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Assessment of the Impact of Anthropogenic Activities on the Coastal Areas of the Indian Ocean: A Case of Bagamoyo, Tanzania

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Abstract

This study assesses the impact of anthropogenic activities on the coastal environment of Bagamoyo, Tanzania, with a focus on identifying pollution sources and understanding their long-term implications on coastal ecosystems and local communities. Using a qualitative case study approach, data were gathered through structured interviews, questionnaires, and direct observations across five coastal beaches: Kaole, Mbegani, Badeko, Msalabani, and Mwaroni. A total of 76 respondents, including fishermen, boat drivers, and tourist guides, provided insights into the primary pollutants, including plastic waste, iron remnants, food debris, and plant debris from mangroves. The findings reveal that fishing, tourism, and unregulated coastal construction are the primary drivers of pollution, contributing to both environmental degradation and socio-economic risks, such as the disruption of marine ecosystems and threats to livelihoods. The study highlights the urgency of addressing these issues through strengthened waste management practices, community engagement, and stricter enforcement of environmental laws. Additionally, the research underscores the need for integrated coastal management strategies that balance economic activities with environmental protection. These findings contribute to the broader discourse on sustainable coastal development by offering practical recommendations for local authorities, policymakers, and non-governmental organizations. The study advocates for a collaborative approach that ensures the long-term sustainability of Bagamoyo's coastal regions while protecting both the environment and the local economy.

Keywords

Coastal Pollution, Anthropogenic Activities, Environmental Degradation, Sustainable Coastal Management, Bagamoyo

1. Introduction

Anthropogenic damage to oceans has been ongoing for decades, primarily driven by industries such as fishing, land development, and oil and gas extraction. Initially, it was widely believed that the vastness and resilience of the ocean would prevent significant harm from human activities. However, modern evidence reveals that this assumption was deeply flawed. Increasing global populations and heightened consumption patterns have led to the expansion of ocean-reliant industries, often operating with unsustainable practices. As these industries grow, the degradation of marine environments intensifies, resulting in negative impacts on aquatic ecosystems, the overall environmental health of the planet, and the well-being of human communities dependent on these resources. The scale of human influence is alarming, with only 13% of the ocean remaining untouched by human activity, emphasizing the urgency for more responsible environmental stewardship (Jones, 2018).

Coastal areas, where the land meets the sea, are critical zones that provide a wide range of ecological and economic benefits. These areas are defined as strips of land extending from the coastline to where the land rises inland, and they serve as important interfaces between air, land, and sea (Vikas & Dwarakish, 2015). The World Health Organization (WHO) defines coastal pollution as the introduction of harmful substances whether from human activities directly or indirectly into marine environments, which can have serious repercussions on marine life, human health, and the usability of sea water for various purposes. Coastal areas support key services, such as climate regulation, biodiversity conservation, and recreational activities (Ocean & Climate Platform, 2022). Coastal areas support essential provisioning, regulating, supporting, and cultural services, including fisheries, climate regulation, biodiversity conservation, shoreline protection, and recreation (Agardy et al., 2005; Ocean & Climate Platform, 2022). Additionally, nearly 40% of the global population lives within 100 kilometers of the coastline, underscoring the economic and social importance of these zones (Tallis et al., 2012). However, despite these critical roles, coastal areas are increasingly subjected to harsh environmental pressures from both natural forces and human activities, requiring more focused efforts in sustainable coastal management.

In Tanzania, Bagamoyo stands out as a key coastal region, essential to both environmental conservation and the livelihoods of local communities. The Bagamoyo coastline supports various economic activities such as fishing, tourism, and small-scale agriculture, all of which are highly dependent on the health and stability of the coastal ecosystem. However, the rapid growth of these activities, combined with inadequate regulation, has made the region highly vulnerable to environmental degradation. Uncontrolled construction, improper waste disposal, and over-exploitation of marine resources have led to significant pollution levels. This threatens not only the ecological health of the coastal region but also the long-term viability of the local economy, which relies heavily on these natural resources. Bagamoyo serves as a microcosm of the broader challenges faced by many

coastal areas in Tanzania, where the balance between economic development and environmental conservation is increasingly difficult to maintain.

Several studies have explored pollution levels in Tanzania's coastal areas, shedding light on the severity of the problem. For instance, Machiwa (2010) investigated the contamination of coastal waters in the West Indian Ocean, focusing on microbial pollutants and heavy metals, and found that pollution levels in Tanzanian waters exceeded recommended environmental quality targets (EQTs). Similarly, Maione (2019) studied the emergence of plastic pollution on tourism beaches in Zanzibar and Bagamoyo, identifying the tourism industry as a significant contributor to coastal pollution. Despite these important findings, many of these studies offer broad assessments of pollution but fall short of providing a detailed analysis of the specific activities driving pollution in coastal regions like Bagamoyo. This study aims to address this gap by examining the direct relationship between human activities and coastal pollution in Bagamoyo, offering insights into the specific drivers of pollution and proposing actionable strategies for more effective coastal management in Tanzania.

Based on the identified gap, this study was guided by the following specific objectives: first, to identify the main anthropogenic activities contributing to coastal pollution in Bagamoyo; second, to examine the types and sources of pollution observed across selected beaches in Bagamoyo; and third, to assess the perceived environmental and socio-economic impacts of coastal pollution on local communities and coastal-based livelihoods. Accordingly, the study addressed the following research questions: What anthropogenic activities contribute to coastal pollution in Bagamoyo? What types and sources of pollution are commonly observed along Bagamoyo's beaches? How does coastal pollution affect the environment, livelihoods, and socio-economic activities of coastal communities in Bagamoyo?

2. Literature Review

2.1. Global Impact of Anthropogenic Activities on Coastal Ecosystems

Human activities have increasingly shaped coastal ecosystems across the globe, leading to a variety of environmental changes that rival natural geological processes. Waters et al. (2016) describe how rapid urbanization, industrialization, and agricultural expansion have significantly altered the natural landscapes and sedimentary processes of coastal regions. These anthropogenic pressures result in the degradation of coastal ecosystems, with consequences for biodiversity, water quality, and the sustainability of marine resources. Coastal vegetation and dune habitats are particularly sensitive to land-cover modification because changes in vegetation structure can weaken ecological stability and accelerate coastal degradation (Acosta et al., 2005). The conservation of different coastal habitat types is also important because some dune habitats make disproportionately important contributions to coastal plant-species diversity (Acosta et al., 2009). The erosion of coastal land, habitat destruction, and pollution are direct results of human activi-

ties, often exacerbated by the increased demand for resources driven by population growth and economic development. For example, industrial discharge and untreated wastewater are common sources of pollution, carrying heavy metals, chemicals, and organic pollutants into marine environments, thus disrupting marine life and endangering public health.

Globally, the issues faced by coastal regions are multifaceted, affecting not only environmental conditions but also social and economic dynamics. Overfishing, pollution from industrial and agricultural runoff, and unsustainable tourism practices have become major contributors to the degradation of coastal ecosystems. Hooke et al. (2012) highlight the cumulative impact of these activities, including increased sedimentation, habitat loss, and the alteration of nutrient cycles in coastal waters. These effects are not limited to developed nations but are increasingly evident in developing countries, where regulatory frameworks are often weaker, and enforcement of environmental protections is limited. This global perspective underscores the need for comprehensive management strategies that address the environmental, social, and economic dimensions of coastal sustainability.

2.2. Coastal Pollution in Tanzania: A Growing Concern

In Tanzania, the impacts of global environmental issues are particularly pronounced in its coastal areas, which are crucial to both local livelihoods and the national economy. Tanzanian coastal regions, including Dar es Salaam and Bagamoyo, are facing severe pollution challenges due to the discharge of untreated wastewater and industrial effluents directly into the ocean. Machiwa (2010) conducted a study on the levels of microbial contamination and heavy metals in coastal waters in Dar es Salaam and found alarming results, highlighting the direct threat these pollutants pose to marine ecosystems and human health. The study pointed out that these contaminants not only degrade water quality but also accumulate in marine organisms, affecting the food chain and putting local communities at risk due to their reliance on seafood.

Furthermore, Mohammed (2003) reviewed water quality and pollution studies in Tanzania, revealing that inadequate waste treatment infrastructure is a significant contributor to coastal pollution. The rapid growth of urban centers along the Tanzanian coastline has led to a surge in domestic and industrial waste, which is often discharged without proper treatment. This pollution jeopardizes marine life, damages coral reefs, and leads to the depletion of fish stocks, which are vital for local communities. Other destructive anthropogenic practices, including illegal and destructive fishing methods, have also historically threatened Tanzania's marine habitats and fishery resources (Slade & Kalangahe, 2015). The increasing levels of pollution in Tanzania's coastal waters, coupled with limited regulatory enforcement, indicate a need for stronger waste management systems and more comprehensive environmental policies to protect these critical ecosystems.

2.3. Tourism and Plastic Pollution in Tanzanian Coastal Regions

Tourism, a key economic driver in coastal Tanzania, has brought both benefits and significant environmental challenges. As tourism has grown in regions like Zanzibar and Bagamoyo, so too has the problem of plastic pollution. Maione (2019) found that the tourism sector is a major contributor to the accumulation of plastic waste along the Tanzanian coastline, particularly in popular tourist destinations. Beaches once known for their pristine conditions are now littered with plastic bottles, bags, and other debris left by visitors. The lack of effective waste management systems exacerbates this problem, as local authorities are often ill-equipped to handle the volume of waste generated by both tourists and local residents.

This issue of plastic pollution has far-reaching consequences. The plastic waste not only affects the aesthetic value of these beaches, which are a major attraction for tourists, but also poses a threat to marine life. Marine animals often mistake plastic debris for food, which can lead to ingestion, entanglement, and death. Furthermore, plastic breaks down into microplastics, which are difficult to remove from the environment and can accumulate in marine food chains, ultimately affecting human health. Ngowi (1997) argued that Tanzania's marine environmental protection laws need to be strengthened to address these growing challenges, particularly in high-tourism areas. Despite the existence of environmental regulations, enforcement remains weak, and the legal framework does not fully account for the specific pressures that tourism places on coastal ecosystems.

2.4. The Role of Mangroves in Coastal Protection and the Impact of Human Activity

Mangrove forests are a critical component of coastal ecosystems in Tanzania, providing natural barriers against coastal erosion and supporting marine biodiversity. However, human activities such as deforestation, agriculture, and urban development have led to the degradation of mangrove forests along Tanzania's coast (Tallis et al., 2012). These forests play an essential role in protecting coastlines from the effects of storms and rising sea levels, while also serving as nurseries for many marine species. The destruction of mangroves, therefore, not only increases the vulnerability of coastal areas to environmental threats but also disrupts the ecological balance necessary for the sustainability of local fisheries.

Krushelnytska (2018) highlighted the need for better implementation of environmental policies aimed at protecting mangrove ecosystems. Although national policies in Tanzania recognize the importance of mangroves, enforcement remains inconsistent, with many areas continuing to face illegal logging and land conversion. The degradation of mangroves has a direct impact on the livelihoods of coastal communities, particularly those dependent on fishing and tourism. Without the protection offered by mangroves, coastal erosion intensifies, further threatening the integrity of coastal ecosystems and the economic activities they support. This calls for more robust conservation efforts, including community-

based initiatives and stricter enforcement of existing environmental laws to ensure the long-term sustainability of Tanzania's coastal regions.

3. Methodology

This study employed a case study approach to investigate the impact of anthropogenic activities on coastal pollution in Bagamoyo, Tanzania. The case study design was selected because it allows for an in-depth exploration of complex environmental and socio-economic issues within a specific context. Bagamoyo, with its blend of economic activities such as fishing, tourism, and small-scale agriculture, provided a suitable setting for examining how these activities contribute to coastal pollution. The research focused on five beaches: Kaole, Mbegani, Badeko, Msalabani, and Mwaroni, all of which are critical to both local livelihoods and the ecological health of the region.

The study used purposive sampling to recruit respondents from the five selected beaches of Kaole, Mbegani, Badeko, Msalabani, and Mwaroni. Respondents were approached at each beach based on their direct involvement in or regular interaction with coastal activities relevant to the study. Fishermen were recruited from landing sites and fishing areas, tourism operators and tour guides were identified around beach-based tourism points, local residents were recruited from nearby coastal settlements and small-scale trading areas, while construction and boat repair workers were recruited from areas where coastal construction, boat maintenance, and repair activities were taking place. The inclusion criteria required respondents to be aged 18 years or above, to have direct experience with the selected beaches, and to be either involved in coastal livelihood activities or regularly exposed to coastal environmental conditions in Bagamoyo.

The study involved 76 respondents in total. Of these, 34 respondents participated in semi-structured interviews, while 42 additional respondents completed structured questionnaires. The two groups were treated as separate participants to avoid double counting and to ensure that the interview and questionnaire data represented distinct respondent inputs. This separation also allowed the interviews to generate detailed qualitative explanations, while the questionnaires provided structured supportive information on the frequency of reported activities, pollution types, and perceived impacts.

Respondent Categories:

Fishermen (45%): A total of 34 respondents were fishermen who operate along the Bagamoyo coastline. These individuals provided valuable insights into the changes in fish populations, breeding grounds, and the impact of pollution on their daily livelihoods. Their perspectives are crucial as they directly experience the consequences of coastal degradation.

Tourist Operators (25%): This group included 19 respondents, primarily tour guides and operators working with local and international tourists. They shared observations about how pollution affects the attractiveness of the beaches, changes in tourist numbers, and the economic implications of declining coastal conditions.

Local Residents (20%): A further 15 respondents were local residents who regularly use the coastal areas for recreation and small-scale commerce. Their input offered a community perspective on issues such as waste management practices, local awareness of pollution, and perceived changes in the coastal environment over time.

Coastal Construction Workers (10%): The remaining 8 respondents were individuals involved in construction and maintenance activities along the coastline, such as boat repair and coastal building projects. They provided information on the disposal of construction waste, the environmental impact of their activities, and the regulatory environment.

Geographic Distribution of Respondents:

Respondents were drawn from five key beaches in the Bagamoyo region: Kaole, Mbegani, Badeko, Msalabani, and Mwaroni. This geographic distribution ensured that data were collected from areas experiencing different levels of human activity and pollution.

Kaole Beach: 21 respondents were from this beach, including a significant number of fishermen and tourism operators, as it is a hub for both activities.

Mbegani Beach: 10 respondents, predominantly involved in boat construction and fishing, provided insights into pollution from iron remnants and fishing waste.

Badeko Beach: 17 respondents, many of whom were small-scale vendors and tourist guides, offered perspectives on the impact of tourism-related waste.

Msalabani Beach: 17 respondents, mostly fishermen, highlighted the effects of construction waste and declining fish stocks.

Mwaroni Beach: 11 respondents included a mix of recreational users and local residents who shared their experiences with plastic debris and general pollution levels.

Demographic Information:

Age Range: The respondents ranged in age from 25 to 54 years, allowing for a diverse set of viewpoints. Younger respondents (25 - 34 years) often emphasized long-term environmental impacts, such as the future of tourism, while older respondents (45 - 54 years) were more focused on immediate economic consequences, like declining fish catches.

Gender: The sample included 58% male and 42% female respondents, reflecting the gender distribution in activities like fishing and tourism in the region. This diversity helped to capture gender-specific challenges and perspectives, such as the impact of pollution on women engaged in beach-based vending activities.

Education Levels: Respondents varied in their levels of education, from primary school to higher education diplomas, particularly among tourism operators. This variation allowed the study to capture different levels of awareness and understanding of environmental regulations and sustainable practices.

Frequency of Beach Use and Activities:

The frequency of beach use varied among respondents, with 60% visiting the

beaches daily, mainly for fishing or work-related activities, while the remaining 40% visited weekly or less frequently for leisure or tourism. This information helped to understand how different activities correlate with observed pollution levels and types.

Types of Activities: Fishing, tourism, construction, and small-scale trade were the primary activities represented. This focus ensured that the study captured a wide range of human interactions with the coastal environment, each contributing differently to pollution patterns.

For this study, a qualitative case study approach was chosen due to its ability to provide an in-depth understanding of complex environmental and socio-economic issues within a specific context. The case study design is particularly suitable when exploring how various anthropogenic activities contribute to coastal pollution, as it allows for detailed examination of interactions between human activities and their impacts on local ecosystems.

This approach is effective because it enables the collection of rich, descriptive data through methods such as interviews, direct observations, and documentary reviews. Semi-structured interviews were conducted to gather detailed insights from key stakeholders, such as local fishermen, tourism operators, and coastal residents, allowing for an understanding of their perceptions and experiences with pollution. Direct observations complemented the interviews, providing visual evidence of pollution types and their distribution across various coastal sites. Additionally, documentary review was employed to analyse secondary data from government reports and previous studies, ensuring a comprehensive understanding of the issue.

The qualitative approach is preferred in this context because it focuses on the depth rather than the breadth of information, making it suitable for exploring phenomena that are not easily quantifiable. It allows the study to capture the nuances and complexities of how different human activities interact with the environment, which might not be fully revealed through quantitative methods alone. Moreover, this method supports the formulation of actionable recommendations tailored to the local context, offering insights that can inform policy decisions and community interventions.

By choosing a qualitative case study methodology, the research ensures a holistic understanding of the problem, aligns with the goal of exploring the underlying causes of coastal pollution, and provides a detailed perspective that can inform sustainable coastal management strategies.

3.1. Data Collection

Qualitative methods were used to gather detailed and nuanced information from the respondents. Data collection involved three primary techniques: interviews, questionnaires, and observations.

Interviews: Semi-structured interviews were conducted with 34 respondents to explore their perceptions of coastal pollution and how their daily activities might

contribute to it. Semi-structured interviews allowed flexibility in questioning, encouraging participants to provide detailed insights while also enabling the interviewer to probe further based on the respondents' answers. These interviews were recorded (with the participants' consent) and later transcribed for analysis.

Questionnaires: A set of structured questionnaires was administered to 42 additional respondents, with a focus on gathering data about the frequency of beach use, types of human activities observed, and awareness of coastal pollution. The questionnaires contained both closed and open-ended questions to capture quantitative data, such as the number of times respondents visit the beach each week, and qualitative data, such as personal experiences with pollution.

Observations: Direct observation was used to document visible pollution on the beaches and note the types of human activities that might be contributing to it. A checklist was used to guide observations, ensuring consistency across the five beaches. Photographs were taken to visually capture the extent and types of pollution (e.g., plastic debris, iron waste, plant debris), and these were later used to complement the data collected from interviews and questionnaires.

To examine how anthropogenic activities, affect coastal pollution, the conceptual framework was developed and used in this study (Figure 1). Seven key elements were established in this study, namely: the trading activities, scraping activities, boat maintenance, Boat construction, recreational activities, agricultural activities and industrial activities.

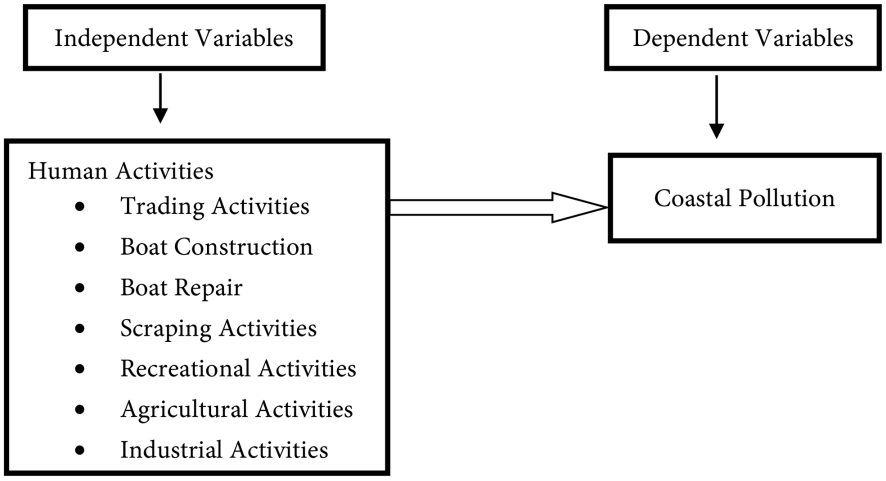

Figure 1. Conceptual framework.

For consistency across the study, anthropogenic activities were grouped into five operational categories. Fishing-related activities refer to fish harvesting, landing-site operations, handling of fishing gear, disposal of nets, and other activities directly connected with fishing livelihoods. Tourism and recreational activities include beach visits, tour guiding, food consumption, recreation, and tourism-related commercial services. Boat construction and repair activities include boat building, scraping, painting, maintenance, and disposal of metal, wood, and other

repair-related residues. Coastal trade and food-vending activities refer to small-scale beach-based selling of food, drinks, and other goods that may generate packaging and food waste. Coastal construction and settlement-related activities include building, maintenance, informal settlement use, and disposal of construction-related materials along or near the beach. These categories were used consistently in the analysis to link observed pollution types with the human activities most commonly reported by respondents and observed at the study sites. Fishing methods and the types of gear employed can influence the quantity and characteristics of fishing-related materials entering the coastal environment (Eyo & Akpati, 1995).

3.2. Data Analysis

The data gathered from interviews, questionnaires, and observations were analyzed using thematic analysis, a method well-suited for identifying patterns and themes in qualitative data. Thematic analysis involves a systematic process of coding and categorizing the data into key themes that reflect the research questions and objectives.

Data Familiarization: The first step involved transcribing the interview recordings and thoroughly reading the questionnaire responses and observation notes. This process allowed for a deep understanding of the data and helped in identifying initial codes.

Coding: The data was then coded using a combination of inductive and deductive coding approaches. Deductive codes were based on the research objectives, such as "sources of pollution" and "types of human activities", while inductive codes emerged from the data itself, capturing new insights that were not anticipated, such as the role of informal waste management practices. Each code was systematically applied to sections of the data that represented similar themes.

Theme Development: Once coding was completed; similar codes were grouped together to form broader themes. For instance, codes related to "plastic waste", "tourism-related pollution", and "iron remnants" were grouped under the theme "Human-induced pollution". Themes such as "economic dependency on the coast" and "perceptions of environmental responsibility" also emerged from the data, offering deeper insights into how local communities view and interact with their coastal environment.

Data Triangulation: To enhance the credibility of the findings, data from interviews, questionnaires, and observations were triangulated. This involved cross-checking the themes identified in one data set with those found in another. For example, observations of plastic waste accumulation were cross-referenced with respondents' reports of improper waste disposal practices from the interviews and questionnaires.

Interpretation and Synthesis: Finally, the themes were interpreted in the context of the research questions, focusing on how different human activities contribute to pollution and the socio-economic implications of this pollution on coastal

communities. The findings were then synthesized to provide a comprehensive understanding of the impact of anthropogenic activities on Bagamoyo's coastal areas.

Although the study adopted a qualitative case study design, questionnaire data were incorporated to support and triangulate the qualitative findings. The questionnaire was not used for statistical hypothesis testing, but rather to organize respondents' perceptions into descriptive categories that could complement interview narratives and direct observations. The percentages reported in the results therefore represent descriptive summaries of respondent reports and should be interpreted as indicative patterns rather than inferential quantitative findings. These descriptive results were integrated with interview themes and field observations during thematic analysis to strengthen interpretation and provide a clearer picture of recurring pollution types, human activities, and perceived socio-economic impacts across the selected beaches.

No statistical comparison was conducted across demographic subgroups such as age, gender, or occupation. Any demographic patterns discussed in the results are therefore presented as descriptive qualitative tendencies emerging from respondents' narratives and questionnaire comments, rather than as inferential quantitative relationships.

3.3. Study Area

The study area refers to the geographical location selected for conducting the investigation. This study was carried out in Bagamoyo, situated at 6.4456˚S and 38.8989˚E. Data were collected by the researchers from five selected beaches: Kaole, Mbegani, Badeko, Msalabani, and Mwaroni, as illustrated in Figure 2 below.

Figure 2. Study area boundary map.

3.4. Ethical Considerations

The study adhered to ethical research guidelines, ensuring that participants were fully informed about the purpose of the study and how the data would be used. Informed consent was obtained from all participants, and their anonymity was guaranteed. Sensitive data were securely stored, and respondents were given the opportunity to withdraw from the study at any time without any consequences.

4. Results and Analysis

The findings from this study provide an in-depth understanding of the sources, types, and impacts of pollution along Bagamoyo's coastline. Data were collected through interviews, questionnaires, and direct observations from five coastal beaches: Kaole, Mbegani, Badeko, Msalabani, and Mwaroni. A total of 76 respondents were involved, and the results reveal significant pollution in these areas, driven by various anthropogenic activities such as fishing, tourism, and coastal construction. This section provides a detailed analysis of the key findings and links them to the broader socio-economic and environmental consequences for the local community.

4.1. Types and Sources of Pollution

The study identified several types of pollution prevalent across the five coastal beaches. Plastic debris, iron remnants, plant waste, and food waste were the most commonly reported pollutants.

Table 1. Multiple-response summary of pollution types observed or reported at Bagamoyo beaches.

Type of Pollution	Number of respondents reporting/ observing the pollutant	Percentage of respondents, n = 76
Plastic debris (bottles, bags)	47	62%
Iron remnants and construction-related waste	23	30%
Plant debris including mangrove leaves and branches	38	50%
Food waste (from beach) Restaurants and food (vending areas)	18	24%

Table 1 is interpreted as a multiple-response summary rather than a mutually exclusive distribution of respondents. For example, one respondent could report observing both plastic debris and food waste, while another could report plastic debris, plant debris, and iron remnants. This explains why the total frequency of reported pollution types exceeds the total number of respondents.

The most frequently observed pollutant was plastic debris, reported by 62% of respondents. This included plastic bottles, packaging materials, and food containers, which were commonly found on all five beaches. The persistence of plastic in the environment, coupled with inadequate waste management systems, contributes significantly to coastal degradation.

Iron remnants were another notable source of pollution, particularly at Mbegani and Msalabani beaches, where ongoing boat construction and repair activities are prevalent. The presence of these iron wastes poses physical hazards and introduces heavy metals into the coastal waters, threatening both marine life and human health.

Plant debris, particularly mangrove leaves and branches, was observed frequently, especially at Kaole Beach. This is linked to the deforestation of mangrove forests in the area, which results in increased amounts of plant waste being washed ashore.

4.2. Socio-Economic Impacts of Pollution

The results of the study reveal that pollution along Bagamoyo's coastline has significant socio-economic impacts, particularly on industries reliant on fishing and tourism. Several respondents working in tourism and fishing expressed concerns about the long-term sustainability of their livelihoods, given the high levels of pollution in the area.

Table 2. Multiple-response summary of socio-economic impacts reported by respondents.

Socio-economic impact	Number of respondents reporting the impact	Percentage of respondents, n = 76
Reduced income from tourism	25	33%
Decline in fish stocks	22	29%
Decreased attractiveness for tourists	28	37%
Health hazards (due to pollution)	14	18%

The results in Table 2 indicate the range of perceived socio-economic impacts associated with coastal pollution rather than separate respondent groups. Since the same respondent could experience or report more than one impact, such as reduced tourism income and declining beach attractiveness, the categories are overlapping. The percentages therefore show the proportion of all respondents who mentioned each impact.

A significant proportion of respondents (37%) reported that the visible pollution along the coastline has made Bagamoyo's beaches less attractive to both local and international tourists. This has resulted in a noticeable decline in tourism revenue, directly affecting local businesses such as hotels, tour guides, and restaurants. Additionally, 33% of respondents indicated a direct reduction in their income from tourism-related activities.

Fishing communities were also notably impacted, with 29% of respondents reporting a decline in fish stocks due to pollution. Fishermen mentioned that pollution, especially plastic debris and metal waste, is disrupting breeding grounds and contaminating marine habitats. This is consistent with global trends, where marine pollution has been linked to declining fish populations and biodiversity loss.

4.3. Long-Term Environmental Impacts on Marine Ecosystems

The environmental consequences of pollution along Bagamoyo's coastline are not limited to immediate aesthetic degradation but pose long-term threats to marine ecosystems. The presence of plastic debris is particularly concerning due to its persistence and ability to break down into microplastics, which can enter the marine food chain. Marine species such as fish, turtles, and seabirds are at risk of ingesting plastic particles, which can cause internal injuries, blockages, and death.

Iron remnants from construction activities contribute to the introduction of heavy metals, such as lead and copper, into the coastal waters. These metals are toxic to marine organisms and can disrupt growth, reproduction, and overall ecosystem health. Over time, the bioaccumulation of these metals in marine organisms can also affect human populations through the consumption of contaminated seafood (Table 3).

Table 3. Environmental impacts of pollution on marine ecosystems.

Pollutant Type	Environmental Impact	Affected Marine Species
Plastic debris	Ingestion by marine animals, habitat destruction	Fish, turtles, seabirds
Iron remnants	Heavy metal contamination, habitat degradation	Fish, coral reefs
Plant debris	Increased organic matter, contributing to shoreline erosion	Coastal vegetation, marine species

4.4. Respondent Demographics and Reported Pollution Experiences

The demographic analysis of the respondents reveals interesting patterns in how pollution is perceived and experienced based on factors such as age, occupation, and frequency of beach visits (Table 4).

Table 4. Demographic distribution of respondents and pollution awareness.

Demographic	Most Reported Pollution Sources	Pollution Impact Focus
Age Group 25 - 34	Plastic debris, tourism-related pollution	Long-term environmental impact
Age Group 45 - 54	Iron remnants, fish stock decline	Immediate economic consequences
Frequent beach users (fishermen)	Construction waste, plastic debris	Economic sustainability, fishing stock depletion
Occasional beach users (tourists)	General littering	Aesthetic and recreational value loss

The demographic responses also suggested some variation in how different age groups perceived the impacts of coastal pollution. However, because the study adopted a qualitative case study design and did not conduct statistical subgroup testing, these differences should be interpreted as descriptive patterns rather than conclusive age-based comparisons. Younger respondents, particularly those within the 25 - 34 age range, tended to express concern about the long-term implications of pollution for tourism, environmental sustainability, and future coastal livelihoods. In contrast, older respondents, particularly those within the 45 - 54 age

range, more frequently emphasized immediate livelihood concerns, including declining fish catches, reduced income, and the day-to-day economic effects of pollution. These observations provide useful qualitative insight into how pollution is experienced differently across respondent groups, but they should not be interpreted as statistically significant differences.

Occupation-based trends: Fishermen and other frequent beach users were more acutely aware of specific pollution sources, such as construction waste and plastic debris, which directly affect their livelihoods. In contrast, tourists and occasional beachgoers reported pollution in more general terms, such as litter or dirty water, without necessarily identifying specific causes (Table 5).

Beach-specific trends: The variation in the types of pollution across different beaches suggests that different human activities are contributing to pollution in different ways. For example, Kaole Beach suffers primarily from plant debris due to deforestation, whereas Mbegani is heavily affected by iron remnants from boat construction. These insights can help local authorities target specific activities and sectors when formulating pollution control measures.

Table 5. Beach-specific pollution trends.

Beach	Main Pollutant	Contributing Activity
Kaole	Plant debris, plastic bottles	Mangrove deforestation, tourism
Mbegani	Iron remnants, plastic bags	Boat construction, tourism
Badeko	Food waste, plastic containers	Beachside restaurants, tourism
Msalabani	Iron waste, fishing gear remnants	Coastal construction, fishing activities
Mwaroni	Plastic debris, plant leaves	Recreational activities, tourism

5. Discussion

The findings of this study illuminate the significant impact of anthropogenic activities on Bagamoyo's coastal environment, with pollution primarily caused by plastic debris, iron remnants, plant waste, and food waste. These pollutants not only degrade the marine ecosystem but also have substantial socio-economic repercussions for the local community. By analyzing the sources of pollution and their effects, this study contributes to the growing body of research that highlights the urgent need for sustainable coastal management strategies.

5.1. Plastic Debris and Its Environmental and Economic Impact

Plastic debris was identified as the most pervasive pollutant across the five coastal areas studied. This is consistent with global patterns, where plastic pollution has become one of the most significant environmental challenges of the 21st century (Derraik, 2002). Plastics are non-biodegradable and break down into microplastics, which persist in marine environments for centuries, posing risks to both marine life and human health. In Bagamoyo, plastic waste, including bottles, packaging, and containers, was frequently (Figure 3, Figure 4).

Figure 3. Plant debris observed along the shoreline.

Figure 4. Accumulation of mixed coastal waste at the study site.

Observed along the shoreline, particularly in areas with high tourist activity. Respondents noted that the unsightly accumulation of plastic has reduced the aesthetic appeal of the beaches, which in turn has negatively affected tourism a key economic sector in the region.

The economic impact of this pollution is profound. As highlighted by Orams (1999), the attractiveness of coastal areas is crucial for sustaining tourism. Beaches are therefore important tourism assets whose environmental quality requires active and continuous management (Orams, 2003). The decline in beach cleanliness has led to fewer tourists visiting Bagamoyo, directly affecting local businesses such as hotels, restaurants, and tour guides. This is a common issue in coastal regions

globally, where the economic benefits of tourism are often offset by the environmental degradation caused by poor waste management (Burak et al., 2004). Furthermore, the respondents' concerns about the impact of plastic pollution on marine species reflect broader environmental issues. Marine animals, including fish, turtles, and seabirds, often ingest plastic, mistaking it for food. This can lead to digestive blockages, malnutrition, and death, as noted by studies like Kühn et al. (2015), which emphasize the fatal consequences of plastic ingestion for marine species.

In addition, microplastics present in the water can accumulate in the food chain, potentially affecting human health when contaminated seafood is consumed (Wright & Kelly, 2017). The presence of microplastics in marine organisms not only threatens biodiversity but also poses risks to local communities that rely heavily on fishing for their livelihoods. This aligns with findings by Machiwa (2010), who reported a significant decline in fish stocks in polluted coastal areas of Tanzania, further exacerbating the economic vulnerability of local fishermen.

5.2. Iron Remnants from Coastal Construction

Iron remnants from boat repair and coastal construction activities were another major pollutant, particularly at Mbegani and Msalabani beaches. These remnants introduce heavy metals such as iron, lead, and copper into the marine ecosystem, which are toxic to marine organisms and can have long-term ecological impacts. The toxicity of heavy metals has been well-documented in studies such as those by Milliman & Farnsworth (2011), which describe how these metals disrupt the physiological processes of marine life, inhibit growth, and affect reproductive success.

In Bagamoyo, the presence of iron waste poses direct threats to both marine biodiversity and human safety. Iron remnants not only contribute to the contamination of coastal waters but also disrupt important breeding grounds for fish and other marine species. Coral reefs, which are already under threat from climate change and ocean acidification, are particularly vulnerable to heavy metal contamination, which can weaken their structures and reduce biodiversity (Price et al., 2011). Fishermen who participated in this study reported that fish populations in areas near construction sites had significantly declined, a finding supported by similar studies in other developing coastal regions (Jackson, 2011).

The socio-economic consequences of this pollution are severe. As fish stocks diminish, local fishermen face reduced catches, which directly affects their income and food security. This reflects the broader challenge of balancing economic development, such as coastal construction, with environmental sustainability. Without proper regulation and management of construction waste, the long-term viability of Bagamoyo's fishing industry is at risk. This underscores the importance of stronger enforcement of environmental regulations, such as Tanzania's National Environmental Management Policy (NEP, 1997), which calls for sustainable practices in industrial and construction activities (**Figure 5**).

Figure 5. Iron remains.

5.3. Mangrove Deforestation and Coastal Erosion

Mangrove deforestation is another critical issue identified in this study, contributing to both environmental degradation and increased pollution levels. Mangroves are essential for protecting coastlines from erosion, filtering pollutants, and providing habitat for a wide range of marine species (Tallis et al., 2012). However, the deforestation of mangroves in Bagamoyo has led to significant environmental consequences, including the accumulation of plant debris along the beaches and increased vulnerability to coastal erosion.

The loss of mangroves exacerbates coastal erosion, leaving the shoreline more susceptible to the impacts of storms and rising sea levels. Assessing shoreline susceptibility is therefore important for identifying sections of the coast that require priority protection and erosion-control interventions (Valpreda & Simeoni, 2003). This finding is consistent with studies by Burak et al. (2004), who emphasized the role of mangroves in stabilizing shorelines and preventing land degradation. In Bagamoyo, the destruction of these vital ecosystems has resulted in more plant debris being washed ashore, which, while seemingly natural, contributes to the overall pollution problem. As mangrove roots are removed, the ability of the coastline to retain sediment and prevent further erosion is weakened, leading to more debris being introduced into the coastal waters. Furthermore, mangrove deforestation disrupts the breeding habitats of many marine species, leading to a decline in biodiversity. This is particularly problematic for fish species that rely on mangroves as nursery grounds. The decline in fish populations, as reported by local fishermen, not only threatens marine biodiversity but also has direct economic consequences for the fishing industry. The destruction of mangrove ecosystems also increases the vulnerability of coastal communities to natural disasters, such as storm surges and floods, as the protective buffer provided by these forests is lost (Tallis et al., 2012). This highlights the need for reforestation efforts and stricter enforcement of conservation laws to protect these critical ecosystems.

5.4. Food Waste and Tourism-Related Pollution

Food waste, particularly from restaurants and beach vendors, was identified as another significant pollutant. Respondents noted that leftover food and packaging from local eateries are often discarded irresponsibly, contributing to the degradation of the coastal environment. This problem is especially prevalent in tourist-heavy areas like Badeko Beach, where the influx of visitors exacerbates the strain on local waste management systems. Food waste, particularly from restaurants and beach vendors, was identified as another significant pollutant. Respondents noted that leftover food and packaging materials from local eateries were often discarded irresponsibly, contributing to the degradation of the coastal environment. This problem was especially prevalent in tourism-intensive areas such as Badeko Beach, where the influx of visitors placed additional pressure on local waste-management systems. Evidence of food debris observed along the shoreline is presented in Figure 6.

Figure 6. Food debris.

Tourism, while economically beneficial, often leads to environmental challenges if not properly managed. Beach tourism depends heavily on the environmental quality, accessibility, cleanliness, and recreational appeal of coastal destinations (Pincken, 2017). Rapid tourism growth can also place additional pressure on local infrastructure and communities when waste-management capacity does not expand at a similar rate (Sivadasan, 2018). As seen in other tourist destinations worldwide, such as Portugal and Chile, unmanaged tourism leads to littering, pollution, and habitat destruction (Santos et al., 2005). The findings of this study align with Maione (2019), who also identified tourism as a significant contributor to coastal pollution in Zanzibar and Bagamoyo. The improper disposal of food waste not only impacts the cleanliness of the beaches but also attracts scavenging animals, which can further spread the waste and disrupt the local ecosystem.

The long-term consequences of tourism-related pollution are severe. As beach cleanliness deteriorates, tourist numbers may decline, leading to reduced revenue for local businesses. Additionally, the accumulation of organic waste contributes to water pollution, as decomposing food releases nutrients that can lead to algal blooms, further degrading water quality and harming marine life. This reinforces the need for more sustainable tourism practices and improved waste management systems to mitigate the environmental impact of tourism on Bagamoyo's coastline.

6. Recommendation

To effectively address the impact of anthropogenic activities on coastal pollution in Bagamoyo, the following recommendations have been categorized based on the responsible entities, ensuring that each group understands their role in the implementation of sustainable practices:

Local Government Authorities:

Strengthening Waste Management Infrastructure: Invest in improved waste collection systems along the coastline, including additional trash bins, regular waste collection schedules, and proper disposal facilities. This would reduce the accumulation of plastic and other waste in coastal areas.

Enforcement of Environmental Regulations: Increase the enforcement of existing environmental laws, such as those governing waste disposal, construction practices, and fishing activities. Enforcement should also be coordinated with national fisheries legislation governing fishing methods, resource conservation and the protection of aquatic habitats (United Republic of Tanzania, 2003). Regular inspections and penalties for non-compliance can act as deterrents against harmful practices.

Developing Coastal Management Plans: Formulate and implement integrated coastal management plans that balance development with conservation, ensuring that activities such as tourism and construction do not compromise the health of coastal ecosystems.

Community Groups and Local Residents:

Community Clean-up Initiatives: Organize regular beach clean-up campaigns in collaboration with local NGOs and schools. Engaging community members directly can foster a sense of ownership and responsibility towards maintaining a clean environment.

Environmental Education Programs: Promote awareness programs focused on the importance of waste segregation, recycling, and the environmental impact of improper waste disposal. Education initiatives can be particularly effective when targeted towards youth and schools.

Participatory Conservation Efforts: Encourage the active involvement of local communities in mangrove reforestation projects and other conservation activities. This can help restore natural barriers that protect the coastline from erosion and improve fish breeding habitats. Limiting uncontrolled trampling and other direct

human disturbances can further support the passive recovery of degraded coastal vegetation and dune systems (Acosta et al., 2013).

Industry Stakeholders (Tourism, Construction, and Fishing):

Adoption of Eco-Friendly Practices: Tourism operators should adopt eco-friendly practices, such as reducing the use of single-use plastics, offering incentives for tourists to participate in beach clean-up efforts, and ensuring that waste generated from tourism is properly managed.

Waste Management Training for Fishing Communities: Provide training for fishermen on proper disposal of fishing gear and other waste materials to prevent ghost nets and other forms of marine debris. Fishermen can be encouraged to participate in "net retrieval programs" that remove abandoned fishing gear from the ocean.

Sustainable Construction Guidelines: Coastal construction companies should follow guidelines that minimize environmental impact, such as using materials that do not leach into the marine environment and ensuring that waste from construction activities is properly disposed of.

Policymakers and National Government:

Revision of Environmental Legislation: Update and amend national environmental laws, such as the National Environmental Management Act, to include stricter regulations on coastal activities and waste disposal. This ensures that the legal framework reflects the current challenges facing coastal areas.

Incentivizing Green Investments: Introduce incentives for businesses and industries that invest in green technologies, such as biodegradable packaging and waste-to-energy solutions. Tax breaks or grants for such initiatives can encourage broader adoption of sustainable practices.

Support for Research and Development: Allocate funding for research on sustainable coastal management strategies and support pilot projects that test new methods for reducing coastal pollution. Collaboration with academic institutions can facilitate the development of innovative solutions tailored to local needs.

Non-Governmental Organizations (NGOs) and International Partners:

Facilitating Technical Support and Funding: International partners and NGOs can provide technical support and funding for projects aimed at improving waste management systems and building local capacity for environmental conservation.

Promoting Cross-Border Collaboration: Support regional efforts to combat marine pollution by working with neighboring countries on shared challenges, such as plastic waste and overfishing. Cross-border initiatives can include joint training programs, research efforts, and awareness campaigns.

Monitoring and Evaluation: NGOs can play a key role in monitoring the effectiveness of implemented measures and providing feedback to ensure continuous improvement. Regular assessments can help adjust strategies as needed to meet environmental goals.

7. Conclusion

This study underscores the profound impact of anthropogenic activities on the

coastal environment of Bagamoyo, revealing how plastic debris, iron remnants, food waste, and mangrove deforestation are driving both environmental degradation and socio-economic challenges. The pervasive plastic pollution poses a severe threat to marine life through ingestion and entanglement, while iron remnants from construction activities introduce toxic heavy metals into the ecosystem, disrupting fish habitats and reducing local fish stocks that are crucial for both biodiversity and local fishermen's livelihoods. Mangrove deforestation exacerbates coastal erosion, depletes essential nursery habitats for marine species, and increases the vulnerability of the coastline to storm surges and flooding, threatening the safety and stability of coastal communities. Moreover, the tourism industry, while vital to the local economy, contributes significantly to coastal pollution through the improper disposal of food waste, which further degrades the beaches and diminishes their appeal to tourists. The socio-economic consequences are evident, with declining tourism and reduced fishing yields impacting local incomes and food security. To mitigate these effects, there is an urgent need for stricter enforcement of environmental regulations, improved waste management practices, and the restoration of mangrove ecosystems to strengthen coastal resilience. Sustainable tourism practices must also be encouraged to balance economic growth with environmental preservation, ensuring that the natural resources on which the local economy depends are protected. This study not only highlights the immediate challenges facing Bagamoyo but also contributes to the broader understanding of coastal management in Tanzania, calling for collaborative efforts between policymakers, local authorities, and community stakeholders to safeguard the coastal environment and ensure its long-term sustainability for future generations.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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