



Investigating the Effects of Climate Change on Coastal Women in Aiyetoro Southwest Nigeria

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Planet Earth is amid a climate crisis occasioned by human activities that release greenhouse gases into the atmosphere and natural processes that affect the planet's warming and cooling patterns. As a result, sea levels are rising, coral reefs are dying, and the pH of the world's oceans is decreasing; the planet is becoming progressively hotter, forest cover is reducing, and weather patterns are becoming increasingly erratic. These effects are experienced universally, but traditionally, vulnerable groups of the population are affected more severely. For instance, climate change exacerbates the vulnerabilities experienced by women from coastal communities. Mindful of the understanding that coastal women's experiences and vulnerability to climate change vary across communities, we sought to investigate the effects of climate change on coastal women using the women of Aiyetoro in Southwest Nigeria. Men and women from Aiyetoro (N=150) were interviewed to gather information on the effects of climate change on women in the community. Their responses were analyzed, showing that the women are aware of and have experienced extensive effects of climate change, including rising sea levels and temperatures, coastal erosion, ocean acidification, extreme weather events, deteriorating health and well-being, and death. This study adds to the existing pool of knowledge by highlighting how coastal women experience climate change and identifying avenues to engage them, teach them, and learn from them about their potential role in addressing the climate change crisis.

Keywords: Climate change, gender, coastal community, climate-resilient activities, coping strategies

INTRODUCTION

Climate change is a rapidly evolving global phenomenon that has far-reaching impacts on ecosystems and societies. One of the environments most affected by climate change is the coastal zone, which is highly vulnerable to the impacts of rising sea levels, ocean acidification, and coastal erosion (Hoegh-Guldberg *et al.*, 2017). These impacts can cause widespread damage to coastal communities, infrastructure, and ecosystems and have far-reaching social, economic, and environmental consequences (Berman *et al.*, 2020; Hastings *et al.*, 2020). While the impacts of climate change on coastal communities are well documented (Rao *et al.*, 2019; Hans *et al.*, 2021; Vercillo *et al.*, 2022), the effects on women in these communities have received less attention (Desai & Zhang, 2021; de la Torre-Castro *et al.*, 2022; Vercillo *et al.*, 2022). Women in these communities are particularly vulnerable to the effects of climate change due to their unique social, economic, and political positions, which manifest through widespread gender inequality, a high incidence of gender-based violence, limited access to relevant information, and behavioral restrictions that limit their social and economic participation (de la Torre-Castro *et al.*, 2022; Kantamaneni *et al.*, 2022).

Coastal women's vulnerability to climate change is pegged on their reliance on natural resources to care for their families and communities. The consequences of climate change have influenced many of their everyday activities, including access to clean and safe water, food, and fuel for food preparation, lighting, and other domestic responsibilities. The women's limited access to these resources is exacerbated by various factors, including their limited mobility and children's inability to swim, which leads to more women and children perishing during disasters compared to their male counterparts. Additionally, rising sea levels and coastal flooding threaten housing affordability and security in coastal areas (Buchanan *et al.*, 2020). The lack of secure housing increases harassment, preventing women from seeking space in shelters during disasters caused by climate change (Zahan, 2022; Hasan & Shovon, 2019). Women's health is still quite vulnerable during disasters. Numerous studies have shown a relationship between climate and weather and the evolution and spread of infectious illnesses. This increases the prevalence of infectious diseases, including cholera, malaria, and dengue fever, since the risk seasons are extended and disease vectors are distributed more widely geographically (Khan *et al.*, 2003). Further, women and young girls frequently experience urinary tract infections due to a lack of lavatories in addition to violence inside and outside of their households from male family members and strangers (Alam *et al.*, 2008; Zahan, 2022).

However, it is crucial to remember that while women in coastal communities are particularly susceptible to the effects of climate change, they have been shown to play critical roles in community mitigation, adaptation, and resilience (Shahin *et al.*, 2022). Women in these communities often have deep connections to their local environment and a wealth of knowledge about their local ecosystem that may be used for methods for reducing catastrophe risk, adapting to climate change, and all of these things in between. They are often leaders in the development of innovative solutions to the impacts of climate change, such as the creation of new livelihood opportunities and the development of new ways of living that are more resilient to the impacts of climate change (Adeleke *et al.*, 2020; de la Torre-Castro *et al.*, 2022). Climate change projections show that women's vulnerability will become more pronounced regarding limited access to natural resources (particularly land and water), finance and markets, knowledge and information, and other factors (Chayal *et al.*, 2013; McMahon & Johra, 2012).

Several studies have been conducted in different regions around the world, including in Southeast Asia and Africa, to examine the impacts of climate change on women in coastal communities. For example, studies by Md *et al.* (2022), Zahan (2022), and Shahin *et al.* (2022) found that women in coastal communities in Bangladesh are particularly vulnerable to the impacts of sea level rise, as they are often responsible for collecting water and cultivating crops that are vulnerable to flooding. Similarly, a study by Allen *et al.* (2021) in Kenya found that women in coastal communities are more vulnerable to climate change due to their dependence on natural resources for their livelihoods and limited access to education and resources to cope with these changes.

The investigation of de la Torre-Castro *et al.* (2022) into the fundamental elements enhancing coastal women's potential for adaptation in Zanzibar (Unguja Island), Tanzania, utilising Cinner *et al.* (2018) five domains typology for adaptive capacity—assets, flexibility, organisations, learning, and agency showed that demonstrate that women's poor levels of adaptability, their persistent poverty, and their substantial reliance on the red algal seaweed industry—a source of meagre income that is already having a significant negative impact on their well-being—are all factors in the world's changing climate. In his essay, Onwutuebe (2019) demonstrated how patriarchy contributes to a high rate of exposure of women to the harmful effects of climate change using Nigeria as a case study. Through the preservation of specific advantages for men, patriarchy promotes gender disparity against women. This disparity serves as the foundation for men and women using their authority differently, and it is a significant contributor to the disproportionate impact of climate change on them. Threats to gender security in society are exacerbated by climate change. It serves as a threat multiplier, catalysing and escalating the issue of women's marginalisation. The dependence on men for survival

worsens when climate change affects agricultural activity and jeopardises the livelihood of women engaged in farming (Laczko & Aghazarm, 2009; Onwutuebe, 2019).

Another aspect of evaluating and broadening the scope of land snatching is the patterns and dynamics of land deprivation in which Nigerian women either need to be adequately recognised or wholly excluded. Women suffer far greater risk in places where they cannot participate in other economic or public activities like men do in the face of the mounting challenges posed by climate change (Cotula, 2013; Onwutuebe, 2019). This means that after a man passes away, his possessions, mainly landed property, are taken or divided among the family's relatives. It is sometimes said that all considerable property, including the land, belongs to the husbands, and the woman herself is practically regarded as a type of "property" (Aluko, 2015). Women are more susceptible to climate change when they lack land access (Nigerian Environmental Study Team, 2011). Therefore, many have little or no other employment options save small-scale farming. Nigeria's lack of access to land continues to undermine efforts to empower women.

From the above case studies, rising sea levels emerge as one of the most visible impacts of climate change and have devastating effects on coastal communities worldwide (Adegun, 2023; Kubiszewski *et al.*, 2020). Women in these communities are often the first to feel the impacts of rising sea levels, as they are often responsible for caring for their families, including their homes and livelihoods. Women have often been forced to abandon their homes and communities due to rising sea levels, leading to increased poverty, displacement, and loss of traditional knowledge and cultural heritage (Onwutuebe, 2019). Ocean acidification is another climate change impact severely affecting coastal communities, including women. The acidification of oceans is having a profound impact on the marine food chain, leading to decreased availability of fish, shellfish, and other essential food sources for coastal communities (Hoegh-Guldberg *et al.*, 2017). Women in these communities are often the primary food providers for their families and are the first to suffer from the impacts of declining food security (de la Torre-Castro *et al.*, 2022). Third, coastal erosion is another impact of climate change that is devastatingly affecting coastal communities, including women. The loss of land and homes to coastal erosion has severe social, economic, and political impacts on coastal communities, including increased poverty, displacement, and loss of traditional knowledge and cultural heritage (Kalacska *et al.*, 2017). Women in these communities are often the first to feel the impacts of coastal erosion, as they are often the primary caretakers of their families and homes (de la Torre-Castro *et al.*, 2022).

Coastal communities, especially in developing countries, are highly vulnerable to the impacts of climate change. These communities often depend heavily on the ocean and its resources for their livelihood. They are thus at increased risk from rising sea levels, increased frequency and severity of storms, and other climate-related impacts (Glavovic *et al.*, 2022). One such community is Aiyetoro, located in the Ilaje Local Government Area of Ondo State, Nigeria. Aiyetoro was once known as the "Happy City" because of its inhabitants' unique and communal lifestyle. However, today, the community has lost its happiness due to the devastating effects of climate change (Akinsemolu & Olukoya, 2020). The rise in sea level, resulting from global warming and oil exploration, has led to severe flooding that has washed away homes, the cemetery, and the iconic worship centre of the town (Adeleke & Balogun, 2013). Despite a multi-billion-naira shore protection project awarded by the NDDC (The Niger Delta Development Commission) sixteen years ago, with billions of naira already paid to the contractors, nothing has been done to stop the ocean surge rapidly erasing the community (Akinsemolu & Olukoya, 2020; Adeleke & Matthias, 2016). Women are the most vulnerable to the impacts of climate change, particularly in coastal communities such as Aiyetoro. Coastal areas are often home to lower-income communities, and women in these communities are often responsible for securing food, water, and shelter for their families (Thomas *et al.*, 2019; Andrijevic *et al.*, 2020). Climate change exacerbates these already challenging circumstances, putting even greater pressure on women to find resources and cope with the effects of rising sea levels, more frequent and intense storms, and increasing temperatures (Lauria *et al.*, 2018; Nyangoko *et al.*, 2022).

This study aims to assess these impacts of climate change on coastal women in the Aiyetoro community. The study will focus on how the changing climate affects the livelihoods, health, and well-being of women in Aiyetoro by assessing the impacts of climate change on the population of the study, examining the relationship between the identified effects and the women's livelihoods, investigating coping mechanisms, identifying challenges faced by the women in adapting to the impact of climate change, and inferring recommendations on how to enhance the resilience of coastal women in Aiyetoro in the face of climate change.



Figure 1: Map showing the location of Aiyetoro (S7), Ilaje district in Ondo State, Nigeria Akinsemolu & Olukoya, (2020).



Figure 2: Women on a search for fish, firewood and other materials in Aiyetoro (Author fieldwork, 2017).



Figure 3: Image showing women selling domestic items on the sea (Author fieldwork, 2017).



Figure 4: Image showing the interview session between the researcher and a respondent (Author fieldwork, 2023).



Figure 5: Image showing a focus group discussion during the fieldwork to Aiyetoro (Author, fieldwork, 2023)

MATERIALS AND METHODS

A mixed-methods approach incorporating qualitative and quantitative data collection techniques was used to comprehensively understand climate change's impact on coastal women in Aiyetoro. Aiyetoro is a coastal town in Ilaje District, Ondo State, Nigeria. Once nicknamed "Happy City" due to the unique and communal lifestyle adopted by its inhabitants, the town has gradually lost its once characteristic happiness due to the devastating effects of climate change (Akinsemolu & Olukoya, 2020). As of 2015, Aiyetoro had an estimated population of 65,863, with 32,200 (48.9%) being male and 33,663 (51.1%) being women (City-Facts, 2015). In the eight years since, the population of the coastal city has dropped to just 5,000 inhabitants, with locals attributing the rapid decline to the submersion of parts of the city due to rising sea levels (Jamiu, 2023).

Two primary data collection methods were used to conduct a community assessment in Aiyetoro. First, a series of focus group discussions were organised to allow the women to discuss their experiences, challenges, and coping strategies in response to the impacts of climate change. Second, key informant interviews were conducted among relevant stakeholders, including government agencies, NGOs, and community leaders, to gain insight into the current policies and interventions for climate change in the area as well as the challenges faced by women in the community in adapting to the impacts of climate change. All findings were populated in a questionnaire, which captured the demographic characteristics of the respondents together with other information relevant to the study. The collected data was analyzed using SPSS into themes and subthemes, including the demographic characteristics of the respondents, the effects of climate change experienced by women in Aiyetoro, their impacts on the women's livelihoods and the coping strategies they have adopted, and the effects of climate change on their health and general well-being. The following results were derived from the collected data.

Results

The gender and age of the respondents (N=150) varied, with female respondents making up the majority of the respondents. Additionally, respondents aged under 18 made up the smallest percentage, while those aged 35-40 made up the most significant proportion of all age groups, as shown in Figures 1 and 2 below. Additional demographic information, including the education level, religion, marital status, and occupation, was collected and presented in Figures 3, 4, 5, and 6 below as a testament to the diversity of the insight derived from the respondents on the topic of study.

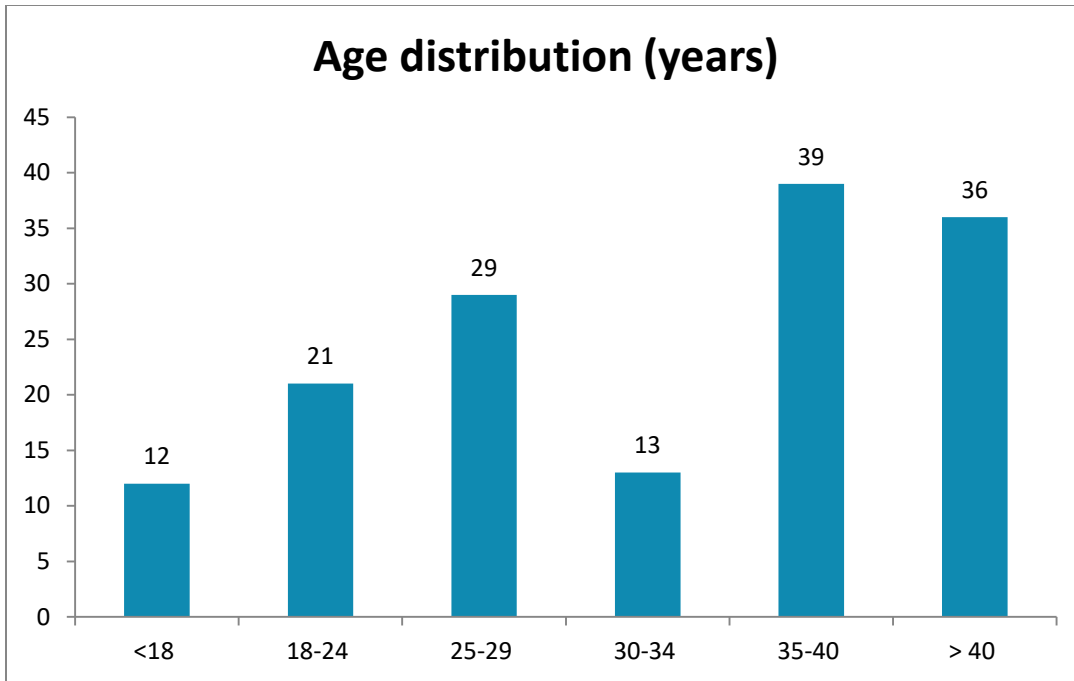


Figure 1: The Age Distribution of the Respondents

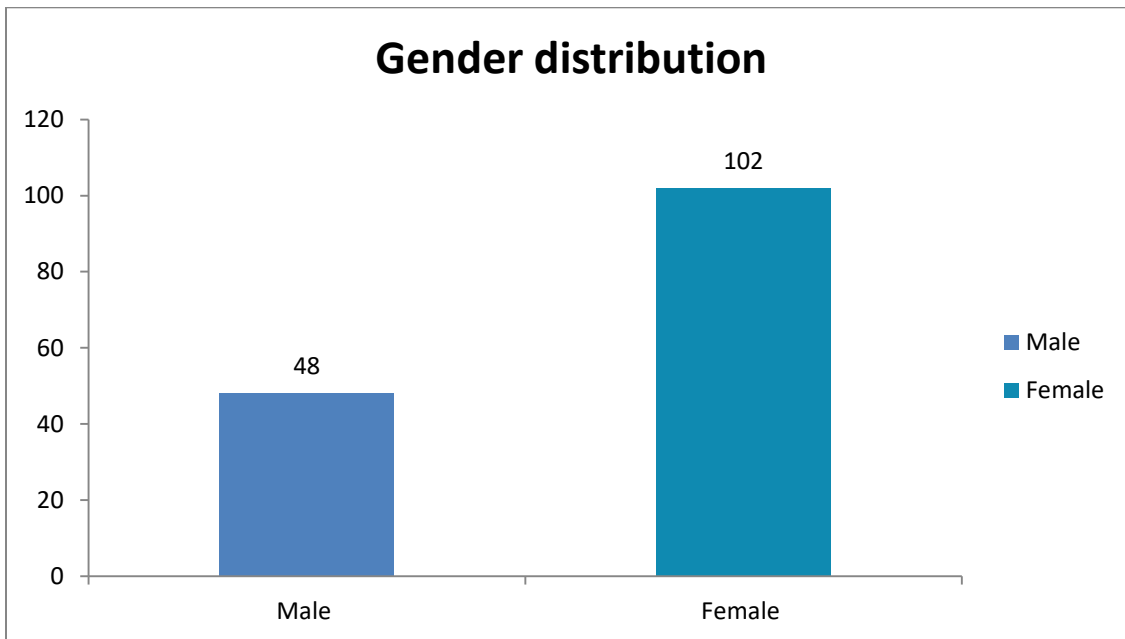


Figure 2: The Gender Distribution of the Respondents

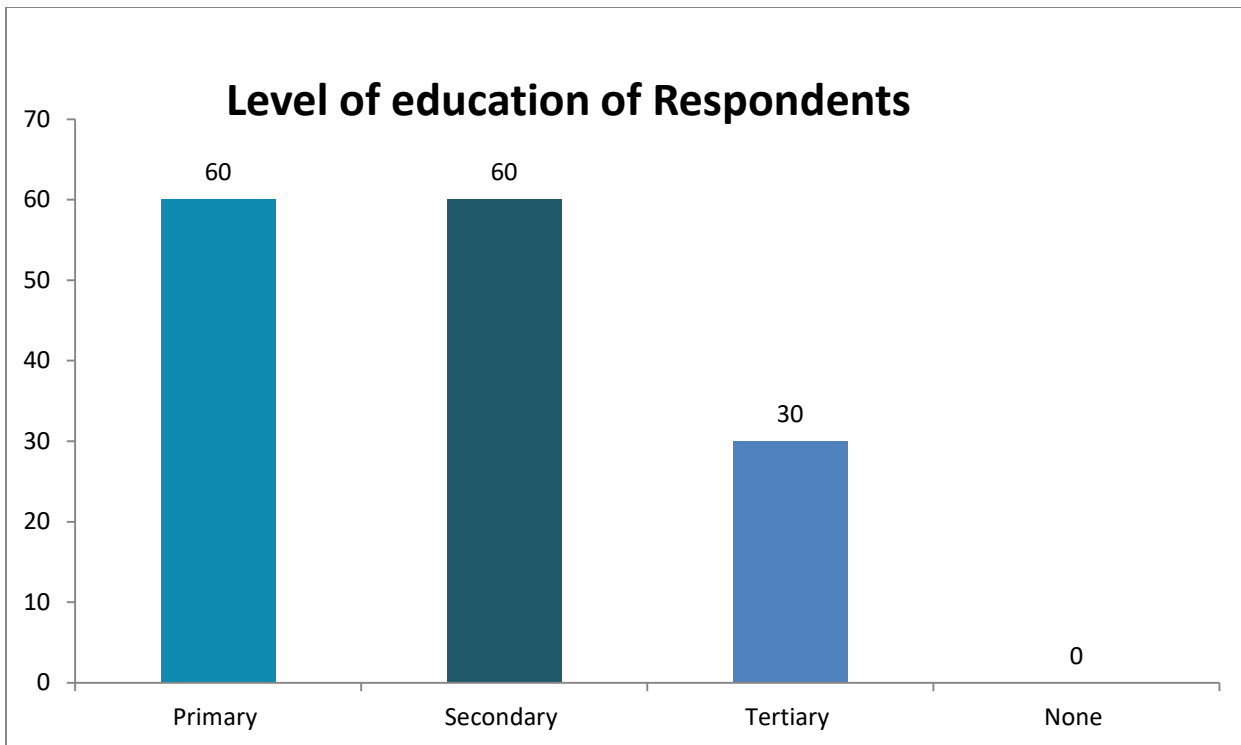


Figure 3: The Education Level of the Respondents

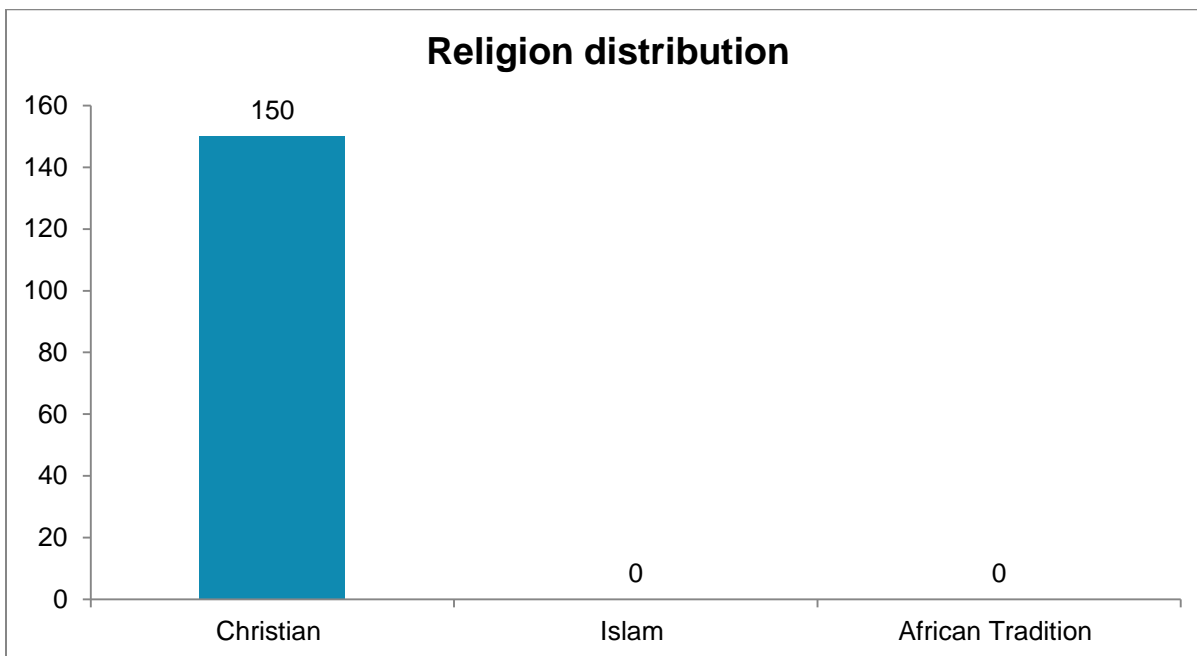


Figure 4: The Religion of the Respondents

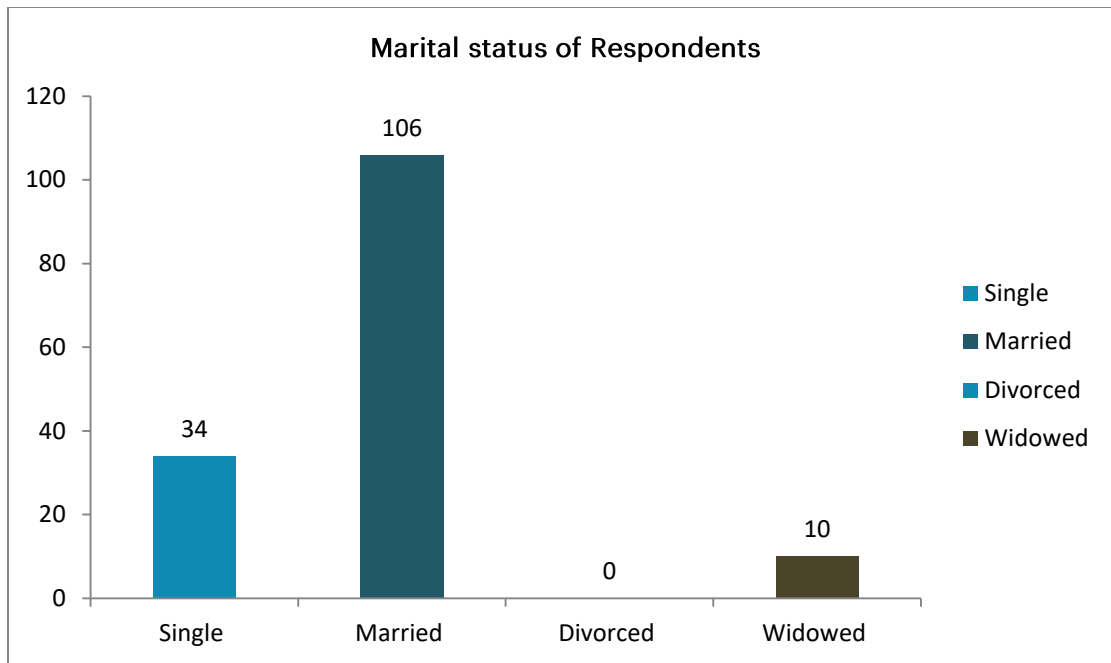


Figure 5: The Marital Status of the Respondents

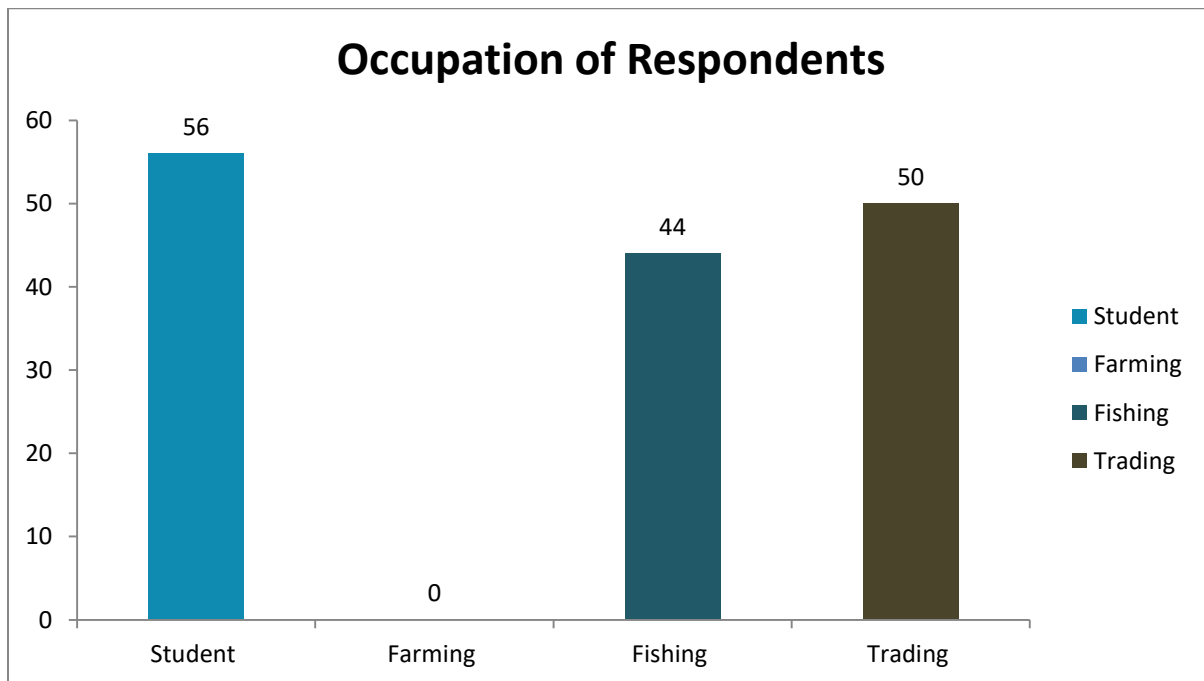


Figure 6: The Occupation of the Respondents

An initial assessment of the respondents' understanding of climate change uncovered different levels of their understanding of the concept, with 39 respondents having a good grasp of it. At the same time, three (3) did not understand climate change. Notably, most respondents reported having a limited understanding of the concept, with nearly half stating that they needed help understanding it, as shown in Figure 7 below.

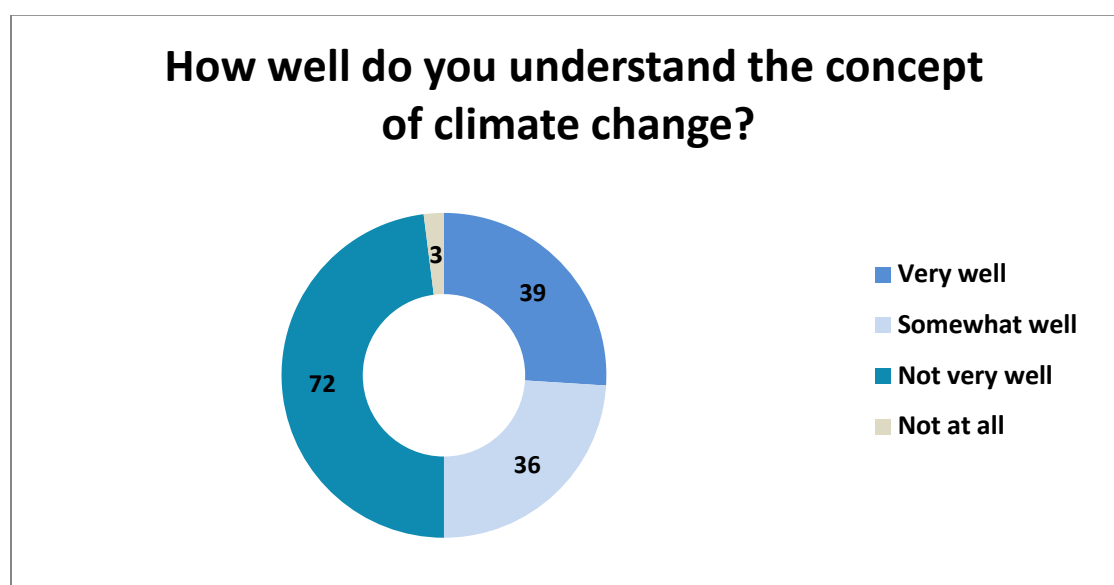


Figure 7: The Respondents' Level of Understanding of the Concept of Climate Change

The church in Aiyetoro emerged as the residents' primary source of knowledge on climate change, with the media, through Television, Radio, and newspapers, following closely behind, while schools and NGOs trail as the institutions through which the respondents first learned of the concept of climate change as shown in Figure 8 below. In a follow-up question, only 15 respondents had received formal training or education on climate change, with the rest learning about climate change informally.

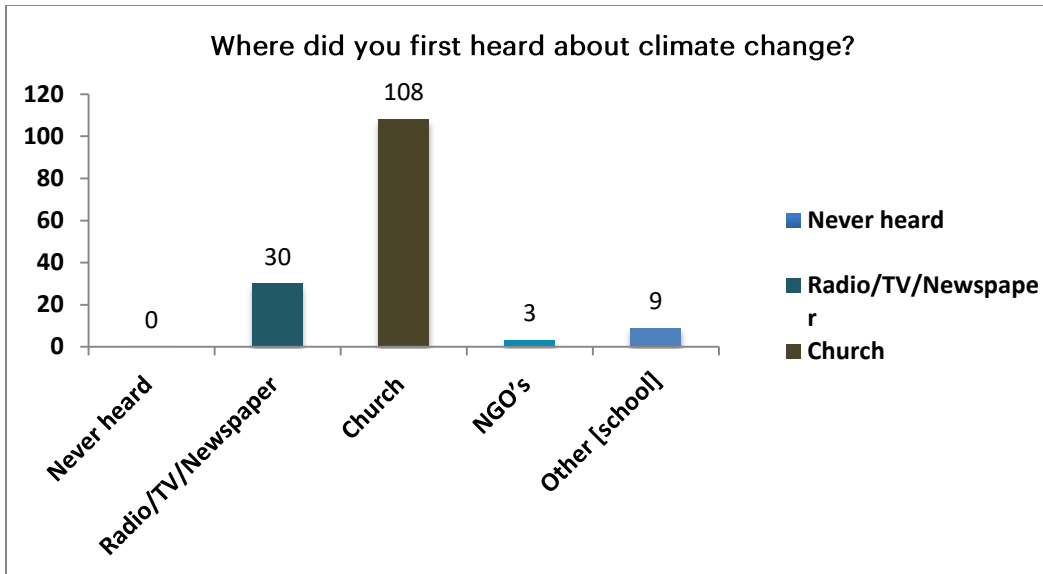


Figure 8: Sources of Knowledge on Climate Change

It was interesting to note that while the community does not fully understand the concept of climate change, the effects of the concept have been observed and experienced universally by all the respondents. Specifically, 130 of the 150 respondents reported that despite not comprehending the concept entirely, they were aware of climate change and its potential impacts on their community. Similarly, all respondents had witnessed and experienced these effects personally, as demonstrated in Figures 9 and 10 below.

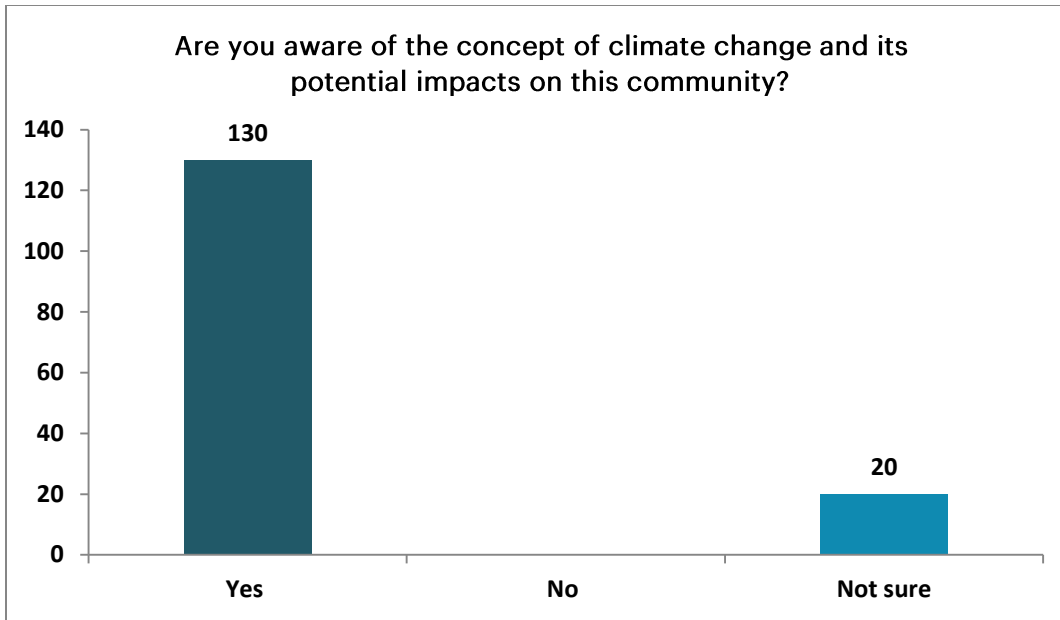


Figure 9: Respondents’ Awareness of Climate Change and its Potential Impacts on their Community

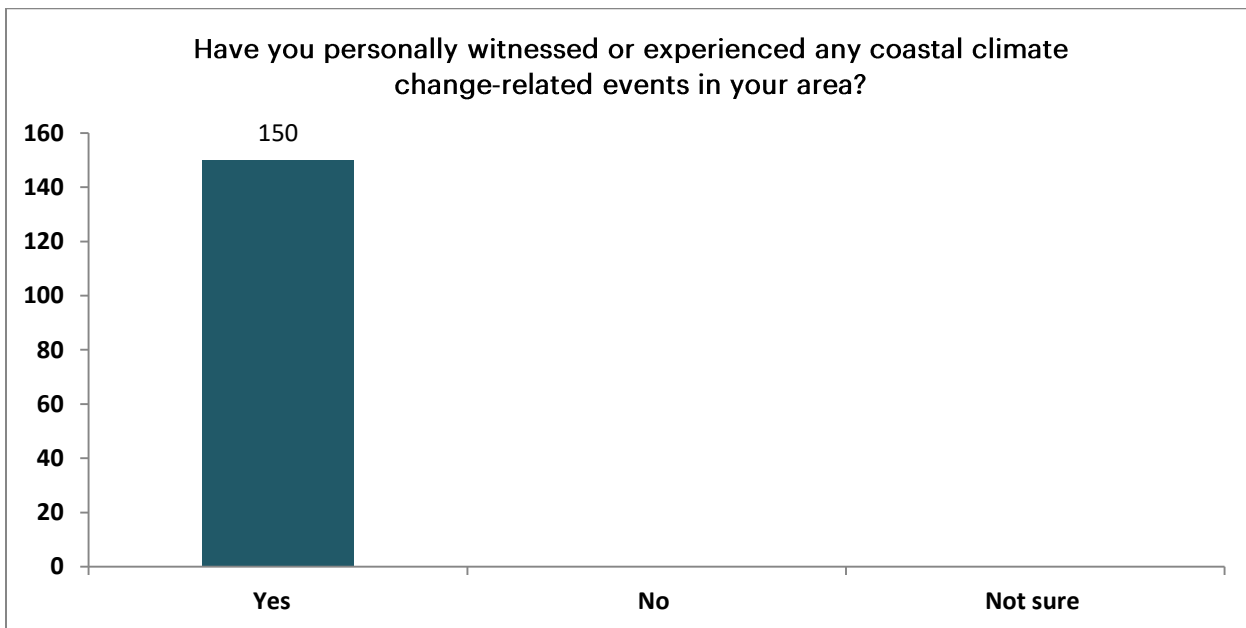


Figure 10: Respondents’ Witness to or Personal Experience of Climate Change-Related Events in Aiyetoro

While all respondents had witnessed or experienced the effects of climate change, some specific effects were experienced universally, while others were rarely experienced. All respondents reported observing the water levels in the Atlantic Ocean rising and eroding their coastal land and experiencing extreme weather events such as storms and hurricanes. One hundred twenty-six (126) respondents reported experiencing rising temperatures, while 129 reported experiencing or observing ocean acidification. However, only three respondents reported having witnessed deaths related to climate change, as shown in Figure 11 below. Rising sea levels were the most visible of all the identified effects of climate change, as shown in Figure 12 below. However, temperature changes are equally palpable since, when further asked to share their perception of the area, 145 respondents stated that temperatures had risen while five noted drops, as shown in Figure 13 below.

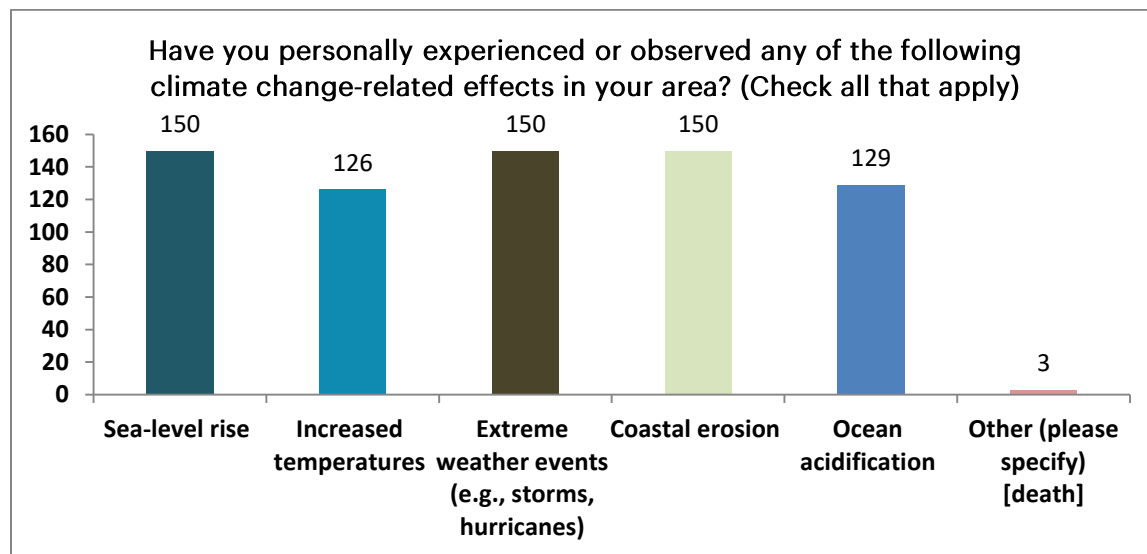


Figure 11: Climate-Change-Related Events Experienced by the Residents of Aiyetoro

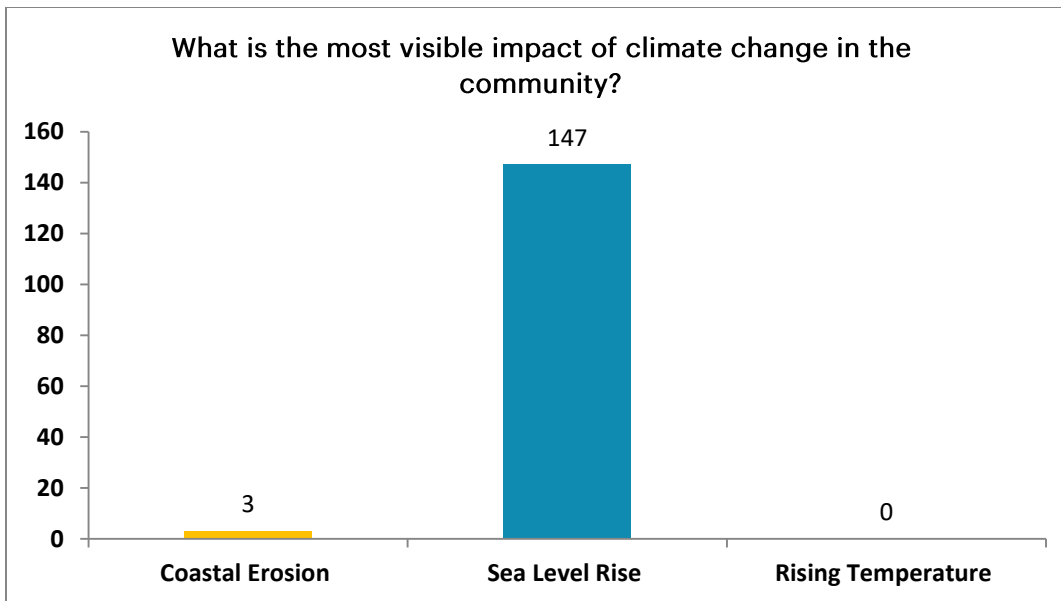


Figure 12: The Visibility of the Effects of Climate Change in the Community

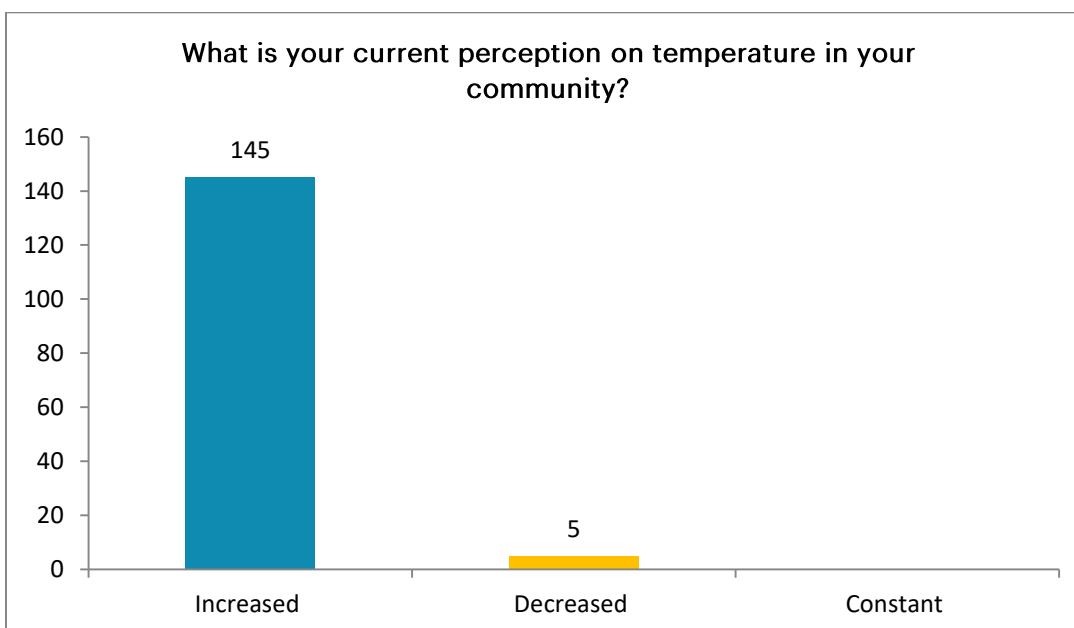


Figure 13: Perception of Temperature in the Community

Climate change has affected the livelihoods of the inhabitants of Aiyetoro, prompting them to adopt various coping strategies. 147 of the 150 respondents have all had to change their livelihood activities, with three not changing their lifestyle to cope with climate change. Similarly, most workers rated climate change's overall impact on their

livelihood as severe. The most common ways that the livelihoods of the respondents have been affected include reduced fishing yields, increased health risks, displacement or the loss of housing, and rising cost of living, with a few respondents reporting less common effects such as the loss of agricultural productivity and the disruption of their everyday lives as shown in Figure 14 below.

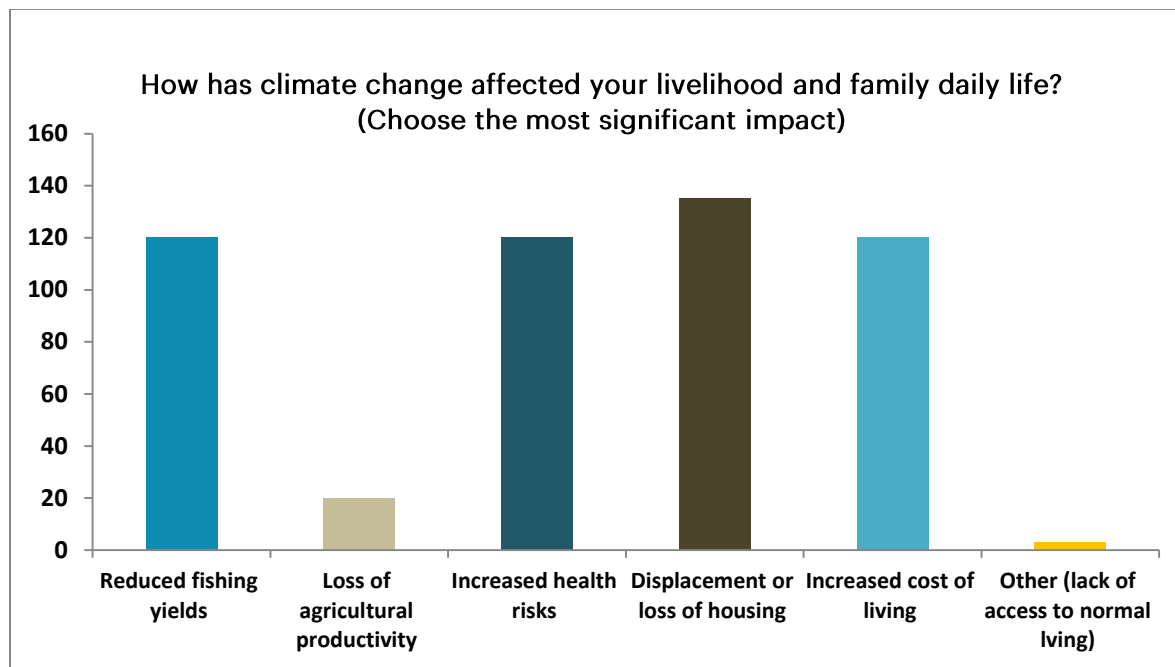


Figure 14: Effects of Climate Change on Livelihoods and Daily Life

While these effects are universal, some are unique to women. These include increased caregiving responsibilities, limited access to climate information, gender-based disparities in decision-making, insufficient resources for climate-resilient activities, and others, as listed in Figure 15 below.

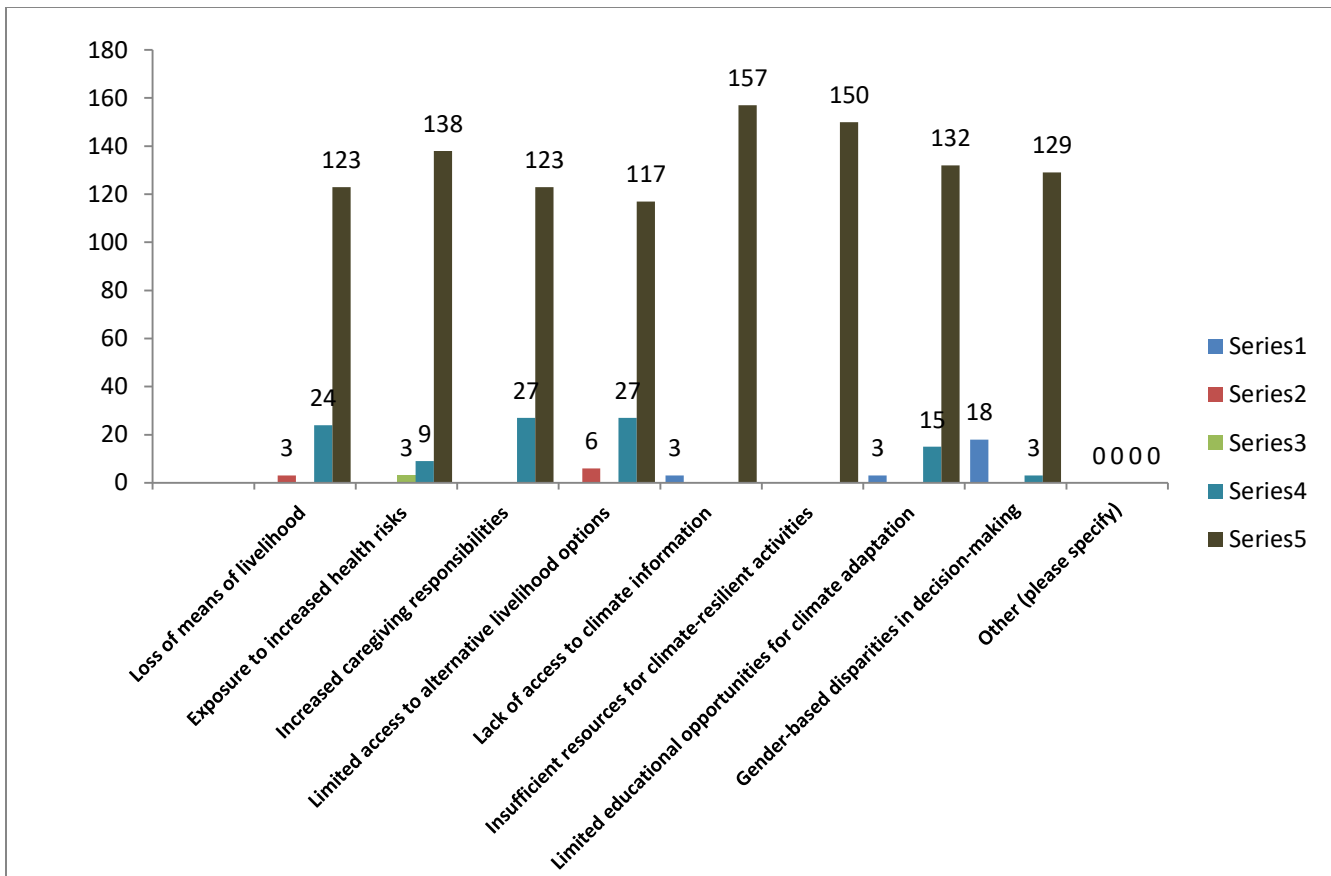


Figure 15: Challenges Faced by Coastal Women in Adapting to Climate Change

The women in Aiyetoro have adopted various measures to counter the above challenges. These include diversifying their sources of income, relocating to less vulnerable areas, community-based adaptation initiatives, and early warning systems and disaster preparedness. However, none of the respondents reported receiving government help to cope with the effects of climate change, as shown in Figure 16 below. Besides, none of the coping strategies are gender-specific. Nevertheless, the identified strategies have been highly effective in addressing the effects of climate change, according to 120 of the 150 respondents, despite the lack of support by the Nigerian government or NGOs, as demonstrated in Figure 17.

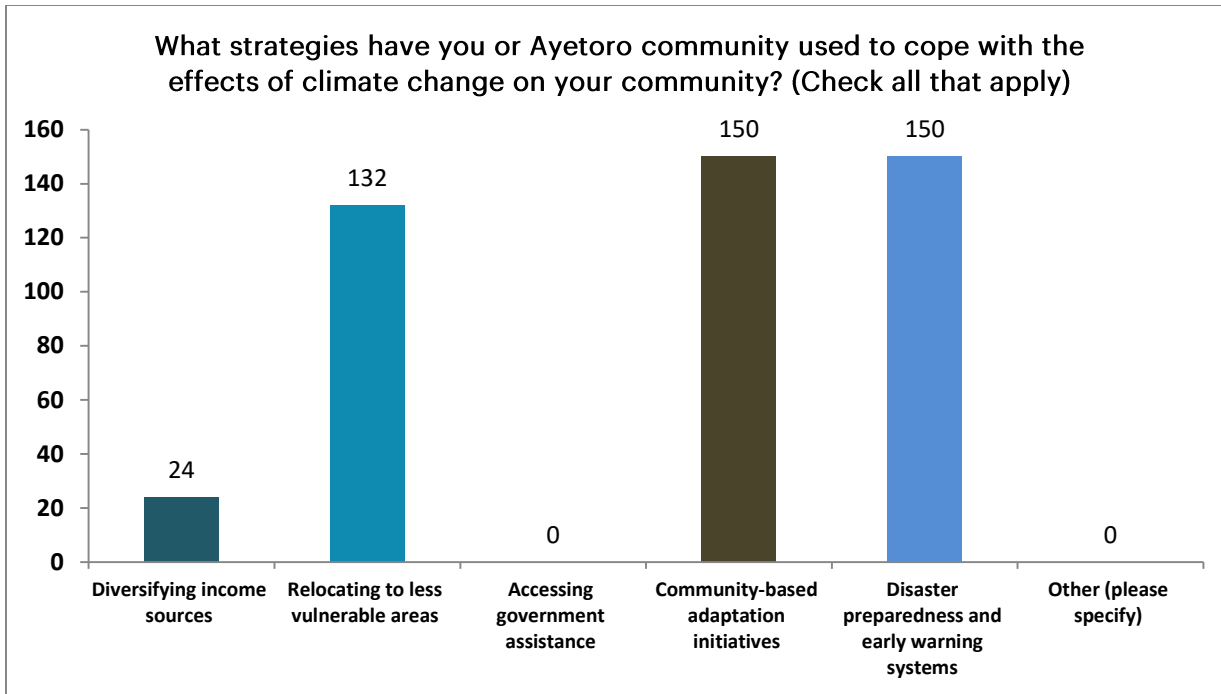


Figure 16: Coping Strategies Adopted in Aiyetoro

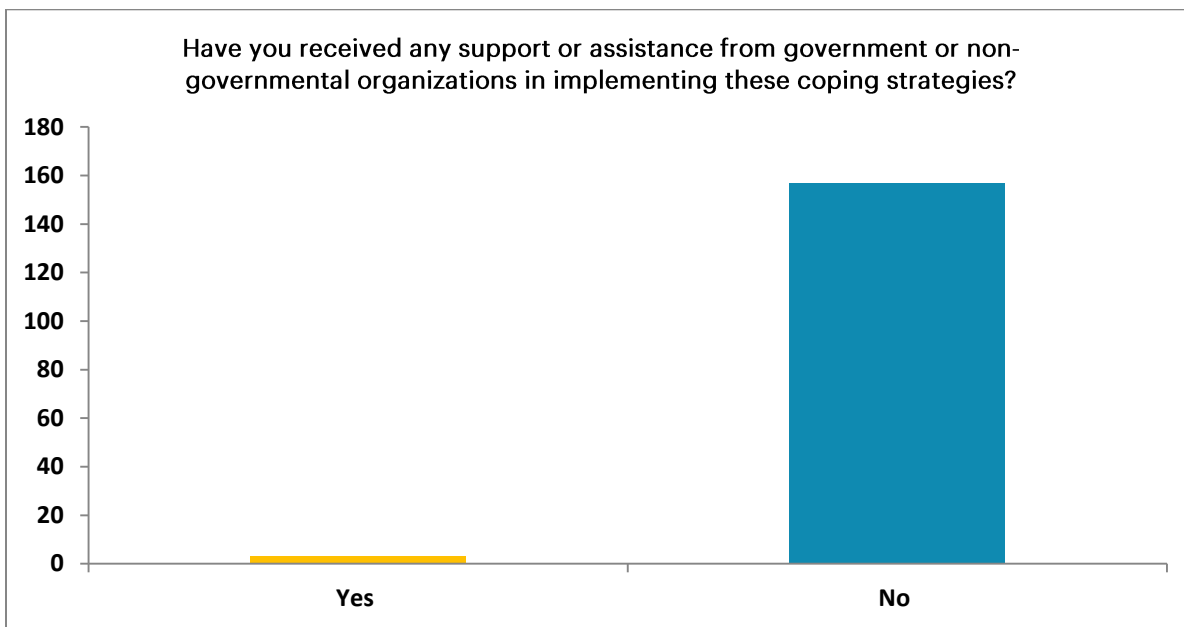


Figure 17: Government and NGO Support in the Implementation of Coping Strategies

Finally, while the strategies are effective in addressing the impacts of climate change, the women in Aiyetoro report experiencing extreme stress and anxiety. Some of the coping

mechanisms they have adopted in response to distress from the effects of climate change include talking to friends and family, engaging in climate change and activism, participating in community resilience programs, seeking professional help or counseling, religion, and practicing mindfulness or meditation as shown in Figure 18 below. These mechanisms have proven effective for most respondents, as demonstrated in Figure 19 below.

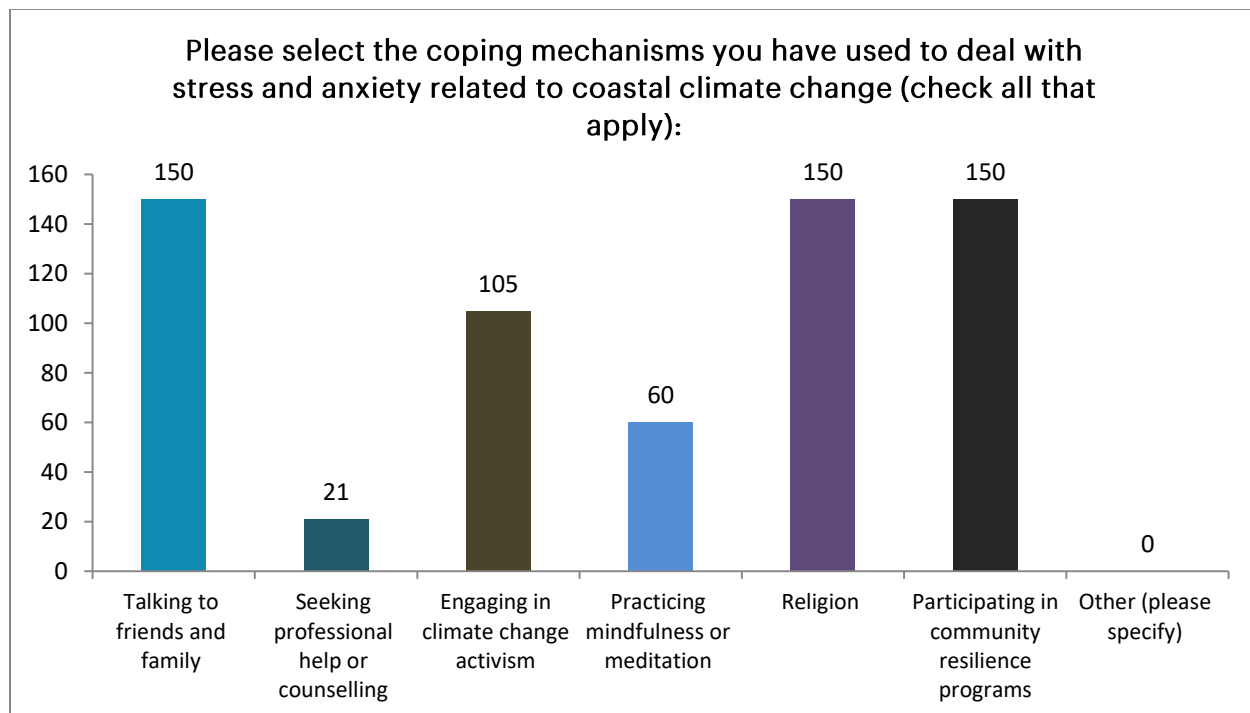


Figure 18: Coping Mechanisms Used to Deal with Stress and Anxiety Related to Coastal Climate Change

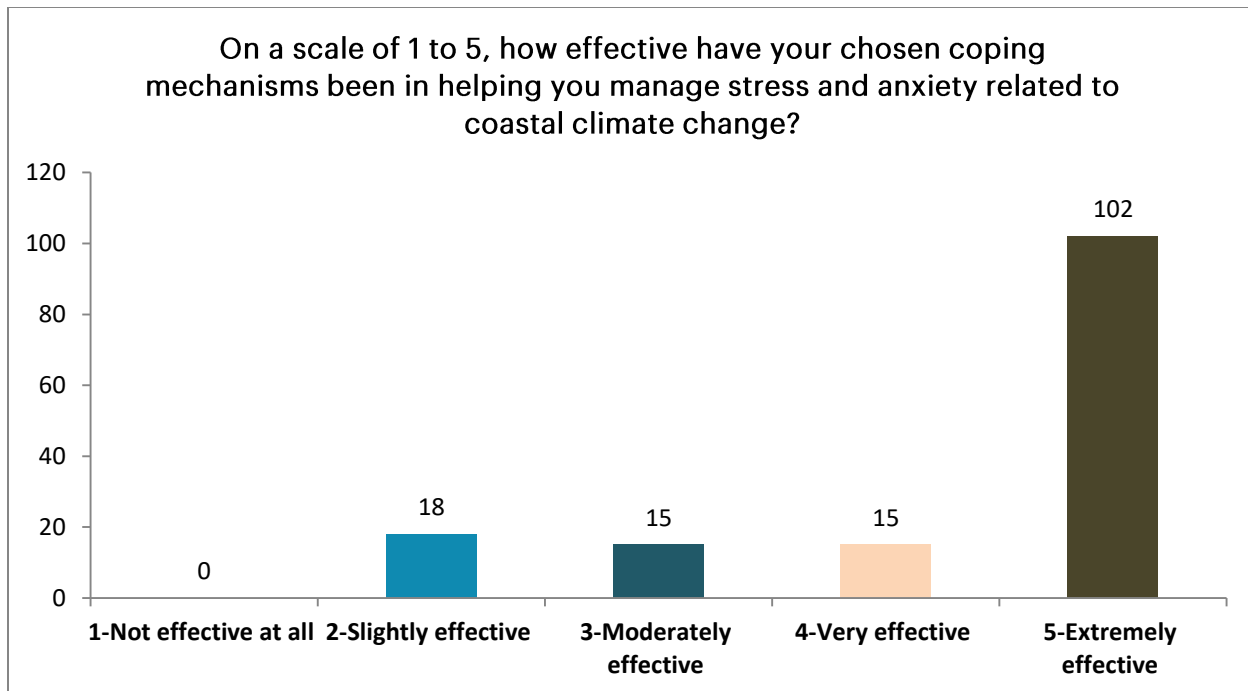


Figure 19: The Effectiveness of Coping Mechanisms Used to Manage Stress and Anxiety

DISCUSSION

The current study confirmed the disproportional burden women in coastal communities bear in experiencing and dealing with the effects of climate change. Some unique impacts of climate change on women's lives in Aiyetoro include increased caregiving responsibilities, which stem from deeply entrenched gender roles in Nigeria that leave caregiving solely in the hands of women (Allotey *et al.*, 2022). While women in Aiyetoro are burdened with the role of taking care of their families and community, their input in decision-making is limited, as evident in the reported gender-based disparities in their involvement in efforts to address the effects of climate change. Their limited input in such crucial decisions, in turn, yields community interventions that do not consider women's needs. This is reflected in both formal and informal policies in response to

climate change, which relies on gendered assumptions and has prompted calls for gender mainstreaming in issues related to climate change and environmental sustainability (Rainard *et al.*, 2023).

Consequently, women are further disenfranchised, particularly since their access to resources and information is also limited, as are the opportunities available to organize, lead, and participate in climate action initiatives. Women in Nigeria, for instance, are the most disempowered and food-insecure population group in the country, with a level empowerment rate of 11.78% compared to an average national rate of 21.63% (Ashagidigbi *et al.*, 2022). The dwindling water resources and reduced output from integral economic activities such as fishing, agriculture, and tourism compound the disempowerment of the women in Aiyetoro, not only threatening their ability to survive and take care of their families but also impairing their health and well-being while reducing their ability to take advantage of coping mechanisms such as diversifying income resources, which required a level of adaptability that the women lack or seeking professional help of counseling, which requires financial input. Instead, the women have resorted to coping mechanisms that do not require financial input, including talking to friends and family and seeking refuge in religion. Further, women are gradually rising to participate and contribute to community programs seeking to address the effects of climate change, as evidenced by their participation in climate change activism and community resilience programs. However, the barriers to their participation must be addressed for these strategies to be effective. Current barriers identified in the study include limited education and access to information on climate change and its effects, limited assistance from the government or NGOs in the development and implementation of strategies to deal or cope with the effects of climate change, a disproportional burden of caregiving, and insufficient resources for climate-resilient activities. Addressing these challenges will ultimately enhance the women's

understanding of climate change, ability to cope with its effects, and contribution to efforts to mitigate the effects of climate change and enhance Aiyetoro's resilience against them.

CONCLUSION

Women in Aiyetoro are vulnerable to the impacts of climate change, which have affected their sources of income, such as fishing, tourism, and agriculture, compounding their limited access to information, resources, and opportunities for education on climate change and the actions they can take to mitigate or cope with its effects. The findings of this study provide essential insights into the challenges faced by women from coastal communities in Southwest Nigeria and inform the development of strategies to help these communities adapt to the changing climate. By examining the experiences of coastal women in Aiyetoro, we identified the specific challenges women face in coastal communities, which include stress and anxiety, physical health impairments, an increased burden in their role as caregivers, and dwindling resources that limit the women's sources of income. Limited education opportunities, information, and support from the government and NGOs emerge as key impediments to women's participation in mitigating climate change and enhancing their community's resilience against climate change. The impediments present an opportunity to inform strategies to address most of the challenges facing women in Aiyetoro through education, access to information, and general empowerment to increase their participation and contribution to addressing climate change and its effects on their community and land.

RECOMMENDATIONS

The study's findings provide essential insight into the challenges faced by women from coastal communities, contributing the following recommendations to address these challenges and build more resilient communities in the wake of climate change. First, the lack of information and limited education on climate change and its effects are the leading inhibitors of women's participation and involvement in the restoration of their community and influence their ability to cope with the effects of climate change. Community education and awareness programs will bridge the gap in women's education and harness their economic and social participation in restoring their community's resilience against climate change while allowing them to adopt effective coping mechanisms such as participation in community resilience programs, diversifying income sources, and disaster preparedness. This involves practical steps such as providing access to up-to-date scientific data and research and using the institutions through which the community derives information, such as religious institutions and schools. Second, one of the problems cited universally by the respondents is the lack of government support in addressing climate change in the community. The provision of funding for climate change adaptation projects by the government or NGOs is a viable actionable plan that will equip the women in Aiyetoro with the resources they need to participate in awareness programs, run adaptation projects, and improve the community's infrastructure to enhance its resilience against extreme weather conditions and other effects of climate change. The government can boost the community's ability to address the effects of climate change further by establishing policies and enforcing regulations that secure women's place in the fight against climate change.

CONCLUSIONS AND FUTURE PERSPECTIVES

This review highlights the significance of microbial enzymes in PLA degradation. An optimal PLA degradation process should focus on enzymatic degradation, especially under alkaline conditions, and consider factors like pH, temperature, and the influence of other materials. This process offers a sustainable and environmentally friendly approach to managing PLA end-of-life products and contributes to reducing plastic pollution. Given the limited literature on the use of microbial enzymes, there is a need for ongoing research in this area. Therefore, researchers should conduct in-depth studies to further optimize and expand the use of microbial enzymes for PLA degradation. Promoting collaboration between researchers from different fields, including biology, materials science, and engineering, to tackle the subject's complexity and find innovative solutions for plastic pollution will be a good approach.

It is recommended that researchers and industry should continue exploring microbial enzymes' potential for PLA degradation. Enzymes like proteinase K, Savinase, and Alcalase have efficiently broken down PLA and should be further investigated. There is a need to conduct systematic and well-optimized experiments to understand better the most effective processes and conditions for microbial enzymatic PLA degradation. This includes investigating optimal pH levels, temperature ranges, and reaction times. We should also consider the impact of environmental factors on enzymatic degradation. For example, cellulose nanocrystals have been shown to influence the degradation of PLA positively. Understanding these factors can lead to more efficient degradation processes. Investigating genetic modification techniques that can enhance the enzymatic activity of microbial enzymes will prove beneficial. This approach could make enzymatic degradation even more efficient. Policymakers should consider supporting research and development efforts focused on bioplastics and environmentally friendly degradation methods. This can include funding for research and incentives for industries to adopt sustainable practices. Industries should explore and implement efficient recycling methods for PLA. Microbial enzymatic degradation can play a significant role in the recycling of PLA products.

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DATA AVAILABILITY STATEMENT

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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