International Journal of Maritime and Interdisciplinary Research
©2025 IJMIR/Volume 7(3) SE (1) | ISSN: 2734-3286.
Journal homepage: www.ijmir.edu.ng

ASSESSMENT OF CLIMATE CHANGE AWARENESS AND ADAPTATION ON WORKFORCE DEVELOPMENT IN THE MARITIME INDUSTRY IN NIGERIA

ADAGBOR Pedro Uwadum
Health Education Department
Tai Solarin University of Education
Ijagun
Ogun State

Corresponding Author's e-mail: Puwadum@gmail.com

ABSTRACT

Climate change poses a significant challenge globally, affecting socio-economic structures, environmental sustainability, and industrial operations, including the maritime sector. This study examines the influence of climate change awareness on adaptation strategies and workforce development in Nigeria's maritime industry. A descriptive survey design was employed, and data were collected from 200 maritime workers in Tin Can Port and Rivers Port using a structured questionnaire. Hypothesis testing using Analysis of Covariance (ANCOVA) revealed that climate change awareness had a significant but moderate effect on workforce development ($\eta p^2 = .078$, $p < 0.05$) and adaptation strategies ($\eta p^2 = .071$, $p < 0.05$). These findings indicate that a higher level of climate change awareness enhances workforce preparedness and facilitates the integration of adaptive strategies to mitigate climate-related risks. Given the increasing threats posed by climate change, this study underscores the need for maritime industry stakeholders to incorporate climate awareness into decision-making processes, invest in climate-resilient infrastructure, and implement policies that promote long-term sustainability. Strengthening workforce training

programs and fostering industry-wide collaboration on climate adaptation are essential to ensuring the resilience of Nigeria's maritime sector.

Keywords: Climate change awareness, climate change adaptation, maritime and workforce development

1.0 INTRODUCTION

Climate change is a big problem that affects the whole world. It has major impacts on our society, economy, politics, and the environment. It disrupts the balance between humans and nature, causing more severe and unpredictable weather. This weather harms communities, economies, and ecosystems everywhere (Ricart *et al.*, 2019). Countries that are still developing, like Nigeria, are especially at risk from these effects, particularly because the country relies heavily on farming, coastal resources, and the maritime industry for its economy and people's livelihoods. For example, the farming sector, which is very important to Nigeria's economy, is very sensitive to changes in the climate. Changes in rainfall and more extreme weather events make it harder for farmers to grow food. Gori *et al.* (2018) also mention that climate change has changed how land is used and put more pressure on water resources, making it even more difficult for ecosystems to support food production and other important services. Climate change is a global issue that has devastating effects on countries that depend more on marine resources, such as Nigeria, because shipping, fishing and coastal tourism contribute immensely to our economic system. Higher sea levels, changing weather, and marine ecosystem changes put Nigeria's maritime sector at risk. So, Nigeria needs to create good plans to adapt to these changes and protect its maritime workers and infrastructure from the bad effects of climate change (Afriyie *et al.*, 2018). Adapting to climate change involves using strategies to adjust our actions, systems, and processes to reduce the negative impacts of climate change and make the most of any positive opportunities. In Nigeria's maritime industry, adapting to climate change is becoming increasingly crucial. Historically, climate policies primarily focused on cutting greenhouse gas emissions, but now there's a greater emphasis on dealing with the immediate, local effects of climate change (Zakaria et al., 2020). In Nigeria's maritime world, adapting could involve making infrastructure stronger, changing

shipping routes to avoid stormy areas, and getting better at responding to disasters. Training the workforce is also very important for these adaptation efforts, making sure workers have the right knowledge and skills to carry out these methods effectively (Alidu *et al.*, 2022). Building climate change awareness is a key component of adaptation in the Nigerian maritime industry. Awareness of climate change is not only about understanding the causes and consequences of the phenomenon but also recognizing its direct and indirect impacts on maritime operations and coastal communities. In the Nigerian context, where the majority of the population lives near the coast and depends on maritime activities for their livelihoods, awareness is the first step toward effective adaptation. This includes educating port workers, fishermen, shipping operators, and policymakers on the risks posed by climate change and the adaptive actions that can be taken to mitigate these risks (Alizadeh *et al.*, 2022). As Zolnikov (2019) asserts, awareness efforts should focus on local experiences, climate uncertainties, and observed impacts, enabling communities and industries to adapt more effectively. The process of adjusting in the maritime industry includes both immediate and long-term plans. Quick changes are usually made in response to current situations and rely on local expertise, like changing the schedule of activities or improving local facilities to handle severe weather. In contrast, long-term adaptations may require transformative changes, such as adopting sustainable technologies or relocating vulnerable infrastructure. Both approaches are crucial for minimizing the risks posed by climate change to Nigeria's maritime industry (Saleem *et al.*, 2019). Workforce development is integral to the successful implementation of adaptation strategies in the maritime industry. Workers need to be trained not only in climate change science but also in the practical skills required to respond to climate-related challenges. This includes training in climate risk assessment, disaster preparedness, sustainable shipping practices, and coastal resilience strategies. In the Nigerian maritime sector, adaptation practices could include improving port infrastructure to withstand rising sea levels, upgrading coastal protection measures, and adopting greener, more energy-efficient technologies (Alves *et al.*, 2020). Furthermore, the workforce must be equipped to handle these changes through continued education and training. For example, diversifying job skills within the maritime workforce and providing continuous professional development in climate change-related areas will increase workers' ability to adapt to changing conditions; this could involve partnerships between government agencies, private sector companies, and educational institutions to create training programmes tailored to the evolving needs of the maritime industry. Climate change poses significant risks to Nigeria's maritime

industry, and effective adaptation strategies are essential to mitigate these impacts (Ali & Erenstein, 2017). Hence, it is therefore imperative examine the effect of climate change awareness on its' adaptation and workforce development in maritime industry. The objectives of this study include evaluating the relationship between climate change awareness and workforce development in the sector and investigating how climate change adaptation strategies influence workforce development.

Hypotheses

The following hypotheses were tested.

i. There is no relationship between climate change awareness and workforce development in the Maritime industry
ii. There is no relationship between climate change adaptation and workforce development in the Maritime industry

2.0 CLIMATE CHANGE AWARENESS (CCA)

Climate change awareness means understanding why climate change occurs, how it impacts us, the dangers it brings, and the importance of ways to adapt to and reduce these effects. Different types of media, like newspapers, the internet, and TV, are important in spreading information about climate change to the public. Knowing about climate change helps people and organizations make smart choices that can affect policies and how we treat the environment and society. In Nigeria, the maritime industry is crucial for the economy. It's important to educate people about climate change, so everyone, including organizations, can prepare for the new difficulties brought on by changing weather conditions (Amondo *et al.*, 2019). As Sultan *et al.* (2019) pointed out, understanding climate change is very important for industries to be able to handle the problems it causes. Similarly, Sorgho *et al.* (2020) stressed that this understanding helps people involved in industries to better know about climate risks and what needs to be done to reduce them. In Nigeria's maritime industry, the direct effects of climate change—like higher sea levels, more storms, and coastal flooding—require workers who not only know about these risks but also know how to fix them. So, helping the maritime workers understand climate change can greatly improve the industry's ability to deal with climate problems.

Adapting to climate change means changing how we do things, how we make things, and how we build things to reduce or prevent the bad effects of climate change. In Nigeria's shipping and port areas, adapting is very important because the country's ports, shipping paths, and coastal towns can be hurt by climate change. These changes could involve building ports that can handle climate problems better, using greener technologies in shipping, and making good plans to handle disasters. It's also important to teach people who work in the shipping industry about the risks of climate change so they can help with these changes (Ayodotun *et al.*, 2019).

Saeed *et al.* (2022) says that understanding climate change helps create good ways to deal with it. In the shipping business, workers need to know what to do to use these methods. Knowing about climate change risks can make people act more quickly, like using greener methods, lowering pollution, and getting ready for disasters. Also, by including climate change knowledge in their plans, the shipping industry can better handle the effects of climate change, making sure the business stays strong. For instance, the Nigerian Maritime Administration and Safety Agency (NIMASA) might organize efforts to inform port workers, shipping companies, and coastal residents about climate change. These efforts could emphasize the significance of cutting greenhouse gas emissions, enhancing waste management, and protecting coastal environments. Furthermore, training sessions could be created to instruct workers on how to handle risks related to climate change, like floods and storm surges, which endanger maritime facilities and activities (Saeed *et al.*, 2022). Developing the workforce is an important part of adapting to climate change. In Nigeria's maritime industry, it is crucial to give workers the skills and knowledge they need to deal with climate change, which includes training on managing climate risks, using sustainable shipping methods, and building infrastructure that can withstand climate challenges. As the maritime sector faces increasing pressure from climate change, a skilled workforce is needed to develop and maintain adaptation strategies. Workforce development programmes should focus on building technical skills related to climate change, such as using renewable energy sources for shipping, retrofitting ships to withstand extreme weather, and constructing flood-resistant infrastructure (Azumah & Ahmed, 2023). Additionally, workers should be educated on the importance of environmental stewardship, which involves reducing the environmental footprint of maritime operations and enhancing the sustainability of the industry. Investing in training for the maritime industry helps it adapt to climate change and also boosts economic growth and job

creation. Specialized training on adapting to climate change can create a more skilled workforce, better prepared to face climate-related challenges. This ensures that Nigeria's maritime sector stays competitive despite environmental changes (Bahri *et al.*, 2018).

2.1 CLIMATE CHANGE ADAPTATION (CCAD) IN NIGERIAN MARITIME INDUSTRY

Climate change awareness means knowing about the dangers of climate change, why it happens, and what we need to do to reduce its effects and adjust to them. In Nigeria, understanding climate change is very important, especially in the maritime industry, which is affected by things like higher sea levels, more frequent storms, and coastal flooding. Even though this industry is very important to the country's economy, more awareness is needed among workers and leaders about the risks of climate change and what can be done to lessen these risks (Barange *et al.*, 2018). Different sources, like news outlets, social media, government programmes, and school lessons, help spread information about climate change. But in Nigeria, people's understanding of this issue is not the same everywhere. Some areas and groups know more about it than others. In the world of ships and ports, knowing more about climate change can help people like port managers, shipping companies, and sailors understand the possible dangers better. This knowledge lets them plan ahead and make better strategies to deal with these risks (Beveridge *et al.*, 2018).

As Sultan *et al.* (2019) point out, knowing about climate change affects how businesses and people see the risks of climate change and how they prepare for them. In Nigeria, where the maritime industry is very sensitive to climate change effects, making sure the workers understand climate change is an important step to making the industry stronger. The Nigerian government, working together with industry leaders, can help improve awareness about climate change. For instance, the Nigerian Maritime Administration and Safety Agency (NIMASA) can start awareness campaigns, explaining how climate change will impact maritime infrastructure, shipping routes, and coastal areas. Training programmes for port workers, ship crews, and other industry staff can also help them better understand the risks of climate change and how to adapt to them. According to Carr *et al.* (2022), adapting to climate change means changing how we do things, make rules, and plan to lower the harm from climate effects. In the shipping world, these changes are very important to lessen the bad effects of climate change. The Nigerian shipping business has many

problems because of climate change, like higher sea levels, coastal damage, and stronger, more frequent storms. These changes can cause trouble for shipping activities, facilities, and coastal areas. So, the industry needs to use good ways to adapt to make sure it can handle these problems.

Adaptation is a complicated process that involves many different aspects. According to Owusu *et al.* (2021), adaptation means changing how we do things or what we do to be less affected by changes in the environment. In the shipping industry, this could mean building ports that can handle floods and using technologies that don't harm the environment to lower the amount of pollution from ships. Also, being ready for disasters and knowing how to respond quickly is very important to reduce the damage from things like hurricanes and floods, which can cause problems at ports and harm ships. New technologies are a big part of adaptation. For example, making ships that can handle tough weather, using clean energy in shipping, and having ports that are good for the environment can make the industry better at dealing with climate problems. But adapting is not just about technology; it also includes changes in policies and behaviours. For instance, rules that set higher environmental requirements and offer rewards for using methods that can handle climate change can push the shipping industry to make positive moves toward adaptation (Cinner *et al.*, 2022).

2.2 WORKFORCE DEVELOPMENT FOR CLIMATE CHANGE ADAPTATION IN NIGERIA'S MARITIME SECTOR

Workforce development is an important part of dealing with climate change in the maritime industry. As climate change affects this sector, it's crucial to create a workforce that can understand and handle climate risks. This means investing in training programmes that give maritime workers the knowledge and skills needed to effectively use climate adaptation strategies. In Nigeria, the maritime workforce includes various people like port workers, ship operators, maritime engineers, and policymakers. Each group needs to be taught about the risks of climate change and the steps they can take to adapt. Training programmes should focus on areas such as climate risk management, the use of sustainable technologies in shipping, the construction of climate-resilient port infrastructure, and the development of disaster response plans (Eihakpor *et al.*, 2019). In Nigeria, schools and vocational training centers can be very important in teaching the skills needed for a maritime workforce that can handle climate challenges (Eihakpor *et al.*, 2019). The

government, working together with businesses, can help by funding education programmes, giving certificates in adapting to climate change, and encouraging maritime companies to train their workers on climate issues. Also, working with international groups like the United Nations Framework Convention on Climate Change (UNFCCC) can give Nigeria's maritime sector the special knowledge and resources it needs to better prepare its workforce for climate challenges (Essegbey *et al.*, 2020).

2.3 CLIMATE CHANGE ADAPTATION ISSUES (CCADI)

The ways countries and regions can adjust to climate change are affected by different challenges. These challenges are complicated. Recent research has focused on specific obstacles to adapting to climate change, beyond the obvious climate-related and non-climate-related issues that make it difficult, especially in developing countries. Studies show that a lack of knowledge about climate change, not having enough resources (such as farming supplies, water, irrigation, and land), and financial problems (due to low income, limited access to credit, and complex banking systems) are big issues. There is also a shortage of workers and not enough support from the government or agricultural services (Antwi *et al.*, 2017). Experts say that there are big gaps in what we know, which makes it hard for information to be shared properly. This makes it difficult for people to adapt. But just knowing isn't enough to make the changes we need. Studies show that both rich and poor countries see these knowledge gaps as big problems for adapting (Ortiz-Bobea et al., 2021). Also, Omollo et al. (2018) pointed out that information is very important for helping people adapt. Besides knowledge, physical challenges also affect how well people can adapt. Using technology to share information is key to helping societies deal with climate change at all stages of adapting. Adapting to climate change is seen as a very important way to reduce the harm from it (Ogunyiola *et al.*, 2022). In areas with little water, organizations that rely on water have less ability to handle changes in water availability, whether they are temporary or long-lasting. This affects how well they can adapt to ensure there is enough water. This challenge also impacts other important areas such as energy, farming, and food supply (Ngoan, 2018). Similarly, the quality of soil and water can greatly restrict farming activities, affecting how well agricultural systems can adjust to climate change. Farmers, who are the main decision-makers in agriculture, work in a complicated setting that includes political, economic, natural, and institutional factors. Also, personal traits, farming methods, and local environmental conditions further influence how

farmers respond to climate change and their ability to adapt. Well-informed farming communities are better able to make smart decisions and use effective techniques, which helps them adapt better to climate change. However, some external factors that farming communities can't control hinder adaptation, and these factors don't necessarily improve with more awareness of climate change (Moran & Blair, 2021). Ravi and Patil (2019) list these challenges as including insufficient money for farmers, bad market access because of poor transportation and market information, limited access to loans or insurance, no subsidies for important farming supplies, doubt about current weather predictions, unreliable electricity, inadequate knowledge about farming technologies that meet specific needs, lack of understanding about climate change and how to adapt, and poor irrigation systems. Other challenges involve physical and environmental limits, technological issues, financial difficulties, information and understanding barriers, and social and cultural hurdles. When examining the connection between climate change awareness and adaptation, the outcomes are usually unfavourable. In sum, while knowledge and awareness are important, they must be accompanied by tangible support mechanisms such as financial resources, infrastructure, and institutional support to enable effective adaptation. The complexity of these barriers highlights the need for a more holistic approach to adaptation that considers both the informational and structural challenges faced by communities, especially in agriculture, to improve their resilience to climate change.

3.0 METHODOLOGY

3.1 RESEARCH DESIGN

This study adopted a descriptive survey method to investigate the influence of climate change awareness and adaptation on workforce development in Nigeria's maritime industry.

3.2 STUDY POPULATION

The population for this study comprised of maritime workers in Tin Can Port and Rivers Port. According to the data, Tin Can Port has a total of 1,988 workers, while Rivers Port has 1,011 workers. The total population across both ports is 2,999 workers. The study incorporated a broad range of stakeholders, including both public and private sector operators as well as local and international maritime organizations, ensuring comprehensive representation. Key participants

were drawn from the Nigerian Maritime Administration and Safety Agency (NIMASA), Private logistics firms, Shipping management companies, and Port operators.

3.3 SAMPLE AND SAMPLING TECHNIQUE

The sample comprised 210 respondents, a simple random sampling method was used to select the sample size of 210 by selecting approximately 10% of the maritime workers from the population of the study.

3.3.1 Instrumentation

A structured questionnaire was used as the primary research instrument. The questionnaire was carefully designed to capture critical demographic information, including age, gender, educational qualifications, years of experience and rank; as well as gather information about the hypotheses raised to guide the study.

3.3.2 Validity and Reliability of the Instrument

A pilot study was conducted with 20 respondents to test the reliability of the instrument, and the Cronbach's alpha coefficient obtained was **0.82**, indicating high internal consistency.

3.3.3 Inclusion and Exclusion Criteria

Inclusion criteria: Participants with at least three years of experience in maritime operations and roles involving decision-making or engagement with climate-related issues.

Exclusion criteria: Individuals without direct maritime involvement or those who declined to provide informed consent.

3.3.4 Data Collection

Before data collection, informed consent was obtained from all participants. Additionally, departmental heads signed consent forms, ensuring institutional approval. Ethical guidelines were strictly adhered to, safeguarding participant confidentiality and voluntary participation. Out of the 210 questionnaires distributed, 200 were successfully retrieved and deemed valid for analysis, yielding a response rate of 95.2%.

3.4 DATA ANALYSIS

Simple percentages and frequency distributions were used to summarize demographic characteristics. The study employed Analysis of Covariance (ANCOVA) to assess the relationship between climate change awareness, adaptation strategies, and workforce development. All statistical analyses were performed using SPSS version 26.0, ensuring accuracy and reliability in data interpretation.

4.0 RESULTS

Hypothesis One: There is no significant relationship between climate change awareness and workforce development in the maritime industry.

Table 1: Summary of Analysis of Covariance (ANCOVA) of Climate Change Awareness and Workforce Development in the Maritime Industry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	18.337a	1	18.337	20.543	.000	.078
Intercept	112.450	1	112.450	127.198	.000	.389
CC Awareness	18.337	1	18.337	20.543	.000	.078
Error	220.825	198	1.115			
Total	2500.000	200				
Corrected Total	239.162	199				

a. R Squared = .078 (Adjusted R Squared = .074)

The ANCOVA analysis showed a strong connection between how aware people are about climate change and how their skills develop in the maritime industry ($p<0.05$, F-value=20.543). This means that climate change awareness matters for workforce development in this industry. The partial Eta squared value of .078 tells us that climate change awareness explains 7.8% of the changes in workforce development. This is a moderate effect, meaning that while climate change awareness does have a noticeable impact, other things also play a role in the remaining 92.2% of the changes in workforce development, which this study didn't look at. Therefore, we can say that the idea that climate change awareness doesn't really affect how people work is not true. The results show that knowing about climate change is important for making plans about how people work in the shipping business in Nigeria.

Hypothesis Three: There is no significant relationship between climate change adaptation and workforce development in the Maritime industry.

Table 2: Summary of Analysis of Covariance (ANCOVA) of Climate Change Adaptation and Workforce Development in the Maritime Industry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	16.125a	1	16.125	18.390	.000	.071
Intercept	110.375	1	110.375	128.327	.000	.391
CC Awareness	16.125	1	16.125	18.390	.000	.071
Error	205.912	198	1.041			
Total	2400.000	200				
Corrected Total	222.037	199				

a. R Squared = .071 (Adjusted R Squared = .067)

The ANCOVA analysis showed a strong connection between how aware people are about climate change and how they adapt to it in the maritime industry ($p<0.05$, F-value=18.390). This means that climate change awareness has a significant impact on adaptation issues in the maritime

industry. The partial Eta squared value of .071 suggests that climate change awareness explains 7.1% of the differences in how people adapt to climate change in the maritime sector. This is a small to moderate effect, meaning that while climate change awareness does have an important influence, 92.9% of the differences in adaptation issues are due to other factors not covered in this study. As a result, the idea that there is no important connection between understanding climate change and dealing with its effects is not supported. The findings show that awareness of climate change is very important in how Nigeria's maritime industry handles adaptation problems.

5.0 DISCUSSION

The study showed that there was a significant relationship between climate change awareness and workforce development in the Maritime industry. This finding aligns with the study of Azumah and Ahmed (2023), who noted that workforce development is crucial for building technical skills needed for climate change adaptation in the maritime sector. Training maritime workers on climate risks, sustainable shipping practices, and disaster management strategies enhances the industry's resilience to climate impacts. Additionally, Bahri *et al.* (2018) argue that investing in workforce development programmes not only strengthens the capacity of the maritime industry but also contributes to job creation and economic growth. On the contrary, this finding is not in line with the work of Eihakpor *et al.* (2019), who suggested that while training programmes exist, the gap in knowledge and skills among the workforce often hinders the successful implementation of climate change adaptation strategies. The study showed that there was a significant relationship between climate change awareness and climate change adaptation issues in the Maritime industry. This finding aligns with the study of Carr *et al.* (2022), who stated that awareness of climate change risks is essential for identifying and addressing adaptation issues in the maritime sector, such as the need for climate-resilient infrastructure and improved disaster preparedness. Similarly, Sorgho *et al.* (2020) stated that heightened awareness helps stakeholders understand climate risks and the required actions for mitigating them, which directly influences adaptation practices. Furthermore, Sultan *et al.* (2019) asserted that climate change awareness helps industries better understand the challenges they face, enabling them to develop appropriate strategies for overcoming these barriers. However, this finding contradicts the study of Moran and Blair (2021), who found that despite awareness, many stakeholders in the maritime industry struggle to address climate change adaptation issues effectively due to a lack of financial resources and adequate infrastructure.

Moreover, this finding is also not in line with the study of Barange *et al.* (2018), who found that despite awareness efforts, the Nigerian maritime sector still faces challenges in effectively implementing adaptation strategies due to insufficient resources and institutional support.

5.1 Conclusion and Recommendations

In conclusion, climate change awareness in the maritime industry is essential for driving adaptation measures. As climate change increases risks like rising sea levels, storms, and coastal erosion, industry stakeholders—including port authorities, shipping companies, and engineers—can implement strategies to reduce vulnerabilities. Awareness helps inform decisions such as investing in resilient infrastructure, altering shipping routes, and using climate-resilient technologies. It also guides strategic planning, ensuring future developments address long-term climate impacts. In essence, climate change awareness enables the industry to adapt proactively, minimizing the risks and ensuring the sustainability of maritime operations; this helps safeguard the industry's future from climate-related disruptions. Workforce development in the maritime industry focuses on improving employees' skills to address climate change challenges. Increased climate change awareness drives the integration of sustainability and resilience into training and capacity-building initiatives. Employees need expertise in areas like climate resilience, environmental management, and sustainable practices, such as low-carbon shipping and renewable energy.

Furthermore, awareness also encourages collaboration and innovation among workers, fostering a culture of sustainability. Climate change adaptation in the maritime industry involves addressing both physical impacts, such as sea-level rise and extreme weather, and socio-economic challenges, like trade disruptions and increased costs. Climate change awareness helps stakeholders recognize and manage these issues. It encourages better forecasting of climate-related disruptions, development of resilient infrastructure, and the creation of policies to withstand environmental changes. Awareness drives proactive risk management, prompting investments in resilient infrastructure and emission-reducing innovations. It enables the industry to focus on long-term resilience, ensuring preparedness for future climate challenges and minimizing the sector's vulnerability to climate change. The following recommendations are suggested:

(i) Maritime industry stakeholders should prioritize the integration of climate change awareness into all levels of decision-making to ensure sustainable practices are embedded into operational and strategic planning, thereby mitigating future risks associated with climate change impacts.

(ii) Shipping companies should invest in climate-resilient technologies and alternative fuels to reduce the environmental effect of their operations and comply with emerging sustainability regulations.

(iii) Port authorities should improve their infrastructure to handle extreme weather and rising sea levels by using designs like flood barriers and stronger structures.

(iv) Government regulators should implement and enforce policies that require climate risk assessments for all new maritime infrastructure projects and shipping operations to safeguard long-term resilience.

(v) Maritime training institutions should incorporate climate change adaptation, environmental management, and sustainability practices into their curricula to prepare workers with the necessary skills to address climate-related challenges.

(vi) Industry leaders and policymakers should foster collaboration between private and public sectors to develop innovative, cost-effective solutions that enhance the climate resilience of the maritime industry while promoting global sustainability goals.

REFERENCES

Afriyie, K., Ganle, J. K., & Santos, E. (2018). The floods came and we lost everything: Weather extremes and households' asset vulnerability and adaptation in rural Ghana. *Climate and Development, 10*(3), 259–274.

Agbonmiewalent, I. O. (2007). *Research methods in social sciences: Theory and application*. Lagos: Adeyemi Press.

Ali, A., & Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management, 16*, 183–194. https://doi.org/10.1016/j.crm.2016.12.001

Alidu, A. F., Man, N., Ramli, N. N. (2022). Smallholder farmers' access to climate information and climate-smart adaptation practices in the northern region of Ghana. *Heliyon, 8*(5), e09513. https://doi.org/10.1016/j.heliyon.2022.e09513

Alizadeh, M. R., Adamowski, J., & Inam, A. (2022). Integrated assessment of localized SSP–RCP narratives for climate change adaptation in coupled human-water systems. *Science of the Total Environment, 823*, 153660. https://doi.org/10.1016/j.scitotenv.2022.153660

Alves, B., Angnuureng, D. B., & Morand, P. (2020). A review on coastal erosion and flooding risks and best management practices in West Africa: What has been done and should be done. *Journal of Coastal Conservation, 24*, 1–14. https://doi.org/10.1007/s11852-020-00755-7

Amondo, E., Simtowe, F., & Rahut, D. B. (2019). Productivity and production risk effects of adopting drought-tolerant maize varieties in Zambia. *International Journal of Climate Change Strategies and Management, 11*(4), 570–591.

Ayodotun, B., Bamba, S., & Adio, A. (2019). Vulnerability assessment of West African countries to climate change and variability. *Journal of Geoscience and Environment Protection, 7*, 13–25.

Azumah, B. S., & Ahmed, A. (2023). Climate-induced migration among maize farmers in Ghana: A reality or an illusion? *Environmental Development, 45*, 100808. https://doi.org/10.1016/j.envdev.2023.100808

Bahri, T., Barange, M., & Moustahfid, H. (2018). Chapter 1: Climate change and aquatic systems. In M. Barange, T. Bahri, M. C. M. Beveridge, *et al.* (Eds.), *Impacts of Climate Change on Fisheries and Aquaculture, Synthesis of Current Knowledge, Adaptation and Mitigation Options* (pp. 1–16). Food and Agriculture Organization of the United Nations.

Barange, M., Bahri, T., Beveridge, M. C. M. (2018). Impacts of climate change on fisheries and aquaculture. *UN Food and Agriculture Organization, 12*(4), 628–635.

Beveridge, M. C. M., Dabbadie, L., Soto, D. (2018). Chapter 22: Climate change and aquaculture: Interactions with fisheries and agriculture. In M. Barange, T. Bahri, M. C. M. Beveridge, *et al.* (Eds.), *Impacts of Climate Change on Fisheries and Aquaculture, Synthesis of Current Knowledge, Adaptation and Mitigation Options* (pp. 345–366). Food and Agriculture Organization of the United Nations.

Carr, W. T., Mkuhlani, S., Segnon, A. C. (2022). Climate change impacts and adaptation strategies for crops in West Africa: A systematic review. *Environmental Research Letters, 17*(5), 053001. https://doi.org/10.1088/1748-9326/ac61c8

Cinner, J. E., Caldwell, I. R., Thiault, L. (2022). Potential impacts of climate change on agriculture and fisheries production in 72 tropical coastal communities. *Nature Communications, 13*(1), 3530. https://doi.org/10.1038/s41467-022-30991-4

Ehiakpor, D. S., Danso-Abbeam, G., & Dagunga, G. (2019). Impact of Zai technology on farmers' welfare: Evidence from northern Ghana. *Technology in Society, 59*, 101189. https://doi.org/10.1016/j.techsoc.2019.101189

Essegbey, G. O., Nutsukpo, D., & Karbo, N. (2020). National Climate-smart Agriculture and Food Security Action Plan of Ghana (2016–2020). Food and Agriculture Organization of the United Nations. https://faolex.fao.org/docs/pdf/gha169288.pdf

Maulu, S., Hasimuna, O. J., & Haambiya, H. L. (2021). Climate change effects on aquaculture production: Sustainability implications, mitigation, and adaptations. *Frontiers in Sustainable Food Systems, 5*, 609097. https://doi.org/10.3389/fsufs.2021.609097

Moran, D., & Blair, K. J. (2021). Review: Sustainable livestock systems: Anticipating demand-side challenges. *Animal, 15*(Suppl. 1), 100288. https://doi.org/10.1016/j.animal.2021.100288

Ogunyiola, A., Gardezi, M., & Vij, S. (2022). Smallholder farmers' engagement with climate smart agriculture in Africa: Role of local knowledge and upscaling. *Climate Policy, 22*(4), 411–426.

Omollo, E. O., Wasonga, O. V., & Elhadi, M. Y. (2018). Determinants of pastoral and agro-pastoral households' participation in fodder production in Makueni and Kajiado Counties, Kenya. *Pastoralism, 8*(1), 9. https://doi.org/10.1186/s13570-018-0113-9

Ortiz-Bobea, A., Ault, T. R., & Carrillo, C. M. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change, 11*(4), 306–312.

Owusu, V., Ma, W., & Emuah, D.. (2021). Perceptions and vulnerability of farming households to climate change in three agro-ecological zones of Ghana. *Journal of Cleaner Production, 293*, 126154. https://doi.org/10.1016/j.jclepro.2021.126154

Palmer, T., & Stevens, B. (2019). The scientific challenge of understanding and estimating climate change. *Proceedings of the National Academy of Sciences of the United States of America, 116*(49), 24390–24395.

Parker, R. R., Blanchard, J. L., & Gardner, C. (2018). Fuel use and greenhouse gas emissions of world fisheries. *Nature Climate Change, 8*(1), 333–337.

Rutkayová, J., Vácha, F., & Maršálek, M. (2017). Fish stock losses due to extreme floods—findings from pond-based aquaculture in the Czech Republic. *Journal of Flood Risk Management, 11*(1), 351–359.

Saeed, W., Haqiqi, I., & Kong, Q. (2022). The poverty impacts of labor heat stress in West Africa under a warming climate. *Earth's Future, 10*(11), e2022EF002777. https://doi.org/10.1029/2022EF002777

Sorgho, R., Quiñonez, C. A. M., & Louis, V. R. (2020). Climate change policies in 16 West African countries: A systematic review of adaptation with a focus on agriculture, food security, and nutrition. *International Journal of Environmental Research and Public Health, 17*(23), 8897. https://doi.org/10.3390/ijerph17238897

Sultan, B., Defrance, D., & Iizumi, T. (2019). Evidence of crop production losses in West Africa due to historical global warming in two crop models. *Scientific Reports, 9*(1), 128–134.

Townhill, B., Harrod, O., & Painting, S. (2023). Climate change risk and adaptation for fisher communities in Ghana. *Journal of Coastal Conservation, 2*(1), 27–45.

Trisos, C. H., Adelekan, I. O., & Totin, E. (2022). Africa. *IPCC AR6 WGII Chapter 09*. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter09.pdf

Verner, D., David, T., & John, R. (2018). Climate variability, drought, and drought management in Côte d'Ivoire's agricultural sector. *World Bank Group*. https://openknowledge.worldbank.org/handle/10986/30603

Wassmann, R., Villanueva, J., & Khounthavong, M. (2019). Adaptation, mitigation, and food security: Multi-criteria ranking system for climate-smart agriculture technologies illustrated for rainfed rice in Laos. *Global Food Security, 23*, 33–40.

Wongnaa, C. A., & Babu, S. (2020). Building resilience to shocks of climate change in Ghana's cocoa production and its effect on productivity and incomes. *Technological Forecasting and Social Change, 62*, 101288. https://doi.org/10.1016/j.techsoc.2020.101288

Yiridomoh, G. Y., & Owusu, V. (2021). Do women farmers cope or adapt to strategies in response to climate extreme events? Evidence from rural Ghana. *Climate and Development, 14*(7), 678–687.

Yiridomoh, G. Y., Sullo, C., & Bonye, S. Z. (2020). Climate variability and rural livelihood sustainability: Evidence from communities along the Black Volta River in Ghana. *GeoJournal, 86*, 1527–1543.

Zakaria, A., Azumah, S. B., & Appiah, T. M. (2020). Adoption of climate-smart agricultural practices among farm households in Ghana: The role of farmer participation in training programmes. *Technological Forecasting and Social Change, 63*(1), 101338. https://doi.org/10.1016/j.techsoc.2020.101338

Zolnikov, T. R. (2019). *Global Adaptation and Resilience to Climate Change*. Studies in Climate Resilient Societies (1st ed.). Springer International Publishing.

Zougmoré, R. (2018). Facing climate variability in sub-Saharan Africa: Analysis of climate-smart agriculture opportunities to manage climate-related risks. *Cahiers Agricoles, 27*, 34001. https://doi.org/10.1051/cagri/2018019

Mumtaz, M., Puppim de Oliveira, J. A., & Ali, S. H. (2019). Climate change impacts and adaptation in the agricultural sector: The case of local responses. In *Climate Change in Agriculture* (pp. 1-14). https://doi.org/10.5772/intechopen.83553

Ricart, S., Olcina, J., & Rico, A. M. (2019). Evaluating public attitudes and farmers' beliefs towards climate change adaptation: Awareness, perception, and populism at the European level. *Land, 8*(4).

Saleem, A., Husnain, I., Jan, M., Ashfaq, M., Rashid, M., & Hakoor, U. (2018). Farmers' adaptation to climate change in Pakistan: Perceptions, options, and constraints. *Sarhad Journal of Agriculture, 34*(4), 712–1000.