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Research Article

Awareness on Climate Change Adaptation Options About the Mangrove Ecosystem Conservation: A Case Study of Chwaka Bay

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Abstract

This study aimed to evaluate people's awareness of climate change adaptation options for mangrove ecosystem conservation in villages around Chwaka Bay in Unguja Zanzibar. The study involved 278 participants from Chwaka, Michamvi, and Ukongoroni, with data collected through questionnaires and semi-structured interviews. The data was analyzed using SPSS software and descriptive statistics, and visual representations were created using Microsoft Excel. The findings show that great proportions of the area's residents are aware of ecosystem-based adaptation since they identified it as the catalyst for local adaptation. The adaptation options that were practiced are reforestation, the construction of protective walls, raising public awareness among the government, committee, and community members, and protecting any barriers surrounding the mangrove ecosystem. They also make use of alternative energy sources, building materials, diversifying their rural livelihoods, and migrating, all of which have a positive effect on the mangrove ecosystem conservation. This study uses a binary logistic model, whereby the odds ratio (B) is > 1 which means that the event is more likely to occur, and when the odds ratio is < 1, depicting that the event is less likely to occur. Following the binary logistic model shows that the locals are aware of the adaptation strategies utilized in mangrove conservation. Alternative energy sources, on the other hand, received a B value of 0.4, indicating that the majority of people choose to use the mangroves' resources over other alternative energy sources. Migration to neighboring cities, it has a 0.5 times lower impact on the mangrove ecology than when they choose to extend their community within Chwaka Bay. This is because moving to a different city prevents people from advancing on the mangrove forest to build homes, protecting the mangrove trees from being cut down for building sites. The study recommends the government allocate funds for mangrove forest conservation, including tree planting, barrier construction, and plant information dissemination.

Keywords: Mangrove Ecosystem Conservation; Adaptation Options; Awareness of the People

Introduction

Mangrove forests are attractive intertidal communities in tropical and subtropical areas, with unique features like breathing roots, stem-supporting structures, and salt-excreting leaves [4]. Eight species, including Sonneratia alba, Rhizophora mucronata, Brugiera gymnorrhiza, Avicenna marina, and Lumnitzera racemosa, are found in East Africa's coastal regions [4]. Mangroves cover 150,000 km^2 globally, with Tanzania's coastline covering 1355 km^2. In Unguja Island, they develop in estuaries and protected bays like Makoba, Chwaka, and Menai [10]. Other mangrove swamps occur in Maruhubi, Tumbatu, Nyamanzi, Makoba Bay, Chukwani, Pete, Unguja-Ukuu, Uzi, Fumba, and Kisakasaka. However, most of the east coast is high-energy, unsuitable for mangrove swamp formation [17]. Mangroves in Chwaka Bay offer economic, ecological, and environmental benefits to local and national economies [18]. People from various villages rely on mangrove resources for construction and fishing, with Ukongoroni and Charawe villages providing 15% of mangrove poles used in Zanzibar town [9]. Mangrove cutting for firewood and charcoal production has degraded forests in Chwaka Bay. Mangrove poles are used for beds, seaweed farming, and herbal medicine manufacturing [16]. Mangroves also provide livelihoods like fishing and beekeeping, as they provide breeding grounds for marine organisms like Chanos and crabs [19]. Mangroves, crucial for coastal protection, fish and wildlife habitats, sediment and pollution filtering, and carbon sequestration, have experienced a significant population reduction in recent decades [6]. Climate change also enhances the effects additional to direct human pressures [21]. For example, in Unguja, there is a loss of natural forests (including mangroves of about 10 km^2 annually) which is depicted by a significant decline in the mangrove forest of Zanzibar by a total of 19,748 ha, with 58.29 km^2 in Unguja and 139.19 km^2 in Pemba hectares [10]. However, It had been reported that the mangrove growing stock in Unguja Island has declined drastically with 18.9 m^3/ha, this is which then the

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double decline of the decline (of 41.0 m^3/ha) recorded in the previous inventory of 1992/1993 [10]. In Pemba Island, however, the mangrove growing stock decline per hectare is noticeably small (39.8 m^3/ha to 38.3 m^3/ha hectares) [10]. Mangroves are impacted by climate change in ways such as variations in temperature, precipitation, sea level, and atmospheric CO_2 concentration. Among these factors, sea level rise may be comparatively more significant [7]. One of the most significant effects of global warming is expected to be an increase in sea level of 12 to 22 cm throughout the 20th century [12]. Over the decades that follow, several climate models predict an increased rate of rise [7]. According to Grimsted et al. (2010), there is a range of forecasts for the rise in global sea level from 1980 to 1999 to the end of the 21st century (2090–2099) of 0.18–0.59 m. Three factors have been identified as contributing to the mangrove ecosystem's vulnerability to the effects of climate change: exposure to stresses, sensitivity to those stresses, and related adaptation capability [15]. Since mangrove ecosystems are more susceptible to the effects of climate change, vulnerability assessment takes into account a wide range of parameters to provide a quantitative and qualitative understanding of the processes and outcomes of vulnerability [1].

Applied to intertidal mangrove ecosystems, vulnerability assessment can enhance planning for climate change adaptation [6]. Adaptation to the effects of climate change is required since mangrove habitats are more susceptible to its effects. Adjusting behaviors, procedures, and organizational frameworks to mitigate possible harm or take advantage of climate-related possibilities is part of adapting to the effects of climate change [2]. Due to the effects of climate change components such as coastal erosion, many communities worldwide are implementing adaptation strategies to lessen the mangrove ecosystem's vulnerabilities and increase its resistance to the effects of climate change [2]. For instance, in Zanzibar, various adaption strategies are used, including: Removal of non-climate stresses on mangroves such as deforestation and pollution is done around the areas of Chwaka Bay and Menai Bay [10]. Establishment of mangroves protected at Jozani-Chwaka Bay and Menai Bay [10], restoration of mangroves in areas where mangrove habitats previously existed. Provision of education and outreach programs that inform the community about the value of mangroves and other ecosystems. These include awareness and education to fisheries and the community in general on the importance of mangrove forests at has been provided to the people at Kisakasaka [17 and villages surrounding the Chwaka Bay [9]. Diversification of livelihood activities is practiced example, the introduction of seaweed farming as an alternative livelihood activity at Kisakasaka [17].

Although the majority of research on particular adaptation strategies and initiatives argues that there will probably be obstacles as well as constraints to adaptation in response to climate change [3], The extent and speed of climate change may be one source of certain constraints, while institutional, financial, technological, cultural, and cognitive impediments may be the cause of others. Certain restrictions are likely to have an impact on adaption strategies because of their ecological and physical origins.

One country is more vulnerable to the effects of climate change than another since different locations, countries, sectors, and people have different capacities for adaptation and different procedures for achieving it, as a result, the alternatives for adaptation can differ depending on the country [2]. Due to the aforementioned facts about the constraints and obstacles that adaptation options must overcome to address the effects of climate change and little research in Zanzibar on the Awareness of People on climate change adaptation options on Mangroves necessitate the assessment of people's awareness of the options for reducing the destruction of mangrove ecosystems to properly use and manage mangrove forests for sustainable development and ecosystem integrity.

Methodology

Research Design

To address the objectives of the research, a mixed methods design comprising both qualitative which has used Open-ended questions to gain information on objective number one and has enabled researchers to gain more understanding of the awareness of the people on climate variability that influences climate change since open-ended questions allow respondents to include more information and feelings relating to the research problem. And quantitative techniques were employed to gather quantitative data on ecosystem-based adaptations to mangroves through semi-structured interviews and field observation. Key informants shared their experiences and attitudes.

Study Areas

The study was conducted on Unguja Island in Zanzibar, focusing on the villages of Chwaka, Michamvi, and Ukongoroni around Chwaka Bay, a dense mangrove forest. The area was chosen due to its vulnerability to climate change impacts and potential representative data, suggesting government awareness towards effective adaptation options.

Population of the Study Areas

According to the National Bureau of Statistics (web) estimate the Central Unguja districts have a population of about 76346 (Census Report, 2012), whereby the selected villages surrounding the Chwaka Bay like Chwaka has a population of 3196, Michamvi 1572, and Ukongoroni 896 (Census Report, 2012).

Data Analysis and Presentation

This study collected qualitative and quantitative data for analysis using SPSS software version 20 to assess local people's awareness of adaptation options in mangrove conservation. Descriptive statistics were used for qualitative data analysis, and figures were drawn using Microsoft Excel.

Results and Discussion

Local People's Awareness on Climate Change and its Variability

Over the past ten years, respondents were asked if they had ever observed any changes in the weather, climate, or environmental trends. According to Figure 2, about 80% of the people who live near Chwaka Bay in the Michamvi, Chwaka, and Ukongoroni areas reported seeing changes in the weather, climate, and environmental patterns over the previous ten years, whereas 19.78% did not. This demonstrates how the mangrove ecosystem is vulnerable to damage due to changes in climate variability.

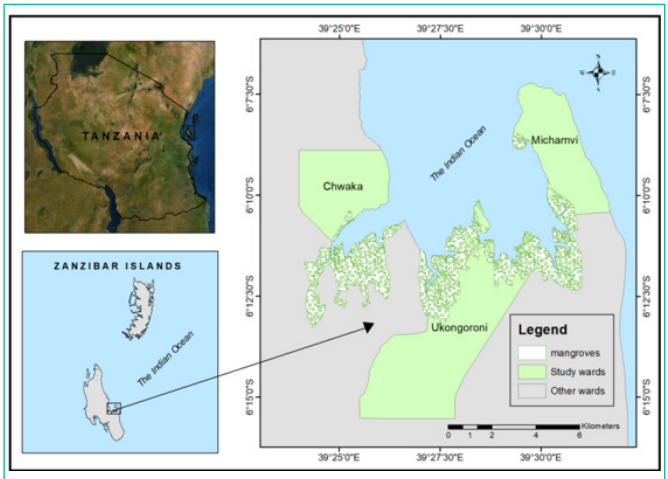

Figure 1: Study Areas.

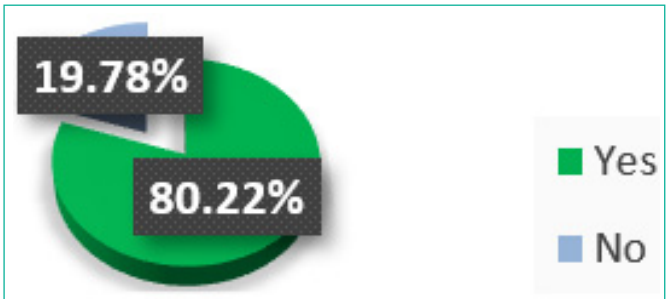

Figure 2: Local People's Awareness on Climate Change and its Variability.

The Community's Reaction to the Preservation of the Mangrove Environment and Ecosystem-Based Adaptation

According to the data in Table 2, the majority of the study area's residents are aware of ecosystem-based adaptation since they identified it as the catalyst for local adaptation. The majority of locals said that the government doesn't take adequate responsibility when it comes to planting new mangrove trees. This can be the result of the government's heavy workload and possible poor oversight of these efforts. The mangrove ecology is harmed by the current lack of planting of mangrove trees. However, the majority of locals have indicated that planting new mangrove plants is a regular activity in the neighborhood. This can be a result of the locals' proximity to the mangrove areas and the ability to see the reforestation's advancement. It appears like a good approach to aid in the recovery of the mangrove ecosystem, and they are more qualified to accomplish this task than the government. The majority of locals have noted that the committees in charge of maintaining the mangroves are not concentrating on planting new mangrove plants. This implies that the local community is handling this work instead of these organizations or the government since they are more qualified to handle it. Since the community planted the trees themselves, they also feel a feeling of ownership. In addition to raising awareness and educating one another about the importance of protecting mangroves, this may make it more difficult for them to remove the trees they have laboriously planted. Hence, it appears that these organizations may not have much success reforesting the mangrove region. Furthermore, the researcher noted that the community, committee, and government all reforest mangroves around Chwaka Bay, which positively impacts the mangrove ecosystem. Ellison (2000) noted that mangrove restoration is another

Table 1: Required Sample Size for each Study Site.

Study site	Population Size of the area (Census,2012)	Number of questionnaires that can be collected
Chwaka	3196	96
Michamvi	1572	92
Ukongoroni	896	90
Total number of people from the selected study site		278

Table 2: The Responsible Group for the Reforestation of Mangroves in Chwaka Bay.

Adaptation options	Responses	Number of residences	Percentage of residences %
Reforestation of mangroves by the government	No	164	59.0
	Yes	114	41.0
Reforestation of mangroves by the community	No	122	43.9
	Yes	156	56.1
Reforestation of mangroves by committee	No	161	57.9
	Yes	117	42.1

option for adaptation. Large-scale mangrove tree restoration is one of the goals of community restoration initiatives. Restoring these areas could also lessen the strain on nearby mangrove ecosystems and assist local populations in establishing sustainable means of subsistence. Furthermore, statistics point to a clear relationship between having a range of mangrove restoration aims and planting a variety of species to reforest an area.

The majority of residents in the study areas stated that neither the local government nor the community takes much initiative in building protective barriers, according to the analysis of results in Table 3. There might be several causes for this. The government may not be paying close attention to this issue because they are handling a lot of large projects and financial issues. On the community side, financial difficulties and a lack of enthusiasm may prevent them from performing this role effectively. Furthermore, the majority of locals stated that the committees responsible for maintaining the mangroves are frequently the ones building barriers to keep the mangrove forest safe. This can be a result of these organizations' expertise in garnering funds for wall construction. They receive funding from a variety of sources, including donations, trade, and revenue-generating endeavors. Because these groups can distribute jobs among themselves with ease, they are also good at ensuring that the work is completed on schedule. Building these walls is a very effective way to protect the mangrove ecology by preventing excessive tree-cutting.

Table 3: The Responsible Group for Building Protected Walls of the Mangrove Forest in Chwaka Bay.

Adaptation Options	Responses	Number of residents	Percentage of residents %
Building protected walls by the government	No	151	54.3
	Yes	127	45.7
Building protected walls by community	No	140	50.4
	Yes	138	49.6
Building protected walls by committee	No	118	42.4
	Yes	160	57.6

Table 4: The Responsible Group for Increasing Awareness of the Importance of the Mangrove Ecosystem in Chwaka Bay.

Adaptation Options	Responses	Number of residents	Percentage of residents %
Increase awareness of the importance of the mangrove ecosystem by the government	No	141	50.7
	Yes	137	49.3
Increase awareness of the importance of the mangrove ecosystem by the community	No	153	55
	Yes	125	45
Increase awareness of the importance of the mangrove ecosystem by committee	No	116	41.7
	Yes	162	58.3

Table 5: The Adaptation Options Practiced in Chwaka Bay.

Adaptation Options	Responses	Number of residents	Percentage of residents %
Use alternative sources of energy	No	1	0.4
	Yes	277	99.6
Use alternative materials for building.	Yes	278	100
Diversification of rural livelihood	Yes	278	100
Migration	No	1	0.4
	Yes	277	99.6

Table 6: The Responsible Group for Removing a Barrier to Restore Natural Tidal Flow in Chwaka Bay.

Adaptation Options	Responses	Number of residents	Percentage of residents %
Removing barriers to restore natural tidal flow by the government	No	141	50.7
	Yes	137	49.3
Removing barriers to restore natural tidal flow by the community	No	150	54
	Yes	128	46
Removing barriers to restore natural tidal flow by mangrove committee	No	131	47.1
	Yes	147	52.9

According to Table 4's results, 58.3% of respondents claimed that the mangrove environment committee was the one that first raised awareness of the ecosystem's significance, 49.3% said the government was the one who did so, and 45.0% said the community as a whole. This demonstrates that although the people in the studied areas are aware of the significance of the mangrove ecosystem, the mangrove ecosystem committee is more important in spreading awareness of the need to conserve mangrove forests because of its larger role in the mangrove ecosystem than the government and the community at large. Additionally, the researcher reports that the government, committee, and community near Chwaka Bay all offer information about the mangrove ecology, which has been shown to have favorable effects on the ecosystem [7].

Community support for adaptation initiatives can be strengthened through outreach and education initiatives. This is because the importance of protecting wetlands is frequently undervalued, particularly in developing nations with rapid population growth and significant development pressure, where short-term financial gains from actions that negatively impact wetlands are frequently prioritized over the intangible long-term benefits that come from using wetlands sustainably. By creating a more informed community, education and outreach initiatives aim to influence attitudes and behavior, recognizing the importance of ecosystems such as mangroves. Moreover, Macintosh et al. (2012) provide support for the idea that educating the public about the importance of mangroves aids in the local community's ability to make more informed decisions about how to use its resources, which in turn fortifies political will and wins public support for laws intended to preserve and manage mangroves sustainably.

According to the results presented in Table 8 above, 52.9% of respondents in the study areas claimed that the mangrove committee itself was the one who first proposed the adaptation option to remove the barrier and restore natural tidal flow, 49.3% claimed that the community was responsible, and only 49.3% claimed that the government was responsible. This has demonstrated that the community and government are less successful than mangrove ecosystem committees at protecting mangrove forests, which improves mangrove ecosystem management. As a result, to preserve the mangrove ecosystem, managers of the mangrove ecosystem should keep offering adequate information about the significance of this adaptation method.

Many residents of Ukongoroni, Chwaka, and Michamvi villages around Chwaka Bay indicated in table 5 below, show that they are taking action to save the mangrove trees from damage brought on by climate change and other human-caused stresses. They are diversifying their rural livelihoods, employing alternative energy sources, building with alternative materials, and occasionally even relocating to safer locations. This could be beneficial in protecting the mangrove plants, particularly from issues brought on by people. By giving the trees more space and time to develop healthily and maintain their natural form, these activities can lessen the effects of climate change. Their astute decisions could play a significant role in protecting the mangrove environment from being damaged. Additionally, the researcher found that the people living in Chwaka Bay diversify their rural livelihoods, which benefits the mangrove ecosystem. This is corroborated by the findings of other scholars, including Pramova et al. (2012), who noted that alternative livelihoods, like producing charcoal from coconut shells rather than mangroves and harvesting honey in mangroves, tend to support agroforestry and the preservation of existing mangrove forests.

Conclusion

The study explores locals' perceptions of climate change and their knowledge of adaptation strategies to mitigate mangrove ecosystem degradation in the Chwaka Bay region.

Climate change is perceived to reduce coastal protection, flood control, honey production, fish spawning, and air conditioning shading, impacting mangrove-dependent communities' livelihoods. These include increased demands for firewood, charcoal, aquaculture, beekeeping, and village expansion. The most significant adaptation strategies mentioned was the locals' reliance on the mangrove ecosystem, their changing of occupation, their diversification of livelihoods, the government's reforestation of mangroves, raising public awareness of the ecosystem's significance, removing barriers to restore the natural tidal flow, using alternative energy sources, and moving to other areas. Ecosystem-based adaptation depending only on the mangrove ecosystem may result in the overuse of mangrove resources. Encouraging ecosystem-based adaptation and man-made solutions is crucial for local livelihoods and well-being. Healthy mangrove ecosystems and their services are essential for helping people adapt to environmental changes, despite challenges in determining climate variability's impact.

Soft loans for individual fishermen could boost offshore fishing and reduce coastal fisheries' vulnerability. Long-term climate modeling is needed to understand mangrove impacts.

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