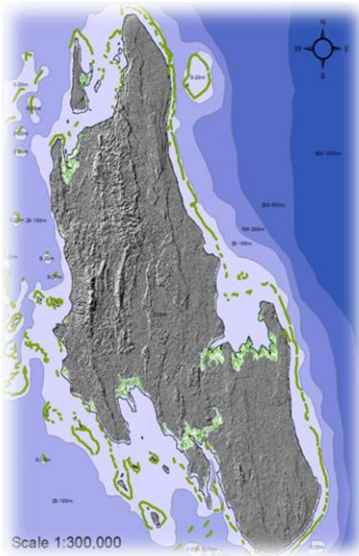




LAND-BASED POLLUTION SOURCES

Mapping of the Potential Land-based sources of Pollution in Zanzibar



ZANZIBAR FISHERIES AND
MARINE RESOURCES RESEARCH
INSTITUTE

JULY 2024

ABSTRACT

To be completed

TABLE OF CONTENTS

ABSTRACT	i
TABLE OF CONTENTS	ii
LIST OF FIGURES AND TABLES	iii
INTRODUCTION.....	4
STUDY AREA	6
METHODOLOGY.....	7
GEOGRAPHY AND GEOLOGY OF ZANZIBAR	7
POPULATION AND DEMOGRAPHIC STATISTICS OF ZANZIBAR.....	8
LAND USE/ LAND COVER	9
TOURISM.....	10
DENSITY.....	11
WATERSHEDS.....	12
DISTRIBUTION OF SOURCE OF POLLUTION ON DISTRICTS	13
CONCLUSION AND RECOMMENDATION	23
REFERENCES.....	24

LIST OF FIGURES AND TABLES

To be completed

1.0 INTRODUCTION

Land-based pollution is a major threat to the marine and coastal environments and ecosystems, significantly impacting marine life and habitats. Approximately 80% of marine pollution originates from land-based sources. These pollutions include plastic waste, agricultural runoff containing pesticides and fertilizers, industrial effluents and municipal sewage *inter alia*. Land-based pollution significantly impacting marine and coastal environments, such impacts include nutrient overloads, which create algal blooms and dead zones, and physical harm to marine animals, with over 1 million seabirds and 100,000 marine mammals dying annually due to plastic ingestion or entanglement (United Nations Environment Programme, 2021). An annual estimated of 8 million metric tons of plastic waste enter the oceans, leading to significant problems to oceans and marine ecosystems.

“Municipal, industrial and agricultural wastes and run-off account for as much as 80 per cent of all marine pollution.”

(<https://www.unep.org/topics/ocean-seas-and-coasts/regional-seas-programme/land-based-pollution>)

Marine pollution is a notable problem in Tanzania coastal waters and it poses significant threat to the marine environment and the economy. The per capita plastic waste generation in Tanzania is approximately 5.6 kg/year, much lower than the global average of 29 kg/year (IUCN, 2021), nonetheless much of these wastes end up in the ocean and coastal areas. In 2018, Tanzania produced about 315,000 tonnes of plastic waste, with an estimated 29,000 tonnes leaking into oceans, rivers, and lakes (IUCN, 2021).

Similarly, marine pollution is becoming a serious problem to some marine and coastal areas of Zanzibar. Tourism sector, coastal agriculture and municipal wastes and sewages significantly contributing to marine pollution. For example, much of the plastic waste

originating from tourism sector find their way to the marine and coastal environments (Maione, 2019).

Projects on land-based sources of pollution cover a wide range of issues ranging from analysis of the present state of the coastal and near-shore environment to the response of provincial and local governments to these broad-based issues. The projects include issues on organic agriculture, sewage treatment, water quality monitoring programmes, risk assessments, habitat management, local integrated coastal management, waste treatment technologies, and incentive schemes for good practices.

MAIN GOAL – the present work is dedicated to identify and mapping potential land-based sources of pollution around the coastal zone of Zanzibar Island, for effective monitoring and management of water quality to maintain the good status on marine environments and its biodiversity.



2.0 METHODOLOGY

2.1. STUDY AREA

Zanzibar is an island state located in the Indian Ocean, lies about 30 miles off the coast of East Africa, about 25-50 kilometers off the coast of mainland Tanzania. Zanzibar consists of two main islands, Unguja (commonly referred to as Zanzibar Island) and Pemba, along with over 50 smaller islets. The archipelago is positioned at approximately 6° South of the Equator and 39° East of the Prime Meridian.

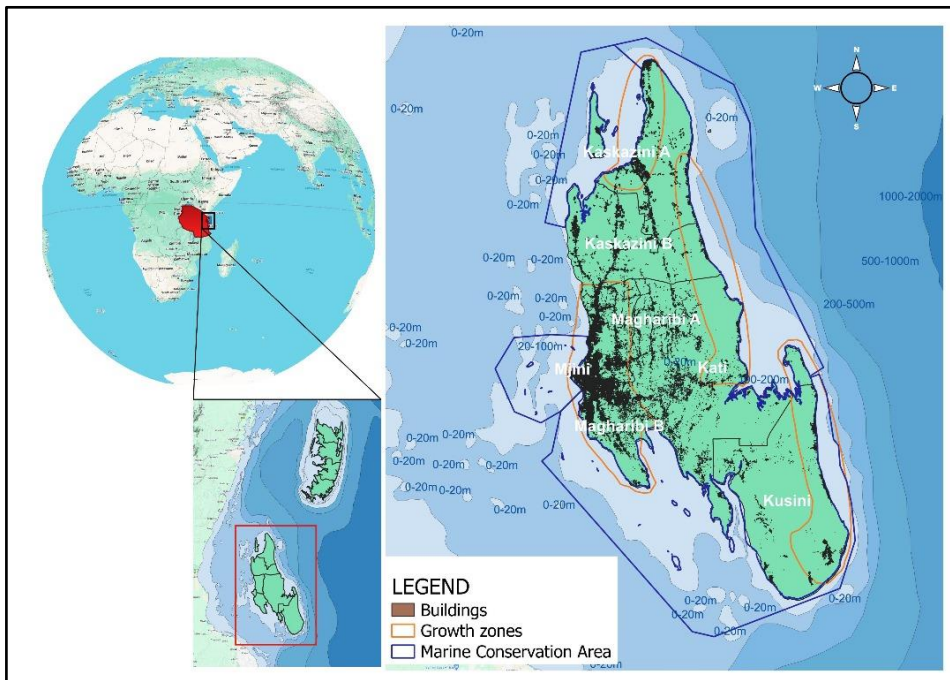


Figure 1: The Mapping of Land-based pollution sources was conducted in the coastal areas of Unguja island (also known as Zanzibar).

This study was conducted in seven districts of Zanzibar island, namely North A, North B, Urban, West A, West B, Central and South, all together cover the total of 145 Shehias (local administrative units). These 145 Shehias are located within the buffer of 3km landward from the high tide water mark.

2.2. METHODOLOGY

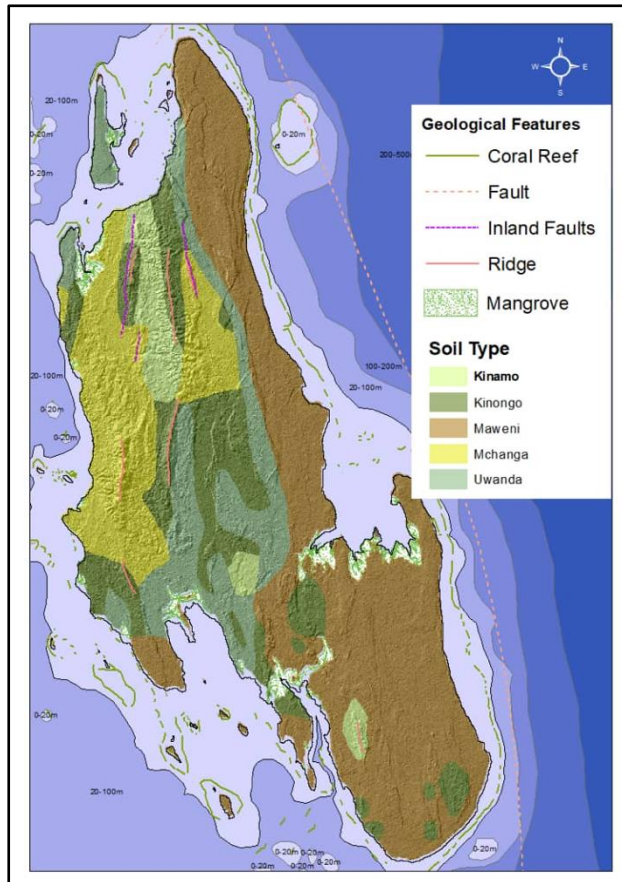
Data for land-based pollution sources was collected using Kobo collect Toolbox embedded in a Tablets, which enables the capture of both locational and attribute information of the pollution sources. After data collection, the information was downloaded as an Excel spreadsheet from Kobo toolbox.

The subsequent data analysis involved data cleaning and processing within excel to produce relevant graph. For data visualization, ArcGIS 10.4 software was utilized to create maps illustrating the spatial distribution of potential land-based sources of pollution along the coast of Zanzibar. This approach provided a comprehensive overview of pollution sources, combining precise location data with detailed attribute information to support effective environmental management and planning

2.3. GEOGRAPHY AND GEOLOGY OF ZANZIBAR

Zanzibar, an archipelago off the coast of Tanzania, is primarily composed of sedimentary rocks that date back to the Jurassic and Cretaceous periods. The geology is dominated by coral rag, a type of limestone formed from coral reefs, and clastic sedimentary rocks. The islands exhibit karst landscapes, characterized by sinkholes and underground rivers, due to the dissolution of limestone. Additionally, the presence of marine deposits reflects the island's geological history linked to sea level changes and tectonic activities. These geological features play a significant role in the formation of Zanzibar's unique landscapes and influence its soil fertility and groundwater resources (Mohammed, S. N et al, 2009). The region experiences a tropical monsoon climate characterized by distinct wet and dry seasons. Annual rainfall varies considerably, averaging around 1,600 mm, but it can exceed 2,000 mm in some areas, especially during the long rains from March to May and

the shorter rains in November and December (Sheriff & Ferguson, 1991). Zanzibar's terrestrial ecosystem includes both coastal forests and mangrove forests. The coastal forests, which are rich in endemic species, are primarily found on the main island of Unguja. These forests are critical for protecting soil from erosion, maintaining water



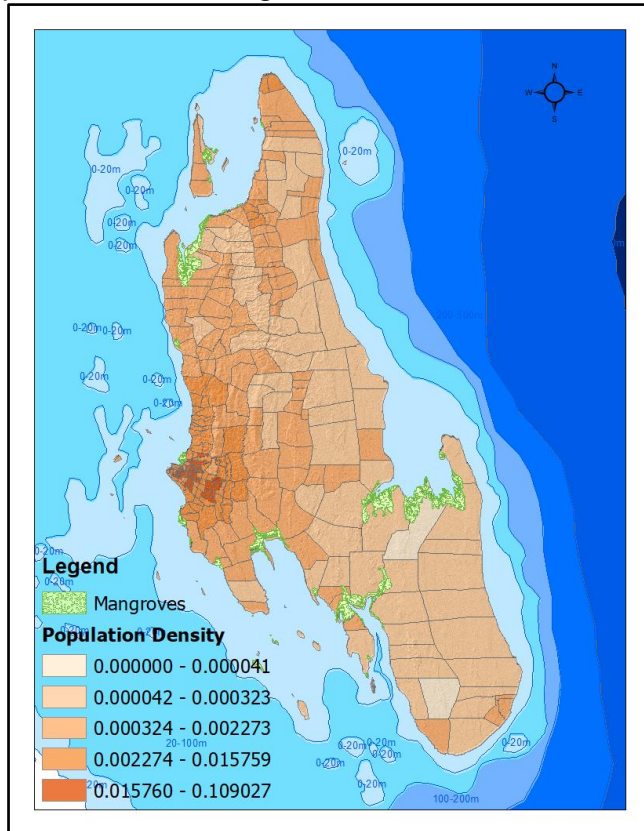
quality, and providing habitat for wildlife (Myers, 1988). The geological features of Zanzibar, including its coastal topography and river systems, facilitate the transport of land-based pollutants into the marine environment. Sediments from erosion, along with attached pollutants, are carried by rivers and streams, ultimately depositing in the coastal waters. These sediments can smother marine habitats, alter water quality, and introduce harmful substances into the marine food web.

Figure 2: Geological characteristics of Zanzibar Island that include soils distribution and geological features.

2.4. POPULATION AND DEMOGRAPHIC STATISTICS OF ZANZIBAR

The population of Zanzibar according to the 2022 Tanzania Population and Housing Census, Zanzibar consist 1,889,773 with growing at a rate of 3.7 percent per annum from 2012 to 2022, urban Population growth in rural area was 3.2 percent and 4.3 percent in urban area. Zanzibar has five (5) regions in which Mjini Magharibi Region was found to have the largest population of 893,169 accounting to 47.3 percent of the total population

in Zanzibar. The region with the smallest population is Kusini Unguja with a population of 195,873 that is equivalent to 10.4 percent of the total population in Zanzibar according to 2022 census. The population growing in Zanzibar has led to the increases of pollutants productions through vehicular emissions, and domestic waste that contribute to the



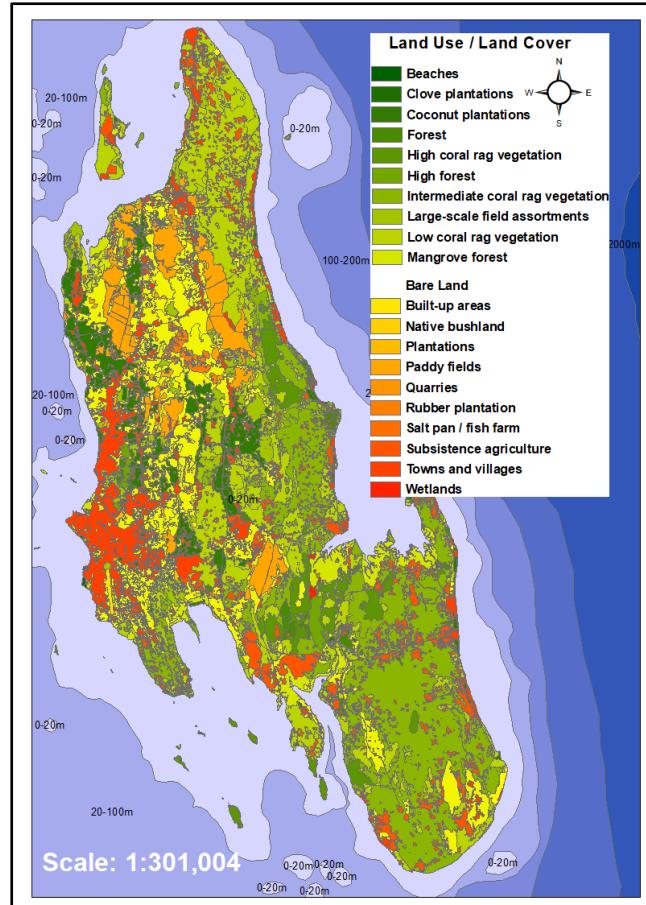
accumulation of pollutants such as heavy metals, hydrocarbons, and nutrients in the air and on land. These pollutants always find their way into waterways through runoff, storm water drains, and untreated sewage. In particular, during rainfall, contaminated runoff from roads, factories, and residential areas carries pollutants directly into rivers, which eventually flow into marine environments.

Figure 3: Demographic characteristics of Zanzibar Island that show the distribution of population density.

2.5. LAND USE/ LAND COVER

The Zanzibar islands can be roughly divided into two potential agricultural land use categories, namely the deep soil and the coral rag areas. Deep soil areas are characterized by permanent cultivation and forest, and the coral rag by shifting cultivation and consequent scrublands. Hence the population density of Zanzibar is increased the human activity will contribute pollution to the environment. Especially around the marine

environment, for example in Zanzibar the main human activity is fishing activities hence is the main economic activity it will lead to environmental degradation and pollution around coastal areas. Agricultural land uses can affect the quality of water and watersheds. And Runoff from pesticides, fertilizers, and nutrients from animal manure can also degrade water quality.



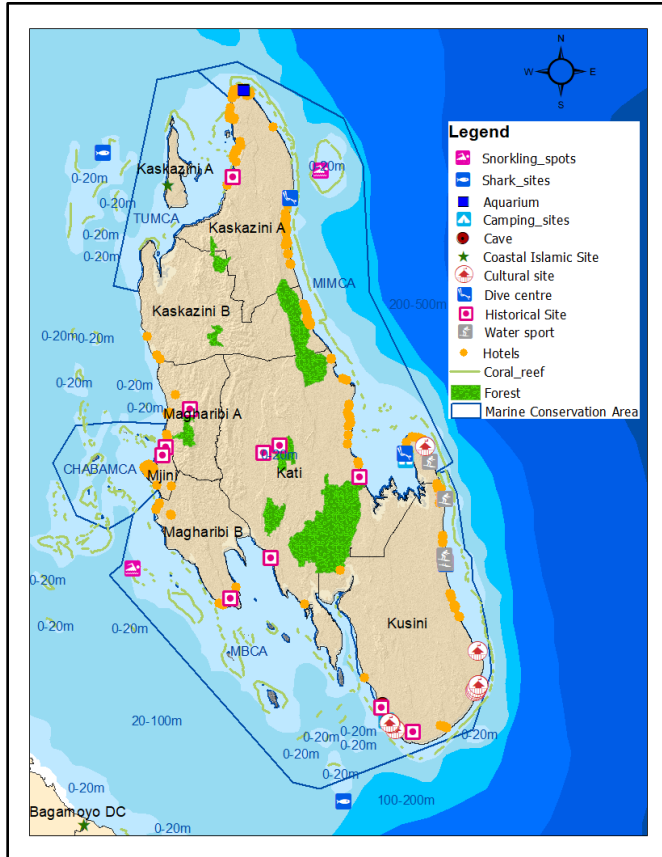
TOURISM

Tourism plays a vital role in Zanzibar's economy, attracting visitors to its coral reefs, spice plantations, and marine biodiversity (Mkumbukwa, 2017). However, the growth of tourism has also led to increased land-based pollution, adversely affecting marine ecosystems. Waste from hotels, resorts, and other tourism-related activities often ends up in the ocean, contributing to pollution that threatens coral reefs and marine life (Mongi et al., 2016). Sustainable tourism practices are essential to mitigate these impacts and protect Zanzibar's natural environment.

The management of waste and the discharge of chlorinated swimming pool waters from hotel developments on coastal waterfronts is seen as a growing problem, particularly in

locations without significant tidal flushing and unpredictable expansion in the tourist population.

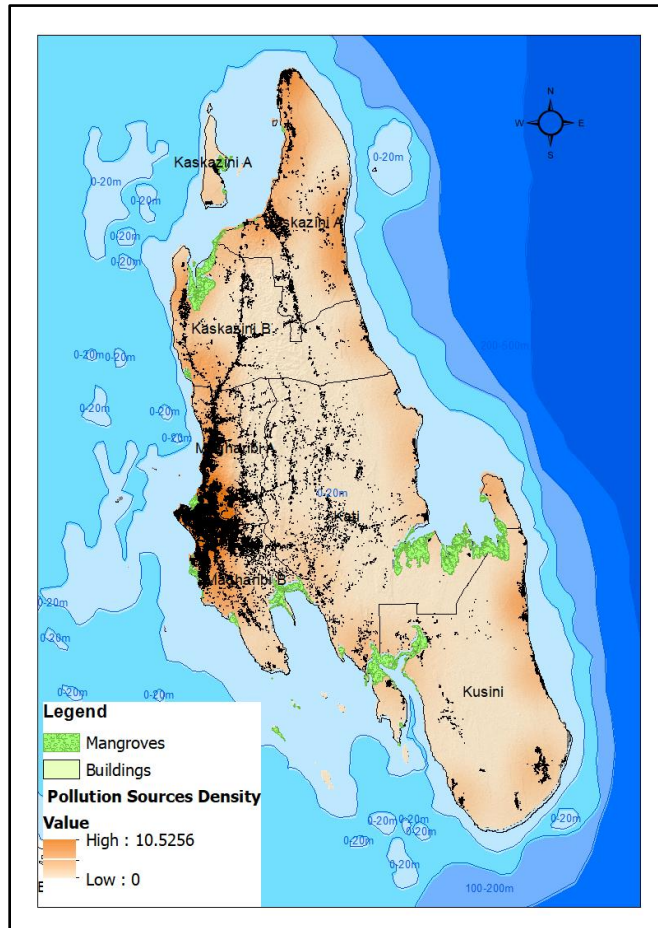
Although individually small, there are many of these sources on some coastal regions,



and their combined long-term impacts on the health of platform and reef habitats could be considerable. Other tourism-related activities which are growing and possible sources of direct pollution in sensitive habitats include the use of power boats and jet skis. The power boats and skis may cause physical habitat degradation through accidental running aground in the shallow waters, anchors and oil spills.

DENSITY

Pollution source per unit area across the district of Zanzibar(Unguja island) it shows that Urban area have the highest concentration of pollution source, this might be due to urban development and the presence of different human activities, The major pollutions source have been found to be Dumping site followed by Garages, there are also hospitals and dispensary witch give out pharmaceutical wastes and chemical wastes in which all type of wastes when wash away by rain water goes to the ocean as stream water and contribute to marine water pollution.

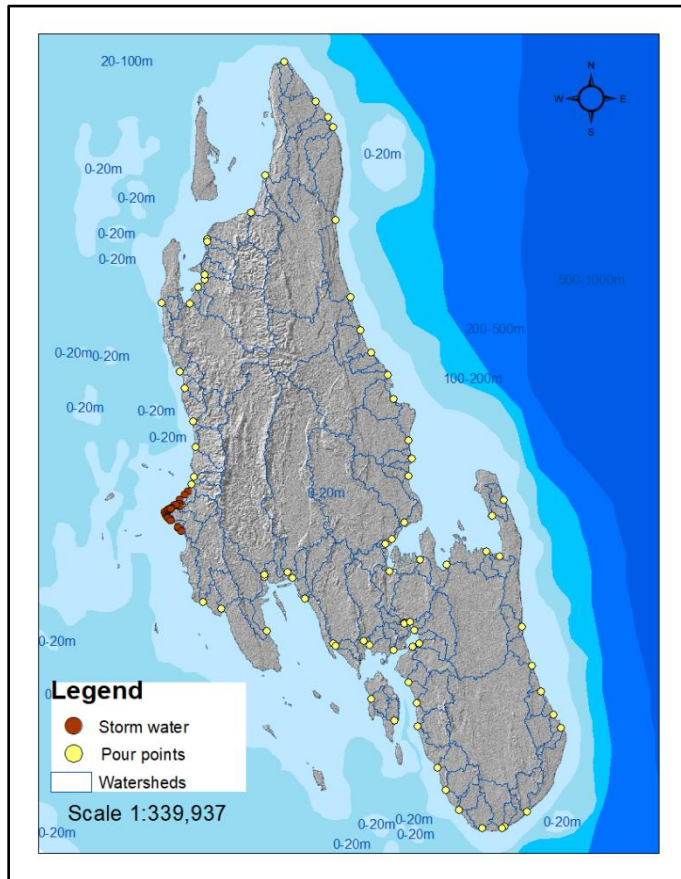


At the North A of Unguja Island produce more pollution due to the presence of many hotels around its coastal areas, some hotels give out waste-water discharge direct to the ocean and cause marine pollution.

WATERSHEDS

Zanzibar, the island is predominantly covered by watersheds, which play a significant role in the transportation of materials from highland to lowland areas, ultimately affecting the marine environment. Watersheds act as natural drainage systems, collecting precipitation and surface runoff from various land areas and channeling it into streams, rivers, and eventually the ocean. In Zanzibar, the presence of extensive watersheds means that pollutants from agricultural activities, urban areas, and other land-based sources are efficiently transported to the marine environment. This process is facilitated by the island's topography, where rainwater and runoff quickly flow from the higher elevations to the coastal regions.

As water moves through the watershed, it can pick up a variety of pollutants, including sediments, nutrients (such as nitrogen and phosphorus from fertilizers), pesticides, and other contaminants. These pollutants can significantly impact marine ecosystems, leading to issues such as algal blooms, coral reef degradation, and the decline of marine biodiversity. Rapid transportation of materials due to the watershed's structure can exacerbate the effects of heavy rainfall and storms, causing increased erosion and sedimentation in coastal areas. This can further stress marine habitats and reduce water quality.



DISTRIBUTION OF SOURCE OF POLLUTION ON DISTRICTS

The distribution of source of pollution on the seven districts are show that North A is the leading district for pollution sources, following with Urban district.

The urban population of coastal towns and population of North A is rising at a greater rate than the average population growth rate, due to rural-urban migration. Rapid urban population growth particularly in the coastal towns has led to rapid changes in land use

patterns. Natural ecosystems are being disturbed or replaced by agricultural crops. The large population is also putting pressure on the marine and coastal resources. Lack of infrastructure and treatment facilities for the large quantities of domestic sewage generated by expanding coastal urban populations, and an increasing number of visiting tourists, represents the greatest threat to coastal habitats. There is a direct relationship between population growth and waste generation. In the case of most large urban centers the solid waste and sewerage facilities have remained the same while the population has increased leading to decline in percentage population served by the facilities. Domestic sewage infrastructures are poorly developed in Zanzibar and this is considered a major source of pollution to near shore coastal waters. For the overall result in all district show that the dumping site is more common for the all districts. Also, it is a leading pollution source in most districts.

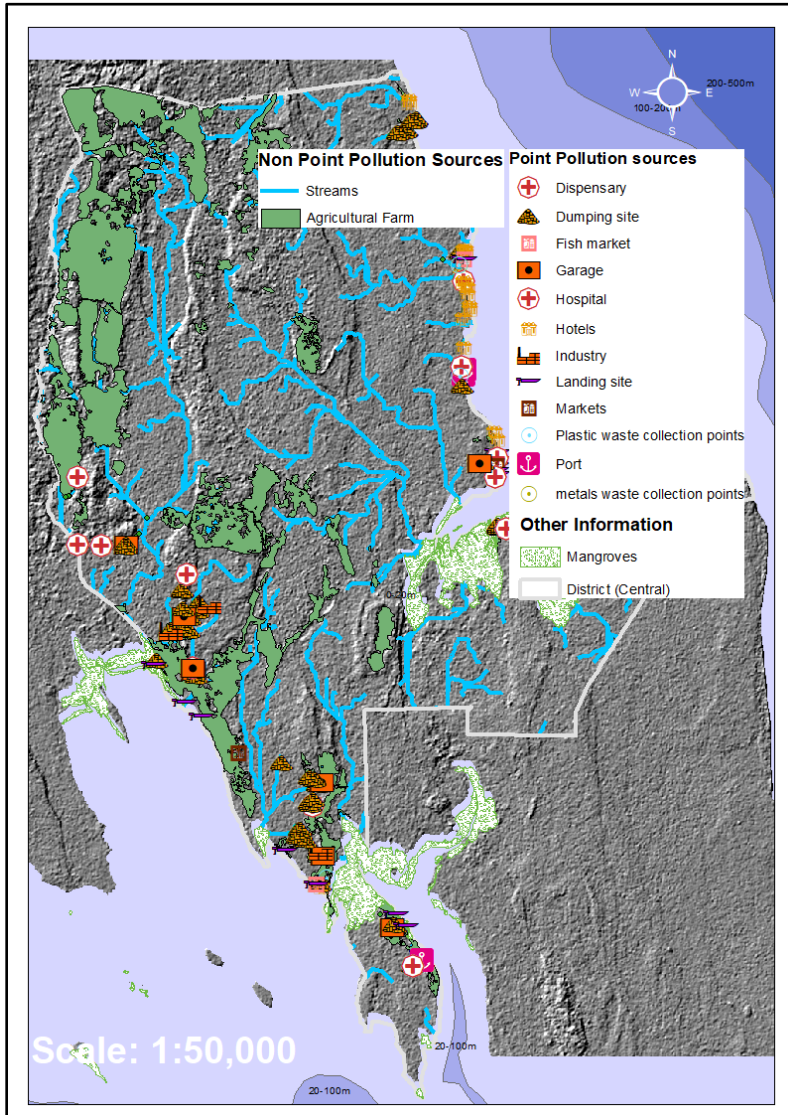
In contrast to the other states, high population densities are not confined to the large urban centres on Mauritius (Port Louis and Plaines Wilhems), but occur 9 in rural areas where 55.5% of the total population resides according to the 1990 census. The two large urban centers have sewerage systems, although the system in Plaines Wilhelm's constructed in 1960 is inadequate to deal with peak flows during heavy rainfall resulting in frequent discharges of raw sewage to surface watercourses. The remainder of the population generally use pit latrines, soakage pits or septic tanks. No data concerning the microbial contamination of groundwater by domestic sewage. The release of domestic sewage to coastal waters from urban areas and poorly planned housing developments on reclaimed wetlands is recognized as a cause of eutrophication resulting in growth of algae and the choking of coral. Algal blooms are observed annually at Trou aux Birches

and isolated cases have been reported at the sewer out fall at Bain des Dames near Port Louis. (Francis, J.; Mmochi, A.J, 2002).

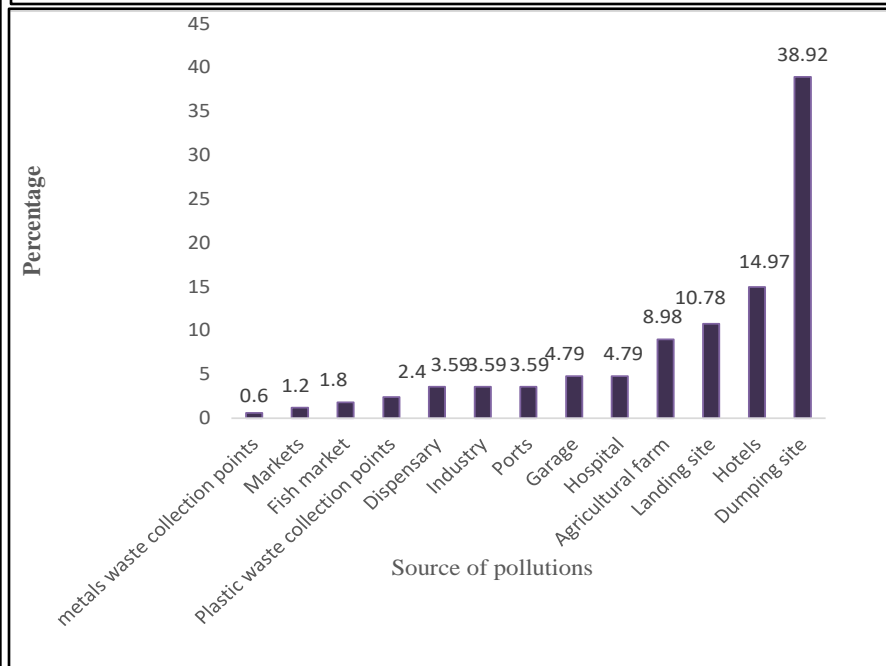
In Dar es Salaam, domestic waste is the most serious source of pollution. The waste generated by 15% of the city residents who are connected to the sewer system is discharged into the sea untreated. As a result, the coastal waters, especially in vicinity of the Dar es Salaam harbour, are heavily polluted. Discharge of untreated sewage in Dar es Salaam has resulted in high faecal and total coliform levels in the same areas. The situation is made worse by a broken sewer pipe which discharges untreated sewage on sandy-mud flats near the harbour which is said to threaten invertebrates and fish (Bryceson, 1981, Bryceson et al, 1990). The harbour area also suffers from oil pollution from the refinery at Kigamboni, and industrial wastes from Keko, Chang'ombe, Kurasini, Mtoni and Temeke. These discharge heavy metal, pesticide, organic, and paint wastes into the nearby area (Bryceson, 1983).

In another study, Bryceson (1981b) reviewed some problems of marine conservation with particular reference to Tanzania. A comprehensive review of the sources of pollution in Tanzania mainland was conducted by Mgana and Mahongo (1997), who quantified all major human activities that contributed to pollution of the marine environment. A similar kind of review was carried out in Zanzibar by Mohammed (1997) who investigated land-based sources of pollution affecting coastal, marine and associated freshwater environments on the islands.

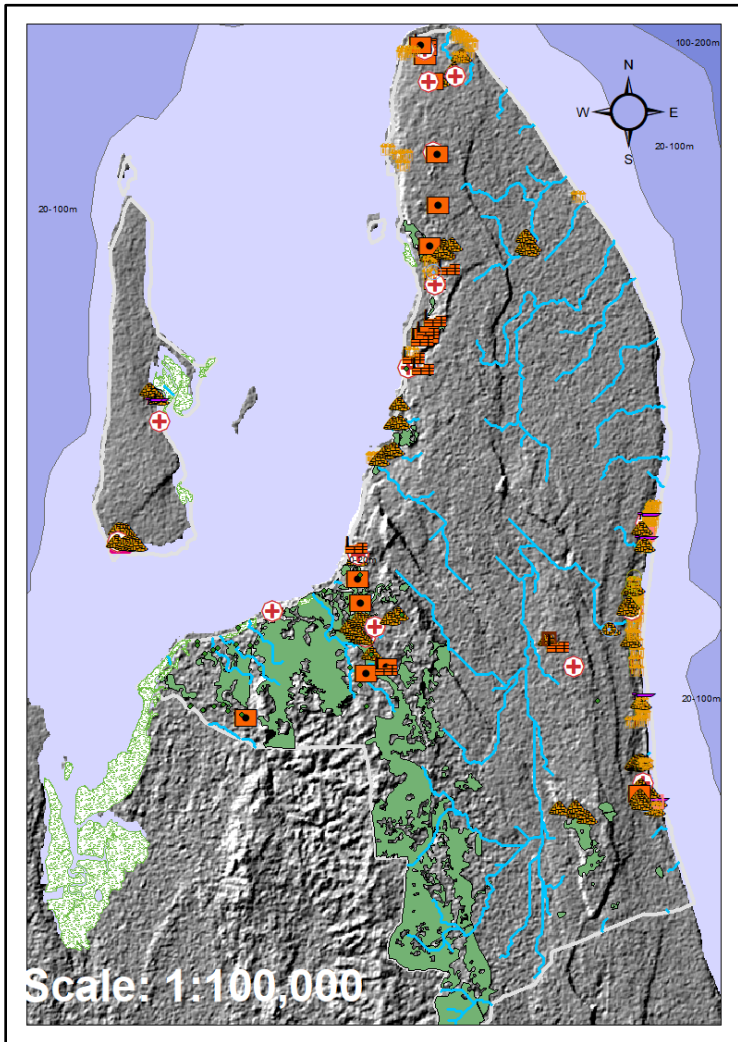
CENTRAL DISTRICT



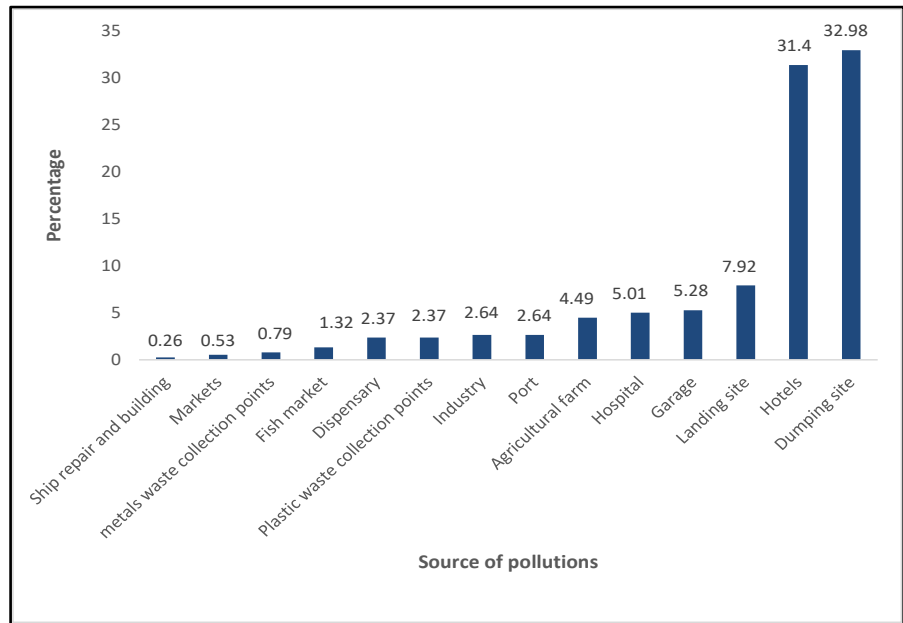
Central District, one of seven areas studied, the map shows where pollution comes from. Central District is in the fourth place compared to the other District. The graph below gives a closer look at the types of pollution source in District, as illustrated dumping site is the leading source at 38.92% followed by Hotels at 14.97% and metals waste collection point is the least at 0.6%. Central District is Rank 4th in overall waste production.



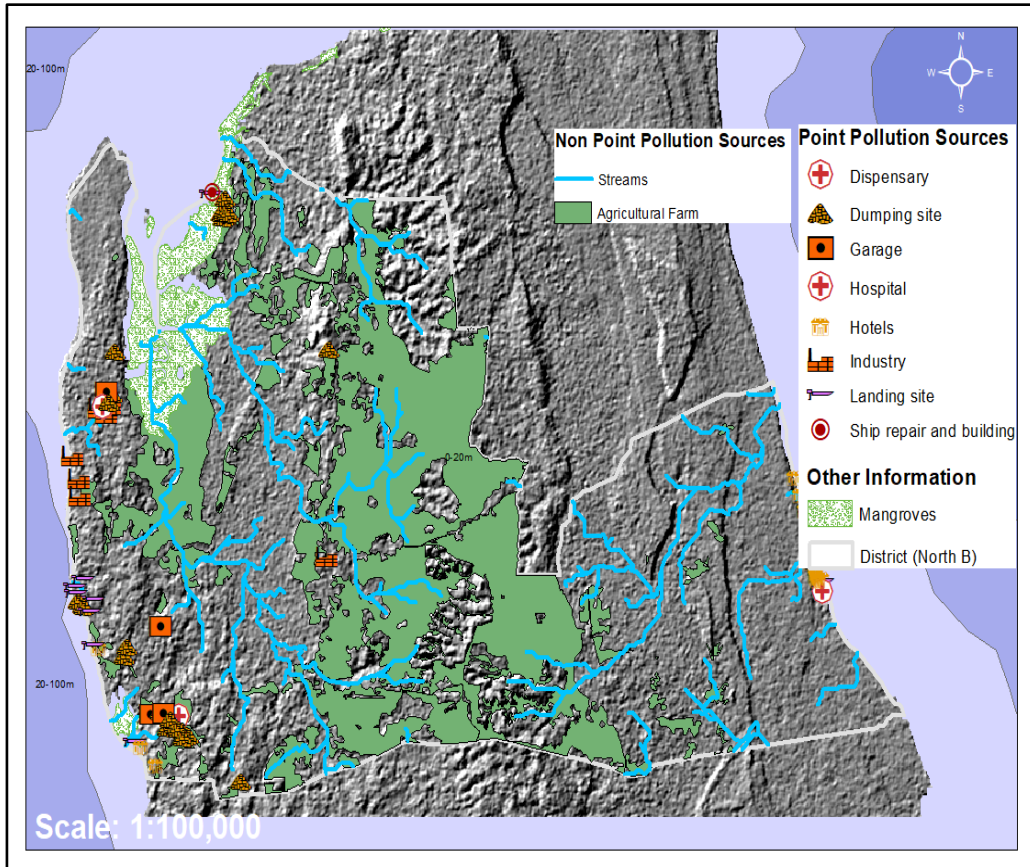
NORTH A DISTRICT



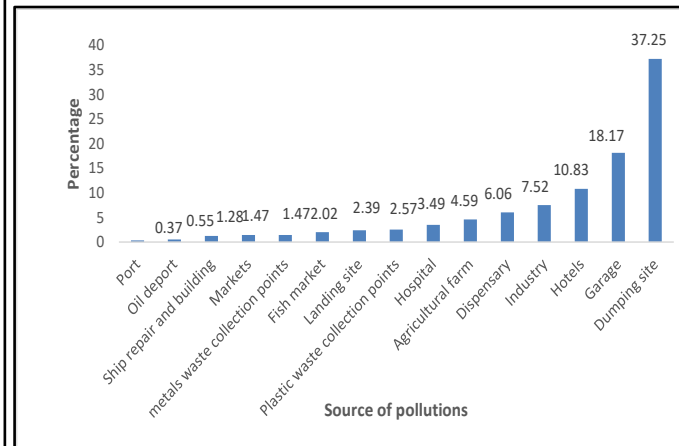
The map of District A reveals a concentration of pollution sources in the Area, primarily near the costal zones. The accompanying graph shows that the dominant type of source of waste is Dumping site, accounting for 32.98% of the total pollution. Hotels follows at 31.4%, and least is Ship repair and building site at only 0.26%. North District ranks 1st in overall waste production.



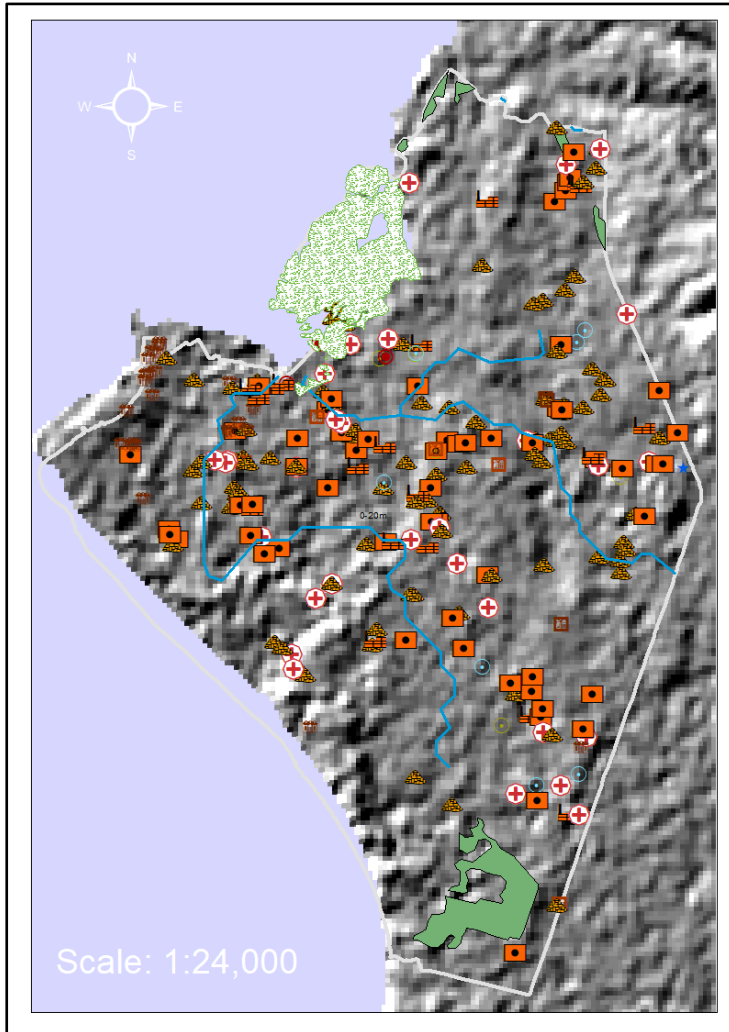
NORTH B DISTRICT



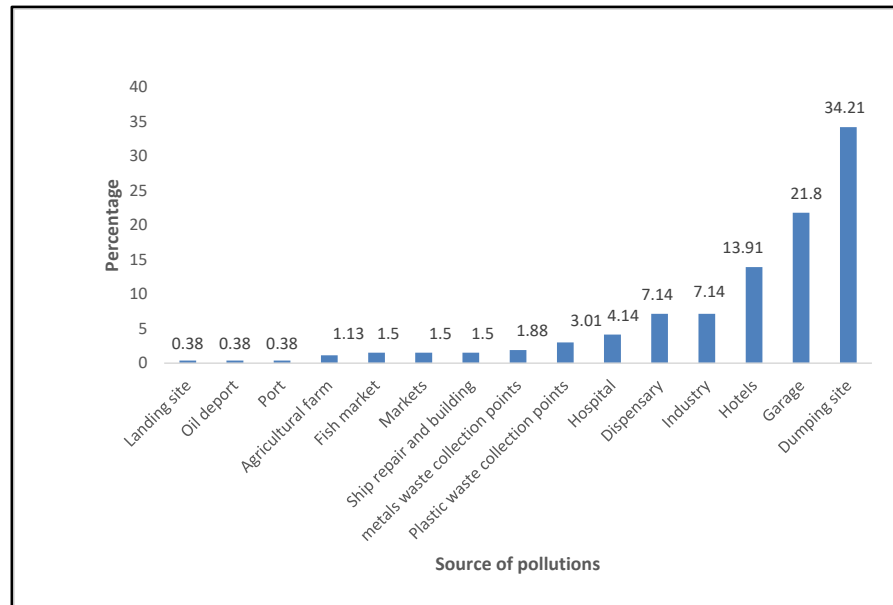
The map of North B District displays pollution sources predominantly along the West side. The graph underscores Dumping site waste as the primary pollutant at 37.25%, followed by Garage waste at 18.17%, and the least is Port waste at 0.37%. North B is ranked 6th in overall producing waste.



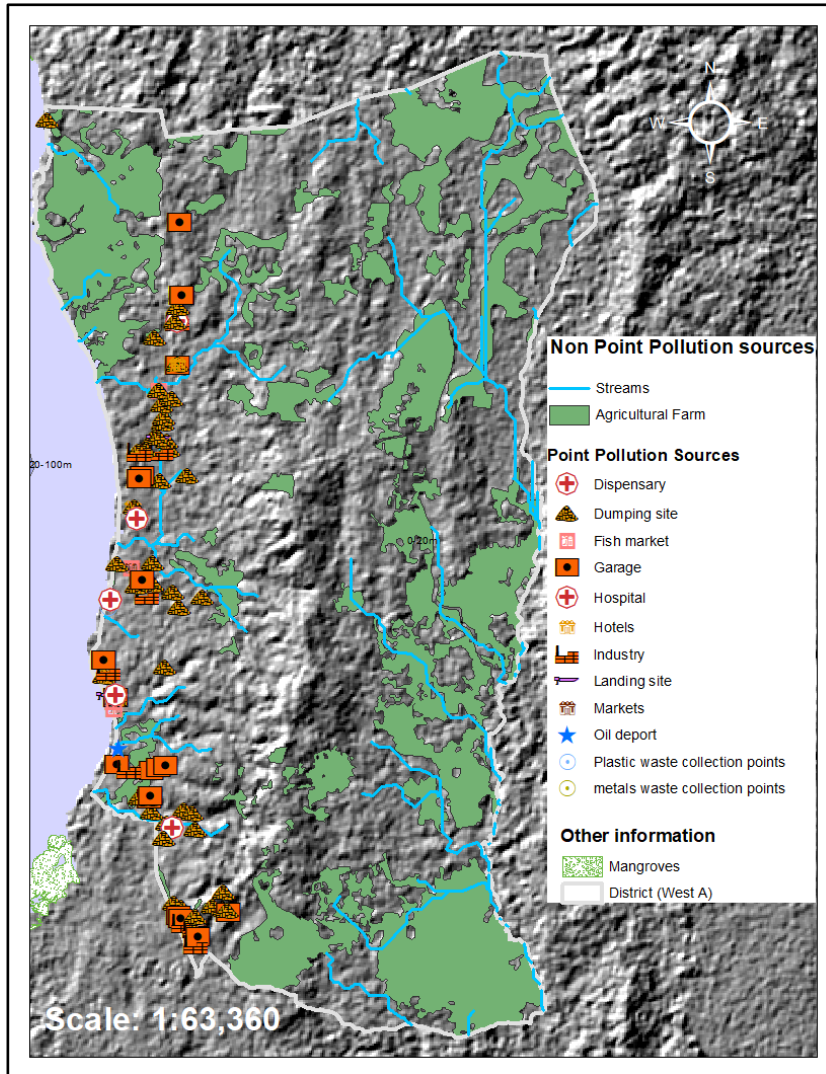
URBAN DISTRICT



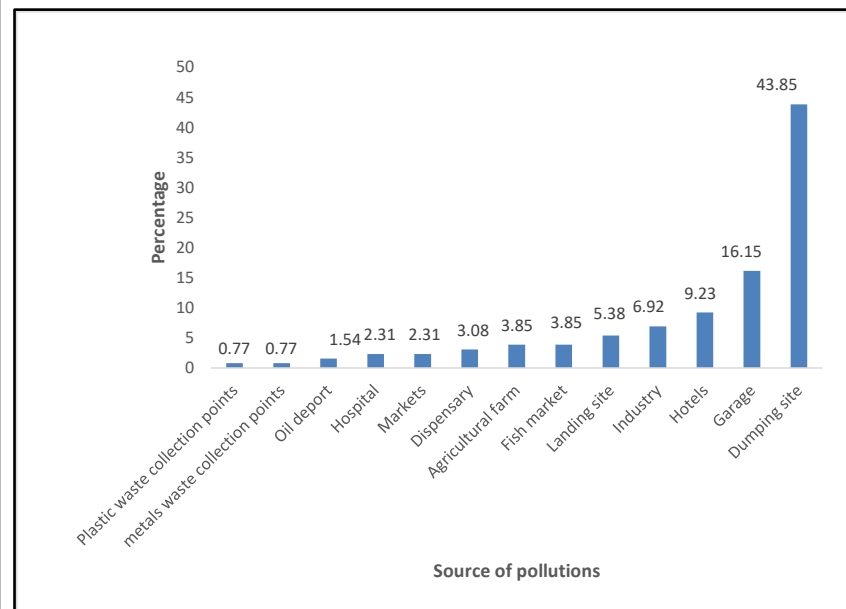
The Urban District map shows a high density of pollution sources around the whole zones and Residential Areas. The graph reveals Dumping site waste as the most significant contributor at 35.21%, with Garage waste at 21.8%, and the least contributor was landing site waste at 0.38%. This district ranks 2nd in waste production.



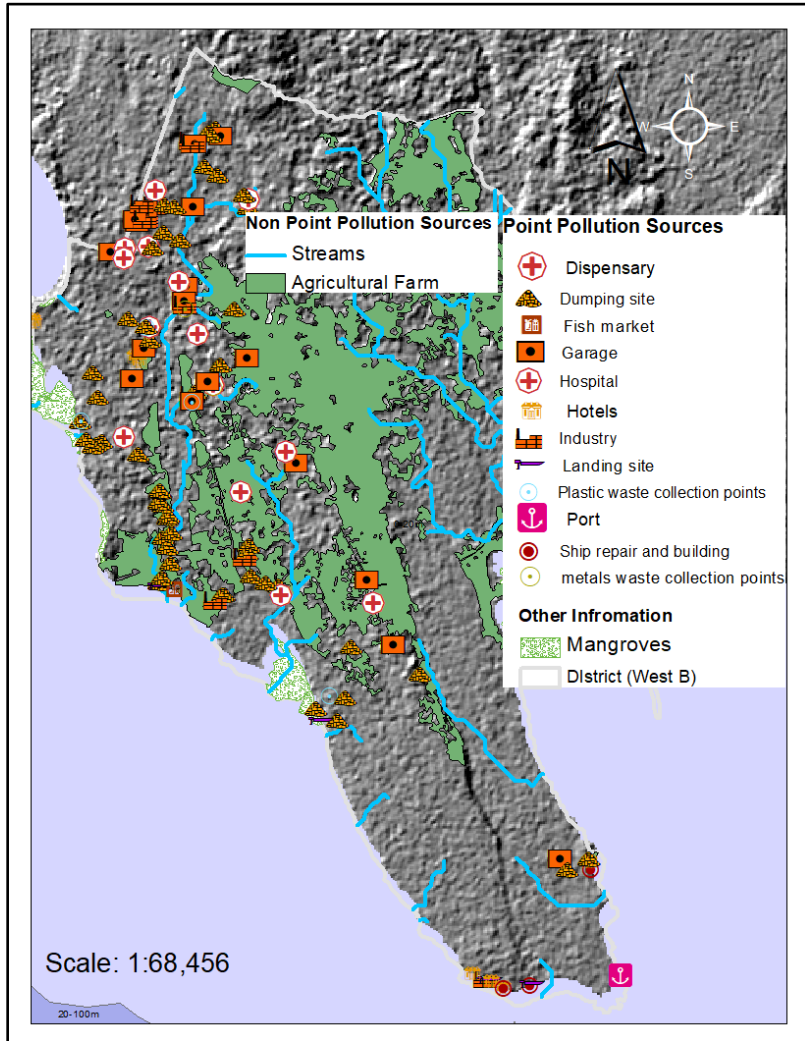
WEST A DIATRICT



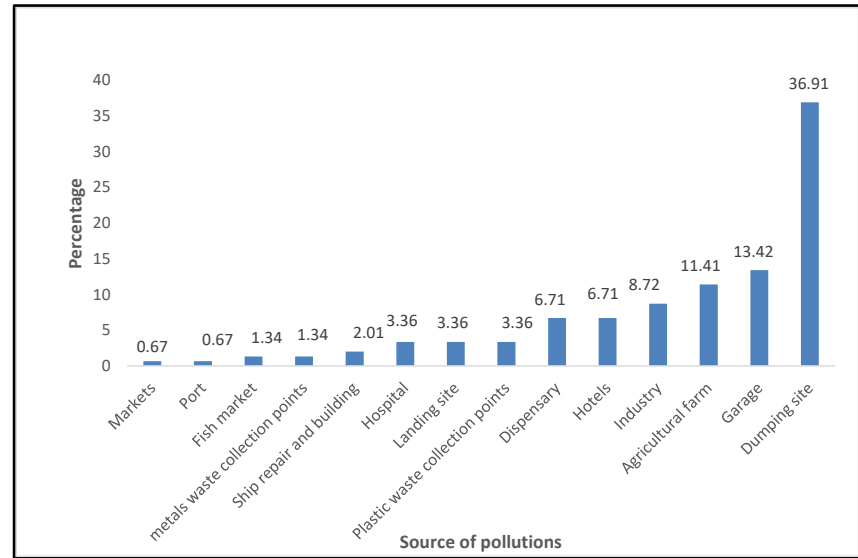
The map for West A District illustrates pollution sources mainly in the Western part near the coastal areas. The graph indicates that Dumping site is predominant at 43.85%, followed by Garage waste at 16%, and the last is Plastic waste collection point waste at 0.77%. District E is ranked 7th in total waste production which is least area with pollution source.



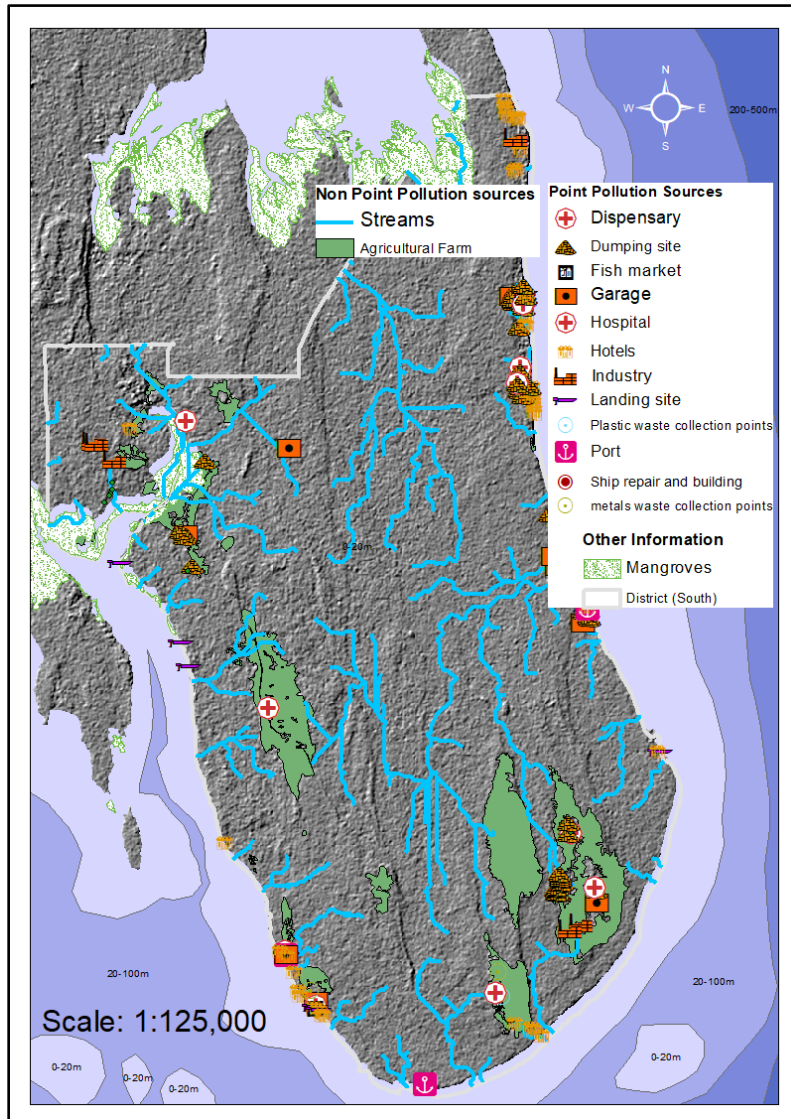
WEST B DISTRICT



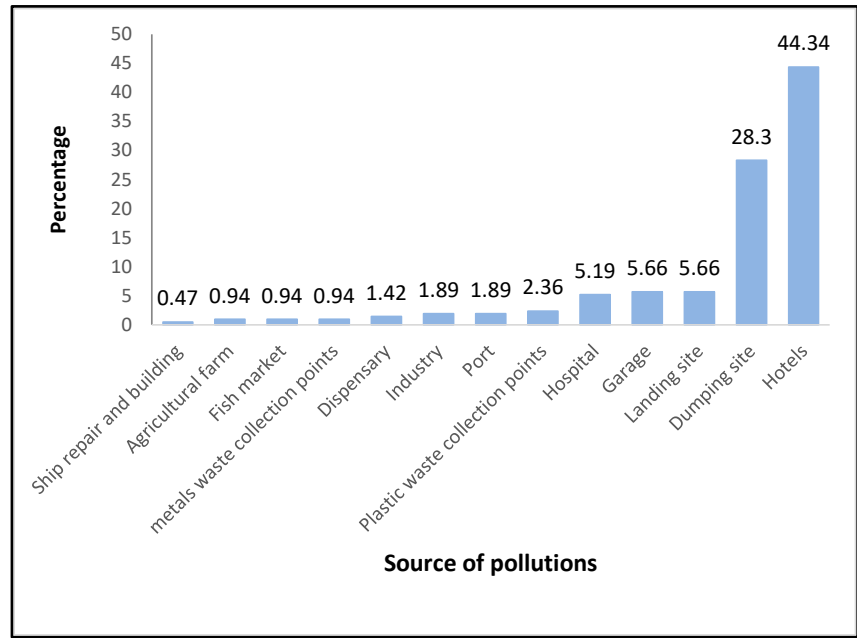
In West B District, the map shows a dispersed pattern of pollution sources with minor clusters at the region. The graph reveals that also Dumping site waste as the leading type at 36.91%, Garage waste at 13.42%, and the last is Markets waste at only 0.67%. This district ranks 5th in waste production.



SOUTH DISTRICT



The map of South District highlights a high concentration of pollution sources Eastern and Western side of the district and surrounding residential areas. The graph shows that Hotels waste is the primary type of pollution at 44.35%, followed by Dumping site waste at 28.3%, and the last is Ship repair and building waste at 0.47%. South District ranks 3rd in overall waste production.



CONCLUSION AND RECOMMENDATION

Not a single city or town in Zanzibar has sewage treatment facilities. Invariably, waste from these cities/towns is discharged untreated into the environment, mainly into coastal waters via local sewer networks and rivers and through. Over 80% of the households in the city use pit latrines and septic tanks. The frequently overflow, especially during the rains are washed directly to the marine coastal waters (Mohammed, S, M, 2000).

The Zanzibar sewerage system which dates back to the 1920s serves only about 18% of the population (Mohammed,S M, 2000). Waste from the town's residents is dumped untreated in the nearby coastal waters. The same situation prevails in other towns along the coast of Zanzibar. For the long-term sustainability of the coastal zone and its resources, it is important to develop better facilities including treatment plants. However, given the potentially huge investment requirements for secondary or tertiary waste treatment, it is recommended that there should be installed at least primary waste treatment facilities in the major cities to facilitate initial waste treatment before discharge. Tourist hotels and industrial plants should have their own onsite treatment facilities to reduce waste loads in the public sewer networks as well as avoid haphazard waste discharge. The promotion of local awareness is key to the effective management of pollution and the health risk associated with the problem. For example, there should be formulated guidelines on the design and construction of wells and pit latrines with the view to reduce pollution in peri-urban areas

REFERENCES

National oceanic and atmospheric Administration, *land based source of marine pollution* (2022)

International Institute for Sustainable Development (IISD), *Global agreement on marine pollution from land based sources yield lessons: Policy brief* (2021)

United nations university: *Land-based pollution sources*

United Nations Environment Programme. (2021). *From pollution to solution: A global assessment of marine litter and plastic pollution*. Nairobi: UNEP. Retrieved from <https://www.unep.org/resources/pollution-solution-global-assessment-marine-litter-and-plastic-pollution>

Mkumbukwa, A. R. (2017). *Tourism development in Zanzibar: Challenges and opportunities*. *Journal of Tourism Studies*, 25(2), 133-149.

Mongi, H., Lyimo, J. G., & Mremi, R. (2016). *The impact of tourism on marine environments in Zanzibar: Case study of Unguja Island*. *Marine Pollution Bulletin*, 105(2), 629-636.

Bryceson, I., 1983: Pollution of Dar es Salaam Coastal environments by industrial and domestic effluents. In: Status and Problems of Marine Resources Development in Tanzania. Recommendations and selected papers from the workshop on "The Current State and Development of Marine Sciences in Tanzania." Zanzibar, 2-8 April, p. 32-41.

The United Republic of Tanzania (URT), *Administrative Units Population Distribution Report; Tanzania, December 2022*.

Mohammed, S. N., & Misana, S. (2009). *Geological and Geomorphological Features of Zanzibar Islands*. In *Geography of Zanzibar* (pp. 35-45). University of Dar es Salaam Press.

Francis, J and Mmochi, A.J. (2002). *Land Based Activities and Sources of Pollution to the Marine, Coastal and Associated Fresh Water Ecosystems in the Western Indian Ocean Region* , Institute of Marine Sciences, Zanzibar, Tanzania.

Bryceson, I., 1981: A review of some problems of tropical marine conservation with particular reference to the Tanzanian coast. *Biological Conservation*, 20: 163-171.

Bryceson, I., T.F. De Souza, I. Jehangeer, M.A.K. Ngoile, and P. Wynter, 1990: State of the marine environment in the Eastern African region. *UNEP Regional Seas Reports and Studies* No. 113

Mgana, S. and S. Mahongo, 1997: Land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment: Tanzania Mainland. Report presented at the UNEP Regional Workshop, Institute of Marine Sciences, Zanzibar. 6-9 October, 1997. 50p.

Bwathondi, P.O.J., S.S. Nkotagu, and S. Mkuula, 1991: Pollution of the Msimbazi valley. Report commissioned by National Environment Management Council (NEMC), Dar es Salaam, 28p.

Mohammed, S. M., 1997: Land based sources and activities affecting the coastal, marine and associated freshwater environment along the coast of Zanzibar. FAO.18p.

Mashauri, D.A. and A. Mayo, 1989: The Environmental impact of industrial and domestic wastewater in Dar es Salaam. In Symposium on Environmental.

Shilungushela, J.M.S., 1993: Inventory of destructive activities to the freshwater bodies and the marine environment along the Tanga region coastal area. Report commissioned by National Environment Management Council (NEMC), Dar es Salaam, 57p.

Mohammed,S.M., 2000: The Assessment of Water Quality and Pollution in Tanzania.

Chaggu, E.J., 1993: Ground water pollution Majumbasita, Tanzania. Final Research Report. Ardhi Institute. 107p.

Sheriff, A., & Ferguson, R. (1991). Zanzibar Under Colonial Rule. James Currey.

Myers, N. (1988). *Threatened biotas: "hot spots" in tropical forests*. *The Environmentalist*, 8(3), 187-208.

European Union. (2021). *Coastal and marine conservation is critical to Zanzibar's Blue Economy drive*. Retrieved from EEAS

IUCN. (2021). *Tanzania National Guidance for Plastic Pollution Hotspotting Report*. Retrieved from IUCN

Maione, C. (2019). *Emergence of plastic pollution on tourism beaches in Zanzibar, Tanzania*. Retrieved from Deep Blue - University of Michigan

McIlgorm, A. (2023). *Report: How marine plastic pollution impacts countries that rely on tourism*. Retrieved from Phys.org