EVALUATION OF PUBLIC PERCEPTION ON VIABLE OPTIONS FOR REUSE AND INTEGRATION OF POST-MINE BROWNFIELDS INTO THE PLANNED URBAN LANDSCAPE OF KISUMU CITY, KENYA

BY

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DEDICATION

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ABSTRACT

Over time, urban development has spread into areas where mining activities were once carried out, hence the presence of degraded landscapes referred to as post-mine brownfields within the urban landscape. Brownfields constitute a poor fit into the urban realm and are largely seen as problem spaces. They are a safety concern due to crime and hazards associated with abandoned sites. They also take up vital urban land that could be used more productively, besides not being aesthetically appealing to residents of neighboring property. While there is need to rehabilitate Kisumu's brownfields into more productive urban land uses, it is not clear how such rehabilitation should proceed since the spatial attributes of these sites is not known. Similarly, public perception of the effects of these sites on the living environment is not clearly understood; as are public preferences on possible options for planned reuse. The main objective of this study therefore is to evaluate the public perception on viable options for reuse and integration of post-mine brownfields into the planned urban landscape of Kisumu City. The specific objectives of the study are: to examine the spatial attributes of the post-mine brownfields; to assess the public perception of the effects of post-mine brownfields on the ecological and social environment; and to analyze public preferences on possible rehabilitation land uses that the brownfields can be planned into. Cross sectional research design was used, with the unit of analysis being the brownfields and households living within a 500-metre radius from each brownfield boundary. The study found out that each post-mine brownfield had unique spatial attributes, meaning that planning for rehabilitation must be site-specific. The brownfields were generally small with sizes ranging from 0.45 Ha to 1.2 Ha and were all privately-owned. They had depths ranging from 3 to 15 metres, which posed a risk of falling in. They were also characterized by waterlogging and illegal dumping of wastes, which presented health hazards. The respondents indicated that the most preferred reuse option was construction of public facilities like school, community hall. Since all the brownfields were located within residential areas, the study concluded that the public facilities proposed must be compatible with the surrounding residential land use. Meanwhile, since the sites are currently used as illegal dumpsites, alternative waste management practices would need to be planned for. The findings should inform both policy and practice on the rehabilitation of post-mine brownfields, not only in Kisumu but in other Kenyan cities as well.

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ACRONYMS AND ABBREVIATIONS:

HOMBRE	-	Holistic Management of Brownfield Regeneration.
CABERNET	-	Concerted Action on Brownfield and Economic Regeneration Network.
COBRAMAN	-	Manager Coordinating Brownfield Regeneration Activities.
CLARINET	-	Contaminated Land Rehabilitation Network for Environmental Technologies
TIMBRE	-	Tailored Improvement of Brownfield Regeneration in Europe.
KNBS	-	Kenya National Bureau of Statistics.
KUP	-	Kisumu Urban Project.
KIWASCO	-	Kisumu Water and Sewerage Company.
NEMA	-	National Environment Management Authority.
EMCA	-	Environmental Management and Coordination Act, 1999.
EIA/EA	-	Environmental Impact Assessment/ Environmental Audit.
EMP	-	Environmental management plan.
GIS	-	Geographical information systems.
GPS	-	Geographical positioning system.

Kisumu ISUD plan - Kisumu Integrated Strategic Urban Development plan.

OPERATIONAL DEFINITIONS

1. **Post-mine brownfields**: Abandoned, underutilized landscapes that are degraded, distressed and ruined as a result of mining/quarrying for resources such as stones and sand. They are often but not always contaminated and require reclamation, rehabilitation to revitalize and bring them back into beneficial use.
2. **Urban landscape**: The built and unbuilt aspects of the city which includes the physical elements such as mountains, rivers, vegetation and human elements that include different forms of land use, buildings and structures.
3. **Integration:** Putting the abandoned post-mine sites into compatible land uses to the zoned, surrounding land uses through rehabilitation to merge and be in unity with the urban landscape.
4. **Derelict land:** Refers to land that because of mining, drilling or other industrial process, or by serious neglect is unsightly and cannot be beneficially utilized without mediation.
5. **Greenfield sites:** Undeveloped sites, usually on the urban periphery.
6. **Spatial attributes:** Refers to the site-specific characteristics of the post-mine brownfield like the geographical location, history, access/transport link, ownership structure, size of the site, type of previous use, topography, vegetation, views and neighborhood, fauna, activities on-site and land uses around the brownfield.
7. **Rehabilitation:** Means the transformation of land affected by mining into a new and beneficial land use.
8. **Reclamation:** Applies to derelict and abandoned lands such as post-mine brownfields. It requires returning disturbed land to a state where pre-disturbance conditions to a condition that is appropriate to the surrounding land uses and conditions.

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1.0 INTRODUCTION

1.1 Background of the Study

Mining is regarded as a crucial economic activity worldwide, however it is associated with significant negative impact on the environment as affects the ecological and aesthetic integrity of the landscape (Kuter, 2013). According to Arbogast et al (2000), increased demand for construction materials such as sand and gravel, crushed stone, dimension stone and clay due to rapid urbanization alters the landscape and is largely perceived as harmful to the environment.

Russ (2000), states that the derelict mine residue sites and abandoned industrial properties may also have real or perceived contamination and are hence considered as problem sites known as brownfields. Brownfields, according to Ferber et al. (2006), are sites that have been affected by the former uses of the site and the surrounding land and are derelict, underused and may have real or perceived contamination problems that require intervention to bring them back to beneficial use. Examples include abandoned sites of industry, construction, depots, mining, military installations, railways and other derelicts due anthropogenic activities. Jackle & Wilson (1992) portray various types of landscape dereliction to include underutilization, disinvestment, abandonment, vacancy, degradation and decay.

The presence and state of post-mine brownfields pose several safety threats in terms of crime and other social evils. They are possible accident sites and generally affect the environment negatively due to poor aesthetics (Dixon et al. (2007); Buckley & Mason, 2012). Mine residue sites have different spatial attributes and therefore different effects on their immediate environments. According to Dixon et al. (2007), and Siebielec (2012), problems on the environment range from economic and social to ecological, and may include being safety threats, crime areas, source of air pollution, as well as water and soil pollution. They are hence a source of health problems, besides not being aesthetically appealing to residents of neighboring property and the general public. Abandoned sites of quarries, according to Buckley & Mason (2012), attract a host of harmful and unhealthy land uses. These sites are commonly targeted for illegal dumping. Neglected quarry sites often become hang-out sites of local gangs, fuelling various forms of crime. Hazards associated with abandoned post-mine sites include serving as havens or dens for snakes,

bats and other dangerous fauna. Each post-mine site is unique and presents a variety of environmental and safety risks that may vary over time.

Brownfield geographical context, according to Frantal et al. (2012), shows that developed countries such as US, Great Britain, France and Germany have long experience with the problems of brownfields, which had already emerged during the 1970's as a result of massively declining mining and heavy industries. According to Russ (2000), in the United States for example various researchers estimate that from 25,000 to 40,000 sites may be considered brownfields. While these properties are generally considered a legacy of the urban industrial past, brownfields are also found in small towns and rural areas throughout the United States. In 2007, it was estimated that there are 64,000 hectares of brownfield land in England, 300,000 hectares in the UK much of which presents severe environmental challenges. Brownfield reclamation has become a major policy driver in developed countries and bringing such land into active use has taken a new urgency among several stakeholders (Dixon et al. 2007).

Most cities have not paid attention to reclamation issues of derelict brownfields within their jurisdiction. According to CLARINET (2002), inventories of derelict brownfields can be used as a tool to support both planning activities and marketing of the site. The lack of integrated datasets about brownfields is one significant obstacle for redevelopment. Jackson (2002), states that brownfields are a land use, planning and real estate problem that affects the entire community, reduces its quality of life, threatens its social integrity and depletes its property values. Brownfields stand both as an opportunity for recovering urban land and as a reminder of the harmful and wasteful practices of the past. According to Ferber et al. (2006), lack of spatial information including number, size, type of brownfields, infrastructure, and contamination has been defined as one of major bottlenecks for more frequent utilization of brownfields.

According to Kuter (2013), there is no unique reclamation planning scheme for the post-mining landscapes as each site is different and reclamation depends on site-specific characteristics that differ with each site and locality. Brownfields found in different areas have varying spatial attributes in terms of sizes, previous uses, locations, different effects to the environment. It is therefore vital to understand each brownfield in its own context before appropriate land use option for reuse is considered. Ramani et al. (1990) state that

the process of integration of post-mining sites starts with reconnaissance, site investigations until the final reuse option for the site is determined after engaging several stakeholders at different stages of the planning process. Viable options on how to reverse the negative effects and integrate the brownfields to be in harmony with other urban land uses must proceed from a careful analysis of each individual site.

In Kenya, several areas have realized continued quarrying for stones, clay, sand and other materials needed in the construction industry. All these have resulted into abandoned post-mine residue areas and more is still expected. Kisumu City has ongoing quarrying at several places for materials needed in the construction industry. Past industrial mining activities have left behind several acres of derelict sites within the urban area and peri-urban areas. The sites are considered as brownfields and some are within residential neighborhoods like Migosi, Nyawita and the Greater Mamboleo. The abandoned post-mine sites take up vital land that would otherwise be utilized in a beneficial way, are hazards due to crime and other social evils and are not aesthetically appealing due to illegal dumping of wastes within them making. Currently, information regarding the types of brownfields in Kisumu City, their spatial characteristics, effects on the environment and the best land-use options for reuse through reclamation is not known. This constitutes the knowledge gap that this study hopes to bridge. The study specifically intends to address the site-specific attributes of the post-mine sites within Nyawita, Migosi, Wathorego and Kanyawegi sub-locations.

1.2 Problem Statement

Most brownfields take up large portions of land within the core areas of the city that would otherwise be very useful in many ways, especially with the reality of shrinking urban land. Kisumu City has several degraded, distressed landscapes emanating from past mining activities. Past quarrying activities within the city resulted into brownfields that have not undergone any rehabilitation. These sites are currently seen largely as urban voids and problem spaces. Furthermore, the sites have since been fully engulfed into the expanding residential neighborhoods. They constitute a big reminder of the past industrial activities, while also posing several environmental challenges within the current land use and property development regime. Meanwhile, peri-urban quarrying for building materials like murram needed for ongoing roads construction is steadily creating the potential brownfields of tomorrow. There have been recent concerns by the County

Government of Kisumu on the need for sustainable mining and as well as rehabilitation of abandoned quarry lands Similarly, the recent debates surrounding the Kachok Dumpsite have led the County Government to consider the use of some of the old brownfields as possible recipients of debris emanating from the decommissioned Kachok dumpsite.

Nevertheless, each post-mine site has its site-specific characteristics (Kuter, 2013). This necessitates different integration options depending on the specific spatial attributes of the site. Thus, while similar studies have been done in other contexts, these cannot directly and fully inform the re-planning of post-mine brownfield rehabilitation in Kisumu City owing to varying spatial attributes and other site-specific characteristics.. Currently, specific information regarding the types of brownfields we have in Kisumu, their spatial characteristics, effects on the living environment and the best land-use options for reuse is not known. This lack of information on the current status of brownfields in Kisumu and their possible land use reuse options constitutes the problem statement for the current study.

1.3 Research Objectives

Main Objective

To evaluate public perception on viable options for reuse and integration of post-mine brownfields into the planned urban landscape of Kisumu City, Kenya.

Specific Objectives

1. To examine the spatial attributes of the post-mine brownfields in Kisumu City.
2. To assess the public perception of the effects of the post-mine brownfields on the living environment.
3. To analyze public preferences on possible rehabilitation land uses that the post-mine brownfields can be planned into.

1.4 Research Questions

1. What are the spatial attributes of the post-mine brownfields in Kisumu City?
2. What is the public perception of the effects of the post-mine brownfields on the living environment?
3. What are the most preferred land uses by the public that the brownfields can be planned into during rehabilitation?

1.5 Justification of the Study

Continued presence of post-mine brownfields without planning for their reuse into beneficial land uses through rehabilitation means the physical and social problems they pose will continue to be felt within their localities. If the present state is not addressed, then the risk of hazards due to accidents, safety threats due to crime, social evils and problems like illegal dumping that impact negatively on the environment will continue to be felt within the neighborhoods that host the abandoned brownfields. The presence of post-mine brownfields should thus be addressed through rehabilitation to eliminate their negative effects so as to achieve social acceptance, environmental sensitivity, and economic gain. If not done, environmental stigma associated with these sites continues and the urban landscape in general suffers. Koudela et al. (2004) state that brownfields reduce the intensity of utilization of an area, which negatively affects the urban economy by extension.

Reclamation is important in bringing the derelict brownfields that are considered wastelands and problem spaces back into beneficial use. Integration options vary from one urban area to the other and from locality to locality and hence a preferred reuse option applied in one area may not necessarily yield similar success in another brownfield in another locality. The study is vital to all the stakeholders including the quarry landowners, residents within the quarry locations, County Government of Kisumu, NEMA and planning and design professionals to rethink the need to address the presence of post-mine brownfields into beneficial land uses and thus eliminate their negative effects on the living environment.

1.6 Scope and limitations of the study

The study's geographical scope of the study was limited to four post-mine sites within the four sub-locations of Nyawita, Migosi, Wathorego and Kanyawegi. The four sub-locations were selected because of the long history of stone mining within them. The brownfields studied were once the sites of stone mining that was converted into ballast and other concrete products.

The limitations was partly due to the nature of the four sites under study due to the waterlogged nature, untamed overgrown vegetation and dangerous fauna like monitor lizards, snakes that hindered the access to some parts for onsite data collection of

attributes like pit depths at various places. The researcher was only limited to the areas of the abandoned quarry pit that he could safely and conveniently access. Pit depths for each site have therefore be presented as ranges to represent different areas within the sites.

Due to safety and security concerns, on site observation was only carried out during the day. Respondents who were unwilling to participate in the study may have also hindered the collection of important information on the effects of the post-mine brownfields and their choice of the preferred reuse options. As participation was voluntary, those who were unwilling to participate were skipped and those willing were sampled until the required sample size was reached in every site.

2.0 LITERATURE REVIEW

2.1 Spatial Attributes of Post-mine Brownfields

According to Harris & Dines (1998), the key to successful reclamation begins with a basic knowledge of the site and the nature of disturbance. There are many site factors that influence the various methods of reclamation like existing soil characteristics, existing vegetation, drainage patterns, etc. The actual methods used to reclaim disturbed landscapes will vary somewhat from region to region depending on the many differences involved between basic site factors.

Utilization of brownfields depends on many factors among them the availability of spatial information including size, type of brownfields, infrastructure, and contamination. Good documentation as inventories of spatial information on brownfields is therefore important. (Siebielec, 2012 citing Ferber et al. 2006). According to CLARINET (2002), the physical characteristics of the post-mine brownfields is one of the key elements in the determination of the after use of the post-mine brownfields during reclamation. Each brownfield has its unique physical attributes in terms of location, size, depth, drainage, landform, vegetation, etc. and are very important in determining the best reuse during reclamation. In general, considerations of after use operate at two levels: strategic land use planning and detailed site specific planning decisions. According to Hersch et al. (2010), site specific planning and assessment are integral to the proposed after-use of the site. They are interactive processes that ensure that constraints and aspirations are effectively addressed and proposals are thus appropriate for the site. Specific planning aspects like landform, drainage and vegetation have to be integrated at an early stage of the planning phase.

Frantal et al. (2012) state that some experts and researchers have emphasized that brownfields reclamation is a highly individual process, i.e. each project is specific and no generalization is possible. Hersch et al. (2010), emphasize that the physical dimensions of the site can have a significant effect on its highest and best use. If the site is too small and irregular in shape or has topographical challenges, traditional reuse options like residential are limited. Brownfield site access to primary transportation routes also has a positive effect on its future monetary value. Locations near public transportation routes or along major transportation corridors generally have higher values than those with poor access to transportation.

Novasak et.al (2013) states that spatial analysis of brownfields is very important in the redevelopment of brownfields and should not be considered in isolation. The location of brownfields close to highway network may be an important development factor for relatively large brownfields. Herberle & Wernstedt (2006) add that brownfields are placed and rooted in certain geographical space and time, which is hierarchically and functionally structured and therefore brownfields have to be perceived in their spatial context. We should therefore take into account site-specific attributes when assessing them. Site-specific factors and general factors such as location factors are among the most important in identifying and analyzing the relative importance of each brownfield. According to Siebielec (2012, citing Ferber et al. 2006), preservation of existing natural areas within brownfield environment to protect flora and fauna is important.

All the above reviewed literature point to the fact that each post-mine brownfield should have its site-specific spatial attributes analyzed in its own context and this forms important part of the planning process for the rehabilitation reuse option that may be implemented. Each of the sites under study should first have their spatial attributes inventorized before other steps in the rehabilitation planning process are considered. The study objective on spatial attributes will be addressed through a developed framework that will analyze and inventorize aspects on geographical location including GPS coordinates, access/transport link, history of the site, land ownership structure, size and depth of the quarry pits, topography of the quarry location, drainage within the quarry pit, views within the quarry, neighborhood, flora, fauna, activities on-site and possible land use conflicts.

2.2 Public perception of effects of the Post-mine Brownfields

Brownfields have several impacts on the urban structure of cities and their locations. Koudela et al (2004), suggest that "brownfields negatively affect the functional utilization of an area and they reduce the intensity of utilization of the area of concern which negatively affects the urban economy. Due to their neglected appearance, the inhabitants and visitors to the city form an impression of failure, social destruction and pessimism which is dangerous for the general social and political atmosphere of a city. According to Siebielec (2012), individual brownfields or areas with high brownfield density can generate environmental, social and economic problems. The type and scale of the related problem is a basic issue for feasibility of brownfield reclamation. Kryzystofik et al.

(2012), state that brownfields as a component of the urban environment interact negatively in most cases with the remaining elements and that there is need for rational usage of the post-industrial and post-mining areas as new elements of spatial and environmental components.

According to Koudela et al. (2004) and Siebielec (2012), the general problem of brownfields is the existing or assumed contamination of their soil that is linked to their ground water. Siebielec further states that other environmental problems that might appear are human exposure to contamination, hazardous wastes disposal and, air pollution. Buckley and Mason (2012), state that post-mine sites are commonly targeted for illegal dumping and this has negative impacts on the health of a community. Often it begins with someone using the abandoned lot to throw away their trash and once the first pile of trash appears more are sure to follow. This behavior is a nuisance and lowers the quality of life for the residents, besides creating serious health problems for the community.

According to the U.S Environment Protection Agency (2005), the sources and types of contamination at mine sites vary and can affect soil, groundwater and surface water. Surface water runoff from open pits can carry both toxic and non-toxic materials such as silt to stream and lakes. Seepage from water filled pits can also release contaminants to surface water and ground water. It must be clarified that not all brownfields sites are contaminated. According to Buckley & Mason (2012), studies have long linked high crime rates to areas that have visible physical deterioration. Many post-mine brownfields- are overgrown with untended vegetation and filled with trash from illegal dumping while Siebielec (2012), points out frequent social problems as migrations, job loss, concentration of problematic inhabitants, vandalism and crime risk, movement of labor.

Perception surveys are most often used when one is trying to find out how people understand or feel about their situations or environments. The study sought to assess the public perception of the residents within the four post-mine neighborhoods air pollution, any negative visual impact, possible contamination within them, breeding of mosquitoes in relation to waterlogging and untended overgrown vegetation.

According to a research carried out by Martinat et al. (2014) in Brno and Ostarva cities in Czech Republic, the public perception of contamination of brownfields in Brno and Ostrava strongly varies. More than half of the respondents (53%) from Ostrava were disconcerted about potential pollution of soil, water, and the environment in their city, while in Brno worries about possible contamination were showed by merely one quarter of respondents, which left almost three fifths (58%) of respondents perceiving the contamination as being not such a big problem (in Ostrava, though, this feeling was held by just one quarter of respondents). Significant differences in the opinions of Brno and Ostrava respondents appeared when discussing the perception of urgency (or lack thereof) in solving the brownfield problem. Brownfields are perceived as an important problem in Ostrava by almost 40% of the respondents (in Brno, only 16%); brownfields as a problem of the medium level of urgency were described by 80% of the respondents in Ostrava (62% in Brno).

Krause (2001), states that landscape is perceived as a visual resource. The holistic image of a landscape comprises not only its spatial and structural aspects but also the formal visual and cultural aesthetic expression of the landscape. The aesthetic value of landscape is one of the most threatened attributes of the human environment. This threat is particularly dramatic in post-mining landscapes. Sklenicka & Kasparova (2008), state that the key aesthetic problem of post-mining areas is the negative visual impact of the mining sites on the surrounding landscape. This means that the aesthetic value of the adjacent landscape is degraded mainly by the negative visual impact of the un-reclaimed sites. The negative visual impact of the mining sites unavoidably lowers the aesthetic value of the landscape and its surroundings. So, post-mining landscape planning and rehabilitation activities should strictly consider the previous aesthetic characteristics of the land and their future development within an interdisciplinary approach.

According to Simpson (1979), a person's perception of a mine in terms of visual impact is affected by distance from the mine, the viewing location, orientation of the mine, time of the day and conditions of the areas surrounding the mine. How visible a mine is from the residents also affects people's perception although the relationship between the magnitude of a mines visual impact and its visibility is debatable. As an example, most southern Appalachian mines in the U.S.A are not visible from major roads and

communities due screening from the mountainous topography and vegetation hence less visual impact. (Simpson, 1979).

When reclamation programmes do not integrate local community views about perceived quality of the landscape, a lack of acceptance and thus negative public reactions are likely to result. For brownfield regeneration projects to be effective, they should explore community views and consider all the functions that reclaimed sites can perform, in addition to mere economic functions". (European Commission on Environment, 2013).

2.3 Rehabilitation and Reuse Options for Post-mine Brownfields

Reclamation means the recovery of derelict land (abandoned industrial land including that from mining) to some productive use (Saperstein1990). According to Franks & Eskine (2012), rehabilitation means the process of improving disturbed land, including the development of new plant communities that may include some of the original plant species and may or may not have economic outcomes. The rehabilitation of disturbed land is a key environmental and social issue in the mining sector .The legacy of disturbed sites has created long-term challenges in many jurisdictions. The necessity to reclaim mining landscape arose in Europe with the massive closing of coal mines in the 1960's and 1970's. According to Bendor et al. (2011), an aspect of urban revitalization that has garnered widespread political support is redevelopment of under-utilized brownfield sites that are often located in dilapidated but core urban areas. In recent years, brownfield redevelopment has emerged as a sustainable land use strategy and one of several ways to address urban sprawl and promote economic development through new job creation.

Loures and Panagopoulos (2007), state that with increased perturbation as a result of abandoned past industrial landscapes, there has been increased deep public concern about reclamation. The strategies to reclaim derelict industrial sites should be the sustainability, quality and multi-functionality of the space with special attention to historic, socio economic and cultural aspects. There is need for reuse of urban brownfields and suburban greyfields in order to promote sustainable planning, design and management. (Lagro, 2008). "Greyfields" describes economically obsolescent, outdated, or underutilized lands such as older retail malls or strip centers that no longer attract adequate investment or tenants. Greyfields typically are not environmentally contaminated, but may contain older types of infrastructure that may need to be replaced. These lands are similar to

brownfields to the extent that they are underutilized. Sustainable brownfield regeneration as stated by Concerted Action on Brownfield and Economic Regeneration Network. (CABERNET, 2006),is the management, rehabilitation and return to beneficial use of brownfields in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations in environmentally sensitive, economically viable, institutionally robust and socially acceptable ways within the particular regional context.

Restoration of a landscape destroyed by opencast mining is very often understood as a technical or economic problem only (Bradshaw, 1987). Formerly, only forestry and agricultural forms of recultivation were regarded as being in the public interest. However, authors such as Pietsch, (1998) and Schulz & Wiegleb, (2000) report that recently, nature conservation and recreation have also been considered as land-use options. Successful rehabilitation of post-mining landscapes requires a holistic approach involving, among others, the ecological and aesthetic context.

Ruelle et al. (2012), state that for brownfield reclamation projects to be effective, they should explore community views and consider all the functions that regenerated sites can perform, in addition to mere economic functions. Koudela et al. (2004), state that reclamation of brownfields may improve negatively regarded urban structures of cities and offer solutions to traffic problems, construction of public utilities of a city-wide importance as well as the realization of recreational activities, the development of tourism etc. Hollander et al. (2010), state that brownfields are central to a sustainable planning strategy of thwarting urban sprawl, preserving or regenerating open space, reducing greenhouse gas emissions and reinvesting in urbanized areas. They further argue that compared to “greenfields”, farmland, forest or pasture lands that have never been developed, brownfields offer a more sustainable land redevelopment choice. Besides, it offers the advantage of addressing the urban sprawl issue, which has the crucial goal of achieving “smart growth”.

Brownfield revitalization is often long term, complex, and involves a wide range of professional disciplines as well as political actors and different stakeholder groups. Co-ordination and communication are essential to sustain complex projects, and the management of the process as such is more evident than sole technical aspects

(COBRAMAN, 2009). According to the American Planning Association (2010), determining re-use options of brownfields involves four steps. First, define the allowed uses of the given parcel of land in terms of local zoning policies. Secondly, determine the market conditions in terms of the highest and best use. Assessing the community needs comes third. The goal of this step in the re-use analysis is to determine what uses would improve the quality of life in the target area. The fourth step involves analyzing the options and determining an appropriate end use. Having generated a list of possible reuse options this final step involves measuring these options against the opportunities for collaboration and funding to help achieve a specific end use. If the intended reuse is harmonious with local comprehensive or neighborhood plans, partnering with the local government or with other private entities to redevelop the site is a viable option.

Wang et al. (2013) state that post-mining land use planning and design is a complex activity that requires knowledge about mining, skill and ability in planning and design, experience and collective input and that post-mining design projects should be ecologically sensitive, economically thoughtful, culturally aware, functionally capable and aesthetically appealing. Mborah et al. (2015) stress that the ultimate objective of post-mine land use and reclamation planning is to identify alternate land uses to which mined land could be put and this depends on land resources (such as physical, biological and cultural characteristics'), ownership, type of mining activity, legal requirements, location, needs of the community, economic, environmental, technical and social factors.

According to HOMBRE (2012), brownfields re-use can be for several uses that include unchanged use because of the ecological value of the site, adapted use on-sites that offer a basis for touristic or leisure related activities and use as community asset such as parkland. Other uses include return to agricultural production or forestry (such as urban farms and urban woodland), interim or final use for the production of renewable resources (biomass, solar power, wind power). According to De Sousa (2000), rehabilitation into parkland offers a good greening experience for redeveloping brownfields that has several benefits such as decreasing the risks of public health and safety, restoring former landscape, renewing urban cores, counteracting negative social stigmas associated with such sites.

The future uses, according to Görcelioğlu (2002), Topay et al. (2007), and Tshivhandekano (2004), can be the original land use, afforestation, forestry, agriculture, nature conservation and wildlife, hydrology, recreation, site improving, special reserve, settlement or industry. According to HOMBRE (2010), some derelict brownfields can be used to address the problem of urban sprawl into greenfields that is a major concern across many major cities. They can also be a good opportunity to plan and design new neighborhood green spaces for recreation in the face of shrinking public open spaces in the core areas of the cities. Michaud & Bjork (1995) state the use of abandoned mine sites as landfills to manage the increasing solid waste production can provide a means of reclaiming abandoned mines if done in an environmentally safe manner. These can also generate needed revenue and jobs and also ensure landfill space for future use due to increasing environmental protection and public opinion. Examples of abandoned mine lands used as landfills include Eagle Mountain Landfill project in Canada, Glenridge Quarry waste disposal at Niagara Falls Ontario Canada, Parklands reclamation (Formerly a clay pit) in Bordentown New Jersey USA. Landfills have been successfully constructed in limestone quarries, surface coal mines and clay pits. Stone quarries serve as landfills with good design and efficient installation of the impermeable liner and leachate collection system.

Quarries have a long history of being used for horticultural purposes, from gardens and orchards to parks. In the beginning of 1904 for example Butchart Gardens in British Columbia, Canada was reclaimed from 50 acres of an exhausted limestone quarry to a premier botanical garden that was opened in the 1940's and it receives more than a million visitors each year. (Arbogast et al, 2000). The post-mine sites if rehabilitated into neighborhood parks/parkettes can offer vital recreation spaces and act as breathers/lungs within the environment. Construction of public facilities can also be a reuse of the rehabilitated quarry lands. Behrens & Watson (1996), state that the location of a public facility depends on the specific function it performs and that there is need to analyze the site and determine which public facilities are required for residential settlements. Public facilities may include cultural facilities such as community centres, churches, health facilities like clinics, hospitals, educational facilities like nursery, primary school and administrative facilities such as police stations, information centres.

Mbora et al. (2015), citing Lintukangas et al. (2012), state that due to the special characteristics of natural stone quarries (which include physically stable quarry faces and benches created by quarrying, a water pond at the bottom of the quarry) post-mining uses such as scuba diving, climbing, forestry, fish or crab farming, amusement parks have also been recommended as appropriate alternate land uses. Some researchers (Narrei & Osanloo, 2011; Soltanmohammadi et al, 2010; Banjian et al, 2012; Masoumi & Rashidinejad, 2011) have provided a framework of classification which groups all feasible post-mining land uses under eight groups containing 21 or more individual land uses. The eight groups (table 1) are agriculture, forestry, lake or pool, intensive recreational land use, non-intensive land use, recreational, construction, conservation and pit backfilling.

Table 1.1: Possible alternatives for post-mine land-uses

No	Land-use	Types of post-mining land uses
1.	Agriculture	Arable farmland, garden, pasture or hay-land, nursery
2.	Forestry	Lumber production, woodland, shrubs and native forestation.
3.	Lake or pool	Aquaculture, sailing, swimming, water supply
4.	Intensive recreation	Sport field, sailing, swimming, fishing pond, and hunting.
5.	Non-intensive recreation	Park and open green space, museum or exhibition of mining innovations.
6.	Construction	Residential, commercial (such as shopping center), industrial (such as factory), educational (such as university), sustainable community.
7.	Conservation	Wildlife habitat, water supply (surface and groundwater).
8.	Pit backfilling	Possibility of landfill (as last resort).

Source: Mbora et al. (2015), citing Narrei & Osanloo (2011).

2.5 Knowledge Gap

Currently information regarding the types of brownfields in Kisumu City, their spatial characteristics, impacts on the environment and the best land-use options for reuse is not known. This constitutes the knowledge gap in this study. The review of literature in this section has helped to map out the key ideas about post-mine brownfields, in terms of their

spatial attributes, (perceptions of) their effects on the environment in terms of economic, social, ecological; and their possible reuse options through rehabilitation. Successful rehabilitation and integration of brownfields into the planned urban landscape depends on understanding their site-specific characteristics, their effects on the living environment and analyzing the best reuse options that are acceptable to the people within the immediate neighborhood, besides being in line with the current policy in terms of land use planning and development control by the relevant authority.

2.6 Theoretical Framework

This study employs the theory of landscape urbanism to help conceptualize the problematic of post-mine brownfield rehabilitation. Landscape urbanism is a theory of urban planning arguing that the best way to organize cities is through the design of the city's landscape, rather than the design of its buildings. The phrase 'landscape urbanism' first appeared in the mid-1990s. Since this time, the phrase 'landscape urbanism' has taken on many different uses, but is most often cited as a postmodernist or post-postmodernist response to the failings of new urbanism and the shift away from the comprehensive visions, and demands, for modern architecture and urban planning . The phrase 'landscape urbanism' first appeared in the work of Peter Connolly, a Masters of Urban Design student from RMIT Melbourne in 1994. According to Livesey (2009), it was after the Landscape urbanism symposium and exhibition that was coordinated by Charles Waldheim in Chicago in April 1997 that there was emergence of coherent group of theorists and designers like James Corner, Stan Allen, Alex Wall, among others.

Waldheim (2006), states that landscape urbanism is a term that combines architecture and landscape architecture. The approach of working with landscape urbanism is first of all the understanding of the contemporary city as an urban landscape where the boundary of what is built, meaning urban, and what is unbuilt, meaning landscape, is no longer relevant. Secondly, landscape urbanism approaches the design of urbanity as a flexible and unpredictable process where the flexibility is enabled by the strategic process-oriented work with the urban landscape. The theory as stated by Waldheim advocates for the idea of treating landscape as a medium for understanding and designing cities. Landscape considerations should be given more prominence in city building rather than believing that you get a city by piling up buildings. According to Mostafavi & Najle

(2003), as cited by Armstrong (2006), Landscape urbanists are interested in how permanent and temporary landscapes can restore the dynamism in post-industrial cities.

Why then landscape urbanism? Well, it meets the needs and challenges of ecological and sustainable urban form. According to Kongjian (2010), five traditions of landscape urbanism thinking include greenways, greenbelt, ecological network, ecological infrastructure and ecosystems services. Green ways entails landscape as an infrastructure of recreation and aesthetic experience through green spaces and parks. Greenbelt considers landscape as the urban form maker in terms of stoppers, green wedge, separators and connectors. At the end of the 19th century, the idea of greenbelt as a city stopper was appropriated by Ebenezer Howard and it became a fundamental element of his "garden city model". Ecological network considers landscape as infrastructure for biological conservation and play a decisive role where environments have been mostly humanized. Ecological infrastructure and ecosystems services considers landscape as integrated infrastructure for sustainable city and land and is the bridge between smart development and smart conservation.

The literature reveals several land use options that can be alternative reuse options for rehabilitated brownfields such as public parkland, construction of public facilities, agricultural production, landfill for waste disposal, forestry/conservation, human settlement and production of renewable resources. Landscape urbanism theory argues that the design of urban landscapes is the best way to organize cities however the characteristics of the brownfields, the reuse options should be understood in order to inform sustainable integration of brownfields into the urban landscape. Positive effects of brownfield integration after reclamation are therefore to be achieved through use of landscape urbanism.

Reviewed literature on landscape urbanism show that several planning and design professionals are advocating for landscape urbanism in shaping our cities. According to Shane (2005), the reason why landscape urbanism theory/approach can be applied in growing and declining areas is that it looks at the city as a dynamic and changeable process where it is important to incorporate social, cultural and economical aspects into the planning of the city. According to Corner (1999), the five general themes that characterize the practice of landscape urbanism are horizontality, infrastructures, forms of

process, techniques and ecology. Horizontality maximizes opportunities for roaming, connecting, interrelating, assembling and moving. Infrastructures include urban infrastructural systems that include transportation networks, utilities.

According to Livesey (2009), the most celebrated demonstration of landscape urbanism and its principles is the Downsview Park. Downsview Park was initially an isolated brownfield site on the extreme periphery in suburban Toronto, Canada. To transform the site, proposals through design competition were received from various designers among them Rem Koolhas, Bernard Tschumi and James Corner/Stan Allen which gave prominence to landscape to organize the spaces through landscape urbanism. The Downsview Park design is yet to be fully implemented and the design competition offered a good opportunity to study new ways of approaching urban parks design. The winning design was by James Corner and Stan Allen under their firm Field Operations.

2.7 Conceptual Framework

In the conceptual framework below (figure 1), the urban landscape is at the core of various effects from land uses within it. Its appearance is a result of both the positive and negative effects that originate from various land uses within it. Presence of post mine sites within core areas of residential neighborhoods and other former mining areas has the overall effect of impacting negative effects on the neighborhoods and the whole city at large. Post mine brownfields have several perceived negative effects like being a source of crime/social evil, hazards, air pollution. Possible contamination and breeding ground for mosquitoes. Planned land uses include residential, commercial etc. while post mine brownfields is a result of mining as an industrial land use that is affecting the neighborhoods within which they are found and the city at large. The presence of the un-reclaimed post mine brownfields has a relationship with the negative effects that they are perceived to be causing within the neighborhoods where they are found.

Site rehabilitation should be undertaken to reverse the negative effects of the brownfields. This can be done through several appropriate reuse options such as park land, agricultural production, construction of public facilities etc. in order to integrate the brownfields into the urban landscape. The study suggested the alternative reuse options listed in the figure 1 below to the respondents to choose their most preferred option to be implemented during rehabilitation of the various abandoned post mine sites. They included public

parkland, construction of public facilities, agricultural production, landfill for waste disposal, forestry/conservation, human settlement and production of renewable resources. Expected positive effects of integrating post mine sites into the planned urban landscape include safe and healthy environments and pleasant visual quality.

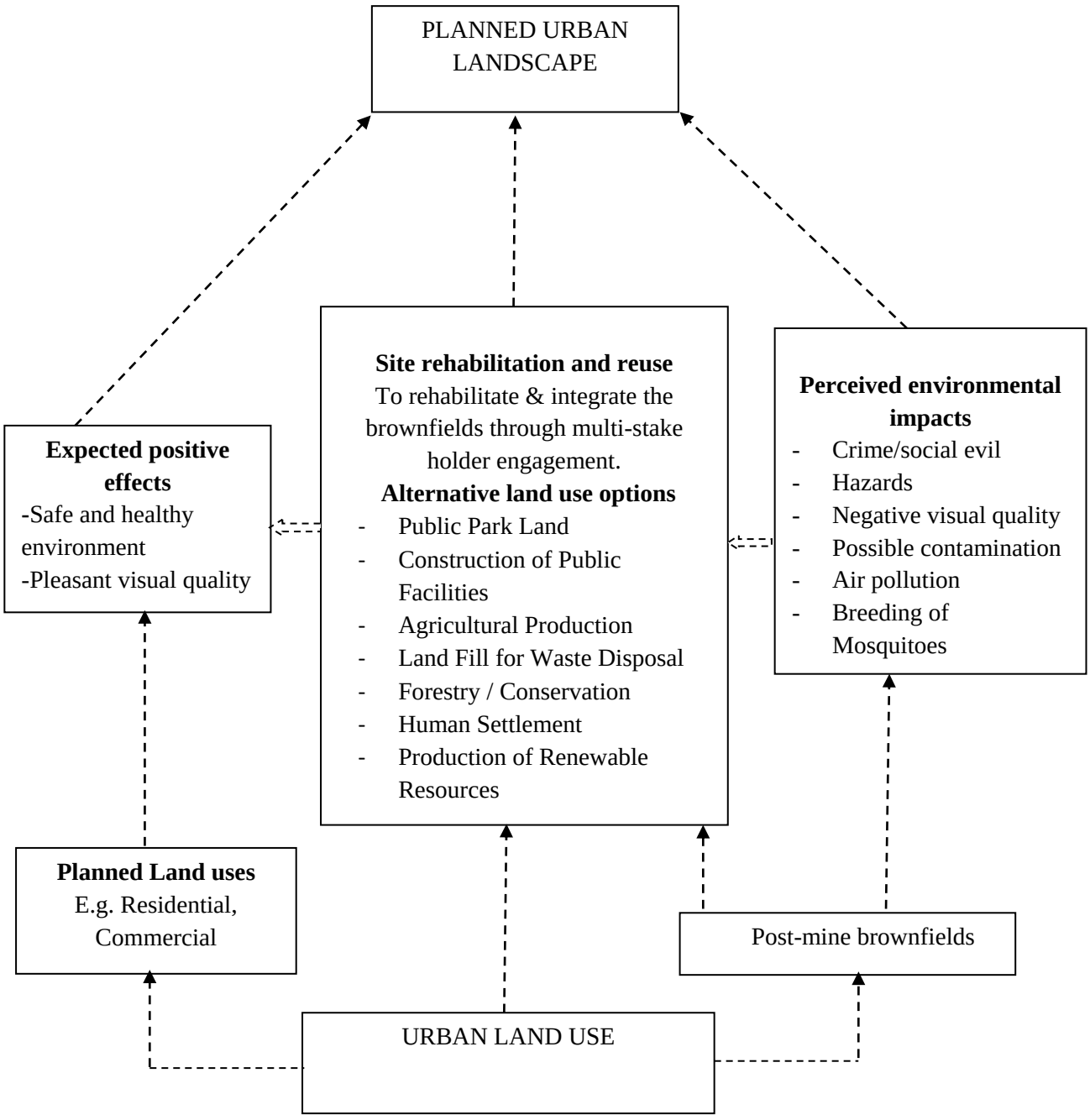

Figure 1: Conceptual model for integration of post-mine brownfields into the urban landscape. Source: Author own design.

3.0 METHODOLOGY

3.1 Area of Study

The study was conducted in Kisumu City which is in Kisumu County. Kisumu is the third largest city in Kenya and is the headquarters of Kisumu County. The city is divided into three electoral constituencies namely Kisumu Central, Kisumu West and Kisumu East. Kisumu City's population according to 2009 census report is 409,928. (KNBS 2009).Population and settlement patterns shows distribution of density throughout the city matches settlement typologies with unplanned areas exhibiting highest density in relation to Sub-locations size while in terms of growth currently unplanned areas record highest rates. (French Development Agency, 2013). It is 265 km north-west of Nairobi (346km by road), standing at the cusp of the Winam Gulf on Lake Victoria. It lies about 1,146 m above sea level and located 0^{o} 6' south of Equator and 34^{o}45' East. It is the largest city in Nyanza region and second most important city after Kampala in the greater Lake Victoria Basin. The city is located on the Eastern shore of Lake Victoria, the continent's largest fresh water body (68,000 sq km) at the heart of the African Great Lakes region. (French Development Agency, 2013). Kisumu has sub-humid and semi-humid tropical climate with high mean temperatures of about 23°C and rainfall that varies with altitude. The study will focus on post-mine brownfields within Kanyawegi, Migosi, Nyawita, and Wathorego.

Kisumu City has increased demand for building materials like sand, stones that are quarried within several areas. The road industry that is undergoing expansion has also spurred the quarrying for backfilling material like murram, sand and stones and this has led to more and more landscapes that are distressed and degraded within the quarry areas.

Migosi Sub-location is within Kondele Location of Kisumu Central Constituency/Sub-County and was as a result of Municipal site and service scheme that ensured it has necessary tarmac road network, Council sewer lines, electricity and water supply currently supplied by KIWASCO. The neighborhood is well planned with most developments having secured planning and development permissions from the City Council. It is dominated by semidetached bungalows and flats for residential rentals. According to KNBS (2009), census report it is densely populated at 4795 households within an area of 1.9 square kilometers and total population of 19,826 people. It's cosmopolitan with people from different ethnic origins.

Nyawita Sub-location is found within Kondele Location of Kisumu Central Constituency/Sub-County. According French Development Agency (2013),Nyawita falls under the large belt of unplanned settlements and has informal housing mostly consisting of non-approved developments. It is densely populated with 4099 households within an area of 1.3 square kilometers. It has a total population of 14,747 people. (KNBS, 2009). It is served by untarmacked earth road networks within it, electricity supply, and water supply from KIWASCO. It however lacks any sewer line network from the County Government of Kisumu. Main economic activity within Nyawita is various forms of businesses like retail shops, salons etc. Nyawita has an urban market called Ayanga whose land was donated by the locals. (French Development Agency, 2013).

Wathorego is within Kajulu West Location of Kisumu East Constituency/Sub-County. KNBS (2009), census report shows that it has a total population of 11,823 people, 2849 households within a total area of 9.0 square kilometers. It has water supply by KIWASCO, lacks municipal sewer line and has electricity supply within it. Main economic activities include agriculture and quarrying for sand and stones. Quarrying for stones is carried out by companies that crush the stones into ballast and other products that they further use to process concrete products like building blocks, road kerbs and paving slabs. The quarrying companies are a major source of employment within Wathorego Sub-location. The quarrying that is still within the two main companies found there is a major source of land use conflict with the nearby residential houses due to noise, vibrations and dust emissions. Wathorego has a suburban market that is an important exchange place for the peri-urban population within it. (French Development Agency, 2013).

Kanyawegi Sub-location is within Kisumu South West Location of Kisumu West Constituency/Sub-County. Land use designated for the area is peri-urban farmland i.e. agricultural use and land tenure is mostly private freehold. (French Development Agency, 2013). It has a total population of 6,529 people. It is sparsely populated at 1454 households within an area of 17.4 square kilometers. (KNBS, 2009). The main economic activities are agriculture, quarrying and various forms of businesses such as retail trading. Agriculture is mainly subsistence and is by the households. Quarrying is undertaken by three main companies that is Shajanand Holdings Limited, Pride Enterprises, Hayer Bishan Singh and Sons Limited. The companies quarry for stones that are further crushed

into other by products like ballast of various sizes and quarry dust. They further use the by-products to manufacture concrete blocks, road kerbs, paving slabs etc. They are a major source of employment within Kanyawegi Sub-location. The quarrying activity that is still ongoing within this neighborhood is a major source of land use conflict with the residential households already in their vicinity in terms of noise, dust pollution, vibrations. Kanyawegi Sub-location has electricity supply within it but lacks sewer lines provided by the County Government of Kisumu. With continued urbanization and population increase within core areas of Kisumu City. Kanyawegi and its environs is a perfect area for suburbanization with more households settling there. Trade within the area is within the centres of Chuth Ber and the nearby suburban market at Obambo that is designated by the local authority.

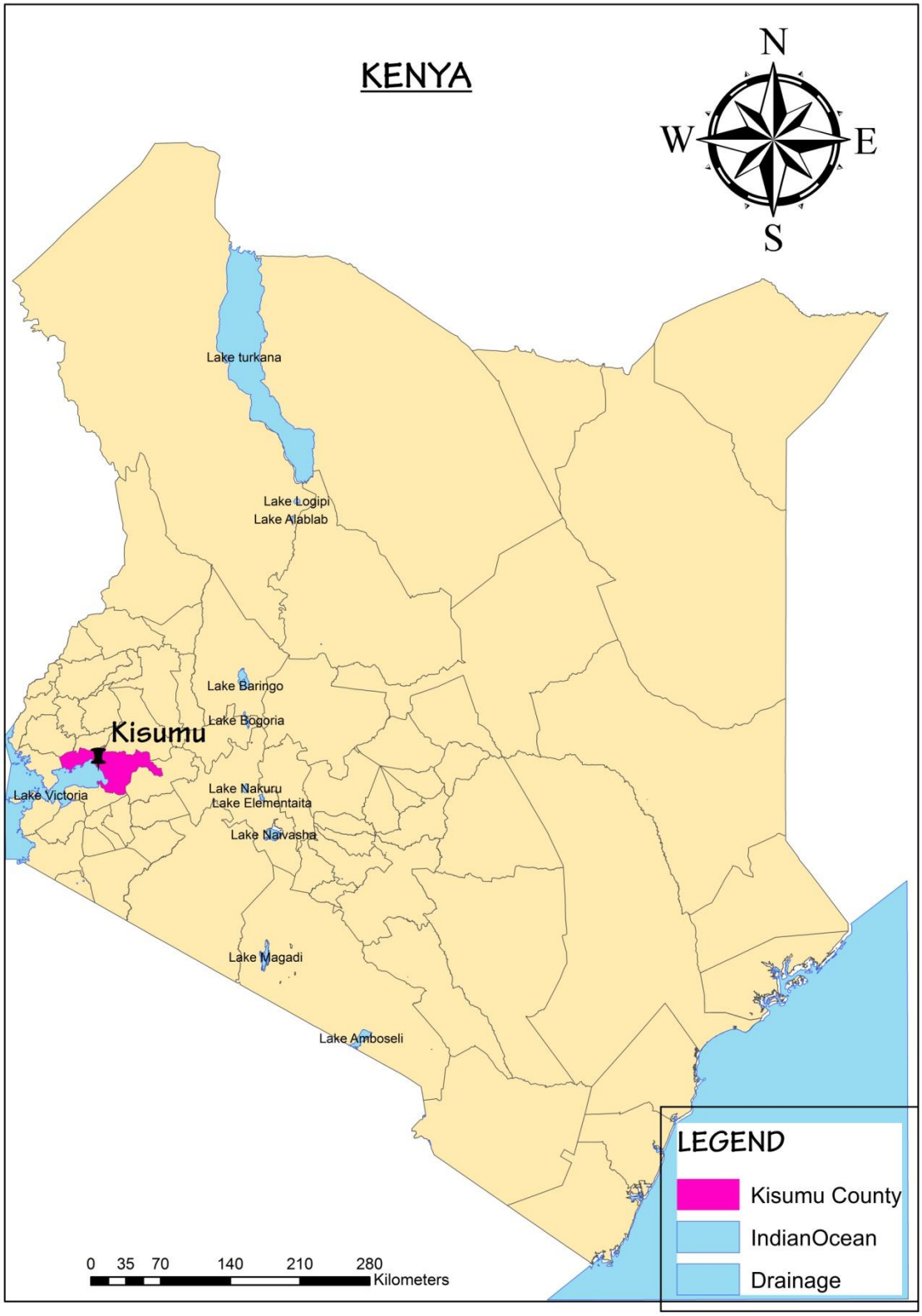

Figure 3.1: Map of Kenya showing location of Kisumu County.

Source: Internet Google maps.

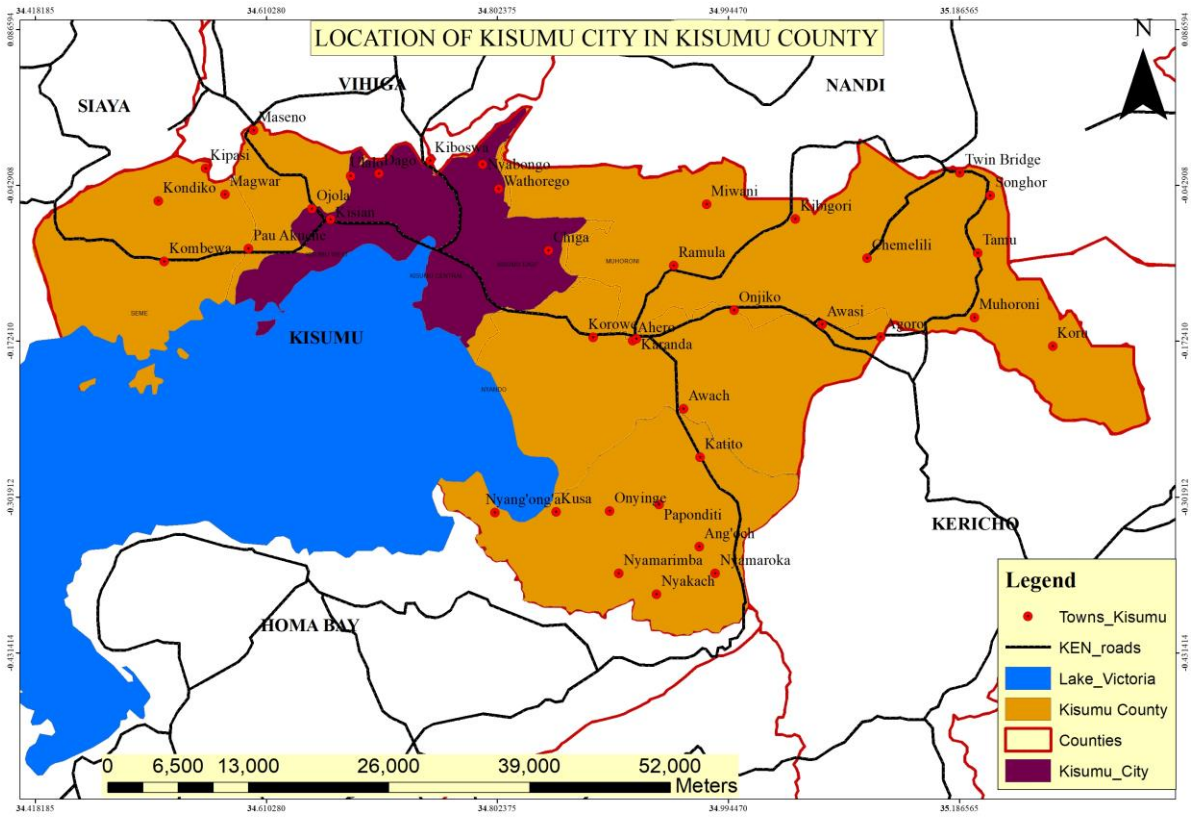

Figure 3.2: Map of Kisumu County showing location of Kisumu City.

Source: Digitized satellite aerial imagery.

3.2 Study Population

The study area comprised four sub-locations namely Wathorego (Kisumu East Constituency/Sub-County), Kanyawegi (Kisumu West Constituency/Sub-County) and Migosi and Nyawita within Kisumu Central Constituency/Sub County. The total population within the four Sub-locations is 52,925 people and 13,197 households however from the reconnaissance carried out not all the population and households were aware of the post-mine brownfield within the sub-location.

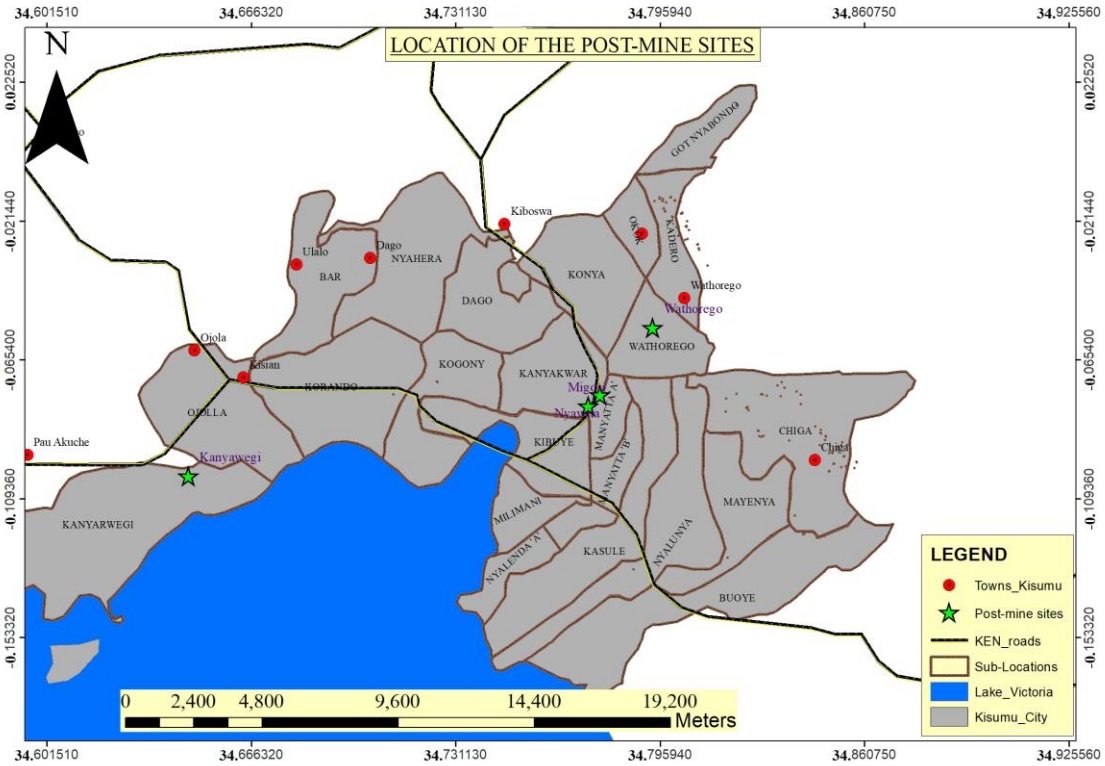

Figure 3.3: Map of Kisumu City showing location of the four post-mine sites under study. Source: Digitized satellite aerial imagery.

3.3 The Research Design

The cross sectional research approach was used to study the post-mine brownfields in terms of their physical and social effects on the environment, the preferred rehabilitation reuse options to determine the viable land use options. Reconnaissance study was conducted in the month of February, 2015 to identify and locate the post-mine brownfields within the study area of Migosi, Nyawita, Wathorego and Kanyawegi sub-locations. The reconnaissance was carried out by interviewing the area sub-chiefs who are well versed with the location, number and landowners of the brownfields within their areas of jurisdiction. The study was carried out between October and December 2016 for data collection and analysis.

According to Pearsall (2010), as cited by Fisher (2011), other studies have defined a brownfield neighborhood as a 500 meter (0.3 mile) circular radius around a brownfield. Other studies by Esoka (2010), considered a slightly larger radius of 0.5 mile to allow for more general understanding of socio-economic character of areas adjacent to brownfields.

The study was based on households that are living within the 500 metres from the boundary of the brownfield within each of the four sub-locations due to the fact that some households within the brownfield localities were not aware of the presence of these abandoned quarry sites and felt they were not affected by them. Data was collected from residents around each post-mine brownfield. The criteria for selecting the respondents was that they lived within a 500 metres radius from the boundary of each post mine brownfield within each sub location boundary.

3.4 Sample Size and Sampling Frame

The sample size from the number of households for the post mine brownfields within the study area was obtained as follows. According to KNBS (2009), the four sub locations where the four post mine sites are found have a total of 13,127 households. A total of 3300 households constituting a quarter number for all the households within the four sites was used to calculate the total sample size for all the four sites.

Sample size calculation according to Mugenda & Mugenda (2013), for population less than 10,000 the sample size is calculated as follows.

$$nf = \frac{n}{1+n/N}$$

Where: nf= the desired sample when population is less than 10,000

n= the desired sample size when population is more than 10,000

N= the estimate of population size

$$\text{Therefore } n = \frac{384}{1+10{,}000/3300}$$

Sample size: **96 households**

A total of 96 households was sampled for the four sub locations to represent the whole study area was used. The sub samples for each site was calculated proportionately according to the total number of households it has within the total for all the households within the four sites. The number of households that constituted the sample for each sub location was therefore Migosi 35 households, Nyawita 30 , Wathorego 21 and Kanyawegi 10 households as shown in the sampling frame in the table below.

Table 2.1: Sampling Frame:

Kisumu city constituencies/sub counties	**Sub locations**	**Sampled sub locations & Total population**	**Total number of households (KNBS,2009)**	**Number of households sampled**
Kisumu east (12 sub locations)	Got Nyabondo, Kadero, Okok,Konya, Wathorego, Buoye, Chiga, Mayenya, Manyatta B, Nyalenda A, Nyalunya, Kasule	Wathorego (Population 11,823)	2,849	21
Kisumu central (7 sub locations)	Kanyakwar,Bandari, Nyawita,Migosi, Kaloleni, Manyatta A, Nyalenda B	Nyawita (14,747) Migosi(19,826)	4,099 4,795	30 35
Kisumu west (19sub locations)	Ojolla,Osiri, Kanyawegi, Kogony,Dago,Mkendwa, Bar A & B, Nyahera, Newa, Upper Kadongo, Lower Kadongo, Kapuonja, West Karateng, East Karateng, Sunga, Marera, Korando A & B.	Kanyawegi (6,529)	1,454	10
Total for the 4 sampled sub locations		**52,925**	**13,197**	**96**

Source: Author

Table 2.2: Key Informants

Key informant	Organization
Director of City Planning	County Government of Kisumu, Planning Department
Director of Environment	County Government of Kisumu, Environment Department
Senior official	Kisumu Urban Project (KUP)
Director NEMA	NEMA, Kisumu County office
Mines and Explosives officer	Ministry of Mining ,Mines and Geology Department
Physical planner	Ministry of Lands, Physical Planning Department
Private practicing Planner	Private office
Brownfield/quarry landowners	Nyawita (2 no.), Migosi (1 no.), Wathorego (1 no.) & Kanyawegi (1 no.).

Source: author

3.5 Sampling Procedure

-Selecting sampling sites

A reconnaissance study was carried out for post mine brownfields within Kisumu City and those sampled were the abandoned quarry sites formerly quarrying for stones that were in areas of long history of mining and that had population of people living around them. All the four brownfields under study were identified and selected for study using purposive sampling method due to their large sizes. Each brownfield became a sample site due the fact that they were existing sites of former stone mining areas and that they no longer carried on with mining activities.

-Selecting sample households

Selecting the households for each brownfield site was based on the sampling frame above with a total of 96 households for all the four sites. Random sampling was used to collect data from the households from the boundary of each site and in the subsequent radii within the 500 metres boundary. Five concentric circles were drawn in GIS were used to approximate the various radius for data collection around each site. Data was collected from the respondents within each diameter of the concentric rings around each site with each first household being selected randomly and others within the ring picked randomly at various ends all-round the diameter.

Proportional stratified sampling technique was used to calculate the number of households to form the sub samples to be interviewed within each of the four sub locations of the study area. Respondents within the various radii were distributed equally.

The unit analysis in the study are the individual brownfield sites and the households found within 500m metres radius of the brownfield neighborhood for each site. All respondents were picked and included to form the sample size where the household members were willing to participate in the study. Data collection was limited to the various boundaries of each sub location even in cases where the 500 metres radius overlapped into the other neighboring sub location like in the case of Migosi and Nyawita.

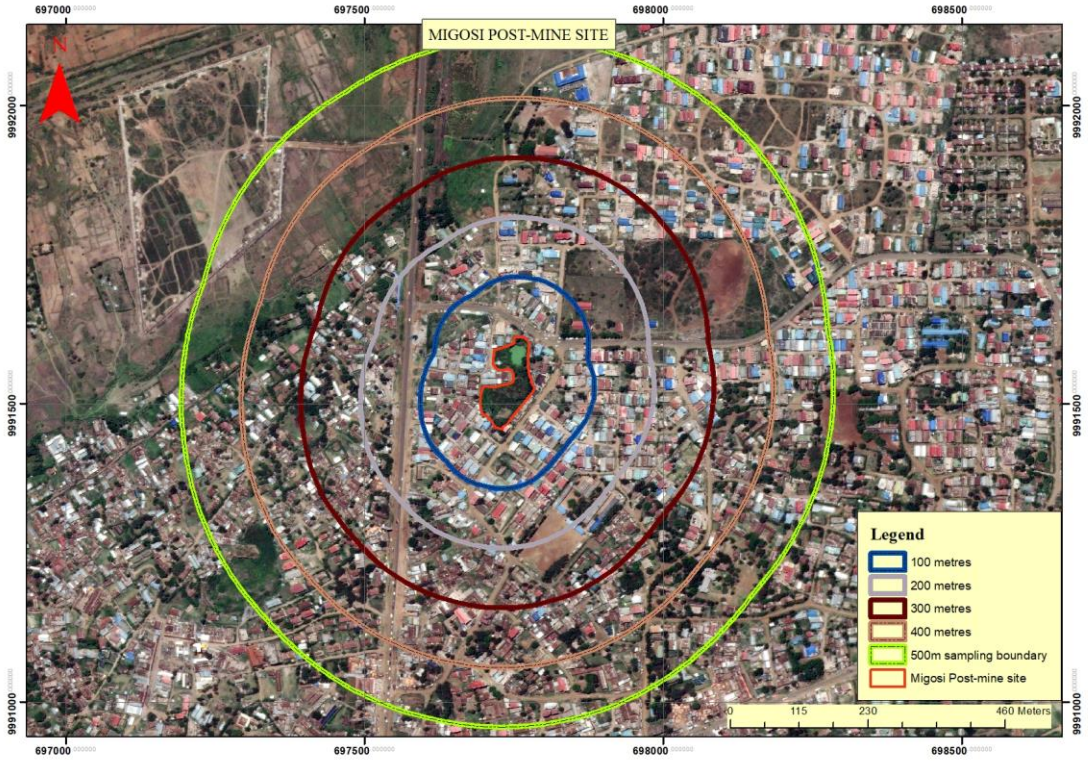

Figure 3.4: Satellite aerial image showing sampling radius intervals and the 500 metres sampling boundaryaround the Migosi post-mine site.
Source: Satellite aerial image

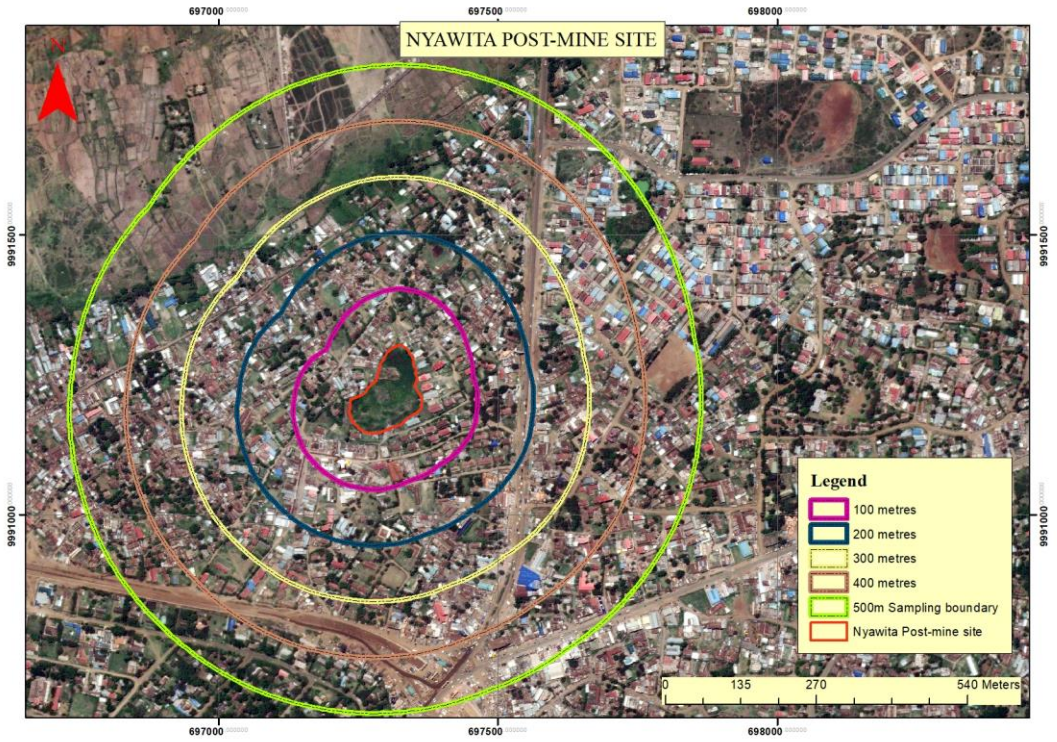

Figure 3.5: Satellite aerial image showing the sampling radius intervals and the 500 metres sampling boundary around the Nyawita post-mine site.
Source: Satellite aerial image

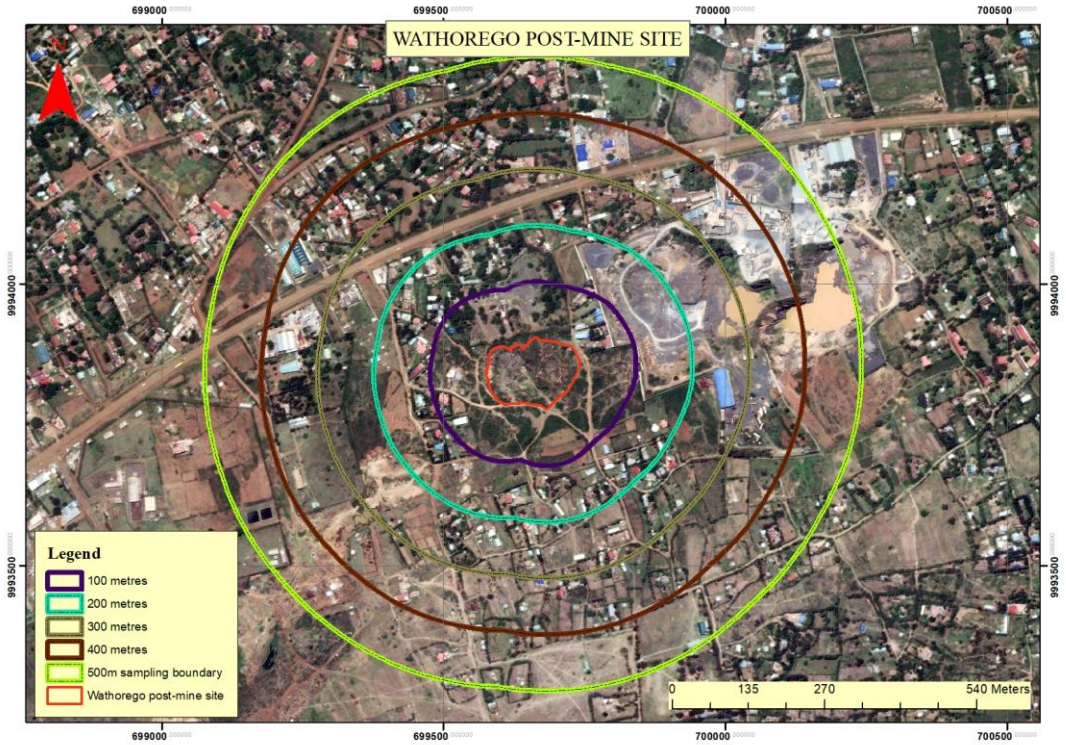

Figure 3.6: Satellite aerial image showing the sampling radius intervals and the 500 metres sampling boundaryaround the Wathorego post-mine site.
Source: Satellite aerial image

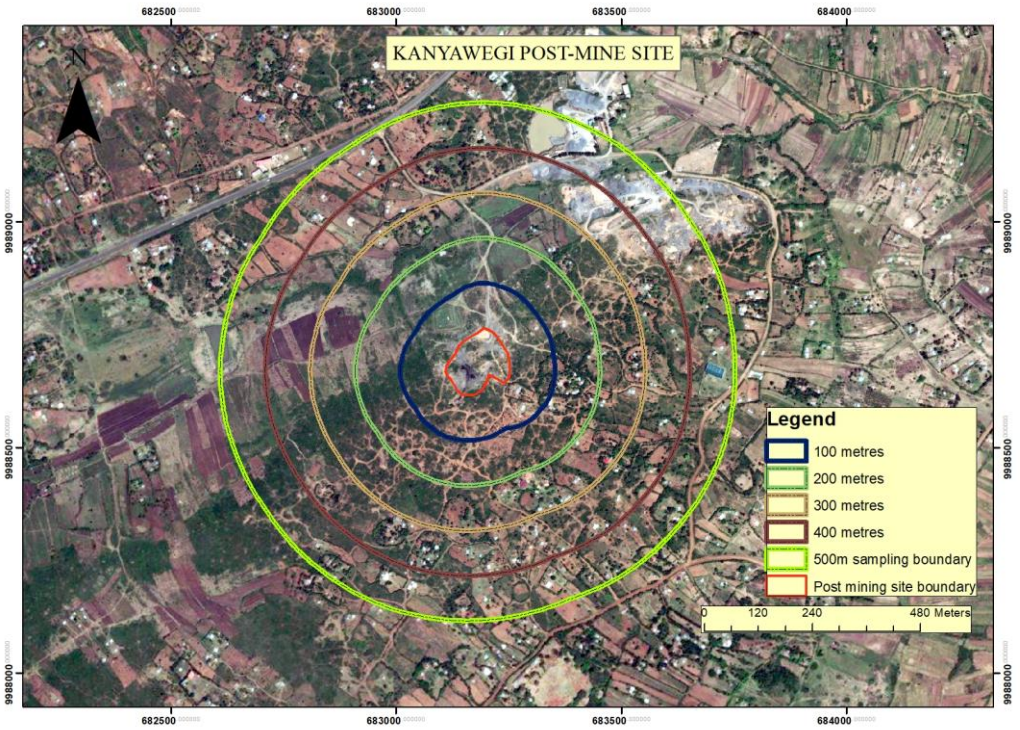

Figure 3.7: Satellite aerial image showing the sampling radius intervals and the 500 metres sampling boundaryaround the Kanyawegi post-mine site.
Source: Satellite aerial image

3.6 Data Collection

3.6.1 Secondary data

Secondary data was collected from books and journals from the library and the internet. Other secondary sources included maps from the County Government of Kisumu's geographical information section and the internet. Secondary data obtained has given an insight into the spatial attributes of post-mine brownfields, their physical and social effects on the environment and possible reuse options that can be applied due to reclamation.

3.6.2 Primary data

Three approaches were used to collect primary data i.e. questionnaire, observation guide and photography and lastly interview schedule for key informants. Primary data was collected to address the three objectives of the study.

3.6.2.1 Questionnaire

This was the major research instrument used in the survey. Study objective two and three guided the formulation of the questionnaire. The respondents were asked their perception on various effects of the post-mine sites within their neighborhoods and the preferred reuse option to rehabilitate the abandoned quarry sites into. Structured questionnaires which consisted of open and close ended questions were used during the data collection process. The questionnaires were administered by the researcher and involved first identifying himself then clarifying the purpose of the study. The researcher ensured the respondents completed all questions by checking during the handing over of the questionnaires. The sample questionnaire that was used for data collection is attached as Appendix I at the end of the document.

3.6.2.2 Observation guide and photography

On site observation was carried at random times of the day for each of the four sites under study. Direct observation involved checking on dumping of wastes. The site visit was carried out to collect data on spatial attributes such as size of the quarry, pit depths, flora and fauna, topography and drainage, existing land uses around the site, activities on site.
Data on size and pit depths for each site was carried out through measurement by the use of tape measures and calculating the areas of the quarry through GIS software ArcGIS after plotting the each site boundaries in the software. Pit depths were measured for areas within the quarry land that were safe and accessible by use of tape measure. Hindrances included overgrown untended vegetation, water logging that made some areas inaccessible.

Photography using a digital camera was done to record various spatial attributes such dumping of wastes at various ends of the quarry lands, activities carried within the sites, existing land uses around the sites, flora and fauna, topography and drainage. Observation and digital photography helped the researcher to cross check some of the responses from the respondents done through questionnaire. The photographs taken have utilized in various sections of this study report. Data collected during the site visits through measurements, observation and photography were important in addressing the first specific objective of the study. The attached observation guide (appendix VI) was used to carry out the observation on-site.

3.6.2.3 GPS and GIS mapping

A geographical positioning system (GPS) equipment was used to record the latitude and longitude coordinates to give the exact location of each of the four sites. The coordinates were later used to map each brownfield site and immediate neighborhood by use of satellite google images. Geographical information system (GIS) software was used to map each of the four sites and approximate the distances from the central business district of Kisumu City. Sampling radii from each post mine site was also done through GIS to determine the 500 metres boundary to guide collection of data from respondents.

3.6.3.3 Key informant interviews

Key informants included quarry land owners, director of city planning, director of environment at County Government of Kisumu, senior officer at Kisumu Urban Project, Physical planner at Ministry of Lands, Director of NEMA Kisumu County, Mines and explosives officer at Ministry of Mining and a private practicing planner. The data to address various aspects of the three specific objectives was collected through various interview schedules that consisted of open ended questions. Interview schedule used to collect data from the various key informants are attached as appendix II to V.

3.7 Data Analysis and Presentation

Data collection tools were checked to ensure completeness. The respondents were requested to complete any parts they have left out before the questionnaires are collected. Open ended questions were be coded through content analysis. The data has been analyzed quantitatively. Quantitative data was analyzed using descriptive statistics including percentages. Analyzed data has been presented using texts, tables and figures. Data collected on-site through photography was analyzed to give information on spatial attributes such as quarry depths, activities on-site etc.

3.8 Data Reliability and Validity

A pilot study was carried out to determine the reliability and validity of the data collection instruments. Survey questions were administered to three household heads in each sub location under study where the post-mine brownfields were sited all within 500 metres from the abandoned quarries. The respondents were sampled randomly and the total 12 respondents is 12.5% of the total sample size for the four sub locations under study. Two male respondents and one female was sampled randomly to test the data

collection instrument. Those selected in the pilot test were later not included during the data collection for the study.

The designed instruments for data collection were counter checked by the research supervisors and peers in order to check the contents to ensure they are valid. Pre-testing during pilot study ensured that the questions asked were clear and easily understood. Pre-testing was carried out to improve the contents and estimate the time required in undertaking the data collection exercise from each household head selected. Issues arising from the 12 randomly selected respondents were clarified and addressed accordingly before data collection for the study.

To minimize biases, standard questionnaires and observation guides were used. The respondents were briefed on the aim of the study during the introduction and their consent sought before issuing them with the questionnaire or conducting the interview. Validity was be ensured by accurate data that represents the research questions and making meaningful inferences during analysis. Data collected on spatial attributes through on-site observation such as approximate size of quarry land was confirmed with data provided by the quarry landowners.

Test-retest was carried out by giving selected respondents the same questionnaire during two different occasions. Two respondents from each brownfield site were selected for test retest method. The respondents gave similar answers to the questionnaire questions at the different times after a day that they were approached. The Pearson's correlation coefficient result after the test-retest revealed 0.9 (90%) that indicates very high correlation hence good reliability in their responses.

3.9 Research Ethics

The confidentiality and anonymity of respondents was respected by not including the names of the respondents within the questionnaires and assuring them that the information will be used only for the purposes of the study. Voluntary participation of the respondents during data collection was ensured. Those respondents who were unwilling to fill the survey questionnaires were skipped and administering done to those who were ready to provide information during the data collection.

4.0 STUDY FINDINGS AND DISCUSSIONS

4.1 Overview

This chapter first analyzes the spatial attributes of the post-mine brownfield within the four sub-locations. It then presents analysis of the effects on the environment in terms of physical and social. Lastly the most preferred reuse option by the public is presented for the different brownfields.

4.2 Social and Demographic Information

Respondents within the four sub-locations of the study area comprised 41% female and 59% male. The age distribution of the respondents showed that 46% were aged between years 18 and 30, 30% aged 31 to 40years, 15% were aged between 41 and 55while 9% were aged over 55years. Most respondents therefore were between ages 18 and 30.Marital status of the respondents was that64% were married 34% single. Educational attainment of the respondents indicated that 22% had attained primary education, 43% secondary education and 35% had tertiary education and above. How long the respondents had lived within the area of study and the brownfield was also analyzed as depicted in figure 4.1 below. Those who had stayed for less than two years constituted 14%, two to five years was 33% while the majority at 53% had stayed for more than five years.

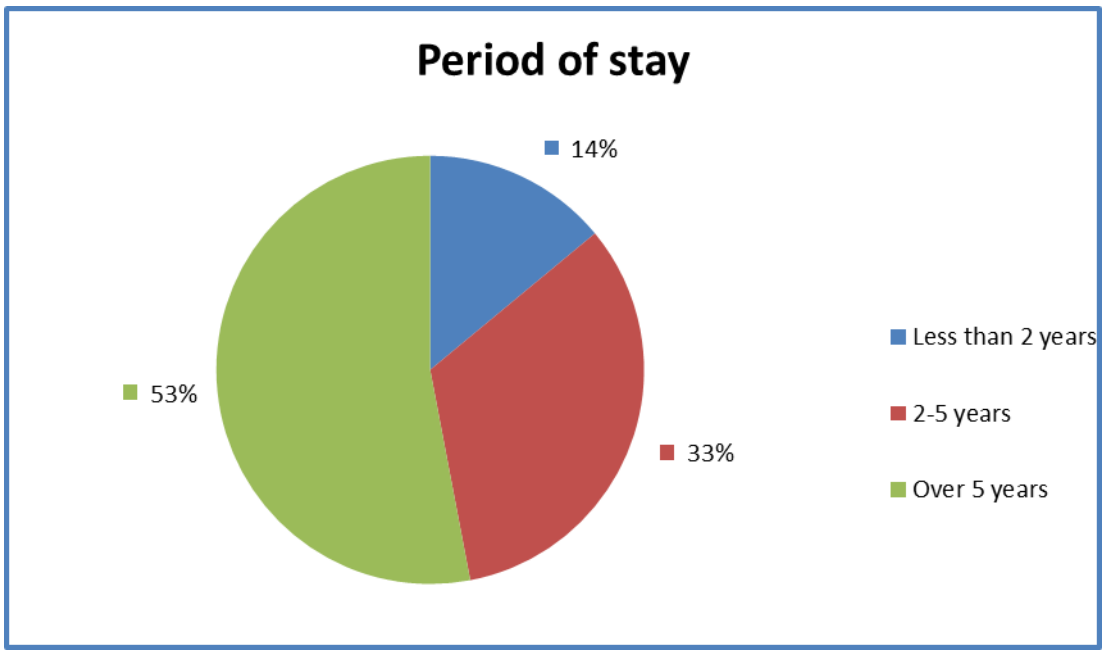

Figure 4.1: Period of stay of the respondents within the four brownfield neighborhoods.

Source: Compiled by author.

Migosi Sub-location respondents consisted of 58% male and 42% female and the age groups was 49% between the ages of 18 and 30, 30% between the ages 31 and 40, while 16% were aged 41 to 55 and the least at 5 % was above 55 years of age. Marital status showed that 34 were single while 66% were married. Educational attainment showed 22 5 had acquired primary education, 50% had secondary education while 28% had tertiary education and above. How long the respondent had lived within the brownfield neighborhood and study sub-location showed that 26% had lived for less than two years, 34% had lived between two to five years while 40% had lived for above five years. Majority of the respondents had therefore lived for more than five years.

Nyawita Sub-location respondents consisted of 62% male and 38% female. Age distribution showed that 51 % were between 18 and 30 years, 25% between 31 and 40 years while 14% were aged 41 to 55 and the least at 10% was above 55 years of age. Marital status revealed that 48% were single, 50% were married while widows consisted of 2%. Educational attainment showed that 28% had primary education while 30% had secondary education and majority at 42% had attained tertiary education and above. Those who had lived within the brownfield neighborhood for less than two years were 10%, those for 2 to 5 years were 26% while majority at 64% had lived for more than 5 years.

Kanyawegi sub-location respondents consisted of 57% male and 43% female and the age groups was 51% between the ages of 18 and 30, 35 % between the ages 31 and 40, while 8 % were aged 41 to 55 and the least at 6% was above 55 years of age. Marital status showed that 34 were single while 66% were married. Educational attainment showed 13% had acquired primary education, 67% had secondary education while 20% had tertiary education and above. How long the respondent had lived within the brownfield neighborhood and study sub-location showed that 33% had lived between two to five years while 67% had lived for above five years. Majority of the respondents had therefore lived for more than five years.

Wathorego sub-location respondents consisted of 59% male and 41% female. Age distribution showed that 34% were between 18 and 30 years, 44% between 31 and 40 years while 16% were aged 41 to 55 and the least at 6 % was above 55 years of age. Marital status revealed that 25% were single, 75% were married. Educational attainment

showed that 16% had primary education while 41% had secondary education and majority at 43% had attained tertiary education and above. Those who had lived within the brownfield neighborhood for less than two years were 6%, those for 2 to 5 years were 41% while majority at 43% had lived for more than 5 years.

4.3 Spatial Attributes of the Brownfields

The first objective of the study was to examine the spatial attributes of the post-mine brownfields in Kisumu City. The information on the different spatial attributes are vital in planning for the rehabilitation/rehabilitation of the post-mine brownfields to ensure successful reuse. The study question to be addressed by this objective is what are the spatial attributes of the post-mine brownfields within Kisumu City? Examining the spatial attributes is important in addressing the main objective of the study which is to evaluate public perception on viable options for reuse and integration of post-mine brownfields into the urban landscape of Kisumu City of Kenya.

Each post-mine brownfield has been analyzed separately in terms of its spatial attributes due to the unique characteristics of each of them. The different spatial attributes examined included location, size, ownership, topography, drainage, vegetation, views within the site, fauna, activities on-site and land uses around the brownfield. The information on spatial attributes helps in making planning and design considerations when implementing the preferred viable options. It is important to understand the spatial attributes as they contribute to the effects on the environment and are important in determining viable reuse options during reclamation.

4.3.1 Location, access and size

Table 4.1: Location, coordinates, size and depth.

Spatial attributes	Post-mine brownfields.			
	Migosi	**Nyawita**	**Wathorego**	**Kanyawegi**
Geographical location	Kondele Location approx. 80 metres off Kisumu-Kakamega Road next Migosi junction.	Kondele Location approximately 350metres off Kisumu-Kakamega Road.	Kajulu West Location approx. 30m off Kisumu-Miwani road.	Kisumu South West Location approx.150m off Kisian-Bondo road.
Reference Coordinates	GPS: Latitude 0.076459^{O}S Longitude 34.776818^{O}E	GPS: Latitude 0.079958^{O}S Longitude 34.773090^{O}E	GPS:Latitude 0.055182^{O}S Longitude 34.793487^{O}E	GPS:Latitude 0.102105^{O}S Longitude 34.646405^{O}E
Size of the quarry pit	Approx. 0.45 ha	Approx. 1.2 ha	Approx. 0.65ha	Approx. 0.8 ha
Depth of quarry pit	Shallow ends at 3m, deepest ends approximately 10m.	Deepest end 12 metres. Most areas quarried between 5m & 10m depth.	Shallow ends 3-5 metres. Deepest ends approx. 10-15 metres	3-6 metres at shallow parts. 5-10 metres at deepest parts

Source: Authors compilation.

Nyawita's post-mine brownfield is located approximately 4.1 kilometres from the city centre and 350 metres off the Kisumu-Kakamega Road within Kondele Location. The main access/transport link leading to the brownfield is an all-weather murram road from Kisumu- Kakamega tarmac road. Main entry is from the northern part of the brownfield and is sloping gently into the quarry land. According to a middle aged son of the quarry owner the abandoned quarry land has a total acreage of approximately five acres. The area was confirmed and proved through Arc GIS software when locating the site through satellite imagery. Depth of brownfield hole varies approximately between 5 metres on the shallow end next to the entry and 12metresat the deepest end of the quarry. Most parts of the brownfield were quarried to depths of 5-10 metres and they show rugged stone within its walls. The quarry land is not fenced at some points on its boundary that are still vacant and not occupied by residential houses. These unfenced areas are a big threat in terms of cases of accidental fall in. Some residential houses have iron sheet fences and wall fences to prevent the risk of falling into the quarry.

Migosi's post-mine brownfield is located approximately 4.6 metres from the city centre and 80 metres off Kisumu-Kakamega road next to Migosi junction road to Kenya–Re estate. The abandoned quarry is approximately 0.45 hectares in size. The site is accessed by all-weather murram roads that branch from Kisumu-Kakamega road and the other from Migosi junction road that leads to Kenya Re-estate. According to a middle aged local the quarried land was originally larger than what is presently visible as the quarry area. Part of the quarried land was back filled by the owners of the plots that had been allocated under the Migosi site and service scheme when they were constructing the bungalows around the quarry boundary. The original quarry boundaries started from the present day Migosi junction to the original boundary of present day Migosi Primary School. Quarrying was done to depths of approximately 3 metres on the shallow ends and about 10 metres on the deepest parts.

Wathorego post-mine is located approximately 8 kilometres from the city centre and 200metres from Obwolo junction off Kisumu-Miwani road. It is accessed by tarmac road from Mamboleo junction and is 30metres off the tarmac road. According to land owner its approximately 0.65 hectares for the three different quarried areas that are adjacent to each other. Quarry depths vary approximately between 3 to 5 metres on the shallow ends and 10-15 metres on the deepest end.

Kanyawegi post-mine brownfield is found approximately 17 kilometres from the city centre and 150 metres off Kisian Bondo road. It's approximately 0.8 hectares in size. According to an official of the company the exact area of the quarried is not known but depths of quarrying were done to 6 metres for most areas of the quarry pit. The post-mine has not been fenced on any of its boundaries and is closely bounded by an access road that is used by motorcycles and pedestrians.

According to the land valuer at the Ministry of Lands at Kisumu County the average cost for 0.02 Ha of land at Migosi and Nyawita is averagely 1.8 million shillings while 0.02 Ha at Wathorego and Kanyawegi is on average 0.6 million shillings. All the sites have good access road network from the city centre with Nyawita being the nearest from city centre followed by Migosi then Wathorego and the farthest being Kanyawegi that is within the peri-urban area of the Kisumu City. The location of brownfields as stated by

Novasak et al. (2013), close to highway network may be an important development factor for relatively large brownfields and hence Nyawita being the nearest to City centre can benefit from this important factor and being the largest in land area.

If the site is too small and irregular shaped or has topographical challenges traditional reuse options like residential are limited as similar studies by American Planning Report (2010), have proved. Similar studies have also proved that reuse option like production of solar energy are only feasible when the land area is a minimum of 40 acres and this means none of the four sites under study can have this as an effective reclamation reuse due to the small land areas they possess.

4.3.2 Ownership and tenure

According to a middle aged son of the land owner of Nyawita post-mine site, the land is still under the ownership of the two private owners under freehold title. Approximately a fifth of the quarry is owned by one owner while the largest part (four fifths) is owned by the other private owner. The owners are aware of their boundaries within the abandoned quarry pit.

Migosi post-mine is currently owned by a private owner under lease hold. Wathorego post-mine and is owned under freehold title by a private limited company and the quarrying has been done within an area of about 2 acres while the Kanyawegi post-mine is also owned by private limited company under freehold title.

Ownership of a mining site according to the U.S. Environmental Protection Agency (2011), can be a significant stumbling block to a site's redevelopment if the site is not wholly owned by one entity or if site ownership is unknown or unclear. If parts of the site are held by different parties with different interest, this can present problems in terms of common interests, decision making delays, and limited forward progress throughout the project. Nyawita post-mine is owned by two different individuals with different sections with different acreage of land within the quarry. According to the director of environment at the County Government of Kisumu the proposed use of the abandoned quarries within Kisumu City during reclamation is likely to be affected partly by issues of land tenure and ownership structure as these abandoned quarries belong to private individuals and not the County Government of Kisumu.

The main objective may not be realized in case the viable options evaluated for the different sites is not supported by the quarry land owners as they are owned privately and not by the public in terms of the County Government of Kisumu. Different opinions held by the different quarry land owners in case of joint ownership may also affect realization of implementation of the viable options during rehabilitation. Viable options for example in the Nyawita post-mine site should be able to get support of the two different quarry land owners who have different ideas on the reuse options to implement during reclamation/rehabilitation.

4.3.3 Topography and drainage

Table 4.2: Topography and drainage.

Spatial attributes	**Post-mine brownfields.**			
	Migosi	**Nyawita**	**Wathorego**	**Kanyawegi**
Topography of quarry location	Gentle slope from the highest point on the eastern side towards the lowest part on western side	Gentle slope from lowest point on northern end to the highest point on southern end.	Highest point on northern side and with gentle slope towards southern side.	High topography area surrounded by immediate areas of gentle slope.
Drainage within Quarry pit	No outlet for drainage of surface runoff hence 100% waterlogged.	Towards the lowest point within the quarry at the entry point on northern end at the outlet.	No outlet for drainage of surface runoff.	Outlet at the lowest point near entry and water logging at deepest part of pit

Source: Authors compilation.

From table 4.2 above, topography within the Nyawita quarry site is gentle slope towards the northern side. On-site observation shows that the main drainage point for surface run-off is at the main entry point to the quarry pit located at the northern end and is the lowest end of the quarry pit. According to a middle aged son of the post-mine water logging due to the blocked outlet on the northern side poses a big health risk due to waterlogging.

On-site observation revealed that Migosi post-mine brownfield has no outlet for surface runoff and hence is entirely waterlogged and swampy and hence covered by dense and long papyrus reeds within its entire area. The brownfield location is on a gentle slope from the western side to the eastern side. The waterlogged swampy nature provides a

good breeding ground for mosquitoes, dangerous fauna like snakes and a major source of air pollution from the dumped wastes within it due to foul smells.

According to the post-mine land owner for Wathorego water logging is a major problem within the site during rainy seasons due to the deep depths that have been quarried without drainage outlet for surface run-off. The post-mine is located within an area of steep slope within the highest part being on the northern part while the southern is at the lowest part. The largest quarry pit among the three pits, has the greatest problem of drainage of surface run-off and it exhibits waterlogging at the middle deepest part. Presence of water logging within the deepest end is a threat to safety of children who may drown when swimming within the quarry.

Kanyawegi post-mine is located within a high topography in reference to the surrounding areas of gentle slope and has no outlet for surface run off during heavy rains. The post-mine has an outlet at the lowest point near entry and presence of water logging at the deepest ends of the quarry pit is evident from on-site observation.

Plate 4.1: Water logging & papyrus reeds within the entire Migosi brownfield.
Source: Author. (October, 2016).

Plate 4.2: Water logging within the Kanyawegi post-mine brownfield.
Source: Author. (October, 2016).

4.3.4 Vegetation and fauna

Table 4.3: Vegetation and fauna.

Spatial attributes	Post-mine brownfileds			
	Migosi	**Nyawita**	**Wathorego**	**Kanyawegi**
Flora/vegetation	Papyrus reeds Eucalyptus species,casuarina equisetifolia, water hyacinth (Eichhornia crassipes), urban agriculture: bananas,mangifera indica, sugarcane.	Papyrus reeds, lantana camara species, cassia spectabilis, cactus varieties, grass species, water hyacinth	Acacia species, lantana camara, grass,various tree,shrub species	Eucalyptus lantana camara and other tree & shub species, grass sp.
Fauna	Scavenger birds, monitor lizards, snakes, frogs.	Monitor lizards, frogs, snakes, birds.	Scavenger birds, monitor lizards	Monitor lizards, snakes, frogs, birds

Source: Authors compilation.

Vegetation cover within Nyawita post-mine include papyrus reeds within the waterlogged swampy area, lantana camara species, cassia spectabilis trees, cactus varieties, grass cover in some areas and water hyacinth (Eichhornia crassipes) within the waterlogged swampy area. Existing fauna include monitor lizards, frogs, snakes and birds. Scavenger birds were present within the dumping areas and within the waterlogged swampy part.

Plate 4.3: Grass cover in dry parts of Nyawita site.
Source: Author (October, 2016).

Plate 4.4: Lantana camara & Acacia species at Wathorego site.
Source: Author. (October, 2016).

Migosi post-mine's vegetation include eucalyptus trees, Casuarina equisetifolia, papyrus reeds, water hyacinth (Eichhornia crassipes), grass species, vines. Urban agriculture in terms of edible species consists of mangifera indica, pawpaw, bananas and sugarcane

planted within the compounds next to its boundary. Fauna include monitor lizards, snakes, birds, frogs. Noisy scavenger birds that feed on the dumped wastes are evident within the site. On-site observation revealed that due to lack of an outlet for surface runoff the quarry pit is entirely waterlogged, swampy and hence covered by dense and long papyrus reeds within its entire area.

Vegetation within the Wathorego quarry pit includes acacia species, lantana camara shrubs, grass, and tree species next to the entry area. Fauna present include monitor lizards, snakes and various bird species including scavenger birds that visit to feed within the swampy water logged area. Kanyawegi post-mine site has vegetation that includes lantana camara, eucalyptus species, grasses and vines. Papyrus reeds are also evident on the waterlogged deep end of the quarry pit. Fauna within this site include frogs, scavenger birds, monitor lizards within the waterlogged deep ends that have papyrus reed vegetation.

4.3.5 Land uses

Table 4.4: Zoning and existing land uses.

Spatial attributes	**Post-mine brownfields.**			
	Migosi	**Nyawita**	**Wathorego**	**Kanyawegi**
Land use zoning	Residential	Residential	Residential	Agricultural
Existing land uses	Residential, commercial	Residential, commercial	Residential, industrial	Agricultural, residential, industrial

Source: Author

Table 4.4 above shows that Nyawita post-mine site is located within an area with its residential houses built within the boundary of the quarry land and consists of both formal planned permanent houses and the informal semi-permanent houses on one end. The neighborhood is densely populated and has been provided with adequate water supply and electricity connection. The quarry land is not fenced at some points on its boundary that are still vacant and not occupied by residential houses. These unfenced areas are a big threat in terms of cases of accidental fall in. Some residential houses have iron sheet fences and wall fences to prevent the risk of falling into the quarry.

Plate 4.5: Well planned residential flats and bungalows on eastern side of Nyawita post-mine site..
Source: Author

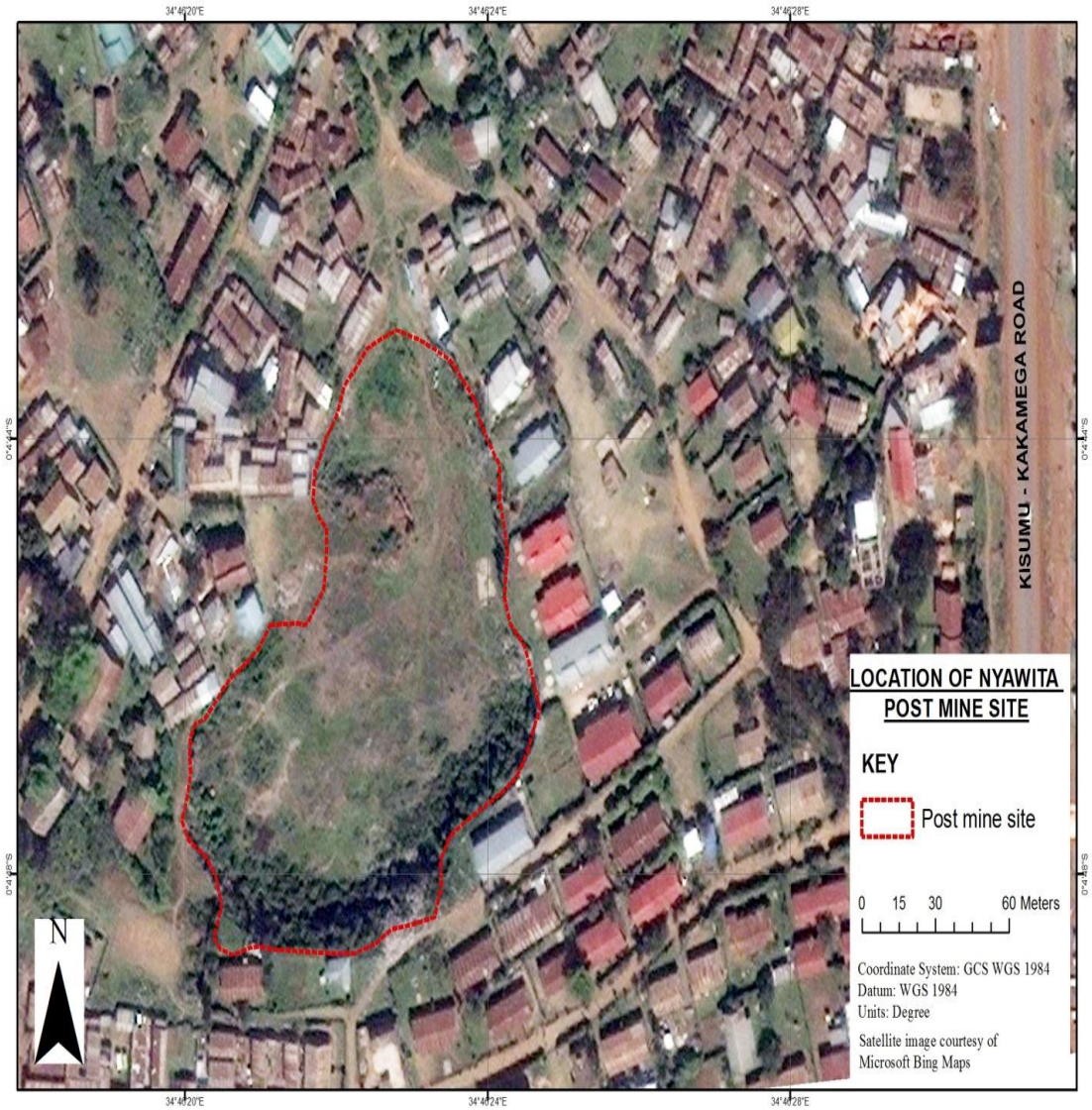

Figure 4.2: Satellite aerial image showing the buildings around Nyawita brownfield.

Source: Satellite aerial image.

The neighborhood of Migosi post-mine site consists of well-planned permanent residential and commercial bungalows and flats. The land uses next the quarry boundary include temporary and permanent commercial ventures and residential houses. Wathorego post-mine site is currently surrounded by several developments with both commercial and residential buildings that have come to the vicinity of the quarry land. The eastern side of the quarry has its neighborhood consisting of residential flat houses and Ndugu Transport Company Limited that is still actively undertaking quarrying activities within Wathorego Sub-location. Construction of new residential developments around the brownfield vicinity is underway and more human habitation towards the brownfield. Presence of access paths next to the deep ends of the quarry is a great risk in terms of falling in. There southern part of the quarry has access road used by vehicles, motor cycles and pedestrians. The quarry has not been fenced on three sides that is the eastern, western and the southern ends that are surrounded by residential developments.

Plate 4.6: Residential houses on the boundary edge of the brownfield at Migosi
Source: Author

Plate 4.7: Commercial developments on the northern side of the Migosi brownfield along the Migosi-Kenya Re. tarmac road
Source: Author

Figure 4.3: Satellite aerial image showing the buildings around the Migosi brownfield.
Source: Satellite aerial image.

Kanyawegi post-mine is located within a sparsely populated area that is majorly agricultural. Residential houses within the area are approximately 30 metres and beyond from the brownfield. The only residential house next to the brownfield is found 2 metres from the quarry boundary.

Plate 4.8: Residential houses next to the boundary of Kanyawegi brownfield.
Source: Author

Figure 4.4: Satellite aerial image showing the vegetation around the Kanyawegi post-mine brownfield.

Wathorego post-mine is located within a sparsely populated area that is majorly residential but with two quarrying companies with ongoing activities in quarrying and production of concrete products. Residential houses within the area are approximately 30 metres and beyond from the brownfield.

Plate 4.9: Residential houses within the neighborhood & access road next to the shallow end of the Wathorego brownfield boundary
Source: Author

Figure 4.5: Satellite aerial image showing the vegetation around the Wathorego post-mine brownfield.

4.3.6 Activities on site

Table 4.5: Activities on site.

Spatial attributes	Post-mine brownfields			
	Migosi	**Nyawita**	**Wathorego**	**Kanyawegi**
Activities on-site	Dumping of wastes. Small scale urban agriculture.	Dumping of wastes. Small scale urban agriculture, Water well for domestic use.	Artisanal quarrying, dumping of wastes.	Occasional artisanal quarrying.

Source: Authors compilation.

On-site observation at Nyawita post-mine site revealed dumping of all types of wastes from the households within the boundary of the quarry (table 4.5). Human wastes present

during the observation showed presence of human beings and use of the quarry for disposal of the same. Dumping was done from different ends of the quarry and is a major source of foul smell in and around the dumping spots thus a major source of air pollution. Other activities within the site include small-scale urban agriculture, occasional picking of stones during dry periods. The quarry land has been abandoned and is a source of decay and degradation. On-site presence of street urchins is a source of theft from the residential houses on the boundary of the quarry.

Activities within Migosi post-mine site include dumping of both household and human wastes. Urban agriculture in terms of planting of nursery seedlings is also carried out on small scale. Abandonment of the site is a major source of negative social effects in terms of presence of street urchins who visit the dumping areas to ravage through the wastes. Wathorego post-mine site has activities that include dumping of household wastes on the shallow ends of the quarry and human wastes at some parts next to the nearby access roads. Occasional artisanal quarrying is carried out at the deepest end of the quarry. Occasional artisanal quarrying for stones and murram is the only activity carried out within the Kanyawegi post-mine site.

Plate 4.10: Dumping of wastes on one end of Migosi post-mine site.
Source: Author. (October, 2016).

Plate 4.11: Dumping of household wastes from the nearby residential houses at Wathorego post-mine site.
Source: Author (October, 2016)

4.3.8 Views within the site

Views within Nyawita post-mine site include high rugged quarry stone walls, dumped wastes, waterlogging next to the entry point at the lowest end. The regular dumping is a major source of bad views into the quarry from various view points and as such negatively affecting the aesthetic value of the neighborhood within the quarry vicinity.

All the other three post-mine sites exhibit similar views as those of Nyawita post-mine with only exception at Kanyawegi post-mine site being lack of dumping of wastes.

Plate 4.12: Part of the Kanyawegi site showing the exposed rugged walls.
Source: Author. (October, 2016).

Plate 4.13: Rugged high stone walls at Wathorego post-mine site and waterlogging within the deepest end of the pit.
Source: Author

Brownfields according to Frantal et al. (2013), are placed and rooted in a certain geographical space, which is hierarchically and functionally structured and also determined by individual sociological contexts. Every brownfield site therefore can be seen as quite unique and should be perceived in their spatial context. When assessing them both site-specific attributes and contextual factors acting at a higher hierarchical level should be taken into account. According to NEMA & Ministry of Mining officials the only known spatial attributes for the four post-mines sites under study was their location however other details on their acreage, depths etc. was not within their records.

4.4 Perceived effects of the Brownfields on the Environment

The second objective of the study was to assess the public perception on the effects of the post-mine brownfields on the environment. Information on the effects of the post-mine brownfields is important in understanding the problems associated with the existence of the sites in their current un-rehabilitated states. This information is important in analyzing the viable options for reuse through rehabilitation in terms of how best to reverse the problems associated with the sites through planning and design.

Effects of the post-mine brownfield was analyzed in terms of the ecological and the social effects within the neighborhoods where they are found. Each brownfield has its different effects on its environment and each was analyzed independently.

4.4.1 Ecological effects

Ecological effects was studied and analyzed in terms of dumping of wastes, air pollution, waterlogging leading to breeding of mosquitoes and possible contamination from past activities. Ecological effects are summarized in the following table.

Table 4.6: Ecological effects of the post-mine brownfields on environment

Effect	**Nyawita post-mine site**		**Migosi post-mine site**		**Wathorego post-mine site**		**Kanyawegi post-mine site**	
	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed
Dumping of wastes	36%	64%	29%	71%	29%	71%	0%	100%
Breeding of mosquitoes	96%	4%	100%	0%	100%	0%	100%	0%
Air pollution	90%	10%	81%	19%	81%	19%	80%	20%
Possible contamination (Blasting with chemicals or dumping of wastes.	90%	8%	74%	23%	70%	10%	90%	5%

4.4.1.1 Public perception on dumping of wastes

Migosi brownfield is a site for unofficial and illegal dumping of wastes and forty three percent of the respondents used it as a dumping ground for their wastes due to nearness/proximity to the brownfield while 55% exploited its abandoned nature to use it for dumping of their household wastes. From table 4.6 above, two percent used it for dumping owing to the expensive charges by the waste collecting companies. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 14% of the respondents, 50% had dumped for 2-5 years while 36% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 58% did not use it for dumping of wastes, 37% did not use it for dumping due to the far distance from their residence to the abandoned quarry. Having a dumping area within some residence made 5% of the respondents not use it as a dumping ground for their domestic wastes. Dumping of the wastes is carried out by several households and that 81% of the respondents were aware

of dumping of the wastes by other households while 19% were not aware of dumping of the wastes by other households. Presence of street urchins during on site observation showed that they came to ravage through the dumped wastes for any valuable items.

According to a middle aged resident and a respondent, Nyawita post-mine in its abandoned state suffered from dumping of wastes that were generated from the nearby Nyawita Maternity & Nursing Home Hospital until it ceased its operations. Twenty percent of the respondents used the post-mine brownfield as a dumping ground for their wastes due to nearness/proximity to the brownfield while 60% exploited its abandoned nature to use it for dumping of their household wastes. Fifteen percent cited both the proximity and abandoned nature for their dumping. Five percent used the post-mine for dumping to lack of alternative dumping area within their residence. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 10% of the respondents, 25% had dumped for 2-5 years while 65% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 37% did not use it for dumping of wastes, 59% did not use it for dumping due to the far distance from their residence to the abandoned quarry. Having a dumping area within some residence and the need for responsible waste disposal made 4% of the respondents not use it as a dumping ground for their domestic wastes. Dumping of the wastes is carried by several households and other sources and that 92% of the respondents were aware of dumping of the wastes by other households while 8% were not aware of dumping of the wastes by other households.

On-site observation at Nyawita showed that by products of alcohol brewing by the brewers within the neighborhood were dumped at the post-mine from time to time and this was a source of air pollution within the waterlogged area next to the entry point. From the field observation carried out, dumping of various wastes within the brownfield occurred at different points within the brownfield. Various points next to the residential houses on the post-mine boundaries showed signs of continued dumping. Nyawita site is the most affected of the four sites due to dumping of wastes that is carried out at different ends.

Kanyawegi post-mine brownfield showed no signs of dumping from the on-site observation and site analysis that was done during reconnaissance and during data

collection. The risk of falling into the brownfield was the reason why 40% did not use it for dumping of wastes, 47% did not use it for dumping due to the far distance from their residence to the abandoned quarry, while 13% considered dumping it the post-mine as being environmentally unfriendly and hence did not engage into dumping within the abandoned quarry. Ninety percent the respondents were not aware of dumping of the wastes by other households while 10% were not aware of dumping of the wastes by other households. Kanyawegi post mine site is the cleanest of the four sites under study due to no dumping of wastes by the households around it.

Wathorego post-mine brownfield is a site affected by minimal dumping of wastes from the households. Dumping only occurred within one of the shallow quarried areas that was next to a graded access road that was on the quarry boundary. Forty three of the respondents used the post-mine brownfield as a dumping ground for their wastes due to nearness/proximity to the brownfield while 57% exploited its abandoned nature to use it for dumping of their household wastes. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 14% of the respondents, 50% had dumped for 2-5 years while 36% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 58% did not use it for dumping of wastes, 37% did not use it for dumping due to the far distance from their residence to the abandoned quarry while 5% did not use it for dumping because of having a dumping area within their residence. Dumping of the wastes is carried by several households and other sources and that 71% of the respondents were aware of dumping of the wastes by other households while 29% were not aware of dumping of the wastes by other households.

Open dumping or “midnight dumping” is the illegal disposal of wastes and this is common at abandoned mine sites. People looking to avoid costs or inconvenience of legal dumping may dispose of their wastes within abandoned post-mines thereby causing additional contamination. (U.S Environment Protection Agency, 2005). Nyawita post-mine site has suffered several years of dumping of various household wastes and wastes from local brewery by products. Migosi post-mine has also suffered disposal of various wastes from the nearby sources and other unknown sources and this is a possible source of pollution and contamination in its post-mine state. Wathorego post-mine so far has experienced minimal dumping and if controlled then contamination from illegal dumping

will be stopped. Kanyawegi post-mine site has no signs of illegal dumping from the households so far and possible contamination within it is only from the sites previous activities related to the quarrying of the stones that was carried out by blasting using explosives and other chemicals.

According to the Director of Environment at Kisumu County Government and the Director NEMA many abandoned quarries within the County are targeted for illegal dumping of various wastes thereby affecting their aesthetic value and affecting the surrounding areas at large.

4.4.1.2 Public perception on waterlogging

On-site observation and site analysis of Migosi brownfield revealed that it is completely waterlogged with vegetation cover within the waters consisting of papyrus reeds and water hyacinth (Eichhornia crassipes) among other shrubs all growing wildly. One hundred percent of the respondents as indicated in table 4.6 above, considered the presence and current state of the brownfield to be a ground for breeding of mosquitoes within that area. Water logging and untamed vegetation within the entire brownfield are attributed to this breeding of mosquitoes. Sixty nine percent attributed the water logging, 20% attributed the untamed vegetation while 11% attributed both to the mosquito breeding within the brownfield.

Nyawita post-mine brownfield on-site observation and site analysis revealed that it is waterlogged at area next to the entry point as this was the lowest in depth and had vegetation cover with the waters consisting of papyrus reeds, water hyacinth (Eichhornia crassipes) among other shrubs all growing wildly. At Nyawita, water logging and untamed vegetation within the entire brownfield are attributed to this breeding of mosquitoes. Sixty six percent attributed the water logging, 8% attributed the untamed vegetation while 22% attributed both to the mosquito breeding within the brownfield. Those who did not consider it a breeding ground for mosquitoes attributed this to minimal water logging.

Water logging was evident at entire area next to the entry point for Kanyawegi post-mine site as it is lowest in depth and had vegetation cover within the waters consisting of water hyacinth (Eichhornia crassipes). Water logging and untamed vegetation within the entire

brownfield are attributed to this breeding of mosquitoes. 88% attributed the water logging, 12% attributed the untamed vegetation to mosquito breeding within the brownfield. Wathorego post-mine brownfield was waterlogged at its deepest ends and had vegetation cover consisting of various tree and shrub species all growing wildly. Water logging and untamed vegetation within the entire brownfield are attributed to the breeding of mosquitoes. Sixty percent attributed the water logging, 8% attributed the untamed vegetation while 31% attributed both to the mosquito breeding within the brownfield.

Nwachukwu & Feng (2012), state that environmental impact assessment of quarry pits in lower Benue trough in Nigeria revealed that stagnant water in the pits supported daily breeding of mosquitoes causing persistent malaria. All the four abandoned quarries under study are experiencing persistent hazard of stagnant water within them and majority of the respondents were of the opinion that they were potential breeding grounds for mosquitoes within these neighborhoods.

According to the Director NEMA and the Director of Environment at Kisumu County, many abandoned quarry sites have waterlogging problems during rainy seasons and hence pose potential risks of children drowning besides causing health problems such as breeding of mosquitoes causing malaria.

4.4.1.3 Public perception on air pollution

At Migosi post-mine site, dumping of various wastes within the stagnant waters of the brownfield occurred at different points within the brownfield. Dumping of the various wastes is the reason for air pollution by 46% of the respondents while 54% associated the water logging within the entire abandoned quarry to the air pollution as indicated in table 4.6 above. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 71% and minimal water logging at 29%.

Dumping of the various wastes at Nyawita post-mine is the reason for air pollution by 67% of the respondents while 20% associated the water logging within the entire abandoned quarry to the air pollution and 13% associated both dumping of wastes by households and the water logging to the air pollution. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 80% and minimal water logging at 20%.

At Kanyawegi, One hundred percent of the respondents associated the water logging within the abandoned quarry to the air pollution while at Wathorego, dumping of wastes is the reason for air pollution by 46% of the respondents while 54% associated the water logging within the abandoned quarry to the air pollution. Field observation carried out revealed that dumping of various wastes within the brownfield occurred at only one point within the brownfield and this was across the road to the residential houses that were nearest to the shallow ends of the abandoned quarry. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 71% and minimal water logging at 29%.

4.4.1.4 Public perception on possible contamination

The respondents in all the four post-mine brownfield neighborhood were asked if the perceived if the sites had possible contamination. From table 4.6 above, forty eight percent of respondents at Migosi associated previous activities like blasting with chemicals to the possible contamination, 17% associated the past and present dumping of various wastes from different sources to the possible contamination while 35% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield. At Nyawita, ten percent associated previous activities like blasting with chemicals to the possible contamination, 60% associated the past and present dumping of various wastes from different sources to the possible contamination while 30% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield.

One hundred percent of respondents at Kanyawegi associated previous activities like blasting with chemicals to the possible contamination while at Wathorego forty eight percent associated previous activities like blasting with chemicals to the possible contamination while 17% associated the past and present dumping of various wastes from different sources to the possible contamination while 35% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield.

U.S Environment Protection Agency (2005), states that wastes associated with operations within the mine site is a source of contamination and this may include machine maintenance, vehicle repair or other activities in which solvents, petroleum, lubricants or

other industrial chemicals may have been used. According to the senior inspector of explosives at the mines and geology department of the Ministry of Mining the chemicals and the explosives used during blasting while quarrying is a major source of contamination within the sites as the remains may be found within the rock fractures of the quarry walls and ground.

According to Arbogast et al. (2000), a mined-out site can be seriously degraded by illegal dumping like in the case of 9-acre Weldon spring quarry in St, Louis Missouri U.S.A where the department of defense and atomic energy commission dumped contaminated debris for nearly thirty years. The aftermath was the contamination of ground water towards well fields that supplied homes and industries throughout the area.

4.4.2 Social effects

The social effects was studied in terms of crime other forms of evil, risk/danger of accidental falling into the abandoned quarry, effects of the post-mine visual quality on aesthetic value of the immediate surrounding. The following table summarizes the social effects across the four sites under study.

Table 4.7: Social effects of the post-mine brownfields on environment

	Nyawita post-mine site		**Migosi post-mine site**		**Wathorego post-mine site**		**Kanyawegi post-mine site**	
	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed
Crime & other Social evil	82%	18%	86%	14%	94%	6%	100%	0%
Risk of accidental falling	92%	18%	88%	12%	100%	0%	100%	0%
Effect on visual quality	90%	10%	76%	24%	90%	10%	100%	0%

4.4.2.1 Public perception on crime and other forms evil

Nyawita post-mine brownfield according to 82% of the respondents as indicated in table 4.7 above is perceived as a threat in terms of crime/insecurity as a hiding ground for thieves and other forms of evil, while 18% did not consider it a security threat. Its

abandoned nature at 18% was attributed to the security threat, 14% attributed to the untamed vegetation that is wildly growing within the entire post-mine and 68% was attributed to the hideouts that exist within the post-mine due to the deep depths at several points. The majority therefore attributed the deep depth that creates possible hideouts within the post-mine to the security threat. Those who didn't consider it a security threat attributed clears views into the post-mine at 86% while some attributed the distance from their residence to the post-mine at 14%.

Twenty six percent of Migosi respondents attributed its abandoned nature to be a security threat. Untamed vegetation that is wildly growing within the entire post-mine was attributed to a security threat by 29% and 45% attributed the hideouts that exist within the post-mine due to the deep depths at several points. The majority therefore attributed the deep depth that creates possible hideouts within the post-mine to the security threat. Those who didn't consider it a security threat attributed clears views into the post-mine at 62% while some attributed the distance from their residence to the post-mine at 38%. Twenty percent of Kanyawegi respondents attributed its abandoned nature to be a security threat while 80% attributed the security threat to the hideouts that exist within the post-mine due to the deep depths at several points. The majority therefore attributed the deep depth that creates possible hideouts within the post-mine to the security threat. On-site observation and site analysis showed that few residential houses were found close to the abandoned quarry boundaries hence no dumping of wastes was evident.

Wathorego's post-mine had its abandoned nature attributed to be a security threat by 9%, 34% attributed the untamed vegetation that is wildly growing within the entire post-mine and 57% was attributed to the hideouts that exist within the post-mine due to the deep depths at several points. The majority therefore attributed the deep depth that creates possible hideouts within the post-mine to the security threat. Those who didn't consider it a security threat attributed the far distance from their residence to the post-mine at on-site observation and site analysis showed that the area immediately around the quarry boundaries has few upcoming developments but they are few and at least 50 to 80 metres distance from the abandoned quarry.

4.4.2.2 Public perception on risk of accidental falling

At Nyawita post-mine, on-site observation and site analysis showed that several residential houses have been built within 5 metres from the abandoned quarry boundaries with most lacking any form of fence/barrier. The unplanned semi-permanent and spontaneous mud walled and iron sheets residential houses next to the quarry boundary lacked any form of barrier/fence while the well planned bungalows and flat houses had either iron sheet and timber barriers while others had live fences. From table 4.7 above, the abandoned quarry's risk of accidental fall in was supported by 92% of the respondents while 8% did not. Closeness of access paths to the post-mine was attributed to the risk of accidental fall in at 24%, while 76% attributed the lack of barrier/fencing to the risk the abandoned quarry posed for accidental fall in. The respondents who did not consider it risky in terms of accidental fall in attributed lack of access paths close it at 67% while 33% attributed presence of fence/barrier as a factor. The respondents had varied response about having heard or witnessed any cases of accidental fall in into the post-mine. Sixty percent of the respondents agreed that a case of accidental fall in had been reported to have occurred within the post-mine while 35% were not aware.

On-site observation and site analysis at Migosi post-mine showed that several residential houses have been built less than 2 metres from the abandoned quarry boundaries with most lacking any form of fence/barrier. The risk of falling into the abandoned post-mine accidentally was supported by 88% of the respondents while 12% did not. Closeness of access paths to the post-mine was attributed to the risk of accidental fall in at 14%, while 80% attributed the lack of barrier/fencing to the risk the abandoned quarry posed for accidental fall in. The closeness of access paths and lack of barrier/fencing were both attributed at 6%. The respondents who did not consider it risky in terms of accidental fall in attributed lack of access paths close it at 100%. The respondents had varied response about having heard or witnessed any cases of accidental fall in into the post-mine. Seventy six percent of the respondents agreed that a case of accidental fall in had been reported to have occurred within the post-mine while 24% were not aware.

Closeness of access paths to the Wathorego post-mine was attributed to the risk of accidental fall in at 59%, while 35% attributed the lack of barrier/fencing to the risk the abandoned quarry posed for accidental fall in and both the closeness of access paths and lack of barrier/fencing was attributed at 6%.The respondents had varied response about

having heard or witnessed any cases of accidental fall in into the post-mine. Ninety percent of the respondents agreed that a case of accidental fall in had been reported to have occurred within the post-mine while 10% were not aware.

At kanyawegi, the area around the abandoned quarry is sparsely populated and only two homes were found close with one being at least 30 metres while that other had its fence being 2 metres from one end of the quarry but the houses being at least 20 metres away. The abandoned quarry's risk of accidental falling into it was supported by 100% of the respondents. Closeness of access paths to the post-mine was attributed to the risk of accidental fall in at 73%, while 27% attributed the lack of barrier/fencing to the risk the abandoned quarry posed for accidental fall in. 100% of the respondents agreed that a case of accidental fall in had been reported to have occurred within the post-mine.

The stagnant waters within the abandoned pits according to Nwachukwu & Feng (2012), are also tempting places to swim and this may pose hazards through objects in the water or toxins which may have leached into the waters. According to the director of Environment Department at the County Government of Kisumu "Abandoned quarries are a source of several safety and health hazards to the public and that there is need to address their rehabilitation and that complaints of injuries and deaths have been reported before for some abandoned quarries".

4.4.2.3 Public perception on visual aesthetics

Baczynska et al. (2018), state that areas of abandoned quarries are an important element of the environment in terms of both their regional and national meaning. Excavated holes left after exploitation of solid rock minerals are characterized by many features, due to which we may talk about their own "landscape". A research they carried out suggest that the main indicator of a quarries' attractiveness is their uniqueness, aesthetic appeal, interest, and the curiosity they raise, which allows the formation of four classification groups for attractiveness: very attractive, attractive, slightly attractive, and unattractive quarries.

Visual quality for the Nyawita post-mine was considered in terms of views on the physical appearance/state of the quarry. Visible aspects included the dumping of wastes at various ends, untamed vegetation within the post-mine, visible rugged landscape

appearance exposed by the deep depths, swampy waterlogged nature that was evident at the shallow entry point of the post-mine as documented from the on-site observation and site analysis. As indicated in table 4.7 above, dumping of wastes was considered by 44% of the respondents to be affecting the visual quality and aesthetic value of the immediate surrounding, while untamed vegetation was considered by 10%, visible rugged landscape by 14% and the swampy water logged nature was considered by 32% by the respondents.

The 10% of the respondents who did not consider the visual quality of the post-mine to be affecting the aesthetic value in a negative way attributed this to minimal dumping of wastes by 60%, few untamed vegetation by 20% and minimal rugged landscape by 20%. None of the respondents considered the water logging to be minimal and this supported the on-site observation and site analysis that had been carried out that revealed the water logging that was evident within the shallow entry point into the post-mine. The dry parts of the quarry during the observation and site analysis also showed signs of being water logged in times of heavy rains.

Plate 4.14: Swampy waterlogged area next to the Nyawita brownfield entry point.
Source: Author

Plate 4.15: Dumping of household wastes on the northern side of the Nyawita brownfield.
Source: Author

Plate 4.16: Quarry depth at one end & creeping vine vegetation on the rugged quarry wall at Nyawita.
Source: Author

Plate 4.17: Untamed vegetation along the quarry wall on the southern border.
Source: Author

Visible aspects affecting visual quality at Migosi included the dumping of wastes at various ends, untamed vegetation within and around the post-mine, visible rugged landscape appearance at some points, swampy waterlogged nature that was evident on the entire post-mine as documented from the on-site observation and site analysis. Dumping of wastes was considered by 32% of the respondents while untamed vegetation was considered by 20%, visible rugged landscape by 3% and the swampy water logged nature was considered by 45% of the respondents. None of the respondents considered the water logging to be minimal and this supported the on-site observation and site analysis that had been carried out that revealed the entire Migosi post-mine to be completely subdued in stagnant water without no outlet at any end to release the surface run off that collected within the post-mine.

Plate 4.18: Waterlogging affecting the entire site at Migosi post mine brownfield.
Source: Author

Plate 4.19: Vegetation consisting of eucalyptus trees, banana trees, papyrus reeds within eastern side of Migosi post-mine site.
Source: Author

Visible aspects at Wathorego included the dumping of wastes at various ends, untamed vegetation within and around the post-mine, visible rugged landscape appearance at some points, swampy waterlogged nature that was evident on the entire post-mine as documented from the on-site observation and site analysis. Dumping of wastes was considered by 32% of the respondents to be affecting the visual quality and aesthetic value of the immediate surrounding, while untamed vegetation was considered at 20%, visible rugged landscape by 3% and the swampy water logged nature was considered by 45% of the respondents.

Plate 4.20: Rugged quarry walls at the deep end of Wathorego brownfield.
Source: Author

Plate 4.21: Water logging within the deepest end of Wathorego brownfield.
Source: Author

Visible aspects affecting visual quality at Kanyawegi included the untamed vegetation within and around the post-mine, visible rugged landscape appearance at most points, swampy waterlogged nature that was evident on one end of the post-mine as documented from the on-site observation and site analysis. Visible rugged landscape was considered by 34% while the swampy water logged nature was considered by 66% of the respondents.

Plate 4.22: Vegetation consisting of shrub varieties within the Kanyawegi brownfield
Source: Author

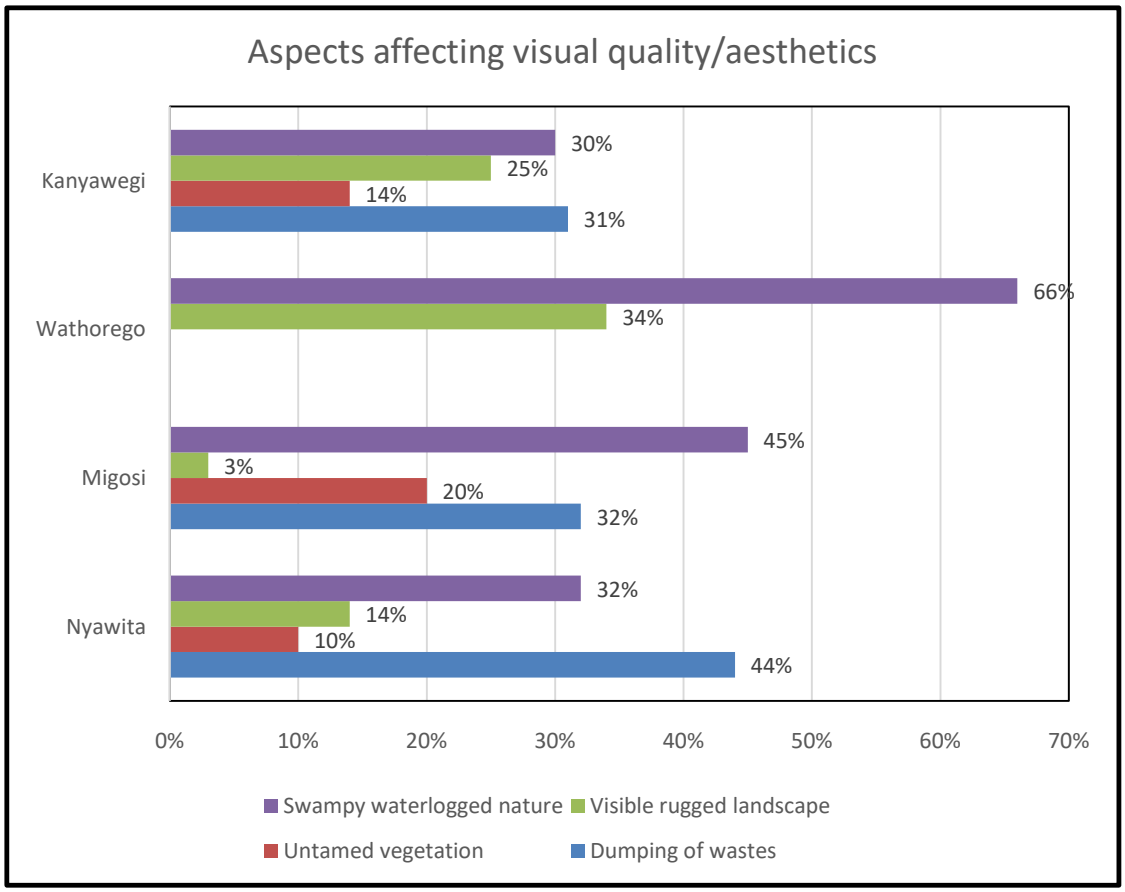

Figure 4.6: Aspects affecting visual quality/aesthetics within the four post-mines.
Source: Compiled by author.

Open pit/surface mining of various resources such as stones extensively changes the landscape and can result in severe visual impacts. The four abandoned quarries under study have changes in their landform, colour, texture and this creates a contrast between the quarry pit and their surroundings leading to major visual impacts. According to Simpson (1979), the physical change and contrast between the mine and its surroundings resulting from mining operation vary over time and that the visual impact of change is dependent upon the viewer's perception of the modified landscape. There is great need to give a consideration to the visual impacts within and around the post-mine brownfields.

The four post-mine sites have an effect on the visual quality of the immediate surrounding and this was rated in terms of how unpleasant it was to the eye. The visual quality of each post-mine brownfield has an effect on the aesthetic value of the immediate surrounding and this was of concern. The aspects used to rate visual quality included the aspects on figure above. The views of the respondents was as follows:

Table 4.8: Rating for visual unpleasantness for the four post-mines

Visual quality	Points/ Percentage	Migosi	Nyawita	Wathorego	Kanyawegi	Average across the sites
No unpleasantness	0	5%	6%	10%	0%	5.25%
Very low unpleasantness	1-20	7%	0%	0%	0%	1.75%
Low unpleasantness	21-40	9%	2%	19%	0%	7.5%
Medium unpleasantness	41-60	17%	42%	16%	20%	23.75%
High unpleasantness	61-80	26%	24%	16%	33%	24.75%
Very high unpleasantness	81-100	36%	26%	39%	47%	37%
Total		100%	100%	100%	100%	

Source: Compiled by author

From the table 4.8 above, very high unpleasantness was selected by majority of the respondents across all the four post-mine sites. Some respondents considered the sites had no unpleasantness except for Kanyawegi post-mine site where none of the respondents felt the site had no unpleasantness. The data above analyzed in terms of mode shows these results: Mode for Migosi, Wathorego and Kanyawegi is 80.5 implying the choice for very high unpleasantness by most respondents.

Simposon (1979), states that a person's perception of a mine is intertwined with the perception of the entire surrounding landscape and will be affected by distance from the mine, orientation of the mine, the viewing location and conditions of the areas surrounding the mine. Visual analysis for this study was based on the spatial attributes of the quarry and that of the surrounding. The spatial attributes and that of immediate surrounding was analyzed in terms of presence/extent of dumping of wastes, untamed vegetation, visible rugged landscape and swampy water logged nature.

The relative distance of the respondents' residence to the post-mine was considered. Simpson's intuition is that public attitude about abandoned mines is influenced (or should be) by the visibility of the mines. Migosi and Nyawita post-mines have been surrounded by residential houses and the only open areas around the quarry pits are the undeveloped

plots but the respondents were aware of its presence and felt it had negative visual impact on aesthetic value of the immediate surrounding. Kanyawegi post-mine is screened by vegetation and by the high topography of the quarried area. Wathorego post-mine is screened by vegetation on one end that is on the high topography while the other sides are exposed to nearby access roads and are not screened off with vegetation. Majority of the respondents in all the post-mines despite the relative distance from their residence to the abandoned quarries had a feeling that the visual impact negatively affected the aesthetic value of the immediate surroundings.

4.3 Public preferences on rehabilitation/reclamation of the post-mine brownfields

The last study objective is to analyze public preferences on possible reclamation/rehabilitation land uses the post-mine brownfields can be planned into. This is closely linked to the main study objective which is evaluate public perception on viable options for reuse and integration of post-mine brownfields into the planned urban landscape of Kisumu City of Kenya.

With the spatial attributes of the abandoned quarries within the study area analyzed, inventoried and their effects on the environment understood then rehabilitation reuse then becomes important final step to plan for. This third study objective is important as involves planning and implementing the preferred reuse options for a given post-mine brownfield and as such reverse their negative effects to the ecological and social effects. This objective was investigated in terms on whether there is need to undertake reclamation of the post-mine sites or leave them in their current state, effect of the abandoned post-mines on aesthetics/visual quality and lastly ranking of the preferred reuse options within a choice of eight uses. This objective was also analyzed in terms of the implementation option for the most preferred reclamation land use option. The viability of each of the reuse option has been analyzed accordingly.

The respondents in each sub-location were asked on whether there was need to undertake reclamation of the post-mine sites within their neighborhood or to maintain them in their current states. The response on whether the Migosi post-mine site should be turned into better uses through reclamation showed that 91 % were in support while 9 % felt there was no need. Nyawita Sub-location respondents with a majority at 96% were of the opinion that the abandoned quarry should be turned into better uses through rehabilitation

and not to be left in its present state. Four percent felt there was no need for rehabilitation. Response at Kanyawegi showed that 100% was in support of the abandoned quarry land being turned into better uses through rehabilitation while at Wathorego 90% were of the opinion that the abandoned quarry land should be turned into better uses through reclamation, 10% did not support reclamation into better uses.

Households living within the brownfield neighborhood were asked to suggest their most preferred choice of reuse option into which the brownfield could be reclaimed/ rehabilitated into. Each brownfield was analyzed separately within its unique setting. The most preferred choice was to be picked after ranking eight reuse options suggested for each of the sites. The choices were preferred as follows:

Table 4.9: Suggested rehabilitation/reuse Options

	Nyawita post-mine (%preference)	**Migosi post-mine (%preference)**	**Wathorego post-mine (%preference)**	**Kanyawegi post-mine (%preference)**
Construction of public facilities e.g. school, community hall, church	40%	24%	24%	0%
Nature conservation/forestry	4%	10%	16%	27%
Agricultural production	6%	21%	15%	33%
Human settlement i.e. housing units	24%	7%	13%	0%
Public open space/parkland	6%	16%	0%	0%
Recreation/leisure grounds	10%	5%	0%	0%
Landfill for waste disposal	4%	2%	19%	13%
Production of renewable resources e.g. solar power	6%	15%	13%	27%

Table 4.10: Most preferred reuse options for the four brownfields.

Sub-location/ post-mine brownfield	**Most preferred reuse option**	**Preference %**
Nyawita	Construction of public facilities	40%
Migosi	Construction of public facilities	24%
Wathorego	Construction of public facilities	24%
Kanyawegi	Agricultural production	33%

Landfill for waste disposal was the least preferred reuse option for all the four post-mine brownfields under study as indicated in table 4.9 above. This was due to environmental pollution in terms of wastes, smell that are associated with it that may affect negatively the residential neighborhoods where the post-mines exist.

In Kenya NEMA guidelines on mining and quarrying requires that the land owner should establish quarry pit rehabilitation and/or after use plan to be approved by the District environment Committee as prescribed in the audit check list. The after use plan according to NEMA should identify suitable alternative land uses for the disused pits such as land restoration for agriculture, recreation, forestry and apiary, exploitation for aquaculture, exploitation as water reservoir and if suitable exploitation for sanitary land filling and these restorations of quarries should be within 12 months of depletion of the quarries. Disused mines should be rehabilitated according to EIA/EA/EMP where applicable or as per restoration provisions under EMCA 1999. Frantal et al. (2013), state that it is very important to analyze and present “best practices” as examples of successful regeneration of brownfields in various geographical and land-use contexts. The study had a total of eight rehabilitation reuse options that were suggested to the households within the study areas of the post-mine sites.

Legal frameworks that give the County Government of Kisumu its authority to monitor quarrying within its jurisdiction include the County government Act 2012, physical planning Act, Urban areas and cities Act 2012, EMCA 1999, Public health Act cap 402.The City of Kisumu under County Government of Kisumu requires that decommissioned quarry sites should undergo restoration that must be executed as per the restoration provisions of EMCA 1999. It requires that quarries that have remained in a state of disuse for the last 5 years posing health hazards such as mosquito breeding grounds and unwanted pools of water where unsuspecting children often drown must be rehabilitated to avoid such danger to the society. Recent efforts by County Government of Kisumu & KUP in the year 2015 to identify and inventorize some of the spatial aspects of some of the active and abandoned quarry sites within its jurisdiction is an exercise in the right direction and this will expedite the need to rehabilitate some of the long abandoned quarries with severe effects on the environment. According to senior KUP official the study to inventorize the quarries did not cover all the abandoned quarries in the final report and that they did not map out the quarries and their spatial attributes.

CABERNET (2006), states that it is important to consider interim uses of brownfields because brownfield regeneration is a lengthy process. Interim uses can be crucial for the long term success of the regeneration scheme. This provides a smooth continuation from the traditional (industrial) use into the future use of the area thus avoiding problems of decay and dereliction and thus making the site safer and livelier.

According to the Standard Newspaper Thursday 23, May 2015 page 10, after several years of coral mining for cement manufacture at Bamburi Mombasa, Kenya, several acres of land was left in ruins with no vegetation and no animals that survived there before and hence there was great need for rehabilitation of the mined land. Reclamation of Bamburi quarry started in the 1970 after mining had been carried out for the last 17 years. The aim of rehabilitation back then was to plant indigenous species to re-colonize the space with flora and fauna that were part of its habitat before mining. The rehabilitation gave rise to Haller Park which is situated 10 kilometres north of Mombasa on Mombasa-Malindi road and is parallel to the coastline. By the year 2000 after 30 years of rehabilitation many indigenous plant species had been established and fauna including mammals introduced. Currently Haller Park is an extensive habitat comprising a game sanctuary, reptile park, fish farm area, palm garden, crocodile pens and giraffe viewing platform. Haller Park is a success case study of reclamation of a former quarry that had been mined to depths of 18 metres and today it's a hallmark of tourist attraction at the coast.

Rehabilitation reuse as a human settlement is a viable option for the four post-mines under study partly because they are located within residential neighborhoods and cases of land use conflicts from the new rehabilitation reuse option will not arise. However the human settlement reuse option should be done without the need for backfilling the quarry holes that will need large volumes of backfill material to completely fill, compact and stabilize for any construction to be undertaken. Backfilling is not sustainable as the material needed will create new brownfields in other areas in the quest to fill these already existing post-mine sites. Nyawita post-mine at about 1.2 hectares is about 12,000 metres square and if excavation was done uniformly at 10 metres within the whole quarry then this translates to 120,000 cubic metres of material that is needed to backfill it, however more than these volume will be needed as the material should be backfilled and compacted to stabilize for any construction to be undertaken. Nova Scotia environment report (2009), state that backfilling of surface mining is highly recommended and that if

the post-mining land use includes structures located on backfilled excavations the reclamation plan needs to specify how and when the backfill material is structurally sound and stable.

Important considerations related to backfilling include the removal of any contaminated materials such as spilled fuel oil, asphalt and solid waste. Construction and demolition debris should not be used as backfill, and the estimation of compaction and settling rates and how these affect future land use is also important. Nyawita post-mine brownfield owners were approached by the environment department of the County Government of Kisumu on the possibility of backfilling the quarry land with the fully biodegraded wastes from its dump site in town that has since then been full and there is need for alternative site. According to the Director of Environment at the County Government of Kisumu there is still need for public consultation and there is the fear of public opposition to this due to likely air pollution due to these wastes within the residential neighborhoods. This use as alternative waste disposal site is likely to be rejected in many areas due to the land use conflicts it will bring about. The two quarry owners for Nyawita were reluctant and did not accept the proposal by the County Government of Kisumu through KUP to use the site for biodegraded wastes from the current dump site.

According to McCandless & Spirn (2013), an example of reclaimed stone quarry reclaimed into a human settlement is in San Diego California. The quarry had served as a major stone and concrete source for construction projects in the region for the last 70 years. The site was proposed into multifamily housing units, retail shops and commercial office space and was started in 2010 and is expected to go on for the next 15 years. An example of best practice of rehabilitation of an abandoned quarry without the need to backfill is in the construction of the “ground scrapper” hotel in Shanghai China that has 16 floors below the earth’s surface. The construction has been done in 100 metres deep quarry after ceasing industrial activities in the year 2000 that left the land neglected, unsightly and dangerous. According to the physical planner at lands ministry, one private planning consultant and a NEMA official reuse of the post-mines sites as human settlement is the least option they prefer because the neighborhoods they are found within already have high human settlement without open spaces for recreation and without breathers within them. They also cite environmental concerns, traffic issues among reasons for not preferring human settlement as a rehabilitation reuse option.

Michaud & Bjork (1995), state that there are many advantages to siting a landfill in a mined area and therefore landfill construction should be considered as a viable reclamation method for mine sites. A landfill/sanitary landfill is an environmentally acceptable disposal of waste on the ground by spreading in layers, compacting and covering with earth at the end of each working day. Reclamation of a mined area through the construction of a solid waste landfill can offer many benefits to the community, county and state in the form of taxes and tipping fees and employment opportunities in an area negatively impacted by mine closure. An example of successful landfill within a quarry is the Congress Development Company Landfill within hillside Illinois U.S.A.

Hough et al (1995), argues that the restoration of quarries poses a number of challenges as there is often limited topsoil left to contribute to the establishment of vegetation. The remaining rock and rubble left on the quarry floor may be exposed to high temperatures and this can cause significant issues in the management of non-native species. There is need to carefully select the indigenous plant species that can do well within the quarries after introducing growth media such as soil that is appropriate. Nature conservation has been successfully been implemented in rehabilitation of Haller park at Mombasa that was initially a limestone mining site. According to Woolley (2003), ecological arguments are likely to play an even more important role in urban investments for our future as it becomes clear that trees, plants, green corridors, pocket parks and urban natural settings can create much healthier micro climates in the city. Forestry works well with other land uses and can provide recreation. Nature conservation when implemented should not only focus on the regeneration of the environment without having an aspect of economic benefit in terms of use of the grounds for activities and tourism to bring economic gain to the owners and the neighborhood at large. Social inclusivity should also be considered by ensuring all members of the public can access it whether at a small fee for various activities. If nature conservation should be used then the sites should undergo appropriate grading and effective storm water management to ensure water stagnation does not choke the planted tree species leading to their death. According landowner for Kanyawegi post-mine site the conservation/forestry option is the best use to rehabilitate the site currently as it adds to green infrastructure and is environmentally friendly in many ways.

Rehabilitation to public parkland is likely to offer a good opportunity for greening of the post-mine brownfield and its advantages to benefit the neighborhood at large. According to De Sousa (2003), the "greening experience" constitutes a valuable opportunity for increasing green spaces and thus bring about benefits such as soil quality improvement, habitat creation, recreational opportunity enhancement, economic revitalization of neighborhoods. Open space within the post-mines can be achieved as parkettes i.e. small parks that offer passive recreational activities such as sitting areas, walking paths etc. for the surrounding neighborhoods. This rehabilitation reuse option is a very viable option for Migosi, Nyawita and Kanyawegi due to their spatial attributes. If accepted and implemented then this can lead to open spaces within the neighborhoods that will act as additional lungs to the neighborhoods and to whole city. Achieving this reuse option can either be achieved exclusively through private funding by the quarry landowners or through partnership between the landowners and the County Government of Kisumu. According to French Development Agency (2013), on Kisumu's ISUD plan, open space provision greatly influences the quality of life and livability of cities and communities and that Kisumu is currently under supplied with quality open spaces which are easily accessible for all and that there is great need for more parks like proposed lake front park and many more. The post-mine sites provide a good opportunity for rehabilitation into neighborhood parks that are within easy access by people.

Private recreation/leisure grounds can be potential neighborhood urban open spaces in the form of parks that offer variety of spaces as playgrounds, facilities for relaxation and for passive and active recreation. The quarry owner can have the grounds planned and designed to accommodate facilities that offer recreational aspect and leisure within them. The sites can offer great opportunity for passive recreation if this can be done without conflicts with the neighboring land use of residential that is so close to the post-mine boundaries especially at Migosi and Nyawita. Woolley (2003), states that neighborhood parks/open spaces provide opportunities for community and cultural activities, allowing groups within a neighborhood to have a focus for some of their activities. They are also important for educational opportunities and are important to the amelioration of the urban climate, environment and are potential wildlife habitats. From the respondents levels of preference for this reuse option then this is a pointer that majority do not prefer it as the most preferred choice to be implemented through reclamation and may face public opposition with many residents of the post-mine sites.

Public facilities may include the construction of a communal conference hall, church, primary and kindergarten school, information centers/library. According to one of the Nyawita post-mine land owners the site is ideal for construction of public facilities mentioned above in case they can get a private investor who can be leased the land to build and operate the facilities for an agreed period of time while paying them agreed amount monthly. Both of quarry landowners however are against public facilities like police post that may be run by the central government or the county government as this is likely to fetch poor returns. According to the physical planner at Ministry of Lands the construction of public facilities is not an ideal reuse option due to the large capital outlay needed the weakened ground structure due to past blasting and difficulty in managing the sewerage from the constructed facilities within the quarry pit.

The U.S. Environment Protection Agency (2011), looks into the use of abandoned mine lands for generation of solar energy, however not all former mining sites are suitable candidates for solar energy projects. Solar energy projects provide multiple beneficial impacts that can restore and return degraded underutilized landscapes to productive use. With solar energy development, communities can harness the emerging need for secure and carbon free energy to promote the remediation and revitalization of many mining sites and facilitate economic development. However for economics of solar thermal facility to be feasible the area of land needed is at least 40 acres. The post-mine brownfields in this study are all having areas far much less than the required 40 acres needed for feasible solar energy production and hence use for solar energy production is not a viable reuse option as it will lack the feasibility needed.

4.3.1 Implementation options

Reclamation/rehabilitation reuses need to be implemented during their planning, design and the whole project management period till they are completed. The three methods suggested to the respondents included private through the quarry landowners, public-private partnership (PPP) and public sector through the County government.

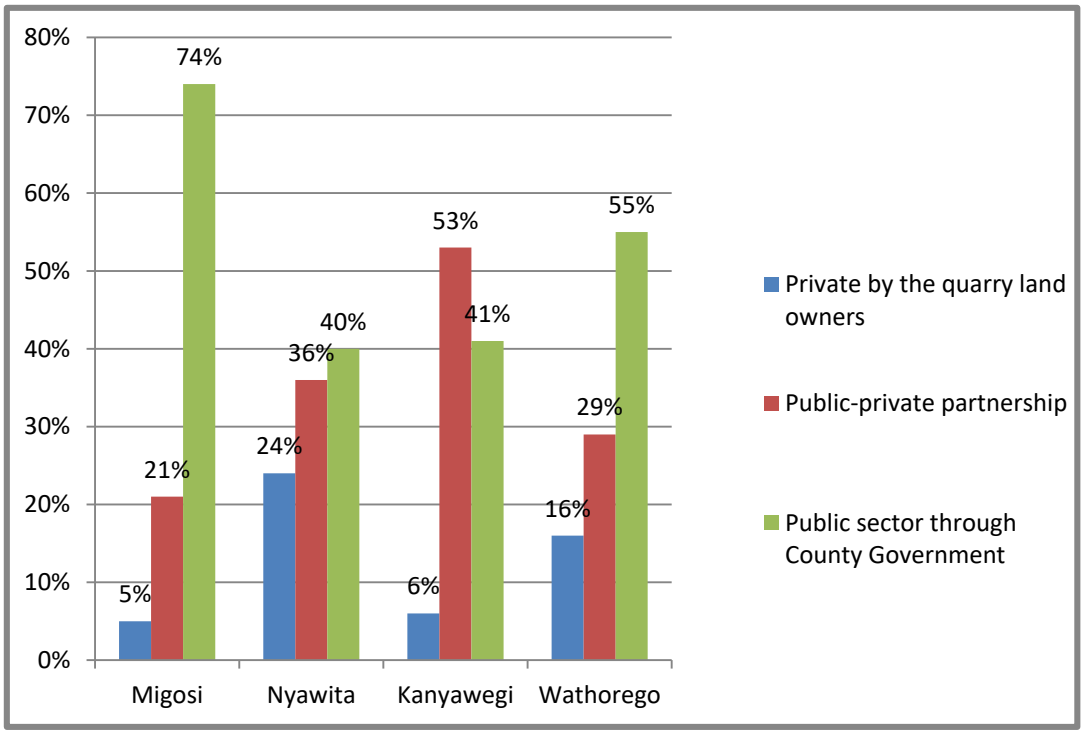

Figure 4.7: Implementation options for the most preferred reuse options for the four post-mine brownfields during reclamation.

Source: Compiled by author.

At Migosi majority of the respondents who preferred the construction of public facilities preferred implementation of the rehabilitation through public sector through County Government of Kisumu as indicated in figure 4.7 above. At Nyawita the majority respondents who had preferred construction of public facilities preferred that it should be implemented through public sector by the County government of Kisumu.

According to both of Nyawita's quarry landowners the most preferred method for implementing the rehabilitation reuse is through a private investor/developer getting into an agreement with him or the company to build and operate the rehabilitation reuse and share the proceeds in an agreed ratio among them. The use preferred by both owners of the quarry is the construction of a shopping mall such as supermarket that utilizes the deep quarry pit below for storage and ample space for parking. The owners prefer this implementation method due to lack of adequate funds to undertake this rehabilitation that requires a large capital outlay and their reluctance to sell the land to interested private developers or even to public entities like the County government of Kisumu.

The implementation method preferred by the Migosi quarry land owner is private by himself in funding the residential housing units he desires to put up there despite the challenges of water logging and whether to undertake this after backfilling the site or not. The land owner is not willing to sell his land to a private developer or County Government of Kisumu to undertake a rehabilitation reuse of their choice. According to the private owner for Kanyawegi post mine site, the most preferred implementation method for their quarry land is private funding for their interim use as conservation area through forestry. Funding needed for implementing a rehabilitation reuse for the abandoned quarry pits is not a problem/hindrance and once the company will consider its time has come then they will undertake the appropriate rehabilitation.

According to Wathorego's private owner the most preferred method for implementing rehabilitation for the Wathorego quarry land is through partnership that involves leasing the land to interested developer to undertake a rehabilitation reuse that is acceptable to them and the neighbors. Through the partnership the developer would build and operate the facility while the profits are shared in agreed ratio with the land owner while the land still belongs to the privately owned company. According to the land owner the rehabilitation has been hindered by inadequate funds to undertake the rehabilitation process.

Key informants opinion from the Director of Environment at County Government of Kisumu, KUP, Ministry of Mining, NEMA, Ministry of Lands and private practicing physical planner the Private Public Partnership (PPP) is the best method for implementation of the rehabilitation of the post-mine sites. KUP under mandate of County Government of Kisumu in 2015 through a private consultant carried out a reconnaissance study that involved locating the various quarries both active and inactive with the Kisumu City and its immediate environs. Some of the post-mine land owners were approached on the possibility of considering their use for relocation of the biodegraded wastes from the current City dumpsite next to Moi Stadium that is full. Quarry owners approached included that of Nyawita however the quarry was not included among those that were in the reconnaissance study. Lake Quarry and Migosi post-mine sites were also not part of the report for the reconnaissance study carried out. According to KUP official with public consultation and willingness of the quarry owner then the County Government of Kisumu can consider partnering with the land owner on possible

filling of the site with biodegraded wastes from the current dumpsite and when full then they can implement the reuses like planting of trees and grass cover until the soil stabilizes.

According to the physical planner at the Ministry of Lands the land use zoning for the four areas under study is that Nyawita is a special planning area considered an informal settlement and is considered a slum belt according to the French Development Agency (2013), Migosi is a residential area with commercial aspects within it like the Migosi market that is designated by the local authority, Wathorego is considered an agricultural peri-urban zone with industrial activities like quarrying allowed within it and currently residential. Kanyawegi Sub-location is an agricultural zone and is considered peri-urban farmland according the French Development Agency, (2013). To implement any rehabilitation reuse option that is currently not allowed within any of the given areas will need a zoning amendment that is done through a change of user requirement. The change of user is needed for the formalization of the different land use within the concerned area.

Implementation of the viable options or the most preferred rehabilitation reuse option can be undertaken through several methods that include privately by the quarry landowners, public sector through the County Government and public-private partnership (PPP). Franco et al. (2010), states that partnerships in rehabilitation of quarries can be in several forms such as partnerships with private companies with economic interest in the mine. Public sector through the County government was the most preferred method for rehabilitation within Migosi, Nyawita and Wathorego. This method was to implement the most preferred rehabilitation reuse of construction of public facilities Given that three of the four abandoned quarry pits are owned by private individuals under freehold titles and only Migosi is under leasehold land tenure then private implementation being least preferred means that the landowners have to consider selling the quarry lands to the County Government of Kisumu in order to undertake rehabilitation of the most preferred reuse or viable option. This method is likely to face resistance from most private quarry landowners in different places as they have to sell and lose ownership of the abandoned quarry lands. The landowners for all the four post-mine sites are unwilling to sell the lands to private developers, County Government of Kisumu in order that the public bodies undertake rehabilitation using public funds.

Kanyawegi post-mine most preferred method of implementation was public-private partnership (PPP) for implementing their most preferred rehabilitation reuse of agricultural production. This method was preferred by 53% of the respondents. PPP is possible implementation option as the complications of the private owner being unwilling to sell and relinquish the landownership is avoided and agreement on partnership can be reached accordingly. A private company not necessarily a mining company may offer to rehabilitate a site so that the site can be used for a different and more productive land use. The benefit is that the site is used for another productive purpose rather than forever remaining an abandoned quarry. Cowan & Mackasey (2006), state that creating partnership between mining companies and the government to fund rehabilitation of abandoned mines can provide win/win outcomes. Both the government and mining companies should be entrepreneurial in devising partnerships where both parties benefit. Case studies of Lynn Lake Mine and the Hollinger Mines in Canada are illustrative of such partnership.

Partnership between the central government and the county government can be formed to assist in cost sharing arrangements for general revenues to undertake rehabilitation. The Giant mine is an example of rehabilitation achieved between the federal-provincial /territorial cost sharing arrangement. The most preferred reuse option at both Migosi and Nyawita that is the construction of public facilities had majority respondents preferring the public sector implementation by the County Government of Kisumu to undertake their rehabilitation. Migosi respondents preferred public implementation at 74%, Nyawita at 40% and Wathorego at 55%. This likely means that they would like the public sector such as County Government to take over the ownership of the abandoned quarry by purchasing them and planning for their rehabilitation in providing public facilities within them.

According to the private practicing physical planner, PPP is best implementation and method as it gives room for negotiations and may yield better results than public implementation by the County government that lacks trust from the public while private implementation may not work in cases where the landowners lack adequate funds needed to fund the rehabilitation. Other key informants like the Ministry of Lands official, NEMA director, Ministry of Mining official were also of the opinion that PPP is the best method for rehabilitation of the post-mines as it gives room for consultations and therefore much public confidence in the process and thus better results on rehabilitation.

Implementation of the most preferred reuse option should be done in line with the landscape urbanism theory.

Landscape urbanism has been put forward by several theorists including Charles Waldheim, Joanna Pierchala, James Corner, Stan Allen among others. According to Pierchala & Laursen(2009), an example of design where landscape urbanism was used is the Parc de la villette by Rem Koolhas and BernardTschumi who were among the finalists for the design competition organized to transform the former slaughterhouses and meat market in Paris France into the largest public park.. The project proposed landscape as the basic framework for an urban transformation of what has been part of the working city left derelict by shift in economies of production and consumption. The winning design was by Swiss French architect Bernard Tschumi in 1982 that took on many standard park features such as large areas for lawns, tree lined alleys, and children play grounds. The park houses museums, concert halls, theatres, themed gardens, children play areas and architectural follies.

The three fold concept of links, hotspots and the landscape as stated by Pierchala & Laursen (2009), are applied in landscape urbanism projects and the preferred rehabilitation reuse options for the four post-mine brownfields can implemented along these concepts. There is need to create links that will provide the connection of the post-mine sites into the general neighborhood and to the city as a whole and as such not be considered as an urban void. Hot spots within the reuse options represent the attractive and nodal character from where the other activities function from and act to strengthen them. The landscape concept represents the construction of new outdoor spaces which combines the layers of linkage, meeting, recreation and as such the landscape becomes a hybrid of ‘natural green” and infrastructure. There is great in need to give the landscape prominence in the rehabilitation of the four post-mine sites and apply the concepts of the landscape urbanism theory in integrating it into the urban landscape at a neighborhood and whole city context.

Brownfield redevelopment as stated by CLARINET (2002), needs early identification of the characteristics of the site and the way in which these can best be integrated into spatial planning decisions. Ways of improving community participation in brownfield redevelopment is also a key issue. Neighbors to the post-mine brownfields are

immediately impacted by the redevelopment. They have legitimate concerns over the impact of storm water, increases in traffic and the general change in character that will occur due to redevelopment. Their concerns may be focused on health, safety, environmental issues but they may also have an economic stake in the project to the extent that it will impact local property values, offer prospects for local employment and provide opportunities for existing and new local businesses. (Russ, 2000).

The U.S. Environment Protection Agency (2005), states that a major goal for systematic project planning is to include all of the stakeholders in the decision making process. A crucial part of reclamation and redevelopment of brownfields is active involvement by including members of the communities in the mine vicinity. CABERNET (2006), identifies stakeholders needed in driving brownfield redevelopment as landowners, regulators, developers, professional advisors, academics, community groups, financiers and technology suppliers. Stake holders identified in this study included brownfield landowners, members of public living within the brownfield neighborhoods. Authorities and regulators included NEMA, KUP, County Government of Kisumu, Ministry of Lands Housing and Urban Development, professional advisors included urban planners. According to Russ (2000), various stakeholders from diverse groups with diverse interests and concerns should be engaged. It is during the site planning phase of a project that many of these concerns need to be addressed. It is important that the designer understand the concerns of each stakeholder and consider how the concerns relate to the proposed project. It's in this respect that the views concerning most preferred rehabilitation reuse option was sought from the respondents and the need to understand the ecological and social effects caused on their environment by the post-mine sites.

5.0 SUMMARY OF FINDINGS, CONCLUSIONS & RECOMMENDATIONS

5.1 Overview

This chapter presents a summary of the main findings for each objective set by the study. It gives the conclusions and their applicability in broad context. The chapter also presents recommendations based on the purpose of the study which was to evaluate viable options for reuse and integration of post-mine brownfields into the urban landscape of Kisumu City of Kenya. Areas for further research are also suggested at the end of the chapter.

5.2 Summary of Findings

The first objective was to examine the spatial attributes of the post-mine brownfields in Kisumu City. The spatial attributes was analyzed in terms of location, access and size, land ownership and tenure, topography and drainage, vegetation and fauna, land use, activities on site and views within the site. The study results revealed that each brownfield has unique spatial attributes and hence the need to plan each differently.

In terms of location, the study revealed that the four post-mine brownfields were within the peri-urban areas and not within the city centre. The reuse options for each therefore should be compatible with the existing land uses zoned for the different areas i.e. residential use for Migosi, Nyawita and Wathorego. Land ownership revealed that all the abandoned quarry lands were on private land either under freehold or leasehold. The land owners must be included in the planning process for the reclamation of the four post-mine sites into beneficial land uses. Sizes of the four sites vary from 0.45 Ha to 1.2 Ha in area. The Nyawita post-mine site is the largest while the smallest in size is Migosi post-mine site. Based on average cost of land within the four sites, Nyawita post-mine being the largest in area would be sold at one hundred and eight million based on value of 0.02 Ha being sold at 1.8 million in case of lands not being quarry lands. Migosi post-mine would be valued at 40.5 million based on 0.02 Ha being sold at 1.8 million. Kanyawegi and Wathorego lands are valued at 0.6 million per 0.02 Ha and hence would be sold at 24 million and 19.5 million respectively. The areas covered by the brownfields are relatively small. The cost of acquisition for each of the sites is relatively within the public means incase of acquisition from the private owners for reclamation into public facilities. Depths and widths vary across the four sites with Nyawita being the widest and Migosi with the least width. The main activity on all the four post-mine sites is dumping of wastes. There is need to provide alternative dumping site if rehabilitation is to be undertaken within the

sites. Drainage was a problem in all the four sites hence water logging within some parts of the abandoned quarry pits. The four sites had common negative attributes like water logging and there is need for the preferred reuse options to plan for this and change it to be a positive aspect. The untamed vegetation promoted crime and hence the reuse option during rehabilitation should address the possible hideouts that lead to insecurity. Dangers posed by the deep depths due to lack of physical barriers should be addressed by the chosen reuse options during rehabilitation to ensure this negative attribute is addressed.

The second objective was to assess the public perception on the effects of the post-mine brownfields on the environment. Ecological effects on environment was in terms of dumping of wastes, air pollution, possible contamination from wastes or past quarrying activities and breeding of mosquitoes. Social effects was in terms of crime and other social evil, risk/danger of accidental falling into the abandoned quarry, effects on the visual quality and aesthetics. Dumping of wastes was evident from on-site observation in all the sites except at Kanyawegi that had no dumping at all. The sites were used for dumping while the reuse as a landfill was the least preferred reuse hence there is need to plan for alternative means of waste management during rehabilitation.

Social effect in terms of risk/danger of accidental falling into the abandoned quarry pits was supported by most respondents and on-site observation across the four sites. The four sites had varying depths from 3 metres to 15 metres that posed great risk and danger of accidental falling into the abandoned pits.

The four sites all posed the threat of being potential areas for crime and other evils. Depths vary from the least ends at three metres while the deepest ends at ten to fifteen metres. Nyawita and Wathorego post-mines are the deepest while Migosi has most of it being the shallowest. The deep depths are a pointer to the security threat in terms of hazard that the four sites pose to the residents within these neighborhoods in cases of accidental falling into the abandoned pits. .Many post-mine brownfields- are overgrown with untended vegetation and filled with trash from illegal dumping. All the post-mines are characterized by high stone walls and untamed vegetation that provide excellent hiding areas both during the day and night hence posing a security threat within their neighborhoods.

The last study objective was to analyze public preferences on possible reclamation/rehabilitation land uses that the post-mine brownfields can be planned into. The eight reuse options suggested to the respondents within the post-mine neighborhood included agricultural production, human settlement i.e. housing units, construction of public facilities e.g. community hall, church, school, nature conservation/forestry, production of renewable resources e.g. solar power, public parkland, landfill for waste disposal and private recreation recreation/leisure grounds. Landfill for waste disposal was the least preferred choice due to environmental problems like visual blight, foul smell that are associated with it .The most preferred reuse option for Nyawita, Migosi and Wathorego sites was the construction of public facilities while agricultural production was most preferred at Kanyawegi site. Public facilities may include the construction of a communal conference hall, church, primary and kindergarten school, information centers/library. The most preferred implementation method by respondents was public private partnership (PPP) although the abandoned post-mine sites are owned by private owners under freehold and leasehold.

5.3 Conclusions

The study established that each brownfield has unique spatial attributes and as such each needs to be planned for differently. All the four sites are within the peri-urban areas of Kisumu City in areas with good access and they vary in size and all under private ownership. The four sites have various negative effects that they pose to the residents living within their neighborhoods. All the negative spatial attributes like water logging, deep depths, untamed vegetation etc. for the four post-mine sites should be addressed to convert them into positive attributes that are beneficial for the preferred reuse options when planning for rehabilitation. Addressing these negative spatial attributes leads to elimination of the negative effects they pose to the ecological and social environment within these neighborhoods.

Effects on the ecological environment like dumping should be addressed during planning for rehabilitation by providing alternative ways, places for dealing with the waste management that is currently done within the post-mine sites. The lack of dumping places is pointer to the fact that the residents within the brownfield neighborhood use it for illegal dumping that is causing several negative effects to the environment. Choosing the landfill option as the least preferred reuse for all of the sites is a point to the fact that the

residents do not like the fact that the sites in their current abandoned states are being used to dump domestic and other wastes.

The most preferred reuse options for Nyawita, Migosi and Wathorego was construction of public facilities. There is need for the County Government of Kisumu to acquire these abandoned quarry lands that are currently owned by private residents. The costs for acquisition can be agreed upon between the parties concerned so that planning for the most preferred reuse option in terms of construction of public facilities can be realized successfully. The most preferred implementation method for this reuse is PPP that calls for partnership between the private and the public entities. The public facilities in terms of school, church, community hall are all compatible with the existing land use that is residential within the brownfield neighborhoods. Agricultural production as the most preferred reuse option for Kanyawegi site is also compatible with the existing and dominant land use within the area that is agricultural.

5.4 Recommendations

Recommendations were drawn concerning brownfields in regard to their spatial attributes, effects on the environment and reuse in terms of rehabilitation/reclamation.

All the four abandoned post-mine sites should have their untamed vegetation managed to avoid possible hideouts that may be security threats. Water logging prevalent in all of the should be addressed by planning for proper storm water management within and around them for the preferred reuse option to be successful and to reverse and eliminate the current problems associated with this negative attribute. There is need for the regional authorities like County Government of Kisumu to have an elaborate database of the various post-mine brownfields within their jurisdiction to aid in planning of the rehabilitation process.

Negative effects on the ecological environment like dumping that is carried out within these post-mine sites should be stopped. Planning for the reuse options should consider providing for alternative ways for managing the wastes generated by the households that use them for illegal dumping. Alternative dumping will ensure that the current problems associated with the dumping like foul smells, negative visual quality are avoided. The reuse option planned for should take advantage of the varying depths of the four sites and

as such should bring to an end the current dangers and risks of accidental falling into the pits and being possible points for insecurity due to the hideouts from deep heights for the quarry walls.

The most preferred reuse option by the residents should be implemented through PPP after the acquisition of the abandoned quarry lands from the current owners. PPP was chosen as the best method that would appeal to both private and public entities during the rehabilitation so that greater acceptance is achieved and hence successful planning for rehabilitation as the desired end result. The post-mine brownfields owners are the most important stakeholders and they should consider the likelihood of getting into partnership with the private investors or public entities like County Government of Kisumu to necessitate the rehabilitation of the sites through construction of any acceptable and compatible public facilities as the most preferred option. The views and concerns of the residents living within the post-mine brownfield neighborhood should also be included in the PPP implementation of the chosen reuse option.

Integration of the chosen reuse option during rehabilitation is a process that should be holistic in nature to include all stakeholders especially land owners since they are all found on private land. From this study, the occurrence and presence of post-mine brownfields is a land use problem that has several ecological and social problems to the environment at neighborhood and whole city's urban landscape. To integrate the post-mine brownfields there is need to first understand their negative effects as has been elaborated within the literature review and the study findings and the discussion and plan for their rehabilitation/reclamation that needs engagement of several stakeholders such as the quarry neighbors, quarry landowners, regulatory authorities, planning and design professionals etc. There is need to understand each post-mine brownfield in its local context in terms of its spatial attributes as each is unique and this has been proved by the study's on-site observations.

5.5 Suggestions for Further Research

As a result of the findings of this study, the following areas were suggested for further research.

- The role of local authorities in the inventorying, prioritizing and marketing of brownfields for rehabilitation process in Kenya.
- Barriers to the redevelopment/ revitalization of brownfields in Kisumu and Kenya as a whole.
- Environmental impact assessment on the various types of brownfields within Kisumu City and Kenya as a whole.
- The effects of the abandoned post-mine brownfields on the property values in Kisumu City.

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APPENDICES

Appendix I: Household Questionnaire

Section A: General information:

Date…… Questionnaire no……..

Post-mine brownfield sub-location……..

Approximate distance of residence from brownfield……..

Name of enumerator……

Section B: Household demographics:

A. Gender

Male ☐ Female ☐

B. How old are you……..

C. Marital status

Single ☐ Married ☐ Widow ☐ Widower ☐

D. Education level

None ☐ Primary ☐ Secondary ☐ Tertiary& above ☐

E. For how long have you lived next to the abandoned quarry……

F. Do you have children?

Yes ☐ No ☐

Section C: Effects of the abandoned quarry on the Environment:

Physical effects

1. Do you consider the presence and state of the abandoned quarry/brownfield a ground for breeding of mosquitoes within this area?

   Yes ☐ No ☐ Any other specify

2. If Yes above what aspect of the abandoned quarry/brownfield do you consider is responsible for the breeding of mosquitoes? (Tick all that apply)

   Water logging/swampy nature ☐

   Untamed vegetation ☐

   Any other specify

3. Do you use the abandoned quarry as a dumping ground for your domestic wastes?

   Yes ☐ No ☐ Any other ☐

4. If Yes above why do you use it as the dumping ground for your wastes? (Tick all that apply)

   Nearness/proximity to it ☐

   Abandoned nature of it ☐

   Any other specify

5. For how long have you been dumping wastes into the abandoned quarry?
6. If No above what hinders you from using the abandoned quarry as a dumping ground for your wastes?

   Risk of falling in ☐

   Far distance from your house to it ☐

   Any other specify

7. Are you aware of dumping of wastes from other households and sources within the abandoned quarry presently or before?

   Yes ☐ No ☐ Any other ☐

8. Is the abandoned quarry a source of air pollution?

   Yes ☐ No ☐ Any other ☐

9. If Yes above what aspects of the abandoned quarry is contributing to the air pollution? (Tick all that apply).

   Dumping of wastes within it ☐

   Water logged nature ☐

   Any other specify

10. If No above what aspects of the abandoned quarry do you suggest are contributing to lack of air pollution? (Tick all that apply).

    Lack of dumping of wastes ☐

    Minimal dumping of wastes ☐

    Minimal water logging ☐

    Any other specify

11. Do you feel that there is possible contamination on the abandoned quarry land?

    Yes ☐ No ☐ Not sure ☐

12. If yes, above what do you think is responsible for the contamination?

    Previous activities such as blasting using chemicals ☐

    Past & recent dumping of wastes ☐

    Both of the above ☐

    Any other specify

    Social effects:

13. Does the abandoned quarry pose a threat in terms of insecurity as a hiding ground for thieves and other forms of crime?

    Yes ☐ No ☐ Any other specify

14. If Yes above what aspect of the abandoned quarry contributes to the insecurity? (Tick all that apply).

    Abandoned nature ☐

    Untamed vegetation ☐

    Hideouts due to deep depth ☐

    Any other specify

15. If No above what aspect of the abandoned quarry makes it not to be a security threat?

    Clear views into it ☐

    Distance from it ☐

    Any other specify

16. Does the abandoned quarry pose a risk in terms of falling in accidentally?

    Yes ☐ No ☐ Any other specify

17. If Yes above what aspect can lead to the risk of falling into the pit? (Tick all that apply).

    Closeness of access paths to it ☐

    Lack of barrier/fencing ☐

    Any other specify

18. If No above what aspects contributes to lack of accidental falling into the pit?

    Fence/barriers around it ☐

    Lack of access paths close to it ☐

    Any other specify

19. Do you consider the quarry in its present state pleasing to the eye/good?

    Yes ☐ No ☐ Any other specify

20. If you consider the current state/appearance of the quarry unpleasant, kindly tick the level of unpleasantness.

No unpleasantness ☐ (0 points).

Very low unpleasantness ☐ (1-20 points).

Low unpleasantness ☐ (21-40 points).

Medium unpleasantness ☐ (41-60).

High unpleasantness ☐ (61-80).

Very high unpleasantness ☐ (above 80 points).

21 If Yes in question 19 above what aspects of the abandoned quarry do you consider make it pleasing /good to the eye? (Tick all that apply).

Minimal dumping of wastes ☐

No/few untamed vegetation ☐

Minimal visible rugged landscape ☐

Minimal swampy waterlogged nature ☐

Any other specify

22 If No in question 19 above what aspects of the abandoned quarry contribute to it being unpleasant/bad to the eye? (Tick all that apply).

Dumping of wastes ☐

Untamed vegetation ☐

Rugged landscape ☐

Swampy waterlogged nature ☐

Any other specify

Integration through rehabilitation/reclamation:

23. Do you think the abandoned quarry should be turned into other better uses or left to remain in its current state/appearance?

Yes ☐ No ☐ Any other specify

24. What use do you suggest the abandoned quarry land should be turned into to improve it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**

Rehabilitation reuse/land use option	**Rank/No. assigned**
Public parkland	
Construction of public facilities e.g. school, church, community hall	
Agricultural production	
Landfill for waste disposal	
Nature conservation/forestry	
Private recreation/Leisure grounds	
Human settlement i.e. housing units	
Production of renewable resources such as solar power	
Any other specify	

25. Which implementation option do you prefer for undertaking the improvement/ rehabilitation of the abandoned quarry?

    Private through quarry owners/developers ☐

    Public sector through County government ☐

    Public-Private Partnership/co-operation (PPP). ☐

    Any other specify?

Appendix II: (Interview schedule for County Government of Kisumu, KUP).

General information.

Date…… Office/Organization……

Designation of official…….

Name of officer to interview……

1. Do you have any data on the location, size and physical state of the brownfields in Kisumu City?

2. Are there any plans to have the spatial attributes of the post-mine brownfields documented for future use?

3. Who are the owners of the abandoned stone quarries within Nyawita, Migosi, Kanyawegi and Wathorego?

4. Have you received any complaints or concerns from the public concerning any negative effects of the brownfields on the environment within their neighborhoods?

5. Suggest some of the concerns of the post-mine brownfields/quarrys that were raised by the public within the neighborhoods.

6. Does your office consider reclamation/rehabilitation of the post-mine brownfields/quarrys as one of the ways to revitalize the urban landscape?

7. What plans do you have for reclamation to ensure the integration is undertaken to ensure harmony of the surrounding land uses with the brownfield/quarry?

8. Are there studies by County Government of Kisumu or any other body that have been done before on the above mentioned abandoned stone quarries on their spatial attributes, effects on the environment and with an aim to rehabilitate them?

9. What do you suggest the brownfields/abandoned quarry within Nyawita, Migosi, WathoregoangKanyawegi should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g school, church, community hall				
Agricultural production				
Landfill for waste disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e. housing units				
Production of renewable resources such as solar power				
Any other specify				

10. Which implementation option for the rehabilitation reuse that you have chosen as most preferred above do you prefer?

    Private by the quarry landowners ☐

    Public sector implementation through County government ☐

    Public-Private Partnership/co-operation (PPP). ☐

    Any other specify?

Appendix III: (Interview schedule for NEMA/Ministry of Environment, Ministry of Mining).

Date…… Office/Organization……

Designation of official…….

Name of officer to interview……

1. Are you aware of the presence of the abandoned stone quarries within Nyawita, Migosi, Wathorego and Kanyawegisub-locations of Kisumu City?

2. Who are the owners of the abandoned stone quarries within Nyawita, Migosi, Kanyawegi and Wathorego?

3. Do you have data on the approximate size in terms of acreage and depth of the abandoned quarries within the four sub-locations named above?
4. Have you received any complaints or concerns from the public concerning any negative effects of the brownfields on the environment within their neighborhoods?

5. Suggest some of the concerns of the post-mine brownfields/quarry's that were raised by the public within the neighborhoods and the actions NEMA took.

6. What steps is NEMA as the body mandated taking to ensure the negative effects of the abandoned quarries are reversed/avoided?

7. Are there studies by NEMA or any other body that have been done before on the above mentioned abandoned stone quarries on their spatial attributes, effects on the environment and with an aim to rehabilitate them?

8. Does your office consider reclamation/rehabilitation of the post-mine brownfields/abandoned quarry's as one of the ways to revitalize the urban landscape?

9. What plans do you have for reclamation/rehabilitation of these abandoned quarries to ensure integration is achieved to ensure harmony of the surrounding land uses with the brownfield/quarry?

10. What do you suggest the brownfields/abandoned quarry within Nyawita, Migosi, Wathorego and Kanyawegi should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8).**

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g. school, church, community hall				
Agricultural production				
Landfill for waste disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e. housing units				
Production of renewable resources such as solar power				
Any other specify				

11. Which implementation option for the rehabilitation reuse that you have chosen as most preferred above do you prefer?

    Private by the quarry landowners ☐

    Public sector through County government ☐

    Public-Private Partnership/co-operation (PPP). ☐

    Any other specify

Appendix IV: Brownfield/Quarry Landowners

General information

Date……

Post-mine brownfield sub-location……..

Brownfield/quarry owner……..

Interview questions:

1. Kindly give a brief history of the post-mine brownfield/quarry in terms of when it was started, when active quarrying ended and any other information on its operation.
2. What is the land tenure for this brownfield/quarry land that you own?

3. What is the approximate size/acreage of the quarry land?

4. Have you received any complaints or concerns from the public concerning any negative effects of the brownfield/quarry on the physical and social environment?

5. Suggest some of the concerns of the post-mine brownfield/quarry that were raised by the public within the neighborhoods.

6. Do you have any intention as a quarry owner on how you plan to use the quarry land? Suggest the plans.

7. Are you willing to seek for solutions from government bodies like City Council, NEMA or any interested investors on how to rehabilitate the quarry land?

8. As the quarry owner what do you suggest the brownfields/quarry should be turned into to rehabilitate it?

9. Are you open to partnership/collaboration with the County government/County Government of Kisumu or private entities in order to rehabilitate the quarry land?

10. What do you suggest the abandoned quarry land should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g. school, church, community hall				
Agricultural production				
Landfill for waste disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e. housing units				
Production of renewable resources such as solar power				
Any other specify				

11. Which implementation option do you prefer for reclamation and integration of your most preferred reuse option?

    Private by the quarry landowners ☐

    Public sector through County government ☐

    Public-Private Partnership/co-operation (PPP). ☐

    Any other specify

12. Is it possible that you can sell the brownfield/quarry land to the County Government of Kisumu or the County Government of Kisumu in order to own it, reclaim into public use?

13. At what cost would you sell the quarry to the above public entities?

14. What hinders you from restoring the quarry to its original state as required state after ceasing of quarrying as required by the Kenyan law (NEMA EMCA act 1999) or rehabilitating into other acceptable reuse options?

Appendix V: (Interview schedule for Architects/Landscape Architects, Urban Planners, Physical planner at Ministry of Lands office).

A) <u>Urban Planner:</u>

1. According to the land use planning what is the zoning land use in the following sub-locations

Sublocation	**Zoned land use**
Nyawita	
Migosi	
Wathorego	
Kanyawegi	

2. What do you suggest the abandoned quarry land should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**.

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g. school, church, community hall				
Agricultural production				
Landfill for waste disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e. housing units				
Production of renewable resources such as solar power				
Any other specify				

3. Which implementation option do you prefer for reclamation and integration of your most preferred reuse option?

   Private by the quarry landowners ☐

   Public sector through County government ☐

   Public-Private Partnership/co-operation (PPP). ☐

   Any other specify

B. <u>Landscape Architects:</u>

1. What do you suggest the abandoned quarry land should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g. school, church, community hall				
Agricultural production				
Landfill for waste disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e. housing units				

Production of renewable resources such as solar power				
Any other specify				

2. Which implementation option do you prefer for reclamation and integration of your most preferred reuse option?

   Private by the quarry landowners ☐

   Public sector through County government ☐

   Public-Private Partnership/co-operation (PPP). ☐

   Any other specify

C. <u>Physical planner at the Ministry of Lands:</u>

1. According to the land use planning what is the zoning land use in the following sublocations

Sublocation	**Zoned land use**
Nyawita	
Migosi	
Wathorego	
Kanyawegi	

2. What do you suggest the abandoned quarry land should be turned into to rehabilitate it? (Rank the reuse options between 1 to 8 with the **most preferred as No.1** and **least preferred as No. 8)**

Rehabilitation reuse/land use option	**Post-mine brownfield sub-location**			
	Nyawita	**Migosi**	**Wathorego**	**Kanyawegi**
Public parkland				
Construction of public facilities e.g. school, church, community hall				
Agricultural production				
Landfill for waste				

disposal				
Nature conservation/forestry				
Private recreation/Leisure grounds				
Human settlement i.e housing units				
Production of renewable resources such as solar power				
Any other specify				

3. Which implementation option do you prefer for reclamation and integration of your most preferred reuse option?

   Private by quarry landowners ☐

   Public sector through County government ☐

   Public-Private Partnership/co-operation (PPP). ☐

   Any other specify.

Appendix VI: On-site Observation Guide

Day……. Time…….

Post-mine brownfield sub-location……..

Location: Urban…….Peri-urban……Rural…….

Spatial attributes:

1. GPS coordinates

2 Access/Transport link

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……..……..

3. Land tenure

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……..…….

4. Approximate area of brownfield:

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5. Approximate depth

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6. Topography & drainage

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7. Activities within the site

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8. Land uses around the brownfield site

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9. Land use conflicts present

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10. Vegetation/Flora

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11. Fauna

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12. Photographs taken

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