

THE UNITED REPUBLIC OF TANZANIA



MARINE PARKS AND RESERVES UNIT

OPPORTUNITIES AND THREATS FACING CORAL REEFS IN TANZANIA



JULY 2025

THE UNITED REPUBLIC OF TANZANIA



MARINE PARKS AND RESERVES UNIT

OPPORTUNITIES AND
THREATS FACING CORAL REEFS IN TANZANIA

RESEARCH REPORT

JULY 2025

PREPARED BY
DR. ROSE KICHELERI AND
MR. GODFREY NGUPULA



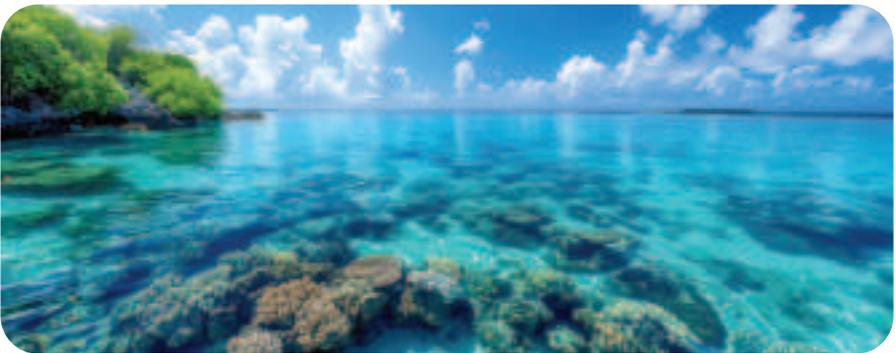
ACKNOWLEDGEMENTS

We sincerely thank all individuals and organizations who contributed to the successful completion of this research on the “Opportunities and Threats Facing Coral Reefs in Tanzania.” This study, conducted across the coastal areas of Mtwara, Lindi, Dar es Salaam, Tanga and the islands of Unguja, and Pemba would not have been possible without their invaluable support. Our deepest appreciation goes to the Marine Parks and Reserves Unit (MPRU) for their generous financial support (through its CRRI – Project), which was essential in funding this comprehensive study, Their dedication to marine conservation in Tanzania is highly commendable and directly made this research possible.

We also extend our sincere thanks to the NGOs and agency experts who participated in this study. Their valuable insights, expertise, and collaborative spirit greatly enhanced the scope and depth of our findings.

Furthermore, we are immensely grateful to the Marine Park officials and dedicated data enumerators in Tanga, Mtwara, Lindi, Dar es Salaam, Unguja, and Pemba. Their exceptional facilitation of data collection, local knowledge, and tireless efforts in the field were crucial in gathering the information needed for this research.

Finally, we are profoundly grateful to the local government authorities and communities across all study regions. Their active participation and willingness to share insights and respond to questions were fundamental to understanding the various opportunities and threats facing Tanzania’s coral reefs. Their contributions have significantly enriched the findings of this research.



EXECUTIVE SUMMARY

Coral reefs are in a decline globally, threatened by a myriad of factors. In Tanzania, little was known about the opportunities and threats facing coral reefs, therefore, this comprehensive study was conducted to examine threats facing coral reefs and the associated opportunities. A cross-sectional study was conducted using the survey, key informant interviews, field observation, and literature review. Both quantitative and qualitative data were collected. Descriptive analysis was conducted for the quantitative data, and content analysis for the qualitative data. Ms Excel software was used for the analysis of both quantitative and qualitative data. Content analysis supplemented the qualitative analysis.

This report highlights both threats and community-related attributes on coral reefs. A profound dependence (83%) of local communities on coral reefs for their livelihoods, with most relying on them for subsistence and income was observed. However, these communities face significant challenges, including limited access to financial services (65% lack credit access) and declining incomes for half the population due to fewer fish, increased competition, and climate change. Despite this, some have seen income growth through improved fishing and market conditions. This underscores the need for interventions that support both sustainable reef management and financial inclusion to build resilient coastal livelihoods.

Major Threats to Coral Reefs include:

- i. **Human activities:** Human activities has been identified as the primary driver of coral reef degradation. Unsustainable fishing practices, including overfishing, destructive methods like drag and seine nets, and metal hook octopus fishing, have significantly increased over the past decade due to higher fish demand;
- ii. **Pollution:** Pollution from domestic waste, sewage, plastics, and agricultural chemicals also poses a serious threat, causing physical damage, bleaching, and reduced coral health;
- iii. **Climate change:** Climate change is a pervasive threat, evidenced by rising ocean temperatures leading to widespread coral bleaching, increased storm intensity, and sea-level rise, causing sedimentation and submerged coastal

areas. Even natural threats like the crown-of-thorns starfish outbreaks are worsened by human impacts on their predators.

- iv. **Declining Fish Stocks and Awareness Gaps:** Fish populations are in decline, with 67% of respondents reporting fewer fish and experts confirming a drop in “catch per unit effort.” This is despite an apparent increase in total catch due to more boats.
- v. **Lack of public awareness:** There’s a significant lack of public awareness regarding political threats to coral reefs, with 40% of respondents unaware. Among those who are aware, insufficient enforcement of regulations is the top concern, followed by outdated legislation and limited public participation.
- vi. **Exclusion in decision making:** Most communities feel excluded from coral reef decision-making processes, lacking feedback on their input. While destructive fishing and unsustainable tourism are significant economic threats. There are opportunities for recovery through promoting sustainable fishing, alternative livelihoods, and eco-tourism. Policies like the Tanzanian National Blue Economy Policy (2024) provide a framework for balancing economic growth with conservation.
- vii. **Technological and Traditional Approaches:** Technology is generally viewed as an opportunity for coral conservation, offering potential for improved monitoring and reduced pressure on reefs, despite concerns about some negative impacts. However, the full scope of technological impacts requires careful consideration.
- viii. **Traditional marine conservation methods:** The traditional marine conservation methods are largely unused today, despite a clear history of effective resource management and spiritual respect for nature. Revitalizing these ancestral practices could significantly bolster modern conservation efforts.

Key opportunities for coral reef conservation include:

- i. Improving fishing methods; through better gear and stricter enforcement against illegal fishing.
- ii. Boosting climate change resilience; through education and coral reef restoration.

- iii. Enhance financial inclusion; with tailored products, community microfinance, and financial literacy.
- iv. Diversify livelihoods; into non-fishing activities like agriculture, small businesses, and ecotourism.
- v. Develop value chains; for sustainable marine products.
- vi. Promoting sustainable fisheries management; such as quotas and marine protected areas (MPAs).
- vii. Investing in sustainable aquaculture; to reduce pressure on wild fish, supporting alternative income sources like marine ecotourism and seaweed farming, developing and implementing eco-friendly fishing methods and responsible aquaculture.
- viii. Empowering local fishers; with knowledge and resources for sustainable practices, creating demand for sustainably sourced seafood through certification and pricing, and Conservation and Environmental Management.
- ix. Regulating of fishing practices; more strictly, focusing on unsustainable and overfishing threats.
- x. Combating pollution; by improving waste management, reducing runoff, and controlling industrial discharges.
- xi. Mitigating climate change impacts; through renewable energy and carbon sequestration.
- xii. Controlling coastal development and tourism; with eco-friendly planning and responsible guidelines.
- xiii. Protecting and restoring; mangroves and seagrasses due to their vital relationship with corals and managing Crown-of-Thorns Starfish outbreaks through targeted research and predator protection.
- xiv. Boosting research; on the impacts of microplastics, oil spills, and agricultural chemicals.
- xv. Implement targeted pollution control programs; for sewage, plastics, and other waste.

- xvi. Enforce stronger environmental regulations; and launch public awareness campaigns.
- xvii. Explore new technologies; for detecting and mitigating marine pollutants. Foster international partnerships for global marine environmental initiatives. Invest in nature-based solutions like restoring corals, mangroves, and seagrasses.
- xviii. Improve research and monitoring to better understand climate impacts and provide early warnings.
- xix. Scale coral reef restoration efforts extensively and establish more MPAs. Governance, Policy & Participation.
- xx. Strengthen governance by building capacity in enforcement agencies and modernizing laws.
- xxi. Boost public engagement through education and awareness campaigns.
- xxii. Enhance community participation in management frameworks, ensuring their voices are heard.
- xxiii. Advocate for environmentally sound development and explore blue economy financing.
- xxiv. Integrate coral reef issues into political agendas and secure commitments from candidates.
- xxv. Seek and allocate more dedicated funding for coral reef conservation.
- xxvi. Strengthen community-based management by empowering groups with resources and decision-making authority. Enhance inclusivity to engage uninvolved community members. Improve feedback mechanisms on how community input is used.
- xxvii. Leverage valuable local ecological knowledge in scientific assessments. Address cultural barriers and promote collective responsibility. Cultivate shared ownership through education and benefit-sharing.
- xxviii. Integrate climate adaptation into development plans and secure funding. Strengthen social cohesion by building trust and collaboration.

- xxix. Advocate for policy reform for more inclusive and effective management.
- xxx. Promote community-based monitoring for effective oversight. Incorporate culturally sensitive educational programs for younger generations. Support community engagement in MPAs, leveraging social structures and leaders.
- xxxi. Economic and Technological Development Tap into sustainable eco-tourism and dive tourism potential. Leverage supportive national policies like the Blue Economy Policy. Utilize access to climate finance for marine conservation. Scale up coral restoration technologies for wider application.
- xxxii. Optimize fisheries management using technologies like Potential Fishing Zones (PFZ).
- xxxiii. Strengthen marine enforcement and monitoring with advanced technologies. Empower artisanal fishers with appropriate and accessible technologies.
- xxxiv. Foster green marine technology and research to understand and mitigate negative impacts. Inform proactive policy development for responsible technology use. Knowledge & Awareness.
- xxxv. Revitalize traditional ecological knowledge by integrating it with modern science. Promote modern conservation ethics based on historical respect for ecosystems. Enhance sustainable management by incorporating traditional practices. These opportunities collectively present a roadmap for healthier coral reefs and more resilient coastal communities.

Key Policy Recommendations:

Emanating from this study emphasize a multi-faceted approach to protect coral reef ecosystems and support coastal communities. Key areas of focus include:

- Strengthening sustainable practices by promoting and providing access to sustainable fishing gear, boosting financial inclusion for fishing communities, and supporting livelihood diversification into non-fishing activities.

- Mitigating threats such as addressing human-induced threats like unsustainable fishing, overfishing, pollution, and climate change. Protect and restore vital interconnected ecosystems such as mangroves and seagrasses, and manage crown-of-thorns starfish outbreaks.
- Combat declining fish populations by implementing comprehensive sustainable fisheries management, investing in aquaculture development, and diversifying coastal livelihoods to reduce pressure on wild stocks.
- Addressing destructive fishing by enforcing stricter regulations against harmful practices, encouraging eco-friendly gear, funding coral reef rehabilitation, and supporting alternative livelihoods.
- Tackling pollution: Improve waste and sewage management, combat plastic pollution, increase research on various pollutants, and enforce environmental laws. Six, to adapt to climate change by prioritizing Ecosystem-Based Adaptation (EbA) by restoring natural coastal defenses, implementing robust coastal zone management, and diversifying livelihoods.
- Empower communities: Support community-led conservation efforts, create sustainable livelihoods, foster social cohesion, and integrate climate adaptation into community planning
- Promoting sustainable economic growth: Enforce sustainable fishing, regulate coastal development and tourism, invest in alternative livelihoods, and research the impacts of the aquarium trade.
- Enhancing political influence: Raise public awareness, increase enforcement, modernize legislation, prioritize funding, and engage political candidates for reef protection.
- Effective community engagement: Establish inclusive participation frameworks, improve feedback mechanisms, strengthen local capacity, and integrate local ecological knowledge.

- Leveraging technology: Promote beneficial technologies for monitoring and restoration, assess risks, educate stakeholders, involve communities, and regulate sustainable technological use.
- Preserving traditional knowledge: Document oral histories, integrate traditional wisdom with modern practices, encourage intergenerational transfer, and empower communities in tradition-based initiatives.



TABLE OF CONTENTS

ACKNOWLEDGMENTS	2
ACKNOWLEDGMENTS.....	2
EXECUTIVE SUMMARY.....	3
TABLE OF CONTENTS	8
LIST OF FIGURES	10
LIST OF TABLES	10
1.0 INTRODUCTION	11
1.1 Background Information	11
1.1 Objectives	11
1.4 The Conceptual Framework	12
2.0 METHODOLOGY	15
2.1 The Study Sites	15
2.2 Sampling.....	17
2.3 Data Collection Methods.....	17
2.4 Data Analysis	18
3.0 RESULTS	19
3.1 Demographic Characteristics of the Respondents.....	19
3.2 Livelihood Activities and Income	19
3.3 Threats and Opportunities	20
3.3.1 Biodiversity Conservation, Ecology, and Environment	20
3.3 Climate Change.....	24
3.4 Social Threats.....	26
3.5 Economic Threats	26
3.4 Severity of each conservation and socio-economic related threats	29
3.5 Politically Related Threats	31
3.6 Institutional Related Threats	33

3.7 Engagement in Decision-Making.....	33
3.8 Technological factors	37
4.0 OPPORTUNITIES	40
5.0 CONCLUSIONS.....	47
7.0 RECOMMENDATIONS	51
8.0 REFERENCES.....	55



LIST OF FIGURES

Figure 1: The conceptual framework on opportunities and threats facing coral reefs.....	14
Figure 2: A Map showing the distribution of coral reefs in Tanzania and the five existing coral reef zones	16
Figure 3: Changes observed in fish populations in the last 10 years.....	21
Figure 4: Changes in fishing practices over the past decade	22
Figure 5: Effects of political decisions on coral reefs.....	32
Figure 6: Involvement in coral reefs’ decision-making processes	34

LIST OF TABLES

Table 1: Sample size by regions and zones	17
Table 2: Economic strategies for improved coral reef health	28
Table 3: Severity of each threat to coral reefs.....	29
Table 4: Reasons of inadequate involvement in coral reef decision-making processes	35



1.0 INTRODUCTION

1.1 Background Information

Empirical research has shown that globally, coral reefs are in decline, threatened mainly by ocean acidification, overfishing, increased ocean temperatures, and coastal development (Aronson & Precht, 2016; Battaglia, 2023; Lin, 2024; Ahmad et al., 2024; Celekli et al., 2024). Since Tanzania doesn't exist in isolation, its coral reefs are also in decline (Chauka & Nyangoko, 2023; Mbije, 2023). Unsustainable fishing practices like the use of dynamite blasts, seine and drag nets, overfishing in the nearshore waters, oil spills, release of chemical wastes, persistent plastic wastes and other marine debris, high-density coastal development, ocean acidification, and climate change impacts have become serious threats to coral reefs of Tanzania (Muchumu and Shukuru, 2024; Gudka, et al., 2024; Mbije, 2023), thus jeopardizing the lives of those heavily dependent on them for their livelihoods.

The primary causes of Tanzania's unprecedented decline in coral reefs are largely human-related, and their effects are exacerbated by natural disturbances, including storms, crown-of-thorns outbreaks, and climate change, which have led to large-scale coral bleaching events. Unlike elsewhere in the world, the Tanzanian reef system is considered more environmentally tolerant to disturbance (Chauka, 2016). Still, a comprehensive analysis of threats and opportunities is vital for its sustainability. This is because the Tanzania reef system is a vital natural resource that coastal fishing communities rely on significantly for their livelihood (Yanda et al., 2023). A comprehensive analysis of the opportunities and threats facing coral reefs in Tanzania at various scales is intended to inform the wider community in the country, emphasizing the need for coordinated efforts to protect and conserve these resilient ecosystems.

1.2 Objectives

The main goal of this study was to analyze threats and opportunities of the coral reef to understand the drivers of reef health for the proper planning of its protection and conservation. This was achieved through the following specific objectives

- 1.2.1 The analysis of threats and opportunities associated with the impacts of human-induced and natural activities on coral reef ecosystem health including social changes, environmental changes, ecological damage, and loss of Biodiversity; and
- 1.2.2 The analysis of threats and opportunities associated with the impacts of human-induced and natural activities on coral reef ecosystem health on Global and regional coverage, however, with more focus on coral reef areas as established by the Tanzania Coral Reefs Task Force.

1.3 The Conceptual Framework

Drawing from both science and traditional knowledge, this conceptual framework presents an understanding of threat/opportunity to understand drivers of reef health, focusing on coral refuge priority areas as case studies.

For a millennium, increased human-environmental interactions have caused noticeable ecological change in terms of vegetation change, and sea-level dynamics in the marine environment of Tanzania (Englonget al., 2023). Unfortunately, the coral reefs have not been spared from anthropogenic pressure that is considered to be critical in endangering coral reef health (Mjine, 2023; Mai, 2024). For example, anthropogenic activities affect ecology, biodiversity, and the environment where coral reefs are found (Muhando, 2009; Mbije, 2023). Additionally, climate change and natural disasters have further aggravated the coral reefs' survival threats (McClanahan, 2009; Chauka and Nyangoka, 2023; Elma et al., 2023).

While opportunities exist for reef resilience such as the establishment of community-based management (Chauka and Nyangoka, 2023), yet, the link between socioeconomic and political attributes and coral reef ecology has remained weak (Muhando, 2009). Mbije, (2023) posits that 'the socio-economic values of coral reefs are realized mainly through coastal fisheries and coastal tourism'. The indirect socioeconomic values could be one of the reasons why reef values are far-fetched. However, this is further compounded by the dearth of information on the role of Indigenous knowledge in coral reef conservation and degradation and, the political stance over coral reef conservation where Mbije, (2023) revealed that coral reefs are facing daunting institutional challenges. When all this is lacking or inadequately presented, horizon scanning becomes difficult.

Furthermore, the coral reef destruction does not happen in a vacuum. Actors at different scales and gender types are included differentially in the processes of coral reef management (Rwamugira, 2022). Little exists on about how actors and different genders participate and are included in reef conservation.

Additionally, the problem of conceptual paucity in marine resources has been recognized (Ishengoma, 2023). However, this framework does not adequately build on coral reefs and how it links with indigenous knowledge, scale, and principles of gender equality, sensitivity, and inclusivity. This research work further builds on Ishengoma's work by including a conceptual framework (Figure 1) by augmenting it with scale, the principles of gender equality, sensitivity and inclusivity (UN, 2006), Indigenous knowledge, and Horizon scanning approach to identify trends and potential future risks that can be worked on to minimize risks and increase coral reefs and livelihoods resilience. The framework shows that from the grassroots level where coral exists, they are influenced by ecological, social, economic, political (institutions = formal and informal rules and organizations), technological factors, climate change, natural disasters, and Indigenous knowledge. To entangle threats and opportunities, the analysis has to use different methods at different scales, i.e., local, national, and international governance levels. Additionally, for sustainability and to avoid future risks, horizon methodologies have to be used to influence policy.

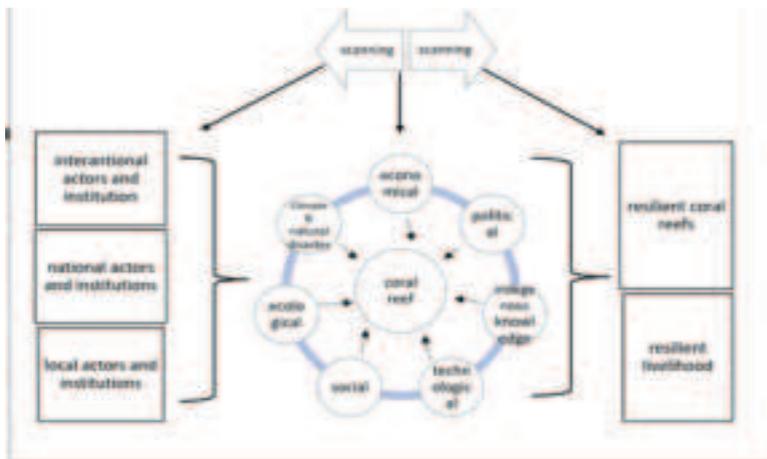


Figure 1: The conceptual framework on opportunities and threats facing coral reefs



2.0 METHODOLOGY

2.1 The Study Sites

Based on the task force report, five zones of priority areas were selected for the study. This study focused on sample areas where coral reefs are abundant and anthropogenic activities have been observed to be significant, as represented in Figure 2. These zones are (i) Zone 1: Tanga region, (ii) Zone 2: Coastal region and Dar es Salaam- Kigamboni town: corals were severely blasted with several wide holes, (iii) Zone 3: Zanzibar, comprised of the Unguja and Pemba, had bleaching, dead coral with algae, and a significant loss of hard corals, (iv) Zone 4: Comprised Mafia and Songosongo: have the highest levels of coral destruction, including the presence of rubble and broken fragments coming from drag nets (v) Zone 5: Comprised of the Lindi and Mtwara regions with high presence of dead cover and higher proportion of macroalgae, and high human activities.



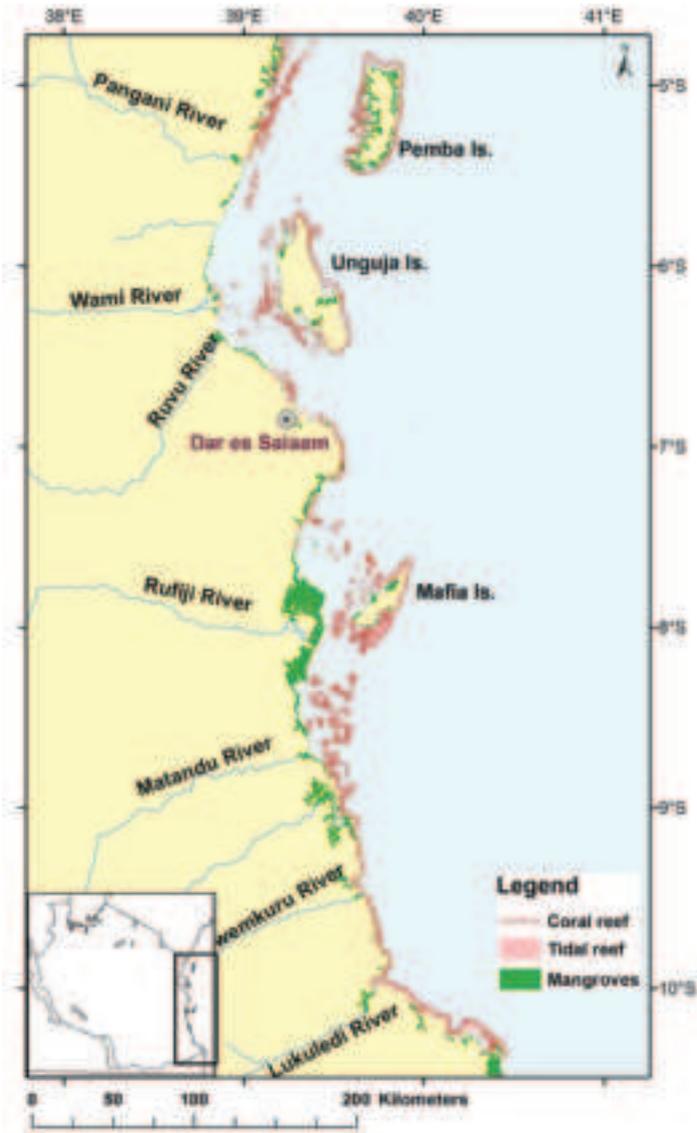


Figure 2: A Map showing the distribution of coral reefs in Tanzania and the five existing coral reef zones.

(Source: TCRTF 2018).

2.2 Sampling

Random sampling was used in household surveys to ensure that each unit in the population has an equal chance of being selected. A sample size of 343 was reached (Table 1). Participants in the survey were selected randomly from the village register in Tanga (Mchuuni village), Zanzibar Unguja (Fumba village), and Pemba (Wesha village), Dar es Salaam region (Kimbiji village), Coastal region -Mafia (Kiegeani village), Lindi-Kilwa (Somanga Kusini), and Mtwara (Msimbati village). Purposive sampling was used in the selection of Key Informant Interviews and participants.

Table 1: Sample size by regions and zones

Region	Zone	Village	Sample size
Tanga	1	Mchukuuni	30
Dar es Salaam	2	Kimbiji	60
Pemba	3	Wesha	30
Unguja	3	Fumba	49
Mafia	4	Kiegeani	49
Lindi	5	Somanga Kusini	64
Mtwara	5	Msimbati	61
Total			343

2.3 Data Collection Methods

An integration of methods and theories from multiple disciplines of social sciences (both qualitative and quantitative) was applied. Data collection methods included desk study, stakeholder mapping matrix, SWOT analysis, questionnaires, key informant interviews, and observation. A desk Study was used for background research about coral reefs governance in the landscapes, via literature review, key informant interviews, and legal and technical document analysis, mainly to identify threats and opportunities. Key informants included local to national-level actors, Non-Governmental Organizations (NGOs), Community-Based Organizations (CBOs), Local Government Authorities, Academic Institutions, and Local Fishing Communities.

To address objective one on threats and opportunities emanating from ecology, environment, and biodiversity, the questionnaire and key informants were used. Further questions focused on awareness, livelihood activities, local observation and experiences, existing indigenous knowledge, and existing initiatives to conserve coral reefs. Empirical research on the diversity, abundance, and changes over time of coral health was examined using already existing empirical data.

To address objective two on threats and opportunities emanating from social and economic livelihood activities, perception, socio-political conditions, and the role of indigenous knowledge were assessed. This entailed using quantitative questionnaires and qualitative methods, including stakeholder consultations and key informant interviews. Quantitative method using household surveys was used. To understand threats and opportunities emanating from involvement levels, questions grounded on perceptions were used. Furthermore, in-depth interviews with other key stakeholders related to coral reef conservation and district and national governments were conducted. Threats and opportunities emanating from climate change, the SWOT analysis approach by Keeley (2006) was used. This was complemented with empirical research, the questionnaire, and key informant interviews. To analyze the scale at which reefs are used, conserved, and decisions are made that pose threats and opportunities, SWOT analysis was used.

2.4 Data Analysis

The questionnaire data was entered into the ODK application. Data was collected face-to-face using the Kiswahili language. Data was then coded into MS. Excel Application. Descriptive and statistical tests were conducted to establish meaningful relationships for the quantitative data. Qualitative data was analyzed using content analysis.

3.0 RESULTS

3.1 Demographic Characteristics of the Respondents

A total of 343 respondents were interviewed. The mean age was 39 years, while the minimum and maximum ages were 18 and 70, respectively. About 94% of the respondents were males, while only 6% were females. The main occupation of the respondents was 86% fishers. The rest include hotelier, tour operator, local government officials, seaweed farmers, small business, carpentry, crop cultivation, district UWT chair, driver, fish trading, MIMP boatman assistant, food vending, mechanics, office assistant, retired, souvenir seller, and casual labour.

Although random sampling was used, the sample was predominantly male (94%), reflecting a strong male presence in the fishing industry demographics. This further implies that the skewed gender distribution warrants further examination into gender roles, equality, and representation within the industry. Purposive sampling will be required to target women respectively. The age range (18-70) was diverse, and the mean age (39) shows a relatively mature population. Fishers make up a significant proportion (86%), indicating a strong presence in the fishing industry, hence aligning positively with the main goal of the study on opportunities and threats facing coral reefs.

3.2 Livelihood Activities and Income

The communities along the coast engaged in diverse livelihood activities. These included coral reef fishing, dive fishing, gleaning, shrimp fishing, fish trading, crop cultivation, finfish fishing, salt making, livestock keeping, work for local government officials, ecotourism services, tour operators, paid employment, marine conservation activities, crab fattening, casual labor, small shrimp fishing, marine conservation rangers, boat transportation services, pelagic fishing, motorcycle riding, famously known as bodaboda in Swahili, and other activities like carpentry, driving, entrepreneurship, farming, hotel work, transportation, food vending, vocational work, petty trading, small businesses, political leadership, souvenir selling, tour guiding, and traditional octopus harvesting. About 83% of respondents' livelihood activities depend directly on coral reefs, mainly for fish, for both subsistence and income. We also wanted to understand whether income has changed over the past 1-10 years. About 50% reported a decrease, while 50% reported an increase. The reasons for decreased income included fewer

fish catches and availability, more fishers, climate change, the use of illegal fishing gear, lack of advanced fishing boats, and COVID-19 impacts. Conversely, those with increased income are credited with better fishing gear, higher catch volumes, increased market prices, high demand for fish, reduced destructive practices, government support, and diversification into non-fishing activities such as agriculture and small businesses. Still, about 65% of respondents report having no access to credit or financial services, while 35% do have access, including banks, telephone network providers, private credits like Kausha Damu and BRAC, and grassroots community-based microfinance institutions, popularly known as Village Community Banks (VICOBA).

3.3 Threats and Opportunities

3.3.1 Biodiversity Conservation, Ecology, and Environment

Respondents revealed that the biodiversity, ecology, and environment of coral reefs are threatened primarily by human activities. These include unsustainable fishing practices (76%), overfishing (69%), pollution (62%), climate change and variability (61%), coastal development (41%), and unregulated tourism, such as boat anchorage (22%). Other threats mentioned are oil spills, bait digging, fishing around rocks, immigrant fishers using steel traps, immigrant fishers using plucked corals as support for traps, limestone (corals) and lime trading, poaching, drag nets, large traps, crown of thorns, and the use of poison in coral areas.

Interviews with experts revealed that the crown-of-thorns starfish poses a potential threat and can cause significant damage to corals by feeding on them. Furthermore, empirical research has shown that large outbreaks of crown-of-thorns starfish are linked to the decline of their predators, including some shrimp, worms, and species of reef fish (Dipper, 2022).

Respondents reported that potential ecological opportunity includes the presence of mangroves and seagrasses. Among the functions of corals is to reduce the pressure of the large currents of water coming to the land. Having well-conserved corals means the current's speed is slowed down, sea grasses and mangroves are protected from destruction. Likewise, mangroves and seagrasses protect corals from dirty rainwater, garbage, and dust from the mainland, acting like filters.

3.3.1.1 Overfishing

Results show that the fish population has decreased. As shown in Figure 3, a considerable number of respondents (67 %) reported a decline in fish numbers, a small minority (17%) perceived an increase, while 14% reported no change, and 2% were unsure.

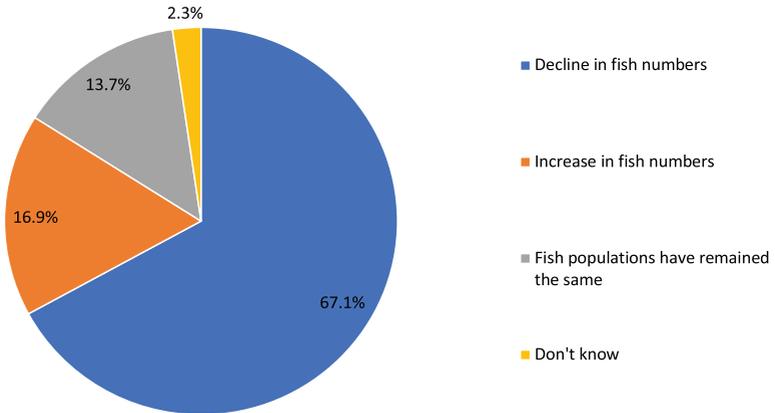


Figure 3: Changes observed in fish populations in the last 10 years

During an in-depth interview with an elderly person in Tanga for example, he confirmed the above findings that one of the changes he has observed is a decrease in the number of fish caught. He further complained that:

“Some fish species have vanished. For example, about ten years ago, on a day like today, we would catch around fifteen rays when fishing. Now, and even in the past two years, you could go an entire week without catching a single fish. Additionally, many fish used to be seen floating, but that’s no longer the case.”

Furthermore, an interview with an expert revealed the same on fish population decline. He narrated that:

“While fish catch may seem to have increased, technically, fish availability has decreased. This is because in the past the big boats, eg. In Mkinga were fewer than ten, but today we are talking about more than a hundred. So, if we look at the load that was brought by ten boats, automatically it must be less than the load brought by a

hundred boats. But, technically, on the catch per unit efforts, and if today we bring three hundred tons, and years ago we were bringing one hundred tons, you find that this three hundred tons of effort is very large, so if we compare it to something we call catch per unit effort, you find that today is smaller than before, but if we only look at the load that comes, you will find that it is larger than before”

3.3.1.2 Unsustainable Fishing Practices

Regarding unsustainable fishing, we aimed to determine whether fishing practices have changed over the past decade. Results show that they have indeed changed. For example, Figure 4 indicates that a substantial number of respondents 65% agreed that fishing practices have changed, while the remaining respondents reported no change.

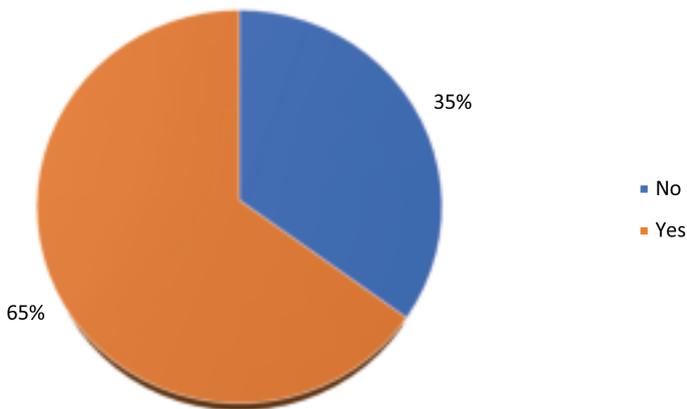


Figure 4: Changes in fishing practices over the past decade

We further inquired why the change in fishing practices. Respondents remarked that the demand for fish has increased. Therefore, the majority of fishers are fishing to meet the demand. As a result, fishers use drag and seine nets that greatly destroy the coral reefs. An in-depth interview to inquire about the trend of coral diversity and its ecosystem with the fishery expert revealed a similar observation, affirming that:

“Oh, the trend is negative because we learned that ten years ago, dynamite fishing was very popular. So, in many places, the reefs have been destroyed. That

is, if you dive into the sea, you only come across pebbles and you see that the rocks have been broken.”

Other unsustainable fishing practices include Octopus fishing using metal hooks, where fishers break the reefs while using metal hooks. Metal hooks, because you find that the octopus usually goes into a cave in the water. Now, the fisherman is looking for it, and the octopus is hiding more and more. With the metal hooks, they break the reef to find the octopus.

Moreover, illegal fishing using dynamite was reported. Before 2023/2024 dynamite use was on the rise, but this has been subdued, shallow ring net uses whose numbers has been increasing, the use of sand as a sinker, which later leaves sand everywhere is increasing, along with the use of metal rods in octopus fishing, which break the reefs cave to search for octopus. The use of sandbags as anchors is most prominent during sardine fishing. Fishers use sandbags as anchors. After they are done, they leave the bags in the ocean. These sandbags have been observed on top of coral reefs, resulting in coral clouding.

3.3.1.3 Pollution

Results reveal several pollutants, including domestic waste, sewage, solid plastics, and other solid wastes, such as yellow sea moss and debris like twigs and rods, which have been observed and reported. For example, in Zanzibar at Mji Mkongwe, all sewage is discharged into the ocean; other debris has been reported in Kilwa, Kibiti, Mtwara, Tanga, and Zanzibar. Supporting these findings, the study by Chauka and Nyangoko (2023) reported pollution as a major threat to coral reefs. Furthermore, turbidity (cloudiness) caused by pollutants has a range of physical and physiological impacts on corals. For example, Jones et al. (2020) observed that turbidity may lead to bleaching and reduced light essential for photosynthesis (Miller et al., 2016). Additionally, key informants indicate that microplastics are a potential and invisible threat to corals (Rahman et al., 2020), which calls for further research. Empirical studies also show that microplastics in corals are a concern and a potential threat to marine ecosystems. For example, Soares et al. (2020) assert that microplastics can impair coral feeding performance, affect photosynthesis and food intake,

and increase corals' exposure to contaminants, while Nchimbi et al. (2022) found that significant microplastics in beach sediment along the coast of both Tanzania and Zanzibar.

Moreover, oil spills have been observed and reported in all study sites. Oil spills in Pemba at Weshu Port, the Dar es Salaam coast, were associated with the drying of mangroves. However, little research has been done to examine the effects of oil spills on mangroves. Likewise, Chemicals from agriculture may be a potential threat. Both cash and subsistence crops are grown in all study sites. However, little has been done to substantiate the potential threats of pesticides and other agricultural chemicals to corals.

3.3 Climate Change

Our goal was first to examine climate-related changes observed over the past decade. Respondents asserted that temperature has increased, rain has decreased, and it has become more unpredictable, storms have increased, and winds have become stronger and unpredictable. There is also an increase in brackish water, especially during the rainy season. During an interview with a key informant, one of the experts stated that:

"The changes I have observed are the increase in temperature and the disruption of the rainy seasons. It is not like it was in the past, but despite that, we have two seasons of north and south winds. Normally, the north wind starts from September to October, and blows until January or February. After that, the south wind begins. However, until now in April, the south wind has not started, which is unusual. The north wind was late to begin; it started in December last year. So, this is a clear and certain change."

Aligning with the observed changes, climate change is claimed to have destroyed 25% of corals worldwide (Heron et al., 2017). In the East African region, increased temperature and flooding were mentioned as among the major threats (Obura et al., 2008). Equally, Chauka and Nyangoko (2023) found that climate change is among the major threats to coral reefs.

Regarding storms, and the sea level rise of the ocean, one of the elders in Tanga said this:

“Storms have become more frequent. These days, they are not even predictable. You only hear about ships sinking, and suddenly there’s an unpredictable wind, lots of wind, and I don’t know where it came from. This is different from how it used to be in the past. Regarding the depth of the sea has risen. For example, the old buildings that were built along the shore have been submerged”.

During the interviews, it was reported that in Lushungi village in Kilwa and Ulange island in Kibiti have almost been submerged.

Bleaching: Several experts attested to the fact that bleaching is happening. All experts associated the bleaching with increased temperature. With regards to coral bleaching, one expert said that:

“This week I had a diving job, I went to four reefs named Chundo, Minyaani, Kiroba, and Bunju, the condition of the coral reefs was not good. Many were bleached. We experienced a large number of reefs that have died. But we need more research on that.”

Consistent with the results above, coral bleaching has occurred globally and is associated with rising ocean surface temperatures. For instance, in 1998, off the western Indian Ocean, the strongest sea surface warming event on record took place, resulting in an estimated 46% of corals being severely affected or dying (Souter et al., 2000). Chauka and Nyangoko, (2023) observed similar findings in Zanzibar.

Floodings: Increase in brackish water (maji makali). For example, the water coming from the Rufiji River is sent directly to the ocean. When the water mixes, it becomes muddy and dusty, and goes directly to cover the corals. Dust and mud make corals stop bubbling and roaring because they can’t access the sun directly. Under clear water and the sun, coral bubbles and roars. One of the experts narrated that:

Apart from the heat that has led to the bleaching of corals, we have witnessed heavy rains that come for a short duration. The rains cause the topsoil, in large quantities, to enter the ocean; the fishermen themselves call it “umbwe,” meaning

the top mud enters the sea, to the extent that the sea becomes like clay in color. Now, when the rain is heavy, and the flood situation subsides, the mud cannot be filtered properly by the mangroves and seagrasses, and it goes to the corals. In the corals, they form a coat in the pores where the polyps live, and unfortunately, because of this, many organisms that stabilize the entire health of the corals have disappeared. Even organisms that eat the algae, trap the algae, or collect dust particles from corals are dead, some are almost extinct."

3.4 Social Threats

Social-related threats were mentioned as climate change (54%) and the community's lack of awareness of coral reef conservation (33%). Other threats were poverty, dependence on resources and resource use conflicts, destructive fishing practices, immigration, an increase in population, pollution, poverty, and limited access to financial services were the main social threats facing coral reefs.

Regarding the contribution of individual factors to coral reefs' decline, further analysis showed climate change, temperature rise, floods, and storms have increased (c.f., section 3.3 of this report). These were claimed to increase hardship and dependence on ocean resources. Concerning immigration, 94% of the respondents believed that migration increases pressure on coral reef resources. It was known that people migrate to the coastal areas from all over the country. Furthermore, about 92% believed lack of awareness about the importance of coral reefs among local communities contributes to the decline of coral reefs. Similarly, 92% lack of sustainable alternative livelihoods for coastal communities contributes to the decline of coral reef biodiversity.

Several social opportunities were mentioned concerning social threats. These were community-led education and awareness campaigns about coral reef conservation and development, community dialogue and conflict resolution, encouraging community-based monitoring and enforcement, building social cohesion and trust among community members, and empowering local communities in reef conservation.

3.5 Economic Threats

Economic threats facing coral reefs were related to economic activities that could threaten corals. Respondents reported destructive fishing methods, coastal development including hotel construction and repairing, overfishing, and commercial fishing to meet the market demand, unsustainable tourism, waste and pollution from hotels, industries, and agricultural pesticides and fertilizers, transportation activities, extraction of sand or coral for construction and souvenirs, lack of grants and loans from conservation and tourism for local community development, and mining activities.

A good example of a reported economic threat was the Mnemba Islands, as stated by one of the experts in a box below:

Box 1: The Mnemba Island case

A threat that we often overlook is unsustainable tourism. For example, in Zanzibar, visitors frequently surpass the area's carrying capacity. Unfortunately, no studies have been conducted to determine this capacity. Visitors who are not environmentally conscious and cannot swim often stand on the coral reef, and these visitors are sometimes brought by boats that anchor on the reefs. As a result, both the boats and the visitors leave a footprint. In the north of Unguja Island, Mnemba Island has one investor.

Monitoring showed that the coral cover has decreased by nearly 80% over time, mainly due to increased visitor numbers. Although the area is small, peak visitor numbers can reach three to four hundred, with up to two hundred boats. To address this, the government negotiated with the investor to establish a "special area." They reduced the number of boats from 100-200 to just 8 per day and cut the number of visitors from 300-400 at peak times to 56 daily. When fully booked, Mnemba hosts 24 guests in its 12 rooms. Therefore, 24 guests would go to the areas, but not all go at the same time. The 14 people go at a time with two boats. Each boat carries seven guests for an hour and a half. As they leave, others come in. Now it's a popular spot, and it's starting to recover.

Other economically driven threats were collecting live corals for the aquarium market. This threat was unveiled by the marine experts, claiming that it could be a potentially significant threat since no research has been done to understand its impact. Nevertheless, empirical research has shown

that corals for aquarium markets is a booming, and lucrative business (Dee et al, 2013; Pacey et al., 2022). While aquariums are beneficial in the conservation of wild populations, but if not well managed, the business can significantly impact coral reef conservation, leading to overharvesting and biodiversity loss (ibid).

On the other hand, the economic threats to corals have direct negative economic effects on diverse stakeholders who directly benefit from coral resources, including the local small-scale fishers, shell collectors, seaweed farmers, local tourism, and others. Empirical results have shown that the economic benefits from well-managed reef resources far exceed costs (Whit et al., 2000).

To curb economic threats, local communities proposed economic strategies that would lead to improved coral reef health, as indicated in Table 2.

Table 2: Economic strategies for improved coral reef health

SN	Economic Strategies	Frequency	Percentage
1	*Strengthening sustainable fishing practices	158	49
2	Financing alternative livelihood activities	67	21
	Supporting sustainable fishing and eco-tourism	60	19
3	Supporting local conservation and management initiatives	18	5
4	Strengthening law enforcement in marine protected areas	16	5
5	Climate change financing and carbon credit	2	0.6
6	Soliciting funds for marine conservation	1	0.4
	Total	322	100

*Mariculture-related activities, e.g., seaweed farming, sea cucumber farming, crab fattening

Concerning economic opportunities, one expert asserted that corals offer habitat for valuable creatures with high economic value. He proclaimed that:

“Aside from ordinary fish, there are shrimp, lobsters, and octopuses, which breed and grow on corals in large quantities; corals are also coral gardens, offering a big opportunity in tourism activities, which, to some extent, we have not yet invested in.”

At the national level, experts highlighted the Tanzanian National Blue Economy Policy of 2024 as a major opportunity in coral reefs conservation and development. This, together with the National Fisheries Policy 2015 (mainland Tanzania) and Zanzibar Fisheries Sector Policy, 2022 and the associated tools including the National Integrated Coastal Environmental Management Strategy (2025), the Marine Park and reserve Act (1994), and the Kunming Global Biodiversity Framework Target 3, which prioritizes coral reef management.

3.4 Severity of each conservation and socio-economic related threats

We further aimed to examine the severity of the mentioned threats under the categories of conservation, socioeconomic, and climate change, as elaborated in the previous sections. Table 3 below shows likert scale results where for each threat for example those who reported severe, the majority of respondents (64%) mentioned destructive fishing practices as a major threat, 42% pointed to dynamite fishing, nearly 42% referred to dynamite fishing, about 40% mentioned ring net, 52% denoted beach sein, 35% pointed at gun/spear, 53% indicated overfishing, 37% pollution, 35% cited sedimentation, 39% reported coral bleaching, 34% stated tourism impacts, 51% denoted plastic waste and marine debris, 40% revealed oil spills and chemical pollution and the majority about 54% mentioned climate change and variability.

Table 3: Severity of each threat to coral reefs

Sn	Challenges	Responses	Frequency	Percentage	n
1	Destructive fishing practices	Major threat	219	63.9	343
		Minor threat	71	20.7	
		Moderate threat	34	9.9	
		I don't know	14	4.1	
		Not a threat	5	1.5	
2	Dynamite fishing	Major threat	124	42.3	293
		Minor threat	76	25.9	
		I don't know	44	15.0	
		Not a threat	41	14.0	
		Moderate threat	8	2.7	
3	Ring nets	Major threat	133	39.6	336
		Moderate threat	77	22.9	
		Minor threat	48	14.3	
		I don't know	44	13.1	
		Not a threat	34	10.1	
4	Beach seine	Major threat	174	51.9	335
		Minor threat	94	28.1	
		Moderate threat	26	7.8	
		Not a threat	25	7.5	
		I don't know	16	4.8	

5	Gun/Spear	Major threat	116	34.7	334
		Minor threat	68	20.4	
		Moderate threat	59	17.7	
		I don't know	53	15.9	
		Not a threat	38	11.4	
6	Overfishing (especially for specific species like octopus or sea cucumbers)	Major threat	179	52.7	340
		Minor threat	78	22.9	
		I don't know	31	9.1	
		Moderate threat	31	9.1	
		Not a threat	21	6.2	
7	Pollution from coastal cities and rivers (e.g. Dar es Salaam, Tanga, Zanzibar)	Major threat	110	36.5	301
		Minor threat	97	32.2	
		I don't know	43	14.3	
		Moderate threat	37	12.3	
		Not a threat	14	4.7	
8	Sedimentation from deforestation in coastal watersheds	Major threat	116	34.9	332
		Minor threat	95	28.6	
		I don't know	56	16.9	
		Moderate threat	45	13.6	
		Not a threat	20	6.0	

9	Coral bleaching events due to rising sea temperatures	Major threat	133	39.1	340
		Minor threat	88	25.9	
		I don't know	60	17.7	
		Moderate threat	49	14.4	
		Not a threat	10	2.9	
10	Tourism impacts (e.g. boat anchoring, diving damage)	Major threat	113	33.6	336
		Minor threat	107	31.9	
		I don't know	54	16.1	
		Moderate threat	32	9.5	
		Not a threat	30	8.9	
11	Coastal development (e.g. port expansion, hotel construction)	Major threat	114	34.2	333
		Minor threat	114	34.2	
		I don't know	41	12.3	
		Moderate threat	39	11.7	
		Not a threat	25	7.5	
12	Invasive species (e.g. clown-of-thorns starfish)	Minor threat	110	34.3	321
		Major threat	103	32.1	
		I don't know	63	19.6	
		Moderate threat	25	7.8	
		Not a threat	20	6.2	

13	Plastic waste and marine debris	Major threat	174	51.0	341
		Minor threat	96	28.2	
		Moderate threat	32	9.4	
		I don't know	27	7.9	
		Not a threat	12	3.5	
14	Oil spills and chemical pollution	Major threat	130	39.5	329
		Minor threat	95	28.9	
		I don't know	54	16.4	
		Moderate threat	32	9.7	
		Not a threat	18	5.5	
15	Climate variability and change	Major threat	182	53.5	340
		Minor threat	78	22.9	
		I don't know	47	13.8	
		Moderate threat	25	7.4	
		Not a threat	8	2.4	

3.5 Politically Related Threats

To identify politically related threats, we examined the politically linked attributes that could threaten coral reefs. Figure 5 shows that 40% of respondents were unaware of any political decisions that could pose a danger to coral reefs. Conversely, 22% reported

insufficient enforcement, 11% cited outdated laws, 10% pointed to inadequate participation and awareness of laws, 9% mentioned increased investments, 6% referred to election campaigns, and 3% identified insufficient funding.

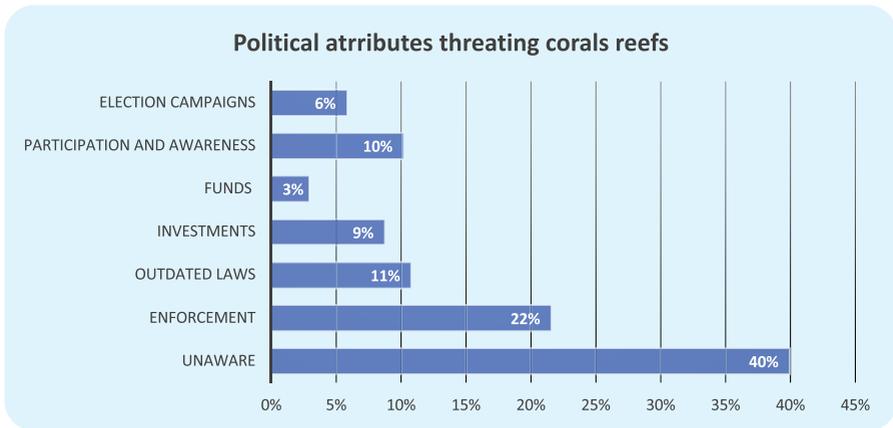


Figure 5: Effects of political decisions on coral reefs

Regarding outdated laws, respondents mentioned the need to amend regulations to keep up with ongoing changes, with some complaining that it's difficult to comply with certain laws, such as the establishment of no-take zones. On inadequate participation and awareness of laws, respondents criticized how policies and laws are formulated without involving local communities' opinions. Concerning increased investments, respondents argued that more investments on islands could

lead to greater coral destruction. Moreover, they emphasized that current investments do not consider how communities can benefit from them. Election campaigns were also linked to political affiliations, where politicians would use their influence to prevent technical staff from enforcing laws effectively. Insufficient funding was related to patrols and reef resource monitoring. Respondents also expressed concern about delayed responses to climate change.

Besides the local-level political challenges, there is a significantly high level of political will and support for coral reefs conservation and sustainability in Tanzania. This manifests through the existing policy framework that aims to bring about positive change in the way corals are managed. This includes the National Fisheries Policy 2015 (mainland Tanzania), Zanzibar Fisheries Sector Policy, 2022, the National Blue Economy Policy 2024, and other related natural resources conservation policies.

Furthermore, respondents advised that some political strategies would lead to improved coral reef health. These include the need to strengthen enforcement of marine conservation laws, improve coordination between agencies and stakeholders, increase transparency and accountability in decision-making, empower local communities in coral reef management, establish clear policies for sustainable coastal development, increase government investment in marine conservation, and create platforms for dialogue and collaboration.

3.6 Institutional Related Threats

While in many countries legal and administrative structures are more likely to destroy rather than conserve coral reefs (Riegl et al., 2009), this study, including the questionnaire and interview results, shows that laws, regulations, and existing administrative structures were clear and aimed at sustainable coral reef conservation. However, enforcement was a significant challenge.

To tackle institutional challenges, improve coral health and

enforcement, 95% of respondents suggested establishing clear roles and responsibilities for each institution; 96% of the respondents pointed to strengthening communication and coordination mechanisms. Additionally, 97% of respondents believed that building the capacity of local institutions would improve coral reef health. Furthermore, 96% of the respondents believed that increasing funding and resources for coral reef conservation would improve coral reef health.

3.7 Engagement in Decision-Making

Results show that about 67% of respondents were not involved in coral reefs decision-making processes, while the rest 33% were involved, as shown in Figure 6 below:

Involvement in Coral Reefs' Decision-making Processes

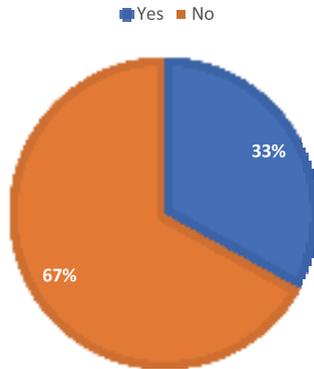


Figure 6: Involvement in coral reefs' decision-making processes

Those who reported being involved asserted that they were involved to provide data and information on coral by different stakeholders during interviews. However, they complained that they do not get feedback of the findings. Other through meetings with fellow community members, VLC, Park, VIKOBA and village level meetings, as member of Shehia fisheries, as a member of BMU, when planning the use of marine resources such as establishing temporary enclosures and breeding areas, and through meeting to prevent damage to the marine environment, for example, during the formation of a joint

committee to control nets for the Menai Bay Conservation Area.

Likewise, we wanted to examine why 67% of the respondents reported to have not being involved in coral reefs conservation decision-making processes. They gave reasons, including not being a member of Shehia committees, SFCs, and the CMG collaborative Management group, not being invited, and a lack of time. However, some more respondents had more interesting responses that may require special consideration when engaging communities in coral reefs management. Examples of these responses are in Table 3 below:

Sn.	Responses
1	I am just a common man
2	They only speak about don'ts, and no room for discussion

3	They normally talk to leaders, not us
4	I don't even think they can listen to me
5	I am not involved, and I don't know why
6	I am not involved; I think some special people are involved.
7	I just see that things have been decided.

Table 4: Reasons of inadequate involvement in coral reef decision-making processes

Reasons of inadequate involvement in coral reef decision-making processes

Moreover, respondents who participated in decision-making processes on coral reefs management reported to be in community groups or organizations as mentioned in Table 4 below.

Table 4: Names of community groups or organizations

District	Community groups or organizations related to reef management
Kigamboni	Beach Management Unit
	Umoja wa Wavuvi Wadogo Kivukoni (UWAWAKI)
	KIWAWAMU
Kilwa	Beach Management Unit
	Environmental groups
Mafia	Village Meetings
	VICOBA
	Village Liason Communities
	Coastal Women Fishers Network
	UWT
	MCS

Magharibi B	Shehia Fisheris Commitee
	Kamati ya Uvuvi ya Shehia
	Kamati ya uvuvi ya shehia
Tanga	Village Liason Communities

Additionally, an in-depth interview with a district expert showed that communities have been involved in curbing destructive fishing practices. For example, regarding the blast fishing crackdown, he recounted that

“From 2019 to 2020, there was a serious operation to eradicate blast fishing, which caused a lot of illegal nets to be burned. Subsequently, the citizens raised their voices regarding the nets used in fishing for sardines. The Fisheries Law states that nets of ten-millimeter size should be used for sardine fishing. But through various forums with experts, fishermen explained that size will not work. They proposed an eight-millimeter net size instead. As a result, the fishing regulations are now being amended to accommodate that change.

Nevertheless, the cultural challenge of ‘muwali’ or nepotism was identified as a key challenge. Local communities would protect

fellow community members in cases of misconduct and illegal activities related to coral access and use. One of the interviewees, frustratingly, said that:

‘Mwali culture delivers a clear message that -we know who is responsible but we can't tell you. This makes our work harder and takes longer to find solutions. Likewise, one needs to have concrete evidence before the court as no community member would appear to confess against fellow members.’

Drawing from their participation experiences, we explored the community's sense of ownership over the local coral reefs. Results show that 49% believed corals belong to the community, while the remaining 51% believed the opposite. Those who felt a strong sense of ownership said it was because they are the primary users of the resources for daily needs and fishing, their livelihood depends on the ocean, and everyone has access to the

coral reefs. Other reasons included being engaged in marine conservation, managing resources at the village level, establishing marine protected areas, setting fishing rules, and being involved in decision-making. This leads to better stewardship, long-term sustainability, reduced conflict, and increased awareness and education. Conversely, those who felt they had no sense of ownership cited reasons such as a general lack of awareness and understanding about coral reef ownership, the widespread belief that everything is decided and owned by the government or entities like marine parks, and limited community involvement in decision-making. Additional reasons included a lack of resources and capacity for management and conservation, a perceived absence of responsibility or

care within the community, and feelings of external control and influence.

Congruent with these findings, Gustavsson et al. (2014) found that community participation in marine parks management in Zanzibar was inadequate and the management was more top-down. Hence, they called for more inclusive management.

To curb participation challenges, 94% of respondents believed that developing effective stakeholder participation mechanisms would improve coral reef health in Tanzania. Nearly 87% suggested streamlining bureaucratic processes would improve coral reef health, and all respondents suggested that creating a national-level coordinating body would improve coral reef health in Tanzania.

3.8 Technological factors

Technological factors posed no significant threat to the destruction of the corals. This is because it was known that many fishers don't have sophisticated fishing gear. They mainly engage in shallow water fishing, with very few able to afford deep-sea equipment. On the other hand, one of the interviewees claimed that:

“There is a huge use of generators in the ocean, and the potential for oil spills is high. The generators produce light that is very strong and has high intensity. Fishers use the light to confuse and catch fish. The light has the potential to harm cytoplanktons and cheplanktoms, and disrupt the food chain”.

Further results showed that in some parts, such as in Tanga

and Kilwa, the technological restoration of coral is being used. Moreover, interviews with experts indicated that they believe advances in technology could help reduce pressure on coral reef areas, such as through the use of Potential Fishing Zones (PFZ), improved patrols, and enhanced monitoring activities.

This is to say, technological advancement was largely viewed positively and as an opportunity. However, the potential negative impacts are unknown and should not be ignored. As Gibbs (2021) argued, as the upscaling of restoration methods is underway, potential social impacts linked to technology need to be considered.

3.9 Traditional and Local Knowledge

Findings show that nearly 93% of respondents reported no known traditional knowledge related to marine and/or coral reefs, while the rest reported the opposite. Therefore, by and large, traditions are not currently being used to conserve coral reefs. However,

ritual sites exist in mangrove areas. For example, in the past, they had some rituals, totems, and traditions that contributed to the protection and conservation of the marine environment in general. These include:

Identification of Coral Reefs:

Corals were identified based on the sounds they produce. Sometimes, coral reefs emit a boiling, bubbling sound that occurs immediately when fire is extinguished by water.

The use of stars: Elders used stars to predict the presence or absence of winds. This helped them to decide whether to go fishing or not. This determined the number of days spent in fishing.

The use of monsoon winds:

They further used monsoon winds to delineate important times for fishing. These were the South Monsoon Winds (SMW) and the North Monsoon Winds (NMW). People depend on the monsoon winds. The South Monsoon Winds (SMW) start in March and end in November, while the North Monsoon Winds (NMW) begin in December and conclude in March. In the past, the South winds started in April, but this has changed. The South Monsoon Winds are characterized by strong winds, which prevent fishing activities until December, when the North Monsoon Winds have started

Conducting oceanic rituals:

on of the elder persons narrated that:

“The spiritual leaders purchase a mixture of herbs from herbalist shops, including perfumes, incense, frankincense, brown sugar, and many other items. They prepare food for numerous people to eat. Afterwards, they recite verses from the Quran and pray. Later, they pray to God for peaceful and successful fishing activities, asking that no one should die or encounter storms while fishing in the ocean. They then throw the herbal mixture into the ocean, believing that the fish are protected by Genies/Satans, so they use the herbs to calm the genies. After the rituals, the ocean opens up for abundant catches. However, if someone goes fishing alone without performing the rituals, the outcome may not be favorable.”

On the other hand, the rituals are no longer fully performed.

Taboos and Totems: After rituals had been conducted, it was offensive to excrete on the coast, conduct any sexual perversion acts, brew making, and drinking. When these are done, one could get diseases and many other punishments. This was because the genies didn't like those acts, and the genies ruled over the whole coast. The rules made people fear the coast. One would never go fishing without the rituals.



4.0 OPPORTUNITIES

1. The opportunities identified for coral reef-dependent communities revolve around enhancing sustainable practices, expanding financial inclusion, and promoting livelihood diversification.

- i. Sustainable Practices: Opportunities exist in improving fishing methods through better gear and stricter enforcement against illegal fishing. There's also a chance to build climate change resilience by educating communities and investing in coral reef restoration to boost ecosystem health.
- ii. Financial Inclusion: A key area for growth is increasing access to financial services through tailored products and strengthening community-based microfinance. Providing financial literacy training and exploring innovative financial mechanisms
- iii. Livelihood Diversification: Significant potential lies in supporting communities to transition into non-fishing activities like agriculture, small businesses, and ecotourism.
- iv. Developing value chains for sustainable marine products also presents an avenue for creating new income streams

and reducing reliance on traditional fishing.

2. Based on the results, several opportunities for coral reef conservation emerge, including:

- i. Sustainable Management of Human Activities;
- ii. Regulate Fishing Practices: Since unsustainable fishing (76%) and overfishing (69%) were the top threats. There is a significant opportunity to implement and enforce stricter regulations on fishing methods and quotas. This includes promoting sustainable fishing gear, establishing marine protected areas (MPAs), and educating local communities about responsible fishing.
- iii. Combat Pollution: With pollution affecting 62% of reefs, opportunities exist to improve waste management systems, reduce agricultural runoff, and control industrial discharges into coastal waters.
- iv. Mitigate Climate Change Impacts: Opportunities include promoting renewable energy sources and supporting carbon sequestration initiatives to lessen the effects of climate change and variability (61%).

- v. Control Coastal Development and Tourism: Addressing coastal development (41%) and unregulated tourism (22%) presents opportunities for implementing eco-friendly coastal planning, enforcing responsible tourism guidelines (e.g., designated mooring areas to prevent anchor damage), and developing sustainable tourism certifications.
- vi. Protect and Restore Mangroves and Seagrasses: The vital reciprocal relationship between corals, mangroves, and seagrasses offers a powerful opportunity.
- vii. Manage Crown-of-Thorns Starfish Outbreaks: There is an opportunity for targeted conservation efforts for species preying on crown-of-thorns starfish, involving focused research on predator populations and potential reintroduction or protection programs.
- ii. Aquaculture development: Investing in and expanding sustainable fish farming to meet demand and reduce pressure on wild populations; this is a significant untapped potential.
- iii. Livelihood diversification: Supporting coastal communities in developing alternative income sources beyond fishing, such as marine ecotourism (snorkeling, diving, island visits), seaweed farming, or value-added marine products.
- iv. Research and innovation: Funding further scientific research into fish biology, ecosystem health, and effective conservation strategies, including better monitoring tools and sustainable fishing technologies.
- v. Policy and Governance Reform: Strengthen legal frameworks and enforcement against illegal, unreported, and unregulated (IUU) fishing, and improve data collection to inform management decisions.

3. The observed decline in fish populations creates multiple opportunities, including:

- i. Sustainable fisheries management: Implementing and strengthening policies for responsible fishing, including quotas, gear restrictions, and marine protected areas.
- 4. Opportunities arising from threats of unsustainable fishing practices include:
 - i. Enhancing monitoring and updating policies to reduce destructive practices like sand

- sinking and reef-breaking for octopus.
- ii. Introducing and incentivizing eco-friendly fishing methods and responsible aquaculture to meet demand.
 - iii. Community Education and Engagement: Empower local fishers with knowledge and resources for sustainable practices.
 - iv. Fostering technological innovation: Develop and implement greener fishing gear and advanced monitoring tools.
 - v. Scaling coral reef restoration by initiating extensive efforts to repair damaged reefs and establishing marine protected areas.
 - vi. Developing Market-Based Incentives: Create demand and rewards for sustainably sourced seafood through certification and pricing strategies.
 - vii. Encouraging Interdisciplinary Collaboration: Promote partnerships among scientists, communities, and policymakers for comprehensive solutions.
- 5. Opportunities arising from pollution threats include:**
- i. Boosting research on microplastics, oil spills, and agricultural chemical impacts on coral reefs;
 - ii. Targeted pollution control programs to reduce sewage, plastics, and other waste discharges;
 - iii. Developing and enforcing stronger environmental regulations;
 - iv. Launching public awareness and participation campaigns for pollution reduction;
 - v. Exploring new technologies for detecting and mitigating marine pollutants;
 - vi. Enhancing coastal ecosystems and blue economy through ecosystem protection;
 - vii. Fostering international partnerships to promote global marine environmental initiatives.
- 6. Climate change impacts present several key opportunities:**
- i. Investing in nature-based solutions like restoring corals, mangroves, and seagrasses for coastal protection and biodiversity;
 - ii. Strengthening community-based adaptation using local knowledge for effective, culturally appropriate strategies;

- iii. Developing climate-resilient infrastructure, including adaptive construction and planned relocations where necessary;
 - iv. Promoting sustainable livelihoods by diversifying income sources away from climate-vulnerable activities;
 - v. Improving research and monitoring to better understand and provide early warnings of climate impacts;
 - vi. Strengthening policy and governance by integrating climate adaptation into development plans and securing necessary funding.
- v. Incorporating climate adaptation strategies by raising awareness and building resilience;
 - vi. Culturally sensitive educational programs to bridge knowledge gaps, teaching younger generations about marine conservation traditions;
 - vii. Supporting community engagement in marine protected areas by leveraging social structures and spiritual leaders, and developing eco-tourism that integrates cultural elements, education, and local livelihoods.

7. Opportunities from social threats include:

- i. Empowering community-led conservation with local ownership through education, dialogue, and direct reef management involvement;
- ii. Developing sustainable alternative livelihoods to reduce dependence on reef resources by supporting new, eco-friendly income sources;
- iii. Strengthening social cohesion by building trust and collaboration, especially in areas with high immigration;
- iv. Promoting community-based monitoring utilizing

8. The results highlight several key opportunities from an economic point of view, including:

- i. Untapped tourism potential: Significant scope for sustainable eco-tourism and dive tourism.
- ii. Supportive national policies like the Blue Economy Policy.
- iii. Proven Recovery: The Mnemba Island case demonstrates that degraded reefs can recover with effective management.
- iv. New livelihood opportunities for communities in mariculture and other alternative activities.

v. Access to climate finance which is the potential for funding marine conservation through climate and carbon credit initiatives.

9. Politically related opportunities emanating from the results included:

i. Strengthened Governance: Insufficient enforcement (22%) and outdated laws (11%) open the door for capacity building in enforcement agencies and urgent legal reform to modernize and effectively implement coral protection policies.

ii. Public engagement boost: The high unawareness (40%) is an opportunity for massive public education and awareness campaigns about social, economic, and political impacts on reefs, fostering greater citizen support and action

iii. Enhanced Participation: "Inadequate participation is an opportunity to empower local communities through participatory management frameworks (e.g., expanding Community-Based Marine Management initiatives) and ensure their voices are heard in policy decisions.

iv. Strategic investment: The mention of increased investments presents a chance

to advocate for environmentally sound development and explore blue economy financing that directly benefits coral reef conservation.

v. Political Leverage: The use of election campaigns highlights an opportunity to integrate coral reef issues into political agendas, securing commitments from candidates and parties.

vi. Optimized Funding: Insufficient funding is a call to seek and allocate more dedicated resources for coral reef conservation, including innovative financing mechanisms.

10. Opportunities that arise from participation in coral reefs decision-making process include

i. Strengthen Community-Based Management: Build upon the existing involvement of community groups (e.g., BMUs, VLCs) by empowering them with more resources, training, and decision-making authority.

ii. Enhance Inclusivity: Develop targeted strategies to engage the 67% of uninvolved community members, addressing their concerns about being overlooked and fostering a sense of ownership.

- iii. Improve feedback mechanisms: Establish clear and consistent channels for providing feedback to communities on how their input and data are being used in conservation efforts.
- iv. Leverage local knowledge: Integrate valuable local ecological knowledge, as demonstrated by the sardine net size amendment, into scientific assessments and management plans.
- v. Address cultural barriers: Develop community-led initiatives and strengthen local governance to overcome challenges like “muhal” (nepotism) and promote collective responsibility.
- vi. Cultivate shared ownership: Implement educational programs and involve communities in direct benefits-sharing to foster a stronger sense of ownership and stewardship over coral reefs.
- vii. Advocate for Policy Reform: Utilize the strong consensus on systemic improvements (better participation, streamlined bureaucracy, national coordination) to push for policy changes that support more inclusive and effective management.

11. The results reveal several significant opportunities related to technology and coral conservation:

- i. Scaling Up Coral Restoration: The existing use of technological restoration in Tanga and Kilwa presents an opportunity to further develop, expand, and innovate these methods for wider application.
- ii. Optimizing fisheries management: Technologies like Potential Fishing Zones (PFZ) offer a chance to guide fishers to more productive areas.
- iii. Strengthening marine enforcement and monitoring: Advanced technologies can enable more effective detection and prevention of illegal and destructive fishing practices.
- iv. Empowering artisanal fishers by introducing appropriate and accessible technologies (e.g., simple navigation tools for PFZs) to local fishers
- v. Fostering Green Marine Technology and Research: The identified “unknown potential negative impacts” of certain technologies create an urgent opportunity for dedicated research into eco-friendly marine technologies and for developing strategies to mitigate any adverse effects of existing ones.

- vi. Informing proactive policy development: there is a need and opportunity to establish forward-thinking policies and regulations that guide the responsible and sustainable use of technology in marine environments, ensuring environmental protection keeps pace with technological advancements.
- 12. The findings, despite showing a current lack of traditional marine knowledge, highlight several key opportunities to boost conservation efforts.**
- i. Revitalization of traditional ecological knowledge by integrating community-based restoration and management, and by collaborating with scientists to study and apply historical observations like coral sounds or traditional navigation.
 - ii. There's an opportunity for culturally sensitive education to bridge the knowledge gap, teaching younger generations about their heritage of marine conservation.
 - iii. Promote modern conservation ethics by drawing on the historical respect for coastal ecosystems embedded in past taboos.
 - iv. Enhance sustainable management by incorporating traditional fishing calendars based on stars and monsoon winds, and by emphasizing the historical ethos of responsible harvesting found in oceanic rituals.
 - v. (v) Community engagement in marine protected areas, leveraging existing social structures and spiritual leaders to ensure local buy-in, and also in developing eco-tourism that features cultural depth, offering both conservation education and alternative livelihoods.



5.0 CONCLUSIONS

- i. The findings reveal a high level of profound dependence (83%) on coral reefs for the livelihoods of respondents, with the vast majority depending on corals for subsistence and income generation. A significant barrier identified is limited access to financial services, with 65% of respondents having no access to credit. It highlights a concerning trend of declining income for half of the population, primarily due to factors like fewer fish, increased competition, and climate change. However, it also points to positive developments, where improved fishing practices and market conditions have led to increased income for others. A significant hurdle identified is the widespread lack of access to financial services, which leaves a large portion of the community vulnerable and limits their ability to adapt and diversify. This underscores the urgent need for targeted interventions that not only support the sustainable management of coral reefs but also enhance financial inclusion to build more resilient and prosperous coastal livelihoods.
- ii. The findings show that human activities are the primary threats facing the coral reef ecosystem. Unsustainable fishing, overfishing, pollution, and climate change are the biggest threats, worsened by coastal development and unregulated tourism. Although the crown-of-thorns starfish is a natural threat, its outbreaks are worsened by the loss of its predators, often linked to human impacts. Despite these issues, the research also highlights key ecological opportunities, emphasizing how mangroves, seagrasses, and coral reefs are connected.
- iii. Most respondents (67%) reported fewer fish, a view supported by an elderly resident who noticed the disappearance of certain species and a sharp drop in catches. An expert explained that while total catch might seem higher because of more boats, the “catch per unit effort” has fallen, confirming a real decline in fish availability.
- iv. Over the past decade, unsustainable fishing has increased significantly, driven by higher fish demand. About 65% of respondents confirmed these changes, noting destructive methods like drag and seine nets. Fishery experts agree, observing a decline in coral diversity from past dynamite fishing and current metal hook octopus fishing that

breaks reefs. While dynamite fishing has decreased, harmful practices like shallow ring nets, sand sinkers, metal rods for octopus, and abandoned sandbag anchors are on the rise, threatening coral reefs overall.

- v. Various forms of pollution affect coastal reefs, including domestic waste, sewage, plastics, and debris, as well as less-studied threats like microplastics, oil spills, and agricultural chemicals. These impacts include physical damage, coral bleaching from turbidity, reduced photosynthesis, impaired feeding, and increased contaminant exposure due to microplastics.
- vi. Climate change is affecting coastal areas, with local observations and experts noting rising temperatures, unpredictable rainfall, stronger storms, and high winds. These changes are linked to widespread coral bleaching, caused by increasing ocean temperatures. Rising sea levels and heavy rains cause sedimentation that smothers corals, and rising sea levels are visible through submerged structures and nearly submerged villages.
- vii. Social threats like climate change and lack of community awareness are major drivers of coral reef decline. These issues, combined with greater resource dependence and immigration, highlight the urgent need for community-led efforts, education, and sustainable livelihoods to protect these ecosystems long-term.
- viii. Economic activities such as destructive fishing, coastal development, overfishing, and unsustainable tourism threaten Tanzania's reefs. The Mnemba Island case shows how unchecked tourism damaged reefs, but successful recovery efforts are ongoing. The aquarium trade also poses an unmeasured but potentially serious threat. Reefs' decline harms local communities relying on these resources. But strategies like promoting sustainable fishing, funding alternative livelihoods, and supporting eco-tourism are vital for reef health. Healthy reefs provide economic value as habitats and tourist attractions. With policies like the Tanzanian National Blue Economy Policy (2024), there is a strong framework to balance economic growth with reef conservation. Based on the Likert scale results, the perceived threat level to reefs is high across all areas—conservation, socioeconomic,

and climate change. Destructive fishing methods like dynamite, ring netting, and beach seining are seen as severe threats by most respondents. Overfishing is also a major concern. Pollutants such as plastics, debris, oil spills, and chemicals are also viewed as highly threatening. Climate change and variability are seen as overarching threats by most.

- ix. The findings highlight a substantial gap in public awareness regarding the political threats impacting coral reefs, with a substantial portion (40%) of respondents unaware of any such dangers. Among those who did identify political threats, insufficient enforcement of existing regulations emerged as the primary concern, followed by outdated legislation and challenges related to public participation and awareness of relevant laws. The less frequently cited concerns of increased investments, election campaigns, and insufficient funding also point to diverse political pressures on these vital ecosystems.
- x. Regarding participation, the study reveals that most communities were not involved in coral reef decision-making processes, feeling unheard and disempowered. While some participate by providing data in filling out questionnaires or in local meetings, they often lack feedback. Cultural barriers like “muwali” (nepotism) hinder enforcement, and mixed perceptions of ownership highlight a disconnect in current management.
- xi. Technological factors are generally seen as an opportunity for coral conservation rather than a threat, primarily because local fishers lack sophisticated gear for deep-sea fishing. While there’s a noted concern about potential negative impacts from generator use (light pollution, oil spills), this is currently overshadowed by the positive view of technology’s role in coral restoration and management. Experts believe advancements like potential Fishing Zones (PFZ) and improved monitoring can significantly reduce pressure on reefs. However, it’s crucial to acknowledge that the full scope of negative technological impacts is still unknown and requires careful consideration, as emphasized by Gibbs (2021) regarding the social implications of upscaling restoration technologies.
- xii. While most people today don’t use traditional methods for marine and coral reef conservation, there’s a clear history of such practices. A few elders could attest to this. These traditions show a deep

respect for nature and include smart ways of managing resources, like identifying corals by sound, using stars to predict fishing conditions, and understanding monsoon winds for fishing seasons. Old oceanic rituals, taboos, and totems also highlight a spiritual side to conservation. These practices used beliefs

about spiritual entities to guide behavior and protect coastal areas from harm. However, these valuable traditions are largely unused now, suggesting a break from ancestral wisdom. Bringing back some of these traditional approaches could greatly help modern efforts to conserve marine and coral reef ecosystems.



7.0 RECOMMENDATIONS

- i. Strengthen Sustainable Practices: including Promoting and providing access to sustainable fishing gear. Additionally, initiatives should focus on climate change adaptation by integrating resilient strategies into livelihood programs and investing in coral reef restoration and conservation to enhance fish habitats. Moreover, there is a need to boost financial inclusion by a critical step is access to affordable and appropriate financial services like credit, savings, and insurance tailored for fishing communities. This involves strengthening and expanding community-based microfinance institutions and offering essential financial literacy and business management training. Exploring innovative financial mechanisms that link conservation with financial returns is also key. Additionally, support livelihood diversification into non-fishing activities like agriculture, small businesses, or sustainable tourism. This includes providing vocational training, technical assistance, and initial capital. Likewise, developing value chains for sustainable marine products can also add value and create new income streams, reducing over-reliance on traditional fishing.
- ii. Based on biodiversity, ecology, and environmental threats, it is recommended to focus on mitigating human-induced threats, especially unsustainable fishing practices, overfishing, pollution, and climate change. Protecting and restoring interconnected ecosystems like mangroves and seagrasses is vital, as they benefit each other by filtering runoff and buffering currents, thus safeguarding both themselves and the coral reefs. Addressing the potential threat of crown-of-thorns starfish outbreaks—possibly through predator protection or direct management—also deserves attention.
- iii. To counter declining fish populations, it is advised to implement and strictly enforce comprehensive sustainable fisheries management strategies, along with significant investment in aquaculture development and diversification of coastal livelihoods. This multi-pronged approach will reduce pressure on wild stocks, offer alternative food sources and income, and promote a more resilient, sustainable marine ecosystem.
- iv. To combat destructive fishing methods, we suggest strengthening enforcement

through stricter regulations against harmful fishing practices, encouraging and subsidizing the use of eco-friendly gear, and funding coral reef rehabilitation programs. Additionally, supporting alternative livelihoods for fishers, raising public awareness about responsible seafood choices and the impacts of destructive fishing, increasing surveillance to detect and prevent illegal activities, and promoting sustainable gear are vital.

v. Regarding pollution threats, we recommend improving waste and sewage management via better treatment facilities, enhanced waste collection and recycling, and combating plastic pollution through education and policy measures. Further, there is a need to increase research on microplastics, oil spill impacts, and agricultural chemical threats to corals, coupled with regular environmental monitoring. Enforcing and updating environmental laws, developing specific anti-pollution policies, adopting integrated coastal zone management, and involving communities through environmental education, cleanup activities, and waste initiatives are essential. Restoring ecosystems like coral reefs and mangroves,

expanding protected areas, and strengthening inter-sectoral and international cooperation will support pollution control efforts.

vi. Addressing climate change-related threats, key recommendations include prioritizing Ecosystem-Based Adaptation (EbA) by investing in the restoration and protection of coral reefs, mangroves, and seagrasses as natural coastal defenses; implementing robust coastal zone management with climate-informed land-use plans that consider sea-level rise and potential relocation; supporting diversification towards climate-resilient livelihoods; improving early warning systems for extreme weather; and investing in research, monitoring, and capacity building, while empowering communities with adaptation knowledge. Fostering collaboration between local and scientific knowledge is critical.

vii. Concerning social threats, we recommend empowering local communities through support for community-led education, dialogue, and direct involvement in reef conservation; creating sustainable livelihoods by investing in alternative income sources to reduce dependence on destructive practices; fostering social cohesion by

- building trust and collaboration; strengthening local monitoring with community participation; and integrating climate adaptation strategies into community planning.
- viii. To protect coral reefs and promote sustainable economic growth, we suggest enforcing sustainable fishing by controlling destructive practices and promoting eco-friendly methods, regulating coastal development with rigorous environmental assessments, managing tourism responsibly through capacity limits and education, and investing in alternative livelihoods to reduce reliance on reef resources. Additionally, we should research the impacts of the aquarium trade on coral populations and formulate regulations to control the trade, leverage national policies like Tanzania's Blue Economy Policy, and bolster monitoring and scientific research for better management.
- ix. To enhance political influence on coral reef conservation and sustainability, we recommend raising public awareness through targeted campaigns, increasing enforcement efforts with stricter penalties, modernizing legislation to address emerging threats, creating accessible avenues for public participation, prioritizing funding for conservation, and engaging political candidates to secure commitments for reef protection.
- x. For effective community engagement, we propose establishing inclusive participation frameworks, improving feedback mechanisms to build trust, strengthening local capacity, integrating local ecological knowledge, addressing cultural barriers such as nepotism, fostering shared ownership through awareness campaigns and benefits-sharing, and advocating systemic reforms like streamlined bureaucracy and a national marine conservation body.
- xi. The recommendations emphasize a dual approach combining technology and conservation efforts: promoting beneficial technologies for monitoring and restoration, assessing and mitigating risks with impact assessments, educating stakeholders about potential hazards, involving communities in tech development, and establishing regulations for sustainable technological use.
- xii. To preserve fading traditional marine conservation knowledge, we advise documenting and archiving oral histories, integrating traditional wisdom

with modern practices (like aligning fishing with monsoon wind patterns), encouraging intergenerational knowledge transfer, exploring cultural and spiritual conservation aspects,

empowering communities to lead tradition-based initiatives, and investigating reasons behind the decline of traditional practices to inform revival efforts.



8.0 REFERENCES

- Arnstein, S.R. (1969) "A Ladder of Citizen Participation," *Journal of the American Planning Association*, Vol. 35, No. 4, pp. 216-224.
- Boult, M., Jassal, V., de Souza, R. S., Byatt, G., Kirkman-Page, J., Smith, K., ... & Glennie, C. (2018). *Horizon Scanning: A Practitioner's Guide*.
- Chauka, L. J., & Nyangoko, B. P. (2023). Climate change impacts outweigh conservation efforts in coral reefs that are highly exposed to thermal stresses in Zanzibar, Tanzania. *Ocean & Coastal Management*, 238, 106575. <https://doi.org/10.1016/j.ocecoaman.2023.106575>
- Chauka, L.J., & Nyangoko, B. P. (2023). Climate change impacts outweigh conservation efforts in coral reefs that are highly exposed to thermal stresses in Zanzibar, Tanzania. *Ocean & Coastal Management*, 238, 106575.
- Chauka, L.J. (2016). Tanzanian Reef Building Corals May Succumb to Bleaching Events: Evidences from Coral-Symbiodinium Symbioses. In: Diop, S., Scheren, P., Ferdinand Machiwa, J. (eds) *Estuaries: A Lifeline of Ecosystem Services in the Western Indian Ocean*. *Estuaries of the World*. Springer, Cham. https://doi.org/10.1007/978-3-319-25370-1_10
- Dee, L. E., Horii, S. S., & Thornhill, D. J. (2013). Conservation and management of ornamental coral reef wildlife: Successes, shortcomings, and future directions. *Biological Conservation*, 169, 225-237. <https://doi.org/10.1016/j.biocon.2013.11.025>
- Dipper F. 2022. Human impacts 2: problems, mitigation and conservation. In *Elements of Marine Ecology (Fifth Edition)* Pg 459-511
- ECOSOC Humanitarian Affairs Segment, 2006, 'Addressing Gender-based violence in Humanitarian Emergencies, "Gender-based violence and the role of the UN and its Member States' [www.un.org/docs/ecosoc/meetings/2006/docs/Presentation%20Mr.%20Michel.pdf].
- Elma, E., Gullström, M., Yahya, S. A., Jouffray, J. B., East, H. K., & Nyström, M. (2023). Post-bleaching alterations in coral reef communities. *Marine Pollution Bulletin*, 186, 114479.
- Englong, A., Punwong, P., Marchant, R., Seelanan, T., Wynne-Jones, S., & Chirawatkul, P. (2023). High-Resolution Multiproxy Record of Environmental Changes and Anthropogenic Activities at Unguja Ukuu, Zanzibar, Tanzania during the Last 5000 Years. *Quaternary*, 6(1), 21.

- Erftemeijer, P. L., Riegl, B., Hoeksema, B. W., & Todd, P. A. (2012). Environmental impacts of dredging and other sediment disturbances on corals: a review. *Marine pollution bulletin*, 64(9), 1737-1765.
- Gibbs, M. T. (2021). Technology requirements, and social impacts of technology for at-scale coral reef restoration. *Technology in Society*, 66, 101622. <https://doi.org/10.1016/j.techsoc.2021.101622>
- Gustavsson, M., Lindström, L., Jiddawi, N. S., & De la Torre-Castro, M. (2014). Procedural and distributive justice in a community-based managed Marine Protected Area in Zanzibar, Tanzania. *Marine Policy*, 46, 91-100. <https://doi.org/10.1016/j.marpol.2014.01.005>
- Heron, S. F., Eakin, C. M., Douvère, F., Anderson, K. L., Day, J. C., Geiger, E., ... & Obura, D. O. (2017). Impacts of climate change on World Heritage coral reefs: a first global scientific assessment.
- Jones, R., Giofre, N., Luter, H. M., Neoh, T. L., Fisher, R., & Duckworth, A. (2020). Responses of corals to chronic turbidity. *Scientific Reports*, 10(1), 1-13. <https://doi.org/10.1038/s41598-020-61712-w>
- Keeley, E. J. (2006). How to conduct a SWOT analysis.
- Machumu, E. W., & Shukuru, M. V. (2024). Assessment Of the Rate of Sedimentation at The Entrance Channel of the Dar Es Salaam Harbour. *African Journal of Land Policy and Geospatial Sciences*, 7(4), 1111-1122.
- Mai, T. (2024). Assessing the impacts of anthropogenic activities on coral reef health in Ushongo, Tanzania using coral diversity and parrotfish abundance as indicators.
- Mbije, Nsajigwa Emmanuel (2023) *Tanzanian Coral Reef in Peril, are we Fighting a Losing Battle?* In: *Novel Perspectives of Geography, Environment and Earth Sciences Vol. 8*. B P International, pp. 68-88. ISBN 978-81-19315-54-3
- McClanahan, T. R., Muthiga, N. A., Maina, J., Kamukuru, A. T., & Yahya, S. A. (2009). Changes in northern Tanzania coral reefs during a period of increased fisheries management and climatic disturbance. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 19(7), 758-771.
- Miller M, Karazsia J, Groves C, Griffin S, Moore T, Wilber P, Gregg K. 2016. Detecting sedimentation impacts to coral reefs resulting from dredging the Port of Miami, Florida, USA. *PeerJ*, 4, e2711.

- Muhando, C. A. (2009). Coral reef monitoring in Tanzania: an analysis of the last 20 years. *Western Indian Ocean Journal of Marine Science*, 8(2).
- Nchimbi, A. A., Shilla, D. A., Kosore, C. M., Shilla, D. J., Shashoua, Y., & Khan, F. R. (2022). Microplastics in marine beach and seabed sediments along the coasts of Dar es Salaam and Zanzibar in Tanzania. *Marine Pollution Bulletin*, 185, 114305.
- Obura, D.O., Tamelander, J., & Linden, O. (Eds) (2008). Ten years after bleaching, facing the consequences of climate change in the Indian Ocean. *CORDIO Status Report 2008*. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC. Mombasa. <http://www.cordioea.org>
- Pacey, K. I., Caballes, C. F., & Pratchett, M. S. (2022). Size-weight relationships for estimating harvestable biomass of *Acropora* corals on Australia's Great Barrier Reef. *Marine Environmental Research*, 177, 105633. <https://doi.org/10.1016/j.marenvres.2022.105633>.
- Rahman, M. N., Shozib, S. H., Akter, M. Y., Islam, A. R. M. T., Islam, M. S., Sohel, M. S., Kamaraj, C., Rakib, M. R. J., Idris, A. M., Sarker, A., & Malafaia, G. (2023). Microplastic as an invisible threat to the coral reefs: Sources, toxicity mechanisms, policy intervention, and the way forward. *Journal of Hazardous Materials*, 454, 131522. <https://doi.org/10.1016/j.jhazmat.2023.131522>
- Ribot, J. C., & Peluso, N. L. (2003). A theory of access. *Rural sociology*, 68(2), 153-181.
- Riegl, B., Bruckner, A., Coles, S. L., Renaud, P., & Dodge, R. E. (2009). Coral Reefs. *Annals of the New York Academy of Sciences*, 1162(1), 136-186. <https://doi.org/10.1111/j.1749-6632.2009.04493.x>
- Rwamugira, R. (2022). Influence of stakeholders participation on sustainability of community development projects with a case study of EU-WWF fisheries co-management (fishcom) project at Kilwa, Kibiti and Kigamboni Districts, Tanzania (Doctoral dissertation, IAA).
- Soares, M. D. O., Matos, E., Lucas, C., Rizzo, L., Allcock, L., & Rossi, S. (2020). Microplastics in corals: An emergent threat. *Marine Pollution Bulletin*, 161, 111810. <https://doi.org/10.1016/j.marpolbul.2020.111810>
- Souter, D., Obura, D., & Linden, O. (2000). Coral reef degradation in the Indian Ocean. Status report.

Stafford-Smith, M.G. 1992. Mortality of the hard coral *Leptoria phrygia* under persistent sediment influx. In: Proceedings of the VII International Coral Reef Symposium, Guam, Vol. 1 p. 289-299.

White, A. T., Vogt, H. P., & Arin, T. (2000). Philippine coral reefs under threat: the economic losses caused by reef destruction. *Marine Pollution Bulletin*, 40(7), 598-605.

Yanda, P. Z., Mwajombe, A. R., & Gwambene, B. (2023). Coastal communities' livelihoods conditioned by resource use dynamics and changing environments in Lindi Region, South-Eastern Tanzania. *Marine Policy*, 150, 105532. <https://doi.org/10.1016/j.marpol.2023.105532>

