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**MSc Programme in Urban Management and Development**

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**Thesis**

Title: The Influence of Human and Financial Resources on the Operation and Maintenance of Storm Water Drainage Systems for Reduction of Localized Urban Floods in Nairobi, Kenya

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**Title**

The Influence of Human and Financial Resources on the Operation  
and Maintenance of Storm Water Drainage Systems for the Reduction  
of Localized Urban Floods in Nairobi, Kenya

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## **Summary**

Proper management of storm water drainage systems enhance the benefits of flood protection, pollution control and social and environmental protection particularly in urban areas where the community served by the system is larger. This thesis presents the findings on the influence of human and financial resources for operation and maintenance of the storm water drainage system for the reduction of localized urban floods in Nairobi, Kenya. The operation and maintenance of the storm water drainage system in Nairobi lies under the mandate of the Department of Roads, Public Works and Transport and has recently been facing challenges in execution of these duties. This Department falls within the Nairobi City County Government, following devolution of the county governments in Kenya in 2010, and has had challenges pertaining to both human and financial resources to deliver services.

The main aim of the study was to establish how human and financial resources influence operation and maintenance of storm water drainage systems in Nairobi to reduce localized urban flooding. In order to fulfil this, the study was undertaken as a single holistic case study within Nairobi with a focus on two selected areas, that is, Madaraka Estate and Mbagathi/Lang'ata intersection. The study is explanatory in nature and has made use of qualitative data collection and analysis methods in order to give an in-depth understanding of the relationships presented in its objective. 13 questionnaires were administered to staff within the responsible department as a pre-test, which was then followed by 9 interviews to department heads, experts in the fields and employees within disaster response units in order to triangulate the responses given. Furthermore, some of the information collected was verified through review of secondary data in the form of official Department records and documents.

The responses received revealed major shortcomings pertaining to allocation and availability of finances for operation and maintenance of the storm drains as well as a lack of support of the staff in terms of adequacy of staff numbers, skill development and performance monitoring. These are major factors that have affected the efficient performance of the department with respect to management of the storm water drainage system and have resulted in failure of the drainage system to perform adequately from poor maintenance. Further to this, corruption and a slow adjustment to the devolution of government functions has crippled execution of duties.

This research revealed that the lack of financial resources and human resources has affected the successful operation and maintenance of the storm water drainage system in Nairobi and this has exacerbated the problem of localized urban flooding in the Capital City of Kenya.

## **Keywords**

Human Resource, Financial Resource, Operation and Maintenance, Reduction of Localized Urban Floods

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## Abbreviations

IHS	Institute for Housing and Urban Development
O&M	Operation and Maintenance
The Department	The Department of Roads, Public Works and Transport
NDMU	National Disaster Management Unit
MAM rains	March-April-May
KRC	Kenya Red Cross
NCCG	Nairobi City County Government
Kshs	Kenyan Shillings
PAS	Publicly Available Specification
ISO	International Standards Organization
CRA	Commission on Revenue Allocation

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# Chapter 1: Introduction

This chapter introduces the topic to be studied. The aim of this study is to explain how operation and maintenance of storm water drainage systems in urban areas has a role to play in the reduction of localized urban flood events. This shall be done by looking into the factors that influence operation and maintenance activities of the storm water drainage system within the responsible branch of the county government in Nairobi and how subsequently O&M may exacerbate or reduce the occurrence of localized urban floods. The problem statement will reflect the situation in Nairobi, Kenya and thereafter a review of the scope and limitations of the study. The study will be justified through its relevance to academia and society.

## 1.1 Background

Proper management, efficient operation and well-executed maintenance of storm water drainage systems are essential to the sustainability of the drainage asset and protection of the communities they serve. These practices enhance the benefits of flood protection, pollution control and social and environmental protection among others (International Commission on Irrigation and Drainage 1998, Martin, Ruperd et al. 2007). In urban areas particularly, the community served by the drainage system is larger and more dynamic than in rural areas and thus the general management of these drainage systems may in essence be more tasking and complex. However, the management, the operation and the maintenance of the storm water drainage systems are generally poorly carried out particularly in developing countries leading to failure of the drainage systems causing increased localized urban flooding and pollution of the downstream watercourses. This poor management of drainage systems is mainly attributed to inadequate finances, weaknesses in institutional arrangements, low technical proficiency of the personnel and managerial shortcomings of the organizations tasked with the care of the drainage systems in urban areas (International Commission on Irrigation and Drainage 1998, Bahl, Linn 1992, Nairobi, Urban Infrastructure Development Strategy 2014).

Traditionally, urban storm water drainage systems were solely designed for the projected quantity of rainfall to remove surface runoff from the area in the fastest way possible through underground pipes to prevent local flooding (Falkirk Council 2009). The poor performance of the storm water drainage system with respect to its intended purpose of removing surface runoff from an area has resulted in inundation of storm water and flooding of the surrounding area causing damages and losses. The urban drainage system is an extensive asset involving complex interaction of the urban landscape such as buildings, roads, public sewers, private sewers and watercourses. Thus, such large systems must be efficiently managed as this complex interaction puts a higher amount of property and population at risk of damage and loss (Department of Public Works Republic of South Africa 2015, Butler, Davies 2004).

Flooding is essentially a natural phenomenon whereby water exceeds the capacity of its channel, whether natural or manmade, and overflows onto adjacent lands and on many occasions causes significant damage where there is development and settlements within the flood affected area. The type of flood varies depending on its related causes such as river flooding, coastal flooding, groundwater flooding and urban flooding. Urban flooding is the type of flooding that is most related to the storm water drainage system. Urban flooding may be defined as the type of flooding that result from the sensitive and limited capacity of the existing drainage network. It is also referred to as pluvial or surface water flooding and constitutes of roughly 25% of all flooding events worldwide (Douglas, Alam et al. 2008, Falkirk Council 2009). Thus, urban flooding is more likely to affect all types of urban settlements regardless of their proximity to rivers, oceans or the underlying rock and water

table of the area because an essential element of urban areas is the storm water drainage systems.

A storm water drainage system is a network of canalized trunk drains, ditches and storm sewers that drain surface runoff of an area particularly during rainfall events. The capacity and eventual proper functioning of the storm water drainage system may be overwhelmed when the volume of the surface runoff off exceeds the functioning capacity of the system. This capacity may be exceeded due to three main reasons. Firstly, capacity may be exceeded due to heavy rainfall and resultant overland flow that is beyond the design considerations of the drainage system and the surface's absorptive capacity (Falkirk Council 2009, Wachira 2016). Secondly, the capacity of the drainage system may be exceeded due to increased urbanization of an area which is related to the increased impermeable surfaces. Urbanization is related to increase in extent of paved impermeable surfaces, increase in population and even generation of solid waste and or debris that may compromise the capacity of the drainage system. Thus, even in situations where the amount of rainfall is not beyond the design considerations of the system the resultant increased overland surface flow that cannot be absorbed into the ground immediately may exceed the design capacity of the drainage system (Falkirk Council 2009, Freni, Oliver 2005, Ochoa-Rodriguez 2017). The third reason that the capacity of the drainage system may be exceeded is due to the technical conditions of the system. This is encompassed in many aspects such as the design, size and slope of the system, the materials used in construction as well as the operation and maintenance of the system. The design and size of the system may be insufficient to carry the amount of the storm water as the runoff flow may exceed the design flow capacity. Furthermore, with respect to slope, a sufficient slope that ensures steady flow of the water without damming or excessive corrosion of the system is necessary to drain storm water away sufficiently and avoid flooding. The materials used in constructing the system are directly related to the lifetime of the channel and its ability to resist wear and tear. Finally, poor operation and maintenance of the system may cause blockage and constriction of the flow channels or a reduced lifespan of the system and hence resulting in improper drainage of surface runoff during rainfall events (Wachira 2016, Douglas, Alam et al. 2008).

All these factors are important and must be considered in efforts to reduce floods and their impacts especially in parts of the world that are facing increasing number and magnitude of flood events. However, as earlier mentioned, the operation and maintenance of the storm drainage system is an aspect whose importance is often overlooked in efforts to reduce urban flooding especially in developing countries. Redesigning and reconstruction of the storm water drainage system to accommodate the increased runoff and the growing population may be beyond the scope of what developing countries may immediately be able to handle, particularly when at-hand methods that improve the functioning of the storm water drainage system such as proper operation and maintenance of the have not been fully utilized (Douglas, Alam et al. 2008).

According to (Backmann, MacCleery 2006), operation is the process of using physical works to ensure the delivery of a service while maintenance refers to the care of these physical works through cleaning, repair, replacement and general preservation of the asset. Both activities together form part of the technical aspects that are necessary to deliver a service, which in this case is flood protection, and extend the asset life, with the asset in this case being the storm water drainage system. Operation and maintenance of any asset is an essential part of asset management which is "a strategy for the creation or acquisition, maintenance, operation, rehabilitation, modernization and disposal of assets to provide an agreed level of service in the most cost-effective and sustainable manner" (Narrandera Shire Council 2012, Malano, Chien et al. 1999). In their study of urban flooding in major Scandinavian cities, (Torgersen, Bjerkholt

et al. 2014) notes that in many parts of the world in general, the existing drainage systems are often old systems that lack proper maintenance resulting in an increased negative impact of rainfall in urban areas. Concurrently, (Douglas, Alam et al. 2008) in a study of flooding in the African cities of Maputo, Kampala, Accra, Lagos and Nairobi, says that flooding in developing countries is exacerbated by human activities, particularly poor construction and maintenance of storm water drainage channels rather than by the increase in rainfall. That study revealed that the drainage systems, that are mainly concrete-lined structures with minimal absorptive features, are often silted up with urban debris. The focus group participants of the study emphasized that the national and local governments in the respective cities ceased any involvement in the maintenance of the channel once construction was completed and thus the community had been forced to self-organize and provide man-power and financial resources especially just before the onset of the rainy season to clear the drainage channels and protect themselves from damage and loss.

In the city of Bangalore in India that is rapidly growing and developing, urban flood events have rapidly increased due to the dilapidated state of the storm water drainage system that does not drain away surface water runoff in rainfall events but rather are blocked by waste causing the waters to pond the streets and enter buildings. The local governments have focused much of their resources and attention to development projects within the city and ignored maintenance requirements of the storm water drainage system to keep up with the growing population (Gouri, Srinivas 2015). Furthermore, in a study of flooding and storm water drainage in the city of Nairobi, (Wachira 2016) explains that urban flooding in the vibrant city over the recent years has been exacerbated by three main factors namely, an increase in rainfall intensity, the clogged and poorly maintained storm water drainage system and the insufficient capacity of the existing drainage system in many parts of the city. Following reports that the main reason localized flooding in the Capital of Kenya has increased due to the poor state of the drainage system, the county department tasked with the responsibility of managing the system in Nairobi claim to have been unable to maintain the system due to lack of finances, inadequate staff and lack of a maintenance plan with which they can effectively follow (Nairobi, Urban Infrastructure Development Strategy 2014).

There may be several factors that have caused governments especially in developing countries to essentially ignore the proper management of the storm water drainage systems in their urban areas, some of these factors being:

- Lack of or low financial resources
- Weak institutional arrangements that fail to properly designate responsibility and offer support
- Poor technical proficiency and low number of staff needed for operation and maintenance activities
- Poor use of technical instruments such as the Operation and Maintenance plans

(International Commission on Irrigation and Drainage 1998, Douglas, Alam et al. 2008, Gouri, Srinivas 2015, Wachira 2016, Nairobi, Urban Infrastructure Development Strategy 2014)

## **1.2 Problem Statement**

The increase of localized urban flooding events and their related disasters in Nairobi, the capital city of Kenya, has caused widespread attention and alarm over the recent years. Flooding has recently been experienced in neighbourhoods and along road sections that the drainage of surface runoff during and after a regular rainfall event has always been efficient and the inundation of the area and damages due to flooding rarely happened (Juma 2016b, Teng'o 2015). The city is considered to be rapidly growing, and is centrally located within the country

and strategically located between neighbouring towns and cities of the entire East African region and “one of Africa’s most important cities and a major hub for finance, media technology and air travel” (Economist Intelligence Unit 2011). This popularity and location has caused a rapid growth in population, urbanization and economic activity putting urgency on urban governance activities to ensure protection and sustainable growth of the city. The city experiences a subtropical highland climate with two rainy seasons in a year; the first from March to May (MAM long rains) and the second from October to December (OND short rains) with an average of 925 millimetres annually. The rapid urbanization and population growth together with the amount of rainfall received annually automatically put pressure on the storm water drainage system particularly during rainfall events to efficiently drain away the surface runoff and the necessary maintenance it needs to function efficiently.

In 2015, during the season of the MAM long rains, the city’s drainage systems were overwhelmed on several separate occasions by the volume of the surface runoff and were unable to quickly drain roads and neighbourhoods of the excess runoff appropriately in many parts of the city. This resulted in the collapse of perimeter walls, impassable roads and traffic snarl ups and even the loss of life (Davies 2015). This was the same case during the 2016 MAM long rains that were reported. In an article in the local media by (Juma 2016b), great damage was reported in South C neighbourhood in Nairobi City after 6 hours of rainfall whereby the resultant surface runoff had no proper channel to flow as the drainage channels had been blocked by construction debris from the construction the Southern Bypass in the area and no maintenance or clearing was done in good time. According to (Teng'o 2015) the aged storm water drainage system in many parts of Nairobi City has barely undergone adequate and regular maintenance and rehabilitation since its construction in the 1920s to match both the unplanned and planned development within the city. This is a view that was reiterated by the city county’s Governor, Dr. Evans Kidero as he highlighted reasons for the increased flooding within the city and emphasized on poor maintenance of the storm water drainage system as one of the main causes (Muchiri 2016, Daily Nation 2016). Furthermore, a scientific study of urban flooding and storm drainage system in the city revealed that the state of the drainage system in many parts of the city was poorly maintained and was the main reason that the city has experienced increased flooding regardless of the amount of rainfall received (Wachira 2016). On the other hand, the Department of Roads, Public Works and Transport that is in charge of the management of the storm water drainage system of the city constructed by the public sector, through a report on Integrated Urban Development explained the factors that affected the operation and maintenance activities of the system thus leading to increased occurrence of localized urban floods were:

- Lack of adequate number and skilled staff responsible for inspection and maintenance of the drainage system resulting in slow implementation the operation and maintenance plans and activities
- Poor allocation of finances for O&M activities due to lack of commitment and political will
- Loss of technical data of the existing storm water drainage in 2014. (Nairobi, Urban Infrastructure Development Strategy 2014)

According to (International Commission on Irrigation and Drainage 1998) management, financial and personnel processes are not very flexible in the public sector because they must conform to central government administrative requirements. It is common practice that operation and maintenance budget is the first to receive budget cuts when other projects gain attention and support from the central government. However, in the long term, this decision may have severe impacts on the condition of the drainage system and lead to bigger flood disasters. Furthermore, the cost of repair of the system together with the subsequent cost of

damages caused may be higher than expected and can be accommodated for. In combining these factors with the above problems identified by the Department of Roads, Public Works and Transport of Nairobi County, this research will focus on two of these factors, namely financial and human resources required for proper operation and maintenance of the storm water drainage system in order to explain the extent to which they influence flood reduction efforts in Nairobi; particularly around the Lang'ata/Mbagathi road intersection and Madaraka Neighbourhood. The focus of this research will not eliminate the influence of factors such as urbanization and increase in rainfall in their role in the increased flooding events but rather it will highlight the importance of human and financial resources for proper O&M of storm water drains to reduce the impact and occurrence of flooding.

### **1.3 Research Objective**

This research intends to explain how operation and maintenance of storm water drainage systems may influence the reduction of localized urban flooding in Nairobi City through adequate provision of human and financial resources.

### **1.4 Research Questions**

#### **1.4.1 Main Research Question**

- To what extent does *human and financial resource* influence *operation and maintenance* of storm water drainage systems for the *reduction of localized urban floods* in Nairobi?

#### **1.4.2 Sub Research Questions**

- How does human resource influence operation and maintenance of the storm water drainage system?
- How does financial resource influence operation and maintenance of the storm water drainage system?
- What are the critical aspects of operation and maintenance of the storm drainage system and how do they influence localized flood reduction?
- What are the causes and trends in localized urban flooding in Madaraka Estate and Mbagathi/Lang'ata intersection and its relationship with the storm water drainage system?

### **1.5 Significance of the Study**

This research aims to assist the responsible department that is in charge of operation and maintenance of the storm water drainage system in Nairobi to better understand the effect of human resource and financial resource on operation and maintenance of the system. According to (Douglas, Alam et al. 2008, Wachira 2016, Gouri, Srinivas 2015) poor operation and maintenance of storm water drainage systems has resulted in increased flooding events around the world and inversely that improved maintenance can reduce the occurrence of localized urban flooding. In order to build on to this knowledge on the relationship between operation and maintenance of the storm drainage system, this research seeks to explain the factors that have influenced the poor operation and maintenance of the system in Nairobi and how this in turn has affected the occurrence of localized flood events, with particular focus on human and financial resource. This research aims to pave way into the improvement of operation and maintenance of the storm water drainage system which will improve the protection against flooding and mitigate the associated disasters. Finally, this research intends to add to the existing body of academic knowledge on the importance of operation and maintenance of storm water drainage systems and its relationship with localized urban flooding through the use of common concepts. The research intends to stir further academic studies into other factors that

influence operation and maintenance of storm water drainage systems and how these may aid the reduction of urban flooding events and their impacts across the world.

## **1.6 Scope and Limitations of the Study**

The scope of this study is to explain the extent to which human resource and financial resource influences operation and maintenance of storm water drainage systems in the reduction of localized urban floods in Nairobi, Kenya. This research shall focus on two locations within Nairobi that have faced damaging impacts of the localized urban floods recently, these are, Lang'ata/Mbagathi road intersection and Madaraka Estate. There are many other areas that have been affected but due to the short time period within which data is to be collected and analyzed for this research, the areas were narrowed down to two areas. Furthermore, as much as there are many other factors identified that may influence operation and maintenance of storm water drainage systems such as the institutional arrangements that designate responsibility and offer support and the availability and use of technical instruments such as O&M plans among others, this research will highlight particularly on human resource and financial resource due to limitations in time and budget of this particular study. Another limitation of this study is the influence of other factors such as urbanization rate and increased rainfall as factors that are causing the increase of flooding events in the city. The angle of this research will not eliminate the importance of such factors but rather it will highlight on the importance of adequate human and financial resources in operation and maintenance of storm water drainage systems for flood reduction. It is for this reason that this study will look into the opinions and expert knowledge of the respondents on the influence of human resource and finances on operation and maintenance of the storm water drainage system and subsequently on the reduction of localized urban floods as well as objective indicators such as number of staff required and the amount of budget required.

## Chapter 2: Literature Review / Theory

Urban flooding is a phenomenon whose occurrence and impact is steadily increasing across the world. This type of flooding has led to costly damage of property and loss of lives and poses a challenge to urban managers due to its seeming unpredictability (Jha, Bloch et al. 2012, Tucci 2007). The previous chapter stated in the problem statement the challenges faced by the Department of Roads, Public Works and Transport with respect to human and financial resources among the factors affecting operation and maintenance of the storm water drainage system in the reduction of localized urban floods in Nairobi City. The purpose of this chapter is to give a theoretical review of the variables identified in the main research question, i.e. human resource, financial resource, operation and maintenance and reduction of localized urban floods. This shall be done by looking at the wider scope of concepts of asset management and urban flooding to fully explain each variable and its associated indicators of measurement. Finally, the identified concepts, variables and indicators shall be summarized in a diagrammatic representation of the relationship they have with each other.

### 2.1 Introduction to the Concepts of the Study

As mentioned above, the first concept identified for this research is urban flooding. For the purpose of this study, urban flooding is defined as *the inundation of a built up urban area that happens when surface water runoff from rainfall overwhelms the capacity of the existing storm water drainage of the area it serves* (Jha, Bloch et al. 2012, Verworn 2002).

The second concept to be used for this research is asset management. Asset management refers to the “*systematic and coordinated activities and practices through which an organisation optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan*” (Esmaili 2012). The successful management of physical assets is dependent on other associated non-structural assets such as planning, information, financial, and human assets, among others.

### 2.2 Urban Flooding

Flooding is the most common of all natural disasters and over the last twenty years the number of flood events that have been reported worldwide has increased significantly (Jha, Bloch et al. 2012). Floods are known to cause widespread devastation, huge economic damages and the loss of life. Flooding is a natural phenomenon that occurs in many parts of the world, both populated and non-populated areas, with the description and categorizations of flood events varying and based on a combination of sources of flood water, associated causes and impacts of the event. Flooding may be classified according to its associated causes such as urban flooding, river flooding, coastal flooding and groundwater flooding (Falkirk Council 2009, Jha, Bloch et al. 2012).

Against the background of increased urbanization and climate change, this study focuses on one particular type of flooding, that is, urban flooding. This type of flooding poses a serious challenge to the successful development of urban areas and particularly the lives of residents of rapidly growing towns and cities of developing countries. According to (Jha, Bloch et al. 2012) referring to the International Disaster Database, from the measurement of recorded flood events, the current and project flood events and impacts caused give seriousness to the need to make the management of flooding in urban settlements a high priority in both the policy and political agendas worldwide. This can be done through understanding the causes and effects of flooding and the measures that can be undertaken to minimize the impacts and occurrences of flooding. Flooding that occurs in urban areas is one of the major hazards that affect cities

around the world thus causing huge economic losses and negative social and environmental impacts due to the high concentration of people and property within a relatively small area (Ochoa-Rodriguez 2017, Jha, Bloch et al. 2012). Hence, in essence, flooding is understood to be associated with damage.

Urban areas contain most of the social and economic attributes and asset bases of any national population so when flooding occurs in urban areas causing damage and disruption in the city, the effect is felt beyond the scope of the actual floodwaters and often carries more serious consequences for societies (Diakakis, Deligiannakis et al. 2017, Jha, Bloch et al. 2012). Urban areas can be flooded by rivers, coastal floods, pluvial floods, ground water floods and floods through artificial system failures (Jha, Bloch et al. 2012). The term “urban flooding” has been defined varyingly by different authors and researchers. Urban flooding has been used to refer, in general, to the inundation of the built up urban area with no particular reference to the cause of flooding in itself. For example, (Jha, Bloch et al. 2012) refer to it as a general term for flooding that happens in cities that is a result of overflow of rivers, ocean water and storm water, while (Falkirk Council 2009) specify the term “urban flooding” to refer to the particular form of flooding in an urban area that is as a result of overflow of storm water due to the sensitive and limited capacity of the drainage system of an area. On the other hand, (Verworn 2002) defines urban flooding as a “condition where waste water and/or surface water escapes from and cannot enter a drain or sewer system and either remains on the surface or enters buildings”.

Drawing from the common aspects of the definitions of the concept of urban flooding are the location it happens, that is the urban areas, and the fact that it is the inundation of the area by surface water. For the purposes of this research, it is necessary to specify the source of the surface water causing the inundation as well as the expected conveyance channel. Hence, urban flooding may be referred to as the inundation of a built up urban area that happens when surface water runoff from rainfall overwhelms the capacity of the existing storm water drainage of the area it serves. This surface water runoff that is expected to be carried away from the surfaces of an area by the storm water drainage system is also referred to as storm water. It is the rain or any other form of precipitation that falls on built up and usually highly impermeable area and flows in liquid state. In this regard, we shall focus on the localized urban flooding for this research.

### **2.2.1 Localized Urban Flooding**

Localization of a flood occurrence happens when the inundation of surface water is contained to a small area or neighbourhood. Localized urban flooding is very typical as the failure of the storm water drainage system in conveying the surface runoff away mostly occurs in the area where the state of the drainage system is poor with minimal impact being transferred downstream or upstream of the location immediately. Urban flooding due to the failure of the drainage system is usually referred to as localized because it happens quickly, with very little warning in areas that are not as obviously prone to flooding thus making it difficult to predict, manage and in some cases, mitigate (Ochoa-Rodriguez 2017).

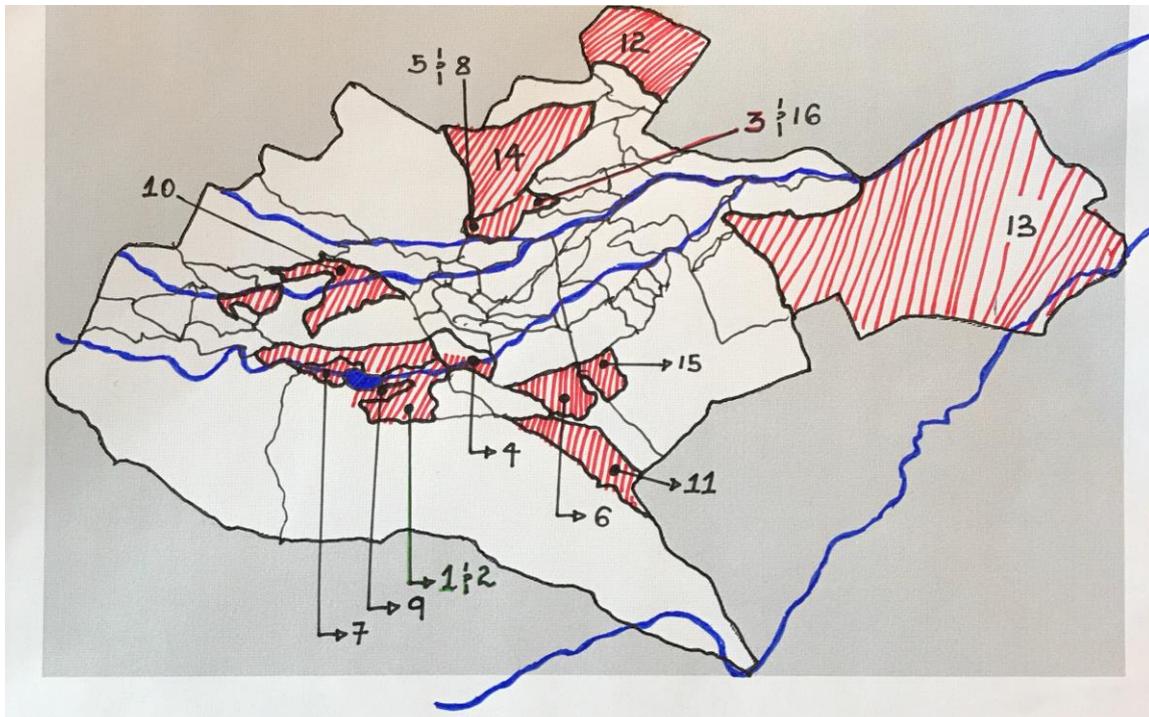
In Nairobi, in recent years, the occurrence of localized urban floods has greatly increased affecting roads and neighbourhoods resulting in massive traffic snarl ups, damage of property and buildings and even loss of lives. This has been indicated through the increase in reports on flood damage and occurrence throughout the city as recorded through local media and the National Disaster Management Unit. In 2015 during the MAM rains, many parts of the city experienced an increase in flooding occurrences as the storm water drainage system in several areas was overwhelmed by the resultant surface water runoff. This resulted in major traffic snarl ups, collapse of walls and building and damage to property and loss of life (Davies 2015).

In 2016, the same occurred with many more areas that had not experienced flood damage before being inundated when the drainage system caved under the amount of rainfall received (Juma 2016a). According to media reports by (Nzioki 2016) and confirmed by the (former) County Governor Dr. Evans Kidero, the most vulnerable areas at risk of localized urban flooding in Nairobi City are, but not limited to:

1. Madaraka Estate
2. Mbagathi/Lang'ata intersection
3. Thome Estate
4. Bunyala Road
5. Loresho Bypass
6. Mukuru slum
7. Kibera slum
8. Muthangari neighbourhood
9. Highrise Estate
10. Kileleshwa/Ring Road interchange
11. South C Estate
12. Kahawa West
13. Ruai
14. Roysambu
15. Utawala
16. Garden Estate

These locations can be identified in Figure 1 that delineates the zoning of Nairobi County as well the major rivers that traverse within the county.

**Figure 1: Map of Nairobi County indicating flood-prone areas**



**Source: Adapted by the Author**

Some of the locations are adjacent to the flood plain of the rivers, while others are not. The locations are distributed across the City. Out of these aforementioned areas, this study shall

focus on two locations, that is, Madaraka Estate and the Mbagathi/Lang'ata intersection due to limitations in scope and time.

### **2.2.2 Causes of Localized Urban Flooding**

In order to effectively understand and deal with urban flooding, it is necessary to understand the factors that lead to the increase in surface runoff, inundation and overall flooding. As much as flooding may be termed as a natural phenomenon, human activities have exacerbated and in many cases failed to mitigate its effect especially in urban areas where a large number of the human population resides and depends on municipal services and infrastructure to protect against flood damage. Urban flooding may be caused and exacerbated by a variety of factors, namely rapid urbanization, increase in rainfall and the limited, ageing and/or poorly maintained storm water drainage system (Jha, Bloch et al. 2012, Wachira 2016, Falkirk Council 2009, Freni, Oliver 2005, Douglas, Alam et al. 2008).

#### *a) Excessive Rainfall*

Flooding, as a natural phenomenon, is as a direct result of heavy rainfall. The design of traditional urban storm drainage systems considered and used extreme rainfall events in the design of the drainage channel capacity. With the onset of climate change, however, there has been a notable and unprecedented increase in rainfall in many parts of the world and in many cases the resultant amount of rainfall exceeds the design capacity of the storm water drainage channel causing flooding to occur (Falkirk Council 2009). The changes in meteorological patterns which are associated with a warmer climate are potentially the drivers of increased flooding experienced in many parts of the world (Global Facility for Disaster Reduction and Recovery 2017). For example, in Europe, climate change is being experienced through the onset of warmer and wetter winters leading to more frequent rain and less frequent snow. This increases the potential of flooding in these areas. However, according to Jha, Abhas K. Bloch, Robin Lamond, Jessica, (2012) as much as climate change can increase the occurrence of increased precipitation and flooding events, majority of individual extreme weather events cannot be attributed to climate change especially in parts of the world that have not experienced this phenomenon as much as others. However, it is a factor to be considered for a longer time-scale of flood management.

#### *b) Urbanization*

Urbanization refers to the gradual increase of the number of people living in urban areas and the ways in which the society adapts to this change. Urbanization is the defining feature of demographic growth and has been implicated in the compounding of urban flooding (Jha, Bloch et al. 2012). This is because the adaptation that is associated with demographic growth is development and increase of built up area. This increase in built up area increases the total impermeable surface in urban areas resulting in increased overland flow during rainfall events. This directly puts pressure on the urban storm water drainage system and in instances when the flow of surface water exceeds the capacity of the drainage system, flooding may occur (Falkirk Council 2009, Freni, Oliver 2005). For example, in London, increased flooding events have been linked to impermeable surface of both the built up area and the London clay which leads to more rainfall running off the surface and not being absorbed into the ground. This is further exacerbated by the high population in London putting even greater pressure on the existing drainage system (Ochoa-Rodriguez 2017). Further to this, urbanization and the growth of the population has often been associated with increased generation of waste and urban debris, which if poorly handled finds its way in to open storm water drainage channels causing further blockage. In developing countries, poorly planned and managed urban growth also contributes to the increasing flood hazard due to unsuitable land use change. As cities grow outwards to

accommodate population increase, large-scale urban expansion often occurs in the form of unplanned development in floodplains, as well as in other flood-prone areas (Jha, Bloch et al. 2012).

*c) State of the storm water drainage system (Technical Condition of the System)*

During the design stages it is necessary to take into account the amount of expected surface water runoff after a rainfall event in order to adequately obtain the channel capacity that will accommodate the expected flows. This may be done by taking into consideration projected rainfall amounts and projected urbanization rates. This puts pressure on engineers to forecast possible runoff volumes and even with these apparent hurdles in the estimation of the volume of surface water runoff, it is not a very hard task to estimate the carrying capacity of the urban conduits based on estimation of peak flow. However it is not as easy to estimate the degree to which the storm water drainage channels will be obstructed overtime with respect to the presence of solid material and thus there is even greater effort needed to ensure proper operation and maintenance of the system to reduce obstruction of the drains (Tucci 2007). Thus, even after successful design and construction of an adequate storm water drainage system where the expected volume of surface runoff was well taken care of, the operation and maintenance of the system is a necessary aspect in the management of the drainage system. Maintenance of public assets, being the responsibility of local governments in many cases, would require fiscal discipline and reliance on local resources to realize this (Bahl, Linn 1992). Operation and maintenance of the storm drains would involve cleaning of the conduits, repair of the channels and the general preservation of the drainage system to ensure that it properly conveys as much surface runoff as possible away from the surface of an area in order to reduce the likelihood of localized urban flooding. Poor operation and maintenance of storm water drainage system is one of the factors that have been linked to the increasing occurrence of localized urban floods during rainy seasons. It results in the reduced capability of the constructed drainage channel to contain and direct surface run off away. The surface runoff eventually curves its own path and due to the limited routes in dense and developed urban spaces, the water floods roads and buildings causing significant damage to property, traffic congestion and even loss of life (Douglas, Alam et al. 2008, Freni, Oliver 2005, Parkinson 2003, Paola, Galdiero et al. 2015, Torgersen, Bjerkholt et al. 2014, Wachira 2016).

### **2.2.3 Reduction of Localized Urban Floods and their Impacts**

The agglomeration of people and assets that is a characteristic of urban areas is beneficial for the cumulative socio-economic success of a given society but at the same time has an increase in potential damages and losses in the event of disasters and calamities such as urban floods. The noted increase of flooding events and impacts across the world gives high urgency to the need to make reduction of urban floods a high priority in both the political and policy agendas. Additionally, in managing the risk of floods today, and in planning for the future, urban managers must find a balance between the strategies that minimize flood impacts through improved urban management and maintenance of existing flood mitigation infrastructure, and the far-sighted strategies which predict and protect the society against future flood hazard by building new flood mitigation infrastructure thus radically reshaping the urban environment (Jha, Bloch et al. 2012, Ochoa-Rodriguez 2017). The reduction of flood occurrence and impacts may be done in two-fold:

- Structural measures – these measures include hard-engineered structures like flood defences and drainage channels as well as more natural and sustainable complementary or alternative measures such as wetlands and natural buffers. They aim to reduce flood risk by controlling the flow of water both outside and within urban settlements (Jha, Bloch et al. 2012).

- Non-structural measures – these measures include early warning systems, community awareness campaigns and waste management programs. Their purpose is to keep people safe from flooding through better planning and management of urban development (Jha, Bloch et al. 2012).

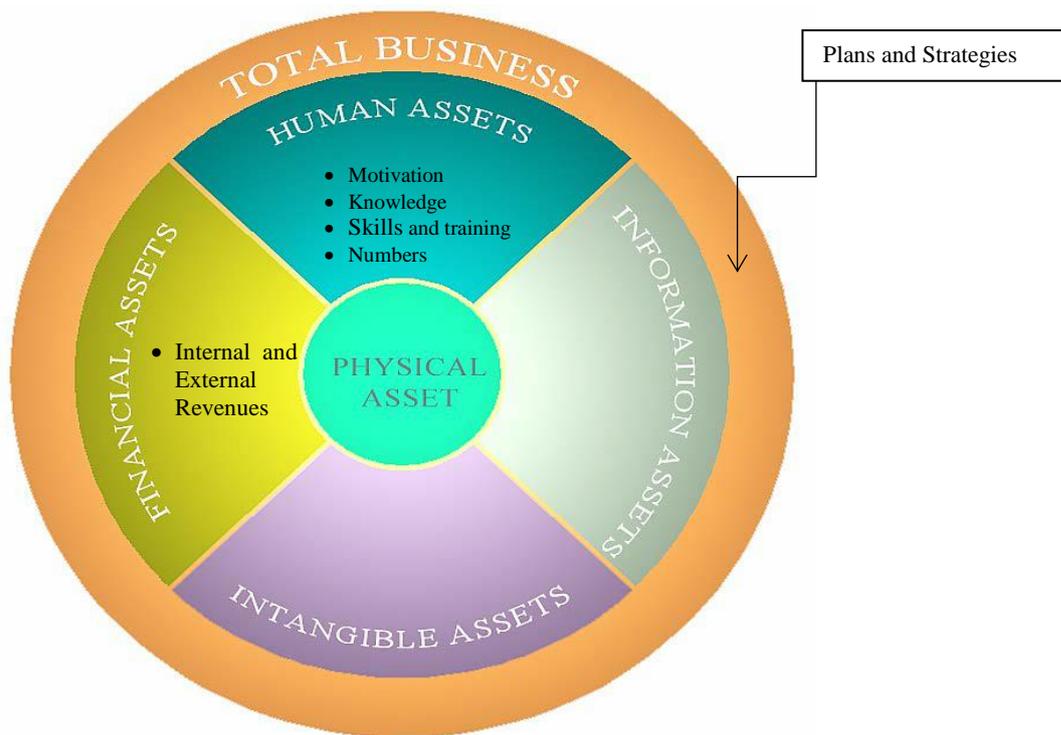
Both of these measures best work complimentary to one another. Structural measures may be deemed as long-term measures that require large investments. However, there are also urban management measures that can be implemented more quickly such as better operation and maintenance of flood protection infrastructure like storm water drainage systems and improved drainage and solid waste management. These measures enable occupation of flood risk areas while reducing the expected impacts from flooding (Jha, Bloch et al. 2012). In Nairobi, urban flooding events have increased over the last few years. Flooding has been reported as localized in certain neighbourhoods and along select road sections, many of which are directly related to poorly maintained storm water drainage system (Juma 2016a, Muchiri 2016, Mbugua 2016, Teng'o 2015, Daily Nation 2016).

### 2.3 Asset Management

Municipal services and infrastructure such as drainage systems that serve a large number of people must be managed appropriately. Municipal infrastructure managers are custodians of a service that ensures the quality of life for their communities. The term Municipal Infrastructure refers to civil assets under the control and responsibility of municipalities. These assets include, but are not limited to: storm water, drinking water, waste and sewer systems, energy networks, sewage treatment plants, transportation networks (roads, bridges and transit systems), and parks (Vanier, Rahman 2004). Though the principals of asset management may be applicable to all of the above, the scope of this thesis, as already established, is limited to storm water drainage systems. Storm water drainage infrastructure consists of a large number of extensive assets usually dispersed over very large areas (Malano, Chien et al. 1999). With the increase in urbanization and population in urban areas, there is great importance in managing storm water in order to minimize risk and consequences of flooding. Management may be defined as the art of achieving goals through financial, human and technical resources (Esmaili 2012). The management process of municipal infrastructure such as storm water drainage systems is encompassed within the concept of asset management.

(The Institute of Asset Management 2008) defines asset management as “*the systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their lifecycles for the purpose of achieving its organizational strategic plan*”. It involves the strategic management of equipment inventory including planning, assessment, procurement, utilization review, maintenance, repair and disposal of equipment to reduce costs and improve efficiency. It refers to the combination of management, financial, economic, and engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost effective manner (Lindley 1992, Malano, Chien et al. 1999, Narrandera Shire Council 2012). The management of assets in a service organization can be understood using figure 2 which is adapted from the Institute of Asset Management’s PAS 55-1:2008 that provides an outline of the requirements for good asset management. According to this framework, the successful management of physical assets is dependent on other non-structural assets such as human, financial, information, plans and so on.

**Figure 2: Asset Management Framework**



**Source:** Adapted by the Author from (The Institute of Asset Management 2008, Hastings 2015)

An asset management plan involves specifying activities, resources, responsibilities and timescales required to achieve specific objectives (Hastings 2015). The success of asset management is measured through various factors that include minimization of risk, understanding of the network and the customers' needs, ensuring financial sustainability and making accurate forecasts for reliable service delivery (Esmaili 2012). The effectiveness and efficiency of these success factors in asset management depends on internal factors such as the quality of staff, adequacy of equipment and finances, the institutional arrangements and the timely flow of management information as illustrated in Figure 2.

The general functions of asset management according to (Malano, Chien et al. 1999) include:

- Asset planning and creation strategies – new assets are created, constructed or acquired for development of new systems or augmentation of existing ones.
- Operation and maintenance activities – this is the manipulation of assets with the purpose of performing a function and the subsequent care of the asset to extend the asset life and enhance its performance.
- Performance monitoring – this is the detailed knowledge of the asset base and performance that forms the core of the development and implementation of asset management
- Accounting and economics – this is the identification and calculation of infrastructure costs throughout the lifecycle of the asset based on the assets intended function and level of service
- Audit renewal and analysis – this is a process that ensures sustainability of function and level of service of assets by considering options that maintain or increase performance.

Clear institutional arrangements make it clear which unit or organization is responsible for different arms of management of an asset or system, one of which is the operation and maintenance. Through these arrangements, responsibilities, sources of funding, interactions

with related organizations, staff capacity and political interference and the entire management framework are addressed. Furthermore, financial and personnel procurement processes are not very flexible in the public sector as they must conform to central government administrative requirements (International Commission on Irrigation and Drainage 1998). In Nairobi, as mentioned earlier, The Department of Roads, Public Works and Transport is the department responsible for the management of the storm water drainage system of the city constructed by the public sector. The Department of Roads, Public Works and Transport is an office of the City County Government and must also conform to central government procedures and standards.

According to (Hastings 2015), a lack of asset management focus can lead to problems from poor communication between operations and maintenance on the one hand and senior management support on the other. This applies to both the understanding of physical situations and to the financial steps needed to address an actual or potential problem. Good asset management on the other hand provides benefits of attaining service delivery and regulatory targets of human and financial resource utilization, environmental protection and asset life-cycle preservation (Hastings 2015).

### **2.3.1 Operation and Maintenance of Storm Water Drainage Systems**

Storm water refers to water that comes from rainfall or snowmelt events that flows over land and impervious surfaces and does not immediately soak into the ground (USEPA 2016). The volume of this storm water increases with the amount of precipitation that falls, coupled with the increase in impervious surfaces. Storm water volumes must be properly managed and channelled in order to avoid flooding and subsequent damages. From the 19<sup>th</sup> century, storm water has been managed through the construction of ‘modern’ storm water drainage systems (Verworn 2002). Storm water drainage systems are a network of canalized drains, ditches and storm sewers that drain surface water run-off from an area. Traditionally, storm water drainage systems were designed with particular attention to quantity of surface run off it is expected to carry away as fast as possible to prevent local flooding (Falkirk Council 2009, Verworn 2002).

In order to adequately channel and contain storm water, the condition of the storm water drainage system must be maintained through activities that ensure service delivery and extended asset life. According to (Backmann, MacCleery 2006) , operation is the process of using physical works to ensure the delivery of a service while maintenance refers to the care of these physical works through cleaning, repair, replacement and general preservation of the asset and both activities together form part of the technical aspects that are necessary to deliver a service and extend asset life. The operation and maintenance of an asset is one of the management practices that are necessary for proper service delivery and life cycle management. The operation and maintenance of an asset such as the storm water drainage system, is dependent on a pre-determined strategy that depends on the age of the asset, the condition of the asset and the nature of works required, the sources and availability of funds required and the resources available and needed to carry out the operation and maintenance activities (Malano, Chien et al. 1999).

When drainage systems are not properly maintained throughout their operational lifetime, the capacity and proper functioning of the channels in the network is reduced and this leads to increased failure to effectively drain an area of surface water runoff during rainfall events. While the single blockage of a small section of the storm water drainage system through siltation would be regarded as low risk of entire system failure and eventual flooding an accumulation of several low risks may lead to a systemic failure which might become catastrophic (Department of Public Works Republic of South Africa 2015). The operation and maintenance planning should list such potential critical systemic failures as separate

components and evaluate the risk of such events separately. The condition of the system is reliant on its age and the measures that have been taken to preserve and prolong its life and adequate functioning.

An operation and maintenance plan gives an indication that a facility is in continued compliance with applicable regulations and permit conditions. It also specifies the key system operating parameters and limits, the maintenance procedures and schedules, as well as a documentation of methods necessary to demonstrate proper operation and maintenance of a system. The purpose of an operation and maintenance plan is to determine the impact of O&M activities on service delivery, on the people the system serves and on the finances and design life of the asset in order to prioritize and determine the maintenance approach, cost and scheduling. It deals with issues such as human resources (manpower), finance and development (International Commission on Irrigation and Drainage 1998, Department of Public Works Republic of South Africa 2015). In order to develop an effective O&M plan it is beneficial to have a good understanding of the asset failure modes, the effects of asset failure, the criticality of the asset and up-to-date maintenance records. Furthermore, the Plan should be optimized in terms of resource usage, scheduling, time used in maintenance activities and the availability of O&M manuals to the staff (Esmaili 2012).

The key elements of an O&M plan and the associated O&M activities as adapted from (Esmaili 2012, Sullivan, Pugh et al. 2010) are:

1. Asset inventory

This activity identifies and keeps a record of all fixed and mobile assets available to an organization. Fixed assets refer to those assets that are purchased or constructed for long-term use such as land, equipment and infrastructure. Mobile assets refer to the assets and resources used in the management of the fixed assets such as human resource and financial resources. This helps in identifying the maintenance needs of the organization as well as forming a baseline for data management. This activity may be regarded as a continuous process of record keeping and updating of database that contains the status of each asset and identification of gaps and improvement requirements.

2. Maintenance standards

The two types of standards used are quality standards and quantity standards. Quality standards refer to the tasks and frequency of carrying out the tasks and it defines the quality of maintenance service that will be performed. Quantity standards refer to the resources to implement the tasks such as amount of labour, materials, finances and equipment. This can be measured through use of international and national pre-set standards and the attainment of these pre-set standards.

3. Budget preparation

The operation and maintenance budget is prepared using the results of the inventory activity and the maintenance standard selected. Where gaps and needs were identified through inventorying, provision is made to meet these needs. Furthermore, the maintenance standards used may specify frequency and resources necessary to attain the set standard level. The operation and maintenance budget generally includes the costs for regular maintenance, rehabilitation tasks and capital improvements and defines sources of the required funding.

4. Maintenance strategies (scheduling)

The English Dictionary defines maintenance as “the work of keeping something in proper condition; upkeep”, thus implying that maintenance should be actions taken periodically to prevent a system component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order . The need for maintenance is based on actual or impending failure. There are three main types of maintenance strategies that are based on time and failure of the system. These are reactive maintenance, preventive maintenance and *predictive* maintenance (or reliability centred maintenance). *Reactive maintenance* is whereby the system or equipment is operated with no maintenance up until the point of failure and it is only upon failure that maintenance is done to restore it to a state of adequate performance. This may also be referred to corrective maintenance. *Preventative maintenance* is the strategy of maintaining the system at pre-determined intervals, or corresponding to prescribed criteria, and intended to detect, preclude or mitigate the probability of failure or the performance deterioration of an asset. Preventative maintenance is planned or carried out on opportunity. *Predictive maintenance* refers to maintenance that is based on the condition of the asset or system and it is not based on a pre-set schedule (Sullivan, Pugh et al. 2010). The type of strategy employed is governed and influenced by factors such as the standards in place and the finances readily available for the maintenance activity.

## 5. Tools of implementation

This refers to the work order system, record keeping, and management of materials, monitoring, evaluating and reporting. Work orders include parameters such as asset location, required work, specifications, special tools required, work completed, relevant dates, man-hours and crew composition. Many of these tools of implementation may be computerized such as record keeping and work order systems. However, the level of computerization depends on the financial flexibility of the organization as well as the ability of the staff to be proficient with the computerized systems.

The above five elements of the operation and maintenance of assets such as the storm water drainage system are dependent on various factors in order for the objectives of draining of surface water runoff and flood control to be achieved. A good operation and maintenance plan for a storm water drainage system operating at its peak efficiency ensures safety of residents, reduces risk of flooding, ensures that the design life expectancy of the asset is achieved and in some cases exceeded and last but not least it is proactive and corrects situations before they become problems (Sullivan, Pugh et al. 2010). According to (International Commission on Irrigation and Drainage 1998, Torgersen, Bjerkholt et al. 2014) as well as the focus study area of Nairobi (Nairobi, Urban Infrastructure Development Strategy 2014) human and financial resources are key factors that influence the operation and maintenance activities and the implementation of all the above elements of the operation and maintenance plan of a storm water drainage system. This is in line with (The Institute of Asset Management 2008, Hastings 2015) asset management framework adapted for this study in Figure 2 earlier.

Below we shall focus on human and financial resources within the scope of this study.

### 2.3.2 Human Resource

Human resource refers to the “the pool of human capital under the firm’s control in a direct employment relationship” with the required knowledge, skill and ability to carry out the required tasks (Wright, McMahan et al. 1994). Human resourcing is the process of enabling an organisation to have the right people, doing the right jobs at the right time (Itika 2011). Thus, for duties such as operation and maintenance of the storm water drainage system of a city, human resourcing would involve employing staff with a technical background related in some way to the task as well as knowing which aspects of O&M would require additional staffing

support such as manual field work and extensive drain rehabilitation. According to (International Commission on Irrigation and Drainage 1998) a human resource management plan is necessary within any operation and maintenance plan as it categorizes the levels of human resource needed to carry out specific tasks, it keeps track of new skills required, or existing skills no longer required to address future activities as well as training needs analysis based on maintenance programs, such as regular or routine ongoing training programs, e.g., induction, skills training, management training, special programs to meet specific needs among others. The effectiveness of planning is only as good as the knowledge it is based on, therefore it is essential that maintenance staff and operators are adequately trained and equipped to carry out their duties. Operation and maintenance staff in essence, are responsible for the safety of those that rely on the proper functioning of the storm water drainage system and thus must be properly trained at their job and supported to execute their duties (Sullivan, Pugh et al. 2010). According to (Nairobi, Urban Infrastructure Development Strategy 2014), in the case of the Department of Roads, Public Works and Transport under the County Government of Nairobi, that is responsible for the management of the storm water drainage system of the City, the human resource required to effectively carry out these duties has reportedly been under capacity. This is both in terms of numbers as well as skill-development, which has crippled the Department with respect to carrying out of all responsibilities under its docket. Referring to the Resource Dependency Theory, (Itika 2011, Emerson 1962) agree that human resource is essential to the power and success of any organization in the effective execution of its duties and thus should be acquired (hired) effectively, utilized, developed and retained. Highlighting these key factors from hiring of staff, utilization of their various skills, developing their skills and retaining them through effective motivation and providing a productive work environment are seen as the effective ways of managing human resource and ensuring success in the duties they are expected to perform. These factors may be adapted from (Itika 2011) into the following indicators of human resourcing:

- Number and quality of employees – the number of staff and the quality of the staff in terms of their education and skill is guided by the various job categories of the organization. In operation and maintenance of the storm water drainage system, there are various categories ranging from record keeping, inventory and reporting, work planning, maintenance field work and rehabilitation of the system among others. Each category may vary in the number and quality of staff that may handle the job. Usually field work operations such as drain clearing, require a larger number of staff to ensure the work is completed on time and may often make use of outsourced labour with a low skill level to supplement the employed staff with a higher skill level.
- Personnel training and development – the performance of an organization in its duties depends largely on the competence of its workforce. This requires training and development of the staff not only for present jobs and duties but also for the future of the organization. (Dessler 2012) defines training as techniques that give employees the skills they need to perform their jobs. The head of the personnel department must identify training and development gaps and develop effective strategies and programmes for training and developing staff. In most large organisations and more so in government ministries, there are departments and officers responsible for ensuring that personnel training and development functions are carried out effectively.
- Performance Appraisal – the performance of individuals and teams must be measured through a system of techniques and tools that ensure performance targets are set agreed upon and measured and methods put in place to address any performance gaps. This requires a value judgement about the employees that is void of bias.
- Staff incentives and motivation techniques - employees need different types of compensations or rewards for the effort they expend on the job. It is the duty of the

human resource department through the responsible officers to evaluate different types and levels of jobs in order to develop appropriate compensations or rewards in terms of pay and other incentive packages.

In developing countries, duties such as operation and maintenance of the storm water drainage system are often not prioritized and hence the required human resource for these duties is not managed effectively (Douglas, Alam et al. 2008).

### **2.3.3 Financial Resource**

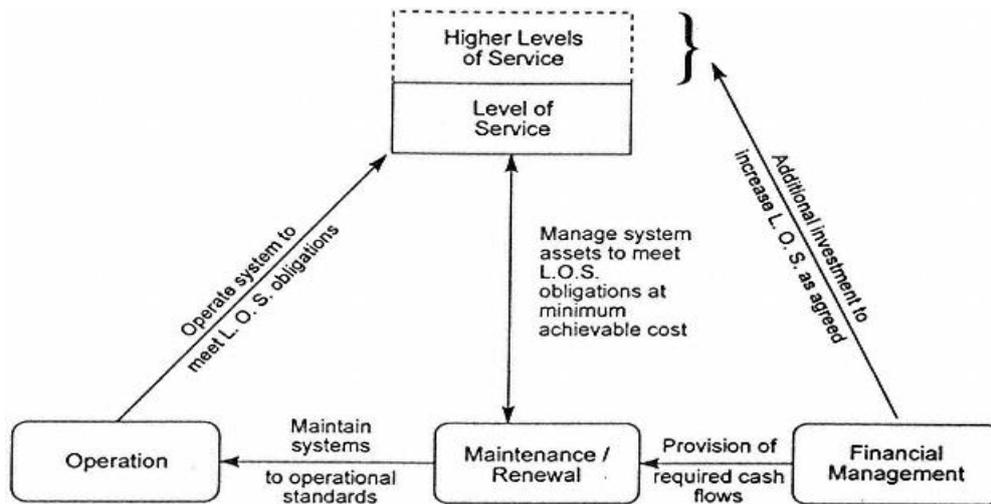
Financial resource is the money available to an organization “in form of cash, liquid securities and credit lines” needed to operate efficiently and carry out its required tasks (Business Dictionary 2017). Under-provision of cash-flow can lead to the shortening of asset life due to cut backs in maintenance activities. Additionally, in the longer term the system owners will be required to incur substantial financial commitments for restoration of the assets earlier than necessary (International Commission on Irrigation and Drainage 1998, Bahl, Linn 1992). Often Municipal or County Governments defer the expenditures for maintenance of the system by giving it lower priority over other county responsibilities. By deferring Operating expenditures such as maintenance the condition of the asset is likely to deteriorate compared to that of infrastructure that is properly maintained, and the longer the delay, the greater the cost to restore the condition of the asset to acceptable operating levels. On the other hand, if there is too much focus on maintenance, then there may be insufficient allocation to capital expenditures such as improving or expanding the network, which reduces the capacity to meet demand and population growths (Stiff, Smetanin et al. 2011, Bahl, Linn 1992). Accordingly, municipalities must carefully trade off whether to allocate investments to increase the network size, or to maintain the existing network.

Maintenance of public assets, such as storm water drainage systems, under the mandate of local governments, requires fiscal responsibility and reliance on local resources to achieve this successfully (Bahl, Linn 1992). In the case of storm water drainage systems in Nairobi, where operation and maintenance cost of the system is funded by the county government budget, the relationship between the cost of the service and the capacity or willingness to pay that cost is unclear. This is because there are no fees received by The Department of Roads, Public Works and Transport for the management of the storm water drainage system. According to (NCCG - Finance & Economic Planning 2016) the financial resource to the County and its departments is dependent on NCCG revenue performance from both internal and external sources as well as allocation from the Central government through the Commission on Revenue Allocation (CRA). Once revenue is received, it is then dispensed to public service dockets based on their contribution to the revenue percentage and the perceived level of importance of the service. Based on this, the funds received by the Department of Roads, Public Works and Transport are neither always constant nor adequate to cover all duties under its mandate, particularly operation and maintenance of the storm water drainage system that does not generate its own fees nor attract the necessary prioritization. This results in low commitment of the county government in allocating finances regularly to operation and maintenance activities.

According to (Esmaili 2012) the political environment is an external constraint that can impact the organization from the strategic to operational levels. The most obvious political impacts can be seen in public organizations and offices in the finances allocated to and/or cut from the infrastructure based on central government decisions. However, a commercial approach to management of storm water drainage system assets and service delivery, in which giving value for money is important in order to visualize the importance of operation and maintenance (International Commission on Irrigation and Drainage 1998, Department of Public Works Republic of South Africa 2015). This approach may seek to highlight on the imminent damages to property, interruption of traffic and economic activities and the loss of life as a consequence

to poor operation and maintenance of the storm water drainage system and thus put emphasis on the need for proper budget allocation to prevent these losses. Storm water drainage system managers must identify the future cash flow requirements to ensure the sustainability of the system, and quantify the effects of under-provision of these cash flows such as shortening of asset life and inability of the system to safely channel away surface water runoff thus resulting in flooding. On the other hand, increased cash flow (additional investments) and effective financial management increases the level of service and the maintenance standards attained, as can be seen in figure 3 adapted from (International Commission on Irrigation and Drainage 1998).

Figure 3: Effect of Financial Management on O&M and Level of service



Source: (International Commission on Irrigation and Drainage 1998)

A financial management plan is necessary to express the organizations financial requirements for its duties, to indicate sources of funds and cost recovery policies and targets as well as to indicate strategies for dealing with shortfalls and emergencies, and generally for promoting financial efficiency. It may be appropriate to include in the budget, a special reserve fund to be accessed to repair or maintain the system in the event of unforeseen needs. This may include damage caused by major disasters, such as floods, earthquakes or structural failures (International Commission on Irrigation and Drainage 1998).

Furthermore, financial resources are utilized in support of other resources required in the operation and maintenance of the storm water drainage system such as in human resourcing. The number of staff hired is reliant on the available financial resource to compensate them for the work they do. Additionally, factors such as staff training and development programs and reward systems, often rely on the financial power of the organization to effectively carry out these processes.

## 2.4 How Human and Financial Resources Influence O&M of Storm Drains for the Reduction of Localized Urban Floods

Resources are necessary for activities such as operation and maintenance to be carried out effectively (International Commission on Irrigation and Drainage 1998). As discussed above, such vital resources include human and financial resources. Effective human resource utilisation is critical for the good of the organisation and for the good of individual employees and the teams within which they work. Under-utilised staff is a lost resource to the organisation in terms of opportunity cost because even if the employee has enough work to earn a salary, the added marginal labour value will not be realised. The under-utilized employee will also not have the advantage of realizing and using his/her full potential and get extra rewards. On the

other hand, over utilisation of staff will lead to stress, fatigue, and other health problems or even the risk of loss of life. It is the duty of the human resource manager to put in place job strategies, objectives and targets, which are challenging enough, but not overstretching the staff ability.

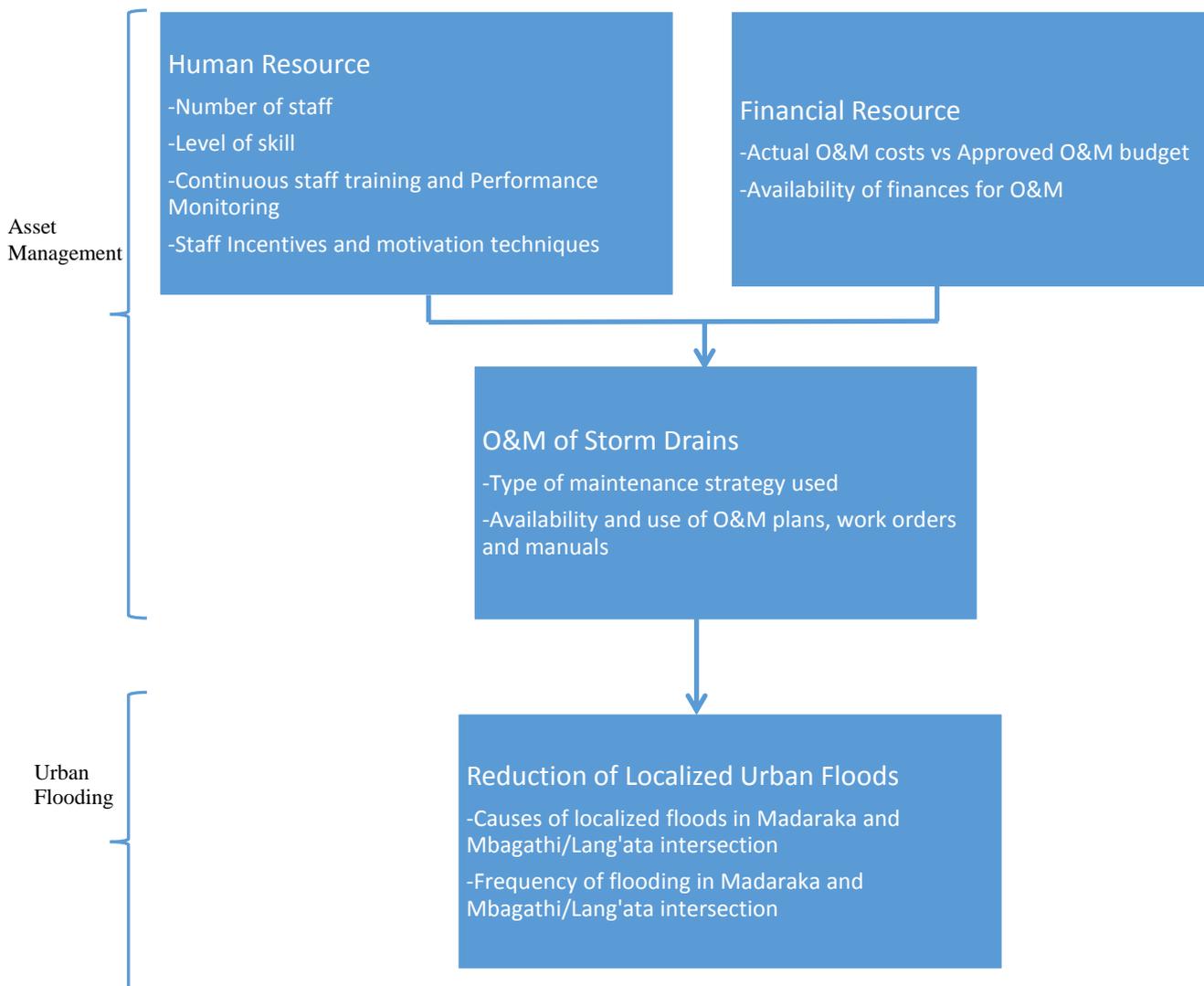
For flood reduction strategies through operation and maintenance of the storm water drainage system, there are a number of ways to manage the staff. Firstly, the number of staff required to effectively carry out the task must be adequate and must follow stipulated guidelines within the organization's objectives and reflected in the maintenance strategies (Hammond Murray-Rust, Svendsen et al. 2003). Staff numbers follow matters such as amount of work, severity of damage to the drainage system and the time span within which to complete the work among others. Secondly, the skill level of the staff that is responsible for the maintenance of the channel can have great effect on how properly the channel is maintained and this must also be keenly adhered to. In the public sector, processes of staff hiring must follow central government administrative guidelines (International Commission on Irrigation and Drainage 1998). Thereafter, there is a framework within which the skill of the staff is regularly monitored and increased through trainings and workshops and their performance is measured and rewarded. Adherence to these aspects of human resource improves the quality of work done with respect to the operation and maintenance of the storm water drainage system and improves the performance of the drainage system, thus reducing localized flooding.

Financial resources are just as important as human resource. Activities within operation and maintenance of the storm water drainage system require adequate allocation of finances. Finances are utilized in support of the duties and activities of O&M, as well as in support of the staff responsible for O&M. Just as in the case of human resources, due to the fact that the management of the storm water drainage asset falls within the mandate of a public sector department in Nairobi, the allocation of finances must follow central government guidelines and is dependent of commitment and attention from authority levels often higher than the operation and maintenance department. The budget allocation is not often flexible and may be subjected to budget cuts when the needs of the central treasury are redirected (International Commission on Irrigation and Drainage 1998). However, this lack of flexibility in the processes of staffing and financial allocation should not affect operation and maintenance activities due to the importance of O&M of the storm water drainage system. Execution of effective financial and human resource plans ensures that operation and maintenance of the storm water drainage system is not under-prioritized. In the long term, low attention to operation and maintenance of the storm water drainage system may have severe impacts on the condition of the drainage system and lead to bigger flood disasters (Sullivan, Pugh et al. 2010). Furthermore, the cost of repair of the system together with the subsequent cost of damages caused may be higher than expected and can be accommodated for.

## 2.5 Conceptual Framework

Figure 4 is a diagrammatic representation of the variables and indicators for this study. In this case, asset management is a concept that covers both human and financial resources as well as operation and maintenance of the storm water drainage system. This is generally because employees, finances and the drainage system are considered assets that are used in the management of surface water runoff. Employees and finances are non-structural assets that an organization uses in the construction, operation and maintenance of the third structural asset, the drainage system. Management of each asset follows its own individual management plan that must incorporate the management plan of the other two assets in order to ensure successful and appropriate service delivery. The service being delivered in this case is the reduction of localized urban floods, and is dependent on the successful management of the three assets.

**Figure 4: Conceptual Framework for this study**



**Source: Adapted by Author from Reviewed Literature**

## Chapter 3: Research Design and Methods

This chapter explains the methodology that was used in the research and highlights on the revised research questions following the review of literature, the research strategy, the operationalization of the concepts, variables and indicators, the sampling techniques, the data collection and analysis tools.

### 3.1 Research Questions

#### 3.1.1 Main Research Question

- To what extent does *human and financial resource* influence *operation and maintenance* of storm water drainage systems for the *reduction of localized urban floods* in Nairobi?

#### 3.1.2 Sub Questions

- How does human resource influence operation and maintenance of the storm water drainage system?
- How does financial resource influence operation and maintenance of the storm water drainage system?
- What are the critical aspects of operation and maintenance of the storm drainage system and how do they influence localized flood reduction?
- What are the causes and trends in localized urban flooding in Madaraka Estate and Mbagathi/Lang'ata intersection and its relationship with the storm water drainage system?

### 3.2 Operationalization: Concepts, Variables and Indicators

The two main concepts of this study have been identified as asset management and urban flooding. These two concepts have been selected as they each individually embody the various variables contained in the research questions. The concept of asset management encompasses the aspect of human resource and financial resource as factors that affect operation and maintenance of the asset, that is, the storm water drainage system. Urban flooding has been highlighted as the concept under which localized urban flooding draws its definition.

#### *Definition of Concepts and their Variables*

#### 3.2.1 The Concept of Asset Management

This is “the systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over their lifecycles for the purpose of achieving its organizational strategic plan” (Esmaili 2012).

The following variables and their indicators are defined under the concept of asset management for the purpose of this study:

##### 3.2.1.1 Human Resource

This is “the pool of human capital under the firm’s control in a direct employment relationship” with the required knowledge, skill and ability to carry out the required tasks (Wright, McMahan et al. 1994). For the purposes of this study, this variable has been measured by:

- The number of staff available for O&M of the storm water drainage system
- The level of skill the staff possess and require
- Factors dictating the staff numbers and skill
- The continuous training programs and performance monitoring
- Incentives in place to motivate the staff

### **3.2.1.2 Financial Resource**

Financial resource is the money available to an organization “in form of cash, liquid securities and credit lines” needed to operate efficiently and carry out its required tasks (Business Dictionary 2017). For the purpose of this study, this variable has been measured with respect to the following indicators:

- Actual O&M costs vs approved O&M budget
- Availability of finances for O&M

### **3.2.1.3 Operation and Maintenance**

“Operation and maintenance are the decisions and actions regarding the control and upkeep of property and equipment. These are inclusive but not limited to the following; actions focused on scheduling, procedures, and work/systems control and optimization; and performance of routine, preventive, predictive, scheduled and unscheduled actions aimed at preventing equipment failure or decline with the goal of increasing efficiency, reliability and safety” (Sullivan, Pugh et al. 2010). For the purpose of this research this variable has been measured through the use of the following indicators:

- Type of maintenance strategy used
- Availability and use of O&M Plans, work orders, inventories, manuals by staff

## **3.2.2 The Concept of Urban Flooding**

This is the inundation of a built up urban area that occurs when surface water runoff from rainfall overwhelms the capacity of the existing storm water drainage system of the area it serves (Verworn 2002, Falkirk Council 2009). It is under this concept that the definition of localized urban flooding is contained, together with the required indicators for the purpose of this research.

### **3.2.2.1 Localized Urban Flooding**

This refers to urban floods that occur quickly, with very little warning and are usually contained within a small area or neighbourhood due to the limited capacity of the existing storm water drainage system of within the area (Falkirk Council 2009, Ochoa-Rodriguez 2017). For the purpose of this study, this variable has been measured through the following indicators:

- The main causes of localized urban flooding in Madaraka Estate and Mbagathi/Lang’ata intersection
- The frequency of localized urban flooding in Madaraka Estate and Mbagathi/Lang’ata intersection

Table 1 shows a summary of the concepts, their variables and indicators as well as the data collection techniques used.

**Table 1: Operationalization Table**

Research Question	Concept	Variable	Indicator	Questions	Data Type/ Analysis	Data Collection Method	Data Source
How does human resource influence operation and maintenance of the storm water drainage system?	Asset Management	Human Resource	<ul style="list-style-type: none"> <li>➤ The number of staff available for O&amp;M of the storm water drainage system</li> <li>➤ The level of skill the staff possess and require to carry out their duties</li> <li>➤ Factors dictating the number and skill of the staff</li> <li>➤ Continuous trainings and performance monitoring</li> <li>➤ Staff incentives in place to motivate the staff</li> </ul>	Refer to Annex 1	Quantitative, Qualitative	Interview, Questionnaire	Correspondents within the Dept. of Roads, Public Works and Transport.  Experts in the field of Urban Drainage
How does financial resource influence operation and maintenance of the storm water drainage system?		Financial Resource	<ul style="list-style-type: none"> <li>➤ Actual O&amp;M costs vs approved O&amp;M budget</li> <li>➤ Availability of finances for O&amp;M</li> </ul>	Refer to Annex 1	Qualitative, Quantitative	Interview, Questionnaire	Correspondents within the Dept. of Roads, Public Works and Transport.  Experts in the field of Urban Drainage
What are the critical aspects of operation and maintenance and how do they influence localized flood reduction?		Operation and Maintenance	<ul style="list-style-type: none"> <li>➤ Type of maintenance strategy used</li> <li>➤ Availability and use of O&amp;M Plans, work orders, inventories, manuals by staff</li> </ul>	Refer to Annex 1	Qualitative	Interview, Questionnaire	Correspondents within the Dept. of Roads, Public Works and Transport.  Experts in the field of Urban Drainage
What are the causes and trends in localized urban flooding in the selected locations in Nairobi and its relationship with the storm water drainage system?	Urban Flooding	Localized Urban Flooding	<ul style="list-style-type: none"> <li>➤ Main causes of flooding in Madaraka and Mbagathi/Lang'ata intersection</li> <li>➤ Frequency of flooding in Madaraka and Mbagathi/Lang'ata intersection</li> </ul>	Refer to Annex 1	Qualitative	Interview	Kenya Red Cross, NDMU

Source: Adapted by Author from Reviewed Literature

### 3.3 Research Strategy

The study is a deductive research based on its position in the empirical cycle and the fact that it seeks to explain this aim through a wide existing body of knowledge. In this regard, the type of research is explanatory and therefore requiring mainly qualitative data collection in order to obtain an in-depth understanding of the causal link between the two independent variables, the intervening variable and the dependent variable. The study shall also make use of limited quantitative data as a pre-test to give statistical meaning to the research as well as to triangulate the qualitative data. In view of this, the research strategy selected for this research is a single holistic case study. A case study approach is usually applied to study a contemporary phenomenon in its real-life setting that represents a critical, unique or revelatory case (Thiel 2014, Yin 2014). In this context, the poor operation and maintenance of the storm water drainage system by the Department of Roads, Public Works and Transport due to financial limitations and staff challenges represent a critical case with the increase of localized urban flooding in parts of the city of Nairobi being a threat to property, traffic systems and life (Mbugua 2016, Muchiri 2016, Teng'o 2015, Nairobi, Urban Infrastructure Development Strategy 2014).

### **3.4 Data Type and Collection Methods**

This research has made use of primary qualitative as well as quantitative data collected through interviews and questionnaires in order to achieve an in-depth explanation of the causal links between the variables mentioned in the main research question. It has also made use of secondary data obtained from desk research of online sources as well as documents from the Department of Roads, Public Works and Transport.

#### **3.4.1 Primary Qualitative and Quantitative Data**

Primary data refers to data that is collected directly from first-hand experienced specifically for a particular research and may be either qualitative or quantitative in nature. Qualitative data refers to data that is non-numerical in nature such as statements collected through interviews or observation of images. Quantitative data on the other hand, is data that is numerical in nature, with the numbers having an intrinsic meaning or numerical scores depending on the research purpose it was collected for (Thiel 2014). For this research, primary data was collected through semi-structured interviews and semi-closed questionnaires centred on collecting the opinions and knowledge of the respondents with respect to human and financial resources for operation and maintenance of the storm water drainage system and the relationship with localized flood events.

#### **Primary Data Collection Instruments**

This research made use of questionnaires as well as semi-structured interviews as the primary data collection instruments.

##### **3.4.1.1 Questionnaires**

Questionnaires consist of a set of close-ended questions or semi-closed questions (Thiel 2014). For this research, the questionnaire consists of both types of questions. The closed-ended questions are in the form of yes/no responses as well as scale response questions whose values have been represented graphically. The semi-closed questions gave the respondents opportunity to explain a few of the closed-ended questions to obtain more qualitative and in-depth responses. These were administered to the staff of the department responsible for operations and maintenance as a pre-test before conducting the interviews. The value of the pre-test questionnaires was to give direction of the topics to be discussed during the interviews and a clearer understanding of the research topic and the views of the staff. They also served as a mode of triangulating of the collected data, as consistency between the results of the questionnaires and the interviews was sought (See Annex 1 – Questionnaire).

##### **3.4.1.2 Semi-structured Interviews**

A semi structured interview is guided by use of an interview manual that contains a number of topics the study seeks to discuss with the interviewee with respect to the subject of study (Thiel 2014). The interview manual for this research contains an introduction section, a topic list, the actual interview questions and topics to be discussed and a concluding section (See Annex 1 Interview Guide) and is based on the operationalization table in table 1. Interviewing requires logic and creativity during the interview, based on the respondents in order to obtain as much information as possible on each topic listed. The interviews were conducted on key respondents within the Department of Roads, Public Works and Transport, the National Disaster Management Unit, the Kenya Red Cross as well as researchers and experts of urban flooding and urban drainage systems.

#### **3.4.2 Secondary Data**

Before proceeding for field work, secondary data in the form of both published and unpublished materials was collected through desk research mainly from internet sources and were used to inform the state of the art on the subject under study. This consisted of official public

government reports that revealed the shortcomings of The Department of Roads, Public Works and Transport such as (Nairobi, Urban Infrastructure Development Strategy 2014) as well as reports on increased localized flooding such as (Davies 2015, Daily Nation 2016, Chemweno 2016, Juma 2016a) among others.

During the field work, additional secondary data was collected to assist in answering the specific research questions, particularly pertaining to financial capability, human resource data and operation and maintenance documents. This data was mainly collected from the Department of Roads, Public Works and Transport in the form of human resource records, financial performance reports (NCCG - Finance & Economic Planning 2016) and annual operation and maintenance reports. However, most of these documents are not made public and were only available during the interviews conducted within the Department.

### 3.4.3 Study Area

This research was carried out in Nairobi, which is the capital city of Kenya. For the purpose of this study, two locations have been selected as a focus. These are Mbagathi/Lang'ata road intersection and Madaraka Estate.

### 3.4.4 Unit of Analysis

The unit analysis for the purpose of answering the posed research question is the Department of Roads, Public Works and Transport, which is responsible for the operation and maintenance of the storm water drainage system in Nairobi. Thus, interviews and questionnaires were administered within the department and for purposes of triangulation of data; interviews were also conducted with other respondents from National Disaster Management Unit, Kenya Red Cross and experts in the fields of urban drainage and urban flooding.

### 3.5 Sample Size and Selection

The sample size and the respondents in this research were selected on the basis of their knowledge on the topic of research as well as on their responsibilities and duties within their respective places of work. The sampling technique therefore was non-probability purposive sampling. This is a technique whereby the selection of respondents is made by the researcher on theoretical grounds (Thiel 2014). The O&M staff within the Department of Roads, Public Works and Transport consists of 16 individuals, which is a relatively small number and thus the entire team was issued with the questionnaire as mentioned earlier. Furthermore, these were to be supplemented by 7 interviews to the heads of departments, experts and researchers. The table 2 shows the initial list of respondents.

**Table 2: Initial List of Respondents**

	<b>Position</b>	<b>Qualification/ Department</b>	<b>Data Collection Method</b>	<b>Nos.</b>
1	O&M Staff - the Department of Roads, Public Works and Transport	Responsible for O&M	Questionnaires	16
2	Head of O&M department - the Department of Roads, Public Works and Transport	Responsible for O&M	Interview	1
3	Head of Finance Department - the Department of Roads, Public Works and Transport	Responsible for source and allocation of funds	Interview	1
4	Head of HR department - the Department of Roads, Public Works and Transport	Responsible for staff	Interview	1

5	Eng. J. Kiptala	Researcher/Expert – Urban Drainage	Interview	1
6	Mr. Bernard Juma	Expert – Urban Flooding (Kenya MET)	Interview	1
7	Manager – National Disaster Management Authority	Responsible for disaster responses and mapping	Interview	1
8	Manager – Kenya Red Cross	Responsible for disaster responses and evacuation	Interview	1
TOTAL				23

### 3.6 Validity and Reliability

#### 3.6.1 Validity

##### ➤ *Internal Validity*

This refers to the cogency of the study itself i.e. the accurate establishment of a causal relationship between the operationalized variables. Simply put, it is whether the study measured what it intended to measure (Thiel 2014). Internal validity for this study has been achieved through proper operationalization of variables from the theoretical review resulting in clearly defined and exclusive measurement instruments for the identified indicators. Furthermore, the research has triangulated the data obtained from all sources through the pre-test questionnaires, the interviews and the review of official records and documents. Triangulation refers to having all sources of data point to one answer and thus increases internal validity.

##### ➤ *External Validity*

This refers to the extent to which the study can be generalized and whether the results hold for other persons, institutions and locations (Thiel 2014). The use of a single holistic case study limits statistic generalization of the results obtained as the results are unique to the case being studied. Furthermore, the relatively small sample size used in this case greatly limits statistical generalization of the results as the sample size is not representative of a larger population. However, according to (Thiel 2014) it is almost always possible to relate single cases to higher abstraction levels of domain to which the case belongs. It is therefore often possible that findings can be regarded as representative of similar situations within the same research domain. For this reason the results of the research can be relevant to academia, science and similar institutions. This relevance may be done particularly in the findings of the extent to which human and financial resources are important for operation and maintenance activities. Therefore, the theoretical knowledge gained from this study seeks to be generalizable to other operation and maintenance departments of storm water drainage systems.

#### 3.6.2 Reliability

The reliability of a research refers to the accuracy and consistency with which a research was carried out such that another researcher may follow the steps used in the research for the same case and be able to obtain the same results as the initial researcher (Yin 2014, Thiel 2014). Reliability is often difficult to achieve when using an open research design such as a case study as the interviews may differ slightly from one to another. For this case study, in order to ensure reliability the researcher has maintained a case study logbook in which all steps taken during the study and any changes made to the initial proposition will be documented. In addition, the

application and use of a case study protocol log file will be used as a systematic guide during data collection. Any changes made will be documented adequately.

### 3.7 Data Analysis Methods

The data obtained for this research has mainly been analysed qualitatively, and described through the use of frequency and percentages of the responses received. The responses from the questionnaires have been tabulated and the frequency of responses was analysed graphically through bars and charts. Due to the small number of respondents for the questionnaire, it was not possible to analyse the responses using a statistical tool such as SPSS. In order to analyse the interview data, the information was managed and structured and boundaries were delineated between the different units of information received. The interviews were transcribed and validated through a member check with the respective respondents. The transcribed responses were coded using Atlas Ti Version 8.0.40. The selection of the codes for the analysis of this data was guided initially by the background knowledge of the subject being studied as well as the indicators identified for each variable. The codes focus on human and financial resources, operation and maintenance and localized urban floods. These codes were revised and updated based on the responses from the interviews, yet within the boundaries of the research. Outputs based on each will be generated and compared.

### 3.8 Challenges Faced

As the main unit of analysis was within the Department of Roads, Public Works and Transport, which is a government office, written consent to conduct research within the offices had to be sought according to official protocol, a process which took some time and thus reduced the limited time for data collection. However, this did not affect the results.

In addition to this, the political atmosphere within the country at the time of data collection was slightly tense due to the general elections which led to hesitation and overly cautious respondents particularly within the government offices. In order to overcome this, a friendly rapport had to be created as well as trust established that the data collected was purely for educational purposes and confidentiality would be highly adhered to.

### 3.9 Significant Changes Made During Data Collection

Out of the 16 employees of The Department that received the questionnaire, 13 were reverted and used for this study. Furthermore, there were a few changes in the respondents who were interviewed due to their availability. The final list of respondents is shown below in table 3.

**Table 3: Final List of Respondents**

Position	Qualification/ Department	Data Collection Method	Nos.
O&M Staff - the Department of Roads, Public Works and Transport	Responsible for O&M	Questionnaires	46-13
Head of O&M department - the Department of Roads, Public Works and Transport	Responsible for O&M	Interview	1
Head of Finance Department - the Department of Roads, Public Works and Transport	Responsible for source and allocation of funds	Interview	1
Head of HR department - the Department of Roads, Public Works and Transport	Responsible for staff	Interview	1

Eng. J. Kiptala	Researcher/Expert – Urban Drainage	Interview	1
Mr. Bernard Juma	Expert – Urban Flooding (Kenya MET)	Interview	4
Dr. J.K Mwangi	Researcher/Expert – Urban Drainage	Interview	1
Eng. Wangai	Researcher/Expert – Urban Drainage	Interview	1
Eng. Mark Gwena	Expert – Management of Drainage Systems	Interview	1
Manager Correspondent – National Disaster Management Authority	Responsible for disaster responses and mapping	Interview	1
Manager Correspondent – Kenya Red Cross	Responsible for disaster responses (rescue and evacuation)	Interview	1
TOTAL			23-22

## **Chapter 4: Research Findings and Analysis**

This chapter presents the research findings of the conducted fieldwork described in the previous chapter. An overview of the research case is given, describing the unit of analysis and a brief background of the problem. The findings from the data collected during the fieldwork are arranged according to the main variables identified during the operationalization and the indicators that were developed in order to answer the main research question. Data collected from the interviews is analysed by arranging responses obtained during interviews according to codes developed using Atlas Ti software. The data obtained from the questionnaires is ordered using Microsoft Excel and analysed using frequency and percentage methods. This data was also verified where necessary using official departmental records and reports. Finally the findings are discussed according to the theoretical review and conceptual framework in chapter 2.

### **4.1 Description of the Case**

The research was based on a single holistic case study of the Nairobi City County Government department that is responsible for storm water management systems in built-up areas in Nairobi (the Department of Roads, Public Works and Transport). The Department is also in charge of County roads, public road transport, traffic and parking and street and other lighting. However, the performance of The Department has come under scrutiny in the last 5 years, particularly with respect to the state of the storm water drainage system in Nairobi, due to the increase in localized urban flooding disasters mainly being attributed to poorly maintained storm water conveyance channels under their mandate. The increase in flooding due to the poor state of the drainage system has led to cases of loss of lives, destruction of property and infrastructure and traffic snarl ups up to 8 hours long (Chemweno 2016, Angote 2016, Davies 2015, Juma 2016b, Juma 2016a). In response to these claims, The Department has claimed to be suffering in terms of human and financial resources to efficiently carry out their duties (Nairobi, Urban Infrastructure Development Strategy 2014).

### **4.2 Data Presentation and Analysis**

The data collected from the secondary data and both the interviews and questionnaires have been presented according to the sub-research questions below:

- How does human resource influence operation and maintenance of the storm water drainage system?
- How does financial resource influence operation and maintenance of the storm water drainage system?
- What are the critical aspects of operation and maintenance of the storm drainage system and how do they influence flood reduction?
- What are the causes and trends in localized urban flooding in the selected locations in Nairobi City and its relationship with the storm water drainage system?

The results of the questionnaire are presented first as they were used as a pre-test before conducting the interviews. The results of the interviews are presented second and thereafter a comparison between the findings from both the questionnaire and interview is done and where applicable, supported by the data from secondary sources. This has also been done according to the selected indicators for the variable of each sub question. The results are then linked to previously reviewed theory before a summary of the answer to the sub question is made. The data from the questionnaire is ordered and analysed using frequency of the responses and presented graphically. The data from the interviews is ordered using Atlas Ti and the frequency of responses similarly tabulated and discussed.

## **Demographic Information of the Questionnaire Respondents**

The questionnaire, as earlier mentioned, was administered only to the staff within The Department. The sample was selected through purposive sampling based on their position and duties within The Department as part of the technical team responsible for O&M of the storm water drainage system. A total of 16 questionnaires were administered and 13 responses were received. From the background information collected, all 13 respondents were male. The educational background ranged from 3 Diploma level staff who had been employed in The Department between 1 and 3 years; to 8 Bachelor of Science Degree holders employed from 1 to 7 years and finally 2 Postgraduate Degree holders who have been part of The Department for 9 years.

### **4.2.1 The Influence of Human Resource on Operation and Maintenance of the Storm Water Drainage Systems**

Human resource is an essential asset in the success of any organisation, and in terms of this research, in the successful management of storm water and its drainage systems. This section looks into the responses received pertaining to human resource and its influence on the operation and maintenance of storm water drainage systems. This will answer the sub question: *How does human resource influence operation and maintenance of the storm water drainage system?* Specific questions to the respondents revolved around the adequacy of the number of staff, their education and skill, the factors that dictate both the staff number and their skill level, their participation in continuous training programs, monitoring of their performance of their duties as well as techniques used to motivate them.

#### *a) The number of staff for the Operation and Maintenance of the Storm Water Drainage Systems*

The total number of technical staff within the Department of Roads, Public Works and Transport responsible for operation and maintenance of the drainage system is 16, headed by one head of department. In addition to the storm drainage management duties, they are also in charge of management of County roads, public road transport, traffic and parking and street and other lighting. These staff numbers are supplemented by outsourcing of temporary casual labour on a need basis particularly during field work exercises. From the 13 questionnaires that were first received from the technical staff within The Department of Roads, Public Works and Transport, 54% of them said that the number of technical staff within The Department is 'average' as can be seen from figure 5. 31% of the questionnaire respondents viewed the staff number as 'poor' over the remaining 15% who said the staff number was 'good'. From these responses, the number of technical staff within the Department does not seem to be a pressing issue to the internal staff. This could be because of the use of outsourced temporary casual labour during the field work which aids in the O&M of the storm water drainage system.

**Figure 5: Rating of Staff numbers**



**Source: Questionnaire to Department Staff**

In addition to their rating of the staff numbers, the questionnaire respondents were asked whether a higher number of staff or a lower number of staff than the current staff numbers within The Department of Roads, Public Works and Transport would improve the quality of O&M of the storm drainage system in Nairobi and to explain their answer. Their responses can be seen in the table 4. Unanimously, 100% of the questionnaire respondents did not think that a lower number of staff would improve the operation and maintenance of the storm water drainage system in Nairobi, while 62% agreed that a higher number of staff would improve O&M of the drainage system in the city.

**Table 4: Questionnaire Response on staff numbers**

	<b>Would a higher number of staff improve O&amp;M?</b>		<b>Would a lower number of staff improve O&amp;M?</b>
Yes	8 (62%)	Yes	0 (0%)
No	5 (38%)	No	13 (100%)

**Source: Primary data - Questionnaire to Department Staff**

Through this question, it can be seen that a higher percentage of the staff believe that a higher number of staff would be a positive move for their operation and maintenance duties showing an inclination to dissatisfaction with the current staff numbers that was expressed earlier in Figure 5. From the reasons given by the technical staff, a higher number of staff would reduce the strain of work on the existing staff as their duties go beyond the management of the storm drains and it would also allow for better allocation of duties without sacrificing other duties and make it easier to request for official leave days without crippling The Department. For the 38% of respondents that did not believe adding to the staff numbers would improve the quality of O&M duties, the main reason was that better support of the existing staff through providing training for all and making available required equipment and finances for activities would do more to improve the quality of O&M of the storm drainage system than higher staff numbers. The fact that 100% of the questionnaire respondents did not support lowering the number of staff, may indicate that they are working at capacity according to them.

The 9 interviews that were carried out once the responses of the questionnaires were evaluated in order to triangulate the information sought to look into the adequacy of staff numbers and mainly expressed that the staff numbers are poor as can be seen in table 5, contrary to the 54% majority seen earlier in the questionnaires in figure 5. The responses also gave insight into

balancing of outsourced labour which is a method used by the county government to keep staff costs low but at the same time ensure that the services are delivered. The summary of responses has been tabulated in table 5.

**Table 5: Interview Responses regarding staff numbers**

Indicator	Question	Summary of Responses	Frequency of Response
Number of staff for O&M of the storm water drainage system	<p>1. In your view, how does the number of staff responsible for O&amp;M of the storm water drainage system at The Department of Roads, Public Works and Transport affect carrying out of O&amp;M activities?</p> <p>2. The current number of staff within the Department of Roads, Public Works and Transport that is responsible for O&amp;M of the storm drains in Nairobi is 16 technical staff, kindly comment on the adequacy of this number.</p>	<ul style="list-style-type: none"> <li>The staff numbers within The Department of Roads, Public Works and Transport are low, with respect to the extensive storm water drainage system in the City and the fact that they have other responsibilities such as management of county roads, traffic, street lighting and public transport.</li> </ul>	7
		<ul style="list-style-type: none"> <li>The low staff numbers have to be supplemented through outsourcing of casual labour on a need basis to ensure the field work and manual duties such as drain clearing is done</li> </ul>	7
		<ul style="list-style-type: none"> <li>Inadequate numbers at The Department affects the time taken to complete work. Maintenance field work, inventory, inspections and reports face back log. Furthermore, when drains are not cleared or rehabilitated in time due to the slow work, the system fails to contain surface runoff during rains</li> </ul>	6
		<ul style="list-style-type: none"> <li>Increasing staff numbers must be feasible to the county budget to avert wastage of resources that would otherwise be channelled towards O&amp;M and development projects. Current staff costs (compensation) are over 50% of county budget. money is directed more towards salaries rather than actual equipment or functions</li> </ul>	5
		<ul style="list-style-type: none"> <li>Low staff numbers at The Department result in them becoming overwhelmed, overworked and demoralized. Duties become neglected as they have to prioritize importance based on the number available to work. Usually O&amp;M of storm drains is ignored due to the temporal nature of storms</li> </ul>	7
		<ul style="list-style-type: none"> <li>There should be an optimal balance between the number of skilled (employed within the Department) and the number of casual labour that is outsourced</li> </ul>	8
		<ul style="list-style-type: none"> <li>The number of staff is also dictated by other factors such as amount of work,</li> </ul>	7

		HR policies, management of the department and the resources available	
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Source: Primary data - interviews

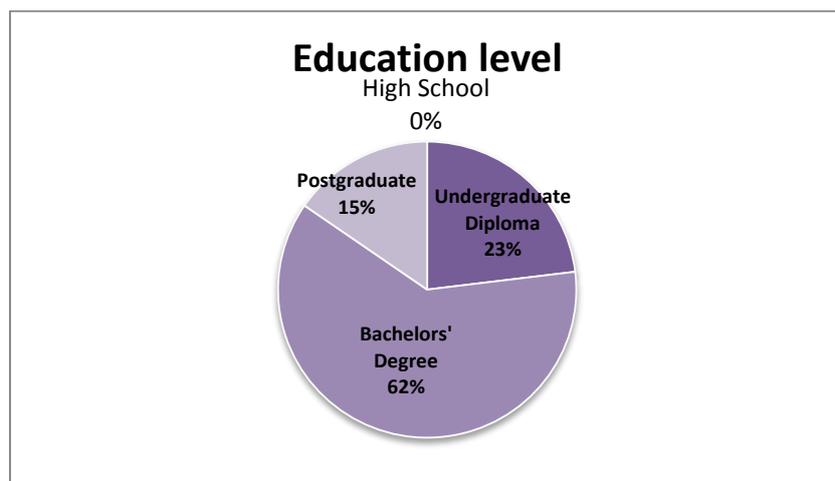
As can be seen from table 5, the staff numbers are considered low according to 7 out of 9 of the interview responses and could be affecting the operation and maintenance of the storm water drainage system. However, the low number of technical staff within The Department is supplemented by hiring of temporary casual labourers on a need basis to assist in the manual duties such as drain clearing and system rehabilitation. This could be the reason the staff responses through the questionnaire had a majority of “average” with respect to their rating of staff numbers as they responded with respect to the internal staff as well as outsourced labour, while the interview respondents mainly considered only the internal staff numbers. The outsourcing of duties to temporary casual labourers keeps the duty burden on the staff light, but gets the work done and also keeps the staff costs low. However, the outsourced casual labour must always be supervised by the technical staff of The Department during their work. Quoting the head of the technical O&M team, *“At the end of the day, it is us (the permanent skilled staff of the Department) who are responsible for the efficient working of the system and not watu wa mjengo (manual unskilled labourers). Nobody will come after them if anything goes wrong, so we must make sure there are enough of us to monitor and work with them when we call them in to help. At times there are many duties to be done outside the office that require our supervision and we are too few”*

The adequacy of staff numbers is a major factor in the successful operation and maintenance of the storm water drainage system. From these responses from both the questionnaires and the interviews, it is evident that the numbers of the skilled staff within the Department are not adequate. This is consistent with reviewed literature stating one of the main reasons behind lack of O&M on the storm water drainage system is due to poor staff numbers (Nairobi, Urban Infrastructure Development Strategy 2014). The technical staff is supplemented through outsourcing of casual labour. This approach does not solve the problem of low technical staff numbers. This is mainly because operation and maintenance of the storm water drainage system is not the only function of the Department. A reasonable working balance must be struck between the numbers of the technical staff of The Department and that of the outsourced casual labourers without overstretching the responsibilities of either one. The responses also revealed that support of the staff is a vital aspect of ensuring successful performance of the staff. This support is in forms of providing a productive work environment through provision of equipment. Increasing of staff numbers at The Department of Roads, Public Works and Transport would have no direct effect on the operation and maintenance of the storm water drainage system in Nairobi if they are not supported and provided with tools to implement O&M plans (International Commission on Irrigation and Drainage 1998, Sullivan, Pugh et al. 2010).

*b) The level of education and skill of the staff*

The level of skill of the staff within the Department was sought by looking into their educational background as well as the training they receive. Operation and maintenance of storm water drainage systems is a specialized field and a minimum education and skill level must be attained to work in this field according to the human resource policies applied to the Nairobi City County Government. The education levels attained by the staff within The Department are shown in the figure 6. It can be seen that their education levels are good and seem capable of handling their duties with majority of the employees (62%) having a Bachelors’ Degree.

**Figure 6: Education level of Department staff**



Source: Primary data - Questionnaire to Department staff

According to the policy on human resource and hiring of skilled individuals used by the Nairobi City County Government, the minimum education level is a Diploma and the Department of Roads, Public Works and Transport has adhered to these requirements for their technical staff. The interview responses in table 6 are consistent with this. According to the responses from the interviews operation and maintenance of the storm water drainage system is a specialized area and thus requires well trained staff to carry out the duties and even supervise any outsourced labour. The responses from the interviews are summarized in table 6.

**Table 6: Interview responses regarding skill level**

Indicator	Question	Summary of responses	Frequency of responses
Level of skill of the staff	The staff in the Department of Roads, Public Works and Transport is comprised of individuals with Diploma, Bachelors' degree and Postgraduate level education. How does the level of education and skill of the staff at responsible for O&M of the storm water drainage system affect carrying out of O&M activities?	<ul style="list-style-type: none"> <li>Education and skill level have adhered to the Department HR policies. O&amp;M of the storm drains is a specialized technical field and thus needs at least educated staff in the area to oversee and execute the duties pertaining to this.</li> </ul>	8
		<ul style="list-style-type: none"> <li>The skill level of the staff should always be improved, preferably through organizational support such as continuous training and sponsorships for further studies</li> </ul>	9
		<ul style="list-style-type: none"> <li>Outsourced casual labour does not need to meet education level but are very important but should be closely supervised.</li> </ul>	8
		<ul style="list-style-type: none"> <li>Specialized skills and education fields improve O&amp;M through innovation in duties pertaining to management of the storm water drainage system</li> </ul>	5

Source: Primary data - Interviews

8 out of 9 of the interview respondents agreed that the minimum Education level required of the technical staff within the Department of Roads, Public Works and Transport has been adhered to. One respondent with reference to the level of skill of the staff and the supervision

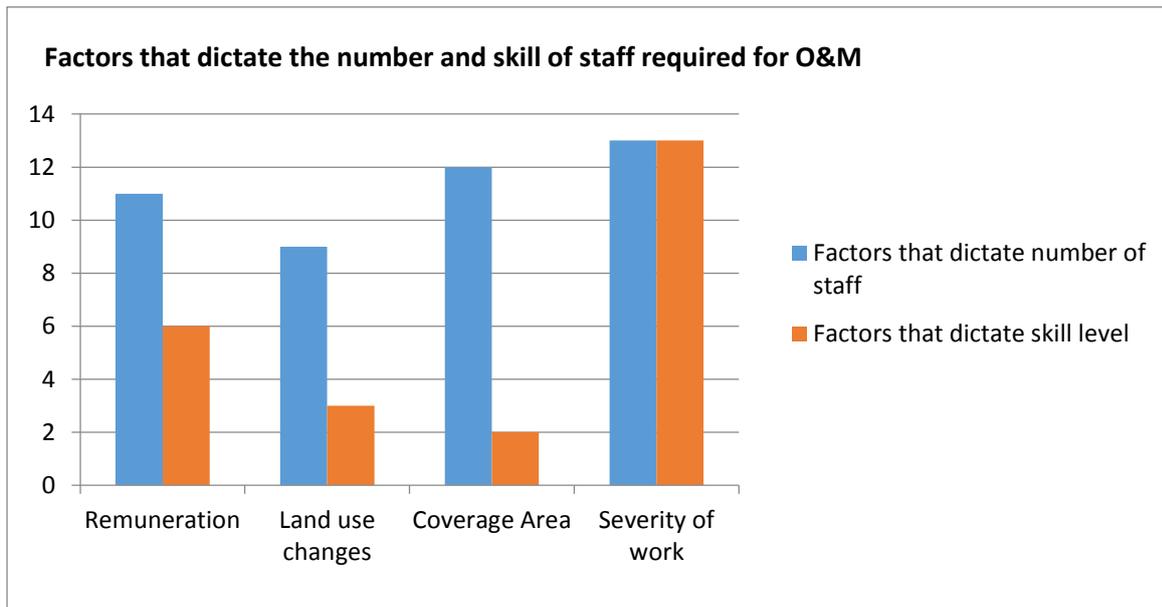
of outsourced casual labour said *“For example, it is not as simple as clearing the system of debris. It should be followed by proper disposal. There are many instances that the debris has been piled just beside the open channels and when it rains, it is all washed right back into the drainage system causing blockage and then inundation. I believe with close supervision and someone who knows what is required and is following an O&M plan this would not be common”*. The respondents further highlighted that the outsourced labour need not have specified education levels but must always be supervised by the technical staff from the Department. Additionally, specialized skills from the technical staff within The Department may spark innovation in O&M of the storm drainage system and this may be achieved through continuous training and opportunities to further their studies.

It is clear from the responses received pertaining to education and skill of the staff, that the minimum educational requirement of the staff has been adhered to and is of high importance as the management of the storm water drainage system is a specialized area that requires a particular set of skills. This result is expected as according to Institute of Asset Management’s PAS 55-1:2008 framework adapted from the review of literature in Figure 2 which demonstrates that the successful management of physical assets goes beyond just technical activities to include non-structural assets such as human assets whose skill and knowledge play a big role. In addition to this, in the event of outsourcing of casual labour, strict supervision from the skilled staff is very important to ensure the work is properly done. Based on the problem faced with the increase of localized flooding in Nairobi and the role that operation and maintenance of the storm water drainage system plays, the findings presented on education and skill of the staff is not a problem influencing O&M of the storm water drainage system at this time.

*c) The factors that dictate the number and level of skill of the staff*

The factors that dictate the number and level of skill of the staff responsible for the operation and maintenance of the staff are another important element in the efficiency of human resource. From the responses of the questionnaire, 4 factors were highlighted. These included the remuneration of the staff, the changes in land use and the coverage of service as well as the severity of the work required in the drainage system. The questionnaire responses are shown in figure 7. All the staff within The Department of Roads, Public Works and Transport that responded to the questionnaire said that the severity of work on the drainage system is the most important factor that dictates both the number and the skill of the staff required for operation and maintenance of the storm water drainage system in Nairobi. The number of staff was also said to be dictated by the coverage area, which is directly linked to the amount of work, hence a larger coverage area would require more staff to complete the duties in good time. The remuneration to the staff also dictated staff numbers due to limitations in finances to pay staff. When the O&M budget is low, there are fewer funds allocated to pay the staff and this reduces the number of staff that can be supported.

**Figure 7: Factors dictating number and skill of staff**



**Source: Primary data - Questionnaire to Department Staff**

As can be seen, all the four mentioned factors dictated the number of the staff required for O&M more than they dictated the skill of the staff required. This may be due to the fact that in this scenario, skills are linked to education level attained which is the basis of employment and some of these factors do not particularly dictate this. However, the severity of work does dictate the skill as generally lower skills can handle simple drain clearing while a higher skill is needed for duties such as rehabilitation or upgrade of the system to accommodate changes in surface water runoff.

The 9 interviews conducted confirmed some of these responses and highlighted other factors such as the Government policy on required human resource per department as well as their ability to support and pay a particular number of staff. Finances also dictate the number of outsourced casual labour, according to some of the interviewees. The summary of responses from the interviews can be seen in table 7.

**Table 7: Interview responses regarding factors dictating number and skill of staff**

Indicator	Question	Summary of responses	Frequency of responses
Factors that dictate number and level of skill of staff required for O&M	What would you say are the factors that dictate staff numbers and their skill and education level for O&M by the Department of Roads, Public Works and Transport?	<ul style="list-style-type: none"> <li>Hiring of staff, as well as their minimum level of education is dictated by Government policies on HR</li> </ul>	7
		<ul style="list-style-type: none"> <li>The County's financial ability to compensate staff dictates how many staff can be supported at a time. This also includes the number of outsourced casual labourers</li> </ul>	8
		<ul style="list-style-type: none"> <li>Other than severity of work and HR policies the external factors do not have much impact on skill required by the staff</li> </ul>	5
		<ul style="list-style-type: none"> <li>The amount of work and the severity of damage on the drainage</li> </ul>	9

		system also dictates the number of staff in the department and outsourced	
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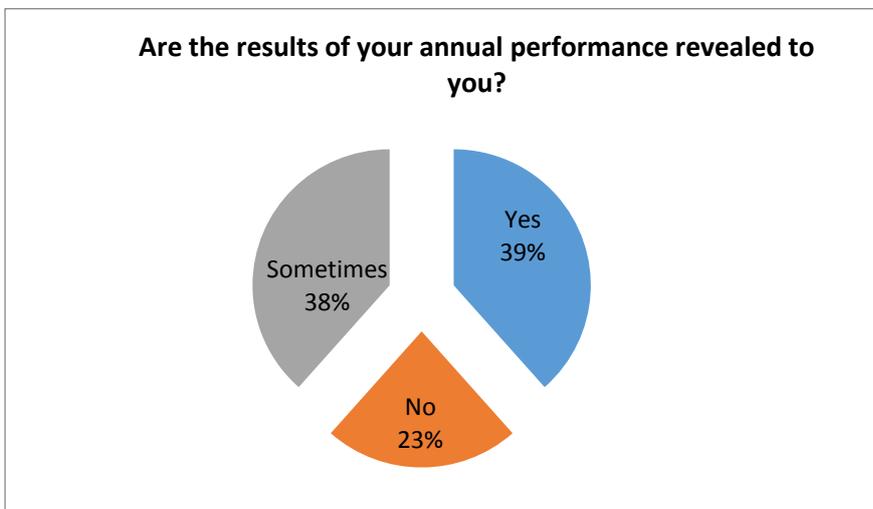
Source: Primary data - Interviews

From the findings of the interview regarding the factors that dictate number and skill of the staff it emerged that amount and the severity of work required on the system as well as the government policies on employee education level, did dictate both number and skill. The number of staff required for operation and maintenance of the storm water drainage system is indeed influenced by all 4 factors as well as government employment policies. From previous results on the number and the skill of staff in sub-sections a) and b) above, the number of staff is very important for O&M of the storm drainage system and hence having more external factors dictate it makes it more volatile. Issues such as remuneration affects staff numbers because when there are not enough finances to compensate the staff, the turnout of numbers particularly for outsourced casual labour is low and either slows down or stops manual drainage system maintenance completely. Furthermore, poor remuneration of the technical staff within the Department breeds unmotivated staff with no willingness to work. The coverage area also affects numbers as it is directly related to the amount of work expected to be done on the drainage system.

*d) Continuous training and performance monitoring*

Pertaining to continuous staff training, only 23% of the staff within The Department of Roads, Public Works and Transport that responded to the questionnaire (3 out of 13) had attended training for their duties of operation and maintenance of the storm water drainage system. This shows a gap in development of skills of the staff responsible for operation and maintenance of the storm water drainage system and according to (Itika 2011) may directly affect the quality of work done. Their performance is however monitored annually through a performance appraisal system. However, despite annual performance monitoring, the responses regarding feedback given to them of the results of their performance by higher level management was inconsistent as can be seen in Figure 8. 38% of the questionnaire respondents said the results of their performance was “sometimes” revealed to them, 39% did say that it was revealed to them while 23% said the results were not revealed to them. Furthermore, action such as rewards of penalty was not taken after the appraisal. The responses regarding the feedback from the performance monitoring can be seen in figure 8.

Figure 8: Feedback in Performance Monitoring



Source: Primary data - Questionnaire to department staff

The responses from the questionnaire show a performance gap of the staff as they had no indication as to areas that needed improvement, or areas they could maintain to ensure efficient performance. For those that answered “Yes” above, they still felt that there was no reward or consequence related to how they performed and thus still resulted in a gap in the performance of the staff. These results indicate a gap in the training and the performance monitoring systems in place. The low number of staff attending training for their O&M duties was confirmed by the interviews conducted with the heads of O&M, human resource and finance department. According to the responses from the interviews in table 8, continuous training of the staff helps in improving the skill set of the staff thus improving the quality of their work and also improves their attitude towards work. Performance monitoring was also highlighted as important in improving the quality of O&M by ensuring the staff work at their best and shows them areas of improving. The inconsistency in feedback from the annual staff performance monitoring was also confirmed by the 3 interviews to the department heads. It also emerged that performance monitoring works hand in hand with a performance-based reward system.

**Table 8: Interview Responses on Staff training and Performance monitoring**

Indicator	Question	Summary of responses	Frequency of responses
Continuous staff training and performance monitoring	In your opinion, what is the importance of continuous staff training and how can it be utilized to improve operation and maintenance of the storm water drainage system in Nairobi?	Continuous staff training is important for O&M of storm drains as it improves the skill to be directly applied to duties of the responsible staff	9
		There are rarely opportunities and support for staff training for their O&M duties	3
		Continuous staff training sparks innovation in handling of duties pertaining to the drainage system	7
		Continuous staff training is important for O&M of storm drains as it boosts the morale of the staff when they are appreciated and developed	7
	What is the importance of staff performance appraisal in the O&M of the storm water drainage system?	Staff performance appraisal ensures optimal performance of staff in their O&M duties and pinpoints areas of improvement	8
		The feedback from the annual staff performance monitoring is inconsistent. There are years where the feedback has been thoroughly discussed with each staff and years where after the staff handed in their appraisal forms, no feedback was given at all	3
		It also works best with a reward (and/or penalty) system based on the results of the appraisal	6

Source: Primary data - Interviews

The 3 responses that said there were rarely opportunities for training offered to all the staff came from the 3 internal interview respondents linked to The Department of Roads, Public Works and Transport. This confirmed the findings from the questionnaire that revealed that

only 23% of all the technical staff of The Department had undergone training for their O&M duties. This is a clear gap in the development of the skills of the staff and directly can affect their operation and maintenance duties according to (The Institute of Asset Management 2008) and (International Commission on Irrigation and Drainage 1998). Furthermore, an explicit and implementable policy on training and development shows how organizations are committed to maximizing their employees' potential (Itika 2011).

*e) Techniques used to motivate staff (Incentives)*

Despite having annual performance appraisal as seen earlier in sub section d), according to the questionnaire responses, the staff did not receive any recognition for achieving prior-set targets. Further to this, the staff within The Department expressed that activities such as team building and provision of equipment would motivate them to work together and enable them to execute the management of the storm water drainage system efficiently. Similar responses were received from the interviewees as can be seen in table 9.

**Table 9: Interview Responses on Incentives given to motivate staff**

Indicator	Question	Summary of responses	Frequency of responses
Incentives given to staff and techniques used to motivate staff	<ul style="list-style-type: none"> <li>Is a reward system an effective way of motivating the O&amp;M staff within The Department staff to improve their performance?</li> <li>What is the most appropriate method of basing the rewarding staff?</li> </ul>	Rewarding achievement of prior-set targets motivates staff to improve and improves attitude towards O&M duties	7
		Rewards are best based on performance and achievement of targets	7
		Within the Department there is currently no reward system for performance	3
	In your opinion, in this situation, what other ways may be used to motivate staff?	Group activities such as team building sessions motivate staff, encourage team work and de-stresses staff enabling them to work better	8
		Providing a productive work environment through provision of equipment and support	9

Source: Primary data - Interviews

The three responses from the department heads stating that there is currently no reward system in place for performance validated the responses from the questionnaire regarding lack of recognition of the staff for achieving prior-set targets. According to (Itika 2011) incentive based rewards is important in assessment of performance and helps to determine whether an organization is achieving its objectives.

*Summary of how human resource influences operation and maintenance of the storm water drainage system in Nairobi*

From the findings of this research the main factors of human resource influencing the operation and maintenance of the storm water drainage system are the low staff numbers within the Department that have to be supplemented by outsourced temporary casual labour, the lack of continuous training programs and opportunities for the staff to develop their O&M skills and the gap in comprehensive performance monitoring system that would give the staff feedback on their performance of duties. These findings are consistent from both the questionnaire responses as well as the interview responses and validated by official human resource records of The Department. Human resources are decisive factor in achieving organizational success and thus all factors pertaining to the successful utilization of this resource must be well managed and executed (Cole, Kelly 2011).

The staff employed within The Department of Roads, Public Works and Transport are utilized in the inspection of the system, record keeping of all works undertaken and required resources and inventory of the state of the system and the related equipment as well as manual maintenance and upgrade of the system. From the responses received above regarding the indicators of human resource it is possible to explain how inadequate staff numbers and lack of training can influence the operation and maintenance of the storm water drainage system as indicated in the conceptual framework in Chapter 2, Figure 4. Inadequate staff numbers slow down the maintenance of the storm water drainage system, leaving it vulnerable to failure during storm events and thus failing to channel away surface water leading to flooding of the surrounding areas. Furthermore, poorly trained staff most often perform sub-standardly in their duties and in this regard, poorly trained staff do not sufficiently maintain the system leading to failure of the storm water drainage system in flood protection (Backmann, MacCleery 2006, Cole, Kelly 2011, Itika 2011).

Sufficient support of the staff responsible for management of the system is key in ensuring that they perform their duties well. Supporting the staff may be done through efficient balancing of workload through balancing of staff numbers, both employed and outsourced, skills development to enhance innovation and improve their attitude and finally regular and comprehensive monitoring of performance and related rewards. According to (Esmaili 2012) qualified, skilled, well-motivated and supported staff are important in the delivery of efficient operation and maintenance duties. The underlying factor behind the inadequate numbers and lack of training in this research appears can further be attributed to low finances. The financial support enables most of these aspects to improve as well as adherence to staff management policies. In this study, it is clear that when the staff is well supported through provision of adequate numbers, training and feedback of performance, their attitude towards work and their performance of O&M duties may improve and subsequently improve the state of the drainage system to adequately channel surface runoff away.

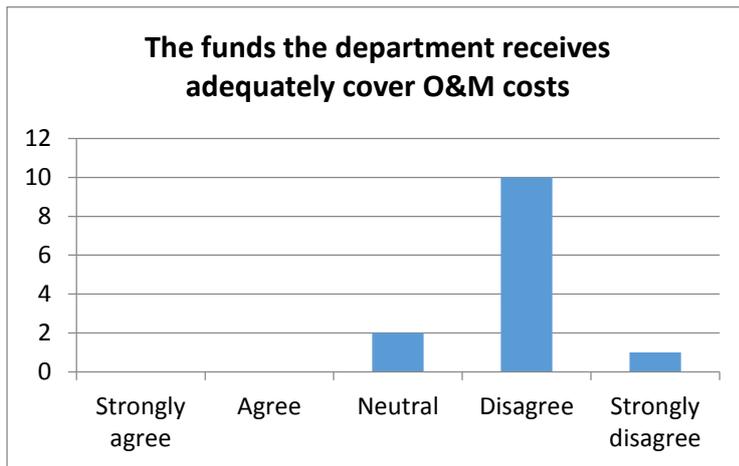
#### **4.2.2 The Influence of Financial Resources on the Operation and Maintenance of Storm Water Drainage Systems.**

This section analyses the responses received pertaining to the financial resources required by The Department of Roads, Public Words and Transport and the effects of inadequate funds on the operation and maintenance thus answering the second sub question: *How does financial resource influence operation and maintenance of the storm water drainage system?* Specific questions to the respondents revolved around the effects of low funding, its availability and the barriers to sufficient funding.

##### *a) Actual O&M costs versus the Approved O&M budget*

From the responses received from the 13 questionnaires, majority of the respondents expressed that the amount of funds the Department receives does not cover the actual O&M costs. This can be seen from their responses in figure 9. This state of affairs has affected the smooth functioning of all O&M duties. For example, the finances are said to cover inspections and record keeping activities, with the maintenance field work not being covered sufficiently and either falling behind or not being done at all. The Department also has to prioritize the locations in the city to receive maintenance work on the storm water drainage system, usually resulting in the low income high density areas being neglected.

**Figure 9: Adequacy of Finances in covering O&M costs**



Source: Primary data - Questionnaire

The approved budget for operation and maintenance of the storm water drainage systems is dependent on the revenue received by the Nairobi City County Government. NCCG receives its revenue from internal sources such as fees and levies, external sources from donor and partnerships as well as allocation from the Central Government based on the Commission on Revenue Allocation (NCCG - Finance & Economic Planning 2016). The responses from the interviews confirmed the shortfall in the actual O&M costs and the approved O&M budget expressed initially in the questionnaires. Some of the financial shortfalls were further explained in the interviews as summarized in table 10.

**Table 10: Interview responses on O&M costs**

Indicator	Question	Summary of responses	Frequency of responses
Actual O&M costs versus the approved O&M budget	How do shortfalls in terms of actual costs versus the approved O&M budget affect the operation and maintenance of the storm water drainage system by the Department of Roads, Public Works and Transport?	The funds received for O&M activities and related duties regarding the management of the storm drains have fallen short of the actual financial needs the last few years due to overall revenue shortfalls of NCCG	2
		<ul style="list-style-type: none"> <li>• Shortfalls in the budget result in a prioritizing of duties, and usually O&amp;M is less prioritized</li> <li>• Furthermore, the low-income high density areas in Nairobi fall lower in the priority list when there is not enough finances for O&amp;M for the entire drainage system</li> </ul>	8
		Shortfalls in the budget affect the number of outsourced casual labour available, usually resulting in slow or poor manual clearing of drains in time for the rains. This also affects the employed staff	6

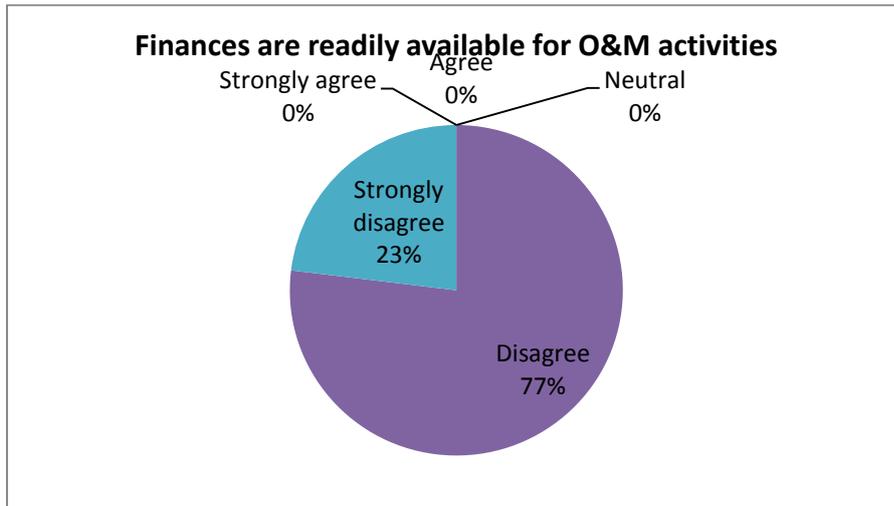
Source: Primary data - Interviews

Full knowledge on the financial costs and shortfalls is felt and understood mostly by the finance department and the staff within the O&M docket. For this reason, the interview answers from most of the respondents were in a general qualitative manner, while two respondents were able to give specific qualitative and quantitative answers regarding the financial position. The two responses regarding the reason behind financial shortfalls in table 10 held great value as this was knowledge from the finance department and the head of the Department of Roads, Public Works and Transport. They were able to validate the questionnaire responses that mostly expressed that the funds received do not adequately cover all O&M costs. According to the correspondent from the finance department of NCCG with reference to financial documents, *“NCCG revenue performance for 2015/16 was 25.1B, 86.6% of the county budget for that financial year. In 2014/15 it was 76.5% of the budget. These shortfalls in budget trickle down to all the branches of service delivery within NCCG, including the management of the storm water drainage system. The management of the storm water drainage system does not earn revenue of its own through fees and thus related duties such as O&M do not garner financial attention. Compared to all the 47 Counties, Nairobi County receives the lowest per person revenue according to CRA parameters.”* The fact that County revenue does not meet its targets results in corresponding financial allocation to departments and functions such as operation and maintenance of the storm drains failing to meet the actual costs of service delivery. This directly affects factors such as quality of work done, prioritizing of duties and locations to receive maintenance of the drainage system as well as the number of casual labourers that will be outsourced, causing further slow implementation of O&M activities in the field. According to (NCCG - Finance & Economic Planning 2016) revenue shortfalls continue to hinder effective budget implementation through a constrained budget supply side. This subsequently affects maintenance of the system, the resultant state of the storm water drainage system and its ability to safely channel all surface water runoff.

*b) Availability of Finances for Operation and Maintenance of the Storm Water Drainage Systems*

According to the staff within The Department that responded to the questionnaire, all the staff expressed that funds were not readily available for O&M activities as can be seen in figure 10. Finance' being readily available means that it does not take a long time between official requests and the receiving of the finances to the Department to proceed with their duties. This may be partly due to government procurement procedures, but also due to poor allocation of finances in general for O&M activities as was highlighted in the previous sub section about actual O&M costs and approved O&M budget. 77% disagreed that funds are readily available and 23% strongly disagreed, giving a unanimous view on the topic.

**Figure 10: Availability of Finances for O&M activities**



Source: Primary data - Questionnaire

The poor availability of funds affects the urgency with which operation and maintenance activities can be carried out. Due to the fact that The Department of Roads, Public Works and Transport is a docket under Nairobi City County Government, any financial and procurement must follow strict procurement procedures. Furthermore, finances are allocated and budgeted once annually based on revenue reports and the National Budget allocation. The 9 interviewees gave some insight behind the probable factors that affect the availability and adequacy of finances for operation and maintenance of the storm drainage systems as can be seen from the summary of responses in table 11. They mainly attributed it to the temporal nature of flood events, corruption in public offices and the devolution of county governments that occurred with the promulgation of the Constitution of Kenya in 2010. The responses confirmed the answers obtained from the questionnaires, strongly seen through the responses from the finance department and the head of O&M that have full knowledge on the availability of finances for operation and maintenance of the storm water drainage system in Nairobi City.

**Table 11: Interview responses on availability of finances**

Indicator	Question	Summary of responses	Frequency of responses
Availability of finances for O&M of the storm drains	In your opinion, what factors would you say affect the availability and the adequacy (in terms of amount) of financial resources at The Department of Roads, Public Works and Transport for operation and maintenance of the storm water drainage system?	Availability of finances for O&M is poor as it depends on government procurement procedures which are often lengthy	2
		Devolution of county governments resulted in financial outfalls of the counties in nearly all urban management sectors thus affecting prompt availability of funds for O&M	7
		The temporal nature of storm events coupled with the annual allocation of finances for government duties and service delivery has made adequate allocation hard to predict and account for annually	5

	Considering that The Department of Roads, Public Works and Transport falls within the Nairobi City County Government, what are the barriers to or benefits of availability of finances associated with this?	Corruption in government offices has hindered availability of finances for operation and maintenance of the storm water drainage system in Nairobi	5
		Being a government office, the Department of Roads, Public Works and Transport has easier access to donor funding to improve their service delivery and/or skill development for staff	8

Source: Primary data - Interviews

Similar to the indicator regarding the actual operation and maintenance costs, issues regarding availability of finances are known best to those working within the Department. According to the finance office, the availability of finances for operation and maintenance of the storm water drainage system is dependent on the revenue available to the whole county and the government procurement procedures that are often lengthy and prone to corruption. Furthermore, one respondent said in addition to low revenue experienced by the entire NCCG, *“there are no direct fees or taxes applied to the residents and users of the storm water drainage system resulting in even lower perception of county finance officials to honour budget requests for finances to maintain the system. Usually funds are dispensed when major failure of the system has occurred and there are many complaints of flooding in an area due to blocked drainage system.”* This further explains the low availability of finances for O&M of the storm water drainage system.

Interesting to note also is the positive outlook on financial availability to The Department of Roads, Public Works and Transport due to it being a government office and thus giving it access to donor funds to improve service delivery and/or skill development of the staff. However, this apparent benefit does not seem to be applicable at this time for this particular Department as it has major shortfalls in finances and opportunities for skill development for the staff as seen through the responses reviewed.

#### *Summary of how financial resources influence operation and maintenance of the storm water drainage system in Nairobi*

From the data collected from both the questionnaires and interviews, the Nairobi County revenue has been below budgeted costs and this has directly affected availability of finances for the delivery of services, particularly with respect to operation and maintenance budgets for the storm water drainage system often being under-prioritized. In the case of The Department of Roads, Public Works and Transport, availability and adequacy of finances for operation and maintenance of the storm water drainage system has been crippled by three factors according to this study. Firstly, shortfalls in O&M budget due to low revenues received by NCCG trickle down to inadequate budget allocation (NCCG - Finance & Economic Planning 2016). Secondly, corruption in public offices and the lengthy procurement procedures required by law to dispense funds have resulted in finances not being readily available. Finally, the slow adjustment to the recent devolution of county governments has affected financial stability of the entire NCCG. This has resulted in slow implementation of O&M plans and poor remuneration of staff. Financial resources are the backbone of many organizations. In the operation and maintenance of storm water drainage systems, finances are required to pay staff, buy equipment and support a productive working environment and thus they must be both available and adequate (International Commission on Irrigation and Drainage 1998).

### 4.2.3 The Critical Aspects of Operation and Maintenance of the Storm Water Drainage System and How They Influence Localized Flood Reduction

According to (Tucci 2007), operation and maintenance of storm water drainage systems is vital in prolonging the life cycle of the system and extending the benefits of flood protection. This section discusses the responses related to the third sub question: *what are the critical aspects of operation and maintenance of the storm water drainage system and how do they influence localized flood reduction in Nairobi?* The information directly related to the maintenance strategy, standards and tools of implementation used by The Department of Roads, Public Works and Transport was gathered from the questionnaire respondents, while the respondents of the interview gave insight into performance of O&M by the department, the critical aspects and flood reduction through O&M.

a) *Maintenance Strategy and Availability and use of O&M plans, inventories and manuals by staff*

From the responses received from the questionnaires, it was clear that all the staff had adequate knowledge of the maintenance strategy in place for the operation and maintenance of the storm water drainage system, which is predictive maintenance. However, their opinion on the efficiency of the strategy in place varied slightly as can be seen from the table 12, with 54% agreeing that the strategy was efficient and 23% disagreeing with this notion. This is mainly due to the poor implementation of the predictive maintenance strategy in place.

This may be further explained through their response regarding being well equipped with tools to implement the aforementioned strategy, such as the O&M plan and all related equipment, with all respondents claiming they are not well equipped with the tools. Despite not being well equipped, 23% of the questionnaire respondents still claimed to take regular inventory of the system, but the majority (62%) disagreed. These responses indicate poor support of O&M activities as seen by the general lack of implementation of the O&M strategy and plan and the low rate of taking inventory of the system.

All the staff within the Department unanimously agreed that proper maintenance of the system would help reduce the localized flood events in parts of the city, indicating they valued the importance of their duties but lacked support to deliver the service.

**Table 12: Questionnaire responses on O&M aspects**

	<b>The O&amp;M strategy in place is efficient for the maintenance of the storm water drainage system</b>	<b>We are well equipped with the tools to implement the O&amp;M strategy</b>	<b>We regularly take inventory of the state of the storm water drainage system</b>	<b>Proper maintenance of the storm water drainage system in Nairobi would help in reducing the localized urban flood events</b>
Strongly Agree	0	0	0	3 (23%)
Agree	7 (54%)	0	3 (23%)	10 (77%)
Neutral	3 (23%)	0	2 (15%)	0
Disagree	3 (23%)	12 (92%)	8 (62%)	0
Strongly Disagree	0	1 (8%)	0	0
<b>Total (n)</b>	<b>13</b>	<b>13</b>	<b>13</b>	<b>13</b>

Source: Primary data - Questionnaire to Department Staff

The responses from the questionnaire in table 12 indicate that availability of an efficient maintenance strategy does not immediately relate to good implementation of the operation and

maintenance plan. This showed that the critical aspects of operation and maintenance such as availability of an efficient strategy and plan must be supported and implemented in order to ensure good maintenance of the storm water drainage system which would then help in reducing localized flooding in Nairobi by efficiently managing surface water runoff.

The 9 interview respondents gave information on the aspects of O&M of the storm drains that influence reduction of localized floods such as adherence to plans, importance of inventory reports and proper solid waste management. The summary of responses has been tabulated in table 13. The responses were consistent with the questionnaire responses in that the main aspect of successful operation and maintenance of the storm water drainage system lies in both having a good plan and implementation of the plan.

**Table 13: Interview responses on O&M aspects**

Indicator	Question	Summary of responses	Frequency of responses
The type of maintenance strategy used by the Department in O&M of the storm drains	Considering the seasonal rainfall received in Nairobi, what would you say is the most appropriate maintenance strategy that would effectively be applied on the drainage system to curb localized flooding and why?	Predictive or preventative maintenance strategy is most appropriate. The strategy should be tailored towards curbing flooding and the financial ability of The Department i.e. inspections can be regular and maintenance should be just before the rainy seasons	8
Availability and use of O&M plans, work orders and inventories	What are the most critical aspects of operation and maintenance of the storm water drainage system in Nairobi?	Strict adherence to the O&M plan is the best way to improve service delivery and the state of the drainage system. Only having a good strategy and plan without implementation does not help.	9
		Importance of inspection and inventory reports. These help guide the O&M plans, budget and staff number	5
	<ul style="list-style-type: none"> <li>• What is your opinion on the performance of The Department of Roads, Public Works and Transport in terms of operation and maintenance of the storm water drainage system in Nairobi City?</li> <li>• How does operation and maintenance of the storm water drainage system influence the reduction or the increase of the occurrence of localized urban flood events in Nairobi?</li> </ul>	Low income high density areas are usually ignored when it comes to service provision with respect to maintenance of the drains	9
		Poor maintenance of the drainage system and its failure is also as a result of poor solid waste management in the City	9
		Dysfunctional (outdated) drainage systems also affect the O&M activities. There is only so much 'maintaining' that can be done to an old/under-capacity system to avert flooding. Performance of the system should also be appraised	8

Source: Primary data - Interviews

From the responses from the interviews summarized in table 13 the main aspect of operation and maintenance of the storm water drainage system that influence localized flood reduction

in the city is the implementation of a good O&M plan tailored to a preventative strategy. Furthermore, it was highlighted that the poor maintenance of the storm water system in the City has been exacerbated by a poor solid waste management system from lack of garbage collection that encourages dumping leading to waste in the drainage system. The poor performance of the storm water drainage system in reducing localized flooding in Nairobi is also due to the dysfunctional and under-capacity drainage system that is characteristic to many old neighbourhoods such as Madaraka Estate.

*Summary of the critical aspects of operation and maintenance of the storm water drainage system and how they influence localized flood reduction in Nairobi*

From the responses gathered in this study, the critical aspects of operation and maintenance of the storm water drainage system lies in the successful implementation of a well formulated operation and maintenance plan. From both the questionnaires and the interviews, the availability and knowledge of the operation and maintenance plan and its strategy had no bearing on the reduction of localized flood due to lack of implementation of the O&M plan and strategy. This has been due to limitations in human and financial resources that has led to the poor performance of the storm water drainage system in reducing localized urban floods in many parts of Nairobi. The critical aspects of operation and maintenance include the O&M plans and an appropriate strategy such as predictive maintenance, which includes tools of implementation and the required resources to execute the activities in a timely fashion.

The plans should be available and clear to all the responsible staff and should strictly be adhered to with all necessary support (Esmaili 2012, Malano, Chien et al. 1999). In accordance with reviewed literature from (Santa Clara Valley Urban Runoff Pollution Prevention Program 1999, Sullivan, Pugh et al. 2010) the availability of an efficient operation and maintenance strategy should always be accompanied by necessary resources to implement it to fully realise the O&M goals of The Department and this does not seem to be the case in this study. In this research there is full knowledge and availability of the plans to the O&M staff, but a gap in resources to support implementation of the O&M plans which has led to poor maintenance of the storm water drainage system in parts of Nairobi City. When drainage systems are not properly maintained throughout their operational lifetime, the capacity and proper functioning of the channels in the network is reduced and this leads to increased failure to effectively drain an area of surface water runoff during rainfall events. Failure to adhere to operation and maintenance plans and allocation of resources has often resulted in poor service delivery particularly to low income, high density areas of the city. Furthermore, dilapidated and outdated systems should be upgraded in order to achieve the purpose of flood protection to the city as a whole and improvement of the solid waste management system.

#### **4.2.4 The Causes and Trends in Localized Urban Flooding in Nairobi and its Relationship with the Storm Water Drainage System**

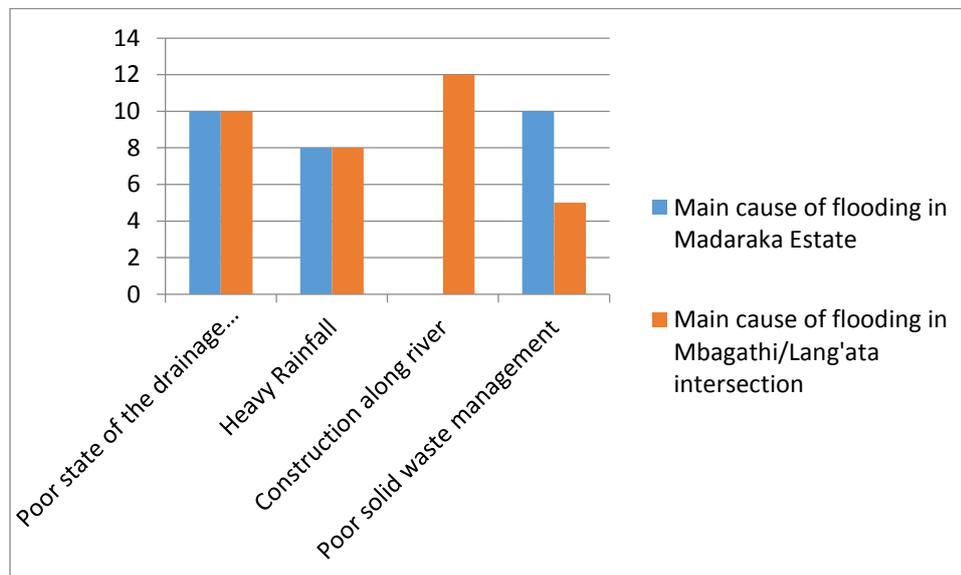
The final sub question in this study seeks to find a link between the localized flooding events in two areas in Nairobi namely Madaraka Estate and Mbagathi/Lang'ata intersection and the state of the storm water drainage system in these areas. The responses from the questionnaires gave an overview of the causes of flooding in these areas according to the staff within The Department while the interview responses validated some of these causes, the flooding trends and their probable solutions.

*a) The main causes of localized flooding in Madaraka Estate and Mbagathi/Lang'ata intersection*

The responses received from the 13 questionnaires are as shown in figure 11. The main cause of flooding in the areas seemed to differ slightly according to the respondents. The main cause

of flooding around the Mbagathi/Lang'ata intersection was attributed mainly to the construction along River Mbagathi that flows nearby that has constricted the channel width. This has been followed by the poor state of the drainage and the heavy rainfall in the area as other causes of rainfall. With respect to Madaraka Estate, the main cause of flooding was due to two reasons namely the poor state of the storm water drainage system as well as the poor solid waste management which directly affects the ability of the storm water drainage system to channel away surface run off. The poor state of the drainage system in both the locations also seemed to be a major reason behind the increase in localized flooding, as well as a poor solid waste management system in place particularly around the Madaraka Estate area. Poor solid waste management further exacerbates the clogging of storm water drainage systems through dumping and uncontrolled disposal of waste. These responses had also earlier been highlighted in section 4.2.3

**Figure 11: Causes of flooding in Madaraka Estate and Mbagathi/Lang'ata intersection**



Source: Primary data - Questionnaire

The responses from the 9 interviews were consistent with the 13 questionnaires. The main cause of increased localized flooding in both Madaraka Estate and Mbagathi/Lang'ata intersection is attributed to dysfunctional (undersized channels) and poorly maintained storm water drainage systems. However, from the interviews, poor solid waste management did not arise as a major issue in these areas as most of the respondents claimed that both the locations had generally good services due to the fact that they are associated with middle income families and users. Interesting also to note is that the amount of rainfall received does not always dictate occurrence of flooding, especially in Madaraka Estate according to one respondent from Kenya Red Cross, “sometimes even the regular amount of rainfall we receive here in the city causes a lot of damage in Madaraka. I believe this is because of the undersized and the blocked and poorly maintained storm water channels. They are working below capacity and thus even with surface runoff that can and should be sufficiently handled by the existing channel size; they are blocked and can't function for average rainfall amounts.” The summary of all responses can be seen in table 14.

**Table 14: Interview responses on causes of flooding**

Indicator	Question	Summary of responses	Frequency of responses
	Recently, during the rainy seasons some areas in	Dysfunctional (undersized channels) and poorly maintained	8

<ul style="list-style-type: none"> <li>Main causes of flooding in Madaraka Estate and Mbagathi/Lang'ata intersection</li> </ul>	Nairobi have experienced flooding that has caused a lot of damage, such as Madaraka area and the Mbagathi/Lang'ata intersection. What would you say are the causes of this flooding?	storm water drainage systems in both Madaraka and Mbagathi/Lang'ata intersection	
		Illegal constructions and encroachment of structures within the flood plain of Mbagathi River (Mbagathi/Lang'ata intersection), which constricts the river channel	5
		Poor solid waste management in both Madaraka and Mbagathi/Lang'ata intersection	3
		Increased rainfall in both Madaraka and Mbagathi/Lang'ata intersection (entire City)	5
	How can such causes of flooding be addressed?	Proper rehabilitation (maintenance) of the storm drainage systems based on a comprehensive evaluation of the state of the system	7
		Upgrade of undersized drainage channels based on a comprehensive evaluation of the state of the system and the volume of surface runoff.  Channel upgrade should also match urbanization changes of the location	8
		Efficient solid waste management especially in low income, high density areas as illegal dumping of waste exacerbates blockage of the storm drainage system	4

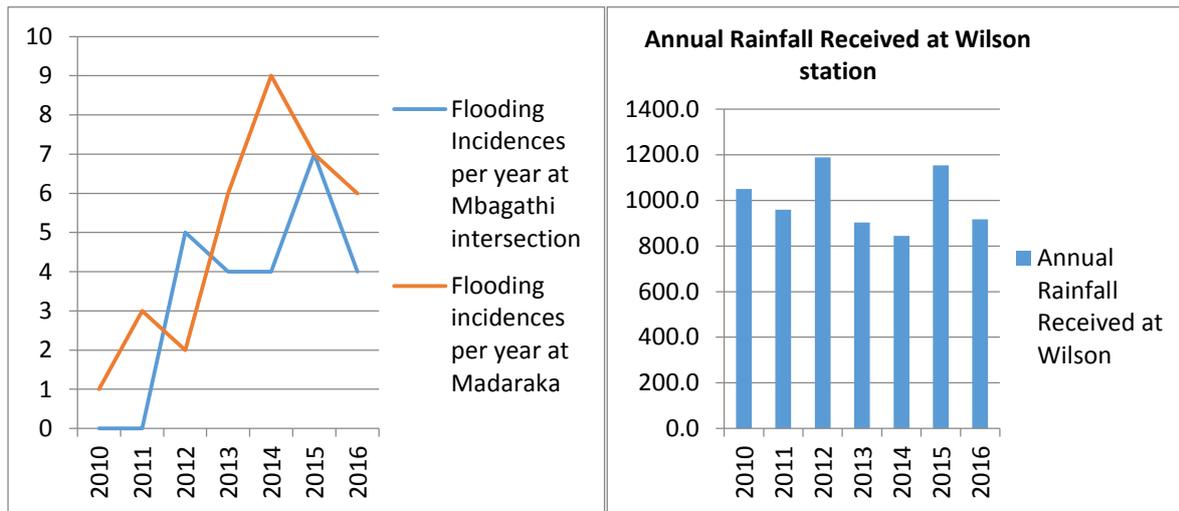
Source: Primary data - Interviews

According to 4 of the interview respondents, Madaraka Estate and Mbagathi/Lang'ata intersection do not always flood when it rains heavily and at times flooding in the areas occurs when the rains are not very heavy. One respondent from NDMU stated, *“From our records, Madaraka Estate is always on high alert when it rains. This is both during the long rains in April, when several other locations flood as well but also it is on high alert in the short rains around November and December. As for Mbagathi area, it is mainly a problem around April because apart from the bad drainage the river sometimes bursts its banks because its natural channel has been constricted.”* This reiterates the response from The Kenya Red Cross respondent.

*b) The frequency of localized flooding in Madaraka Estate and Mbagathi/Lang'ata intersection*

The data on flooding frequency in both Madaraka Estate and Mbagathi/Lang'ata intersection was obtained from the National Disaster Management Unit. It confirmed the reports reviewed in Chapter 2 from local sources. Figure 12 shows side by side charts of flooding frequency in both areas as well as the rainfall received annually from a nearby reference weather station managed by the Kenya Meteorological Department. The figure shows that flooding has increased in both locations between 2010 and 2016.

**Figure 12: Flooding frequency & Rainfall from reference station**



Source: NDMU disaster record database

It can be seen that despite rainfall ranging between 800mm and 1200mm between the years, the frequency of flooding has increased. This indicates a cause of flooding beyond rainfall received in the areas. This further confirms the information received from respondents summarized in Table 14 and Figure 11. The number of recorded flood events in both locations dropped from 2015 to 2016. This may be attributed to the reduced rainfall but also to the improvement of finances for Nairobi City County Government revenue available in FY 2015/2016 compared to in FY2014/2015 that subsequently trickled down to the operation and maintenance department as earlier seen in section 4.2.2 sub-section a).

*Summary of the trends in localized urban flooding in Nairobi and its relationship with the storm water drainage system*

From the data collected, firstly the occurrence of localized flooding in both Madaraka Estate and Mbagathi/Lang’ata intersection has increased over the years. According to all the responses received, poor operation & maintenance of the storm water drainage system is one of the main causes of localized flooding in Madaraka Estate and the Mbagathi/Lang’ata intersection. This confirms the conceptual framework adapted for this study in Figure 4 of Chapter 2. However, this is not the only factor behind the increase in localized flooding in the areas. For example, there has been a highly disputed structure erected over River Mbagathi that is believed to be constricting the river channel and could be causing more damage than the state of the drainage system particularly around the Mbagathi/Lang’ata intersection and causing flooding in the area when it rains. Furthermore poor solid waste management exacerbates maintenance work on the storm water drainage system.

According to (Douglas, Alam et al. 2008) in many developing countries, the impact of storm events causes more damage than it actually should due to the poor state and maintenance of the storm water drainage systems that should essentially drain surface water and ensure flood protection.

## Chapter 5: Conclusions and recommendations

The aim of this chapter is to draw conclusions based on the qualitative and quantitative data collected during the field visit and presented in the previous chapter by answering the research questions of this study and give possible recommendations on a way forward.

The aim of this research is to explain how operation and maintenance of storm water drainage systems by The Department of Roads, Public Works and Transport, may influence the reduction of localized urban flooding in Nairobi City through adequate provision of human and financial resources. This objective was based on the reports claiming that the increase in localized urban flooding in Nairobi has been caused by poor maintenance of the storm water drainage system and that the institutional weaknesses in human and financial resources at The Department were the reason behind the poor operation and maintenance of the storm water drainage systems.

From the review of literature earlier conducted in Chapter 2, operation and maintenance of storm drainage systems is viewed as one of the most critical processes in the proper asset management of drainage systems to ensure protection of society and the environment against floods and pollution of receiving water bodies. With respect to flooding in urban areas, (Douglas, Alam et al. 2008) has attributed the increase in flooding particularly in major African cities to the poor state of the storm water drainage systems. This ranges from lack of drainage systems, to outdated and under-capacity systems, to poor maintenance of existing storm water drainage systems. According to (International Commission on Irrigation and Drainage 1998), poor maintenance of storm water drainage systems in developing countries is attributed to inadequate finances, weaknesses in institutional arrangements, and low technical proficiency of the staff and managerial shortcomings of the organizations tasked with the care of the drainage systems in urban areas.

Based on the findings of this research, it is clear that The Department of Roads, Public Works and Transport within Nairobi is faced with a number of challenges that are reflected in the poor state of the storm water drainage system and in some instances in the increase in localized flooding in some parts of the city.

From the evidence gathered during this study, the most notable factors affecting the quality of operation and maintenance of the storm water drainage system and leading to an increase in localized urban floods from system failure are: *low financial resources* as a result of low county revenue, devolution of county governments and corruption, *limited staff numbers, lack of continuous staff training and a comprehensive performance-based reward system* and *poor implementation of O&M plans* due to the above human and financial resource limitations. The issue of low financial resources affected many aspects of the operation and maintenance of the drainage system, from support of staff to support of O&M activities. This resulted in poor implementation of O&M plans, slow execution of duties and un-motivated staff. The slow and poor execution of O&M duties, then resulted in poorly maintained and blocked storm water drainage channels in many parts of Nairobi causing the system to fail in channelling surface water runoff during storm events and leading to localized flooding in Nairobi.

### Sub Research Questions

**i. How does human resource influence operation and maintenance of the storm water drainage system?**

The influence of human resource on operation and maintenance of the storm water drainage system in this study can be seen through the adequacy of staff numbers, the training of the staff and the monitoring of their performance. The low staff numbers

within the Department have negatively influenced the operation and maintenance of the storm water drainage system by slowing down work and shifting prioritization of work, usually leaving O&M under-prioritized. The low staff numbers have been supplemented during field work of maintenance of the storm water drainage system by outsourcing temporary casual labourers but this is not as efficient especially in handling of other related O&M duties where outsourced labour cannot be used.

Furthermore, the lack of continuous training for all the staff in O&M of the drainage system also negatively influences their quality of work as well as their attitude. This has left a gap in skill development and the possibility of innovation that would have been directly applied to the operation and maintenance of the system.

Lastly, the lack of comprehensive performance monitoring which in this case has been revealed in a gap in the feedback of results of performance, has also contributed to the poor operation and maintenance of the storm water drainage system in Nairobi. This is because the gaps in performance by the staff are not addressed thus affecting successful implementation of duties.

These three indicators have shown how human resource has influenced operation and maintenance of the storm water drainage system in Nairobi as indicated in the conceptual framework in Figure 4 as well as through the views on human resource management by (Itika 2011, Wright, McMahan et al. 1994, Malano, Chien et al. 1999, Sullivan, Pugh et al. 2010). Additionally, this is in line with the framework for successful management of physical assets adapted in Figure 2 from the Institute of Asset Management's PAS 55-1:2008 that highlights the importance of adequate numbers, skill development, motivation and support of human resource.

**ii. How do financial resources influence operation and maintenance of the storm water drainage system?**

The influence of financial resource on operation and maintenance of the storm water drainage system in this study can be seen through the adequacy and availability of finances to cover costs related to the maintenance of the system and in the support of human resources. Lack of financial resources in terms of poor availability and shortfalls in attaining actual operation and maintenance costs has negatively influenced the operation and maintenance of the storm water drainage system.

Lack of finances affects the number of staff that is available and can be hired to support O&M activities. Furthermore lack of finances limit the effective implementation of the predictive maintenance strategy and the operation and maintenance plans. Lack of availability of finances and shortfalls in adequacy cripple the service delivery and demotivate staff hence directly influencing the operation and maintenance of the storm water drainage system in Nairobi. This confirms the literature reviewed from (International Commission on Irrigation and Drainage 1998) citing lack of financial resources, particularly in developing countries as the reason behind the poor management of storm water drainage systems.

The management of the storm water drainage system in Nairobi is not a service that generates its own direct revenue through fees and taxes that can then be redirected into the O&M of the system. This affects the prioritization and perceived importance of the service and the allocation of funds from the County revenue treasury (NCCG - Finance & Economic Planning 2016). The low financial allocation subsequently leads to poor service delivery in terms of O&M, leaving the drainage system in a constant state of deterioration and unable to protect against localized flooding during storm events.

**iii. What are the critical aspects of operation and maintenance of the storm water drainage system and how do they influence flood reduction?**

The critical aspects of operation and maintenance of the storm water drainage system is the successful implementation of O&M plans through a well-executed maintenance strategy. The availability and knowledge of the operation and maintenance plan and strategy must be followed up by effective implementation in a timely fashion in order to mitigate against localized urban flooding. Implementation requires resources and commitment (Hammond Murray-Rust, Svendsen et al. 2003, Jha, Bloch et al. 2012).

In this case, the predictive maintenance strategy in place is good; however, there is poor implementation of the strategy due to limited human and financial resource. The plans should be available and clear to all the responsible staff and should strictly be adhered to with all necessary support. The adherence to these plans determines the success of the O&M activities and the quality of service delivered. When the plans are implemented, the system has a better chance of operating with minimal failure as expected and thus may serve to reduce localized urban floods in the city (Department of Public Works Republic of South Africa 2015). The poor implementation of the operation and maintenance strategy and plan in Nairobi by the Department of Roads, Public Works and Transport has affected the capacity of the storm water drainage channel to sufficiently drain away surface water in many parts of the city thus causing localized flooding.

**iv. What are the causes and trends in localized urban flooding in Madaraka Estate and Mbagathi/Lang'ata intersection and its relationship with the storm water drainage system?**

From the data collected for this study it is also evident that the localized flooding in both Madaraka Estate and Mbagathi/Lang'ata intersection has increased over the years. Poor maintenance of the storm water drainage system in these locations is seen to be one of the causes behind the increase in localized flooding. This confirmed the local reports by (Juma 2016c, Mbugua 2016). The poor operation and maintenance of the storm water drainage system in Nairobi has been mainly as a result of limitation in staff numbers and their skill development and lack of a comprehensive follow-up in performance monitoring as evidenced in the result of sub-question i) above as well as the inadequate finances expressed from the results of sub-question ii).

However, the poor O&M of the storm water drainage system did not emerge as the only cause of localized urban flooding in the City. The failure of the storm water drainage system has also been exacerbated by poor solid waste management in parts of the city, which is also a responsibility of the Nairobi City County. Additionally, the constriction of river channels, and in particular Mbagathi River, from construction of buildings within the flood plain has been the cause of localized urban flooding. This can be broadly related to poorly managed urban development and implementation of City planning laws. Furthermore, the failure to upgrade dysfunctional storm water drainage systems that are under-capacity and cannot manage the change in urbanization and storm water generation has also led to the increase in localized urban flooding. Lastly, the change in meteorological weather patterns characterized by increased rainfall can never be ruled out as it is the basis of flooding events.

These causes of the localized flooding in Nairobi are consistent with the reviewed literature by (Douglas, Alam et al. 2008, Jha, Bloch et al. 2012, Falkirk Council 2009, Freni, Oliver 2005).

Interestingly, in Nairobi, from this study, the amount of rainfall received does not always dictate the possibility of flooding in many parts of Nairobi, making it even harder to predict the occurrence of these localized floods.

## **Main Research Question**

### **To what extent does human and financial resource influence operation and maintenance of storm water drainage systems for the reduction of localized urban floods in Nairobi?**

It can be said, from the evidence presented from the responses of the research that both human and financial resources do have an influence on the operation and maintenance of the storm water drainage system as most of the service delivery is dependent on these two factors. The low numbers and poor support of the human resource responsible for management of the storm water drainage system has had a negative influence on the state of the drainage system. Human resource is utilized in all the manual work pertaining to the system. Furthermore, the poor financial availability and adequacy affects the implementation of operation and maintenance plans and strategies and affects the support given to the responsible staff (Backmann, MacCleery 2006, Cole, Kelly 2011, Douglas, Alam et al. 2008).

Financial resource, from the evidence presented, influences the operation and maintenance of the storm water drainage system more than human resource as it affects both implementation of the O&M activities as well as the human resources required to implement the O&M activities. Finances are used in availing equipment, paying staff and their skill development needs as well as having an influence on the scheduling of activities based on financial availability (Esmaili 2012, Hammond Murray-Rust, Svendsen et al. 2003, International Commission on Irrigation and Drainage 1998). The direct influence of both human and financial resources when properly allocated and managed enhance service delivery, which in this case is ensuring the storm water drainage system works optimally to safely channel excess surface runoff and avert localized urban flooding.

## **Recommendations and Suggestions for Further Research**

In conclusion, a reflection on the literature invokes the need to increase the body of knowledge on ways in which to strengthen operation and maintenance of storm water drainage systems particularly in developing countries. From this research, it was evident that there is a shortfall in financial resources particularly as it is solely dependent on county government treasury allocation of received revenue. The possibility of added fees to building owners for their storm water generation based on the area of impervious surface may be a technique of channelling finances that are directly applied to the management of storm water drainage systems. Furthermore, more research is required on the development of effective maintenance strategies and standards that reflect the ability of The Department of Roads, Public Works and Transport in terms of human and financial resources, to manage the storm water drainage system.

This research was limited in scope by the sample size as it mainly focused on the responsible Department mandated with the management of the storm water drainage system. Further research may seek to expand this scope through looking into the department that is responsible for solid waste management as from the results of this research is closely linked with the failure of the storm water drainage system in protecting the society from flooding.

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# Annex 1: Data Collection Instruments

## Questionnaire

### Introduction

My name is Fiona Osiro, currently a Masters student at Institute of Housing and Urban Development Studies in Rotterdam. I am conducting a research on how human and financial resources influence operation and maintenance of the storm water drainage system for the reduction of localized urban floods in Nairobi. Kindly spare 15 minutes of your time to answer the questions below. I assure you that all the data will be treated confidentially. The information gathered will be anonymous and coded for academic purposes only. Personal data will not be disclosed unless otherwise stated with your permission.

Consent: Yes  No

Date:..... Employee Number:.....

Table 15: Questionnaire

	Question	Response
	<b>Background Information and Personal Details</b>	
1	Gender	Male <input type="checkbox"/> Female <input type="checkbox"/>
2	How long have you been an employee within the operation and maintenance department of Roads, Public Works and Transport?	
3	Educational level	High school <input type="checkbox"/> Diploma <input type="checkbox"/> Degree <input type="checkbox"/> Postgraduate <input type="checkbox"/>
	<b>Human Resource</b>	
4	How would you rate the number of staff available for O&M of the storm water drainage system	very poor   poor   average   good   very good <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>
5	Would a high number of staff improve O&M?	Yes <input type="checkbox"/> No <input type="checkbox"/>
6	Please Explain:	
7	Would a lower number of staff improve O&M?	Yes <input type="checkbox"/> No <input type="checkbox"/>
8	Please Explain:	
9	Human resource is important for the O&M of the storm water drainage system?	Strongly disagree   Disagree   Neutral   Agree   Strongly agree <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>
10	What factors dictate the <i>number</i> of skilled and casual labour needed by the department? (you may select more than one)	1. Remuneration to the staff 2. Changes in land use 3. Coverage area of the service and system 4. Severity of the work required on the system 5. Other.....

11	What factors dictate the <i>level of expertise</i> of skilled and casual labour needed by the department? (you may select more than one)	1. Remuneration to the staff 2. Changes in land use 3. Coverage area of the service and system 4. Severity of the work required on the system 5. Other.....
12	Have you ever attended training or skills development for your duties as part of the O&M team?	Yes <input type="checkbox"/> No <input type="checkbox"/>
13	Please enlist them: <i>(Title of training focus and organizer/ sponsor)</i>	1. 2. 3. 4. 5.
14	Training was helpful towards my duties within the O&M team	Strongly disagree <input type="radio"/> Disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree <input type="radio"/>
15	Continuous staff training is important for the operation and maintenance of the storm drainage system	Strongly disagree <input type="radio"/> Disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree <input type="radio"/>
16	How often is your performance monitored through staff performance appraisal?	<input type="radio"/> Every 3 months <input type="radio"/> Every 4 months <input type="radio"/> Every 6 months <input type="radio"/> Every 12 months <input type="radio"/> Every 2 years <input type="radio"/> Other..... (Specify)
17	Are the results of your performance appraisal revealed to and discussed with you?	Yes <input type="checkbox"/> No <input type="checkbox"/> Sometimes <input type="checkbox"/>
18	Continuous performance monitoring is important for the human resource responsible for O&M	Strongly disagree <input type="radio"/> Disagree <input type="radio"/> Neutral <input type="radio"/> Agree <input type="radio"/> Strongly agree <input type="radio"/>
19	We are rewarded based on our achievement of set performance targets	Yes <input type="checkbox"/> No <input type="checkbox"/>
20	We are rewarded based on an overall reward system <i>(rewards cut across the board regardless of individual performance)</i>	Yes <input type="checkbox"/> No <input type="checkbox"/>
21	We are not rewarded for our performance	Yes <input type="checkbox"/> <i>(no rewards)</i> No <input type="checkbox"/> <i>(rewards)</i>
22	Please state (other) methods that may be used to motivate your performance	1.



34	We regularly take inventory of the state of the storm water drainage system	Strongly disagree   Disagree   Neutral   Agree   Strongly agree ○                      ○                      ○                      ○                      ○
<b>Localized Urban Flooding</b>		
35	In your opinion, what is the main cause of flooding recently in the areas of Madaraka and Lang'ata/Mbagathi intersection?	1. Poor state of the drainage system 2. Heavy Rainfall 3. Construction along River Mbagathi 4. Poor solid waste management 5. Other.....
36	What methods may be used to reduce the flooding occurrence in the two locations mentioned in Q.33?	1. 2. 3. 4. 5.
37	Proper maintenance of the storm water drainage system in Nairobi would help in reducing the localized urban flood events	Strongly disagree   Disagree   Neutral   Agree   Strongly agree ○                      ○                      ○                      ○                      ○

### Conclusion

Thank you for your honest responses. The data collected will be prepared for analysis after which a qualitative analysis will be done in order to answer the research question. In conclusion, the findings will be reported and possible recommendations made. The thesis will be submitted to the school and copy deposited in the Library.

## Interview Guide

### Introduction

My name is Fiona Osiro, currently a Masters student at Institute of Housing and Urban Development Studies in Rotterdam. I am conducting a research on how human and financial resources influence operation and maintenance of the storm water drainage system for the reduction of localized urban floods in Nairobi. I would appreciate it if you would spare about 30 to 45 minutes of your time to answer a few questions. I assure you that all the data will be treated confidentially. The information gathered will be anonymous and coded for academic purposes only. Personal data will not be disclosed unless otherwise stated with your permission. Kindly allow me to record these proceedings for personal research use only.

Consent: Yes

No

1. What is your opinion on the importance of human resource for adequate O&M of the storm drainage system?
2. In your view, how does the number of staff responsible for O&M of the storm water drainage system affect carrying out of O&M activities?

3. Similarly, how does the level of skill of the staff responsible for O&M of the storm water drainage system affect carrying out of O&M activities?
4. The current number of staff within the Department of Roads, Public Works and Transport that is responsible for O&M of the storm drains in Nairobi is 16 technical staff, kindly comment on the adequacy of this number.
5. What would you say are the factors that dictate staff numbers and their skill level?
6. In your opinion, what is the importance of continuous staff training and how can it be utilized to improve operation and maintenance of the storm water drainage system in Nairobi?
7. What is the importance of staff performance appraisal in the O&M of the storm water drainage system?
8. Is a reward system an effective way of motivating the staff to improve their performance?
9. What is the most appropriate method of basing the rewarding staff?
10. In your opinion, in this situation what other ways may be used to motivate staff?
11. In your opinion, how do financial resources influence the O&M of the storm water drainage system?
12. Considering that The Department of Roads, Public Works and Transport falls within the Nairobi City County Government, what are the barriers to or benefits of availability of finances associated with this?
13. In your opinion, what factors would you say affect the availability and the adequacy (in terms of amount) of financial resources for operation and maintenance of the storm water drainage system?
14. How do shortfalls in terms of actual costs versus the approved O&M budget affect the operation and maintenance of the storm water drainage system?
15. What is your opinion on the performance of The Department of Roads, Public Works and Transport in terms of operation and maintenance of the storm water drainage system in Nairobi City?
16. Considering the seasonal rainfall received in Nairobi, what would you say is the most appropriate maintenance strategy that would effectively be applied on the drainage system to curb localized flooding?
17. What are the most critical aspects of operation and maintenance of the storm water drainage system in Nairobi?
18. How does operation and maintenance of the storm water drainage system influence the reduction or the increase of the occurrence of localized urban flood events in Nairobi?
19. Recently, during the rainy seasons some areas in Nairobi have experienced flooding that has caused a lot of damage, such as Madaraka area and the Mbagathi/Lang'ata intersection. What would you say are the causes of this flooding?
20. How can such flooding cases be addressed?

### **Conclusion**

We have now come to the end of the interview. I would like to thank you for your help and cooperation.

Is there anything you would like to add or is there anything you feel I could have left out?

The next step in the research will entail transcribing the interview. As a respondent, you are free to request for the transcript for validation if deemed necessary. The data collected will be prepared for analysis after which a qualitative analysis will be done in order to answer the research question. In conclusion, the findings will be reported and possible recommendations made. The thesis will be submitted to the school and copy deposited in the Library.

Thank you again for your help.

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