**Mapping and Characterization of Fish Landing Sites and Related Infrastructures along the coast of Kinondoni and Bagamoyo Districts, TANZANIA**

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**M.Sc. (Marine and Coastal Resources Management) Coursework & Dissertation**

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**Mapping and Characterization of Fish Landing Sites and Related Infrastructures along the coast of Kinondoni and Bagamoyo Districts, TANZANIA**

**Masumbuko Semba**

**A Dissertation Submitted in (Partial) Fulfillment of the Requirements for the Degree of Master of Science (Marine and Coastal Resources Management) of the University of Dar es Salaam**

**University of Dar es Salaam**

**June 2011**

# CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: Mapping and Characterization of Fish Landing Sites and Related Infrastructures along the coast of Kinondoni and Bagamoyo Districts, Tanzania, in fulfillment of the requirements for the degree of Master of Science (Coastal and Marine Resource Management) of the University of Dar es Salaam.

……………………………………….

Dr. Christopher A. Muhando

(Supervisor)

Date: ---------------------------------

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# DEDICATION

This dissertation is to my beloved wife, for her patience and understanding, who played such an important role along the journey, providing encouragement those times when it seemed impossible to continue. Lastly, thanks to God, the Divine, who continues to make the impossible possible.

# 

# ABSTRACT

Mapping artisanal fisheries activities for Bagamoyo and Kinondoni Districts based on spatial patterns of landing sites was carried out in a Geographic Information System (GIS) environment. Spatial attributes of the fish landing sites from fisheries frame survey database and field collected data was analyzed. The spatial distribution of the fish landing sites was weighted using Average Nearest Neighbor Tool (ANNT). The ANNT revealed that fish landing sites were not scattered but statistically spatially dispersed (P<0.01) in the study area, and the hierarchy for the relative importance of the landing sites in the area was established. Msasani, Kunduchi and Custom were the most prominent ones. Moran I tool (MIT) showed variability of fishing vessels, with a significantly high number of fishing vessels for Kinondoni District landing sites (P<0.01). Analysis of the value of fish landing sites based on the price of fishing vessels showed that Kunduchi had the highest investment value (532.65 Tsh Million), and was dominated by expensive fishing vessels (Boats), which constituted more than 52% of its total fishing vessel. Kunduchi was followed by Mlingotini (256.9 Tsh Million), and Msasani (152.05 Tsh Million), Nchipana(128.8 Tsh Million) and Custom (121.2 Tsh Million). It is important to highlight that price value of fishing vessels come from *in situ* data, while the number of fishing vessels come from fisheries frame survey database. Although, the number of fisheries records used for only ten fish landing sites, the study attempts to provide new insight on the spatial distribution, characteristic and investment value of landing sites, however, further studies will be needed to cover the whole coastline.

# TABLE OF CONTENTS

[CERTIFICATION iii](#_Toc299019499)

[DECLARATION AND COPYRIGHT iv](#_Toc299019500)

[ACKNOWLEDGEMENT v](#_Toc299019501)

[DEDICATION vi](#_Toc299019502)

[ABSTRACT vii](#_Toc299019503)

[TABLE OF CONTENTS viii](#_Toc299019504)

[LIST OF FIGURES x](#_Toc299019505)

[LIST OF TABLES xii](#_Toc299019506)

[LIST OF APPENDICES xii](#_Toc299019507)

[CHAPTER ONE: INTRODUCTION 1](#_Toc299019508)

[1.1 General introduction 1](#_Toc299019509)

[1.2 Statement of the Problem 5](#_Toc299019510)

[1.3 Research Objective 6](#_Toc299019511)

[1.3.1 General Objective 6](#_Toc299019512)

[1.3.2 Specific Objectives 6](#_Toc299019513)

[1.4 Significance of the Study 7](#_Toc299019514)

[CHAPTER TWO: LITERATURE REVIEW 7](#_Toc299019515)

[2.1 Mapping 7](#_Toc299019516)

[2.2 GIS Capability and Spatial Database 9](#_Toc299019517)

[2.3 Characteristic of marine artisanal fisheries 11](#_Toc299019518)

[2.4 Fish Landing Sites 13](#_Toc299019519)

[2.5 The value of Fish landing site 15](#_Toc299019520)

[CHAPTER THREE: MATERIAL AND METHODS 15](#_Toc299019521)

[3.1 Study area 15](#_Toc299019522)

[3.2 Mapping 16](#_Toc299019523)

[3.3 Determination of the length of the Coastline 18](#_Toc299019524)

[3.4 Characteristics of landing sites 19](#_Toc299019525)

[3.5 Density of fishing Vessels 20](#_Toc299019526)

[3.6 Valuing fish landing sites 20](#_Toc299019527)

[3.7 Spatial Statistical Analysis 21](#_Toc299019528)

[CHAPTER FOUR: RESULTS 22](#_Toc299019529)

[4.1 Mapping 22](#_Toc299019530)

[4.2 Length of the coastline 22](#_Toc299019531)

[4.3 Spatial distribution of fish landing sites 23](#_Toc299019532)

[4.4 Spatial Pattern of fishing vessels 24](#_Toc299019533)

[4.5 Characteristics of fishing vessels at the landing sites 26](#_Toc299019534)

[4.6 Characteristics of fishing gears at the landing sites 28](#_Toc299019535)

[4.7 Fish groups landed at the fish landing sites 30](#_Toc299019536)

[4.8 Density of fishing vessels at the landing sites 33](#_Toc299019537)

[4.9 Investment value of fish landing site 34](#_Toc299019538)

[4.10 Percentage of Fishermen at the fishing village 38](#_Toc299019539)

[CHAPTER FIVE: DISCUSSION 41](#_Toc299019540)

[CHAPTER SIX: CONCLUSION AND RECOMMENDATION 46](#_Toc299019541)

[6.1 CONCLUSION 46](#_Toc299019542)

[6.2 RECOMMENDATION 46](#_Toc299019543)

[REFERENCE 47](#_Toc299019544)

[APPENDICES 52](#_Toc299019545)

# LIST OF FIGURES

[Figure 1: A map of Bagamoyo and Kinondoni Districts showing the location of the fish landing sites. 17](#_Toc299019546)

[Figure 2: Length of the coastline for ten fish landing sites at Bagamoyo and Kinondoni Districts. The length of the coastline is color coded from the lowest to the highest as illustrated in the graph attached on the map. 23](#_Toc299019547)

[Figure 3: Graphic display results of Average Nearest Neighbor Tool showing the statistical results of distribution pattern of fish landing sites across the study area. 24](#_Toc299019548)

[Figure 4: Graphic display results of Moran’s I Tool showing the statistical results of distribution pattern of fishing vessels across the study area. 25](#_Toc299019549)

[Figure 5: Showing concentration of fishing vessels at fish landing sites ranges from a small amount of fishing vessels (negative value) progressing toward landing sites with a lot of fishing vessels (positive values). 26](#_Toc299019550)

[Figure 6: Percentage composition of different type of fishing vessels at each fish landing site. 27](#_Toc299019551)

[Figure 7: Bray-Curtis similarity of fish landing sites, fish landing sites at the right are more similar to one another than the landing sites toward the left of the dendrogram 28](#_Toc299019552)

[Figure 8: Percentage composition of different types of fishing gears used at each fish landing site 29](#_Toc299019553)

[Figure 9: Map showing the most dominant fishery type at each fish landing site in the study area 30](#_Toc299019554)

[Figure 10: Most common fish family groups landed at Custom landing site 31](#_Toc299019555)

[Figure 11: Most common fish family groups landed at Kunduchi landing site 32](#_Toc299019556)

[Figure 12: Most common fish family groups landed at Msasani landing site 32](#_Toc299019557)

[Figure 13: A map of Bagamoyo and Kinondoni districts showing density of fishing vessel along the coastline of each fish landing sites across the study area. 33](#_Toc299019558)

[Figure 14: Average price of common fishing gears used for artisanal fishing at the landing sites located along the coast of Bagamoyo and Kinondoni Districts. Figure 14 *(a)* shows fishing gear with low investment cost required where as figure 14 *(b)* are the medium to the most expensive fishing gear. 36](#_Toc299019559)

[Figure 15: Average price of common fishing vessel used for artisanal fishing at the landing sites located along the coast of Bagamoyo and Kinondoni Districts 37](#_Toc299019560)

[Figure 16: Total investment value of the fish landing based on the value of different types of fishing vessel. 38](#_Toc299019561)

[Figure 17: Graph showing the percentage fishermen at the fishing village in the study area. 40](#_Toc299019562)

# LIST OF TABLES

[Table 1: Geographical locations (in decimal degree) for ten fish landing sites at Bagamoyo and Kinondoni Districts 22](#_Toc299019586)

[Table 2: Density of fishing vessels at each landing sites in the study area 34](#_Toc299019587)

[Table 3: Prices of different fishing gears at the study area 35](#_Toc299019588)

[Table 4: Prices of different fishing vessels at the study area 36](#_Toc299019589)

[Table 5: Investment value of the landing sites based on the total value of different type of fishing vessels 38](#_Toc299019590)

# LIST OF APPENDICES

[Appendix 1: QUESTIONNAIRE 52](#_Toc299019593)

[Appendix 2: Fisheries related infrastructural facilities and targeted markets 54](#_Toc299019594)

[Appendix 3: Storage and processing facilities at the landing sites 55](#_Toc299019595)

[Appendix 4: Fish related services and activities at the landing sites 55](#_Toc299019596)

[Appendix 5: Fishery type at each landing sites based on the dominant fishing gear 56](#_Toc299019597)

[Appendix 6: An inventory of the software that were used in data processing and preparation of this report 56](#_Toc299019598)

[Appendix 7: Percentage fish catch for the three fish landing sites in which fish record statistics were available in the study area 57](#_Toc299019599)

# CHAPTER ONE: INTRODUCTION

## General introduction

Marine fisheries in Tanzania are mainly artisanal and undertaken mostly from small, non-motorized fishing vessels such as dugout, outriggers, dhows, and boats (Jiddawi and Stanley 1999). Only about 10% of fishing crafts are motorized. This constraint limits most of the fishing effort to inside the reef and rarely is fishing undertaken beyond territorial waters about 30 km offshore (FA0 2001). The most commonly used fishing gear is the artesian handline, longline, gillnet, traps, and sharknets (MLDF, 2010). Despite the fact that artisanal fisheries use low technology, it lands more than 90% of the total marine fish (Muhando et al, 2001).

Catch are landed on fish landing sites (FLS), which in most cases are located in urban areas or in small fishing village along the coastline. The Food and Agriculture Organization of the United Nation (FAO) defined FLS as sea-land areas where fishermen land their daily catches for auctioning (Karin et al. 2004) and where fisheries related boats are anchored throughout the year (Medina 1988). FLS have different characteristics, largely determined by the nature of the fishing effort (type and number of vessels, gears and fishers), total catch (fish supply), population size (fish demand), landing facilities, accessibility, potable water and electrical supply among others (Karin et. 2004).

Fish landing sites are not distributed randomly in time and space but tend to aggregate usually in response to particular physical feature of environment and fisheries abundance. Distribution of fish landing sites varies strongly in different scales from a few meters to many kilometers (Caddy and Carocci, 1999). Sobo (2007) reported that fish landing sites tend to be scattered on a certain geographical area and some of them were located in areas that are not easily accessible. It has been recognized that for the successful management of the artisanal fisheries, it is important to understand not only characteristic of the fish landing site, but also their spatial distribution patterns (like clustered, randomly or spatially dispersed) (Caddy and Carocci, 1999) and investment value for proper management of the fisheries sector.

In Tanzania, fisheries frame surveys referred to as fisheries census are usually used to generate important information of fish landing sites required for management and planning purposes of artisanal fishery (Sobo, 2007). Fisheries frame survey mainly focus to provide information on number of landing sites, fishers, number and types of fishing crafts and their mode of propulsion, number and types of gears, facilities at the fish landing sites including accessibility as well as service providers. However, the geographical coordinate’s points required for mapping and assessing the spatial distribution patterns of fish landing sites is not recorded during the survey. Sobo (2007) reported that mapping of 250+ fish landing sites surveyed in 2007 could not be done because of the limited geographical coordinate. Therefore there is a need to integrate the spatial component of fish landing sites into the fisheries frame survey for the purposes of producing better information to support decision making and management plans of the fisheries sector.

Mapping refers to representation of geographical position of fish landing sites of the earth’s surface on digital or paper map (ESRI, 2008). Mapping fish landing site has several advantage such as it provides visualization of spatial distributions of both fish landing sites and their characteristics; illustrate social and economical activities (Fabio et al. 2009). In addition, maps reveal critical location such as FLS known for high fish catch (Chapman and Turner 2004). Thus, mapping reveals very valuable information on unnoticed changes in space and time which may not be evident in Fisheries Frame Surveys Reports. Thus, this calls for strengthening of the interface between traditional method for assessing fisheries production factor (Fisheries Frame Survey) and modern technology that integrate the spatial geographical locations of FLS together with their associated characteristics (attribute information).

A Geographical Information System (GIS) is an ideal platform on which mapping the spatial distribution and characteristics of FLS become possible. A GIS is a computer-based tool for mapping and analysing events and places on the Earth’s surface. Mapping software like ArcMap allows display, query, update, and analysis of geographic locations of fish landing sites and the information linked to those locations. A GIS performs six tasks which include data input, data manipulation, data management, query and analysis, and finally visualization (Booth, 2004) as well as statistical analysis of the spatially georeferenced data (Breman, 2003). In addition, GIS has the power not only to create maps, but also integrate different information and visualise scenarios, present ideas, and provide solutions for complicated problems (Kam, 1989).

Much of the "power of GIS" in resource management issues is based on its spatial analysis capabilities (Martin, 2004). Spatial analysis refers to the ability of the analysis to manipulate spatial data into different forms and to extract additional meaning as a result (ESRI, 2008). It encompasses a variety of methods and procedures developed in different disciplines (Martin, 2004). A quantitatively-based framework for spatial analysis can be categorized into three broad classes visualization, exploratory data analysis and model building (Caddy and Carroci, 1999). These vary in complexity from simple map overlay operations to statistical models, such as primary productivity models (Fish, 2007).

GIS is also a fundamental communication tool that can be used to promote interaction between science and various stages of the policy and decision-making cycle. GIS create static and interactive maps, which are the primary means for communicating spatial information of geographical feature like fish landing sites (ESRI, 2008). With its extensive graphic component, GIS created maps can reduce complexity and add value by summarizing, synthesizing and illustrating critical issues facing artisanal fisheries (Booth, 2004). Hence provide information for better decision making with high level of confidence about where and which fish landing site need more management attention and how to allocate management resources (Caddy and Carroci, 1999).

The scientific community involved in the study of fishery resources has recognized that approaches seeking to contribute to the development and management of living marine resources should be integrated, i.e., including the temporal and spatial dimensions of their variability (Mangel et al. 1996). As a consequence, creating maps of the fishery, fishing landing sites and production factor with which they interact, should be a priority task when planning fishing development and management plans (Caddy and Carroci, 1999). As it has been seen in other fields of science in which problems in relation to space do occur, the application of a new and promising tool, GIS, can be translated in a remarkable improvement in spatial management of the fishery sector (Meaden, 2009), in particular when combined with other management methods such as fisheries frame survey.

In Tanzania, the use of spatial information technology for the purposes of planning and management artisanal fisheries is yet to find its rightful place. Therefore this study present the use of GIS for mapping the spatial distribution, characteristic and investment value of fish landing site based on geo-referenced data collected during field visits and fisheries frame survey in Bagamoyo and Kinondoni Districts as case study. The characteristics and investment value of fish landing sites are critically discussed, and some recommendations presented.

## 1.2 Statement of the Problem

Despite having a database for FLS along the entire coastline of Tanzania mainland, the Fisheries Development Division has not been able to produce digital maps showing the spatial distribution of FLS. This is because the geospatial component required for making thematic maps of FLS is not part of the data recorded during Fish Frame Survey. Furthermore, information such as the value of production factors (equipments and/or facilities) of FLS is also not collected, hence the information of the wealth of the fish landing site is limited. Knowing where fish landing sites are geographically located and their investment value is essential information required to support better decision making processes for planning and management of artisanal fisheries in Tanzania.

## 1.3 Research Objective

### 1.3.1 General Objective

This study generally seeks to bridge the gap that currently exists between mapping fish landing sites and fisheries frame surveys information, within the specific context of a small-scale artisanal fishery using Geographical Information System (GIS) technology.

### 1.3.2 Specific Objectives

The specific objectives are:-

1. To map the spatial distribution of fish landing sites along the coast of Kinondoni and Bagamoyo districts
2. To characterize fish landing sites along the coast of Kinondoni and Bagamoyo districts
3. To determine the investment value of the fish landing sites found within the coast of Kinondoni and Bagamoyo districts

## 1.4 Significance of the Study

The overall target of the study is to contribute to the science and knowledge on the use of GIS technology for spatial planning and management of coastal and marine resources, including artisanal fisheries. The findings of this study provide spatial information on spatial distribution (location), investment value and factors influencing FLS along coast of Kinondoni and Bagamoyo district, which can be used to support policy and decision making for improved management and development of the artisanal fisheries sector. The study has also established GIS-based database (spatial database) for fish landing sites found at Bagamoyo and Kinondoni Districts, which will serve as a model for efficient and effective organization, update, and query of spatially georeferenced data of fish landing sites and facilitate analysis of geospatial information. Furthermore, this study serves as a baseline of using a GIS technology as management tool to facilitate easy and timely access of the required information in the right format by different end users, including policy and decision makers, fisheries resource managers, fishers, scientists and the private sector.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Mapping

Mapping helps to locate a FLS on the earth’s surface presented on digital or paper map (Meaden 2009). Fish landing site distributions can be mapped within a GIS environment using georeferenced fisheries data (Noji et al. 2006). Mapping the distribution of fish landing sites helps to visualize and understand where critical or sensitive fish landing sites are located, and this information is essential for successful fisheries management (Fabio et al. 2009). Mapping the fishery and the resources should be among the priority tasks when planning for fisheries management (Caddy and Carrocci, 2004). Butler (1987) prepared a manual with practical guidelines and principles of cartography which elaborated the basic concepts underlying preparation of maps and charts, collection of geographical information and graphical techniques to improve information transfer from cartographic representation to the end user.

Maps enable anyone to overcome the frustration of an 'illiteracy syndrome' that difficult words otherwise impose and so allow everyone to be more content (Fisher, 2007). A special purpose map, prepared with an objective to show distribution of a theme (such as fish landing sites) is known as thematic map (Grimshaw, 1994). A synoptic map can be an invaluable basic document for investment planning and for display of economic information in a spatial context (e.g. socioeconomic status of fishermen, rates of unemployment, etc.). One of the areas where information of different types needs to be combined in this way is in preparation of management plans for fisheries. Caddy and Garcia (1986) pointed that the Food and Agricultural Organization (FAO) of the United Nations (UN) have been recommending that spatial management via mapping should be a prerequisite for the strategic development of fisheries. Although this has been difficult in Tanzania for the past years, recently the advent of GIS has opened up extraordinary opportunities.

A thematic map can be used to highlight the particular coastal areas which support the natural resources (mangroves, coral reefs, MPA etc.) and manmade infrastructural facilities like fisherman villages, landing centers, fish markets, processing plants, export units, which are the basic means to exploit natural fishery resources. All the natural and infrastructural facilities available can be expressed on a thematic map, which is of direct relevance to all users and administrators of the marine environment for proper understanding, planning, managing and optimal utilization of available facilities and resources (Kemp and Meaden, 2002). Also, mapping helps to visualize and understand where sensitive fish landing sites are located, and this information is essential for successful fisheries management (Fabio et al. 2009).

## 2.2 GIS Capability and Spatial Database

A Geographic Information System (GIS) is a computer assisted database usually used to digitally collate, analyze and present geographic data (Kemp and Meaden 2002). GIS is certainly the fastest growing form with the most applications, without which many of the daily functions would not be possible. GIS is used for a vast range of tasks for nearly everything. In Industry and particularly in agriculture, GIS is used extensively for mapping of crop yield and crop rotation cycles, as well as projecting future soil loss on farms, be it from erosion, or poor use (Grimshaw 1994). Since a GIS can be used to manage information from wherever it is located, GIS is becoming increasingly valuable in business management, allowing information to be obtained about where the customers are, what their preferences are (market research), spending patterns, and how to optimally exploit this information to maximize overall market share to minimize effective competition (Petes, 2008).

Cities and city planners cannot do without GIS to track maintenance, keep inventories and map locations, and model scenarios and distribution of services (Petes, 2008). GIS is used daily in the conservation of the environment. Species and resources can not only be mapped but can also be modeled, which allows for a preventative view on possibilities or scenarios, allowing greater solution about a specific problem (Meaden, 2009). Furthermore, managing coastal resources is also more sustainable with the use of a GIS, where the study of mapping of fishing grounds have been conducted (Petes, 2008)

Integration of geographic entities representing real locations spatial information on the earth’s surface is one of the strengths and prominent functionalities of a GIS (Kam 1989). Quantitative information can be combined with qualitative information to create a functional model in GIS to represent a real world (Grimshaw 1994, Borges et al. 2001). GIS use a spatial database for its functions; typically, the database has two elements a spatial database describing the geography of a feature and an attribute database describing any associating characteristics (Orenstein 1986, Borges et al. 2001).

GIS offers powerful tools to address complex issues and allows for efficient and effective organize, update, and query geospatial data (Rolph et al. 2001). It provides the tools for applying spatial analysis, managing data, and mapping the results of the spatially referenced biophysical and socioeconomic information (Greboval 1990, Martin 2004). With GIS, complex spatial systems between biophysical and human processes are easily integrated and analyzed (Chapman and Turner 2004). It also provides a logical function in which FLS mapping is applied and used to calculate some of the necessary attributes (Meaden 2009).

With GIS software geospatial data can be visualized and analyzed in new ways, revealing previously hidden relationships, patterns and trends (Borges et al. 2001). GIS software such as ESRI ArcGIS Desktop is used to visualize the spatial/temporal distribution of fishing activities and the socio-biophysical linkage affecting this distribution (Fisher 2007). Furthermore, GIS supports decision making process by helping to design and develops management practices grounded in regional, biophysical, social and political realities (Bremen 2003). Fabio et al. (2009) reported how mapping enabled visualization of the spatial dimensions of fisheries activities in the northern Gulf of California, the spatial distribution of fishing activities and the social-biophysical linkage affecting this distribution was successfully visualized.

## 2.3 Characteristic of marine artisanal fisheries

A fishery is the interaction between the fishery resource, its environment, and humans. The benefits of a fishery system can be economic, nutrition or sport related. Artisanal fishing is an important economic activity in many countries (Gameiro and Wilson, 2003). It employs thousands of people, provides food to a large part of the population and contributes significantly to foreign exchange earnings (Karin et al., 2004). While artisanal fishing refers to an activity, artisanal fisheries refer to the sector. Artisanal fisheries generally use relatively low levels of technology and investment both for fishing and for processing (Allison and Ellis, 2001). It is also distinguished by its high levels of labor input, which is often recruited through family relationships (Karin et al., 2004). Artisanal fishing in Tanzania is characterized by being carried out within the near shore coastal waters of depth not exceeding 30 meter deep (Muhando and Jiddawi 1998). Some artisanal fishing occurs in depths of 100 m and more by using larger boats such as dhows (Muhando et al. 2001). Fishing communities exist in many small villages scattered along the entire coastline of Tanzania Mainland.

Artisanal fishermen use traditional crafts, mostly propelled by oar, pole or sail and simple fishing gears (Richmond 1998, Jiddawi and Khatib 2007). Common fishing vessels used along the coastline of Tanzania include dugout canoes, outrigger canoe, boats, and dhows. Outrigger and dugout canoe are the most extensively fishing vessels used in marine waters of Tanzania because they are cheaper than boat and relatively more efficient than dhows (Tarbit, 1985). The fishing gears commonly used are lines (handline and longline), traps (fixed and moveable), nets (purse seine, scoop, drift gillnets, demersal gillnets with small and large mesh, shark nets and surrounding gill nets), spear guns and iron harpoons (Jiddawi and Stanley 1999).

Since the main propulsion for the fishing vessel is wind, the fishing areas protected by the coral reef barriers and bays are the only places where it is possible to fish all the year round (Muhando et al. 2001). Fishing is carried out mainly in shallow water areas of coral reefs and seagrass beds (Muhando and Rumisha in press) that are easily accessible from fishing villages and landing sites (Medina 1988). In the intertidal area, fish stocks are supported by a combination of benthic and water column primary productivity (Muhando et al. 2001). The high benthic productivity in shallow habitats like coral reefs, seagrass beds and mangrove attracts corresponding high secondary (zooplankton) and tertiary (fish and invertebrates) productivity.

The best fishing grounds of Tanzania coastal water are found in the Pwani Region (Muhando and Rumisha in press). Areas with relatively high abundance of fish include the areas around Dar es Salaam, Bagamoyo and Zanzibar channel as well as areas around Mafia, Kilwa and Rufiji delta (Muhando and Jiddawi 1998). The channel is characterized by continental shelf extending to the island of Unguja and Mafia, as well as estuaries of the largest rivers such as Pangani, Wami, Ruvu and Rufiji flowing into the Indian Ocean (Tarbit, 1985). These favourable conditions make it the most coastal productive area (Muhando et al. 2001). It is in this zone where there is the highest concentration of artisanal fishing activities (Muhando et al. 2001).

## 2.4 Fish Landing Sites

A landing site is a useful entry point for management and development planning in artisanal fisheries because it is the one geographical place where the majority of stakeholders come together: boat owners, fishers, fish processors, fish traders, mechanics, food sellers and carpenters, fisheries field staff, customs officers and harbor police(Karin et al., 2004). The landing site is thus an effective and efficient starting point for understanding the characteristic of artisanal fisheries as well as on the strategy on how to manage it. A fish landing site may range from a small settlement on a stretch of beach with hardly any infrastructure and facilities to larger artisanal fisheries areas that are part of bigger ports or harbors in or close to urban centers (Karin et al., 2004).

A fish landing site is used for receiving fish from small-scale fishermen, fishing fleets motorized with outboard engines or inboard diesel engines and non motorized sailing vessels (Medina 1988). The bulk of the catch landed is marketed as fresh fish and is sold to consumers in the vicinity of the landing sites and in the densely populated areas (Karin et al. 2004). The FLS attributes depend on the market, which is an institution that enables product exchanges to take place. The market serves as a connection between the producer (fishermen) and consumer (resident, hotel developer). FLS serves both a physical function (buying, selling, storage, processing, Transportation and information) and economic function (price, behaviour).

Some of the facility found at FLS includes fish receiving stations and market, land based fish storage facilities, ice making facilities and processing plants (MNRT 1999). These are facilities to support fishers in their day to day operations. They are meant to facilitate marketing of the catch and reduce post harvest losses (Muhando and Rumisha in press). Other facilities at FLS are fish store, potable water, toilet facilities, boat and net repair facilities, accessibility, weighing scales and electricity supply (Karin et al. 2004). Each FLS is different and is shaped by different forces (social, economic, political, demographic, resource, legal).

## 2.5 The value of Fish landing site

Many factors go into determining fish landing site value. The size of the area and number of buildings plays a large part. Typically, market and auction buildings with facilities increase the fish landing site value (Talbot and Wilkinson, 2001). There are several other features that help determine fish landing site value; located near urban center, close to public transportation and the age and condition of building and facilities of the landing site (Mellors, 1991; Talbot and Wilkinson, 2001). All of these can add to its value. Another factor in fish landing site value is the current fishing efforts (type and number of fishing vessels and gears). The more the fishing effort, the more valuable the landing site, (Talbot and Wilkinson, 2001) particularly if it constitutes vessels which are more valuable such as boats and dhows. Supply and demand fish products and other fish related infrastructural facilities if available adds th e wealth of the landing site (Pollnac and Crawford, 2000).

# CHAPTER THREE: MATERIAL AND METHODS

## 3.1 Study area

The research was carried out in the coastal areas of southern Bagamoyo and the whole Kinondoni District from November 2010 to April 2011. The area has coastline of about 70 km, which includes ten permanent fish landing sites, Custom, Kunduchi and Msasani being locted in urban centers (Fig.1). The climate at Bagamoyo and Kinondoni Districts, as long as the rest of the coast of Tanzania is dominated by monsoon winds which influence the weather and the coastal current patterns such as the East African Coastal Current (Guard, 2002). The reversing monsoon wind occurs between October and March (northeast (NE) monsoon), and the southeast (SE) monsoon season from April to October (Richmond, 1998; Munga et al, 2010). As a result, wet seasons, alternate with dry season (Richmond, 1998). A longer rain period occurs in March to May, and shorter rainy season usually occurs in November. The fish landing lies along the east coast bordering the Zanzibar Channel, one of the most productive marine fisheries areas in Tanzania (Muhando et al, 2001).

## 3.2 Mapping

One among the requirements for mapping is the coordinate points; the geographical coordinates of ten fish landing sites in the study area were collected. A field visit was done and longitude and Latitude as geographical points for each landing site was recorded using hand held Geographical Positioning System (GPS) unit. These points were exported from GPS unit to Drawing Exchange Format (DXF) using Garmin MapSource software to and later converted to GIS compatible vector format (shapefile) in SAGA, GIS software. The setups of Garmin MapSource were first synchronized with those of GPS unit to WGS 84 as a datum using longitude and latitude (in decimal degree) as a geographical position.

The basemap datasets, which included administration boundary, habitat, hydrology, infrastructure and settlement of the study area, were obtained from Institute of Marine Sciences (IMS) GIS database and DIVA-GIS website (<http://www.diva-gis.org/gdata>). All spatial datasets were converted to feature class and stored in a person geodatabase; an ArcGIS platform for storing feature datasets and a way of organizing related feature class (ESRI, 2008). The road network from IMS database was upgraded using Google Earth images of 2010. Google earth image were georeferenced (Aligned to a known coordinate system) first and later combined in ArcMap using Mosaic tool forming a composite image. New roads were created by importing the composite image in ArcMap and traced over the feature of interest (digitize) using Edit Tool.

Study area.emf

Figure 1: A map of Bagamoyo and Kinondoni Districts showing the location of the fish landing sites.

## 3.3 Determination of the length of the Coastline

A coastline dataset available from the World Vector Shoreline (WVS) was much generalized, summarized complex Tanzania’s coastline into a simple line for display, and hence was not suitable for measuring the length of coastline for small scale areas. A detailed coastline for the study area was extracted using high detailed feature class dataset from IMS GIS database. Determination of the length of the coastline was based on the following criteria: 1) the coastline is made up of individual line, which has two or more vertices. 2) The sum of the lengths of the pairs of vertices is aggregated for each individual line, and 3) the sum of the lengths of individual lines was aggregated for coastline. Using ArcMAP, two processes were deployed; first, establishing a line representing a coastline. This was done by converting the polygon feature class of the Bagamoyo and Kinondoni Districts to polyline using “feature to polyline tool” in Data Management toolbox. The polyline feature class was further edited to a single line representing the coastline of the study area. This length of the coastline for the study area was further divided into individual fish landing site using “Split Tool” by taking an equidistant (the same distance apart at every point of the fish landing site) along the coastline.

The second step was to measure the length of the coastline, which was done by using “measuring tool” in ArcMap. The Measurement units of the of the tool was reset from the default map units to kilometers and determined the length by simply clicking directly on the coastline layer of each fish landing site in ArcMap, the results were displayed inside the window of the tool, which made easy to copy and paste them into the attribute table of the coastline feature class. Those portions of the coastline with little possibility for fish vessels to anchor was not considered in determination of the length of the coastline, hence the length presented here is a rough estimate focusing on the fish landing sites and should be used with caution

## 3.4 Characteristics of landing sites

Attribute and spatial information which formed the basis for the characteristics were extracted from Fisheries Frame Surveys Database. Fish landing sites were characterized based on the fish related infrastructural facilities found at the site.. Data collected include, number of fishermen, total catch of fish landed, species composition, type and number of fishing gear and fishing vessels, fish catch, fisheries officers, Beach Management Unit, processing and storage facilities; electricity and tap water availability; accessibility; and other fish related activities such as restaurants, boat builders and gear repair, and. For determination of the investment value of landing sites, semi-structured interviews were deployed in each landing sites to obtain the value of different type of fishing vessels and gears. Questionnaires were prepared in English but administered in Swahili. The interview was directed to different stakeholders at the fish landing sites including influential fishers, beach recorders, fisheries officers, boat builders and the owners of fishing facilities. Collected data was processed and converted GIS compatible environment and then populated in feature class datasets stored in a personal geodatabase.

## Density of fishing Vessels

According to ESRI, 2008, density in spatial measurements is defined as the quantity per unit area or length. Density of vessel was obtained by taking the total number of fishing vessels divided by the length of the coastline of a particular landing site. The coastline was restricted to study area and fishing vessels were distributed evenly across the length of the coastline.

## 3.6 Valuing fish landing sites

There are many factors that contribute for wealth of fish landing site, particularly the infrastructural facilities and fish related attributes found at the landing site. It was observed that artisanal fisheries were mostly influenced by fishing vessels, hence, vessels plays and important economical role at the landing site. Essentially two steps were involved for estimating the current vessel’s price and wealth of landing site. Vessel price were obtained by taking the cost of making or buying it. If the price could not be obtained, the price of materials used to make vessels was determined and multiplied with the quantity of the material. The wealth of landing was estimated as the value of fishing vessels multiplied by the number of that particular type of boat for each landing sites. Then the value of each vessel type was summed up to obtain the total investment value of the landing site. Because of the limited availability of data for other attributes, only fishing vessels were considered for estimation of the investment value of the landing site

## 3.7 Spatial Statistical Analysis

All spatial statistical analyses were performed using “Spatial Statistical tools” in ArcMap. The statistical analyses assessed the spatial distribution of fish landing sites and determined their spatial pattern. “Average Nearest Neighbor statistical tool was” used for understand the nature of spatial distribution, whether the fish landing sites are clustered in one location, random or dispersed in the study area and also for testing if the distribution pattern is statistical significant.

Spatial pattern of fishing vessels was assessed using Spatial Autocorrection Statistical Tool (Moran’s I), which test the statistical significance of dispersion or clustering of fishing vessels across the study area. Since Moran’s tool give the pattern of distribution but does not show where exactly clustering occur, a Hot Spot Analysis Tool (Getis Ord GI Statistic) was used to investigate which Fish landing sites have high clustering of fishing vessels compared to others. Similarity between and among landing site was determined using a method described by Clarke and Warwick (1994).

# CHAPTER FOUR: RESULTS

## 4.1 Mapping

The Geographical coordinate points of ten fish landing sites located in south of Bagamoyo and Kinondoni Districts are summarized in Table 1. These points were used to map the location of fish landing sites in GIS environment. Together with other fisheries attributes, these points enabled making of thematic maps for artisanal fisheries sector in the studied area.

Table 1: Geographical locations (in decimal degree) for ten fish landing sites at Bagamoyo and Kinondoni Districts

|  |  |  |  |
| --- | --- | --- | --- |
| District | Landing site | Longitude | Latitude |
| Kinondoni | Msasani | 39.269 | -6.760 |
| Kunduchi | 39.219 | -6.668 |
| Ununio | 39.178 | -6.627 |
| Mbweni | 39.136 | -6.576 |
| Bagamoyo | Changwahela | 39.087 | -6.523 |
| Mlingotini | 390 | -6.479 |
| Mbegani | 38.970 | -6.472 |
| Kaole | 38.941 | -6.459 |
| Custom | 38.910 | -6.440 |
| Nchipana | 38.907 | -6.436 |

## 4.2 Length of the coastline

The length of the coastline for the studied area was found to be 67.62 km, with Changwahela having the longest coastline followed by Msasani, Kunduchi Mbweni and, Ununio, whereas Nchipana and Custom were observed to be close to each other and were the landing sites with the shortest length of coastline in the study area (Fig. 2). In general, Bagamoyo sites are closer to each other than those at Kinondoni District.

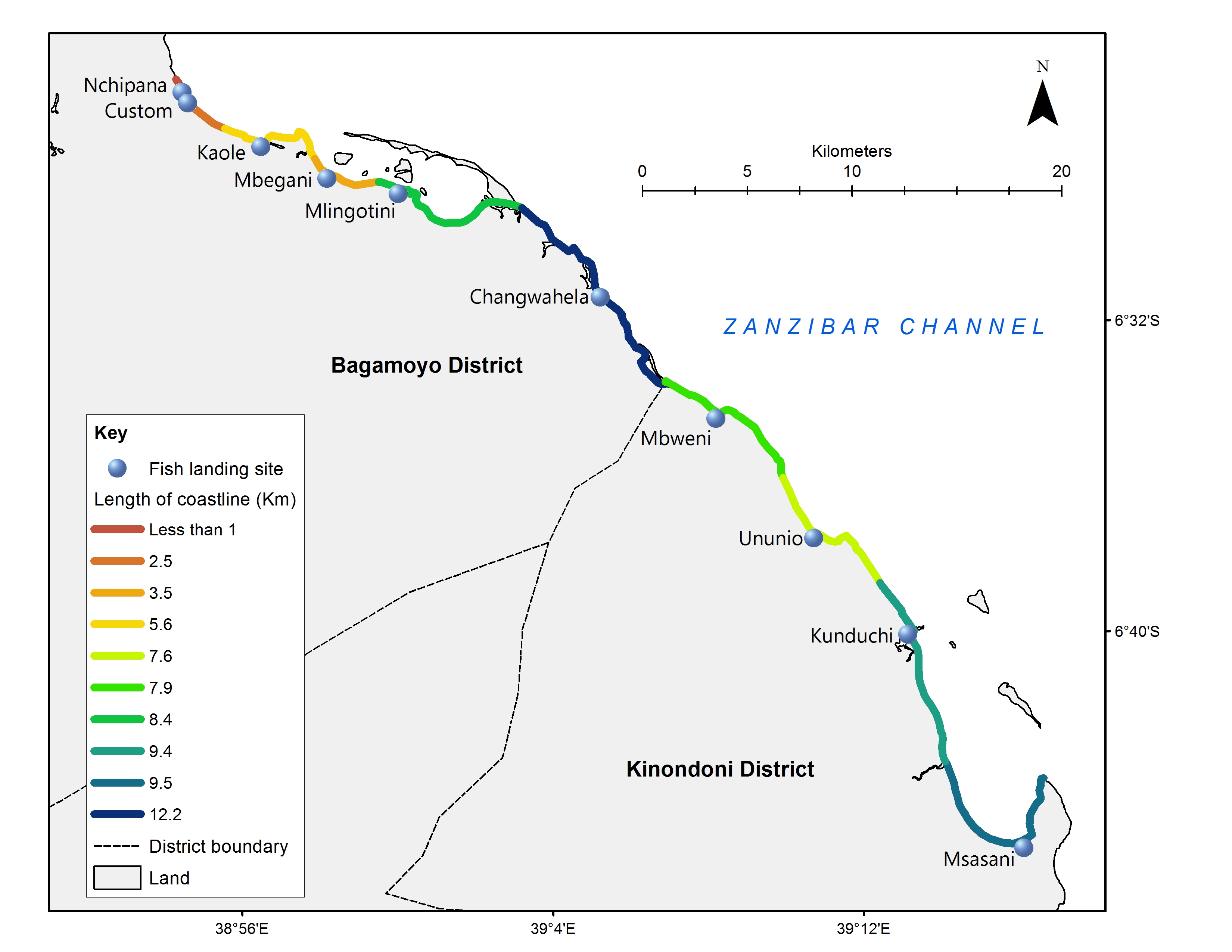


Figure 2: Length of the coastline for ten fish landing sites at Bagamoyo and Kinondoni Districts. The length of the coastline is color coded from the lowest to the highest as illustrated in the graph attached on the map.

## 4.3 Spatial distribution of fish landing sites

The spatial distribution of the fish landing sites was determined using tools of Spatial Statistical Toolbox in ArcView. The Average Nearest Neighbor Tool showed that the distribution of fish landing sites in the study area was not clustered but spatially dispersed, and the result was statistically significant ( P<0.01) (Figure 3).

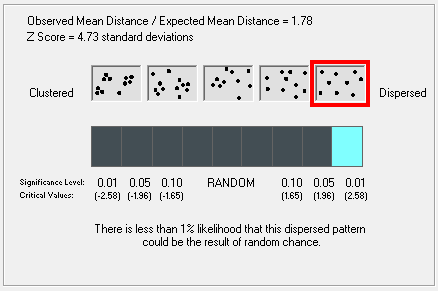


Figure 3: Graphic display results of Average Nearest Neighbor Tool showing the statistical results of distribution pattern of fish landing sites across the study area.

## 4.4 Spatial Pattern of fishing vessels

Fishing vessels were used as spatial attribute to determine the spatial characteristics of the fish landing sites. Two approaches were deployed for the determination of distribution pattern of fishing vessel; the first approach was to determine if there is any kind of pattern of fishing vessels, the results obtained by running Spatial Autocorrection (Moran’s I) tool, showed concentration pattern of fishing (p<0.10, Fig. 4). As shown in the figure 5. Msasani, Kunduchi and Ununio had slightly higher abundance of fishing vessels comapared to other landing sites, and Mlingotini was found to have the lowest number of fishing vessels in the study area

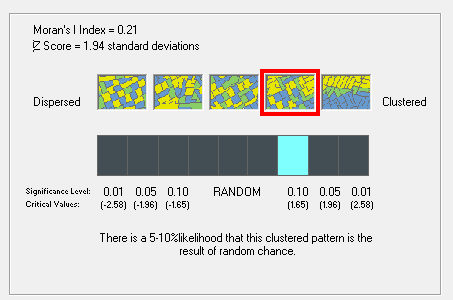


Figure 4: Graphic display results of Moran’s I Tool showing the statistical results of distribution pattern of fishing vessels across the study area.

fishing vessel hotspots.emf

Figure 5: Showing concentration of fishing vessels at fish landing sites ranges from a small amount of fishing vessels (negative value) progressing toward landing sites with a lot of fishing vessels (positive values).

## 4.5 Characteristics of fishing vessels at the landing sites

Surveying among landing site for each vessel category, sites of particularly high fishing vessel percentage composition were identified (Fig. 6). Most notably, boat in Kunduchi landing site was the highest (52.75%) by far surpassed the composition of boats in other landing sites. Outrigger canoe percentage were numerically highest at Ununio (60.81%), followed by Nchipana (50%), custom (56.76%) and Mbegani (67.57%). Dugout canoe constituted 70.37% of all vessels recorded at Changwahela and 52.56% at Mbweni. Dhow contributed 70.37 of all fishing vessels at Mlingotini and Mashua was domint at Nchipana constituting 37.50%.



Figure 6: Percentage composition of different type of fishing vessels at each fish landing site.

**Similarity of Fish Landing Sites**

The similarity of fish landing sites was determined using type and abundance of fishing vessels. Kaole, and msasani had the highest similarity of about 90%, where as kaole and mbegani were very similar (80%). Ununio, custom and Kunduchi showed a similarity with msasani and mbweni by 80, 70 and 64, respectively. While Nchipana and Mlingotini were more different from one another and with the rest landing sites, about 60% of fishing vessels at changwahela showed to be very similar to kaole and mbegani landing sites (Fig.7).

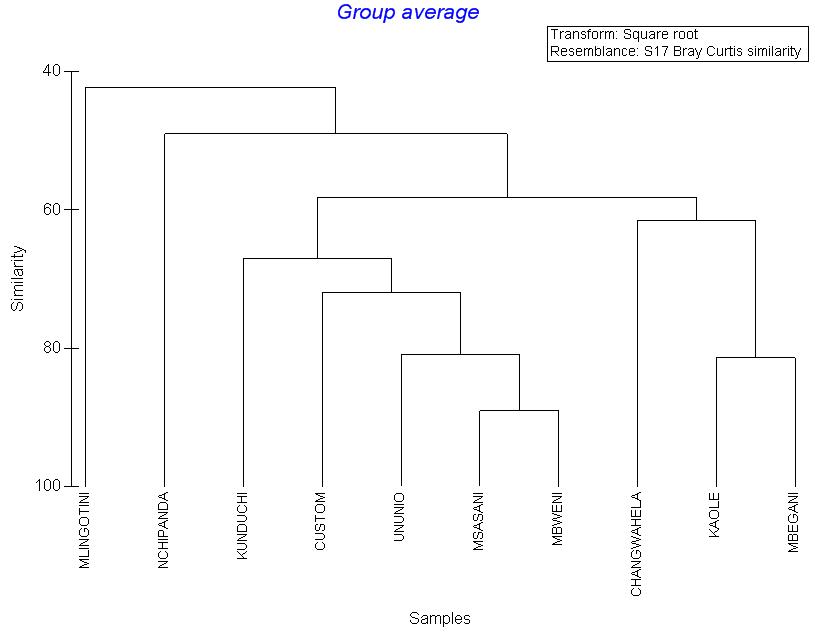


Figure 7: Bray-Curtis similarity of fish landing sites, fish landing sites at the right are more similar to one another than the landing sites toward the left of the dendrogram

## 4.6 Characteristics of fishing gears at the landing sites

Looking on the percentage contribution of fishing gear in the fish landing sites, gillnets were numerically highest at Custom (84.31%), Longline percentage composition at Mbegani (71.09%) far exceeded other landing sites. Trap fisheries were found numerically higher at Mbweni (67.46%), followed by Kaole (Fig. 8). The percentage of destructive fishing gears such as beach seine at each fish landing site was very small, the highest percentage of beach seine and spear was 1.57 and 2.22 at Custom and Kunduchi fish landing sites, respectively.



Figure 8: Percentage composition of different types of fishing gears used at each fish landing site

Fishery type.emf

Figure 9: Map showing the most dominant fishery type at each fish landing site in the study area

## 4.7 Fish groups landed at the fish landing sites

Spatial data for Common fish groups presented here was available for three fish landing sites of Custom (Bagamoyo), Msasani and Kunduchi (Kinondoni). Data limitations prevented detailed error estimation and also any formal consideration of temporal variability in fishing catches. Thus, the result characterizes annual fish catch but does not capture the monthly or seasonal changes that undoubtedly occur. Nine groups of fish were selected for analysis because of their total abundance landed at the landing sites. These groups were considered as dominant in terms of showing highest landings registered.

Fish family group composition landed varies among landing sites. In general, a sardine (Clupidae) had shown to be the most dominant group within the study area. Clupidae was the most landed fish group at Custom,comprise more than 50%, followed by Scombridae, Labridae, Siganidae Lenthrinidae (Fig. 10). At Kunduchi landing site, like Custom, the catches landed was dominated by Clupidae, contributing more than 26% of the total fish landed, followed by Scombridae Lenthrinidae, Hemiramphidae, Siganidae (Fig. 11). Unlike Custom and Kunduchi, where the dominant fish family was Clupidae, Lenthrinidae was most landed fish group at Msasani landing site, contributing more than 38%, followed by Labridae, Carangidae, Scombridae and Siganidae (Fig. 12).



Figure 10: Most common fish family groups landed at Custom landing site



Figure 11: Most common fish family groups landed at Kunduchi landing site



Figure 12: Most common fish family groups landed at Msasani landing site

## 4.8 Density of fishing vessels at the landing sites

Density of fishing vessels varies among landing sites. Fishing vessel densities were numerically highest at Nchipana (74.20 vessels/km) followed by Custom (30.20 vessels/km), and Kunduchi (19.40 vessels/km) (Fig. 13). In general, landing sites located at Kinondoni district showed to have low density of fishing vessel compared to those located at Bagamoyo district (Table 2).

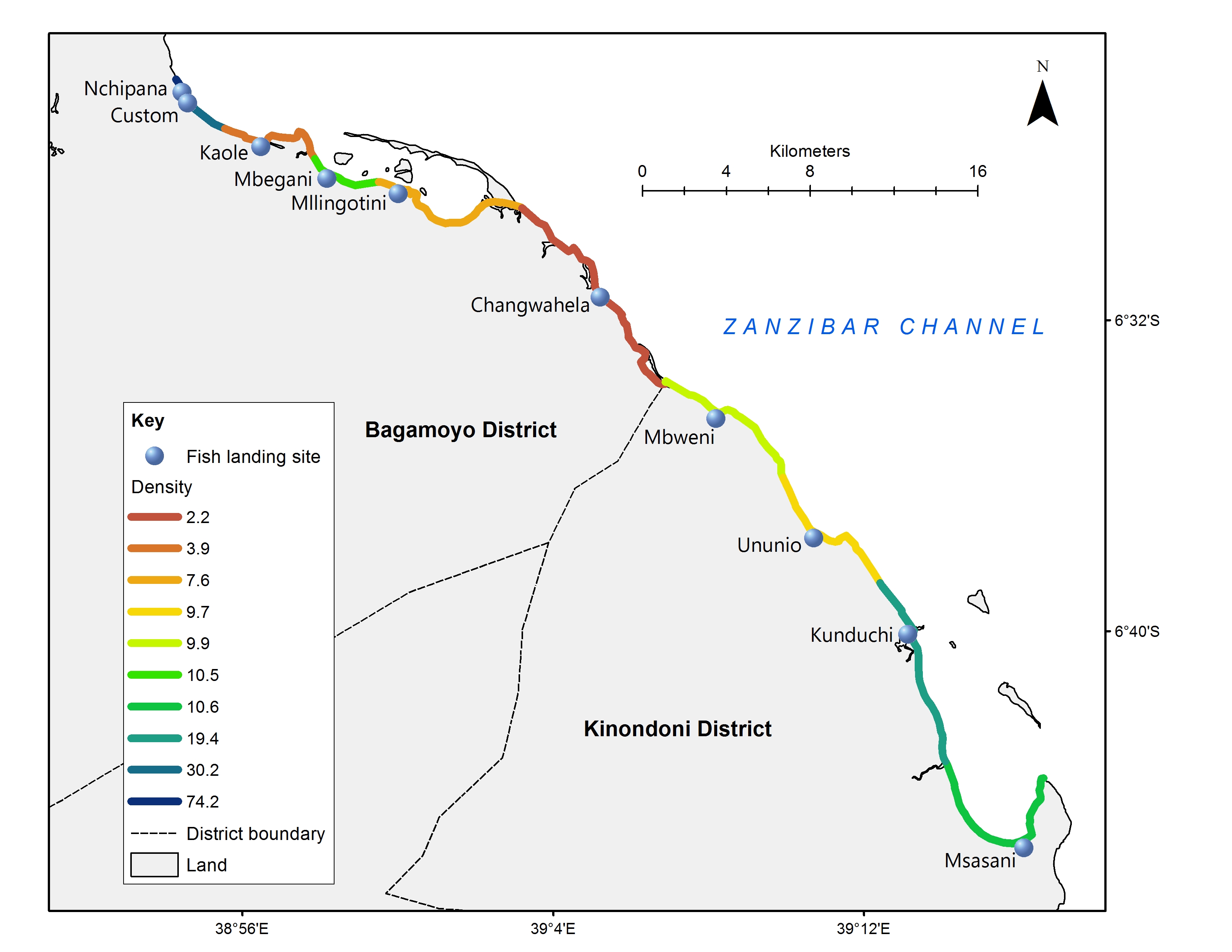


Figure 13: A map of Bagamoyo and Kinondoni districts showing density of fishing vessel along the coastline of each fish landing sites across the study area.

Table 2: Density of fishing vessels at each landing sites in the study area

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **District** | **Landing site** | **Coastline (km)** | **vessels** | **Density** |
| Bagamoyo | Nchipana | 0.97 | 72 | 74.23 |
| Custom | 2.45 | 74 | 30.20 |
| Kaole | 5.62 | 22 | 3.91 |
| Mbegani | 3.53 | 37 | 10.48 |
| Mlingotini | 8.38 | 64 | 7.64 |
| Changwahela | 12.19 | 27 | 2.21 |
| Kinondoni | Mbweni | 7.91 | 78 | 9.86 |
| Ununio | 7.63 | 74 | 9.70 |
| Kunduchi | 9.4 | 182 | 19.36 |
| Msasani | 9.54 | 101 | 10.59 |

## 4.9 Investment value of fish landing site

Table 4 and 5 summarizes the cost of different types of fishing gears and vessels. These tables show the minimum and maximum price of a different gear and vessel type, as well the average price. While gillnets, ring nets, beach seine, shark net, and seine net were observed to be the most expensive fishing gear in the study area (Fig. 14b), traps, spear and handline were the least expensive ones (Fig. 14a). Looking on fishing vessel, the price of fishing vessels by type did not vary much within fish landing sites because most of fishing vessel used in the study area were not made in the area, were bought in Tanga. Three most expensive fishing vessels were Boat, followed by dhow and Mashua with price ranging between 4,000,000 and 4,900,000 Tsh, whereas dugout and outrigger canoe were the cheapest fishing vessels recorded (Fig. 15).

Table 3: Prices of different fishing gears at the study area

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Price range of fishing gears (Tsh)** | | |
| **Gear** | **Minimum** | **Maximum** | **Average price** |
| Handline | 800 | 1200 | 1000 |
| Spear | 12000 | 15000 | 13500 |
| Traps | 11000 | 31000 | 21000 |
| Longline | 6500 | 70000 | 38250 |
| Gill net | 50000 | 600000 | 325000 |
| Beach seine | 1000000 | 1700000 | 1350000 |
| Shark net | 2500000 | 3500000 | 3000000 |
| Seine net | 2500000 | 4000000 | 3250000 |
| Ringnet | 3814000 | 5200000 | 4507000 |



*( a )*



*( b )*

Figure 14: Average price of common fishing gears used for artisanal fishing at the landing sites located along the coast of Bagamoyo and Kinondoni Districts. Figure 14 *(a)* shows fishing gear with low investment cost required where as figure 14 *(b)* are the medium to the most expensive fishing gear.

Table 4: Prices of different fishing vessels at the study area

|  |  |  |  |
| --- | --- | --- | --- |
| **Vessel/Price** | **Minimum** | **Maximum** | **Average** |
| Dugout canoe | 150000 | 400000 | 275000 |
| Outrigger canoe | 300000 | 1200000 | 750000 |
| Mashua | 4000000 | 4000000 | 4000000 |
| Dhow | 4500000 | 5000000 | 4750000 |
| Boat | 4800000 | 5000000 | 4900000 |



Figure 15: Average price of common fishing vessel used for artisanal fishing at the landing sites located along the coast of Bagamoyo and Kinondoni Districts

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Looking on total investment value of fish landing sites based on the fishing vessel, landing sites of particularly high investment were identified. The value of only fishing vessels for the entire study area was estimated to be 1.47 billion TSh (Table 5) and total investment at Kunduchi landing sites far exceeded other landing sites, followed by Mlingotini, Msasani , Nchipana Custom and Mbweni. Ununio, Kaole, Mbegani and Changwahela had total investment value below 100 Millions (Fig. 16).

Table 5: Investment value of the landing sites based on the total value of different type of fishing vessels

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Landing site** | **Boat** | **Outrigger** | **Dugout** | **Dhow** | **Mashua** | **Total** |
| Changwahela | 4900000 | 1650000 | 14250000 | 4750000 | - | 25550000 |
| Mbegani | 24500000 | 6875000 | 5250000 | - | - | 36625000 |
| Kaole | 29400000 | 1375000 | 5250000 | 19000000 | - | 55025000 |
| Ununio | - | 12375000 | 16500000 | 28500000 | 4000000 | 61375000 |
| Mbweni | 9800000 | 6325000 | 30750000 | 52250000 | 4000000 | 103125000 |
| Custom | 78400000 | 11550000 | 8250000 | 19000000 | 4000000 | 121200000 |
| Nchipana | 4900000 | 9900000 | 6000000 | - | 108000000 | 128800000 |
| Msasani | 44100000 | 10450000 | 29250000 | 52250000 | 16000000 | 152050000 |
| Mlingotini | 29400000 | - | 9000000 | 218500000 | - | 256900000 |
| Kunduchi | 470400000 | 5500000 | 48000000 | 4750000 | 4000000 | 532650000 |
| **Total** | **1473300000** | | | | | |



Figure 16: Total investment value of the fish landing based on the value of different types of fishing vessel.

## 4.10 Percentage of Fishermen at the fishing village

While Mlingotini had more than 18% of its population engaging in fisheries, which is the greatest percentage of people in the study area, other fishing villages had less than 10% of their total population (Table 6). It was found that fishing village located at the urban centers, which are Msasani, and Kunduchi had the lowest percentage of fishermen (Fig 17).

Table 6: Population size and the percent of fishermen for fishing village in the study area

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| District | Fishing Village | Population | Fishers | Percent |
| Kinondoni | Msasani | 43259 | 315 | 0.73 |
| Kunduchi | 72275 | 473 | 0.65 |
| Ununio | 2223 | 80 | 3.60 |
| Mbweni | 1541 | 68 | 4.41 |
| Bagamoyo | Mapinga | 3823 | 72 | 1.88 |
| Mlingotini | 1974 | 361 | 18.29 |
| Pande | 1340 | 77 | 5.75 |
| Kaole | 1149 | 66 | 5.74 |
| Dunda | 14460 | 590 | 4.08 |

Source: Tanzania Bureau of Statistics and Fisheries Development Division



Figure 17: Graph showing the percentage fishermen at the fishing village in the study area.

# CHAPTER FIVE: DISCUSSION

In this study, methods for mapping fish landing sites and characterize them using spatial analysis in GIS in order to create fish landing sites according to the spatial pattern are shown. Mapping coastal fish landing sites and their characteristics is one approach to sustainable management of the fisheries sector as it helps to visualize the various patterns across large areas. Efforts to describe and map coastal fisheries have been hindered by the obstacles associated lack of resources directed toward data collection, the distant and dispersed nature of the fisheries, limited data availability, and a scarcity of spatial information (Sobo, 2007).

To date, fisheries assessment methods have been largely described using catch metrics and indices of fishing capacity. Catch statistics are far more readily available and do provide information on fishing activities. However, mapping and characterizing fish landing sites will serve as a more accurate basis for understanding the artisanal fisheries and the effects of fishing. In this study, efforts to map and characterize fish landing sites have highlighted the importance of mapping fisheries activity at the landing sites as a first step toward sustainable fisheries management

Geographical locations of fish landing sites (Table 1) were used to represent geographical position of fish landing sites of the earth’s surface and their spatial distribution (Fig. 1) as well as the length of the their coastline (Fig. 2). Mapping of fish landing sites are significant to not only understanding their spatial distribution, but it help us gain a better perspective of various characteristics of those landing sites. For example, one of the main reasons that Custom, Msasani and Kunduchi are the major fish markets is because of their geographic makeup. Almost all these landing sites protected by lagoon, which protect them from wave action and also allow fishers to land their fishing vessels all the time.

Mapping also helped to determines the relationship between landing sites in the study area. Custom, Msasani and Kunduchi are located in town centers with good road network, fish markets with some storage and processing facilities and large numbers of people, which are the factors influencing fishers other landing sites to come and sell their daily catch because of the high fish demand and good fish price at the sites. These factors also affect the amount of fish landed, for example the fish statistics records were available for only three landing sites of Kunduchi, Msasani and Custom (Fig. 10, 11, 12), implying that fishers from other landing sites prefer to sell their daily catch to towns located landing sites. Conversely, Changwahela has different situation.  As located far from fishing village in an exposed coastal area not protected, it’s not easily accessible by road all the time, making it not easily accessible by customers and difficult to transport fishing materials to the landing sites. it has been used as fishing camp rather than fish landing site.

Maps of fish landing sites based on recorded descriptions of the spatial extent of a fishery are likely to be a more accurate characterization of fisheries within an area. Furthermore, delineating the fishing effort into broad categories also provides information on the differential impacts among gear types; for example, beach seine gear has been documented to degrade benthic habitat, and gillnets, as highly non-selective gear, typically lead to high mortality of juvenile target and non-target species. There is empirical support for these gear characterizations. The percentage of gillnet was found to be particularly high in Custom suggesting that these landing site has the potential to exhibit high collateral effects in coastal fisheries. Other landing sites had high percentage of selective fishing gears such as handline and longline (Fig. 8), and when dominant fishing gears are mapped (Fig. 9), they provide useful information for characterizing the dominant fishery type at the fishing landing.

By mapping fishing vessel for different fish landing sites, spatially-explicit density of fishing vessels was determined across study area (Fig. 13). It was found that the length of coastline was significantly related to densities fishing vessels, which means fish landing sites with longer coastlines typically had lower densities across the area (Table 3) While the links between density of fishing vessels and coastline length are intuitive and may help provide a coarse characterization of fishing pressure at the landing site, they explained a small proportion of the variability in abundance of fishing vessel and do little to identify which vessel types are dominant at the landing sites.

The percentages of fishing vessels vary among landing sites (Fig. 6), in which some landing sites had high concentration of fishing vessels than others (Fig. 5). Comparison between fish landing sites was based on the similarity index. The index of similarity proposed by Clarke and Warwick (1994) was chosen for this study. This index measured the type and abundance of fishing vessels at the landing sites. The result is illustrated in (Fig. 12), where Kaole and Mbegani were similar landing sites at Bagamoyo district, Msasani and Mbweni were similar at Kinondoni district. Other landing sites were not similar to each other. This comparison is useful as it enable fisheries resource manager to understand the characteristic of the fish landing sites which do exist at a certain coastal area.

To appreciate better how much fishing village population depend on fishing and other fish related activities at fish landing sites, further analysis was carried out to establish the proportion of people relying solely on fisheries for their livelihood. The dependency of artisanal fishery varies from village to village. As illustrated in Figure 17, the percentage of people in fishing village depending on fishing was very low, however, Mlingotini fishing village appeared to depend heavily on fishing. This represents a relatively high percentage of fishermen which would suggest a high vulnerability to any negative change in fish exploitation regime. Although the proportion of fishing village depend on fishing was low in the study area, it is relatively high in Kaole, Pande, Dunda, Mbweni and Ununio. The dependence was found to be lowest in urban fishing village of Msasani and Kunduchi. Thus, the results suggest that the strongest level of dependence on artisanal fisheries in term of subsistence and income is found in the rural fishing village of Bagamoyo District (Table 6). However, it should be noted that most villagers depend on other combination of activities like agriculture, and small business.

Finally, one of the most significant findings of the research was that

of the investment value of the fish landing sites, as measured by the value of fishing vessel. The most valued fish landing sites were found to have high higher proportion of expensive vessels whereas low valued landing sites were dominated with few and cheap fishing vessels (Fig. 15). The highest investment value at Kunduchi was striking (Fig. 16), contributed by the high percentage of boats (Fig. 6), which was the most expensive fishing vessel. Although Mlingotini was the second, its investment value was contributed by higher proportion of dhow, second most expensive fishing vessels recorded. Changwahela had the lowest investment value in the study area (Fig. 16), with total investment value of about 25.5 million (Table 5). The low investment value at Changwahela fish landing site was contributed with the dominance of dugout canoe, cheapest fishing vessel recorded in the area. Despite the figures of investment value presented here, it should be noted that value of the landing sites is not determined by fishing vessels only but by other factors that contribute to the total investment value of a particular landing site.

# CHAPTER SIX: CONCLUSION AND RECOMMENDATION

## 6.1 CONCLUSION

Through the use of GIS technology, spatial distribution of fish landing sites has been mapped, and their spatial characteristics have been described. In addition, useful information of the investment values for each fish landing sites has been partially estimated. The study has also outlined a methodology for the incorporation of fisheries frame survey into simple GIS framework and illustrated not only how fish landing sites are spatially distributed, but also how non spatial information collected through fisheries frame survey can be incorporated in GIS to create thematic maps that aid in characterizing fish landing sites.

## 6.2 RECOMMENDATION

Based on the study’s result, it is recommended that integration of Geographical Information Systems (GIS) with fisheries frame survey will improve collection and update of fisheries data as well as providing better information for sound management of fisheries sector in Tanzania. Given the majority of the fish landing sites lacked fisheries related data, there is a need for improving data collection before processing and mapping operations can be undertaken. Since artisanal fisheries is operated in small fishing village, that are scattered along the coast, it is recommended that further research should be done that cover the whole coastline of Tanzania and monitor the fishery trend at the landing sites through compilation and analysis of spatial statistical data, that take into account the geographical location of the landing sites.

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# APPENDICES

Appendix 1: QUESTIONNAIRE

**General information**

I am MSc. Student at the Institute of Marine Sciences of the University of Dar es salaam. It’s a two year program, we have covered one year doing coursework, and right now, we’re conducting research as part of the program. This research, seek to understand the relationship of the investment value of fish landing sites and how the locations where these fish landing sites are found may affect this relationship.

CHECKLIST FOR FISHERIES OFFICERS/BEACH RECORDER

District……………………

Name of the landing site …………………………………

Name of the fisheries officer/ beach recorder …………………………………………

Gear information;

|  |  |  |  |
| --- | --- | --- | --- |
| Gear type | Accompanied equipments | Total number (in the site) | Price range |
|  |  |  |  |
|  |  |  |  |

Are there any other gears you haven’t mentioned yet? ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Other relevant information ………………………………………………………………………………………………………………………………………………………………………………

Vessel information;

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type | No. of motorized | No. of non-motorized | Range of engine size | price range |
|  |  |  |  |  |
|  |  |  |  |  |

Are there any other vessels you haven’t mentioned yet? ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Other relevant information ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Facility and infrastructure information;

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Number | Status | Price range |
|  |  |  |  |
|  |  |  |  |

Are there any other facilities you haven’t mentioned yet? …………………………………………………………………………………………………………………………………………………………………………

Other relevant information ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Other service provisions at the site

|  |  |
| --- | --- |
| Type of activity | Number |
|  |  |
|  |  |

Are there any other services you haven’t mentioned yet? ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Other relevant information ………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Appendix 2: Fisheries related infrastructural facilities and targeted markets

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Landing sites** | **Accessibility** | **Market place** | **Landing building** | **Targeted market** |
| Msasani | Road/water | Building | Permanent | Ferry |
| Kunduchi | Road/water | Building | Permanent | Kunduchi |
| Ununio | Road/water | Building | Permanent | Kunduchi |
| Mbweni | Road/water | Pavement | No | Kunduchi |
| Nchipana | Road/water | Pavement | No | Custom/Ferry |
| Custom | Road/water | Pavement | Permanent | Custom/Ferry |
| Kaole | Road/water | Pavement | No | Custom/Ferry |
| Mbegani | Road/water | Pavement | No | Custom/Ferry |
| Mlingotini | Road/water | Pavement | No | Custom/Ferry |
| Changwahela | Road/water | Pavement | No | Ferry |

*Source:* Fisheries Development Division

Appendix 3: Storage and processing facilities at the landing sites

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Landing sites | Cold room | Freezer | Kiln | Frying | Processing on | Electricity | Water supply |
| Msasani | No | YES\* | YES | YES | Stool | Disconnected | Tap water |
| Kunduchi | Installed | YES\* | No | YES | Stool/ Pavement | Connected | Tap water |
| Ununio | No | YES\* | No | YES | Stool | Connected | Tap water |
| Mbweni | No | No | No | YES | Stool/ Pavement | No | No |
| Nchipana | No | No | No | No | Pavement | No | No |
| Custom | No | No | No | YES | Pavement | Connected | Tap water |
| Kaole | No | No | No | YES | Pavement | No | No |
| Mbegani | No | No | No | No | Pavement | No | Tap water |
| Mlingotini | No | YES\* | No | No | Pavement | No | No |
| Changwahela | No | No | No | No | Stool/ Pavement | No | No |

*Source:* Fisheries Development Division

\*private owned

Appendix 4: Fish related services and activities at the landing sites

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Landing sites** | **Fisheries staff** | **BMU** | **Boat builder** | **Gear shops** | **Mamlishe** | **Toilets** |
| Msasani | YES | Exist | Present | Present | Permanent | Present |
| Kunduchi | YES | Exist | Present | Present | Temporary | Present |
| Ununio | No | Exist | Present | No | Temporary | No |
| Mbweni | No | Exist | Present | No | Temporary | No |
| Nchipana | No | Exist | Present | No | No | No |
| Custom | YES | Exist | Present | Present | Temporary | Present |
| Kaole | No | Exist | Present | No | No | No |
| Mbegani | No | Exist | Present | No | No | No |
| Mlingotini | No | Exist | Present | No | Temporary | No |

*Source:* Fisheries Development Division

Appendix 5: Fishery type at each landing sites based on the dominant fishing gear

|  |  |
| --- | --- |
| **Landing site** | **Fishery type** |
| Msasani | Handline |
| Kunduchi | Handline |
| Ununio | Handline |
| Mbweni | Traps |
| Nchipana | Handline |
| Custom | Gillnet |
| Kaole | Handline |
| Mbegani | Longlline |
| Mllingotini | No data |
| Changwahela | No data |

Appendix 6: An inventory of the software that were used in data processing and preparation of this report

|  |  |  |  |
| --- | --- | --- | --- |
| **Name of Software** | **Version** | **Publisher** | **Year Published** |
| Adobe Illustrator CS5 | 15 | Adobe System Inc. | 2010 |
| Adobe Photoshop CS5 | 12.0 | Adobe System Inc. | 210 |
| Adobe Acrobat Extended | 9 | Adobe System Inc. | 2008 |
| ArcGIS Desktop | 9.3.1 | ESRI | 2008 |
| Saga | 2.04 | SAGA | 2010 |
| Mapsource | 6 | Garmin Ltd | 2004 |
| Notepad ++ | 5.9.2 | Notepadd++Team | 2011 |
| WinRAR | 4 | WinRar GmbH | 2011 |
| Microsoft Office Enterprise | 12 | Microsoft Corporation | 2007 |

Appendix 7: Percentage fish catch for the three fish landing sites in which fish record statistics were available in the study area

|  |  |  |
| --- | --- | --- |
| **Landing site** | **Catch (Tonnes)** | **Percentage** |
| Custom | 151 | 37.46 |
| Kunduchi | 96 | 23.82 |
| Msasani | 156 | 38.70 |

*Source:* Fisheries Development Division