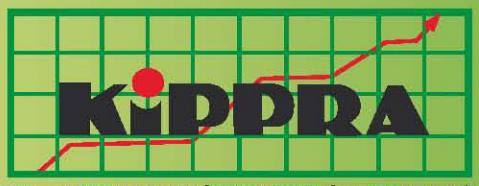
Discussion Paper Series



The KENYA INSTITUTE for PUBLIC
POLICY RESEARCH and ANALYSIS

Destruction of Riparian Zones in the Nairobi Metropolitan Region

Monicah Nyawira Karangi

DP/197/2017

THE KENYA INSTITUTE FOR PUBLIC POLICY
RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING
PROGRAMME

Destruction of Riparian Zones in the Nairobi Metropolitan Region

Monicah Nyawira Karangi

Kenya Institute for Public Policy
Research and Analysis

KIPPRA Discussion Paper No. 197
2017

KIPPRA in Brief

The Kenya Institute for Public Policy Research and Analysis (KIPPRA) is an autonomous institute whose primary mission is to conduct public policy research leading to policy advice. KIPPRA's mission is to produce consistently high-quality analysis of key issues of public policy and to contribute to the achievement of national long-term development objectives by positively influencing the decision-making process. These goals are met through effective dissemination of recommendations resulting from analysis and by training policy analysts in the public sector. KIPPRA therefore produces a body of well-researched and documented information on public policy, and in the process assists in formulating long-term strategic perspectives. KIPPRA serves as a centralized source from which the Government and the private sector may obtain information and advice on public policy issues.

Published 2017

Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

ISBN 978 9966 058 84 3

The Discussion Paper Series disseminates results and reflections from ongoing research activities of the Institute's programmes. The papers are internally refereed and are disseminated to inform and invoke debate on policy issues. Opinions expressed in the papers are entirely those of the authors and do not necessarily reflect the views of the Institute.

KIPPRA acknowledges generous support from the Government of Kenya, African Capacity Building Foundation (ACBF), and the Think Tank Initiative of IDRC.

Abstract

The global development agenda has placed the sustainability of cities as a critical agenda focusing on the development of safe, resilient and sustainable cities. The frequency of flooding in cities and the collapse of buildings in Kenyan urban areas has raised policy concern on the importance of wetland riparian buffer zone protection. Wetland riparian buffer zones, though defined as public land, have often been viewed as idle wastelands, therefore attracting illegal development. The legislative framework provides for divergent assessment of the width of the riparian buffer zone, which further complicates management and enforcement actions by government agencies. Additionally, although the problem is apparent, its magnitude over time and space is unknown. This study seeks to demystify the encroachment problem in the Nairobi Metropolitan Region, highlighting the legislative loopholes and the spatial and regional complexities of land cover changes along the riparian buffer zone from 1988 to 2014. The study reveals that wetland areas within the metropolitan region dropped significantly by 50 per cent between 2010 and 2014, with Nairobi, Northern and the Southern regions experiencing significantly high increase in built up areas and decrease in wetland areas. Results from assessing Landsat imagery for the years 1988, 2000, 2010 and 2014 show that the rate of construction of permanent buildings within the riparian buffer zone significantly increased from -9 per cent between 2000 and 2010 to 262 per cent between 2010 and 2014, with the encroachment highest in the northern region (Kiambu County) and Southern Region (Kajiado County). There is need for harmonization of the legislative framework in the definition of the riparian buffer width, in streamlining institutional mandates in management and development control. Secondly, enhancement of enforcement capacity of government agencies through participatory methodologies in riparian management is encouraged. Thirdly, land governance frameworks, including land use planning and development control can no longer be sidelined. Development of National Land Use Policy and Urban Development Policy should be prioritized, with county governments' capacity built in the preparation and implementation of development plans enhanced. Further, the use of spatial decision support systems is integral in evidence-based policy formulation and in monitoring any further destruction of riparian areas in Kenya.

Abbreviations and Acronyms

CPR	Common Pool Resource
EMCA	Environment Management and Coordination Act
GIS	Geographic Information Systems
MOE&NR	Ministry of Environment and Natural Resources
NMR	Nairobi Metropolitan Region
NEMA	National Environment Management Authority
WRUA	Water Resource User Associations
WRMA	Water Resource Management Authority

Table of Contents

1. Introduction

Urbanization is an inevitable phenomenon, with the urban population estimated to increase from 32 per cent in 2009 to more than 50 per cent of the total population in Kenya by the year 2030 (KIPPRA, 2014). The global appreciation of the potentially adverse environmental impacts of urban development in rapidly emerging cities has led to their inclusion in the environmental sustainability discourse. The Sustainable Development Goals, Goal 11 advocates for the development of inclusive, safe, resilient and sustainable cities. Of importance is in finding a balance between the brown agenda (ecological footprint of human environment) and the green agenda (environmental protection) towards sustainably meeting social, economic and environmental needs of emerging cities (UNHabitat, 2009).

A riparian buffer zone is frequently used to mean the interface between land and a flowing surface water body/wetland. In this study, a wetland riparian area is synonymous to a river bank or riparian reserve. Riparian buffer zones occupy a small area but provide important ecosystem services for urban landscapes, including storing water and recharging sub-surface aquifers, flood control and conservation of biological diversity. Due to their small coverage, urban riparian ecosystems have often been perceived as "underutilized wastelands" and therefore prone to illegal occupation and unprecedented destruction (Ministry of Environment, Water and Natural Resources - MEWNR, 2013, Karisa, 2010).

The Nairobi Metropolitan Region has risen to become the largest and most urban of the metropolitan regions in Kenya, composing of an agglomeration of County Governments, including the Nairobi City County, Kiambu County in the North, Machakos County in the East and Kajiado County in the South. Concomitant with the high rate of urban population increase in the metro has been the expansion in the urban extent attributed to availability of vast affordable land, improved road infrastructure networks, increasing investment and housing needs, and industrial expansion (Mundia and Aniya, 2005). Rapid urbanization demands and the aftermath of past neglect in managing increased urban growth processes has resulted to the continued destruction of wetlands and encroachment on fragile riparian zones resulting into problems such as pollution, depletion of ground water sources, loss of biodiversity and increasing occurrence of urban flooding (NEMA, 2011; Republic of Kenya, 2008).

The urban flood challenge has topped the list of urban resilience challenges in Kenya, accounting for 60 per cent of disaster-related fatalities, with the fundamental reason for increase in flooding attributed to increase in encroachment and obstruction of riparian reserves and natural water courses (Republic of Kenya, 2013c; Ouma and Tateshi, 2014). Though costing economic damages is

difficult to estimate, the Water Resource Sector Memorandum report estimates that using known return intervals, loses accrued from flooding could amount to an annualized loss of 0.8 per cent of GDP largely as a result of loss of infrastructure. Using these estimates, these losses could accrue to over Ksh 49.8 billion based on GDP at market price of 2015 set at Ksh 6.2 trillion (World Bank, 2004; Ouma and Tateshi, 2014; Republic of Kenya, 2016).

Further, riparian buffer zones also play a critical role in ensuring water quantity by replenishing ground water sources and maintaining water quality by filtering sediments from upland runoff and breaking down organic wastes. The Kenya Economic Survey (2016) indicates that to address water scarcity in the country, the National Government allocations on water supplies and related services significantly increased from Ksh 32.5 billion in 2014/2015 to Ksh 41.3 billion in 2015/16, with water infrastructure development accounting for more than half of the total expenditure. Management of wetland areas and protection of riparian buffer zones has been given little emphasis, despite their important ecosystem services. Emerging threats of illegal occupation and destruction of the water reservoirs, including the Ondiri Springs, the Kabete and Karura Forests, and the Ngong' hills has been given little emphasis, therefore putting water quality and water quantity status of emerging urban areas in the Nairobi Metropolitan Region at risk.

The diversity of economic sectors that are heavily affected by flood-related incidences, water pollution and water scarcity demonstrates the need for sound water resource management practice and deliberate interventions at National and city-wide scales towards protection of riparian reserves. By adopting the Nairobi Metropolitan Region as a case study, this paper examines alternative policy approaches to protection of urban riparian zones focusing on two facets of the knowledge gap: firstly, to quantify the magnitude of encroachment on the riparian buffer zone area between 1988 to 2014; and secondly, to assess the effectiveness of legislative responses on riparian buffer protection and management.

1.1 Statement of the Problem

By law, the two pieces of land of not less than 30 metres measured from the high water mark on both sides of any wetland is government land and is to be left in its natural state. These lands have, however, been illegally allocated to individual owners over time, who have subjected them to proscribed alternative land uses leading to their gradual destruction.

The Environmental Management and Coordination Act (EMCA) and the Water Act give absolute powers to the National Environmental Management Authority

(NEMA) and the Water Regulation Management Authority (WRMA), respectively, for monitoring and licensing of riparian zone uses. The Water Resource Management Rules of 2006 prohibit several land uses along riparian buffer zones, including cultivation or tillage, clearing of indigenous vegetation, building of permanent structures and disposal of waste. Despite the existence of legislations, these environmentally fragile ecosystems continue to be exploited and destroyed.

The ineffectiveness of traditional approaches in protecting wetland riparian zones is strongly attributed to three distinct factors; firstly, though the legislative framework clearly defines the extent of these zones, their boundaries have not been defined and gazetted. This has left the task of definition and management to the interpretation of the individuals owning land adjacent to the wetland (Lelo, Chiuri and Jenkins, 2005). The magnitude of encroachment has also not been measured, therefore the magnitude of the problem is not known. Secondly, overlaps in legislative requirements and institutional mandates as it relates to execution and enforcement of regulations on protection of riparian buffer zones aggravates the problem. Thirdly, the ad hoc, disjointed and reactive nature of land use planning and development control activities between the different counties in the Metropolis increases the vulnerability of environmentally sensitive zones. This discussion paper therefore seeks to assess the magnitude of the encroachment problem and the effectiveness of management approaches towards delivering policy recommendations that would ensure the sustainable protection and management of riparian buffer zones.

1.2 Research Questions

This paper therefore focuses on answering three research questions:

1. Is the legislative framework effective in the protection of riparian zone?
2. What is the magnitude of urban encroachment on riparian buffer zones in the Nairobi Metropolitan Region, over time?
3. How has the magnitude and pattern of urban encroachment changed over space between the four sub-regions in the metropolitan region

1.3 Research Objectives

The specific objectives, therefore, are:

1. To examine the gaps in the legislative framework towards protection of riparian zones.

2. To assess the magnitude of urban encroachment on riparian buffer zones in the Nairobi Metropolitan region.
3. To compare the changes in the pattern and magnitude of encroachment by sub-region.

1.4 Policy Relevance

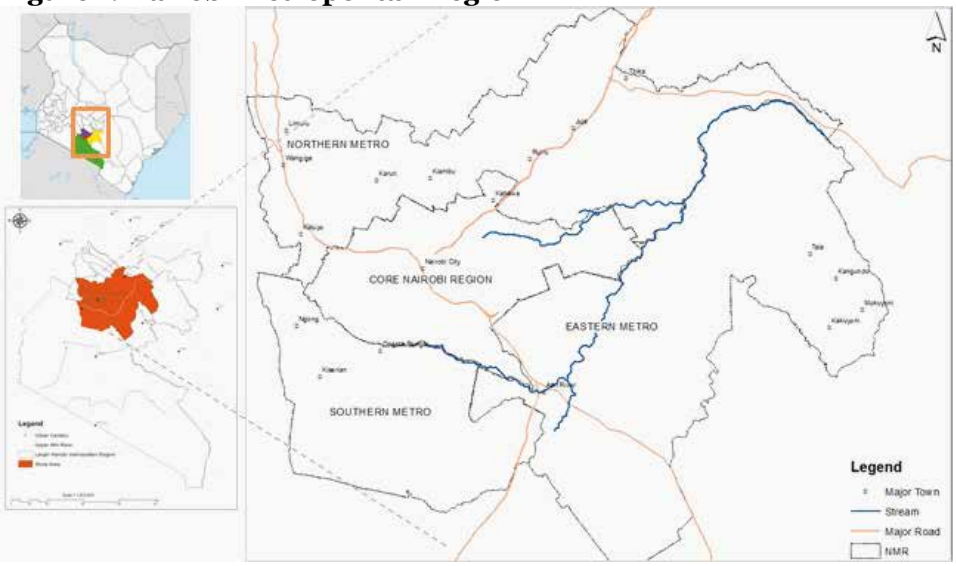
Riparian buffers are vital ecosystems which must be protected. This paper is based on the commitments of the Global Sustainable Development Goals and the Kenya Vision 2030 that provides for integrated development planning and regulation of land management processes towards development of inclusive, safe, resilient and sustainable cities. Kenya's ratification in the Ramsar Convention in 1990 obliges the country to the wise use of wetlands by including wetland conservation considerations in national planning processes. By assessing the land cover changes along the riparian zones, and specifically the magnitude of the encroachment problem, the study informs the discussions on the need for a shift in management approaches of primarily command and control policies, to the integration of co-management approaches and spatial decision support frameworks. The study recommendations are specifically useful for the County Governments and the Nairobi Metropolitan Directorate towards land use planning, and environmental management authorities including NEMA and WRMA in meeting their mandates. The study is also useful in building up on the global urban sustainability discourse..

2. Contextual Framework

2.1 Administrative Context

The spatial extent of the approved Nairobi Metropolitan Region (NMR) is about 4,438 km² of which Nairobi city covers 695 km². The NMR is divided into four spatial sub-regions: Core Nairobi comprising of the City County of Nairobi; the Northern Metro comprising of Kiambu County; the Southern Metro comprising of Kajiado County; and the Eastern Metro comprising of Machakos County. Figure 1 below shows the spatial extent of the broader Nairobi Metropolitan Region and adjusted NMR boundary, which is the study area.

Figure 1: Nairobi Metropolitan Region



Source: Author

2.2 Urban Population Growth

The NMR is a high movement area accounting for 20 per cent of the population in Kenya, 60 per cent of the motorized vehicles and 25 per cent of the wage employment (Republic of Kenya, 2011). The total population of the Nairobi Metropolitan Region (NMR) was 4.8 million in 1999, which increased to 6.7 million in 2000, registering an intercensal growth rate of 3.78 per cent from 1979 to 2009, and is estimated to increase to 13.0 million by 2030.

The rate of urbanization (population within the urban areas) is divergent within the sub-regions, with the Southern metro (Kajiado County) recorded to have

higher intercensal urban population growth rates between 1999 and 2009 at 11.9 per cent compared to the other sub-regions. The Northern Metro (Kiambu County) also registered high intercensal urban population growth rates between 1999 and 2009 at 5.65 per cent compared to Nairobi Core at 3.89 per cent and the Eastern Metro (Machakos County) at 3.82 per cent (Republic of Kenya, 2011). This disparity is evident by observing the urban growth trends of the specific urban centres as shown in Table 1 below.

Table 1: NMR urban centres growth trends

Sub-region		1999	2009	Annual population growth Rate (%)
Core Nairobi	Nairobi	2,143,254	3,133,518	3.89
Northern Metro	Ruiru	109,574	238,858	8.1
	Thika	106,707	139,853	2.74
	Limuru	68,326	104,282	4.32
	Kikuyu	156,131	234,053	4.13
	Kiambu	60,605	88,869	3.9
	Karuri	71,475	129,934	6.16
	Juja	6,009	40,446	21.01
	Githunguri	5,370	10,007	6.42
	Gatundu	5,125	5,550	0.8
Easter Metro	Mavoko	27,168	139,380	17.76
	Machakos	143,274	150,041	0.46
	Kangundo/Tala	179,152	218,557	2.01
	Kathiani	1,823	3,365	6.32
Southern Metro	Kajiado	9,165	18,281	7.15
	Ngong	20,701	107,188	17.87
	Kitengela	9,327	58,167	20.09
	OngataRongai	35,874	40,178	1.14
	Namanga	6,205	9,066	3.86
	Loitoktok	6,150	11,064	6.05
	Sultan Hamud	4,453	6,636	4.07

Source: Republic of Kenya (2011)

Projections by the Nairobi Metropolitan Growth strategy indicate that Nairobi core will continue to exert its primacy in the metropolis, contributing to rising population growth to 50 per cent of the total metropolitan population by 2030. As a result, demographic shifts will be observed by outmigration to the

surrounding regions, with congestion of the core being the major push factor (Republic of Kenya, 2008). Therefore, sustainable policies should advocate for spatial population distribution shift through poly-nucleic urban patterns while introducing measures to decongest the city core.

2.3 Legislative Context

This section assesses the gaps in legislative framework as it relates to the delineation of riparian buffer zone, ownership and management (land administration) and land use planning and development control.

2.4 Riparian Buffer Zone Delineation

The Environmental Management and Coordination Act (wetlands, shores and oceans) of 2009 defines a riparian reserve as the land bordering a river, a lake or a sea measured from the highest normal water mark. The width of the riparian reserve is measured from the highest water mark, which refers to the historical recorded level of contact between the water and the shore or bank. Legislation defining the official size of the strip of government-owned riparian land is not standard and varies according to a non-conventional calculation whereby the riparian area on each side of the river is to be set equal to two times the width of the river (Lelo, Chiuri and Jenkins, 2005). The width of the riparian zone also provides the setback lines below which no permanent construction should be undertaken.

The Water Quality Regulations (2006) under the EMCA provides for a riparian width of a minimum of six (6) metres and a maximum of 30 metres on either side based on the highest recorded flood level below which no developments should be undertaken. The Water Resource Management Rules 2007 derived under the Water Act define riparian width as land on either side of a water course, at a minimum of six (6) metres or equal to the full width of the watercourse up to a maximum of 30 metres on either side of the bank, measured from the top edge of the bank of the watercourse. The width of the watercourse is determined as equal to the distance between the top edges of its banks. The rules also mandate WRMA to demarcate the riparian boundary of any water course or body on land. Additionally, the Survey Act provides that in the alienation of land fronting a tidal river, a reservation of not less than 30 metres in width above the high water mark shall be delineated for government purposes, with the high water mark referring to the mean high water mark of spring tide.

From literature review, the width of the riparian buffer should not be homogenous along the watershed, but should be guided by the intended management objective (Hawes and Smith, 2005).

The legislative framework provides for maximum and minimum riparian widths that should be maintained as government land. These lands have, however, not been gazetted with the official size divergent within different legislations, therefore creating legislative loopholes that have been exploited. The overlapping criterion of delineating riparian buffer widths and the lack of demarcation of riparian buffer zones makes their management difficult therefore magnifying the encroachment problem. Table 2 shows the overlaps in legislative frameworks in defining the riparian width and setback lines.

Table 2: Legal provisions on allowable riparian reserve

State/institution	Recommended setback lines
Water Act (2002)	Minimum of 6 metres and maximum 30 metres from edge of the river
Environmental Management and Coordination Act (EMCA) 1999	Minimum of 6 metres and maximum 30 metres from highest recorded flood level
Agricultural Act	6 to 10 metres , sometimes ad hoc
Physical Planning Act	Minimum of 2m in height and maximum 30m horizontal from the edge of the river
Survey Act	Not less than 30 metres from the high water mark
By-laws	A maximum of 30 metres from the high water mark

2.5 Ownership and Management

According to the Land Act, 2012 riparian zones are government-owned and thus public properties. Though the Land Act gives the National Land Commission rights for the allocation of public land to individual owners, the commission cannot allocate public land that is demarcated as ecologically sensitive that is along watersheds, rivers and stream catchments (Republic of Kenya, 2012b). This therefore is indicative that riparian buffer land being public land and environmentally fragile in nature should not in any case be allocated to any private developer, under the Act.

The emerging question, therefore, would be who would manage the activities on this riparian zone? Overlaps on who should manage land use within riparian lands have been cited. The National Land Commission as mandated under the Land Act (2012) is mandated to identify and demarcate public lands that are considered

as environmentally sensitive, and provide guidelines indicating the management principles and land use. The EMCA Act (1999) mandates NEMA in consultation with the relevant lead agencies, in gazetting riparian land as a protected area and issue guidelines and prescribe measures for the management and protection of areas of environmental significance, taking into consideration the geographical size of the river bank, and interests of the community. Guidelines on resettlement, compensation of private developers, restoration and long term management are critical if the riparian buffer zone is to be effectively protected. The Water Act places delineation and management of wetlands on Water Resource Management Authority (WRMA). Overlaps, therefore, on government mandate in delineation and management of riparian land are evident.

On the other hand, the Water Resource Management Rules 2006 recognize that riparian land does not imply a change of ownership, but instead implies management obligations or controls of water resource on the riparian land owner. In this case, a riparian land owner refers to the registered owner of the land adjacent to a water body. The mandate of demarcation of riparian land has been placed on WRMA, with the riparian land owner required to beacon the riparian boundary at their own cost and seek for approval from WRMA on intended use of the riparian reserve. The rules also provide that the riparian land owner may be facilitated in instituting soil and water conservation plan on the riparian land. Therefore, of policy consideration is would reverting alienated land within the riparian buffer zone areas to government land enhance the management and protection of riparian buffer zones? Would enforcing management obligation of riparian land owners on riparian zones other than reverting riparian land to government land be effective?

The Environmental Management and Coordination Act (2015) provides for instituting co-management strategies in the management of critical habitats. The Water Act (2002) provides for the establishment of Water Resource User Associations (WRUAs). The Water Resource Management Rules empower Water Resource User Associations in water use approval procedures and in ensuring that no illegal construction is undertaken within wetland areas. This provides an alternative, bottom-up management approach that could be explored towards protecting riparian reserves in the region.

2.6 Land Use and Development Control

The Environmental Management and Coordination Act (EMCA) (1999) and the Water Resource Management Rules provide that “no person without prior written approval can excavate, drill, tunnel or disturb the river, direct or block any river

from normal course, or erect reconstruct or place any structure in the river" (Republic of Kenya, 1999). Consensus on prohibition of construction of permanent structures on riparian land has been established across board. Nevertheless, a contradiction in allowable alternative land uses as described in the Acts has been established. The Environmental Management and Coordination Regulations (2009) on wetlands, river banks, lake shores and sea shore management, allows for a variety of activities to be undertaken along a riparian area, including brick making, sport fishing, cultivation, commercial exploitation, construction of roads and railways. On the contrary, the Water Act (2002) forbids tillage or cultivation; clearing of indigenous trees or vegetation; disposal of any form of waste; excavation of soil or development of quarries and planting of exotic species on riparian lands. These two legislations offer conflicting direction on the allowable land uses on riparian land.

Under the new constitutional dispensation, land use planning and development control are devolved functions under the jurisdiction of the County Government. Under the County Government Act (2012), counties are mandated to develop city or municipal land use plans and building and zoning plans, which are regulatory instruments for guiding development control. Laxity in development and approval of land use plans curtails enforcement of development control measures and as a result encourages encroachment and destruction of fragile ecosystems. A key challenge highlighted through the key informant interviews is that the development approval processes are individually undertaken by county governments, sometimes in complete disregard of advice from NEMA and WRMA. The disjointed nature of land use planning and development control in the metropolis is aggravated by absence of key policy frameworks, including the National Land Use Plan, the Urban Development Policy and the Nairobi Metropolitan Land Use Strategy.

Conclusively, for the legislative framework to be effective in protection of riparian lands, it should be clear on the size and the boundaries of the land, who has rights over the land (ownership and user rights) and the permitted land uses over the land. Additionally, the enforcement capacity of NEMA and WRMA needs to be enhanced. This could be through financial and personnel enhancement or through the decentralization of monitoring functions. The role of Water Resource Management Associations (WRUAs) could be enhanced to complement government agency functions in monitoring compliance to environmental and land use legislation.

3. Literature Review

Riparian zones offer significant ecosystem services to both rural and urban ecosystems, including maintaining water quality and quantity by storing water and recharging sub-surface aquifers, reducing storm water flooding and conservation of biological diversity (Iakovoglou, Zaimes and Gounaridis, 2013). A river is a free access resource that provides benefits to a wide range of users, but is not "owned" by a well-defined set of rights holders (Patricia, 2004). The "tragedy of the commons" arises when it is difficult and costly to exclude potential users from common-pool resources (CPR) that yield finite flows of benefits (Ostrom, 2008; Ostrom et al., 1994).

This study adopts the Common Pool Resource (CPR) theory in explaining the management dilemma of wetland riparian areas. Hardin's initial theory of the "commons" drawn from the theory of collective action by Mancur Olson affirmed that individuals or resource users are unable to cooperate voluntarily in achieving a specific goal and, if left to their own peril, have a potential of collectively destroying shared resources (Schlager, 2004). Therefore, the most straight forward way to achieve restraint over use is through coercion, involving centralized top-down authoritarian control of a resource by a government agency or an authority outside the key users of the resource. This can be through several management approaches, including: Command and Control (CAC) policies and incentive-based economic strategies.

Command and Control regulations refer to direct legislation, quality standards derived by government authorities that state clearly what is permitted and what is illegal, and must be complied with. The control part refers to negative sanctions such as penalties, which are enforced as a result of non-compliance to the command. Incentive-based economic strategies to environmental protection are government-driven regulations that encourage behaviour through price signals and incentives, encouraging firms or resource users to undertake environmental conservation efforts that are in their financial self-interest (Anderson, 2002). This follows the "principle of full cost accounting", which requires government to act when market activities fail to reflect the full cost of an activity as destruction of a wetland riparian area. In this case, taxing of environmentally harmful activities raises the price, therefore reducing market demand and making alternative, less harmful forms of development more competitive and economic (Sandborn, 1997). Incentive-based economic policies could include increasing statutory penalties and civil liability of riparian destruction, property tax breaks for ecologically sensitive lands, provide transferable property tax credits to wetland owners, reward sensitive development designs, transferable development rights and performance bonding for developers.

Command and Control policies and economic incentives are sets of instruments that are embedded in complex regulatory systems and are, therefore, influenced by politics, and are primarily top-down in approach. It is, however, argued that centralized solutions that employ powerful coercion fail to consider the instinctive human reaction against compliance, which motivates resource users towards resisting the demanded (Ostrom, 1990; Ostrom et al., 1994). Although the centralized, state-centred, authoritarian approach has been successful in limiting and even reversing resource degradataion, the approach is unable to single-handedly address the complexity of environmental problems (Schlager, 2004).

Studies have demonstrated that users of common pool resources have a capacity to self-organize and develop common systems in successfully managing a CPR without external intervention or support (De Young, 1999; McCay, 1987; Ostrom, 1990; Olstrom et al., 1994). Addressing the challenge of the initial theory of the commons, Olsrom argued that common pool resource dilemmas that emerge from the individualization of resource users can be resolved through self-governing institutions (Ostrom et al., 1994). Studies have shown that engagement of communities to manage their own resource is most effective when the active commitment and collaboration of the stakeholders is critical, for example in the case of privately owned resources, and in cases where access to the resource has implicit impact on the communities livelihoods (Gawler, 2002). Ostrom (1990) notes eight (8) principles that are integral in designing a sustainable self-governing institutions in the management of common pool resources, including principle of exclusion that allows for clear definition of rights, resource users and boundaries of the CPR; clearly-defined set of rules defining user rights, technology, and desired uses; participation of resource users or affected in setting the rules and monitoring them; disciplinary actions derived by the resource users themselves for violations made, and shielding formation and operation of self-governing institutions from external government interference and influence .

3.1 Empirical Assessment on Management Alternatives in Kenya

Co-management approaches are not new in Kenya. Several best practices have been recorded on the importance of participatory management or self-governing institutional approaches in the management of riparian reserves. In Kenya, the Environmental Management Act amendments (2015) introduced a co-management approach to the management of environmental resources. The Act mandates NEMA to develop guidelines and measures that support co-management of critical habitats, taking into account the interests of the local communities.

A study demonstrating the participatory or community-based approach in the management of Nyando wetland in Kenya in the wake of climate change effects established that wetlands in Kenya continue to face immense pressure as a result of human activities, with the greatest challenge to their conservation and management being that wetlands are often unprotected (Raburu , Okeyo-Owuor and Kwena, 2012). Co-management allows for sharing of power and responsibility between the government and the resource users in the management and conservation of the resource. The study notes that community-based wetland management approaches are faced by several challenges, including low level of awareness among communities and market failure in appreciating the value of wetlands; institutional overlaps with lack of a clear institutional framework for management of wetlands; poor enforcement of wetland management policies; lack of clarity on ownership and rights of riparian lands; lack of wetland management plans; and low political goodwill.

The Nairobi River Basin Project sought to demonstrate the importance of public-private-community partnerships in riparian restoration and conservation. The project sought to restore the Nairobi river ecosystem by encouraging green concept to improve the livability of spaces but also boost the livelihoods of communities living adjacent to the river course (Karisa, 2010). Karisa (2010), however, notes that the major challenges that inhibit sustainable management and conservation of riparian lands in Kenya include fragmented legislation, institutional overlap in mandates, inadequate capacity of implementation agencies, lack of integrated information platform that limits decision making and finally minimal understanding of legislative frameworks and implications of unsustainable land use by communities occupying land adjacent to riparian reserves. To address these shortcomings, the integrated planning approach was recommended; this links environmental actions with land use planning, but also links the stakeholders by enhancing partnerships between public, private and community stakeholders.

3.2 Tools in Monitoring Riparian Land Use

Macleod and Congalton (1998) cited that four aspects are of importance when monitoring land cover changes along natural resources: detecting the changes that have occurred; identifying the nature of the change; measuring the area extent of the change; and assessing the spatial pattern of the change. The use of GIS and Remote Sensing tools have been developed and applied to quantify and characterize land cover changes for natural resource management. The main strength of GIS and remote sensing techniques compared to assessment based on traditional socio-economic indicators such as population growth lays on its capacity to represent socio-economic datasets spatially over time and over space

(Herold, Couclelis and Clark, 2005). Numerous studies have been undertaken in Kenya that adopted GIS and remote sensing tools in monitoring land cover changes and urban growth processes.

Mubea et al. (2014) used GIS and remote sensing tools in simulating and assessing urban growth scenarios in Nairobi between 1986 and 2010 and predicting future trends to 2030. Mundia and Aniya (2005) integrated remote sensing and geographic information system (GIS) in mapping the spatial dynamics of land use/cover changes and quantifying the urbanization process in Nairobi city. The studies concluded that expansion of the built-up areas has assumed an accretive as well as linear growth along the major roads networks, with urban expansion being the major cause of loss of forests, wetlands and agricultural land. The study noted that accessibility and transport are perhaps the most important factors in guiding direction of urban growth in Nairobi. Though the studies defined urban growth in relation to other land cover classes, the studies are confined to Nairobi County boundaries, and did not elaborate on the ripple effects of growth of Nairobi to the region.

Katana et al. (2013) used GIS and remote sensing tools in monitoring land cover changes of the Upper Athi River Catchment Area. The study assessed the land use cover changes for three years, 1984, 2000 and 2010 and made predictions of land cover changes along the catchment zone. The findings indicate that agricultural expansion and urbanization will be the main causes of environmental changes within the catchment area by 2030, and that mitigation measures are required to avoid undesirable effects. The main limitation of the study is in its failure to analyse the unique land cover changes per sub-region, as the changes and the impacts on the wetland catchment are not uniformly distributed. This study sought to address this shortcoming.

Olang' et al. (2015) in their study sought to study the spatio-temporal land cover changes witnessed within the Nyando River Basin of Kenya using medium resolution landsat imagery for six (6) epochs between 1973 and 2000. This analysis was supported by a community mapping approach in verification of classification results and in revealing historical land cover trends. The results indicated a drop in forest cover as a result of increase in agricultural activities. The study does not, however, assess the impact of urban development and expansion of Kisumu Metropolitan region on the basin, despite the challenges that the Nyando Basin could face as a result of increasing built up areas and human pressure in the region (Raburu, Okeyo-Owuor and Kwena, 2012).

Twesigye et al (2011) in a regional study investigated the impact of land use activities in the Nzoia River Basin in Kenya, Nakivubo wetland in Uganda and Simiyu Drainage basin in Tanzania using GIS and remote sensing tools and

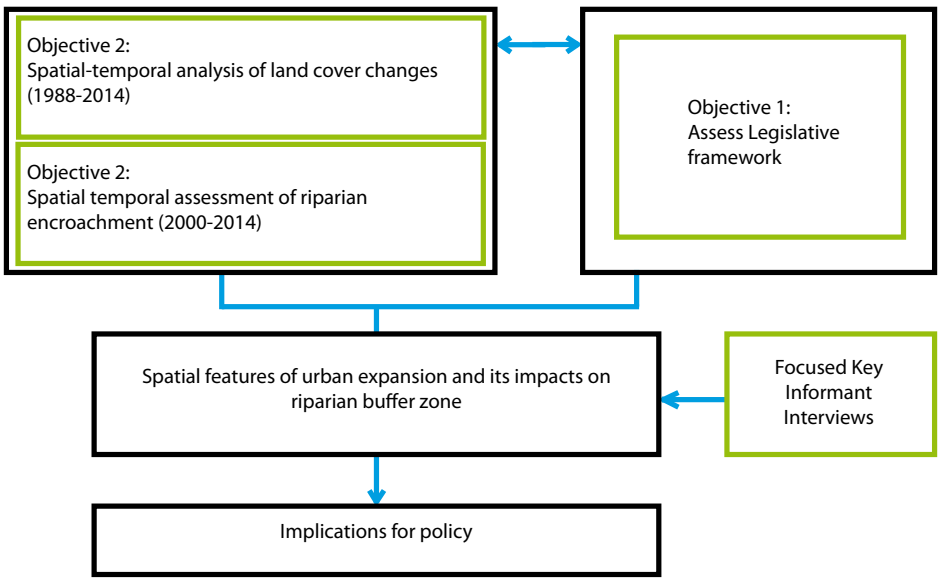
chemical and physical water analysis between 1974 and 2005. The study revealed that in the three sites, vegetation land cover has considerably reduced due to the emergence of industrial, residential and agricultural activities (human pressure), that further aggravated the water quality situation. No studies have been conducted that specifically assess the magnitude of urban encroachment on the riparian buffer zone area within the Nairobi Metropolitan region. This study seeks to fill that knowledge gap.

4. Methodology

4.1 Conceptual Framework

As illustrated in Figure 2 below, the study adopts a multi-criteria approach by integrating quantitative and qualitative techniques, including spatial mapping tools, document analysis and key informant interviews, for deriving policy recommendations. The use of Geographic Information Systems (GIS) analysis is adopted in defining the size of the riparian zone and assessing the magnitude of encroachment over time in the Nairobi Metropolitan Region. This was coupled with participatory research appraisal methods, including targeted key informant interviews, desktop review of legislative and policy documents and previous studies (literature review) and observations. A desktop assessment of the legislative framework was undertaken to further understand the legislative shortcomings that aggravate the encroachment problem. Finally, a range of key informants were interviewed, specifically administered to government implementation agencies to verify the spatial results derived and in guiding the development of policy recommendations(see Appendix 1 for KII respondents and questions) .

Figure 2: Conceptual framework

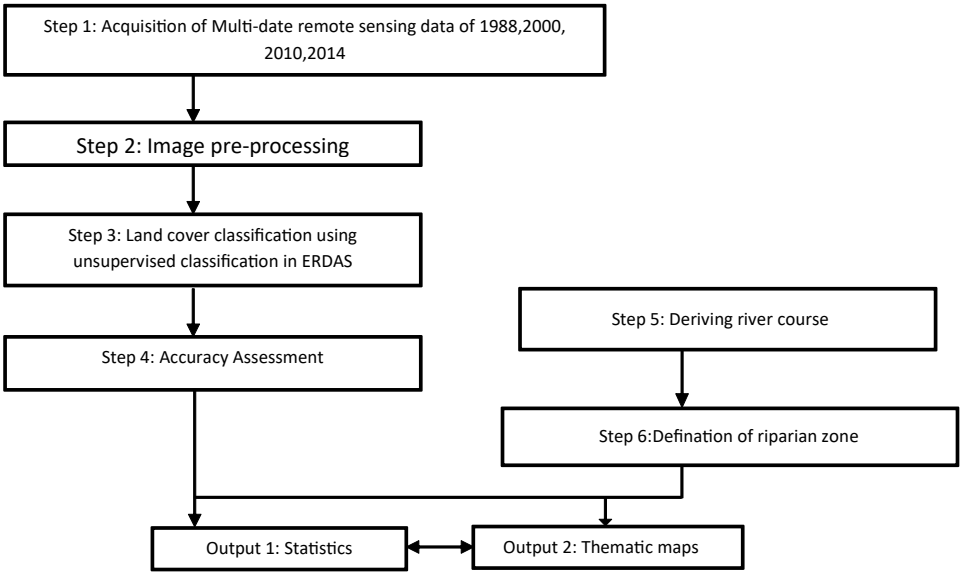


Source: Author

4.2 Data Sources and Image Processing

The flow chart indicating the sequence of processes employed in analysis and deriving empirical data of land cover changes and riparian encroachment that has informed policy recommendations in this study is shown in Figure 3 below.

Figure 3: Flow chart showing the steps in analysis



Source: Author

The data used in this study was both satellite data in the form of Landsat Imagery and ancillary data in the form of aerial imagery from Google maps and topographical maps. Medium resolution Landsat images have been used of 1988, 2000, 2010 and 2014 provided by US Geological Survey (USGS) glovis at uniform pixel size of 30 metres. Though limiting in resolution, a variety of studies have been conducted using medium resolution Landsat images in assessing land cover changes, therefore demonstrating its suitability in this study (Katana, Ucakuwun, and Munyao, 2013; Butt et al., 2015; Iakovoglou, Zaimes and Gounaridis, 2013; Olang' et al., 2015; Mundia and Aniya, 2005; Twesigye et al., 2011).

Secondly, the satellite images were pre-processed in Erdas imagine 12 for georefencing, mosaicking and subsetting of the image based on the area of interest (AOi). Per-pixel signatures were assigned on the satellite imagery, therefore, differentiating the area into four land cover classes, including built up land (urban land cover class), vegetation, wetland and bareland land cover classes (see Table 3). An unsupervised classification approach, which involved unsupervised clustering and cluster labelling by adopting the Iterative Self Organizing Data Analysis

Technique (ISODATA) algorithms allowed spectral clusters to be identified with a high degree of objectivity. Although these clusters are not always equivalent to actual classes of land cover, this method is useful without having prior knowledge of the ground cover in the study site.

Table 3: Land cover classes

Land cover class	Description
Urban/Built	Built up area, including residential, commercial and industrial land uses
Vegetation	Would include deciduous forests, shrub lands and agricultural lands (cultivated)
Wetland	Includes dams, reservoirs, rivers and man-made wastewater collection sites.
Bare lands	Including rocky surfaces, cleared lands, dry lands and rangelands

Source: Author

Using medium resolution Landsat imagery, mixed pixels or spectral confusion are a common problem, especially for urban surfaces that are a mixture of buildings, grass roads trees, water (Butt et al., 2015). Spectral confusion was more discernible in this study especially for the MSS images than the TM and ETM+ images, and also noticeable between differentiating urban and bare lands. Visual Knowledge, coupled by accuracy checks from Google Earth images and local knowledge was employed in splitting spectral confused clusters and recording into their correct land cover classes.

Step four, as indicated in the flow chart below, is in the determination of level of accuracy of the classified images. In land cover change mapping, classification accuracy is an important aspect in assessing the reliability of the final output maps. To ascertain the accuracy of an image, two accuracy assessments can be calculated; the overall accuracy and the Kappa index. The estimation of the overall accuracy alone of an image does not clearly represent the accuracy of the classified image, as the summary value is an average and does not clearly reveal if an error in the classification was evenly or unevenly distributed between classes. To address this weakness, the Kappa estimation provides a measure of agreement between producer and user accuracies. The user's accuracy responds to the error of commission (over classification), while producer's accuracy corresponds to error of omission (under classification). A confusion matrix approach was employed, with 164 test pixels (40 test pixels for each land cover class) selected through visual interpretation of the true colour composite of the Landsat TM image of 2010, and also comparison with satellite images from Goggle earth and topo sheets. The overall accuracy of the 2010 classification was 0.82 per cent while the overall Kappa coefficient was 0.78 per cent. The most misclassified land cover

categories were bare lands and vegetation, which resulted in low user's accuracy. Nevertheless, the land cover classifications of importance in this study are the urban and wetland land cover classes, which had user's accuracy of 97 per cent and 100 per cent, respectively, indicating that the classified images could be used in providing high accuracy assessments in the study.

Table 4: Image accuracy assessment

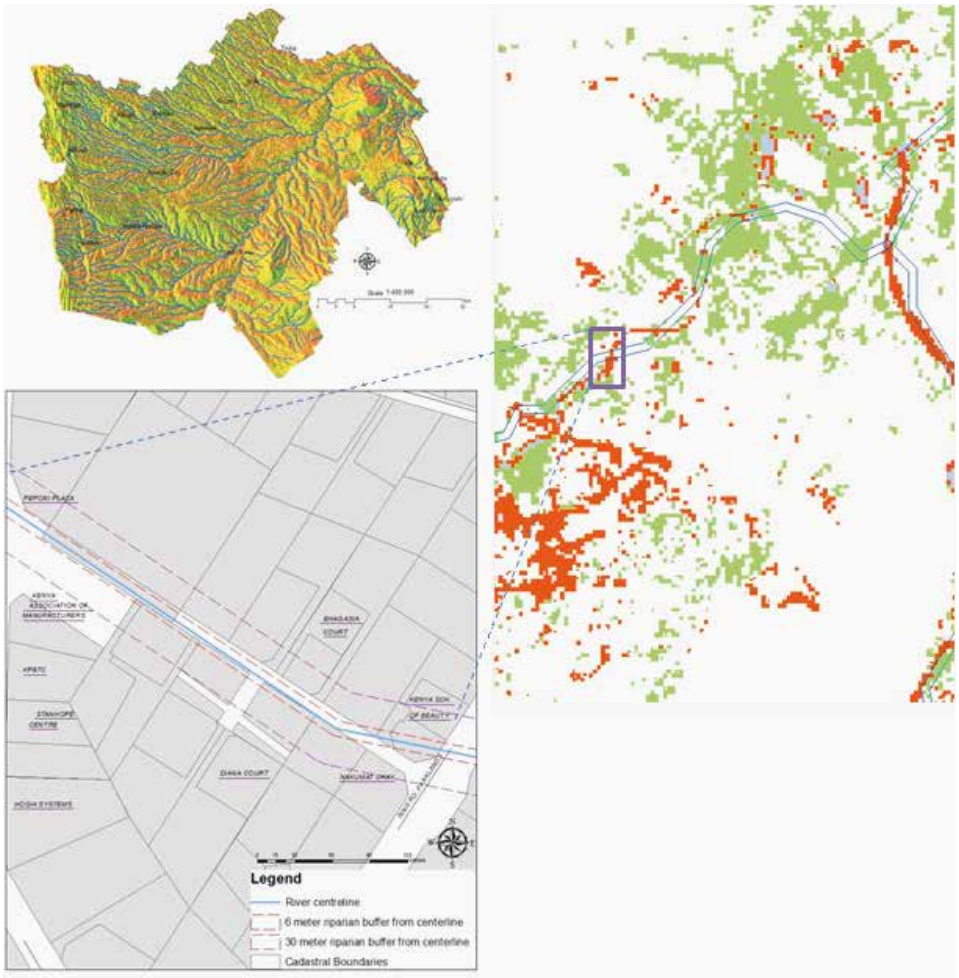
Land cover classes	Producers Accuracy	User's Accuracy
Urban	73	97
wetland	73	100
vegetation	100	73
bare lands	83	72

Source: Author

4.3 Definition of Riparian Buffer Zone Area

The riparian centre line was derived from digitizing topo sheets of the region, at a scale of 1:50,000, obtained from the Survey of Kenya. A 30 meter buffer was then generated in Arc Map on both sides of the centre line to represent the riparian buffer zone area. The 30 meter buffers were derived from natural rivers both permanent and temporary or perennial rivers, making assumptions that the river is still in existence. The river network and buffering has is shown in Figure 4.

Figure 4: River network and delineated buffer zone area



Source: Author

5. Results and Discussions

The Key Informant Interviews' responses as shown in Figure 5 revealed that wetland destruction by urban development coupled with illegal allocation of riparian land were the main concerns facing management of riparian reserves. Pollution and floods were identified as emerging ripple effects of uncontrolled urban development and continuous destruction of riparian reserves.

Figure 5: KII responses on the key concerns facing management of riparian reserves

	NEMA	WRMA	MOE&NR	WRUA	NLC
Pollution					
Uncontrolled water abstraction					
Flood risk					
Wetland destruction by urban development					
Lack of prioritization of natural resource management on National priorities					
Illegal allocation of riparian land					

Source: Author

5.1 Assessing Land Cover Changes in the Nairobi Metropolitan Region

The results from the classification as shown in Table 5 indicates that urban development (built up areas) have consistently increased in acreage, with a noticeable increase from 227,834 ha in 2010 to 486,778 ha in 2014, a change of 113 per cent. The urban land cover class has experienced the highest positive change compared to the other land cover classes in the metropolis. The spike in the rate of change in the built up areas between 2010 and 2014 is observed to be dominant along Nairobi-Thika Highway towards the northern metro (Kiambu County) and along the Nairobi-Mombasa Road towards the southern metros (Kajiado County).

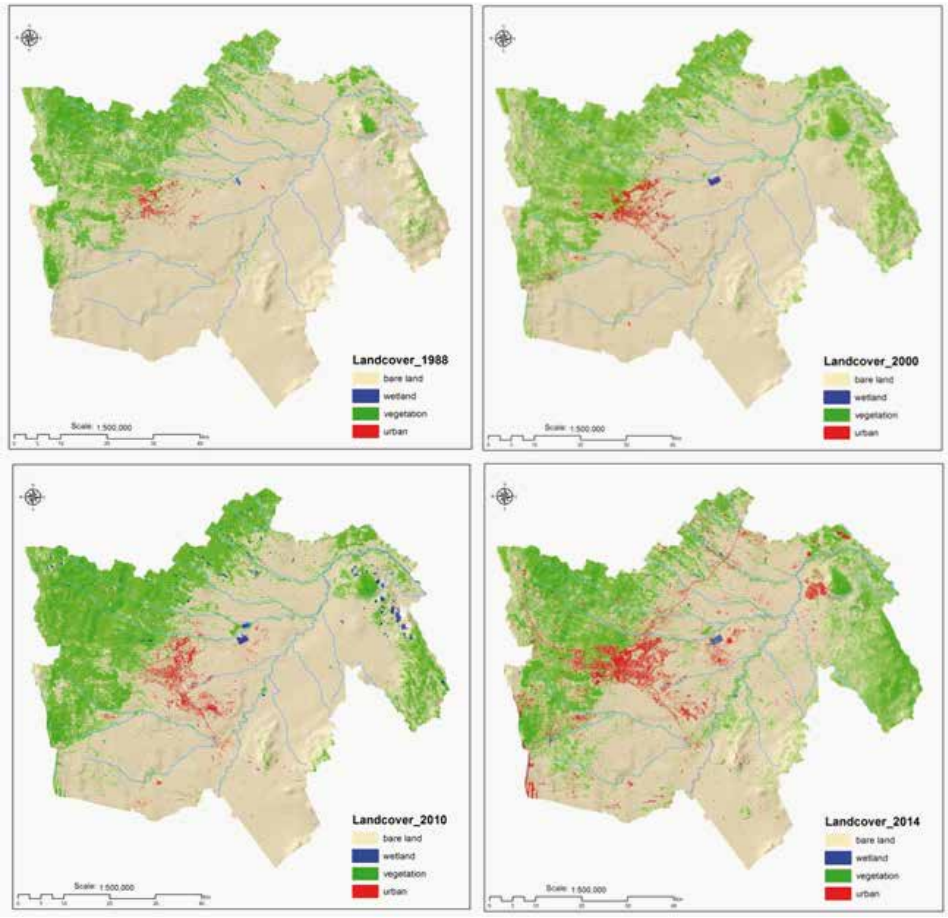
Table 5.1: Land cover changes in the Nairobi Metropolitan Region

	1988(ha)	Change (%)	2000-Area (ha)	Change (%)	2010-Area (ha)	Change (%)	2014-Area(ha)
Bare land	2,813,657.40	-14.45	2,407,112.96	3.00	2,479,379.22	-9.68	2,239,386.64
Vegetation/ Forest	406,373.67	102.26	821,923.54	-10.25	737,639.91	30.75	964,490.22
Urban	205,396.29	-15.53	173,498.47	31.32	227,834.55	113.65	486,778.97
Wetland	110,224.80	4.49	115,172.08	-3.30	111,376.26	-54.27	50,930.53

According to a World Bank ranking of the Kenyan counties by GDP per capita, Kiambu County (Northern region) ranked the highest in the country with a GDP per capita of US$ 1,785 attributed to the occurrence of rich agricultural lands and booming real-estate sector in the region. Kajiado County (Southern region) ranked third with a GDP per capita of US$ 1,466, Core Nairobi region ranked eighth at a GDP per capita of 1,081 and Machakos County (Eastern region) ranked tenth with a GDP per capita of US$ 913 (*Business Daily*, 11th November 2015). Economic development and infrastructure expansion drives urban development within the metropolis, with the GDP per capita in 2014 reaching its all-time high, which could explain the spike in urban expansion experienced between the period 2010-2014. The manufacturing sector accounted for only 22.5 per cent of gross regional domestic product of the NMR in 2010, with industrial development occurring in the northern metro along the Thika industrial hub, and cement factories and EPZ in the Eastern and Southern metros.

The wetland areas have significantly dropped from 111,376 ha in 2010 to 50,930 ha in 2014. This is a significant drop in wetland areas of up to 50 per cent, which may be attributed to encroachment by built up areas or agricultural activities. This is an alarming reduction, calling for the need for a policy shift in seeking to protect wetland areas. Figure 6 shows the spatial extent of land cover changes within the NMR from 1988 to 2014.

Figure 6: Land cover changes, 1988-2014

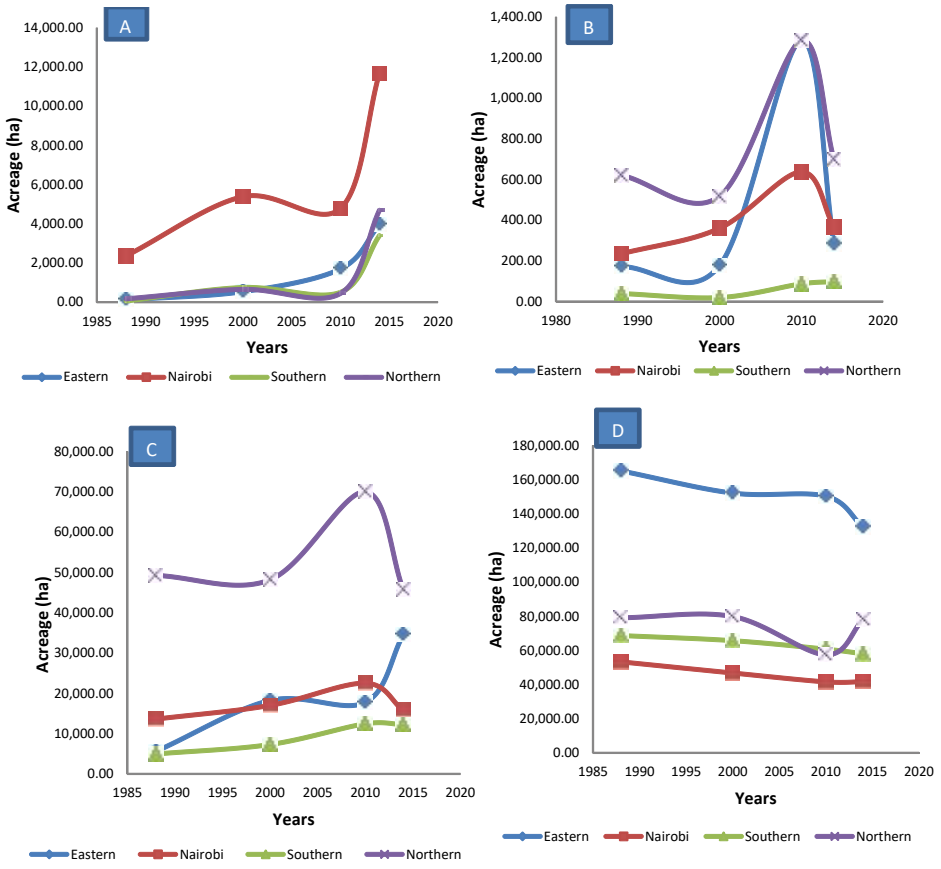


Source: Author

5.2 Land Cover Patterns per Region

Comparatively, as the area under built up areas increased, the wetland areas significantly dropped between 2010 and 2014 across the metropolis. The highest loss of wetland areas has been experienced in Eastern (Machakos County), Northern (Kiambu County) and Nairobi core due to the invasion by other land uses as seen in Figure 7 below.

Figure 7: Land cover changes over time-built up area (a), wetland area (b), vegetation area (c) and bare land area (d)



Source: Author

In the Eastern region (Machakos County), there has been a dip in wetland areas between 2010 and 2014, with a concomitant increase in vegetation land cover. The region has nevertheless experienced a decrease in bare land areas and a slight increase in built up areas in the same time period, seen in Mavoko and Athi River areas.

In the Northern region (Kiambu County), a great loss of wetland areas has been experienced between 2010 and 2014. This is especially alarming due to the occurrence of Nairobi water reserves and protected springs in this region. The region has experienced a sharp increase in built up areas, with a sharp decrease in vegetation cover and a rapid increase in bare lands in the same time period. Changes in Northern Metro towards Ruiru, Juja and Thika could be strongly attributed to spillover effects from Nairobi as a result of completion of the Nairobi Thika Super Highway that has enhanced mobility and access to Nairobi Core. Kiambu County has emerged as one of the fastest growing counties in the metropolis, following Nairobi Region. Caution should therefore be taken in monitoring the sustainability of urban growth and in the monitoring of fragile wetland areas and agricultural lands in the region.

The Southern Region (Kajiado County) has experienced the lowest loss in wetland areas, but a significantly sharp decrease in vegetation cover between 2010 and 2014. The region has nevertheless experienced a significant increase in built up areas and a sharp rise in bare lands in the same time period. The rapid change in built up areas is attributed to industrial expansion along Mombasa Road, and availability of affordable land for housing. An increase in bare lands has only been experienced in the Southern region, signifying increasing clearing of vegetation cover to give rise to built up areas. The Nairobi Metropolitan Strategy projects that the Southern metro is expected to experience dramatic population increase by 2030 to absorb Nairobi's population bust (Republic of Kenya, 2008). This is of high concern due to the fragility of the rangelands in this region that support pastoralist livelihoods. The Nairobi core region is the fastest growing in the metropolis experiencing rapid increase in built up areas and a sharp decline in wetland and vegetation areas between 2010 and 2014. The spatial pattern of built up areas has a geometry that has mainly been shaped by transport infrastructure (Republic of Kenya, 2013a). The increase in built up areas is the fastest in the region, while comparatively the decrease in wetland areas is slower that in northern and eastern regions.

5.3 Assessing Magnitude of Wetland Riparian Encroachment

The size of the 30 metre riparian buffer zone has been estimated as 14,982 hectares (149.8 km^2), therefore occupying 3 per cent of the total NMR land area. From previous assessments, the wetlands areas have experienced a 50 per cent drop between 2010 and 2014. The total area encroached area was 14,818.46 hectares, accounting for 99 per cent of the total riparian reserve. It is therefore critical to assess the patterns of change and measure the rate and patterns of encroachment of the different land cover classes, over four epochs, 1988, 2000, 2010 and 2014.

5.3.1 Contribution in encroachment patterns by land cover classes

An assessment of the share of the total area encroached (ha) to the total riparian buffer area (ha) within the riparian buffer indicates a gradual increase in encroachment from 1988 to 2014, with less than 1 per cent of the total buffer zone left untouched. The contribution of each land cover class (ha) was determined as a per cent of the total area encroached (ha) (equation 1).

$$C_{LC} = LC / TEA \times 100 \quad \text{..... (1)}$$

Where:

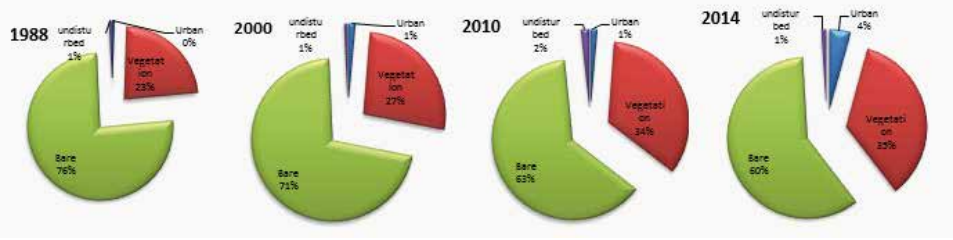
C_{LC} = the Contribution on total encroachment per land cover class

LC = Acreage (Ha) of each land cover class encroached

TEA = Total encroached area (Ha)

It was noted that bare land and vegetation land cover classes dominate as primary use of the riparian buffer zone throughout the four epochs as shown in Figure 8 below. The contribution of built up areas (urban) is still significantly low compared to vegetation and bare lands, and has been stagnant between 1988 and 2010, with an increase experienced between 2010 and 2014.

Figure 8: Encroachment by land cover class



Source: Author

5.3.2 Temporal rate of change of encroachment by land cover class

Although built up areas still occupy a small coverage (area) of the total buffer zone area, an assessment of the temporal rate of change in each land cover class is paramount. The rate of change of each land cover class determined as a percentage is as expressed in equation 2 below:

$$LC_R = (LC_t - LC_{t-n}) / LC_{t-n} \times 100 \quad \text{..... (2)}$$

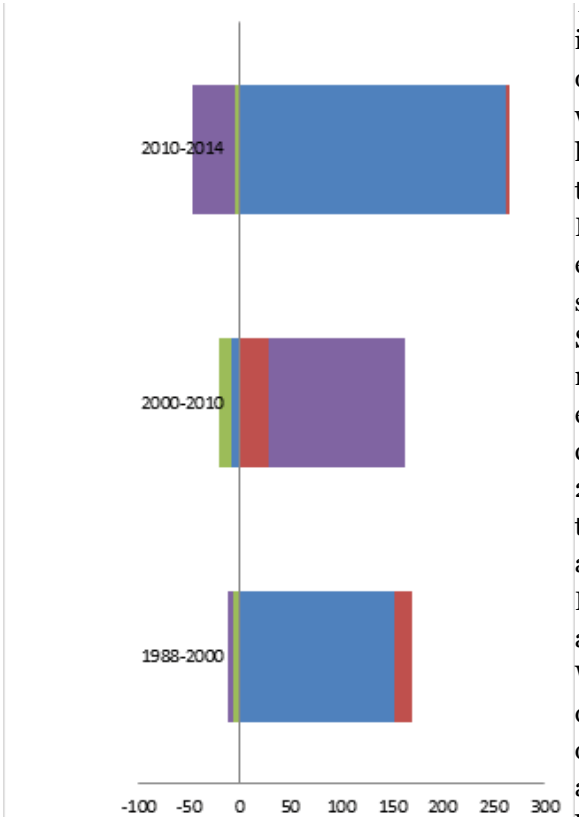
Where:

LC_R = the rate of change per land cover class (%)

LC_t = Land cover area(ha) at current year

LC_{t-n} = the Land cover area (ha) of previous year

Figure 9: Assessment of rate of change of encroachment (%) by land cover class



	1988-2000	2000-2010	2010-2014
Urban	152.3428593	-8.483751809	262.2139067
Vegetation	16.39430601	27.97647617	2.86488142
Bare	-5.937167227	-11.6654051	-5.425861443
undisturbed	-6.502829381	134.1704259	-40.74535888

The results as shown in Figure 9 indicates that the rate of change of built up areas encroached within the riparian buffer zone has been more drastic than all the other land cover classes. Between 1988 to 2000, the encroachment of built up areas significantly increased. Significant slowing down of riparian encroachment was experienced across all land cover classes between 2000 and 2010, which could be attributed to instituting the EMCA in 1999 and the Water Act in 2002, the Physical Planning Act in 1996, and formation of NEMA and WRMA. Of concern is the dramatic increase in encroached of built up areas between 2010 and 2014 by 262 per cent, higher than any other land cover class. This is indicative that in three years, for every hectare of riparian land encroached by buildings the density increased by 20 times.

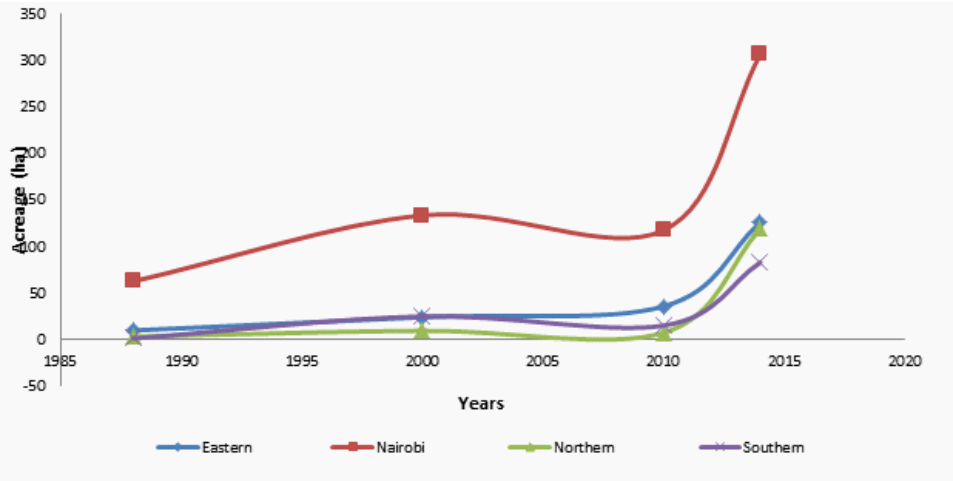
Source: Author

Therefore, though the contribution of built up areas encroached versus the total riparian buffer zone is low, the temporal rate of change of built up areas is alarming. Therefore, of policy is how to slow down and eventual stop the emergence of built up areas within the riparian zone towards gradual restoration. The vegetation land cover and the bare lands have experienced a decrease in rate of change, meaning that though the area covered by bare lands and vegetation is still large, their rate of change is slower than built up area. This, therefore, raises the question on the effectiveness of the legislative framework and the enforcement capacity of government agencies in managing encroachment within the riparian zone.

5.3.3 Encroachment of built-up land cover class patterns by region

Though the rate and magnitude of encroachment of built up areas has significantly changed within the metropolis, the changes are divergent within the sub-regions. In assessing the magnitude in acreage of built up areas encroached over the 30 metre riparian buffer zone between 1988 and 2014, Nairobi core region has the highest acreage of built up areas within the riparian reserve over time, with a sharp spike experienced between 2010 and 2014 (see Figure 10). This is in line with results that indicate that Nairobi is experiencing the highest growth in built up areas and the sharpest decline in wetland areas in the metropolis (see Figure 7).

Figure 10: Riparian encroachment of built up (urban) land cover class by region



Source: Author

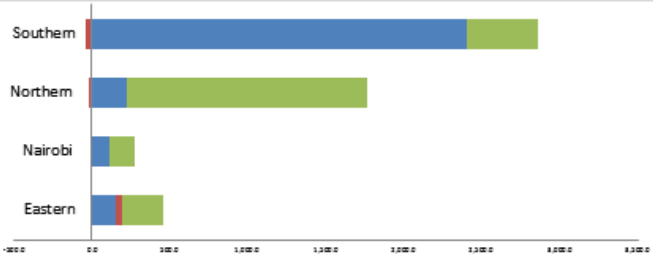
5.3.4 Temporal rate of change of encroachment by region

Equation 2 has been adopted in assessing the temporal rate of change of encroachment by built up land cover class per region. The Northern region experienced the highest change in built up areas within the riparian zone between 1988 and 2000. Between 2000 and 2010, the changes in built up areas within the riparian buffer zone was the lowest. The low increase in built up areas within the riparian buffer zone between 2000 and 2010 could be attributed to changes in policy and legal framework as related to environmental management, including:

- Operationalization of the Millennium Development Goals in 2000.
- Establishment of the Environmental Management and Coordination Act (EMCA) in 1999, which is the principle instrument that governs management of riparian reserves.
- Enactment of the Water Act in 2002.
- Establishment of the Water Resources Management Authority (WARMA) in 2003, charged with the mandate of management of water resources.

The establishment of the Physical Planning Act in 1996 operationalized land use planning functions in the country. As shown in Figure 11, in 1988 to 2000, the Southern region experienced the highest increase in built up areas within the riparian land. Between 2000 and 2010, a dramatic decrease was experienced in encroachment by built up areas across all regions.

Figure 11: Rate of change in urban encroachment (%) by region



	Eastern	Nairobi	Northern	Southern
1988-2000	149.2	114.0	218.7	2,407.4
2000-2010	49.0	-12.0	-21.8	-40.0
2010-2014	254.5	160.8	1,545.4	457.0

Source: Author

Nevertheless, between 2010 and 2014, the Northern region (Kiambu County) experienced a sharp spike in encroachment of built up areas, higher than Nairobi. This is indicative that though Nairobi County has the highest acreage of built up areas encroached in the riparian buffer zone, the Northern and Southern regions are experiencing the fastest rate of change in construction on the riparian buffer zone area, therefore requiring urgent attention.

Spatial snapshots as indicated in Figures 12, 13 and 14 visually indicate the fastest rate of encroachment experienced in different regions between 2000 and 2010.

Figure 12: Encroachment on wetlands in the Northern metro, 2000 and 2014, respectively

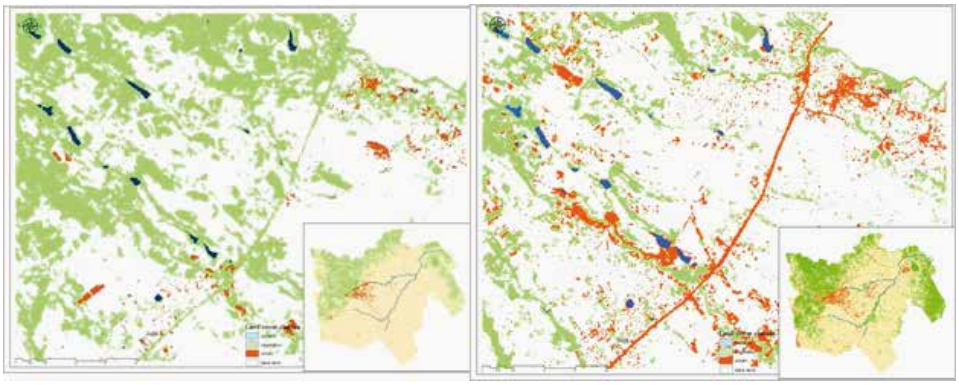


Figure 13: Encroachment on the 30 metre buffer in the Southern metro, 2000 and 2014, respectively

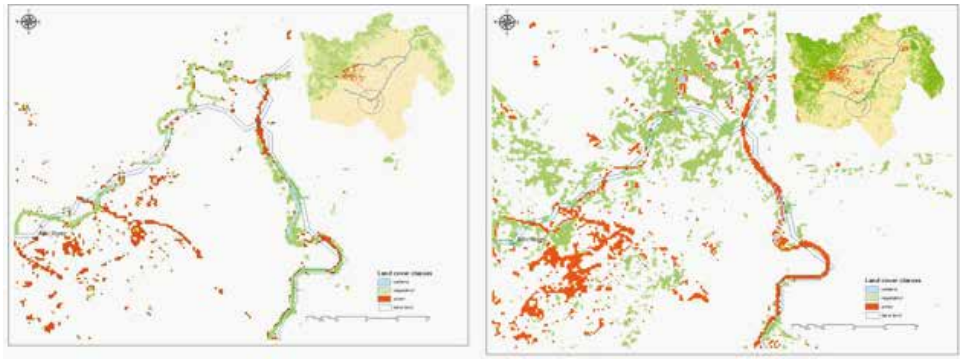
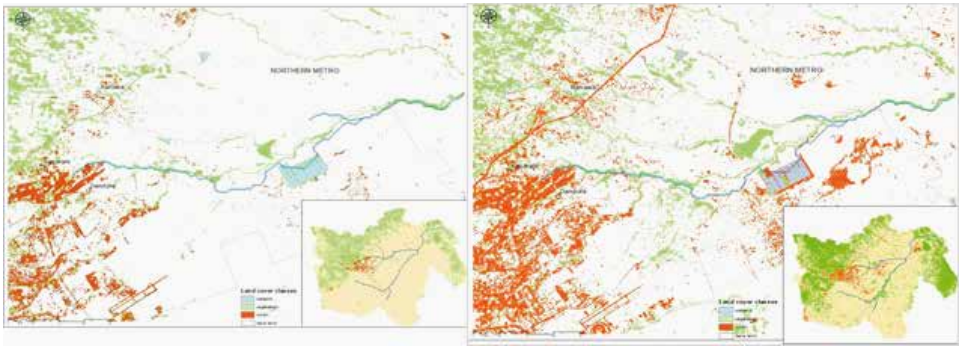


Figure 14: Encroachment on 30 metre riparian in the Northern metro and core Nairobi, 2000 and 2014, respectively



Source: Author

6. Discussions

Is the legislative framework effective in managing wetland riparian zones?

Studies have shown that "command and control" policies are only effective in the management of common pool resources (CPR) upon rigorous implementation and enforcement (Ostrom, 1990). Based on the key informant interviews (see Figure 15) and the review of literature, though the command and control policies are established for controlling encroachment on riparian buffer zones, enforcement has been a great challenge.

The key factors that drive riparian buffer encroachment were primarily as a result of institutional capacity in enforcement of legislative requirements, coupled with gaps in the existing legislative framework in terms of riparian buffer definition, approved land uses and riparian management that aggravates the encroachment problem. Critical to consider is the emerging demand for urban land in the Nairobi Metropolitan Region, with land use plan preparation and implementation clearly reactive than proactive in nature. As a result of poor land use planning and outdated land administration frameworks, illegal construction on riparian reserves has been worsened.

Figure 15: KII responses on factors that drive riparian buffers encroachment

	NEMA	WRMA	MOE&NR	WRUA	NLC
Lack of institutional coordination					
Comments on EIA and EA reports not legally binding					
Boundaries of wetland riparian zones vague					
Lack of appropriate land use planning					
Fragmentation of legislative frameworks					
Demand for urban land					
Political interference					
Low enforcement capacity of implementation agencies					
Poor land use planning					
Long-legal processes and procedures that limit impact of restoration and stop orders					

Source: KII interviews

Key informant response assessment (see Figure 16) on the strengths and weaknesses of the existing legislative framework as it supports environmental management revealed that the greatest strength of EMCA and Water Acts is that they integrate community management principles and participation in the management of water resources. The greatest weakness of the legislative framework was identified as the fragmentation and overlapping in institutional mandates. Also, the effectiveness of legislative framework has been largely weakened by lack of implementation, and poor enforcement and compliance.

Figure 16: Strengths and weaknesses of existing legislative frameworks

		NEMA	WRMA	MOE&NR	WRUA	NLC
Strengths	Enabled the establishment of regulatory institutions as WRMA and NEMA					
	Encourages stakeholder/ community engagement in water resource management					
	Potential of Water Bill in streamlining water resource management activities					
	Punitive fines under the EMCA 2015					
	EMCA 2015 encourages lead agency coordination					
Weaknesses	The regulatory framework is perfect					
	Fragmentation of the legislative framework brings conflict among lead agencies					
	EMCA is not sensitive/ cognizant of the pace of urbanization or the value of urban land					
	Exploitation of communities due to lack of knowledge and capacity on legislative frameworks					
	Lack of enforcement lowers its effectiveness					

Source: KII interviews

Therefore, the effectiveness of legislative framework towards addressing riparian reserve protection and management has to address the overlaps, gaps and implementation and enforcement challenges.

What is the magnitude of urban encroachment on riparian buffer zones in the Nairobi Metropolitan Region, over time?

Based on GIS analysis, built up areas have consistently increased, with a significant drop by 50 per cent of the wetland area experienced between 2010 and 2014. The total buffer zone covers 14,982 hectares, with only 1 per cent of the area left undisturbed from 1988 to 2014. Majority of the land within the buffer zone area is under bare lands and vegetation land covers, with built up areas (urban) occupying only 4 per cent of the total land areas as at 2014. Of policy concern is the increase in the spatio-temporal rate of change of built up areas across time and across regions. Though built up areas occupy the least acreage on the buffer zone area, a rate of increase of above 200 per cent was recorded between 2010 and 2014, higher than any land cover class. This is therefore indicative of an opportunity to revert the unbuilt up areas to government land, and more stringent measures to be employed to ensure no construction is allowed within the buffer zone area.

How has the magnitude and pattern of urban encroachment changed over space between the four sub-regions in the metropolitan region?

This assessment was intended to fill a knowledge gap in explaining the level of divergence of encroachment by regions. The GIS assessment indicates that significant increase in encroachment of built up areas has been experienced in the Northern and the Southern metros. This is in line with the urban population projections by the Nairobi Metropolitan Growth Strategy (Republic of Kenya, 2008). Concomitantly, the loss of wetlands was largely experienced in Nairobi, Eastern and Northern regions between 1988 to 2014. Though Nairobi core region still has the highest acreage of built up land cover within the riparian zone, of great concern, however, is the rapid increase in built up areas occurring in the riparian buffer zone in the Northern and Southern metros. In the Northern metro, in 3 years between 2010 and 2014, for every 1 hectare of riparian buffer encroached by built up areas in 2010, the area increased in density by 15 times in 2014, compared to an increase by 3 times in the Southern metro and only doubling in the Eastern and Nairobi core regions in the same time period. The rate of encroachment of wetland areas in the Northern metro, in a region that is the water reservoir of the Nairobi Metropolis, is of grave concern. Monitoring and control should be both regionally and also specifically targeted to the sub-regions.

7. Policy Recommendations

The policy recommendations made by the key informants are summarized in Figure 17 below. The major policy recommendations where on building the institutional capacity of NEMA and WRMA in the enforcement of environmental regulations, coupled with clear definition of the riparian buffer zone area and streamlining management responsibilities of this zone.

Figure 17: Policy recommendations

	NEMA	WRMA	MOE&NR	WRUA	NLC
The question is not ownership but management: resource users should be held accountable for the management of riparian reserves					
Harmonize institutional mandates and roles					
Increasing the personnel capacity of implementation agencies to undertake sport checks					
Harmonize legislative framework of definition of riparian width, and institutional roles and mandates					
Establishing a coordination body (steering committee) for riparian management					
Mark and peg wetland riparian zones and land reverted as government land to NLC					
Strengthen the enforcement function of WRUAs					
Establishing punitive penalties/economic disincentives					
Awareness of communities or stakeholders on legislative requirements and value of riparian reserves					
Public -Private Partnerships -Adopt a Mile -					
Special land use planning of riparian zones					
Strengthen MOUs with implementation agencies					

Source: Author

1. Harmonize legislative framework on delineation of riparian reserve

The lack of a harmonized definition of the riparian reserve boundary provides for loopholes that encourage illegal occupation and development. A rationalization of the riparian reserve width coupled with harmonization of the land use requirements and the institutional mandates in the management of the riparian zone is a critical step towards long-term management of the riparian zone. The

harmonization of the legislative framework should be followed by "marking and pegging" of the riparian zone and gazetting the zone as environmentally sensitive for protection.

2. ***Enhance enforcement capacity of government agencies through enhancing participatory methodologies.***

Enforcement of EMCA is wanting, with the capacity and ability of NEMA and WRMA to undertake demolitions in areas where the law has been contravened, often not seen. A deliberate policy shift in management approaches of urban riparian areas from centralized, top-down approaches to integrating co-management or participatory policies is recommended, where resource users take responsibility and participate in management of urban riparian areas and in monitoring Government actions. Exploration of economic incentives such as increasing statutory penalties and civil liability of riparian destruction, property tax breaks for ecollogically sensitive lands, provide transferable property tax credits to wetland owners, rewarding sensitive development designs, transferable development rights and performance bonding for developers in encouraging riparian land owners to conserve riparian zones could also be explored. For communities or resource users to fully be capable of monitoring riparian land uses, there is need for awareness and training on legislative frameworks that govern land use planning, land administration and environmental protection.

3. ***Enhance land governance frameworks***

The challenge of encroachment by urban development in riparian zones is a consequence of disjointed land administration, land use planning and development control between relevant institutions. Firstly, of importance is to revert riparian land into Government land. Through the Land Act, the land on the riparian buffer zone is public land, and therefore under the custody of the National Land Commission, with user regulated by NEMA and WRMA. A great opportunity exists in reverting the alienated unbuilt land under vegetation and bare lands on the riparian buffer zone to government land. Management guidelines have to be developed with specific mandates on who has rights over the land and the appropriate land uses to be clearly stipulated . Caution should be taken, nevertheless, as the constitution is careful in protecting the private holding of land. Therefore, an assessment of the nature of land holding of developers within the riparian zone should be carefully undertaken. In the event that legal title has been issued, then compulsory compensation as required by law should be undertaken. The Eviction and Resettlement Bill (2014) provides clear procedures in undertaking resettlement actions.

Though land use planning is a county government action, the absence of guiding policy frameworks as the National Land Use plan and the Urban Development Policy allows for exploitation and destruction of environmental fragile areas. The preparation of Urban Development Policy, the National Land Use Plan and the Nairobi Metropolitan Land Use Plan should be prioritized to ensure sustainable development of cities in Kenya.

4. Enhance capacity of County Governments to manage riparian reserves

The divergent levels of destruction between the counties/regions within the Nairobi Metropolitan region calls for local area specific actions plus regional actions. The capacity of County Governments in sustainable land use planning should be enhanced through training, capacity enhancement and financing. County government strategies should be interlinked with metropolitan land use plans and environmental action plans to ensure a holistic approach to protection of environmentally sensitive ecosystems in the metropolis.

5. Spatial decision support systems in informing environmental policy

To address the challenge of lack of harmonized baseline data (Karisa, 2010; Raburu, Okeyo-Owuor and Kwena, 2012), policy processes in protection of riparian buffers need to be informed by Spatial Decision Support Systems. This is integral in monitoring, in real-time, land cover changes along the wetland areas using remote sensing information, and in the harmonization of land use planning, development control and enforcement policy decisions between implementation agencies. Methodologies such as Open Land Use Mapping where land use maps are launched for online access by stakeholders could be explored. Rationalizing the development approval process and procedures among the different approving institutions to allow for harmony in decision making in the protection of environmentally fragile ecosystems from encroachment could be achieved by the Spatial Decision Support Systems.

8. Limitation and Areas for Further Research

The study was limited by lack of access to high resolution satellite imagery that would be more useful in critically addressing the rate of encroachment, what kind of urban land uses (e.g industrial, residential, commercial were dominantly encroaching on the riparian reserve, and the changes in vegetative cover). The study also seeks to measure the magnitude of encroachment based on a basic definition of the riparian zone as 30 metres from the centerline. For better results, further studies should be developed in mapping high water marks, for a definitive boundary definition of the riparian buffer zone. Further, policy research is required in quantifying the economic impact of destruction of wetlands in Kenya, and in understanding the socio-political, economic and legislative drivers of encroachment on riparian reserves.

References

Anderson, R. (2002), *Incentive-based policies for environmental management in developing countries*. Washington: Resources for the Future.

Bürgi, M., Hersperger, A.M. and Schneeberger, N. (2004), "Driving forces of landscape change: Current and new directions". *Landscape Ecology*, 857-868.

Butt, A., Shabbir, R., Ahmad, S.S. and Aziz, N. (2015), "Land use mapping and analysis using remote sensing and GIS: A case study of Simly watershed, Islamabad, Pakistan". *The Egyptian Journal of Remote Sensing and Space Science*, 251-259.

De Young, R. (1999), "Tragedy of the commons". *Encyclopedia of Environmental Science*, 601-602.

Gawler, M. (2002). What are best practices? Lessons in participatory management of inland and coastal wetlands. Proceedings of a workshop held at the Second International Conference on Wetlands and Development. Strategies for wise use of wetlands: Best practices in Participatory Management, 1-12. Wageningen, Netherlands: Wetlands International.

Hawes, E. and Smith, M. (2005), Riparian buffer zones: Functions and recommended widths. Unpublished.

Herold, M., Couclelis, H. and Clark, K. (2005), "The role of spatial metrics in the analysis and modelling of urban land use change". *Computers, Environment and Urban Systems*, 24(4): 369-399.

Iakovoglou, V., Zaimes, G. N. and Gounaridis, D. (2013), "Riparian areas in urban settings: Two case studies from Greece". *International Journal of Innovation and Sustainable Development*.

Karisa, C. (2010), A negotiated framework for rehabilitation of riparian zones in Nairobi city: The case of Mathare River Valley. Nairobi: Unpublished .

Katana, S., Ucakuwun, E. K. and Munyao, E. K. (2013), "Detection and prediction of land cover changes in Upper Athi River Catchment, Kenya: A strategy towards monitoring environmental changes". *Greener Journal of Environmental Management and Public Safety*, 146-157.

KIPPRA (2014), Leveraging on the metropolitan dividend in the context of devolved Government in Kenya. Nairobi: Unpublished.

KIPPRA,(2015), Review of metropolitan planning and development in Kenya: A situational analysis. Nairobi: Unpublished.

Lelo, F.K., Chiuri, W. and Jenkins, M.W. (2005). Managing the River Njoro watershed, Kenya: Conflicting laws, policies, and community priorities. Research Gate.

Macleod , R. D. and Congalton , R. G. (1998), A quantitative comparison of change detection algorithms for monitoring eelgrass from remotely sensed data. Photogrammetric Engineering and Remote Sensing, 207-216.

McCay, B.A. (1987), *The question of the commons: The culture and ecology of communal resources*. Tucson: University of Arizona Press.

Ministry of Environment, Water and Natural Resources (2013), National Wetlands Conservation and Management Policy (Draft). Nairobi: Unpublished .

Mubea, K., Goetzke, R. and Menz, G. (2014), "Applying cellular automata for simulating and assessing urban growth scenario based in Nairobi, Kenya". *International Journal of Advanced Computer Science and Application*, 5(2), 1-13.

Mundia, C. N. and Aniya, M. (2005), "Analysis of land use/cover changes and urban expansion of Nairobi city using remote sensing and GIS". *International Journal of Remote Sensing*, 26(13): 2831-2849.

Olang, O. L., Kundu, P., Bauer, T. and Furst, J. (2015), Assessing spatio-temporal land cover changes within Nyando River Basin of Kenya using Landsat Satellite data Aided bu community-based mapping. GI_forum.

Ostrom, E. (1990), Governing the commons: The evolution of institutions for collective Action. New York: Cambridge University Press.

Ostrom, E. (2008), The new palagrave dictionary of economics online. Retrieved 16 February 2016 from Dictionary of Economics: www.dictionaryofeconomics.com.

Ostrom, E., Gardner, R. and Walker, J. (1994), *Rules, games, and common pool resources*. University of Michigan Press.

Ouma, Y. and Tateshi, R. (2014), "Urban flood vulnerability and risk mapping using integrated multi-parametric AHP and GIS: Methodological overview and case study Assessment". *Water*, 1515-1545.

Patricia, O. (2004), Groundwater management institutions to protect riparian habitat. Water Resources Research.

Raburu, P.O., Okeyo-Owuor, J.B. and Kwena, F. (2012), Community-based approach to the management of Nyando wetland, Lake Victoria Basin. Nairobi: Nyando Wetland Utility Resource Optimization project.

Republic of Kenya (1994), The Survey Regulations . Nairobi: Government Printer.

Republic of Kenya (1996), Physical Planning Act (Cap 286). Nairobi: Government Printer.

Republic of Kenya (1999), Environmental Management and Coordination Act. Nairobi: Government Printer.

Republic of Kenya (2002). Water Act, Chapter 372. Nairobi: Government Printer.

Republic of Kenya (2006), Water Resource Management Rules. Nairobi: Government Printer.

Republic of Kenya (2006a), Environmental Management and Coordination (Water Quality) Regulations. Nairobi: Government Printer.

Republic of Kenya (2008), Nairobi metro 2030: A world class metropolis. Nairobi: Government Printer.

Republic of Kenya (2009), The Environmental Management and Coordination (wetlands, riverbanks, lake shores, and sea shore management) regulations. Nairobi: Government Printer.

Republic of Kenya (2011), Development of a spatial planning concept for Nairobi metropolitan region. Nairobi: Unpublished.

Republic of Kenya (2012a), County Government Act. Nairobi: Government Printer.

Republic of Kenya (2012b), The Land Act. Nairobi: Government Printer.

Republic of Kenya (2013a), Draft Integrated Urban Development Master Plan for the City of Nairobi.

Republic of Kenya (2013b), Kenya National Housing Survey. Nairobi: Kenya National Bureau of Statistics.

Republic of Kenya (2013c), National Climate Change Action Plan. Nairobi: Government Printer.

Republic of Kenya (2015), Environmental Management and Coordination Act (Amendments). Nairobi: Government Printer.

Republic of Kenya (2016), Economic Survey. Nairobi: Kenya National Bureau of Statistics.

Sandborn, C. (1997), Economic incentives to protect wetlands: Selected issues. Environment Canada.

Schlager, E. (2004), "Common pool resource theory". In *Environmental governance reconsidered: Challenges, choices, and opportunities*. Cambridge, MA: MIT Press.

Twesigye, C. K., Onywere, S. M., Getenga, Z. M., Mwakalila, S. S. and Nakiranda, J.K. (2011), "The impacts of land use activities on vegetation cover and water quality in the lake victoria watershed". *The Open Environmental Engineering Journal*, 66-77.

UN-Habitat (2009), *Planning sustainable cities, policy directions*. London: Earthscan.

World Bank (2004), *The Republic of Kenya: Towards a water-secure Kenya-water resources sector memorandum*. Washington, DC: World Bank.

Appendix

Key Informant Interviews Schedule

Respondents:

1. Water Resource Management Authority (WARMA)
2. National Environment Management Authority (NEMA)
3. Ministry of Environment and Natural Resources
4. Kirichwa Water Resource User Association
5. National Land Commission (NLC)

KII INTERVIEW QUESTIONS

1. What are the main concerns facing management and protection of wetlands in the Nairobi metropolitan region?
2. In your opinion, what are the factors that drive riparian buffers encroachment by urban development in the metropolis?
3. What are the strengths and weaknesses of the existing regulatory framework in effectively protecting riparian areas from illegal urban encroachment? Does the lack of clarity in riparian width or setback lines affect enforcement?
4. How can the issue of illegal encroachment and wetland destruction be curtailed? (strategies, policy recommendations)
5. In regard to capacity of the authority:
    i. How do you ensure compliance to environmental regulations?
    ii. Does the authority have capacity to enforce penalties and orders as relates to riparian buffer protection?
    iii. Are there synergies between land use plans and environmental action plans developed?
    iv. How much is allocated to the authority for planning services and development control?
    v. What actions are being taken by the authority in curbing encroachment and wetland destruction?
    vi. How are institutional synergies in policy execution ensured?
6. Is self-organized management or co-management of riparian buffer zones therefore enforceable?

ISBN 978 9966 058 84 3

Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
PO Box 56445, Nairobi, Kenya
tel: +254 20 2719933/4, 2714714/5, 2721654, 2721110
fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org