***Original Research Article***

# Geo-spatial Analysis of the Nexus between Population Growth, Environmental Transformation and Local People's Livelihoods in Coastal Areas: The Case of Kigamboni Municipality, Tanzania




## ABSTRACT

The world is facing an unprecedented population increase in coastal areas. This situation is mainly the result of human migration. The population increase has multiplier effects on the environment and development. In Kigamboni Municipality, land-use changes have been witnessed and new expansions, including agricultural, commercial, industrial and urban-related expansions, happen every day. Thus, this study investigates the impact of population growth on the environment and the local people's livelihoods in Kigamboni. Land-use/land-cover (LULC) changes were quantified using satellite images. In addition, a total of 156 respondents were randomly selected from four sub-wards in the municipality. Secondary data were collected by reviewing the relevant literature and primary data were collected using a structured questionnaire, in-depth interviews, observations and focus group discussions (FGDs). ~~Geospatial techniques, namely remote~~ Remote sensing ~~and Geographical Information System (GIS), were~~techniques was used to map the spatial and temporal variation of the area between 1995 and 2021using~~. ARandom Forest Classifier model in R software was used to classify and generate land-cover types. Images were classified using the~~ Supervised Classification method in Random Forest Classifier model in R software to generate land-cover types. ~~.~~ Land-cover changes were detected using ArcGIS10 software. Seven major LULC categories were identified. The results show that the area under cultivation and the built-up area increased by 40% and 4%, respectively, and that bushlands, forests and grasslands had 34%, 6% and 13%, respectively. The population increase has both positive and negative effects on the local people's livelihoods, including access to social services, improvement of infrastructure, the availability of markets, the increase in waste, pollution and the increase of the cost of land.The study recommends the formulation of appropriate policies on land-use planning in relation to population dynamics.


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*Keywords: Population growth, land-use/land-cover changes, environmental transformations, livelihoods, Geographical Information Systems*

## 1. INTRODUCTION

The world is witnessing heterogeneous population growth with much concentration in coastal areas. Most coastal residents have been influenced by the availability of vast resources and livelihood opportunities in the areas. The areas are an interface between land and sea, and they are appropriate for recreational use, marine trade and transport [1, 2]. At present, about half of the world's population live within 200 kilometres of a

coastline. This figure is likely to double by 2025 [3]. The world is witnessing unprecedented population growth in coastal areas; the coastal population estimated in 2000 was 638 million people. This number will increase between 58% and 71% in 2050. In African countries, the coastal population was estimated to be 54 million people in 2000; this number will reach 137 to 172 million in 2050 and 130 to 265 million in 2100 [4]. Most of megacities in the world are located in coastal areas. However, the coastal population growth and urbanisation trends are not similar in all parts of the world, and they vary significantly between countries and regions [5, 6].
Population growth in coastal areas is the result of human migration and a natural population increase. The increase in the number of people in a certain area increases the demand for environmental resources. The interaction between population growth and the environment has regularly been sighted differently since time immemorial. Thomas Malthus published 'Essay on the Principle of Population' in 1798. This was a step towards obtaining a scientific understanding of the relationship between population and resources. His pessimistic view on population and resources has been criticised by various scholars, who advocate technological development as a solution to many setbacks caused by population growth in ensuring environmental sustainability and food security. The present study focuses on the perception that population growth in coastal areas has a dual impact on people's livelihoods and the environment. Livelihood options in such areas may lead to certain transformations, including land-cover/land-use changes and climate variations [2]. Changes in land use are, certainly, the most serious concern, as they transform the livelihoods of the local people, who used to rely on farming activities. The development and exploitation of coastal resources has significantly increased in recent decades. At the same time, coasts are undergoing incredible socio-economic and environmental changes [7, 8].

In African countries, demographic factors play a considerable role in environmental degradation; the reason behind this situation is the local people's overdependence on coastal resources as a source of livelihoods. Over 70% of the population in Africa derive their livelihoods from the land on which various activities are undertaken, including subsistence farming, fuel wood extraction and hunting. The nature of the economy, particularly the growing poverty levels, is among the reasons for the high rates of land degradation on the African continent [9]. Population growth and development are significant drivers of change in coastal areas; they exert high pressure on coastal land by increasing the demand for land for both agriculture and settlement purposes. Agriculture reduces biodiversity by replacing human communities with crops, and urbanisation causes habitat loss [10]. Among the most important pressures are habitat conversion, land-cover changes, pollutant loads and the introduction of invasive species [11, 7]. The development and exploitation of coastal resources has increased in recent decades, and coasts are undergoing incredible socio-economic and environmental changes. This is likely to be the case in future as well [2].

The East African region, despite its diverse political, economic and ecological conditions, has a similar kind of environment and a common but varying dependence on the coast and its resources [1]. The region is endowed with some of the world's richest ecosystems with significant environmental diversity. The Eastern African coastal zone is extremely populated due to its growing industrial infrastructure. Tanzania is located on the East African coast. It borders the Indian Ocean and smears between Kenya to the north and Mozambique to the south. The country has a total area of 945,087 $km^2$, which includes the islands of Mafia, Pemba and Zanzibar [12]. Water covers 59,050 $km^2$ of the area, and the coastline is 1,424 km long. A large number of the coastal dwellers in Tanzania depend on coastal resources for their livelihoods.
Mainland Tanzania has over 800 km of coastline, characterised by a mixture of sandy beaches, rocky outcrops, extensive coral reefs and dense mangrove stands, especially around the river deltas [13]. The coastal resources are of vital importance to the country as they provide various opportunities, thus encouraging the concentration of people and development activities on the coast [1]. In Tanzania, over 20% of the population lives in its five coastal administrative regions, which encompass about 15% of the country's land area [14]. The areas are subjected to increasing pressure from a variety of activities such as fishing, coastal aquaculture, salt-making, waste disposal and the indiscriminate cutting of mangroves and coastal forests for fuel and timber. These activities affect the coastal environment.

The coastal area of Mainland Tanzania includes the coastal regions of Tanga, Coast, Dar es Salaam, Lindi and Mtwara with a population of 11,549,190 [15]. The area is a uniquely productive and yet a fragile piece of the environment. The area is important to the wellbeing of the local communities and the national economy [14, 1].The people living in the coastal, rural areas depend largely on smallholder farming and artisanal fishing for

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**Comment [HDM4]:** Restructure sentence to allow flow and add the source.

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their livelihoods. Many other activities, including lime and salt production and livestock husbandry, are undertaken. At national level, the coastal zone is important for agriculture, natural gas extraction, tourism, fisheries, transport and trade and residential development [1]. The coastal resources are currently under pressure, principally because of the population increase as it has led to competition over resources. The competition is coupled with the desire to increase income and has frequently led to destructive practices [9]. Over the years, the steady of population increase in the five coastal regions of Mainland Tanzania has kept changing.

The impact of human pressure on the coastal environment and resources is apparent in many Tanzanian coastal regions. The increased demand for food and fuel has led to the use of destructive methods to exploit the resources. Overdependence on the coastal resources for socio-economic development can lead to coastal environmental changes. Previous studies on population growth and environmental changes, conducted in the coastal areas of Mainland Tanzania, mainly focused on coastal environmental management practices, land-use planning and coastal water management (9, 1, 16,17]. Very little has been done to determine the nexus between population growth, environmental transformation and local people's livelihoods. Therefore, there is a need of ascertaining a synthesized study that investigates the nexus between such parameters.

## 2. MATERIAL AND METHODS

### 2.1 The Study Area

This study was conducted in Kigamboni Municipality, Dar es Salaam Region, ~~. Dar es Salaam is~~ one of the Tanzania ~~coastal regions in~~ Mainland ~~Tanzania~~ coastal town which experiences high population growth. It is the third fastest-growing city in Africa and the ninth fastest-growing city in the world [18]. In 2002, the region had 2.4 million people. The number increased to 4.36 million people in 2012 and to 5.7 million people in 2017. The figure was expected to rise to seven million people in 2021; thus, Dar es Salaam would account for about 10% of the total population in Mainland Tanzania [19]. Kigamboni Municipality is one of the five municipalities in Dar es Salaam City. It borders the Indian Ocean in the east and Mkuranga District in the south. In the north Kigamboni borders the Indian Ocean and Temeke Municipality. The selection of this council was based on its size as it is one of the largest municipalities in Dar es Salaam City with an area of 577.86 km², which is equivalent to 57,786.8 hectares of land [20]. The district has witnessed high population growth over the years. In 2012, there were 162,932 in Kigamboni. In 2018, the projected population was 225,938 people at a 5.4% annual growth rate. As of 2019, Kigamboni Municipality had 238,591 people [20]. The municipality has experienced different urbanisation progression over time. Prior to 2015, Temeke Municipality administered Kigamboni. Population growth in the study area has resulted in urban sprawl, which has, consequently, changed land use, from agricultural to urban use. The local people's livelihoods have also been transformed.

**Comment [HDM9]:** What is the fisrt and the second fastest growing city in Afric? Name them.

### 2.2 Sample and Sampling Procedures

In order for a sample to be representative to the entire population, it is recommended that, at least 20%-30% of the population must be selected, depending on the size of the population concerned [21]. Kigamboni District has nine wards; thus, two wards, which represented 22% of all the wards, were selected. These were Mjimwema and Kisarawe II. The Ward Excecutive Officers (WEOs) provided the total number of sub-wards in their areas and a reprentative sample was selected. The selected sub-wards had a total of 1560 households. Having these households in the study area, at least 10 per cent of them were manageable and representative for this study as suggested by other scholars [22, 23]. Therefore, 156 households representing 10% of the total households were sampled in the selected sub-wards, as Table 1 shows.

**Table 1: Sample Size**

| Ward | Total Number of Sub-wards | Sub-wards Sampled | Name of Sub-wards Selected | Number of Households | Number of Households Selected (10%) |
|---|---|---|---|---|---|
| **Kisarawe II** | 11 | 03 | Kigogo<br>Mkamba<br>Ngoma Mapinduzi | 462<br>267<br>149 | 46<br>27<br>15 |

| | | | | | |
|---|---|---|---|---|---|
| **Mjimwema** | 04 | 01 | Maweni | 682 | 68 |
| **Total** | | | | **1560** | **156** |

### 2.3 Data Collection Methods

Both primary and secondary data were collected to achieve the research objectives. Primary data were collected using a survey and participatory rural appraisal (PRA) methods. The specific survey techniques were a household questionnaire and in-depth interviews. The participatory rural appraisal (PRA) methods were direct observation and FGDs. Primary data were on the dynamics of population growth, the household activities undertaken and their implications for the coastal environment and the local people's livelihoods. Secondary data were collected by reading documents such as journals, textbooks, newspapers, census reports, and library and web-based materials on the research topic. Different research tools were used, namely a semi-structured questionnaire, a checklist of questions for the key informants, a checklist for making observations and a checklist of themes for the FGDs.

This study also analysed Landsat images obtained from the USGS website (https://earthexplorer.usgs.gov). The area is clouded almost throughout the year; thus, obtaining clear sky images at a regular time interval and in the same month was challenging (cloud cover is less than 10%). Therefore, the satellite imagery selected was that of 1995 and 2021, which fell within the same season (June to July) (Table 2). Two images were from the TM sensor (1995), and the third was from Landsat 8 (2021). Landsat TM consists of seven spectral bands with a spatial resolution of 30 metres for optical bands (Bands 1 to 5 and 7) and a thermal infrared band (Band 6) with a spatial resolution of 120 metres. Landsat 8 consists of eleven bands from Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). Nine OLI spectral bands with a spatial resolution of 30 metres for Bands 1 to 7 and Thermal Infrared Sensor (TIRS)Bands 10 and 11 (100m resolution). The optical bands were used to classify the land cover in the study area.

**Comment [HDM10]:** Provide separate heading. Spatial Data type, Processing and Analysis

**Comment [HDM11]:** Second?

**Table 2: AttributesoftheSatelliteImagery Analysed**

| Sensor | Path | Row | Date of Acquisition |
|---|---|---|---|
| Landsat 5 (TM) | 166 | 65 | 25 June 1995 |
| Landsat 8 (OLI) | 166 | 65 | July–October 2021 |

Prior to the classification of the Landsat images, they were processed (atmospheric and radiometric correction, cloud filling and masking were done) using Google Earth Engine's code editor to remove the sensor, atmospheric and illumination artifacts. This was done following the suggestion given by other authors [24]. Then, using an Rs Random Forest(RF) Classifier, land cover types were classified. RF is the most widely used machine-learning remote sensing (RS) in classifying land cover types. Higher resolution images from Planet, Bing maps, Esri, and Google Earth using QGIS plugins to generate accurate training signatures for each LULC, this was essential due to the limited spatial resolution of the images.

A supervised classification method was used to classify the images. The images were stacked and classified; the Random Forest Classifier model in R software opted for the classification and generated the land cover types. The images were put into seven LULC categories: agriculture with scattered settlements, bare soil (sand, exposed soil and areas without vegetation cover), a built-up area (covered buildings and roads, and other impervious kinds of surface), bushlands, forests (natural forests, woodland and mangrove forests), grassland and water bodies (rivers, wetlands and the ocean). Land-cover changes were detected using ArcGIS10 software. The two classified land-cover layers of 1995 and 2021 were used A matrix of land-cover changes was generated using a spatial analysis tool. The function calculates cross-tabulated areas between two datasets and produces a table. The table displays a record for each unique value of the zone dataset and a field for each unique value of the class dataset. Geometry was used to calculate the size of the areas (in hectares) of each type of land cover in the matrix.

**Comment [HDM12]:** Add the install specific libraries used for reading data and the script for image classification in the R software employed

**Comment [HDM13]:** Include the confusion matrix for the random forest model and explan concisely.

## 3. RESULTS AND DISCUSSION

### 3.1 Sociodemographic Attributes towards land use changes

The main attributes of land use changes were analysed from responses given by the household respondents. These were branded to include; human migration from rural areas and internal migration from other municipal districts within Dar es Salaam city. Population growth in the study area led to the magnification of various activities including expansion of agricultural land and establishment of infrastructures such as roads, residential houses and industries. The choice of land use ~~are~~is frequently influenced by household size, age, gender, education level, employment status, attitudes, values, and personal traits of household members [25, 26]. These elements are important in demographic studies because several communities' interactions depend on demographic factors [27, 28]. As indicated in Table 3, majority of the respondents (49.4%) had primary education and therefore they are unlikely to be employed in formal sectors hence depend on land and its resources to meet their needs. In this practice, they have modified land in different ways and intensities. Various studies report that an increase in the level of education of the household lessens the likelihood of causing environmental deprivation. If the community is exposed to knowledge, various economic practices will be environmentally friendly. Moreover, education tends to improve the economic status of the society thus reducing overdependence on land recourses [26]. Also, age has been described as one among the attribute patterning land use change as various activities performed on the environment depend on the working age. In the present study, the majority of respondents were aged between 15 and 55. This signifies that most of the respondents were in the working group. The International Labour Organisation says that the minimum working age should be not less than 15 years [29].

Additionally, the majority of respondents were females (56%) as they were readily available at their homes or in the nearby areas, doing petty trade or urban farming. In addition, it is argued in demographic studies that most of urban dwellers have a rural background. In the present study, about 61% of the respondents were migrants from rural areas (Table 3). This corroborates the general perception. With rapid population growth in coastal areas, sprawling has been inevitable. This is borne out by the size of households as it is argued that the bigger the household size, the more the land needed for undertaking daily activities which, in turn, can result in environmental transformations. In the study area the majority of households had a large number of members, averaging between three and seven people in a single household. The size of households differed between the sub-wards studied. This situation was the result of their location advantages and the activities done. In an urban setting, this is a large household size, given the limited carrying capacity of the urban environment. Many other studies have observed that population growth in an urban setting can lead to environmental degradation, due to the increased demand for land resources [30, 31].

**Comment [HDM14]:** No infomation about the population in the entire work.

**Table 3: Respondents' Socio-demographic Characteristics**

| Variable | | Response in Percentage Points (%) | | | | |
|---|---|---|---|---|---|---|
| | | Kigogo n=46 | Mkamba n=27 | Ngoma Mapinduzi n=15 | Maweni n=68 | Total N=156 |
| **Age** | 15–24 years | 24 | 22.2 | 13.3 | 17.6 | 19.9 |
| | 25–40 years | 21.7 | 26 | 26.7 | 23.5 | 23.7 |
| | 41–55 years | 41.3 | 40.7 | 46.6 | 50 | 45.5 |
| | 56–70 years | 13 | 7.4 | 6.7 | 6 | 8.3 |
| | 70+ years | 0 | 3.7 | 6.7 | 2.9 | 2.6 |
| **Sex** | Male | 41.3 | 55.6 | 46.7 | 41.2 | 44 |
| | Female | 58.7 | 44.4 | 53.3 | 58.8 | 56 |
| **Education level** | No formal education | 6.5 | 7.5 | 0-0 | 8.8 | 7 |
| | Primary education | 43.5 | 48.1 | 53.4 | 53 | 49.4 |
| | Secondary education | 34.8 | 33.3 | 33.3 | 25 | 30.1 |
| | Tertiary education | 15.2 | 11.1 | 13.3 | 13.2 | 13.5 |
| **Origin** | Native | 37 | 40.7 | 40 | 39.7 | 39 |
| | Migrant | 63 | 59.3 | 60 | 60.3 | 61 |
| **Household size** | 1–3 people | 10.8 | 14.8 | 13.3 | 13.2 | 13 |
| | 3–5 people | 58.7 | 51.8 | 60 | 51.5 | 54.4 |
| | 5–7 people | 24 | 26 | 26.6 | 26.5 | 25.6 |
| | More than 7 people | 6.5 | 7.4 | 0-0 | 8.8 | 7 |

**Source:** Survey data, 2022

### 3.2 Impact of Population Growth on the Environment

Kigamboni Municipality has experienced a high population increase in recent years. In 2012, the population density was 273 people/km$^2$; the density increased to 379 people/km$^2$ in 2018 [20]. This increase has led to environmental transformations as residents need land for various purposes, including infrastructure, house construction and agriculture. All these have a negative impact on the environment. Analyses of the Landsat images depicted certain changes in land use and land cover as a result of population growth. The land used for agriculture and scattered settlements changed significantly from 7265 (13%) hectares in 1995 to 22,553 (40%) hectares in 2021, which is an annual increase of 588 hectares. The number of built-up areas increased from 301 (1%) in 1995 to 2,458 (4%) in 2021, as Table 4 shows. The increase in the number of LULC units, in particular agricultural and settlement areas, has been expounded by various authors [32, 33]. Studies conducted in Islamabad, Pakistan, showed an increase of the size of agricultural land between 1992 and 2012, from 11.49% to 32.23% [34]. However, some of the urban studies found that the increase in population could decrease the size of agricultural land [35]. This variation is mainly due to differences in the nature and location of an area. Besides, in 1995, about 54% of the total area (30531 ha) were covered by bushlands, but it had decreased to 34% (19,400 ha) by 2021. Simultaneously, forests varied from 8251 ha (13%) in 1995 to 3,579 ha (6%) in 2021as Table 4 shows. The decrease of bushlands and forests is the result of the encroachment on these LULC types by people who rely on agriculture for their livelihoods.

**Comment [HDM15]:** How? Where is the population figure(s)? Provide the population figures for 1995-2021

**Table 4: Kigamboni Land-use/Land-cover Changes between 1995 and 2021**

| Type of Land Use/Land Cover | Land Cover | | | | Annual Change |
|---|---|---|---|---|---|
| | 1995 | | 2021 | | 1995-2021 |
| | Ha | % | Ha | % | Ha |
| Agriculture with scattered settlements | 7265 | 13 | 22,553 | 40 | 588.0 |
| Bare soil | 385 | 1 | 202 | 0 | -7.0 |
| Built-up area | 301 | 1 | 2,458 | 4 | 83.0 |
| Bushland | 30531 | 54 | 19,400 | 34 | -428.1 |
| Forests | 8251 | 14 | 3,579 | 6 | -179.7 |
| Grassland | 9028 | 16 | 7,559 | 13 | -56.5 |
| Water | 1212.4 | 2 | 1,222 | 2 | 0.4 |
| Total | 56,974 | 100 | 56,974 | 100 | |

**Source**: Analysis of Landsat Images of 1995 and 2021

The ~~graphic~~ LULC map representation of the results is given in Figure 1 ~~shows that~~, in 1995, most parts of Kigamboni District were covered by bushlands, except for the wards of Tungi and Vijibweni. Some parts of the district such as the wards of Pemba Mnazi and Kimbiji had been sparsely built. This shows that, by 1995, the area was sparsely populated for various reasons, including low accessibility of the area because of the existence of poor infrastructure (in particular transport networks) in the area by then. By 2021, most parts of Kigamboni Municipality had been built; thus the bushlands, forests and grasslands have kept declining in size. These findings corroborate those of other researchers, who note that, by 2030, most parts of the Tanzanian coastal areas would have lost about 7624km$^2$ of land due to erosion and submergence.

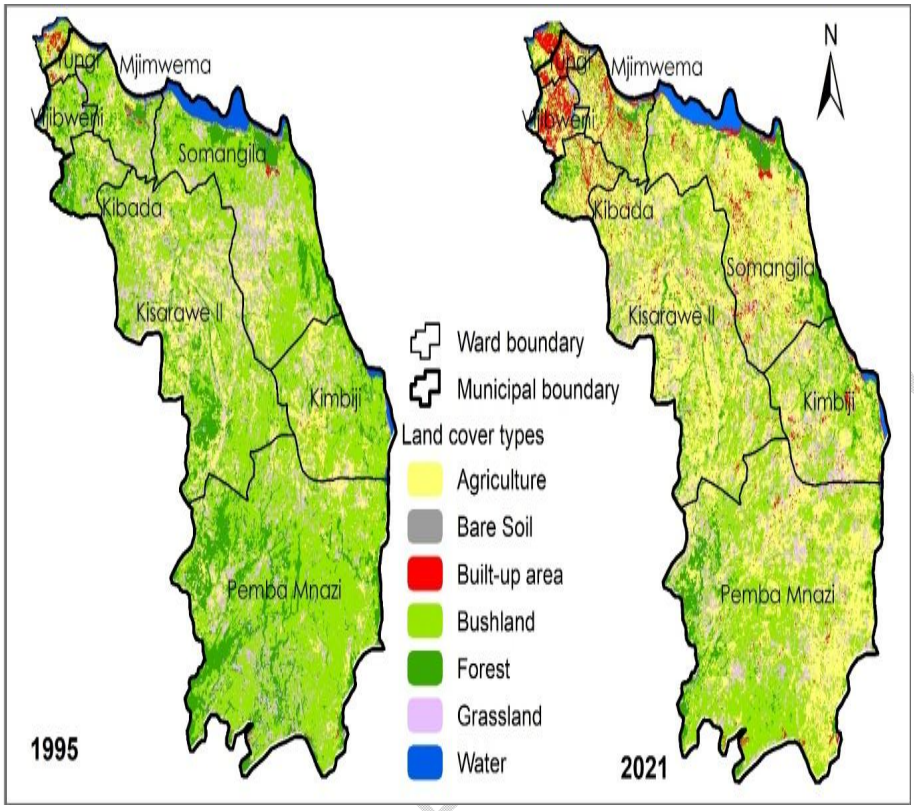


**Figure 1:** Land Cover Types in Kigamboni between 1995 and 2021
**Source:** Spatial data analysis, 2022

Analysis of the overall change in land use/land cover shows that agriculture with scattered settlements and built-up areas have increased (gained) while ~~and that~~ other ~~kinds of~~ land use/land cover types have decreased or disappeared, as shown in Table 5. Unlike the residents of the other municipalities in Dar es Salaam City, those of Kigamboni, apart from engaging in other livelihood activities, are engaged in agricultural activities because there is abundant land in the municipality. Various urban studies and theories observe that urban farming is part of the urban fabric owing to its importance in terms of the provision of food [36, 37]. In the 18$^{th}$ century, Alfred Marshall and William Stanley developed political economy theory which, among other things, sees agriculture as a source of income. However, despite its value, agriculture leads to environmental deterioration in coastal areas, if it is not well planned. Thus, modernist theorists such as Talcott Parsons developed modernisation theory in 1930 to discourage the practice of agriculture in urban areas, arguing that doing agricultural activities means ruralising the urban setting. This argument is based on the impact of farming on the environment.

**Table 5: Budget of the overall change for land use/cover classes (in Ha), 1995-2021**

| **Land Cover** | **Budget of the overall change for land use/cover classes** (in Ha), 1995–2021 | | |
|---|---|---|---|
| | Gain | Loss | Net change (gain - loss) |
| Agriculture with scattered settlements | 18571 | 3282 | 15288 |
| Bare soil | 103 | 286 | -182 |
| Built-up area | 2305 | 148 | 2157 |
| Bushland | 7148 | 18278 | -11131 |
| Forests | 1412 | 6084 | -4673 |
| Grassland | 5873 | 7342 | -1469 |
| Water | 85 | 75 | 10 |

**Source**: Analysis of Landsat Images of 1995 and 2021

In comparison with the other municipalities in Dar es Salaam (Ubungo, Temeke, Kinondoni and Ilala) in a period of 30 years, Kigamboni Municipality had low population. Many parts of Kigamboni District were unoccupied, as Figure 2 shows. Various factors are attributed to the diversities, including the accessibility of the area personal interests and the nature of the activities done by the residents. For many years, Kigamboni had remained underdeveloped because the ferry was the only means of transport to the area [38]. The opening of Nyerere Bridge in 2016 increased mobility; hence the population increase in Kigamboni. Transport networks play a significant role in urban development as they make it easy for both people and goods to move from one place to another [39, 40]. In most African cities, the majority of residents engage in business activities; thus, they are interested in areas with high population and transport networks. Those who engage in farming activities in urban areas are migrants who search for sources of livelihood prior to their familiarisation with urban life [41]. The increase in population in Kigamboni Municipality in recent years means that land-use planning is necessary. It is clear that most of cities in sub- Saharan Africa are growing without appropriate urban planning; this situation has increased environmental problems and informal settlements [5, 42].

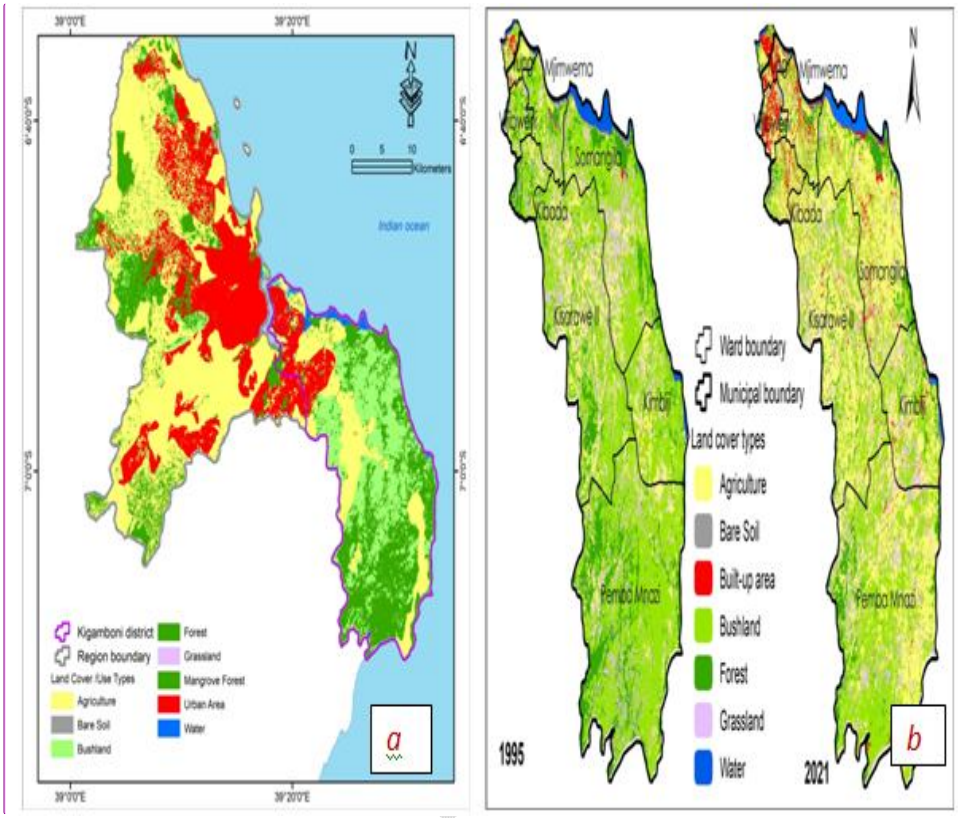


**Figure 2:Built-up** Areas in Dar es Salaam in 2000 (a), Kigamboni District in 1995 and 2021 (b).
**Source:** Spatial Data Analysis, 2022

### 3.3 The Impact of Population Growth on Local People's Livelihoods

Despite the environmental impact on population growth, population growth can affect local people's livelihoods, either positively or negatively. In this regard, this study examined peoples' perception on the impact of population growth on their livelihoods. The majority of respondents (62%) talked about both positive and negative effects of that growth. The positive effects are access to social services, improvement of infrastructure, and the availability of markets and of non-farm opportunities, asTable 6 shows. The respondents mentioned that, with the current population growth, various services have been improved such as transport, electricity, the water supply, health facilities and education centres, namely schools and colleges. Non-farm income generating activities were reported to have increased in number as well. Some of the respondents considered the population increase to have negative effects: an increase of waste, pollution and a high cost of land. The cost of land has increased in recent years because more people from different parts of the city move to Kigamboni in search of residential, industrial and agricultural land. The literature has shown a similar situation in relation to other cities [43, 44, 45].

**Comment [HDM16]:** Present the Kigamboni district map to include the indian ocean to it coastal nature like map (a) in Figure 2

**Comment [HDM17]:** Population impact not yet establish in the study. You need to establish the nexus and present the predictive value. Maybe you regress population and landuse/cover change for the study period(1995 and 2012).

**Comment [HDM18]:** Presented in Table 6

**Comment [HDM19]:** suggest

**Table 6: The Impact of Population Growth on People's Livelihoods**

| Variable | Response (%) | | | | |
|---|---|---|---|---|---|
| | Kigogo | Mkamba | Ngoma Mapinduzi | Maweni | Total |
| | **n=46** | **n=27** | **n=15** | **n=68** | **N=156** |
| Impact of population growth on livelihoods | | | | | |
| Positive and negative impact | 67 | 59 | 53 | 62 | 62 |
| Negative impact | 11 | 15 | 27 | 13 | 14 |
| Positive impact | 22 | 26 | 20 | 25 | 24 |
| | | | | | |
| Positive impact of population growth | | | | | |
| Access to social services | 31 | 38 | 32 | 41 | 36 |
| Improvement of infrastructure | 24 | 22 | 21 | 16 | 21 |
| Availability of markets | 28 | 21 | 29 | 21 | 24 |
| Availability of non-farm opportunities | 17 | 19 | 18 | 22 | 19 |
| | | | | | |
| Negative impact of population growth | | | | | |
| Increase of waste | 35 | 31 | 31 | 28 | 31 |
| Land-use changes | 13 | 15 | 10 | 13 | 13 |
| Increase of pollution | 23 | 26 | 17 | 10 | 18 |
| Increase of the cost of land | 29 | 28 | 42 | 49 | 38 |

**Source:** Survey data, 2022

## 4. CONCLUSION

This paper has shown that the population of Kigamboni Municipality has been growing. This situation has a considerable effect on the environment and local people's livelihoods. Analysis of the Landsat images shows that agricultural land and built-up land are increasing, while bushlands, forests and grasslands are decreasing in size and/or number. This has been associated with the population growth, which had increased the demand for land. On the other side, the growth in question is said to have positive and negative effects on people's livelihoods, including access to social services, improvement of infrastructure, the availability of markets, an increase of waste, pollution and an increase of the cost of land.This state of affairs calls for the development of appropriate policies on land use, as the population in Kigamboni is growing at an alarming rate. The policies can help to reduce the challenges associated with the rapid population growth and make Kigamboni a desirable place for residence and economic development.

**Comment [HDM20]:** To justify, process and add the result of the nexus with the predictive value for the study period(1995 and 2012).

**Comment [HDM21]:** How alarming? Provide figures



## REFERENCES


1. Mohammed S, Francis J. An Evaluation of Coastal Zone Management. Practices in the Eastern African Region. IUCN-Eastern Africa. 2005.
2. Neumann B, Vafeidis AT, Zimmermann J, Nicholls RJ. Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. PLoS ONE. 2015; 10(3): e0118571. doi:10.1371/journal.pone.0118571
3. Creel L.Ripple Effects: Population and Coastal Regions. Making the Link. Population Reference Bureau. 2003.
4. Merkens JL. "Gridded population projections for the coastal zone under the Shared Socioeconomic Pathways". Global and Planetary Change. 2016; 145: 57–66.
5. Seto KC. Exploring the dynamics of migration to mega-delta cities in Asia and Africa: Contemporary drivers and future scenarios. Global Environmental Change; 21, Supplement 1: S94–S107. 2011.
6. Brown S, Nicholls R, Woodroffe C, Hanson S, Hinkel J, Kebede AS. Sea-Level Rise Impacts and Responses: A Global Perspective. In: Finkl CW, editor. Coastal Hazards. Netherlands: Springer. 2013; pp. 117–149.
7. Patterson M, Hardy D. Economic Drivers of Change and their Oceanic-Coastal Ecological Impacts. In: Patterson M, Glavovic BC, editors. Ecological economics of the oceans and coasts. Edward Elgar Publishing. 2008; pp. 187–209. 15.
8. Barau AS, Ludin ANM. Intersection of Landscape, Anthropocene and Fourth Paradigm. Living Reviews in Landscape Research. 2012; vol 6(1)
9. Daffa JM, Bayer TG, Kamalia SK. Tanzania Coastal Management Partnership. Land use Planning Manual for Coastal Tourism Development in Tanzania. Training Module. Coastal Tourism Working Group. 2003.
10. Clark GF, Johnston. Coasts: Population growth and urban development: Coastal development and land use. In: Australia state of the environment 2016, Australian Government Department of the Environment and Energy, Canberra. 2016; DOI 10.4226/94/58b659bdc758b.

11. Crossland C, Baird D, Ducrotoy JP, Lindeboom H, Buddemeier R, Dennison W. The Coastal Zone—a Domain of Global Interactions. In: Crossland C, Kremer H, Lindeboom H, Marshall Crossland J, Tissier MA, editors. Coastal Fluxes in the Anthropocene. Berlin, Heidelberg: Springer. 2005; pp. 1– 37. 16.
12. ASCLME. National Marine Ecosystem Diagnostic Analysis. Tanzania. Contribution to the Agulhas and Somali Current Large Marine Ecosystems. UNDP. 2012.
13. Van Hoof L, Kraan M. "Mission Report Tanzania; Scoping Mission Marine Fisheries in Tanzania." 66. Wageningen. Accessed15 June 2017. http://wwwlibrary. wur.nl/WebQuery/wurpubs/516617/pdf.
14. United Nations Environment Programme (UNEP). Eastern Africa Atlas of Coastal Resources. Nairobi Convention. 2001
15. United Republic of Tanzania (URT). Tanzania in Figures, National Bureau of Statistics, Dar es Salaam, Tanzania.". 2016. http://www.nbs.go.tz/pdf.

16. Mzava P, Nobert J, Valimba P.Land Cover Change Detection in the Urban Catchments of Dar es Salaam, Tanzania using Remote Sensing and GIS Techniques. Tanzania Journal of Science. 2019; 45(3): 315-329, 2019 ISSN 0856-1761, e-ISSN 2507- 7961.
17. Ngondo J, Mango J, Ruiqing L, Nobert J, Dubi A, Heqin C.. Land-Use and Land-Cover (LULC) Change Detection and the Implications for Coastal Water Resource Management in the Wami–Ruvu Basin, Tanzania. Sustainability. 2021; 13, 4092.https://doi.org/10.3390/su13084092.
18. Hill A, Lindner C. Land-use modelling to support strategic urban planning - the case of Dar es Salaam, Tanzania. Simulating informal urban growth in Dar es Salaam, Tanzania; 45th ISOCARP Congress, 2010, 12 p.
19. . World Population Review (WPR) 2022; https://worldpopulationreview.com/world-cities/dar-es-salaam-population.
20. United Republic of Tanzania (URT). Kigamboni Municipal Council, Socio Economic Profile. National Bureau of Statistics and Kigamboni Municipal Council. 2019.
21. Krishinaswami OR, Ranganathanm M. *Methodology of Research in Social Sciences*. Himalaya Publishing House. Delhi. 2005.
22. Kombo DK., Tromp DLA. *Proposal and Thesis Writing*: *An Introduction*. Nairobi. Paulines Publications, Africa. 2006.
23. Kothari CR. *Research Methodology: Method and Techniques*, (2nd ed). New Age International. Delhi. 2004.
24. Young NE, Underson RS, Chignell SM, Vorster AG, Lawrence R, Evangelista PH. A Suvival Guide of Landsat preprocessing. *Ecology*. 2017; 98(4), pp 920-932.
25. Kajembe GC, Luoga EJ. Socioeconomic Aspects of Tree Farming in Njombe District. Consultancy Report to the Natural Resources Conservation and Land use Management Project (HIMA-Njombe), funded by DANIDA, FORCONSULT, Morogoro. 1996; 98pp.
26. Nzunda NG, Munishi PKT, Soka GE Monjare JF.Influence of Socio-Economic Factors on Land Use ond Vegetation Cover Changes in and Around Kagoma Forest Reserve in Tanzania. Ethiopian Journal of Environmental Studies and Management. 2013;Vol. 6 No.5
27. Mbonile MJ. *Bamboo Trade and Poverty Alleviation in Illege District, in Tanzania*. Research on Poverty Alleviation" Research Report No. 8.3. 2006.
28. United Republic of Tanzania(URT). *Analytical Report*, Ministry of Planning and Economics. Dar es Salaam. 2006.
29. International Labour organization (ILO). The International Labour Organization's Fundamental Conventions. InFocus Programme on Promoting the Declaration. International Labour Office. Geneva, Switzerland. 2003
30. Rudel TK. The national determinants of deforestation in sub-Saharan Africa Phil. Trans. R. Soc. B 368 20120405. 2013.
31. Abernethy K, Maisels F, White LJT. Environmental issues in Central Africa Annu. Rev. Environ. Resour. 2016; 41 1–33.
32. Koglo YS., Agyare W, Diwediga B, Sogbedji J, Adden A, Gaiser T. Remote Sensing-Based and Participatory Analysis of Forests, Agricultural Land Dynamics, and Potential Land Conservation Measures in Kloto District (Togo, West Africa). Soil Systems. 2018; 2, Article No. 49. https://doi.org/10.3390/soilsystems2030049
33. Diancoumba O, Toure A, Daou I, Konare S, Hermassi T, Kotti M, Bokar H, Galoul N, Bargaoui Z. Assessing the Effects of Land Use/Land Cover Change on Ground water Recharge in a Sudano-Sahelian Zone: Case of Koda Catchment, Mali, West Africa. Journal of Geoscience and Environment Protection. 2022; 10, 39-54. https://doi.org/10.4236/gep.2022.108004.
34. Hassan Z, Shabbir R, Ahmad SS, Malik AH, Aziz N, Amna BA, Erum S. Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springer Plus*. 2016; *5:812.* DOI 10.1186/s40064-016-2414-z
35. Malekela AA, Nyomora MS Climate change: Its implications on urban and peri-urban agriculture. A case of Dar es Salaam city. Tanzania. *Science and Development Journal*. University of Ghana. 2019; *Vol.3, 40-53.*
36. McLees L. Access to land for urban farming in Dar es Salaam, Tanzania: Histories, benefits and insecure tenure. *Journal of Modern African Studies,* 2011; 49(4): 601–624.

37. Mlozi MRS, Lupala A, Chenyambuga SW, Liwenga E, Msogoya T. Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Dar es Salaam, Tanzania. [Padgham J, Jabbour J. (eds.)]. United Nations Environment Programme (UNEP), Nairobi, Kenya. 2014.
38. Rosen JW. This Tanzania city may soon be one of the world's most populous. Is it ready?. Environment, The Cities Issue. National Geographic Society. 2019.
39. Aljoufie M., Zuidgeest M, Brussel M, Van Maarseveen M. Spatial–temporal analysis of urban growth and transportation in Jeddah City, Saudi Arabia. Cities, 2013. 31, 57–68
40. Chissano MPH, Minnery J. Roads, rates and development: Urban roads and growth in Xai-Xai, Mozambique. Habitat International, 2014; 42, 48–57.
41. Onyango CL. Urban and Peri-urban Agriculture as a Poverty Alleviation Strategy among Low Income Households. The case of Orange farm. South Johannesburg. 2010.
42. Mkalawa CC, Haixiao P. Dar es Salaam city temporal growth and its influence on transportation, Urban, Planning and Transport Research, 2014; 2:1, 423-446, DOI: 10.1080/21650020.2014.978951.
43. Mbiba B. Urban solid waste characteristics and household appetite for separation at source in Eastern and Southern Africa. Habitat International, 2014; 43, 152–162.
44. Wubneh M. Addis Ababa, Ethiopia – Africa's diplomatic capital. Cities, 2013; 35, 255–269.
45. Rizzo A. Rapid urban development and national master planning in Arab Gulf countries. Qatar as a case study. Cities, 2014; 39, 50–57.