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Original Research Article

Factors Which Influence the Patterns of Built Structures in the Riparian Areas of Nairobi River Basin

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Abstract: This study sought to investigate major factors that have influenced the patterns of built structures along Nairobi riparian zones using an analytical approach and some aspects of correlations. The study employed a descriptive research design with various data collecting methodologies, including questionnaires, photos, interviews, and secondary empirical support. The areas covered by the study fall within the Upper Nairobi river basin, which includes Upper Mathare, Motoine, and Nairobi river tributaries. A population of 270 households was sampled within the three areas. Main economic activities in these areas include small businesses, farming, informal and formal employment, as well as Juakali activities. About 59% of the Motoine catchment households understand the term riparian, and 27% do not. In the Nairobi river catchment, 73% understand the term riparian, while the other 27% of the population do not, while in Mathare River, 83% of the household understand a riparian, and 17% do not. Corruption and greed was the main cause of encroachment as observed by 86% of the population, 34% attributed poor leadership, 71% cited lack of law enforcement, and 40% cited ignorance among the people and in government. A positive correlation was identified between the knowledge of riparian and problem of encroachment. In the Motoine River (Pearson's R= 0.715). Nairobi river (Pearson's R=0.54) very strong correlation (Pearson's R= 0.946) was established in the. The study found that the main drivers that influence built structures in riparian zones are overpopulation, poverty, lack of alternative land, ignorance, lack of law enforcement in the government, and corruption. The study established that a high level of ignorance and low levels of formal education as the main contributor to discounting riparian protection among the residents. Lack of law enforcement, political interference, and high levels of corruption in the government attributes to be the cause of undue degree of riparian encroachment, degradation, and lack of zone protection.
Keywords: Riparian, enchroachment, households, Built structures, effects of riparian.

INTRODUCTION

Encroachment has been defined as the unauthorized use of any public or private resource, power, or property (CSR Times, 2015). In the context of land, however, encroachment refers to "building constructions in property borders belonging to the government, an individual, or any institution" (CSR Times, 2015).

Hoffman (2018) emphazies on the importance of the issue of encroachment; According to author, encroachment problems for homeowners are difficult to resolve fully. Due to the complexity of boundary concerns, the use of legal remedies to resolve encroachment problems is only feasible to a limited extent. He suggests solutions such as homeowners cooperating to resolve encroachment concerns. Using experienced land surveyors will result in the peaceful resolution of boundary disputes.

Raedeke (1988) argues that the term riparian is ambiguous owing to its administrative and ecological applications. Administratively, riparian zones are used to define the arbitrary distance of 100 to 200 feet from the water's edge and may include riparian and upland forest communities. The author distinguishes riparian community by emphasizing its distinction as a "functional wetland community." Other researchers, such as Gregory *et al.,* (1996), concur with Raedeke about the definition of the term riparian. According to

Gregory *et al.,* (1996), riparian zones are primarily the resource consisting of plants along streams and rivers. The authors argue further that scientific and policy perspectives are essential for defining the term riparian.

According to (Johnson & Ryba, 1992), numerous authors have addressed the various functions of a riparian zone. This includes determining the chemical, biological, and physical interactions between the terrestrial and aquatic systems, which have been claimed to be intrinsically interrelated (Courtney, 2013). Johnson & Ryba (1992) identify the primary functions of the riparian zone as preventing erosion and stabilizing stream banks, filtration of solids, toxic substances, and nutrients, providing protection for aquatic animals and other wildlife such as birds, and influencing the microclimate of the riparian zone. The author asserts that other critical roles, such as limiting detrimental runoff effects and maintaining the integrity of buffer zones, are frequently neglected (Gathira, 2016). These assertions are comparable to those of Swanson (2008), who describes riparian activities such as filtering of sediments and fertilizers, controlling river turbidity, avoiding pollution, and providing habitat for animals (Johnson & Ryba, 1992).

Musingi (2018) blames the flooding in Nairobi to the encroachment and obstruction of constructions in riparian zones. The author cited the absence of law enforcement as the primary source of these impediments. The author criticizes the National Environment Management Authority (NEMA) for failing to neglect responsibilities that led to the construction of buildings and shopping complexes around rivers.

Data from a research conducted in California to determine the "impacts of rubbish and riparian zone adjustments" (Courtney, 2013), the majority of anthropogenic alterations and increased pollution by trash in riparian zones can be linked to homeless individuals. In this study the author was able to connect the issue of homelessness to the rising encroachment and pollution of riparian areas by doing research and drawing inferences from previous research.

This study aimed to comprehend the various variables Nairobi residents attributed to the establishment and encroachment of structures along the river basin in order to gain a basic understanding of the forces driving the patterns of built structures in riparian areas. These variables were linked with these parameters in order to establish associations. To justify these and other research, this chapter describes these variables in depth, including how the target was attained, the outcomes of the approach, and qualitative descriptions of the region. The chapter concludes with a discussion of the most significant discoveries, providing support and comparisons with previously known facts from other scholars.

2. RESEARCH METHODOLOGY
2.1 Introduction
This section describes the data needs, the sampling methodology, and tools of data collection, analysis, results, presentation, and discussions. It also covers the reviews of existing works by other scholars in supporting the findings and deriving conclusions.

2.2 Research Design and Data Collection
To clearly describe the various factors that have led to the encroachment of riparian areas, the research design applied in this objective is descriptive design. A structured questionnaire with predefined and open questions was formulated to capture all possible details pertaining to the objective. The questionnaires were stratified into three main areas: the household sample population, the professional sample population, and the institution's samples populations. Apart from being popular and cheap, questionnaires are valuable tools for the provision of crucial information, including emergency management information useful for developing risk management strategies. The questionnaire structure should have a minimum response and may be closed or open. The main significant characteristics of the questionnaire include design, sampling technique, delivery mode, and data analysis (Bird, 2009).

2.3 Sampling and Data Types
The study area lies within the Nairobi river basin and within the frames of the mentioned study area scope, three main areas with similar characteristics: Motoine River area, Nairobi River tributary, and Mathare River. The three study areas are located along the tributaries of the Nairobi rivers, which have typical patterns of built structures along the river riparian. The use of stratified sampling was vital in delineating individual strata characteristics and comparisons. Stratified sampling was also crucial in determining the sample allocation ratio, which depended on each area's size. The simple random technique was applied in selecting the household in questionnaire administration, allowing an equal chance for a particular household to participate.

2.3.1 Sample Size Calculations
During the sampling, we used the Taro Yamani formula to calculate the number of units within 30 meters of riparian for all three rivers.

$n = N/ 1+ N (e)2$

Whereby:

n= sample size required

N = number of people in the population

e = allowable error (%)

- Total units within Motoine River riparian = 77
- Total units within Nairobi River Riparian = 336
- Total units within Mathare river = 625
- Overall total units for the riparian of three rivers = 1038.
-

Calculations

n = N/ 1+ N (e)2;

n= 1038/1 + 1038(0.5) ^2;

n= 1038/1 +2.595;

n= 1038/3.595;

n=1038/3.595

n= 288.73.

The sample size for each river was then calculated based on the number of units identified within the riparian to develop specific units for each riparian area.

For Mathare River = (77/1038) *289 = 21 to increase reliability sample was increased to 30

Sample for Nairobi River = (336/1038)*289= 94 standardized to 60

Sample for Motoine River = (625/1038)*289 = 174 standardized to 150

2.4 Data Types

The various data types needed for the study is descriptive data comprising quantitative and qualitative data sets with some aspects of correlation. Social and economic data such as family and income data, education, and land ownership, among other descriptive data regarding the knowledge of the riparian area and land use. Secondary data include empirical evidence supporting claims and reviewing other scholars' works.

2.5 The Study Variable Scope

The objective is to establish the factors in detail that cause encroachment and influence the spread and pattern in riparian areas of the Nairobi river basin. These factors are covered in detail and their relationship, including review and comparisons with existing knowledge. Apart from strengthening the existing claims, the variables play a critical role in ascertaining the truth on the ground level.

3. RESULTS, PRESENTATION, AND DISCUSSION

Table 1: Statistics (see appendix 1)

3.1 Assessment of the Impacts of Built Structures in Riparian Zones in Nairobi

In order to examine the varied impacts of polycentric governance on riparian, 35 professionals from various bodies were required to comprehend the permissible structures in riparian zones and the allocation sizes for the various structures. The relationship was determined by a test of reliability, which yielded a (Cronbach's Alpha =.798), indicating a high co-relationship. 26% of experts said that the construction of high-income residential complexes had no effect on the riparian zone. 31% believed they had little influence, 31% believed they had moderate affects, and 11% said they had significant impacts on the riparian zone. According to the research, professionals do not comprehend or agree that anything formal is detrimental to the riparian zone. Regarding the subject of constructing formal residential structures, few experts mentioned a significant impact.

Table 2: various allocable sizes for different activities as derived from Nairobi county professionals

	Mean	Std. Error of Mean	Median	Mode	Std. Deviation	Variance	Range
Industrial width	60.86	4.087	60	30[a]	24.177	584.538	70
Commercial width allocation in meters from riparian	46.91	2.908	50	30	17.202	295.904	88
Residential (informal) width allocation in meters from riparian	39.46	2.42	35	30	14.319	205.02	74
Residential (formal)width allocation in meters from riparian	35.71	1.692	30	30	10.01	100.21	45
Urban agriculture width allocation in meters from riparian.	25.83	2.902	30	30	17.168	294.734	97
Open spaces width allocation in meters from riparian.	15.77	1.636	15	15[a]	9.68	93.711	38
Infrastructure (sewer) width allocation in meters from riparian	19.26	3.101	15	10	18.344	336.491	97
Institution width allocation in meters from riparian	39.86	2.403	35	30	14.219	202.185	60
Service lines width allocation in meters from riparian	17.94	3.098	15	15	18.33	335.997	98

Regarding the issue of high-income residential impacts, for instance, only one engineer deemed effects to be moderate. Three evaluators said it had no impact, three evaluators believed it had moderate consequences, and two evaluators believed it had moderate affects. Likewise, one GIS analyst believed that high-income housing had little effect. A further 1 GIS expert opined that the impact was mild, while 2 GIS experts opined that the impact was severe in the riparian zone. This is a direct result of the absence of defined regulations and

norms governing the actual amount of a riparian buffer. Two planners indicated that high-income residential structures had minimal impact on riparian zones, whereas two planners indicated that high-income residential buildings had significant impacts on riparian zones.

On the other hand, environmental specialists made the same observations, with two experts stating that high- income residential development had no effect

on riparian, one expert noting moderate affects, and another indicating greater consequences. This was the overall tendency in all other cases involving, for example, informal settlements, utility lines, agriculture, highways, and bridges. There was a weak correlation (Pearson's R= -.101) between professionals and understanding of impacts. Notable is also the paucity of interaction amongst professionals working in the same decision centers. In Nairobi rivers zones and Kenya in general, riparian encroachment can be ascribed to the existence of a polycentric system of governance in which different sectors operate independently of one another, as well as the overall lack of clarity of riparian legislation. This accord with McGinnis's characterization of the numerous interaction issues between decisions centers (McGinnis, 2016).

3.2 Motoine River Structural Pattern Description

The Motoine River (Longitude: 36.7786 and latitude: -1.31496) flows through the Kibera slum, which is marked by intricately haphazard structures covering all the accessible area. The majority of structures along the riverbank are constructed within the river bank, leaving no gaps in the river strait. According to a report (KISIP, 2013) done in Munyaka and Kamukunji in Nairobi, the physical characteristics of the built structures are dense and crowded, particularly in slum regions, which is consistent with the findings of the research. Other structures, such as residences, are hung above the water and pose possible collapse risks.

This neighborhood contains a variety of land uses, including permanent residential buildings, commercial, educational, and public institutions, and informal residential uses, as well as shacks and slums utilized for various activities. The majority of residential constructions along the Motoine River consist of permanent (masonry) two-story homes and temporary structures built of concrete, tin, iron sheets, and mud. According to the same report by KISIP (2013), the informal settlement's primary materials consist of corrugated iron sheets, mud, Makuti roofs, tin, and concrete. The research findings concur with these findings. The majority of residences in the neighborhood are shacks in deteriorating condition, revealing high levels of poverty and ignorance. The dearth of access roads and walks along the building not only exacerbates navigational difficulties in gaining access to a residence, but also poses security and health risks. To reach certain residences, one must navigate a labyrinth of trails that traverse the corridors of the buildings and into the dirty river. The majority of the lanes is tiny, dark, and run beside deep water ravines, providing health risks and insecurity.

Diverse social amenities, such as lavatories and waste disposal facilities, are absent or have been channeled to the river. According to research conducted by Omondi (2014) on the Motoine River, around 77% of the population disposes of their trash and garbage in the river, with 81% disposing of human wastes in the river. As terms of water infrastructure, plastic pipes of varying diameters overlap on the ground surface, while others run parallel to or within dirty water. The majority of them are leaking at various points, exposing piped water to sewage contamination.
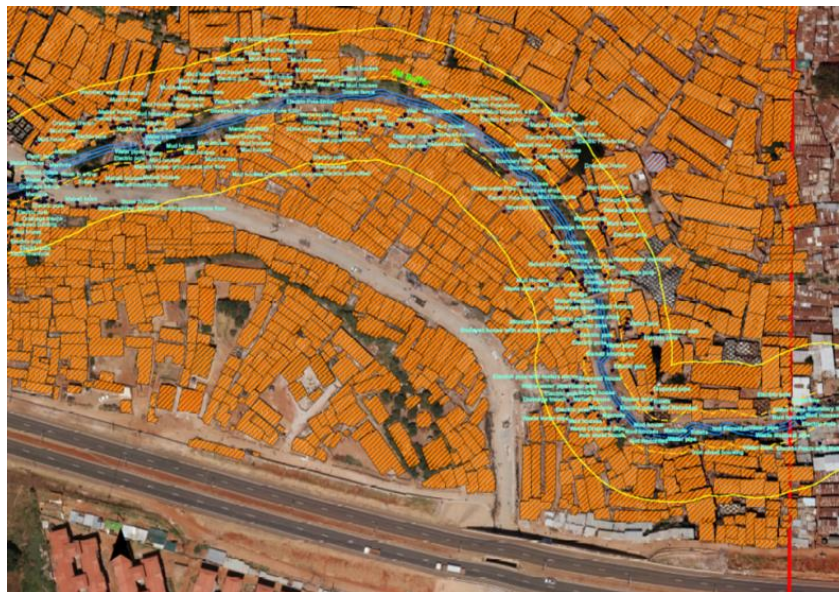
Types of Built Structure

Figure 1: illustrating a section of the Motoine river area (source, author)

Various built patterns are visible that encroach the all the available riparian zone, as depicted by yellow lines. All kinds of built structures have been identified in this area.

Plate 1: General outlook of Motoine river area (source author).

3.3 The Social and Economic Composition of the Motoine River Area

From a population of 180 samples in the Motoine River area, 35% were male, while 65% were female. Women were the majority of the total household sample population, taking 54% of the 270 samples. Most of the families in Kibera are headed by a man and are comprised of young couples that fall between 20 to 40 years. The majority of the families have 4 to 7 family members representing 55%, 1-3 family members' representing 36%, 8-11 members 8%, and over 12 members 1%.

The dense population in Motoine River can, therefore, be attributed to a large number of family members, where most families have more than four members per household, further worsening the encroachment problem. The findings are bolstered by research by (Zaimes, Human Alteration to Riparian Areas, 2004) in the United States, which asserts that increased population led to encroachment of riparian with activities that were adverse to the riparian ecosystem. The research identified that 43% of the population are between 20 to 30 years while another 36% are between thirty to forty years of age. Less than 1% of the population was above 60 years of age. The observation is crucial in establishing the root causes of the population explosion problems and the genesis of the encroachment of riparian zones. It can also be used in modeling urban migration patterns and how they have changed land uses in urban areas. This is in agreement with a case study report by (Mugambi, 2014) who investigated encroachment factors in River Rwaka and found that 25% of the area population had migrated in search of employment opportunities. In further support of population explosion and riparian encroachment, research by (Gathira, 2016) attributes poor rural services and inadequate agricultural yield to urban migration, while lack of housing, inability to afford, and financial poverty are the main drivers of informal settlement development in riparian areas.

The research found that 52% of the household heads have secondary education, 31% primary education 13% college education, 3% university education, and the rest 2 % are illiterate with no formal education. Education plays an important role in determining the factors that have led to intrusion. In regard to economic activities, 1% of Motoine residents engage in farming activities, 44% engage in business, 11% have formal employment, while the majority, 44%, engage in other activities or are unemployed. The typical activities in Motoine include juakali activities like mechanics, car washing, and Watchmen among others. Majority of the women in these areas are housewives with no any source of income. Most of the households in Motoine have a monthly income of less than fifty thousand with only 1% earning fifty to a hundred thousand per month. 23% of the Motoine populations own the land they lived in while the rest 77% were tenants. Most of the tenants pay a monthly rent of between two to five thousand. For those that own land in Kibera majority of these land sizes does less than an eighth acre with a few own between eighth acres to a quarter acre.

3.4 Factors Influencing Built Structures Patterns along Motoine River

In regard to the understanding of factors that influences the encroachment of riparian, a significant number of the Motoine population were ignorant. The research found that 59% of the population understood the riparian area and its meaning, while the rest, 41% of the same did not understand. Of those who understood the riparian, the majority of them understood 30 meters as the basic allocation size of river reserve. A

significant number of the population agreed to riparian being allocated 6 meters or 30 meters reserve. Others mentioned varied sizes ranging from 7 meters to 60 meters.
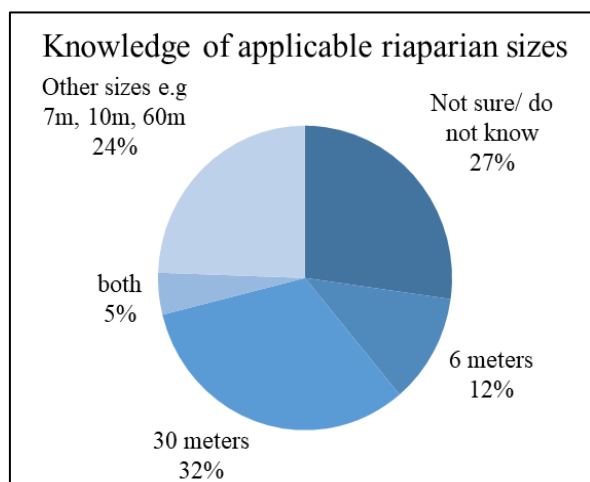

Figure 2: chart depicting knowledge of riparian buffer sizes

About 38% of the Motoine population understands the various structures that are allowed in riparian areas, while the rest, 62%, do not know of any structures that are allowed in the riparian zones. For those who understood allowed structures, the following structures were mentioned that include Building (permanent), Building (temporary), Civil structures (bridges, sewer line, manhole), Boundary wall, Recreation building, others/ not sure, and several of the above structures. The high level of ignorance can be attributed to a lack of knowledge of riparian laws and the general lack of enforcement of riparian laws by the government. Law enforcement is not an easy process because there exist overlapping laws and various bodies, such as the public and private sectors, competing. Research conducted by (Bhatta, 2010), on "analysis of urban growth" agrees with the claim by outlining the various causes as identified using GIS analysis. He points out the lack of harmonious rules, competition among government and individuals, and other assorted development policies that may influence land speculations.

Table 3: What types of built structures are allowed in the riparian zone?

	Frequency	Percent
• Not sure/ no answer	78	43.3
• Building (permanent)	5	2.8
• Building (temporary)	1	.6
• Civil structures (bridges, sewer line, manhole)	21	11.7
• Boundary wall	1	.6
• Recreation building	3	1.7
• Others/ not sure	35	19.4
• Several of the above factors	36	20.0
Total	**180**	**100.0**

Factors Underlying the Encroachment of Riparian and their Impacts in Mutoine River
Various factors attributed to the encroachment in Nairobi riparian areas among the popular include:
- Population pressure and land shortage,
- Population pressure/land shortage,
- Dumping sites,
- Corruption and greed,
- Riparian lands are idle people want to make them productive,
- Poverty and Ignorance,
- Lack of law enforcement by the government.

Most of the lands in Nairobi are expensive to acquire. Free market forces control the existing rental houses and hence tend to charge exorbitant and exploitative prices for rental apartments. Homeless urban residents, therefore, end up occupying the available lands and since the government owns urban riparian land with little control, encroaching becomes easy. Research by (Sietchiping, 2005) agrees with this finding by asserting that the main causes of riparian encroachment result general lack of sustainable housing.

While the questionnaires were conducted adjacent to the river, some of the Motoine River residents confirmed not to have been near the river's riparian area. This could be attributed to those who did not understand the term riparian zone. 78% of the residents have been in a riparian zone, while 22% had never been in a riparian zone. Some of the benefits of a river that were outlined include the following:
- Business opportunities,
- Availability of water/ irrigation purposes,
- Place of easy waste disposal,
- Land for building houses,
- Pathway for the river and overflow areas,
- Recreation areas,
- Agriculture/ farming,
- Pathway for service lines,
- Provides a place for washing and drying clothes and fishing,
- Provides a home for animals,
- Protects and prevents soil erosion,

A significant majority equating to 38%, do not know any benefit of the riparian zone. Although most of them recognized the various adverse effects of the building near the riparian, ignorance plays a critical role in shaping their attitudes and behaviors.
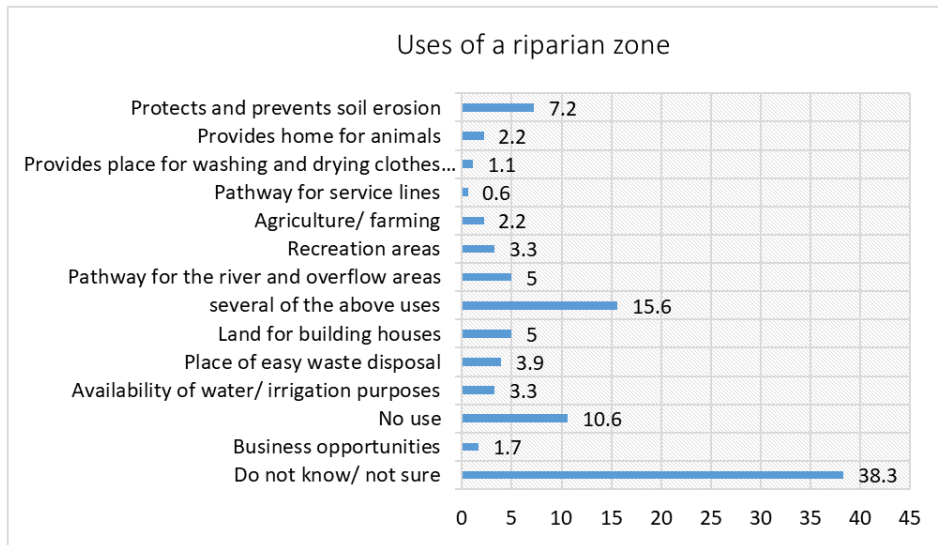

Figure 3: various usages of riparian zones in urban

The different uses outlined for the riparian area along Nairobi Rivers are:
- Planting trees and or vegetation,
- Buildings homes,
- Agriculture,
- Riparian land should remain unused\ natural,
- Fencing and protecting Riparian areas,
- Issuing of title deeds to prevent the development,
- Be used for recreation,
- Build service lines,
- Build large industries in these areas,
- Informal business.

The research observed that the various responses in regard to recommending a particular use mainly depended on the predisposition of the populations. Rather than forging novel recommendations rare in their areas, the resident's experiences and ignorance formed the vital lathe that shaped their responses. Most of these suggestions are, however, implementable, although some are what already existed before the current encroachment. Fewhousehold individuals gave other recommendations like building homes.
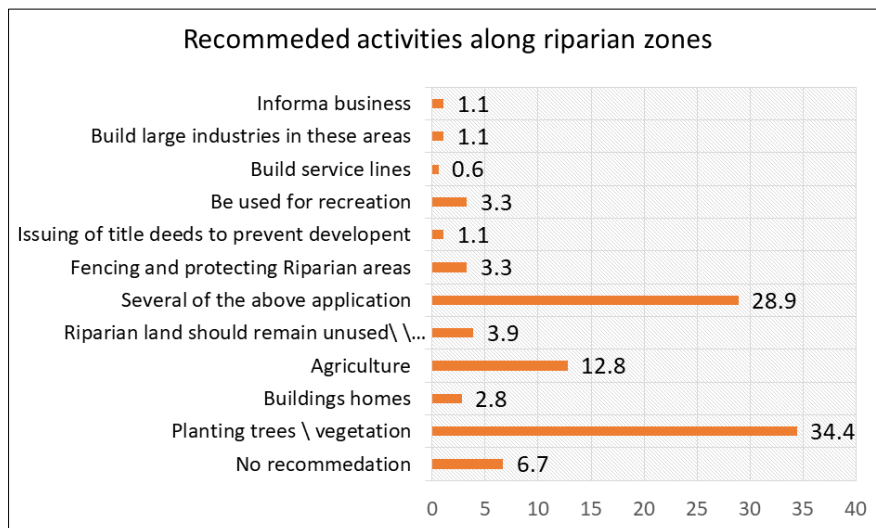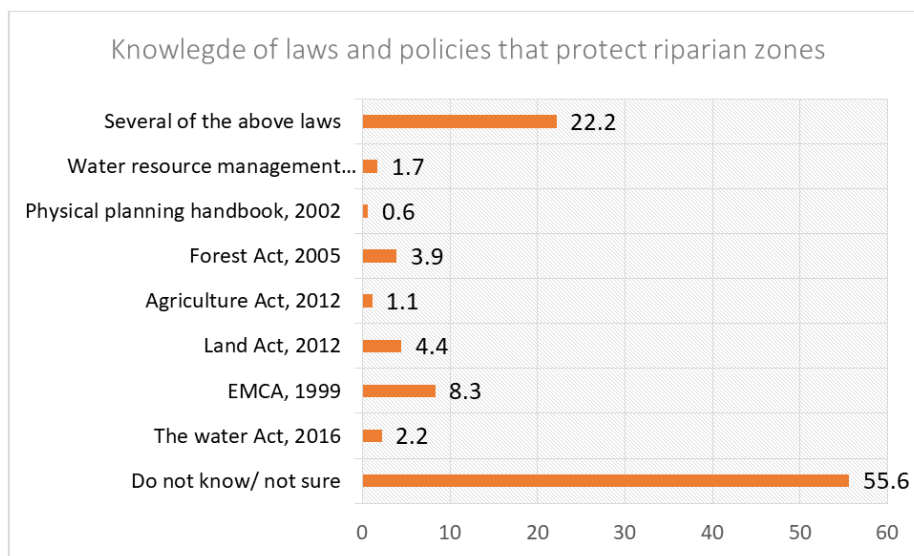

Figure 4: recommend activities along riparian zones

83% of the Motoine population understands the existence of laws and policies that protect riparian areas of Kenya. While some can clearly state specific laws majority cannot outline a specific law or body that enforces riparian laws. Failure of the various governments to enforce the law is the key factor why

the majority of the populations in these areas did not find it challenging to build. However, politics played a key role in contributing to the encroachment in these areas. The politicization of encroachment issues by various individuals who either owned property in riparian areas or for the mere sake of vote hunting acts as the primary obstacle that obstructs law enforcement in Nairobi County. (Bhatta, 2010), recognizes the various contributions of failure to enforce laws with encroachment.

Knowlegde of laws and policies that protect riparian zones

Law/Policy	Value
Several of the above laws	22.2
Water resource management…	1.7
Physical planning handbook, 2002	0.6
Forest Act, 2005	3.9
Agriculture Act, 2012	1.1
Land Act, 2012	4.4
EMCA, 1999	8.3
The water Act, 2016	2.2
Do not know/ not sure	55.6

Figure 5: chart illustrating knowledge of riparian protection laws in Motoine River

Concerning the effectiveness of compliance with government policies in protecting riparian areas, 19% agree that it is very effective, 38% feel that it is moderate, and 30% think that it is effective. 12% of them were not sure.

Effectiveness of level of compliance of governmet laws

- Very effective: 20%
- Moderate: 38%
- ineffective: 30%
- Not sure: 12%
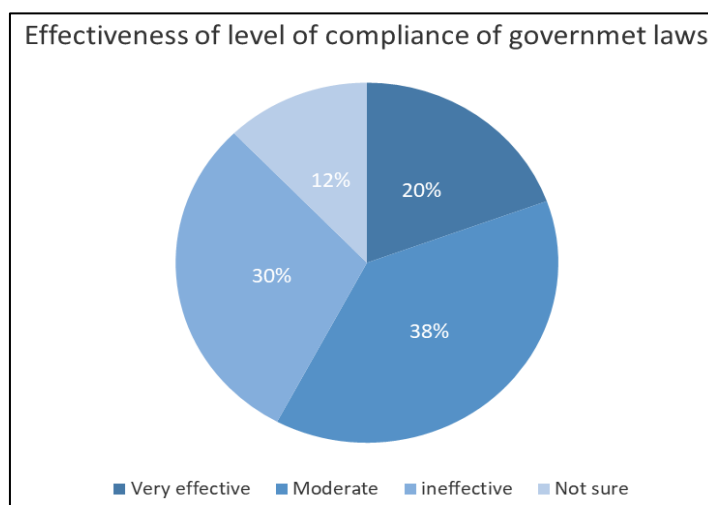
Figure 6: Motoine resident sentiment on the effectiveness of government laws

Reasons given for the ineffectiveness of compliance include:
- The ignorance that makes people keep on building,
- Corruption and greed,
- Lack of alternative lands/ overpopulation,
- Government land lacks proper ownership, and law enforcement,
- Poverty,
- The government does not want people to suffer due to displacement.

The determination of if the current Nairobi buildings were compatible with protecting riparian zones received was agreed upon by 51% of the population as being compatible, while the rest 49%, felt it wasn't. 3% of them were not sure.
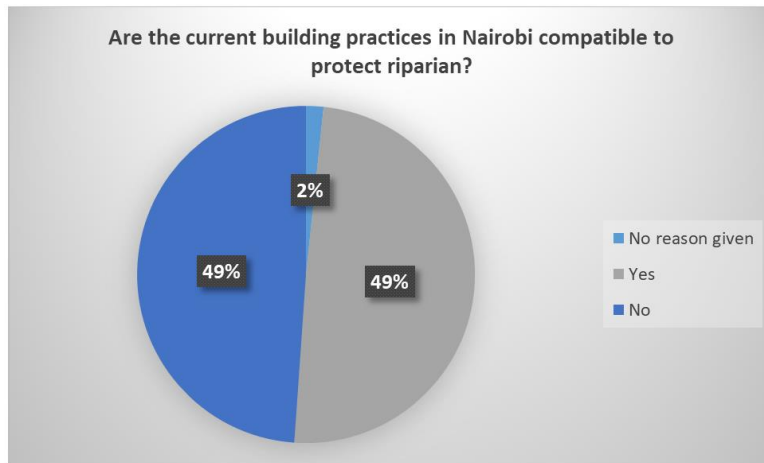
**Figure 7: Motoine residents' responses concerning the compatibility of building policies.**

The following key recommendations were given to enhance compatibility in the building laws.

- Construct compatible structures with proper sanitation infrastructure,
- Planting of trees to act as a boundary,
- Demolition of buildings/ structures in riparian areas,
- Issuing of title deeds and inspecting activities along the riparian areas,
- Government supervision, including the compliance of development with physical planning laws,
- Compensating people with land elsewhere,
- Constructing a permanent barrier along riparian to prevent informal buildings,

- Tackling corruption in the government,
- Public education to sanitize people on the importance of riparian,
- Creating employment for people to enable them to acquire land and livelihood elsewhere,
- Punishing those that violate the laws,
- Creating new rules and enforcing the existing ones.

Various responses regarding whether built structures have a negative or positive impact were met with varied responses where they agreed or disagreed based on individual perception. Some responses were positive and negative, while others had positive and negative opinions.
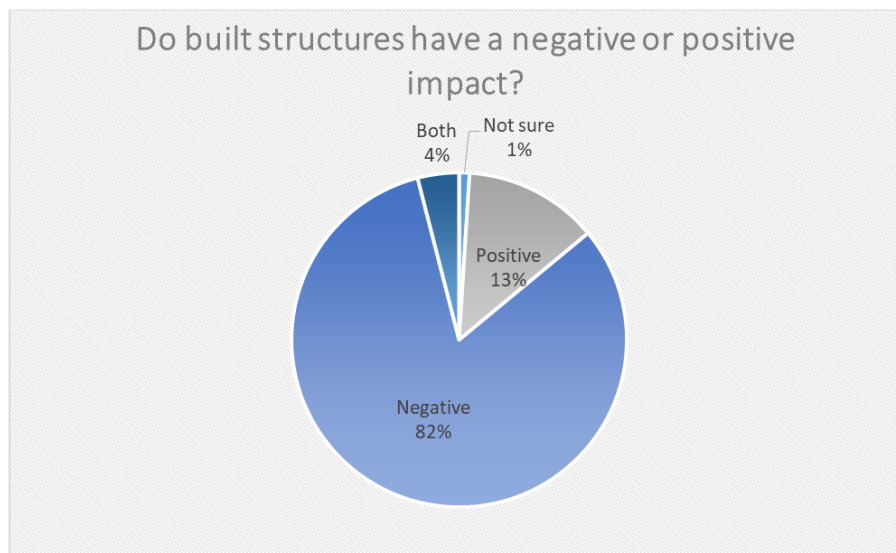
Figure 8: depicting Motoine household responses to the various effects of built structures

Some of the impacts considered positive include:
- Availability of the area for settlement,
- Recreation services,
- Development that leads to income generation,
- Land for flooding during rainy seasons,

Some of the effects of built structures on riparian lands include:
- Water and air pollution,
- Diseases,
- Flooding that leads to death and destruction of properties,

- Solid and liquid waste Disposal,
- Several of the above negative impacts,

- Soil erosion and destruction of plant cover.
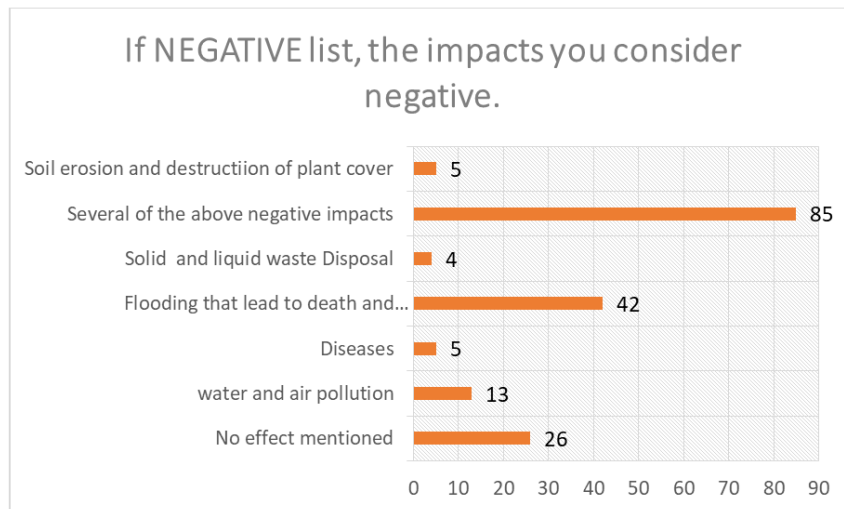
Figure 9: Negative effects of built structures on riparian zone

Several strategies were proposed that the government can employ to enhance the protection of riparian areas from the impacts of built structures along the Nairobi Rivers. They include the following as derived from the study:

- Ending Corruption in the government and individuals
- Secure the area (boundary wall), including proper waste management,
- Plant trees in the area,
- Provision of regulatory laws that guide building along the rivers and protect riparian areas,
- Evicting people who do not own land along riparian areas as well as demolishing structures built,
- Use the area for building service lines,
- Educate the public on the importance of riparian areas,
- The government should compensate property-

owners with lands that are not riparian,
- Employ people to be cleaning the river,
- Building formal buildings for the people as well as creating employment,
- The government should impose penalties for those buildings in riparian areas to discourage the practice.

Regarding the suggestion of activities that should be allowed in a riparian zone, the following conclusions were derived from the Motoine river area people. About 2% of the people did not suggest any built structure in the riparian zone. 1% suggested high-income buildings, less than 1% proposed informal settlement, 6% proposed urban agriculture, 3% proposed urban recreational parks, less than 1% proposed garages, 3% sugggested solid and liquid disposal systems, 13 % proposed roads and bridges, 3% service lines and the remaining 67% suggested several of the mentioned structures.
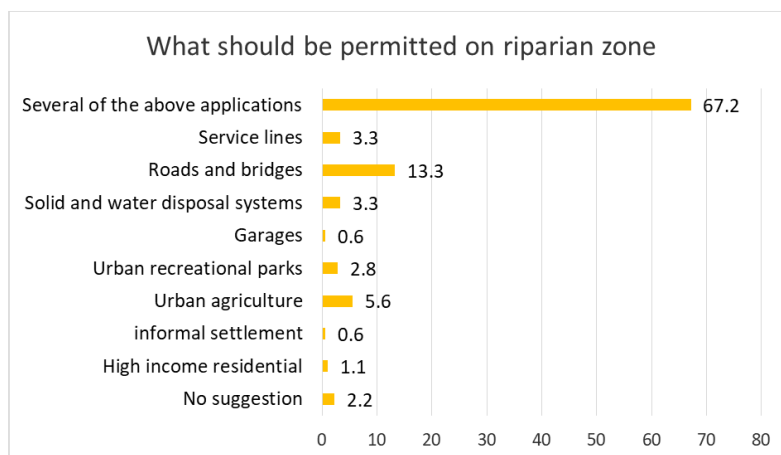
Figure 1: illustrating Motoine residents' response on what should be permitted in riparian

The various responses pertaining to activities that should not be permitted in riparian are as follows:

Table 4: Activities that should not be allowed in the riparian areas

	Frequency	Valid Percent	Cumulative Percent
No suggestion	9	5.0	5.0
High-income residential	5	2.8	7.8
informal settlement	1	.6	8.3
Public institutions	1	.6	8.9
Quarry mining	3	1.7	10.6
Urban agriculture	2	1.1	11.7
Formal Businesses	3	1.7	13.3
Urban recreational parks	1	.6	13.9
Heavy industries	6	3.3	17.2
Garages	1	.6	17.8
Several of the above applications	148	82.2	100.0
Total	**180**	**100.0**	

3.5 Nairobi River Area Description

The Upper Nairobi River region is situated in the Gatina- Waruku region near Lavington in the Dagoreti North constituency. The study region is located between the coordinates 36.7790 and -1.26372. Unlike Motoine, this area is less densely populated and consists of low-density residential housing and temporary structures that have encroached over the river riparian in Waruku. The majority of the constructed structures are permanent residential buildings and apartments, as well as temporary iron-sheet constructions. However, the environment around Gatina/Waruku is filthy with garbage and plastic waste. This region is dominated by agricultural and low-density residential land uses. The surrounding Lavington neighborhood is comprised of well-constructed mansions, bungalows, malls, and other types of apartments that are normally affordable to affluent social strata. The economic attraction and employment prospects that high economic areas provide can be related to the growth of slums in these areas. In such locations, however, the inability to afford services leads to the construction of slum-like structures. The river is polluted by sewage from nearby residential structures, and the majority of river encroachment is the result of high-security fences, utility lines, and agricultural activities.

***Plate 2: illustrating various forms of encroachment in the Nairobi River (source, author).* The river is thoroughly polluted with raw sewage from neighboring residential buildings**

3.5.1 Socioeconomic Demographic Constituents of the Nairobi River

A population of 60 was sampled and comprised of 62% males and 32% females. The age groups of the population comprised 38% of 20-30 years, 42% were 31-40 years, 10% were 42-50 years, and another 10% were 51-60 years. In contrast to Motoine River, the population of Nairobi River was relatively distributed, with more elderly than Motoine. 33% of the households have 1-3 family members, 38% have 4-7 family members, while the rest 4% have 8-11 family members. Regarding education, 5% of the households have a university education, 13% have a college education, the majority, which equates to 68%, have secondary education, and the rest, 13%, have primary education. The main economic activity in these

areas is business at 47%, formal employment at 18%, and other occupations at 40%. The level of formal employment in this area is relatively high. However, most of the household income is below fifty thousand. 5% of the households own land, while 91% are tenants. 3% of households own land less than an eighth, another 3% own land up to a quarter acre, and 2% own 2-5 acres. 90% of the populations are tenants with the amount of rent paid to be less than fifty thousand, while 2% pay rent of fifty to a hundred thousand.

About 73% of the Nairobi river catchment

understands the term riparian, while the other 27% of the population does not understand the term riparian. Of them, 8% understand six meters of allocation of the riparian zone, 43% are aware of 30 meters allocation to riparian while 28% are aware of other allocation sizes and 20% do not know. 48% of them understand various structures allowed in riparian zones while 52% do not know structures allowed in the riparian zone. In to regard understanding of the built structures that are permitted in riparian, the following observation was note as indicated on the table below.

Table 5: Nairobi resident's knowledge of structures built in riparian zones

	Frequency	Valid Percent	Cumulative Percent
Not sure/ no answer	33	55.0	55.0
Building (permanent)	1	1.7	56.7
Building (temporary)	2	3.3	60.0
Civil structures (bridges, sewer line, manhole)	14	23.3	83.3
Transmission lines (power, lighting ,data)	1	1.7	85.0
Several of the above	9	15.0	100.0
Total	**60**	**100.0**	

Nairobi river area populations identified the encroaching factors, which include Population explosion with no alternative land to accommodate them. Also use of riparian as dumping sites, corruption, greed, Lack of law enforcement by the government, people's desire to utilize the idleness of riparian lands, and poverty and ignorance as the main factors influencing encroachment. Most of the population gave more than one of the listed factors, while some of them do not know any factor. 85% 0f the population had been in a river riparian while the rest, 15%, had not. The majority of the population in this area considered the

riparian area as beneficial for recreational and pathway for the excessive runoff. Only less than one percent considered riparian as a place of waste disposal, unlike Motoine River residents. 63% were of the population are aware of laws and policies in Kenya that protect riparian areas while the subsequent 37% do not have a clue of such laws. The commons laws that are clear in this area this area is the EMCA, 1999 and Water Management Act 2016. Majority of the population do not know the laws. In terms of the level of compliance of government laws and policies in protecting riparian zones, divergent views have been observed.
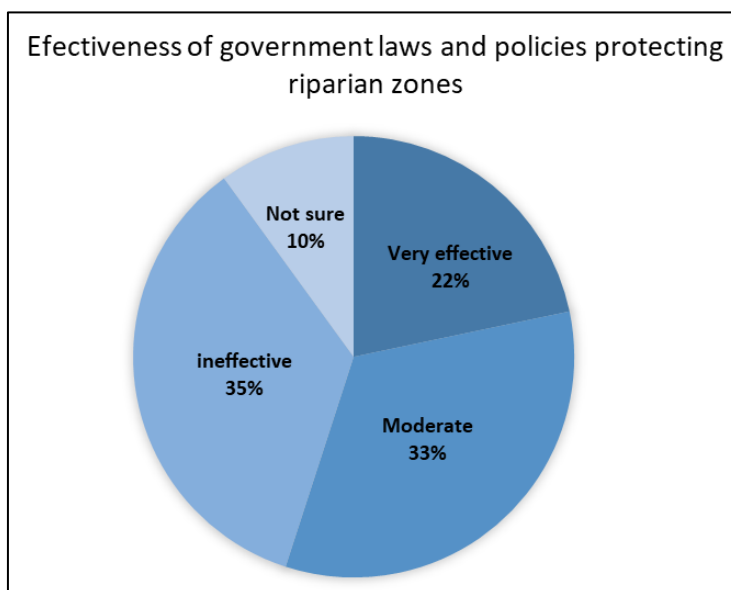
Figure 2: Upper Nairobi responses on the effectiveness of government policies

The factors outlined for the ineffectiveness of compliance are similar for all case study areas .48% of the population believes that the current building policies

are compatible in protecting riparian areas, with the majority advocating for government supervision in building activities, including the compliance of

development with physical planning laws. 86% believe building along riparian areas has negative impacts such as water and air pollution, diseases, flooding that lead to death and destruction of properties, and waste disposal in the water. Among the most popular effects of building structures in riparian areas is the issue of flooding, which most residents consider harmful. To prevent flooding, the resident proposed building barriers in riparian areas and ensuring proper waste management and planting of trees to prevent alternative uses. The various to be permitted and not permitted in the riparian zone are as follows:

Table 6: Activities should be permitted adjacent to riparian areas

	Frequency	Percent	Valid Percent	Cumulative Percent
Roads and bridges	1	1.7	1.7	1.7
Service lines	1	1.7	1.7	3.3
Several of the above applications	58	96.7	96.7	100.0
Total	**60**	**100.0**	**100.0**	

Table 7: activities that should not be permitted in the riparian areas

	Frequency	Percent	Valid Percent	Cumulative Percent
No suggestion	2	3.3	3.3	3.3
Public institutions	1	1.7	1.7	5.0
Several of the above applications	57	95.0	95.0	100.0
Total	**60**	**100.0**	**100.0**	

3.6 Mathare River Structural Pattern Description

A sample population of thirty households represented the area of the Mathare River catchment. The male population assessed was 57%, while the female comprised 43%. The population age composition comprises 20% who are 20-30 years, 37% between 31- 40 years, 20% of 41-50 years, and 23% are 50-60 years old. The general characteristics of the age group can be attributed to the kind of housing ownership in this area. The families in the upper Mathare River catchment is composed of 23%of households with 1-3 members; the majority of household in this area is comprised of 4- 7 members, equating 63%, while those with 8-11 members and over 12 members compromise 7% each. 16% of Upper Mathare areas have a university education, 26% have a college education, 36% have a secondary school education, and 6% have primary education. A household in Upper Mathare basing is hence more educated than those in other areas of this study. A large number of households in this area engage in business, taking about 67% of the population. Business forms the main economic activities of this area and can be attributed to the high population in this area. Business is followed by 20% comprising formal employment while other occupations and farming comprise 10% and 6% respectively. The average Household income in upper Mathare river basin is relatively high than in other areas, with households earning fifty to a hundred thousand. Generally, this is because the area is composed of low residential buildings which are relatively planned. The area is also used for agricultural purposes and hence gets income farming. That is about 10% earn 50,000 to 100000 while the rest 90% earn below fifty thousand. Also notable is the increased land ownership, which accounts for 33% while the rest, 67%, are tenants. The rental incomes in this region are also high compared to those of Nairobi River and Motoine residents. Most of the tenants pay ten to fifty thousand as rent. Upper Mathare River is characterized by increased land ownership. This is mainly because the area is zoned for low residential housing as well as agriculture. Due to increased land ownership, the number of tenants is significantly low as opposed to the other areas taking about 73%. About 67% of the population do not own land while 7% own less than an eighth-acre plot, 7% an eight to half an acre, another 7% over an eighth to a half acre, and finally 13% own half to a one-acre piece of land.

3.6.1 Factors that Cause Riparian Encroachment in the Upper Nairobi River

Majority of the residents in upper Mathare River understand the term riparian and its meaning. About 83% of the household understand riparian while the rest 17%, do not understand. Increased knowledge of the riparian area and its meaning can be attributed to the level of education, which is significantly high in this area as compared to the other parts of the Nairobi river basin covered by this research. In terms of understanding the applicable sizes for riparian zones, the following results were obtained, as illustrated in the table below. The majority of the residents understood a riparian zone of about 30 meters. The main reason behind mentioning 30 meters as the riparian zone application is attributable to zooming in on this area which is a low residential area including urban agriculture. Also, the area is generally covered with trees and vegetation because it is a part of the adjacent Karura forest. The types of development in this region are controlled, comprising urban suburbs.

Table 8: Upper Nairobi household's Knowledge of riparian application sizes

	Frequency	Percent	Valid Percent	Cumulative Percent
Not sure/ do not know	4	13.3	13.3	13.3
6 meters	7	23.3	23.3	36.7
30 meters	13	43.3	43.3	80.0
both	3	10.0	10.0	90.0
Other sizes e.g. 7m, 10m, 60m	3	10.0	10.0	100.0
Total	**30**	**100.0**	**100.0**	

The level of understanding of whether built structures are allowed in riparian areas can, however, be blamed for the various structures identified in riparian zones. For instance, about 53% of the populations do not know if structures are allowed in riparian zones, while the rest 47% understand it. In regard to the types of structures allowed in riparian, the following structures were identified by the Upper Mathare river basin residents as shown on the table.

Table 9: Upper Nairobi household's identification of built structures are allowed in riparian zone

	Frequency	Percent	Valid Percent	Cumulative Percent
Not sure/ no answer	16	53.3	53.3	53.3
Civil structures (bridges, sewer line, manhole)	6	20.0	20.0	73.3
Transmission lines (power, lighting ,data)	1	3.3	3.3	76.7
Several of the above	7	23.3	23.3	100.0
Total	**30**	**100.0**	**100.0**	

In terms of identifying the various factors that cause encroachment, most of the area residents acknowledged several factors with the majority stating increased populations in urban areas and corruption and greed in the government.
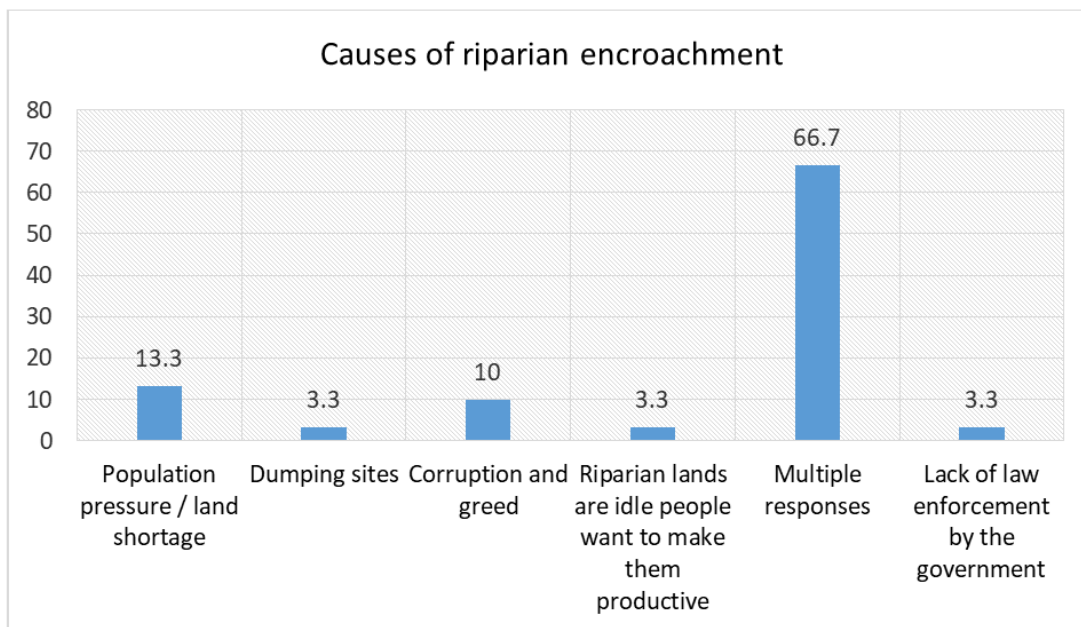
Figure 3: Cause of riparian encroachment in upper Nairobi River

88% of the population of the Upper Mathare River basin has been in a riparian area. This is quite a significant number compared to the other areas whereby large numbers maintained they had never visited a river riparian zone. Notable in this area, the residents have a substantial understanding of the various positive usages of the riparian. For instance, the residents did not mention the dumping site as a benefit of the riparian zone. The majority of the residents maintained the area as being best reserved for the river overflow and recreation area, while 16% were not sure. The table below depicts the various benefits outlined.

| If yes of what benefits is a riparian area of a river?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Do not know/ not sure	5	16.7	16.7	16.7
No use	4	13.3	13.3	30.0
Availability of water/ irrigation purposes	2	6.7	6.7	36.7
several of the above uses	8	26.7	26.7	63.3
Pathway for the river and overflow areas	3	10.0	10.0	73.3
Recreation areas	3	10.0	10.0	83.3
Agriculture/ farming	2	6.7	6.7	90.0
Protects and prevents soil erosion	3	10.0	10.0	100.0
Total	**30**	**100.0**	**100.0**	

Majority of the Upper Mathare River basin proposed planting of trees and vegetation as the main recommendation of Nairobi river riparian use. This comprised about 33%, with another 37% mentioning the same, including other recommendations. The typical de facto use of the land in a certain area seems to influence the choice and the mindset of the population living therein. This is true because the pattern from the three area populations revealed that what exists on the ground translated to what the residents gave as the recommendation. The various recommendations for riparian land use were given as shown below.

What uses would you recommend for the riparian area along rivers in Nairobi?				
	Frequency	Percent	Valid Percent	Cumulative Percent
No recommendations	1	3.3	3.3	3.3
Planting trees \ vegetation	10	33.3	33.3	36.7
Agriculture	4	13.3	13.3	50.0
Riparian land should remain unused\ \ natural	1	3.3	3.3	53.3
Several of the above application	11	36.7	36.7	90.0
Fencing and protecting Riparian areas	2	6.7	6.7	96.7
Be used for recreation	1	3.3	3.3	100.0
Total	**30**	**100.0**	**100.0**	

About 97% of the households in upper Mathare understood the existence of various that protect riparian zones in Kenya, while 3% do not. Of the same population, 7% are not sure or do not know the specific law, 30% understand the environmental management conservation Act 1999, while 3% are conversant with the forest act. The majority of the house did acknowledge several laws.
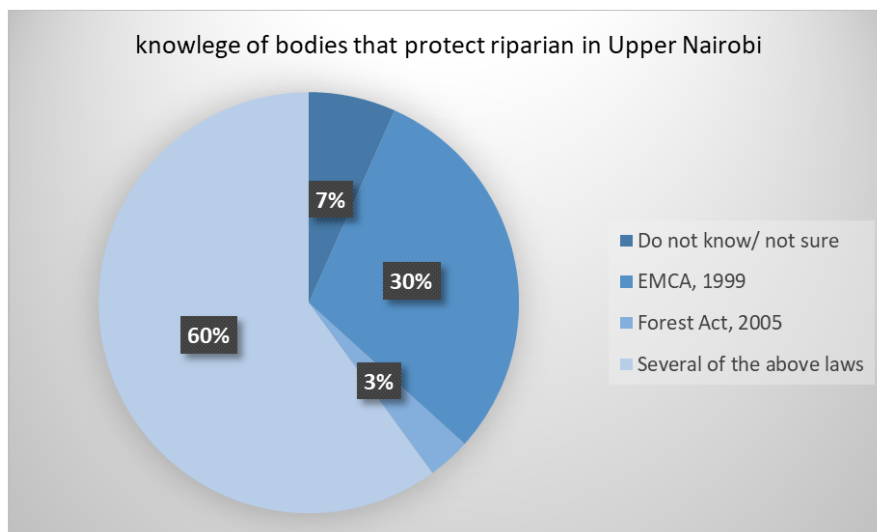
Figure 4: the knowledge of various bodies that protect riparian zones in Upper Nairobi

The issue of determination of if the level of compliance of governmental laws and policies in protecting the riparian areas have been effective received diverse perspectives from different households. For instance, 13% noted that they were very effective, 33% stated that they were moderately effective and 53% felt that the compliance of the law was not as effective as depicted below.
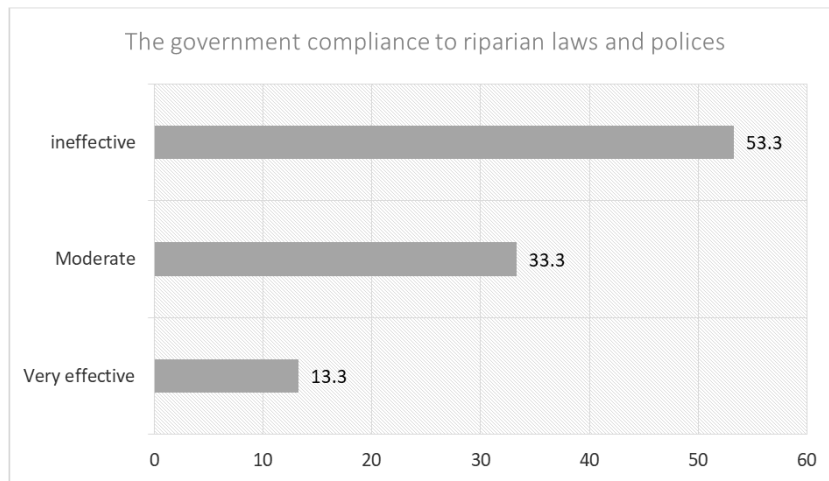
Figure 5: response to government compliance with riparian laws

Reasons given for lack of ineffectiveness were similar to the other areas of the study, as shown in the table.

Table 10: reasons why there is ineffectiveness in compliance

	Frequency	Percent	Valid Percent	Cumulative Percent
No reason given	10	33.3	33.3	33.3
The ignorance that makes people keep on building	5	16.7	16.7	50.0
Corruption and greed	4	13.3	13.3	63.3
several of the above reasons	9	30.0	30.0	93.3
Government land lacks proper ownership, and law enforcement	1	3.3	3.3	96.7
Complexity in retrieving land from the grabbers	1	3.3	3.3	100.0
Total	**30**	**100.0**	**100.0**	

73% of the Upper Mathare basin blamed the current practices in Nairobi as being insensitive in protecting the riparian areas of the Nairobi Rivers. The rest 27%, feel that the building practices were compatible with protecting riparian zones. For those that felt it was not, they gave recommendations similar to those of Motoine and Nairobi Rivers. The main suggestion for the area was government supervision in riparian, including compliance with the physical planning act. The issues of clear boundaries, clear land use policies, and specific riparian zone sizes have been pointed out as the underlying factor that leads to riparian encroachment. Negative impacts of built structures along riparian areas have been pointed out, which outweigh the positive. 10% of the population felt that built structures have a positive impact, 3% claimed built structures have both positive and negative influences, while the majority comprising 87%, reported that built structures have adverse effects on riparian.
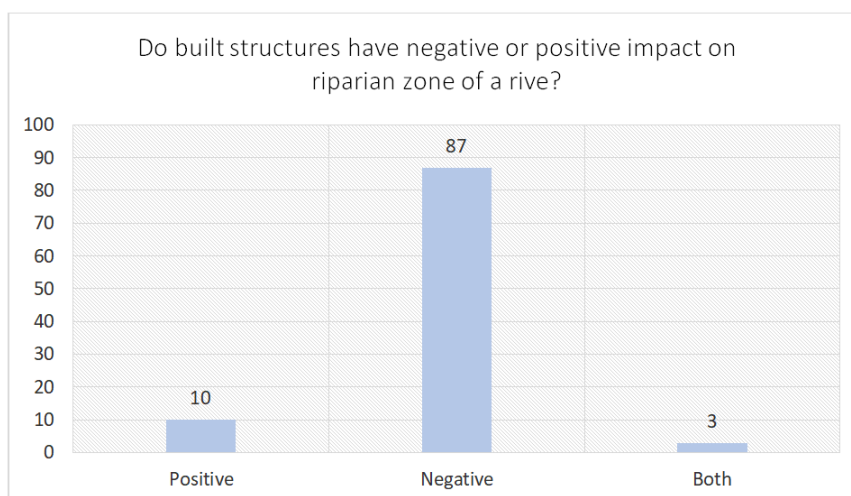
Figure 6: impacts of built structures on riparian

Some of the effects considered positive in the Mathare River area include the following as outlined.

However, most residents did not consider building structures in riparian as having a positive impact.

Table 11: The impacts considered positive

	Frequency	Percent	Valid Percent	Cumulative Percent
Do not consider impact positive	26	86.7	86.7	86.7
Development that leads to income generation	3	10.0	10.0	96.7
Land for flooding during rainy seasons	1	3.3	3.3	100.0
Total	**30**	**100.0**	**100.0**	

The negative impacts of built structures in the Mathare River basin include the following, as shown below.

Table 12: impacts considered negative.

	Frequency	Percent	Valid Percent	Cumulative Percent
No effect mentioned	4	13.3	13.3	13.3
water and air pollution	4	13.3	13.3	26.7
Flooding that leads to death and destruction of properties	2	6.7	6.7	33.3
Solid and liquid waste Disposal	1	3.3	3.3	36.7
Several of the above negative impacts	14	46.7	46.7	83.3
Soil erosion and destruction of plant cover	5	16.7	16.7	100.0
Total	**30**	**100.0**	**100.0**	

The recommendations given by Mathare residents are similar to those of both Nairobi and Mutoine Rivers. Provision of regulatory laws that guide building along the rivers and protect riparian areas as well as evicting the people who have built structures along the riparian was given as the recommendation to protecting the rivers' riparian zones in Nairobi. Other recommendations include: Secure the area (boundary wall) including proper waste management, use riparian zones for building service lines, government to compensate landowners affected with other lands that are not riparian lands, employing people to be cleaning the river, and the government imposing heavy penalties for those building in riparian areas to discourage the practice. In relation to activities to be permitted and those that should not be allowed, the research obtained the following recommendations respectively.

Table 13: Activities that should be permitted adjacent to riparian areas?

	Frequency	Percent	Valid Percent	Cumulative Percent
No suggestion	2	6.7	6.7	6.7
Urban recreational parks	1	3.3	3.3	10.0
Several of the above applications	27	90.0	90.0	100.0
Total	**30**	**100.0**	**100.0**	

Table 14: activities should not be permitted in the riparian areas

	Frequency	Percent	Valid Percent	Cumulative Percent
No suggestion	1	3.3	3.3	3.3
Several of the above applications	29	96.7	96.7	100.0
Total	**30**	**100.0**	**100.0**	

3.7 Discussion of Social, and Economic Factors which Influence the Encroachment of Riparian Areas
3.7.1 Education versus Factors of Encroachment
A strong correlation (where Pearson's R= 0.715) was identified in the Motoine River. A moderate correlation (Pearson's R=0.54) was established in the Nairobi river, and a very strong correlation (Pearson's R= 0.946) was established in the Mathare river area. The majority of Mathare River was educated at both university and college levels hence understanding built structures. In identifying the various structures that are allowed in riparian zones, education also played a critical role whereby Motoine river had a very weak correlation (Pearson's R=0.022), Nairobi river had a very strong correlation (Pearson's R = 0.974), and Mathare River population had a perfect correlation (Pearson's R = 1). The weak correlation of Motoine River can be attributed to the majority of the population not knowing the various kinds of structures that is built in riparian while a strong correlation in the Upper Nairobi River and Mathare is attributed to high levels of education in these areas and the ability to identify the built structures. This implies that the level of education translated to increased understanding if built structures are allowed in the riparian zone; hence, educating the

population would lead to decreased encroachment of river riparian.

4.7.2 Understanding of Riparian and its Meaning Versus Factors of Encroachment

The research established a weak correlation (Pearson's R=.034) between the people's understanding of riparian zones and riparian laws and riparian and factors of encroachment. The bias can be traced to the explanation of what riparian area during the questionnaire leads to an insight of what it is. By gender, the research identified more men understood the factors causing encroachment than women. This is despite the sample population being composed of women as the majority. This implies that ignorance is the key contributor to the riparian encroachment in Nairobi.

4.0 DISCUSSION OF RESULTS

According to the findings of the research, the primary factors contributing to the invasion of riparian zones include dishonesty, rapid population growth, a lack of effective law enforcement, and ignorance. However, the polycentric administration that Kenya has might be seen as the main cause of the country's problems with bribery and a lack of adequate law enforcement. According to the findings of the research, the fact that there are multiple authorities that are responsible for formulating policies that have an effect on riparian zones makes it difficult not only to execute the laws but also to follow-up on them and enforce them. It was clear that the laws and the specific authorities that were tasked with their application and enforcement lacked clarity, and this was observable. On the other hand, enforcement has been hampered by the widespread corruption that exists in Kenya. One example of this would be the politicization of sensitive concerns about the protection of river zones.

Ignorance among the populations that live in slum regions, such as the Motoine neighborhood, contributes significantly to the difficulty of putting this plan into action. During the course of the study, the majority of the people who participated admitted that they were aware of or had been threatened with the demolition of structures; however, the enforcement was never carried out, and in the cases when it was, the residents rebuilt the structures. The most common reason for riparian encroachment is people's ignorance of the regulations and the risks associated with constructing buildings next to riparian regions, as well as the significant levels of poverty that exist in slum areas. The huge population of individuals who have nowhere else to reside, combined with the lack of available land, is another factor that contributes to severe encroachment. In each of the regions under consideration, the majority of households have a monthly income of less than fifty thousand dollars. According to the findings of the research, the vast majority of these individuals lived in rented homes and

paid between one thousand and five thousand Kenyan shillings per month.

Politics plays a significant part in thwarting the execution, which also frequently results in delays and occasionally brings racial tensions into the discussion over the subject at hand. According to the findings of the study, hostility in regions such as Motoine played an important part in blocking enforcement actions such as demolitions. Not only does the presence of unlawful groups and gangs in these regions constitute a threat to the possibility of change, but it also makes maintaining security more difficult. According to the findings of the investigation, there is also a lack of transparency with regard to the actual riparian allocations. During the course of the interviews, a variety of institutions revealed that there was a widespread absence of a cohesive size that was agreed upon by all of the interested parties.

A riparian size allocation that ranged from a minimum of two meters all the way up to one hundred meters was given to illustrate the disparities that exist between each institution. This is taking into consideration the fact that the individual institutions did not specify the particular circumstances under which the allocable sizes could be altered to whatever specified size. Because of this, various planners, environmental specialists, contractors, and project managers have come to different conclusions about the construction of various structures on riparian lands. The research identified that the existence of fragmented laws in Nairobi and, generally in Kenya, is the leading cause of riparian encroachment. When experts from various sectors in Nairobi were enquired about their understanding of permissible riparian sizes, inconsistent responses were given, even when these people worked for the same organization.

5. CONCLUSION

The research concludes that poverty, population explosion, corruption, and lack of law enforcement are the main drivers of riparian encroachment. In addition majority of the resident in the Nairobi, area suffer ignorance and are unaware of the risks of building in riparian zones. The building regulations and laws in Nairobi are not compatible with protecting riparian areas. The main built structures that encroach on Nairobi Rivers are formal and informal settlements, sewer lines, service lines, and agricultural activities. The impacts of built structures in Nairobi riparian areas include destructive flooding, land degradation, and water and land pollution in Nairobi areas.

5.1 RECOMMENDATIONS

The study recommends that sustainable housing and public education be enhanced to combat and sanitize the issue of riparian encroachment respectively. Furthermore, law enforcement should be

enriched, including refining the rules and regulations that protect riparian zones. In areas highly encroached areas, the destruction of the built structures and subsequent erection of barriers and vegetation will prevent encroachment and pollution.

APPENDIX 1 –General Statistics

	Mean	Std. Error of Mean	Median	Mode	Std. Deviation	Variance	Minimum	Maximum
Location	1.44	.042	1.00	1	.686	.471	1	3
Household head Gender	1.55	.030	2.00	2	.499	.249	1	2
Age category	1.87	.058	2.00	1	.953	.909	1	5
Family size	1.71	.040	2.00	2	.655	.429	1	4
Level of household education	3.04	.049	3.00	3	.799	.638	1	5
Household head occupation	2.90	.058	3.00	2	.951	.905	1	4
Average monthly income	1.02	.008	1.00	1	.135	.018	1	2
Do you own the land, or are you a tenant?	1.86	.021	2.00	2	.352	.124	1	2
If you own the land, what is the land size?	0.26	0.047	0.00	0	0.770	.592	0	6
if the tenant state the category of rent paid	.87	.021	1.00	1	.351	.123	0	2
Do you understand the term riparian and its meaning?	1.35	.029	1.00	1	.478	.229	1	2
If yes, which of the following size application of riparian area sizes are you aware of?	1.91	.088	2.00	2	1.440	2.074	0	4
Do you know if built structures are allowed in the riparian zone?	1.59	.030	2.00	2	.493	.243	1	2
If yes, what types of built structures are allowed in the riparian zone?	3.06	.205	2.00	0	3.373	11.375	0	8
Why do you think there is an encroachment of riparian areas along rivers in Nairobi?	3.77	.114	5.00	5	1.873	3.508	0	7
Have you ever been to or in a riparian area of a river?	1.19	.024	1.00	1	.395	.156	1	2
If yes what benefits is a riparian area of a river?	4.28	.258	4.00	0	4.245	18.023	0	14
What uses would you recommend for the riparian area along rivers in Nairobi?	3.30	.143	3.00	5	2.351	5.527	0	11
Do you know that there are laws and policies protecting riparian areas in Kenya?	1.44	.030	1.00	1	.498	.248	1	2
If yes, which of these laws and policies protecting riparian areas in Kenya are you aware of?	3.66	.264	2.00	0	4.330	18.747	0	10
Has the level of compliance of Government laws and policies in protecting the riparian areas been effective?	2.35	.055	2.00	2	.908	.824	1	4
Give reasons why there is ineffectiveness in compliance	1.41	.112	0.00	0	1.839	3.381	0	8
Are the current building practices in Nairobi sensitive/compatible with protecting the riparian areas of rivers in Nairobi?	1.50	.032	2.00	2	.530	.281	0	2
If NO, give recommendations of how compatibility can be enhanced.	3.13	.245	0.00	0	4.030	16.244	0	14
In your opinion, do built structures have positive or negative impacts on riparian areas?	1.90	.025	2.00	2	.418	.175	0	3
If POSITIVE list, the impacts you consider positive	.59	.095	0.00	0	1.563	2.443	0	6
If NEGATIVE, list the impacts you consider negative.	4.03	.143	6.00	6	2.354	5.542	0	7
In your opinion, what strategies can the government employ in order to enhance the protection of riparian areas from the impacts of built structures along rivers in Nairobi?	6.20	.210	9.00	9	3.454	11.930	0	12
In your opinion, which of the above Activities should be permitted adjacent to riparian areas?	13.76	.193	15.00	15	3.166	10.022	0	15
In your opinion, which of the above activities should not be permitted in the riparian areas?	13.52	.246	15.00	15	4.046	16.369	0	15

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