has focused only on what can be done to mitigate impacts. Further study should be done to investigate what and how Cambodia can prioritise climate impacts and mitigations. This could be done through specific factors such as economics, demographics or temporal factors. Finally, it may be useful to gather data specific to different regions that are more at risk to specific climate risks. One of the ways this can be done is surveying people from coastal areas and inland areas, environmental agencies and other organisations to understand what climate risks and mitigations need to be actioned.

F. REFERENCES

Braman, L. e. (2010). Climate change adaptation: integrating climate science into humanitarian work. *International Review of the Red Cross*, 455-474.

Cambodia. (2020). *Biennial update report.* Cambodia.

CCCA. (2012). *Assessment of Community Vulnerability and Risks from Climate Change in the Coastal Zone of Cambodia of the Cambodia Climate Change Alliance.*

Chheang, V. (2010). *Cambodia: Maritime Security Challenges and Priorities.* Phnom Penh: Cambodian Institute for Cooperation and Peace.

Costello, C. C. (2020). The future of food from the sea. *Nature 588*, 95-100.

DoM. (2013). *Statistic of Meteorology Data of the Department of Meteorology of the Ministry of Water Resources and Meteorology.* Phnom Penh, Cambodia.

Francisco, H. (2008). *Adaptation to Climate Change: Needs and Opportunities in Southeast Asia.* Asean Economic Bulletin.

GSSD. (2015). *Cambodia's Second National Communication.* Phnom Penh, Cambodia: General Secretariat of the National Council for Sustainable Development/Ministry of Environment.

GSSD. (2022). *Cambodia's Third National Communication under the United Nations Framework Convention on Climate Change.* Phnom Penh, Cambodia: The General Directorate of Policy and Strategy, the Ministry of Environment/the National Council for Sustainable Development.

Heng, C. (2014). *Report of Baseline Study on Climate Forecasting for Community Protected Areas in Preah Vihear, Siem Reap, Kampong Thom and Mondulkiri Provinces, Cambodia.* Phnom Penh, Cambodia.

Hougton J.T, J. G. (1990). *Climate Change.* Cambridge: Press Syndicate of the University of Cambridge.

IPCC. (2014). *Climate Change 2014: Synthesis Report.* Geneva, Switzerland: IPCC. IPCC. (2020). *Climate Change and Land.* IPCC.

IPPC. (2007a). *Climate Change 2007 - The Physical Science Basis.* Cambridge: Cambridge University Press.

Marineregions. (2023). Retrieved from Marineregions.org: https://www.marineregions.org/eezdetails.php?mrgid=8331

NIS. (2011). *Economic Census of Cambodia.* Phnom Penh, Cambodia: National Institute of Statistics, Ministry of Planning.

NIS. (2019). *General Population Census of Cambodia 2019 of the National Institute of Statistics of the Ministry of Planning.* Phnom Penh, Cambodia.

NRC. (2011). *Climate Stabilization Targets" Emissions, Concentrations, and Impacts over Decades to Millennia.* Washington, DC: The National Academies Press.

Selemon T.F. (2020). Causes of Climate Change: Review Article. *Global Journal of Science Frontier Research Environment & Earth Science*.

Sophun, R. (2020, October 07). *Youtube*. Retrieved from Youtube: https://www.youtube.com/watch?v=8P7Tk1qt-EQ&ab_channel=RathSophun

Sovann, P. C. (2010). *USING GIS AND GEOSTATISTICS TO DEVELOP HAZARD AND RISK MAPS OF ARSENIC IN SHALLOW GROUNDWATERS OF CAMBODIA.*

SPC. (2022). Retrieved from The Pacific Community: https://gem.spc.int/updates/blog/did-you-know/2022/02/ocean-science-fact-94-of-the-earths-living-spieces-are-aquatic#:~:text=Meetings-Ocean%20Science%20Fact%3A%2094%25%20of%20the%20earth's%20living%20 spieces%20are,Our%20Ocean%2C%20Protect%20Our%20Planet!

Yusuf & Francisco, A. A. (2009). *Climate Change Vulnerability Mapping for Southeast Asia.* Economy and Environment Program for Southeast Asia.

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