# Exploring the impacts of climate change on the fisheries industry in Papua New Guinea: A literature review

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## Abstract

Climate change affects fish habitats and distribution globally, posing significant risks to fish populations and the livelihoods of individuals in the fisheries sector, thereby impacting the global economy. This literature-based study focuses on the impacts of climate change on Papua New Guinea's fisheries industry and beyond. Utilising databases such as Google Scholar, Scopus, Web of Science, EBSCOhost, Social Science Research Network, and ProQuest, the study reviewed twenty-five scholarly papers and official reports. The literature identified issues around food security, social security, economic security, health security, environmental security, geopolitical and marine security, as well as insurance and risk management. The literature also revealed that fisheries play a crucial role in providing livelihoods, ensuring food security, and promoting economic growth not only in Papua New Guinea but also in other parts of the world. The study proposed the climate change impact model showing the complex relationship between climate change impacts and fisheries. It is recommended that policymakers, fishermen, and coastal communities prioritise the implementation of sustainable fishing strategies. Additionally, they should also take proactive actions to adapt to and minimise the adverse effects of climate change. This study enhances our understanding of the impacts of climate change on Papua New Guinea's fisheries sector, emphasising the consequences for local livelihoods, ecosystems, and economic viability.

**Keywords**: Climate change, mitigation, adaption, fisheries, Papua New Guinea, coastal areas, livelihoods, vulnerability

## 1.    Introduction

Papua New Guinea (PNG) possesses a flourishing and essential fisheries sector which plays a crucial role in ensuring food security and promoting economic growth. However, it is projected that by 2050, there will be a decrease in the maximum catch potential in marine regions within

the exclusive economic zones of the world (FAO, 2018), as an outcome of the changing climate. This decrease is estimated to range between 2.8 percent and 5.3 percent under the greenhouse gas emission scenario RCP2.6, and between 7.0 percent and 12.1 percent under the greenhouse gas emission scenario RCP8.5 (FAO, 2018). The present study which is drawn from relevant literature discusses the potential effects of climate change on Papua New Guinea's fishing industry, food security, and economic growth. The study aims to answer the question: To what extent does climate change impact the fisheries industry, coastal communities, food security, and economic development in Papua New Guinea and beyond, and what adaptation strategies can be implemented to mitigate these effects?

The chapter is organised as follows: background; theoretical framework; methodology, literature review, discussion, the model, policy implications, implications for theory, and conclusions.


## 1.1 Background

The global fisheries industry is significantly threatened by climate change, which affects fish populations, their distribution, fishing techniques, food security and livelihoods and well-being. Rise in ocean temperatures is a major concern. Oceans absorb a significant portion of the excess heat retained by greenhouse gases. The increase in temperature leads to disruptions in ocean currents alters oxygen levels, and forces fish to migrate to colder places, potentially outside their current fishing grounds (Andersen et al., 2024).

Heightened concentrations of atmospheric carbon dioxide are absorbed by the oceans, resulting in an elevation in their acidity. This impedes the formation of calcium carbonate shells and skeletons, resulting in damage to shellfish, corals, and other marine species that are crucial for sustaining sustainable fisheries (FAO, 2018). Rising sea levels inundate coastal ecosystems, such as mangroves, which serve as breeding grounds for a variety of fish species. Furthermore, the intrusion of saltwater can significantly affect the ecosystems where freshwater fish reside (Dasgupta, et al., 2017).

Furthermore, the heightened occurrence and intensity of storms, cyclones, and floods can inflict damage to fishing equipment, interrupt fishing operations, and alter the dispersion of nutrients in the oceans (Fang et al., 2022). A study conducted by Muhala et al. (2021) in Mozambique revealed that cyclones have a significant impact on the fishing industry in Sofala province. Specifically, over 1,440 fishermen suffered losses of 590 vessels, 1,800 fishing gear, and 67 boat engines. Within Zambezia province, the aquaculture industry suffered the loss of 169 fishponds, two cages, and 606,000 fry. Similarly, in Sofala province, 58 fish tanks, 204 cages, and 257,500 fish fries were destroyed. This study demonstrates that fisheries and aquaculture are highly susceptible to extreme weather occurrences, such as cyclones because of climate change. The compounding environmental effects can lead to the overexploitation of the remaining fish populations, reduced fishing yields, and economic setbacks for fishing communities across the globe (Lam et al., 2020).

Fisheries are essential for supplying protein to millions of individuals globally, particularly in less developed countries, particularly PNG. The decline of fish populations presents a substantial threat to the accessibility of food, especially for coastal communities that heavily rely on fish for their nourishment and sustenance (FAO, 2021). Further, coastal communities dependent on fisheries may face displacement because of increasing sea levels and extreme weather events, potentially leading to social unrest and migration (Huỳnh et al., 2021).

The fishing industry also employs a significant number of workers worldwide. Climate change can have deleterious impacts on the fishing industry, resulting in the closure of certain

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enterprises and adversely affecting individuals' ability to sustain their livelihoods. This can lead to heightened susceptibility in both social and economic domains (World Bank, 2019). For example, a cannery in Papua New Guinea ceased operations, resulting in the unemployment of around 5000 workers. The reason given for the closure was the decline in tuna production (The National, 2023). There could be similar cases in other island countries.

Efficient policy and governance play a vital role in dealing with the consequences of climate change on fisheries globally. Ray Biswas and Rahman (2023) assert that adaptive governance frameworks, which integrate flexibility and stakeholder participation, are crucial for effectively addressing the uncertainties linked to climate change. Policies promoting community-based resource management and adaptive co-management can enhance the resilience of the fisheries sector in Papua New Guinea and beyond. The next section discusses the study's theoretical framework.

## 2.       Theoretical framework: Coupled Human and Natural Systems (CHANS)

Global fisheries are at great risk due to climate change, and island states such as Papua New Guinea are more susceptible to this hazard (FAO, 2018). This study utilises a coupled human and natural systems (CHANS) framework to discuss the diverse effects of climate change on Papua New Guinea's fishing industry. The CHANS framework acknowledges the interdependence of social and ecological systems, emphasising the way human activities affect environmental conditions, which in turn affect livelihoods and societal well-being (Wang, et al., 2023; FAO, 2022). This discussion will be guided by two fundamental theoretical viewpoints within the CHANS framework:

a) Social-ecological resilience refers to the ability of social and ecological systems to effectively absorb and adapt to changes in their environment (Adger, 2000). The discussion is around the susceptibility of PNG's fisheries industry to the effects of climate change, considering variables such as reliance on fish populations, customary fishing methods, and governance frameworks.

b) Adaptive co-management is a strategy that acknowledges the significance of collaboration among resource users, scientists, and policymakers in the management of fisheries amidst evolving environmental conditions (Jentoft et al., 1998). It is also critical to discuss possible adaptation and mitigation strategies that consider local communities' knowledge and requirements, in addition to the scientific understanding of the effects of climate change.

This study seeks to thoroughly understand the challenges and opportunities faced by the fishing industry in Papua New Guinea in the context of a changing environment by including these theoretical perspectives. A deeper understanding of these challenges is essential for creating successful adaptation and mitigation strategies that guarantee the industry's long-term viability and the livelihoods it sustains.

## 3.       Methodology

This literature-based study employs a systematic literature review approach to obtain relevant literature for the study. Databases such as Google Scholar, Scopus, Web of Science, EBSCOhost, Social Science Research Network, and ProQuest were utilised to ascertain pertinent literature for the study. Twenty-five peer reviewed articles and official reports were reviewed to conduct this study.

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*Selection criteria:*

- ➢ Research and authoritative peer-reviewed articles and official reports on fisheries
- ➢ Research specifically focused on the impact of climate change on fisheries
- ➢ Literature about coastal areas and livelihoods
- ➢ Studies on economic development and fisheries.

To maintain the reliability and validity of data the researchers conducted a thorough review of peer-reviewed journals, books, and authoritative sources to gather high-quality and credible data. The researchers prioritised sources with an established reputation for rigorous methodology and accuracy. To enhance reliability, the researchers cross-checked data from multiple sources to identify consistency and discrepancies. For validity, the researchers ensured that the studies selected were relevant to the research question, the theoretical framework and that their findings applied to the context of the study, and could be generalised. Additionally, the researchers critically assessed the methodologies used in the literature to determine the robustness of their findings. By triangulating data and carefully evaluating the sources, they aimed to mitigate biases and strengthen the overall trustworthiness of the study's conclusions.

The data was presented and discussed systematically, organising the information into coherent themes and subthemes that emerged during the literature search. The presentation and discussion highlighted major trends, patterns, and discrepancies. Additionally, the implications of the findings for theory, practice, and future research, linking back to the broader context of the study were also discussed

## 4.        The Papua New Guinea context

Papua New Guinea relies heavily on its fishing sector to guarantee food security and stimulate economic growth (Dasgupta et al., 2024; Sumaila et al., 2019a). Coastal inhabitants heavily depend on fish as a primary source of protein, with each individual consuming an average of 18.2 to 24.9 kilograms per year (World Bank, 2024). Furthermore, the exportation of fishery products makes a substantial contribution to the economy of Papua New Guinea (World Bank, 2024). However, the impacts of climate change are posing a threat to this vital business.

Rising sea temperature is among the factors that pose a threat to these circumstances. Coral bleaching, which can impact the productivity of coral reef ecosystems is one example (Heogh-Guldberg et al. 2007). These ecosystems are crucial habitats for numerous fish species. According to the Intergovernmental Panel on Climate Change (Cooley et al, 2022), the absorption of greater amounts of $CO^2$ by seawater leads to ocean acidification, which negatively affects the calcium carbonate structures of corals and shellfish.

Increased ocean temperatures can lead to changes in the geographic distribution of fish, perhaps causing commercially valuable species migrate from the fishing areas of Papua New Guinea (World Bank, 2019). The increased absorption of atmospheric carbon dioxide leads to ocean acidification, which can have a negative influence on the growth and survival of fish, particularly those that rely on calcium carbonate to build their shells and skeletons (FAO, 2019).

The Asian Development Bank (2024) highlights the need for adaptive management measures to guarantee the sustainability and resilience of Papua New Guinea's fisheries, given their sensitivity to climate change. Traditional knowledge refers to the wisdom, practices, and beliefs passed down through generations within a particular culture or community. Adaptation strategies, on the other hand, are the methods and approaches used to adjust and respond to changes in the environment or circumstances. Traditional knowledge and practices are crucial in the management of fisheries in Papua New Guinea. Berkes et al. (2000) emphasises the

significance of combining traditional ecological knowledge with scientific methodologies to create efficient adaptation strategies. Community-based resource management and adaptive co-management policies in Papua New Guinea can enhance the resilience of the fisheries sector. By utilising local expertise in sustainable fishing techniques and resource management, this integration has the potential to strengthen community resilience in the face of climate change.

Effective policy and governance play a vital role in tackling the effects of climate change on fisheries in PNG and other parts of the world. Ray Biswas and Rahman (2023) contend that adaptive governance frameworks, which include flexibility and stakeholder participation, are crucial for effectively addressing the uncertainties linked to climate change. The next section discusses the themes that emerged during the literature survey.

## 5. Discussion

This discussion centres on the key themes identified in the literature review: economic, social, health, and environmental security, geopolitical maritime security, and insurance and risk management. These themes are explored in detail in the following sections.

## 5.1 Food security

Climate change presents substantial risks to the food security of Papua New Guinea and beyond. It is noted that the fishing industry plays a vital role in providing critical protein and micronutrients, serving as a crucial source of sustenance for several populations (FAO, 2018). Fluctuations in sea temperature, the acidity of oceans, and changes in marine ecosystems have the potential to decrease fish populations and modify the geographical range of fish species, which may result in diminished fish harvests (FAO, 2021). This can have a direct impact on the availability of food and the nutritional state of local communities

Evidence drawn from the literature illustrates the crucial role played by the fishing sector in providing sustenance for numerous coastal villages in Papua New Guinea and beyond (World Bank, 2004). However, the economic stability of these communities can be jeopardised by disturbances caused by climate change. The decline in fish catches and the deterioration of marine environments can result in reduced income and heightened poverty rates (Hoegh-Guldberg et al., 2007). In addition, fishing-dependent communities may be compelled to relocate or transition to alternative forms of employment, which may not offer the same level of profitability or long-term viability, thereby intensifying economic instability.

## 5.2 Social security

As climate change causes a decrease in fish stocks or their movement to different places, there is a possibility of increased competition for these resources (Brander, 2010). This might result in disputes between local fishermen and fishers from nearby areas or countries. These conflicts have the potential to disrupt communities and escalate the likelihood of violence, which weakens the security of both local and regional areas. Climate change consequences, such as the elevation of sea levels and occurrences of severe weather events, can compel coastal communities to relocate (Huỳnh et al., 2021) further affecting their livelihoods and security. This migration might result in societal unrest and disputes around land and natural resources. Diminished fishing activities might heighten susceptibility among groups, resulting in social instability, criminal behaviours, and other adverse social consequences.

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**5.3      Economic security**

Climate change can lead to the loss of livelihoods for communities and the economy. The fishing sector in Papua New Guinea is a significant economic driver for many individuals and the economy. The country exports a substantial proportion of its seafood products, which serves as a crucial source of foreign currency. The impact of climate change on fish stocks can have detrimental effects on both the abundance and quality of fish available for export, which in turn may lead to a decline in export income (Suh & Pomeroy, 2020). This can potentially have wider-ranging economic ramifications, such as a detrimental effect on the country's trade surplus and general economic well-being.   Decreases in fish populations can lead to unemployment and decreased earnings, worsening poverty and economic instability. An example of this is the shutdown of a canary in Papua New Guinea because of the unsustainable cost of tuna (The National, 2023).  This led to the loss of employment to 5000 people affecting their livelihoods.

**5.4      Health security**

The diminished accessibility of fish can result in nutritional insufficiencies, in terms of protein, which can adversely affect the well-being of populations who depend on fish as a primary dietary source (Suh & Pomeroy, 2020). Alterations in marine ecosystems can result in the rapid growth of detrimental algal blooms and other diseases specific to marine life, hence affecting the abundance of fish populations and posing risks to human well-being. Hence, it is imperative to adjust and alleviate these consequences. Community-based resource management and adaptable co-management practices are necessary in Papua New Guinea and similar environments. This has the potential to strengthen the resilience of the fishing sector in Papua New Guinea and other areas.

**5.5      Environmental security**

Climate change can result in the deterioration of marine ecosystems, such as coral reefs, which are crucial for fish habitats. This deterioration can result in a series of negative consequences for biodiversity and the provision of ecosystem services (FAO, 2018). The depletion of fish species and marine biodiversity might weaken the ability of marine ecosystems to withstand and recover from disturbances, hence intensifying the effects of climate change.

**5.6      Geopolitical and maritime security**

Climate change-induced alterations in fish migration patterns might result in conflicts around fishing rights and territories, both within Papua New Guinea and with adjacent nations. Depleted fish populations can cause the occurrence of illegal, unreported, and unregulated (IUU) fishing practices, which pose a threat to both marine security and sovereignty (Huỳnh et al., 2021).

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## 5.7    Insurance and risk management

Due to the escalating impact of climate change, the frequency and intensity of extreme weather events are on the rise. Consequently, the fisheries industry in Papua New Guinea is confronted with elevated risks of infrastructure damage and equipment loss. Muhala et al. (2021), documented similar incidents in Mozambique. To mitigate such occurrences requires the implementation of more advanced risk management systems, which include the necessity for insurance. Nevertheless, there is also a possibility that insurance prices may increase, and the availability of inexpensive insurance may be restricted, imposing a financial strain on fishermen and enterprises operating in the industry.

## 6.0    Limitations of the Coupled Human and Natural Systems (CHANS)

The Coupled Human and Natural Systems (CHANS) framework to study the impacts of climate change on the fisheries industry in Papua New Guinea has its limitations:

- Data availability: Often, CHANS studies require extensive and diverse datasets integrating both human and natural components. In remote or less developed countries like Papua New Guinea, reliable and comprehensive data may be limited, particularly historical data that can show long-term trends.
- Complexity of interactions: CHANS framework aims to capture complex interactions between human activities and natural systems. In the case of fisheries, this includes understanding not just environmental changes but also human responses such as policy decisions, cultural practices, and economic activities. Balancing these factors can be challenging and may require simplifications that could overlook important nuances.
- Interdisciplinary collaboration: Effective CHANS research often requires collaboration across multiple disciplines (e.g., ecology, economics, sociology), each with its own methods and approaches. Ensuring interdisciplinary collaboration can be resource-intensive and challenging, especially in regions with limited research infrastructure.
- Temporal dynamics: Climate change impacts unfold over time, and studying their effects on fisheries requires long-term data and projections. In countries like Papua New Guinea, where seasonal and annual variability in climate and fisheries productivity may be significant, capturing these temporal dynamics accurately can be difficult.
- Policy relevance: While CHANS frameworks aim to inform policy and management decisions, translating research findings into actionable policies that benefit local communities can be complex. It requires understanding not just the ecological impacts but also the socio-economic contexts and governance structures within which policies are formulated and implemented.

Addressing these limitations requires careful consideration of local contexts, robust methodologies, and engagement with stakeholders to ensure the relevance and applicability of CHANS research in understanding and mitigating the impacts of climate change on the fisheries industry in Papua New Guinea and other similar contexts. The next section presents the model for this study.

## 7.    Climate change impact model

The climate change impact model is founded on the context of climate change, its impacts, and the strategies that can be employed to address these challenges. This model provides a

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comprehensive framework for understanding the complex interactions between climate change and the fishing industry by integrating context, impacts, and strategies. An all-encompassing perspective is essential for developing effective measures to mitigate the adverse effects of climate change on fisheries and ensure their long-term sustainability.

## 7.1    Context

The context focuses on the phenomenon of global warming, specifically how it causes an increase in sea temperatures that have an impact on fish habitats and migration patterns. Ocean acidification elevated levels of carbon dioxide ($CO_2$) have detrimental effects on shellfish and coral reefs, both of which play a crucial role in maintaining marine biodiversity. Sea level rise modifies coastal ecosystems and affects the reproductive habitats of numerous fish species. Alterations to ecosystems can cause disturbances to the equilibrium of marine life, resulting in changes to the distribution of fish populations and the overall organisation of the food chain.
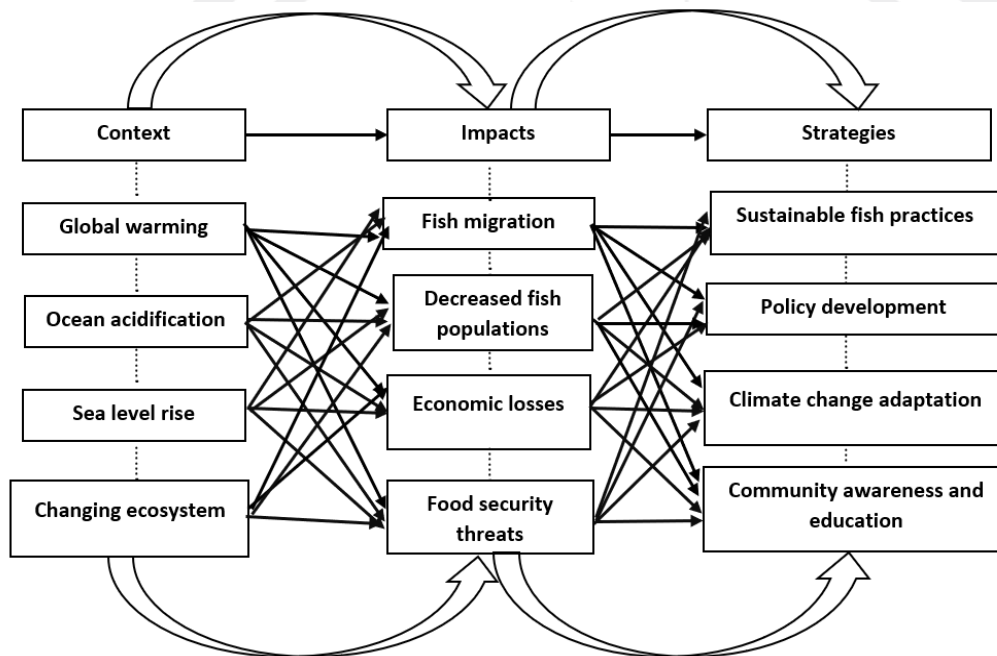


**Figure 1:** Climate change impact model

## 7.2    Impacts

The impacts of climate change result in the migration of fish when temperatures increase, causing fish to move to colder places, which in turn disrupts local fishing industry. Additionally, this phenomenon results in diminished fish populations as a consequence of habitat degradation, excessive fishing, and alterations in water chemistry, ultimately resulting in reduced catches. The depletion of fish stocks has a direct impact on the economic well-being of individuals who rely on fishing as their primary source of income, leading to significant financial hardships. Challenges to ensuring food security given that fish serves as a key source of protein for numerous people, the decline in fish availability poses a significant risk to food security.

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## 7.3    Strategies

The model suggests implementing sustainable fishing practices as a strategy to tackle the aforementioned concerns. Implementing measures to maintain fish populations at sustainable levels and mitigate overfishing becomes imperative. Policy development is crucial. Developing regulatory frameworks and implementing policies to safeguard marine ecosystems and promote environmentally responsible fishing practices is important. Embracing climate change is the optimal path forward. Modifying fishing techniques and equipment to suit the evolving conditions to sustain production is more important than before.

Community awareness programmes are crucial. Disseminating information to communities regarding the consequences of climate change and promoting sustainable behaviours to cultivate local endorsement for conservation endeavors will go a long in the management of the fishing ecosystem.

The model demonstrates the direct influence of each contextual component (global warming, ocean acidification, sea level rise, and altering ecosystems) on the fishing business, resulting in a range of repercussions. For instance, the phenomenon of global warming leads to the migration of fish, while ocean acidification causes a decline in fish populations. Consequently, these effects result in more extensive economic damages and pose risks to food security.

To mitigate these effects, the model proposes a range of options. Effective implementation of sustainable fishing practices and the formulation of comprehensive policies are essential for the proper management of fish stocks and the preservation of marine ecosystems. Climate adaptation strategies assist fisheries in adapting to changing conditions, while community awareness programs guarantee that residents comprehend and endorse these initiatives.

## 8.0    Recommendations

- ➢ The government and key stakeholders should emphasise the importance of aquaculture and the necessity of sustainable fishing
- ➢ The government, the fishing industry, and communities should preserve and safeguard ecosystems and marine biodiversity
- ➢ The government should enforce more stringent laws to mitigate overfishing and facilitate the restoration of fish populations
- ➢ The government should create marine protected areas that can offer safe havens for fish populations to regenerate
- ➢ Developing sustainable aquaculture operations can address the need for protein and alleviate strain on wild fish populations
- ➢ The government should create alternative sources of livelihoods for communities that rely on fisheries
- ➢ The government and key stakeholders should develop more aquaculture and marine life facilities along the coastal territories to carry out awareness.
- ➢ The government should promote community-based resource management and adaptive co-management policies in addressing some of the issues raised in this study.

## 9.0    Areas for further research

Further research should be done to investigate the impact of climate change on the sustenance of fishing communities and the assurance of food security in Papua New Guinea and other parts

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of the world. It is imperative to evaluate the economic impact of the fishing industry on local and national economies in the face of changing climate circumstances. Furthermore, another study can be conducted to examine the effects of climate change on marine biodiversity, specifically focusing on alterations in the distribution and abundance of species. Studying the impacts of increasing sea temperatures and ocean acidification on coral reefs is essential, as these reefs provide vital habitats for numerous fish species.

## 10.    Implications for practice and policy

The study on the impacts of climate change on the fisheries industry in Papua New Guinea has significant implications for practice and policy. It highlights the urgent need for adaptive management strategies that incorporate climate resilience into fisheries practices, ensuring the sustainability of marine resources. Additionally, international collaboration and funding are crucial to support PNG in mitigating climate change impacts and ensuring the livelihoods of communities dependent on fisheries. Policymakers should prioritise the development and implementation of comprehensive climate adaptation plans, including the establishment of marine protected areas and the promotion of sustainable fishing practices. Strengthening local capacity for climate monitoring and integrating traditional knowledge with scientific research can enhance community resilience.

## 11.    Limitations

The lack of localised research relevant to Papua New Guinea (PNG) can result in dependence on more general regional data, which may not adequately represent the local conditions. The presence of temporal gaps and variable techniques in many studies presents difficulties in evaluating long-term patterns and making comparisons between findings. The distinctive biological, social, and economic circumstances of Papua New Guinea may restrict the applicability of conclusions drawn from other countries. Furthermore, the review's results may be distorted by selection and publication biases, and the complex integration of multiple domains adds to the multidisciplinary nature of the issue.

## 12.    Conclusions

The study revealed that fisheries provide a significant contribution to the overall growth of the global economy and the well-being of communities residing in coastal areas. However, climate change has detrimental effects on various aspects including food security, health security, social security, economic security, environmental security, geopolitical and marine security, as well as insurance and risk management.

Additionally, it is crucial to emphasize the significance of community-based resource management systems and adaptive co-management strategies in Papua New Guinea and other regions of the world. This has the potential to improve the resilience of the fishing industry on a worldwide scale. By combining indigenous management practices with science and technology, the global fisheries industry can effectively adapt to and mitigate the impacts of climate change. By using the knowledge and skills of local communities and experts in sustainable fishing methods and resource management, this integration can enhance community resilience in response to climate change. This study asserts that policymakers and other key stakeholders must enact essential adjustments and adopt strategies to mitigate and offset the effects of climate change.

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The model developed in this study can help understand the complex interactions between climate change and fisheries in island countries. Conversely, the CHANS framework can serve as a foundation for comprehending the interdependence of social and ecological systems and how human activities impact environmental conditions, subsequently affecting livelihoods and societal well-being. However, it is crucial to contextualize the CHANS framework for it to be effective.

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