

**RIPARIAN ZONE CONSERVATION IN A CHANGING URBAN
LAND USE ENVIRONMENT:**

A CASE OF NAIROBI RIVER BASIN, KENYA

MUKETHA SILAS MWITI

**Bsc. (in Survey. & Photo.) Hons (Nbi), MA (in Planning) (Nbi), MISK, MKIP, Fellow (ISK)
(Licensed Surveyor/Registered Physical Planner)**

**A thesis submitted in fulfillment of the award of the degree of Doctor of
Philosophy of the University of Nairobi**

**Department of Urban and Regional Planning
School of Built Environment**

MARCH 2014

DECLARATION

I hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

Silas Mwiti Muketha

DECLARATION OF THE SUPERVISORS

This thesis has been done under our supervision and has been submitted for examination with our approval as University Supervisors:

Dr. Isaac K. Mwangi

Dr. Tomiik Konyimbih

Dr.-Ing. Sammy M. Musyoka

DISCLAIMER

This thesis describes work undertaken as part of a PhD study programme at the University of Nairobi. All views and opinions expressed therein remain the sole responsibility of the author and do not necessarily represent those of the University.

ABSTRACT

Riparian zones are vegetated strips of land located on each side of a watercourse or adjacent to a stationary water body. Ideally, the attributes of a riparian zone should include among others uninterrupted continuum of vegetation cover, appropriate vegetation structure and lateral width where ecological, social and economic functions should take place.

However, despite their significance as urban landscape elements, riparian zones are facing pollution, encroachment and degradation from urban land uses in Nairobi River Basin. This is a result of improper determination, use and management. The implications of this stated problem include failure to filter polluted surface run-off, riverbank erosion, increased incidences of flooding and soil erosion, and death of aquatic and terrestrial ecosystems that depend on riparian vegetation for survival. The cost of this problem to Kenya as a nation is monumental.

The main objective of this study was to assess factors that affect the determination, use and management of riparian zones in Nairobi River Basin. The study sought to answer the question of whether the policy and institutional factors, land use and biophysical factors, as well as, professional and land users' factors influence conservation of riparian zones in the basin. This was with a view of developing an integrated model of conservation of riparian zones.

The study followed a descriptive research design which employed a mixed strategy involving quantitative and qualitative methods. Secondary data was collected using archival method. Primary data collection relied on questionnaires, observations and scheduled interviews as the main methods. The technique of content analysis assisted in grouping qualitative data thematically that was presented in a narrative form. Statistical data were mainly analyzed using Statistical Package for Social Scientists (SPSS), and summarized in percentages. The data was presented in tables and graphs to provide visual relationships between variables. However, geographical information systems (GIS) spatial techniques were used to examine the physical extent of the zones in relation to adjoining land uses.

The study established that weak policy and institutional framework have led to haphazard and incompatible multiple uses of the zones. In particular, planning and development control mechanisms are weak and there are unclear land administration guidelines and procedures to secure the riparian width and vegetation. Land use and biophysical factors are also not taken into account when formulating and implementing policies while professionals and land users have limited or no roles at all in securing riparian zones. As a result, these factors have played a major role in the continued indiscriminate invasion and ecological deterioration of riparian zones in the basin.

In conclusion, there is improper determination, use and management of riparian zones in Nairobi River Basin. Therefore, the areas that physically and ecologically fall in these riparian zones are encroached and degraded by urban land uses. The study recommends among others, an integrated model for effective determination, use and management of riparian zones.

Key Words: *Riparian Zone, Conservation, Urban Land Use, Environment, Nairobi River Basin*

ACKNOWLEDGEMENTS

I thank the almighty God for His Grace and favor which enabled me finish this work. He surely is my source of strength.

I also want to thank my dear family: my wife Purity Muthoni, and sons; Kevin Mwenda and Derrick Kinyua. I cannot express my gratitude for the patience, unreserved support and encouragement you gave me during the study period.

Sincere gratitude to my supervisors: Dr. Isaac Karanja Mwangi who is also the Chairman, Kenya Institute of Planners; Dr. Tomiik Konyimbih who is also a Commissioner at the National Land Commission; and Dr.-Ing. Sammy M. Musyoka, who also serves as the Chairman, Department of Geospatial and Space Technology in the University of Nairobi. I am deeply indebted to you all for your steadfast guidance, invaluable advice and moral support. Your magnanimity and wise counsel, insight and continuous encouragement made working on this project a worthwhile experience. I am fortunate to have benefitted so thoroughly from your enthusiastic and generous support of this journey. Indeed, you helped me make the critical steps towards its finalization.

I am also sincerely grateful for the comments and suggestions received from Professor Robert W. Rukwaro, Chairman, Postgraduate School Committee of the School of Built Environment; Dr. Samuel V. Obiero, Chairman, Department of Urban and Regional Planning; Dr. Anyamba, the Dean, School of the Built Environment, University of Nairobi; Professor Syagga; Professor Abel Mugenda; and the late Dr. Francis Mburu. I also appreciate comments from my friends Mr. Charles Osengo and Romanus Opiyo during the early stages of the study.

In addition, particular thanks are due to Eng. Petronilla Ogut (OGW), the Managing Director, National Water Conservation and Pipeline Corporation (NWCP) for allowing me time off from my job to undertake the study. I also sincerely acknowledge many more people who assisted in the collection, analysis, preparation, presentations and final editing of this thesis report. They are Rosemary Karoki, Kevin Kienja, Peter Kinyua, Charles Ochieng, Charles Obila, Immaculate Njeri, Eunice Wahiga, and Christine Muchiri. Others are Caroline Nthambi, Evelyn Makena and Hilda Ndire who assisted in making the necessary drawings. My appreciation also goes to Jane Wanjiru, a student of Architecture for making the necessary models.

Many thanks are also due to Lynette Otwoli, Senior Lecturer, Kenya Institute of Administration for proof reading the thesis and Margaret Maimba of the National Council for Science and Technology for a prompt issuance of a research permit that facilitated the field research. Many thanks are also goes to all respondents who participated in the study including land users, professionals and officers in the public institutions.

DEDICATION

*To you voiceless, dying riparian ecosystem, so that you live another day to provide
insensitive mankind with a lifeline*

TABLE OF CONTENTS

DECLARATION	ii
DISCLAIMER.....	iii
ABSTRACT	iv
ACKNOWLEDGEMENTS.....	v
DEDICATION	vi
TABLE OF CONTENTS.....	vii
LIST OF FIGURES	xii
LIST OF TABLES	xiii
ABBREVIATIONS	xv
CHAPTER 1: INTRODUCTION.....	1
1.1 The Study Background	1
<i>1.1.1 The River Basins - History and Theory.....</i>	<i>1</i>
<i>1.1.2 Defining Riparian Zones</i>	<i>3</i>
<i>1.1.3 Understanding the Significance of Riparian Zones.....</i>	<i>10</i>
<i>1.1.4 The Study in Context.....</i>	<i>11</i>
1.2 Statement of the Research Problem.....	14
1.3 Research Questions	18
1.4 Objectives of the Study	19
<i>1.4.1 Overall Objective of the Study.....</i>	<i>19</i>
<i>1.4.2 Specific Objectives of the Study</i>	<i>19</i>
1.5 Assumptions of the Study	19
1.6 Justification of the Study.....	20
1.7 Scope of the Study.....	21
1.8 Definition of Terms.....	21
1.9 Organization of Thesis	24
CHAPTER 2: RIPARIAN ZONE CONSERVATION AND ITS UNDERLYING FACTORS	26
2.0 Introduction	26
2.1 Concept of Riparian Zone Conservation	26
<i>2.1.1 What is Riparian Zone Conservation?.....</i>	<i>26</i>
<i>2.1.2 Why Conserve Riparian Zones?.....</i>	<i>27</i>
<i>2.1.3 Implications of Biophysical Factors on Riparian Zones.....</i>	<i>28</i>
<i>2.1.4 Methods of Delineation of Riparian Zones.....</i>	<i>31</i>
<i>2.1.5 Research Studies on Determination and Management of Riparian Zones.....</i>	<i>35</i>
<i>2.1.6 Riparian Zone Management Models.....</i>	<i>43</i>
2.2 Implications of Land Use Factors on Riparian Zone	45
<i>2.2.1 Concept of Land.....</i>	<i>45</i>
<i>2.2.2 Land Use Defined.....</i>	<i>46</i>
<i>2.2.3 Land Use in Selected Parts of the World.....</i>	<i>48</i>
<i>2.2.4 Impacts of Land Use on Riparian Zones</i>	<i>52</i>
2.3 Riparian Zone and Land Administration Factors.....	55
<i>2.3.1 Concepts of Land Management and Land Administration.....</i>	<i>56</i>
<i>2.3.2 Concept of Land Tenure</i>	<i>56</i>
<i>2.3.3 Land Administration Principles</i>	<i>58</i>
<i>2.3.4 Land Administration Policies.....</i>	<i>59</i>

2.4 Best Practices in Riparian Zone Conservation.....	62
2.4.1 <i>Case of Thames Estuary Partnership in Britain.....</i>	63
2.4.2 <i>Case of Middlebury River Watershed Partnership in USA.....</i>	64
2.4.3 <i>Case of Nairobi River Basin Programme</i>	64
2.5 Environmental Management and Development Planning Policy in Kenya.....	66
2.5.1 <i>Overview of the State of Human Environments in Kenya</i>	66
2.5.2 <i>Environmental Management Policy in Kenya</i>	67
2.5.3 <i>Development Planning in Kenya.....</i>	68
2.5.4 <i>Evolution of Land Administration Policy in Kenya.....</i>	75
2.6 Chapter Summary	79
CHAPTER 3: THEORETICAL BACKGROUND TO CONSERVATION OF RIPARIAN ZONES.....	81
3.0 Introduction	81
3.1 Theoretical Underpinnings of Conservation of Riparian Zones	81
3.1.1 <i>Theoretical and Philosophical Foundations of Conservation.....</i>	82
3.1.2 <i>Linking Conservation Theories to Riparian Zones</i>	85
3.2 Theories of Development and Underdevelopment	86
3.2.1 <i>Poverty Hypothesis.....</i>	86
3.2.2 <i>Theoretical Approaches to Land Use Change.....</i>	87
3.2.3 <i>Linking Poverty and Theories of Land Use Change to Riparian Zones.....</i>	93
3.3 Rational Spatial Planning Theories.....	94
3.3.1 <i>Concept of Spatial Planning.....</i>	94
3.3.2 <i>Theoretical Underpinnings of Planning.....</i>	94
3.4 Urban Design Principles	97
3.5 Systems Approach to Conservation of Riparian Zone	99
3.5.1 <i>Integrated Resource Management Concept.....</i>	100
3.5.2 <i>Laws of Ecology.....</i>	100
3.5.3 <i>Concept of Systems Approach.....</i>	101
3.6 Research Gaps	103
3.7 Conceptual Framework	105
3.7.1 <i>Conceptual Definition of Riparian Zone.....</i>	105
3.7.2 <i>Key Determinants of the Conceptual Definition</i>	106
3.7.3 <i>Choosing a Working Definition of Riparian Zone.....</i>	107
3.7.4 <i>Justifying the Choice of a 30-Metre Working Definition</i>	108
3.8 Chapter Summary	110
CHAPTER 4: RESEARCH METHODOLOGY	111
4.0 Introduction	111
4.1 Theoretical Perspectives behind the Study Methods	111
4.2 Research Design	112
4.3 Understanding the Study Variable Scope.....	113
4.4 Understanding the Study Geographical Scope	114
4.4.1 <i>Description of Rivers in Nairobi River Basin</i>	114
4.4.2 <i>Profile of Land Uses Adjoining Nairobi Rivers</i>	116
4.4.3 <i>Selection of Rivers for the Study.....</i>	117
4.4.4 <i>Selection of Study Sites in the 30 Metre Buffer.....</i>	119
4.5 Research Procedures	122
4.5.1 <i>Data Collection Tools</i>	122
4.5.2 <i>Research Management and Ethical Considerations.....</i>	122

4.5.3 <i>Monitoring and Quality Assurance</i>	124
4.6 Objective-Specific Methods	125
4.6.1 <i>Influence of Existing Policy and Institutional Factors</i>	125
4.6.2 <i>Implications of Specific Land Use and Biophysical Factors</i>	128
4.6.3 <i>Roles, Perception and Behavior of Professionals and Land Users</i>	137
4.6.4 <i>Integrated Model for Determination, Use and Management of Riparian zones</i>	140
4.7 Limitations of the Study	141
4.8 Chapter Summary	141
CHAPTER 5: GROWTH DYNAMICS OF THE CITY OF NAIROBI	142
5.0 Introduction	142
5.1 Governance of Nairobi in Perspective	142
5.1.1 <i>Governance in the Colonial Era</i>	142
5.1.2 <i>Governance in Post Independent Era</i>	143
5.2 Spatial Planning Endeavors in the City of Nairobi	146
5.2.1 <i>Spatial Planning in the Colonial Era</i>	146
5.2.2 <i>Spatial Planning in Post Independent Era</i>	147
5.2.3 <i>Challenges of Spatial Planning of the City</i>	150
5.3 Demography, Land Administration and Land Use Dynamics	150
5.3.1 <i>Demography</i>	150
5.3.2 <i>Land Administration Issues</i>	152
5.3.3 <i>Land Use Distribution and Zoning in the City</i>	153
5.4 Background to the Study Sites	156
5.4.1 <i>Study Sites along Mathare River</i>	156
5.4.2 <i>Study Sites along Nairobi River</i>	159
5.4.3 <i>Study Sites along Ngong River</i>	163
5.4.4 <i>Study Sites along Kirichwa Kubwa River</i>	167
5.4.5 <i>Study Sites along Kibagare Stream</i>	170
5.5 Chapter Summary	170
CHAPTER 6: ANALYSIS OF POLICY AND INSTITUTIONAL FACTORS	171
6.0 Introduction	171
6.1 Existing Policy Framework for Conservation of Riparian Zones	171
6.1.1 <i>Existing Laws on Conservation of Riparian Zones</i>	171
6.1.2 <i>Constitution of Kenya of 2010 and New Laws</i>	178
6.1.3 <i>Challenges Facing Policy and Legal Framework</i>	182
6.2 Institutional Framework for Conservation of Riparian Zones	182
6.2.1 <i>Existing Institutions before New Constitution</i>	182
6.2.2 <i>Institutions Created by the New Constitution</i>	185
6.2.3 <i>Challenges Facing the Institutional Arrangement</i>	186
6.3 State Interventions in Conservation of Riparian Zones	186
6.3.1 <i>Njonjo Commission of Land Inquiry of 2002</i>	187
6.3.2 <i>Nairobi River Basin Programme</i>	188
6.3.3 <i>Ndung'u Commission</i>	189
6.3.4 <i>Technical Advisory Committee on Riparian Zone Determination</i>	190
6.3.5 <i>Judicial Interventions</i>	191
6.4 Role and Opinion of Officers in Public Institutions	193
6.4.1 <i>Allocation and Occupation of Riparian Land</i>	193
6.4.2 <i>Determination and Management of Riparian Zones</i>	198
6.4.3 <i>Monitoring and Evaluation of Riparian Zones</i>	200
6.4.4 <i>Opinions of Public Officers</i>	201

6.4.5 Suggested Model for Managing Riparian Zones.....	210
6.4.6 Institutional Weaknesses.....	210
6.5 Linking Policy and Institutional Factors to Riparian Zones	211
6.5.1 Policy Factors.....	211
6.5.2 Institutional Factors.....	214
6.6 Chapter Summary	215
CHAPTER 7: IMPLICATIONS OF SPECIFIC LAND USE AND BIOPHYSICAL FACTORS	216
7.0 Introduction	216
7.1 Land Use Variables	216
7.1.1 Distribution of Land Use Types in 30-Metre Riparian Zone.....	216
7.1.2 Land Use Spatial Concentration/ Densities	218
7.1.3 Solid and Wastewater Infrastructure	219
7.2 Land Administration Variables	223
7.2.1 Cadastral Data	223
7.2.2 Land Tenure	223
7.3 Bio-Physical Variables	227
7.3.1 Widths of Rivers.....	227
7.3.2 Test of Hypothesis on Widths of Riparian Zones.....	229
7.3.3 Test of Hypothesis on Ecological Condition of Riparian Zones	232
7.3.4 Riparian Slopes	236
7.3.5 Types and Characteristics of Soil.....	238
7.4 Implications of Land Use and Biophysical Factors	239
7.4.1 Land Use Types	240
7.4.2 Land Use Density/ Spatial Concentration Issues.....	241
7.4.3 Land Administration Issues	242
7.4.4 Bio-Physical Effects.....	243
7.5 Linking Land Use and Biophysical Factors to Policy and Institutional Factors	245
7.5.1 Non-Compliance to Policy Measures	245
7.5.2 Adherence to Policies.....	247
7.6 Chapter Summary	248
CHAPTER 8: ROLES, PERCEPTIONS AND BEHAVIOUR OF PROFESSIONALS AND LAND USERS	249
8.0 Introduction	249
8.1 Opinions of Professionals	249
8.1.1 Response Rate.....	249
8.1.2 Factors Contributing to Encroachment and Degradation of Riparian Zones	249
8.1.3 Strategies for Conservation of Riparian Zones	252
8.1.4 Impacts of Land Use on Riparian Zones	255
8.1.5 Appropriate Widths of Riparian Zone.....	258
8.2 Socio-Economic Profile of Land Users	258
8.2.1 Education and Income Levels of Households	258
8.2.2 Emerging Socio-economic Issues	259
8.3 Roles, Perception and Behaviour of Land Users	260
8.4 Evaluating Professional and Land Users' Factors	262
8.4.1 Roles, Perception and Behaviour of Professionals.....	262
8.4.2 Roles, Perceptions and Behaviour of Land Users	263
8.4.3 Technology Innovation by Land Users.....	264
8.4.4 Need for Private Public Partnerships.....	264

8.4.5 <i>Linking Professional and Land Users' Factors to Riparian Zones</i>	264
8.5 Chapter Summary	265
CHAPTER 9: INTEGRATED MODEL FOR CONSERVATION OF RIPARIAN ZONES	266
9.0 Introduction	266
9.1 Spatial and Non-Spatial Determinants of Riparian Zones	266
9.1.1 <i>Spatial Determinants</i>	266
9.1.2 <i>Non-Spatial Determinants</i>	269
9.2 Integration of Spatial and Non-Spatial Factors of Riparian Zone	271
9.2.1 <i>Proposed Integrated Model</i>	272
9.2.2 <i>Application of the Integrated Model</i>	275
9.2.3 <i>Linking the Integrated Model to the Objectives of the Study</i>	276
9.3 Theory Development	278
9.4 Chapter Summary	279
CHAPTER 10: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS	280
10.0 Introduction	280
10.1 Summary of Findings	280
10.1.1 <i>Influence of Policy and Institutional Framework</i>	280
10.1.2 <i>Implications of Land Use and Biophysical Factors</i>	281
10.1.3 <i>Roles, Perceptions and Behaviour of Professionals and Land Users</i>	282
10.1.4 <i>Integrated model for determination, use and management of riparian zones</i>	283
10.2 Conclusion	283
10.3 Recommendations	285
10.3.1 <i>Secure and Regulated Access to Riparian Zones</i>	285
10.3.2 <i>Planning and Management of Riparian Zones</i>	286
10.3.3 <i>Land Surveying</i>	287
10.3.4 <i>Registration of Riparian Zones</i>	287
10.3.5 <i>Environmental Impact Mitigation on Riparian Zones</i>	288
10.3.6 <i>Stakeholder Involvement in Conservation</i>	288
10.4 Policy Implications	288
10.4.1 <i>Methodology for Conservation of Riparian Zones</i>	289
10.4.2 <i>The Dilemma</i>	289
10.5 Contribution of the Study	290
10.6 Areas for Further Research	291
REFERENCES	292
APPENDICES	303
<i>Appendix 1: Hypothesis Testing on Influence of Policy Measures on Riparian Width</i>	303
<i>Appendix 2: Research Clearance Permit No. NCST/RR1/12/1/ES-011/16</i>	304
<i>Appendix 3: Questionnaire for Land Users</i>	305
<i>Appendix 4: Questionnaire to Professionals</i>	307
<i>Appendix 5: Interview Schedule to Institutions</i>	308
<i>Appendix 6: Soil Laboratory Test Results for Riparian Soils from the Selected Study Sites</i>	310
<i>Appendix 7: We Care about Nairobi do it and Another versus NEMA and Another</i>	311
<i>Appendix 8: Logical Framework for Conservation of Riparian Zone in Nairobi River Basin</i>	313
<i>Appendix 9: Professional Opinions of the Physical Impacts of Land use on Riparian Zone in the City of Nairobi</i>	314

LIST OF FIGURES

<i>Figure 1.1: Main Attributes of a Functional Riparian Zone</i>	6
<i>Figure 1.2: Trend in Population Growth in the City of Nairobi</i>	17
<i>Figure 2.1: Riparian Buffer Width Verses Nitrogen Removal Effectiveness</i>	31
<i>Figure 2.2: Idealized Multi-zone Riparian Zone Model</i>	35
<i>Figure 2.3: Effects of De-vegetated and Vegetated Riparian Zones</i>	53
<i>Figure 3.1: Critical Path for a Descriptive Definition of the Riparian Zone</i>	109
<i>Figure 3.2: Conceptual Model for Conservation of Riparian Zones</i>	110
<i>Figure 4.1: Map of City of Nairobi and its Major Rivers</i>	115
<i>Figure 4.2: Location of Study Sites</i>	121
<i>Figure 5.1: Map of Nairobi Metropolitan Region</i>	145
<i>Figure 5.2: Nairobi Boundary Changes Since 1900</i>	151
<i>Figure 5.3: Land Use Changes in the City of Nairobi</i>	154
<i>Figure 5.4: Planned Public Plots Irregularly and Illegally Allocated</i>	155
<i>Figure 5.5: Encroachments by Informal Settlements along Mathare River</i>	158
<i>Figure 5.6: Informal Businesses and Public Open Grounds along Nairobi River</i>	161
<i>Figure 5.7: Public and Private Institutions Along Nairobi River</i>	162
<i>Figure 5.8: Urban Agriculture and Quarry Mining along Ngong River</i>	165
<i>Figure 5.9: Industrial Land Use Boundaries and Riparian Zone along Ngong River</i>	166
<i>Figure 5.10: Encroachments by Residential Housing along Kirichwa Kubwa River</i>	168
<i>Figure 5.11: Riparian Zone at Arboretum along Kirichwa Kubwa River</i>	169
<i>Figure 5.12: Residential Land Use Boundaries along Kirichwa Kubwa River</i>	170
<i>Figure 6.1: Illegally Re-allocated Wetland Plots in Kinale Settlement Scheme</i>	194
<i>Figure 6.2: Percentage of Public Land Irregularly and Illegally Allocated</i>	194
<i>Figure 6.3: Riparian Zone after Subdivision of Faddville Estate in 1987</i>	196
<i>Figure 6.4: Re-Allocation of Riparian Zone at Faddville Estate in 1994</i>	197
<i>Figure 6.5: Developments on Riparian Zone at Faddville Estate in 2012</i>	197
<i>Figure 7.1: Industrial Buildings on Canalized Ngong River.</i>	217
<i>Figure 7.2: Conserved Riparian Zone at Faddville Estate</i>	218
<i>Figure 7.3: Direct Discharge of Industrial Effluent into Ngong River</i>	222
<i>Figure 7.4: Structures in Riparian Zone at Mathare 4B</i>	227
<i>Figure 7.5: Structures Constructed at the Edge of Mathare River in Mathare 4B</i>	233
<i>Figure 7.6: Elevation Map of the Study Area</i>	237
<i>Figure 8.1: Strategies for Conservation of Riparian Zones</i>	254
<i>Figure 8.2: Professional Opinions on Impacts of Land Uses on Riparian Zones</i>	256
<i>Figure 9.1: Integrated Model of Conservation of Riparian Zones</i>	273

LIST OF TABLES

Table 1.1: Legal Definitions and Applications of Riparian Zones in Kenya.....	8
Table 1.2: Number of Informal Structures and Population within Riparian Zones in Nairobi....	13
Table 2.1: Relationship of Vegetation Type to Effectiveness of Riparian Zones	30
Table 2.2: Recommended Riparian Widths in Britain Based on Size of Watercourse.	37
Table 2.3: Summary of Findings of Studies on Effective Riparian Width.....	37
Table 2.4: Studies on Riparian Width Guidelines	38
Table 2.5: Width of Riparian Zones Based on Purpose/Function.....	40
Table 2.6: Guidelines for Riparian Widths in Malaysia	41
Table 4.1: Nairobi Rivers and their Lengths.....	119
Table 4.2: Officers Interviewed in Sampled Public Institutions	127
Table 4.3: Sample Sizes for both Formal and Informal study sites	135
Table 5.1: Trends in population growth in the City of Nairobi.....	152
Table 5.2: Distribution of Land Use Types in the City of Nairobi	153
Table 5.3: Planned Public Plots Irregularly and Illegally Allocated in Nairobi.....	154
Table 6.1: Public Plots Irregularly and Illegally Allocated in Nairobi.....	194
Table 6.2: Public Officers Opinion on Allocation of Riparian Zones	195
Table 6.3: Opinions of Public Officers on Permitted Land Uses in Riparian Zones.....	204
Table 6.4: Opinions of Public Officers on Restricted Land Uses in Riparian Zones	205
Table 6.5: Challenges Faced by Institutions in Conservation of Riparian Zones.....	206
Table 6.6: Opinion of Public Officers on Riparian Zones Laws	207
Table 6.7: Suggested Factors for Determination of Riparian Zones	207
Table 6.8: Technical Personnel within Public Institutions	208
Table 6.9: Institutional Policies for Riparian Zones.....	209
Table 6.10: Opinions of Public Officers on Collaboration among Public Institutions.....	210
Table 7.1: Riparian Areas Occupied by Different Land Uses in Nairobi.....	217
Table 7.2: Land Use Densities in 12 Study Sites	219
Table 7.3: Water Supply System at Study Sites.....	220
Table 7.4: Human Waste Disposal Systems in Mathare 4B and Faddville Estate.....	221
Table 7.5: Solid Waste Disposal by Residents of Mathare 4B and Faddville.....	222
Table 7.6: Housing Typology in Residential Sites.....	224
Table 7.7: Housing Quality Information in Residential Sites.....	224
Table 7.8: Land Tenure in Riparian Zones and Year of Acquisition/Occupation	226
Table 7.9: Average Widths of Main Rivers in Nairobi.....	228
Table 7.10: Average Widths of Rivers at the Study Sites.....	229
Table 7.11: Average Riparian Widths at Study Sites.....	230
Table 7.12: Riparian Vegetation Cover at 12 Study Sites.....	234

Table 7.13: Observed and Expected Frequencies for Chi-square.....	235
Table 7.14: Calculation of Chi-Square	235
Table 7.15: Average Slopes of Riparian Zones at Study Sites.....	238
Table 7.16: Types of Soils Sampled at the Study Sites	239
Table 8.1: Response Rate of Professional Respondents	249
Table 8.2: Strategies for Conservation of Riparian Zones.....	253
Table 8.3: Variability of Professional Opinions on the Impacts of Urban Land Uses	256
Table 8.4: Likert Scale on Professional Opinion on Impacts of Land Use on Riparian Zone.....	257
Table 8.5: Professionals Opinions on Appropriate Riparian Widths	258
Table 8.6: Education and Income Levels of Households.....	259
Table 8.7: Roles, Perception and Behaviour of Land Users	261
Table 9.1: Main Input-Output Factors for Conservation of Riparian Zones	274

ABBREVIATIONS

ANRA	Australian Natural Resource Atlas
AWSB	Athi Water Service Board
CAAC	Catchment Area Advisory Committee
CBD	Central Business District
CBO	Community Based Organization
CCN	City Council of Nairobi
DRSRS	Department of Resource Surveys and Remote Sensing
EEB	Economics of Ecosystems and Biodiversity
EIA	Environmental Impact Assessment
EMCA	Environmental Monitoring and Coordination Act
ERSWEC	Economic Recovery for Wealth and Employment Creation
FADD	Faculty of Architecture Design and Development
GIS	Geographical Information Systems
GLA	Government Lands Act
GPS	Global Positioning Systems
GPT	Graduated Personal Tax
KNBS	Kenya National Bureau of Statistics
LFA	Logic Framework Analysis
LGA	Local Government Act
LTA	Land Titles Act
LVPC	Lehigh Valley Planning Commission
MBO	Management by Objective
MRWP	Middlebury River Watershed Partnership
NARC	National Alliance Rainbow Coalition
NDP	National Development Plans
NEMA	National Environment Management Authority
NES	National Environmental Secretarial
NGO	Non-Governmental Organization
NLC	National Land Commission
NMGS	Nairobi Metropolitan Growth Strategy
NRBP	Nairobi River Basin Programme

NUSG	Nairobi Urban Study Group
NWP	National Water Policy
NWSC	Nairobi Water and Sewerage Company
PDP	Part Development Plan
PHA	Public Health Act
PPA	Physical Planning Act
PPH	Physical Planning Handbook
PPP	Public Private Partnership
PRSP	Poverty Reduction Strategy Paper
RDA	Regional Development Authorities
RLA	Registered Land Act
RTA	Registration of Titles Act
SDI	Spatial Data Infrastructure
SME	Small and Medium Scale Enterprises
SMR	Social Mutual Responsibility
SPSS	Statistical Package for Social Sciences
TARDA	Tana and Athi River Development Authority
UN	United Nations
UNCED	United Nations Centre for Environment and Development
UNCHS	United Nations Centre for Human Settlement
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
WCMI	Water Catchment Management Initiative
WRMA	Water Resources Management Authority
WRUA	Water Resources Users Association

CHAPTER 1: INTRODUCTION

1.1 The Study Background

Historical, theoretical, conceptual and contextual backgrounds are described to help improve the understanding of the study background.

1.1.1 The River Basins - History and Theory

River basins, all over the world, are experiencing increased conflicts between different land and water uses. Many of the river basins are overexploited and their capacity to meet different social, economic and environmental demands is decreasing (Postel, 1992). According to Postel, the main challenge in the management of river basins is finding ways of turning potential conflicts into constructive cooperation. It also entails turning zero-sum predicament into a win-win proposition. A zero-sum quandary is a situation where one party's gain is another's loss.

Human interaction with riparian areas of rivers has existed throughout human civilization. The concept of riparian comes from the Latin word "ripa" which means the bank of the river. Therefore, riparian zones have complex histories that connect social activities with varied effects on river ecosystem structure and functions (Groffman *et al.*, 2003). Accordingly, access to water for drinking, irrigation and transportation has a strong influence on the development of human settlements (Ibid, 2003).

According to the book of Genesis in the Holy Bible, the first human settlements of the world originated from Eden which defined the nations of antiquity (Life Application Study Bible, 1986). Accordingly, major civilizations of ancient times developed along river banks. The Egyptian civilization sprang from the banks of river Nile, the Mesopotamian civilization along the Tigris and Euphrates Rivers in the modern day Iraq (Kaplan, 2004). The Yellow and the Indus Rivers are attributed to the origins of Chinese and Indian civilizations respectively (Catanese & Snyder, 1979).

Rivers constitute landmarks in history and tell the story of the countryside or urban area (Kaplan, 2004). Therefore, it is important to ensure that river ecosystems remain relevant components of human settlements. Proximity of human settlements to rivers has led to man's exploitation of the river for domestic water needs, irrigation, livestock and transportation, and for urban uses (Catanese & Snyder, 1979). However, social interaction with the river ecosystem shifted from an early emphasis on transportation in pre-1700s to

an extended and persistent period of industrial use from 1730 and to present use as parks and green spaces (Groffman et al., 2003).

Conversely, encroachment and degradation of riparian zones by human activities in developing countries suggests a different way of conceptualizing and constructing the zones. For example, sewerage, industrial effluents, solid wastes, human activities and developments occupy riparian zones in some urban areas of Kenya denying the rivers their natural riparian vegetation. The rivers deserve their green spaces to support ecological, social and economic objectives (Guthiga & Makathimo, 2010).

In 1999, a collaborative initiative spearheaded by United Nations Environmental Programme (UNEP), Government of Kenya through the Ministry of Environment and Mineral Resources and City Council of Nairobi (CCN) established the Nairobi River Basin Programme (NRBP). The aim of NRBP was to rehabilitate the Nairobi River ecosystem. However, these efforts did not resolve the problem because of the complex nature of riparian zone issues.

Riparian zone issues in a basin constitute unique challenges of planning, land use, management, policy and stakeholder coordination because of multiple mandates and interests (Home, 2004; and Guthiga & Makathimo, 2010). Issues concerning water quality, flood incidences, politics and land administration further complicate the matter (Home, 2004; Njogu & Dietz, 2006; and Kajoba, 2009).

Kahara (2002) observed that the main source of pollution to Nairobi rivers include non-implementation of laws to protect urban water resources, intentional or accidental blockage of sewer lines and manholes, poor planning of settlements along rivers and water bodies, and acute shortage of funds in local government to sort out the problems. Considering the large number of studies and projects conducted in the basin, it is puzzling as to why there has been no improvement in conservation of the river ecosystem (Olago & Aketch, 2000).

Several factors have been attributed to the failure to resolve the problem. These include size and growth rate of unplanned settlements along the rivers; lack of sustainable support from the county and national governments to external project intervention; lack of coordination between different projects dealing with the problem; and inability to establish

the exact sources of pollution due to poor data record and irregular monitoring patterns (Olago & Aketch, 2000).

Several studies have been conducted on Nairobi Rivers, but the variables mainly relate to sources of pollution of water (NRBP, 1999). The studies differ in terms of variables sampled, sampling procedures and sample sites (Olago & Aketch, 2000). Unfortunately, no strategy has focused on the definition and conservation of riparian zones as a fundamental solution to the problem of water quality. Other works including (Matrix Consultants, 1993) mainly relate to socio-economic conditions of informal settlers located in the river valleys, but have not explained how the settlements affects riparian zones and vice versa.

From the foregoing, this study is modeled on the postulates of the systems theory of planning because riparian zones issues require integration and are always in constant exchange with their external environment. Some of the exchanges are detrimental to the riparian zone and hence the need for this study.

The theoretical basis for this study is, therefore, derived from the concept of systems approach as described by McLoughlin (1969) and Saleemi (2009). The systems theory is concerned with relationships and interdependence between different variables rather than specific isolated attributes. The theory is, therefore, best placed to integrate and improve the understanding of riparian zones and their underlying factors regardless of their objectives or orientation.

1.1.2 Defining Riparian Zones

The concept of a riparian zone as defined in different parts of the world and Kenya provides an important conceptual background for this study. The methods of delineation of riparian zones also help in understanding the methodology of determining riparian zones. The conceptual definition for this study is finally constructed from these definitions.

1.1.2.1 Definition of Riparian Zones in Other Countries

The concept of riparian zone in its most basic meaning is a vegetated strip of land adjoining a water body. In its most ideal functional form, the zone is an undisturbed strip of land covered by natural vegetation that lies along a stream, river and lake. In classical times, woody vegetation cover associated only with surface flowing water was identified to mean riparian zones (Karisa, 2010). However, more recent definitions have considered

a broader view involving surface and sub-surface water systems (UN, 2006; & Kenya, 2010a).

This new interpretation of riparian areas illuminates the thinking brought forward by the Ramsar Convention (UN, 2006) who defined wetlands as areas that are permanently or seasonally flooded by water where plants and animals have become adapted. In this definition, wetlands include swamps, areas of marsh, peat land, mountain bogs, banks of rivers and areas of marine waters (Ibid, 2006).

Various studies in other parts of the world including the ones by State of Victoria Department of Natural Resources (2002), Booth *et al.* (2004) and the one by Frietag and McGinley (2008) have defined riparian zones as ecosystems located along the banks of rivers, streams, creeks and any other water body. These definitions consider riparian zones as narrow strips of land that line the borders of watercourses.

The State of Victoria, Department of Natural Resources and Environment (2002) in Australia, defines the riparian reserve as the area of land that adjoins and regularly influences the river. The zone varies from a narrow band in upland reaches of waterways to wide floodplains along lowland rivers (Ibid, 2002). The study observes that the vegetation in riparian zones is distinctly different from vegetation found in other terrestrial areas because of water-rich soils. Riparian zones are, therefore, considered as transitional interfaces between land and water environments.

The riparian zone as an interface between aquatic and terrestrial ecosystems is a critical component of a healthy water ecosystem and urban human environment (Broadmeadow & Nisbet, 2004). However, often the process of urbanization and rural activities cause these interfaces to be cleared of their natural vegetation or modified in such ways that reduce the health and vitality of both water and land-based ecosystems (Ibid, 2004).

Broadmeadow and Nisbet (2004), and Fualing (2009) further consider riparian zones as the last line of defense because they ensure effective protection of river ecosystem from adverse effects of land use. According to these studies, the size of the zone varies from the source of a river where it is a narrow band to wider widths in floodplains of low lying lands.

More specifically, the State of New Jersey Department of Environmental Protection (2008): *Riparian Zone Model Ordinance* defines a riparian zone as “*land and vegetation within and directly adjacent to all surface water bodies including, but not limited to lakes, ponds, reservoirs, perennial and intermittent streams up to and including their point of origin, such as seeps and springs.*”

The State of Ohio Department of Natural Resources (2006): *Rainwater and Land Development Manual*, on the other hand, defines riparian zones as “*naturally vegetated land adjacent to water courses that, if appropriately sized, helps to stabilize stream banks, limit erosion, reduce flood size flows and/or filter and settle out run-off pollutants, or perform other functions.*”

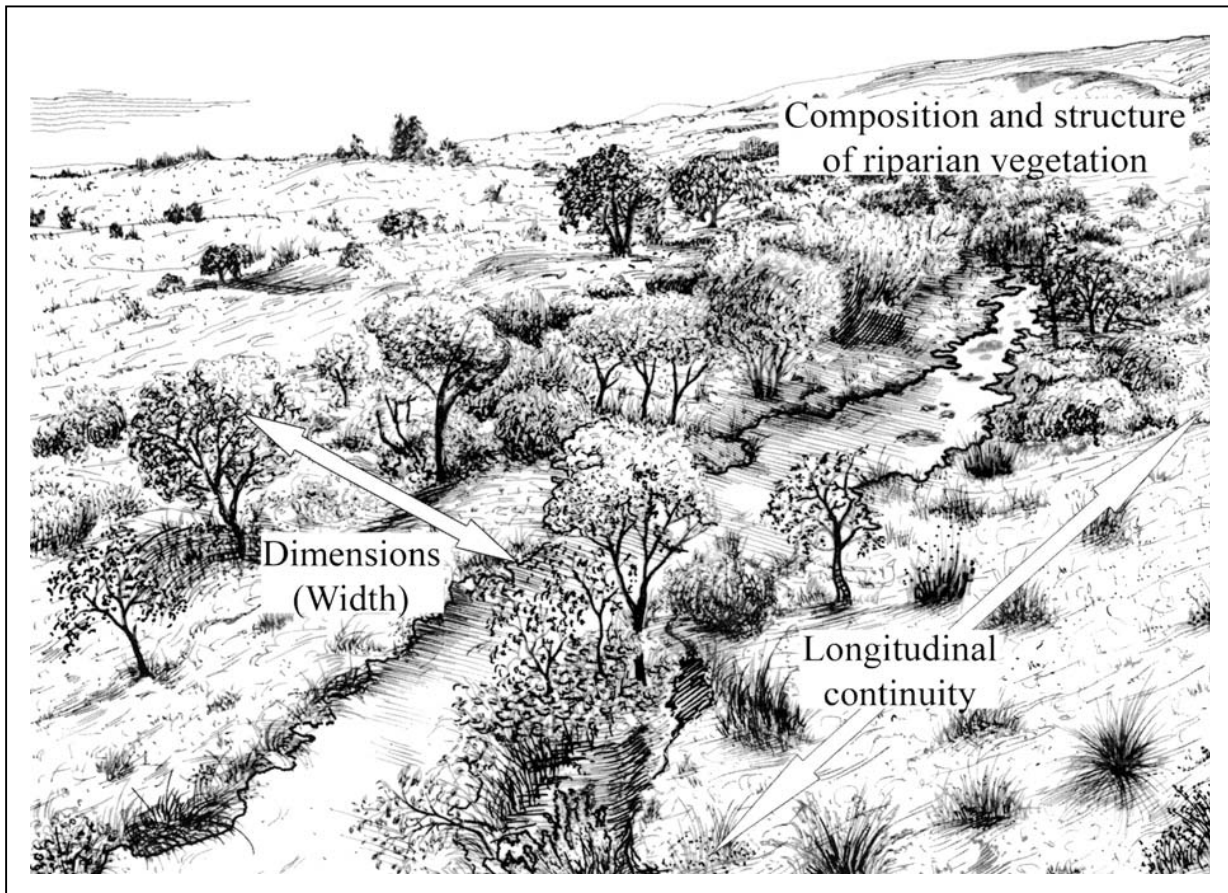
Lowrance, Leonard, and Sherida (1985), have further defined riparian buffers as:

A complex assemblage of plants and other organisms in an environment adjacent to water. Without definitive boundaries, it may include stream banks, floodplain, and wetlands, as well as sub-irrigated sites forming a transitional zone between upland and aquatic habitat. Mainly linear in shape and extent, they are characterized by laterally flowing water that rises and falls at least once within a growing season.

Pointedly, several concepts have been used to define the riparian area. These include riparian zone, riparian reserve, riparian buffer, riparian forest, riparian vegetation, riparian way leave and riparian land. This study prefers the concept of riparian zone because it normatively denotes a distinct fragile area that requires good conservation ethics to achieve ecological, social and economic objectives.

The structure of riparian zones could be characterized by the following seven attributes: (i) longitudinal continuity of vegetation; (ii) the lateral dimensions (width) of the channel containing natural riparian vegetation; (iii) composition and structure of riparian vegetation communities; (iv) the spatial dimensions where riparian functions take place; (v) ratio of natural woody species regeneration; (vi) bank conditions; and (vii) lateral connectivity and permeability of riparian soils (Gonzalez del Tanago & Garcia de Jalon, 2006). Figure 1.1 shows the main elements of a functional riparian zone.

Figure 1.1: Main Attributes of a Functional Riparian Zone



Source: Marta González del Tánago & Diego García de Jalón, 2006:391

1.1.2.2 Kenyan Definitions

Different laws in Kenya have legislated on different policy measures on riparian zones. As a result, different riparian widths are prescribed for the same river. Lelo, Chiuri and Jenkins (2005) have, therefore, argued that the definition of riparian zone is marred with confusion in Kenya.

The laws stipulate different measures and use the centreline of river, river banks and high water marks as different points of reference of measurement of the width of the zone. In addition, despite these laws being enacted at different points in time, some before independence and others in the late 1990s, there is lack of systematic improvement of subsequent definitions to build a coherent concept of riparian zone.

For example, the new Land Registration Act of 2012 which was enacted after promulgation of the Constitution (Kenya, 2010a) recommends application of definitions in the Survey Act (Kenya, 1961) and other legislation, yet they have limitations. For

instance, the Survey Act does not stipulate measures for non-tidal rivers and has no requirement for what condition should be maintained in the zone. This zone should mainly constitute a vegetation cover.

Accordingly, Lelo *et al.* (2005) further observes that, in most cases, management of the riparian reserve is left to the interpretation of individuals owning land adjacent to rivers. This is due to enormity of the task of definition and enforcement.

Practically, the centreline of river has been applied in most planning jobs and cadastral surveys conducted next to rivers in Kenya. Approved survey plans obtained from the Department of Surveys indicate “*the property boundary is the centre line of river*”. This approach is not prescribed in any legislation in Kenya including the Survey Act.

Kimani, Ojwala, Kibet, Anne, and Juma (2009) used a criterion of 30 metres from the centre of rivers to determine the number of structures in riparian zones along three main rivers of Nairobi, Ngong and Mathare. The problem is that the use and management of riparian zones is left to the discretion of land users where more often than not it has been put under incompatible land use.

Analytically, Kenyan definitions do not agree with those reviewed from other parts of the world. Determinations of riparian widths in other countries are based on research which determines specific local biophysical and other site characteristics, effects of adjoining land uses and their intended functions.

Legal definitions of riparian zones in Kenya have largely ignored land use and biophysical factors. Instead, the laws have only provided for generic widths without giving guidelines on what width to use for specific functions and why. In addition, the definitions have omitted the type and composition of riparian vegetation that are critical components of the zone.

In addition, the concept of riparian reserve commonly applied in Kenya implies a preservation ethic that is visibly ignored in Nairobi River Basin. Since the late 1990s, there has been consensus that encroachment and degradation of riparian zones in Nairobi River Basin is a serious problem (Kenya, 2004). Despite this knowledge, spontaneous human settlements, urban development and activities in designated riparian zones have

remained visible elements in most areas adjoining rivers in the city of Nairobi. Table 1.1 presents different definitions of riparian zone as stipulated in laws of Kenya.

Table 1.1: Legal Definitions and Applications of Riparian Zones in Kenya

	Legislation	Legal Definitions	Application
1	Survey Act (Kenya, 1961)	At least 30 metres in width shall be made for Government purposes (Section 111)	Tidal rivers only. Measured from the high water mark. Riparian reservations should be surveyed as a straight line or a series of straight lines at a distance approximating closely to the specified distance from the feature for which a reservation is needed (Section 113).
2	Agriculture (Basic Land usage Rules) (Kenya, 1965)	Minimum of 2m	Strict regulation on cultivation where slope is between 12% - 35%. It restricts cultivation, destruction of soil, cutting down of vegetation on land within 2m unless with a written consent of an authorized officer.
3	Physical Planning Act (Legal notice 140 rule 15(c) and (d) (Kenya, 1998)	Way leaves or reserves along any river, stream or watercourse shall be provided of not less than 10 metres in width	Measured from the river bank except in areas where there is an established flooding
4	Water Resources Management Rules (Kenya, 2007b)	Minimum of 6m and a maximum of 30m. (EMCA water quality regulations are based on this provision)	Seasonal and perennial rivers Measured from the river banks
5	Physical Planning Handbook (Kenya, 2008)	Minimum of 2m or equal to the full width of the river up to a maximum of 30m	Land defined on each side of the watercourse for seasonal and perennial rivers. Measured from the banks of the river.
6	Land Registration Act (Kenya, 2012a)	Land adjacent to the ocean, lake sea, rivers, dams and watercourses as provided under the survey Act or any other written law (2012:229)	There are inherent challenges in the application of this definition owing to the multiplicity of laws which provide different definitions and points of reference

Source: Republic of Kenya (1961, 1965, 1998, 2007b, 2008 and 2012a)

The study, therefore, defines conservation of riparian zones as the management and use of the zones without impairing their physical existence and ecological quality. In addition, the study recognizes conservation as a middle ground between total preservation on one end and total development on the other, where the zone is optimally determined, used and managed.

1.1.2.3 Definitions Based on Method of Riparian Delineation

The process of riparian delineation also influences estimation of riparian resources in a region (Palik, Tang & Chavez, 2004). According to Palik *et al.*, the methods include fixed and variable width methods. Fixed width methods have no functional relationships to the actual riparian areas on the ground, which vary naturally in width among and within systems (Ibid, 2004).

Fixed width determinations could either be insufficient to protect or are overly protective of riparian zones. In the Survey Act (Kenya, 1961), a width of 30 metres should be prescribed on tidal rivers and should be measured from the high water mark. Other legislation in Kenya prescribes general measures ranging from two to 30 metres.

Fixed width methods are inappropriate because watercourses widen from their source to mouth as they collect more water from tributaries (Vannote, Min shall, Cummins, Sedell, & Cushing, 1980). The river geography often consists of different biophysical characteristics and different land uses with different effects (Kahara, 2002). Fixed width methods are, therefore, limited to site-specific determinations, which may not reflect ecological needs of an entire river basin. One general width, therefore, appears inappropriate.

Variable width methods are also defined as functional or hydric soil-based approaches (Palik *et al.*, 2004). Use of different definitions of riparian areas and delineation approaches introduces variations in ecological characteristics of the zone (Ibid, 2004). Ecological or functional delineation methods are considered as site-specific ecological methods that determine the width of riparian zone according to the character and sensitivity of adjacent riverside lands (Murphy, 2000). According to Murphy, this method considers physical site characteristics such as slope, soil type and vegetation cover.

The advantage of variable width method is that riparian zone widths are designed based on-site characteristics and not on arbitrary predetermined width. In Kenya, this approach has not been used to delineate riparian zones in rural (Lelo et al., 2005) or urban areas (Karisa, 2002).

Rather, as shown in Table 1.1, arbitrary and general riparian widths are prescribed in different laws and policies scattered in different sectors. The challenge is that the

consequences of land uses on riparian zones vary considerably even within specific rural or urban contexts.

1.1.3 Understanding the Significance of Riparian Zones

The need to develop appropriate riparian zone principles and a subsequent policy in Kenya is long overdue. The subject of riparian zone in Kenya is not a central theme in environmental management and development planning framework of the country despite the recent promulgation of a new Constitution (Kenya, 2010a). Whereas rivers dictate the drainage system of urban areas, policies and legislation have not dictated the location of land use in relation to riparian zones.

Riparian zones have had no place in the spatial planning of the city of Nairobi. There are visible advantages of including rivers and their riparian zones in spatial planning contexts of urban areas and cities (Kaplan, 2004). It is, therefore, worthwhile to examine riparian zones in the context of land use and other factors which are more encompassing than taking a one-dimensional approach as is presently the case in the basin.

The problem of encroachment and degradation of riparian zones is, therefore, not a one-dimensional issue that encompasses management of water resources only as is the case in Kenya today. Rather, the problem is a multi-dimensional issue that requires integration of different land and water issues (Home, 2004). In this respect, the notion of riparian zone as understood from the perspective of a dynamic and often turbulent underlying urban land use environment forms the central theme of this study.

The underlying strategy is through conservation as an important planning intervention. The need to protect and conserve riparian zones and other important ecosystems in Kenya is more urgent today than it has ever been because the consequences of uncontrolled high population growth rate is threatening the very survival of mankind.

Riparian zones provide such functions as protecting water quality, providing food for aquatic and terrestrial plants and animals, filtering polluted run-off, and storing flood water (Vannote *et al.*, 1980). The zones act as filters by removing sediments and contaminants from surface runoff that could otherwise discharge directly into watercourses and stationary water bodies (Collier *et al.*, 1995). Studies including Broadmeadow and Nisbet (2004) indicate that tree buffers remove up to 90 percent of nitrates entering waterways. The roots of riparian vegetation act as stabilizers for soil

hence mitigate soil erosion. Vegetated riparian zones also act as stores for floodwaters and reduce flood peaks.

Maintaining and restoring damaged riparian zones is an important conservation goal. Healthy riparian zones appear as ribbons of green vegetation along riverbanks, provide a variety of important ecosystem services and are often important habitats for wildlife (Frietag, McGinley, & Tollner, 2008). River waters of conserved zones have low sediment load. Damaged riparian zones, on the other hand have muddy water in the rivers (Smith, 2010). Riparian zone widths, therefore, vary depending on prevailing physical conditions in the basin and magnitude of human interference (Letsinger, 2004).

Given the potential role of riparian zones, there should be concerns when they get converted into spaces for urban development in Nairobi River Basin. Many explanations have been advanced including lack of appreciation of riparian zones (Menya, 2008), weak policy and institutional framework (King'oriah, 1980), and poor planning standards and guidelines (Ayonga, 2008) leading to less than optimal applications by professional practitioners. All these isolated explanations have continued to aggravate the problem of encroachment and degradation of riparian zones in the basin.

1.1.4 The Study in Context

The contextual basis of the study concerns the challenges faced by river ecosystems from urban land use and the complex nature of stakeholder roles in Nairobi River Basin.

1.1.4.1 Evolving Challenges of Riparian Zones in Nairobi River Basin

Rivers in Nairobi at the turn of the 20th century were once “places of cool waters” flowing with clean, fresh water and lined with magnificent indigenous trees and wild riparian vegetation (NRBP, 1999). The rivers which were a source of water and livelihoods for Maasai, Kikuyu, Kamba communities and early European settlements, are today heavily polluted (Nzau, 2003). Similarly, the riparian zones which were once rich in biodiversity in the early period of urban settlements in Nairobi are today dramatically transformed.

The river ecosystem punctuated the geographical transition from the “White Highlands” to drier Athi plains. As a result, the rivers were critical in making Nairobi the Kenya-Uganda railway depot and later the administrative headquarters of the Colonial Government. Presently, the rivers are more like moving sewers and their riparian zones have minimal or no vegetation cover. The riparian zones are predominated with planned and unplanned

development, and are dumping sites for solid and human waste (Kahara, 2002; & Kimani *et al.*, 2009).

Encroachment and degradation of riparian ecosystems in the basin is now a common feature (Mbui, Orata, & Kariuki, 2010). In order to increase spaces that can be used for urban activities and structures, much of the riparian vegetation has been cleared, wetlands drained, rivers straightened and canalized in some sections of the city. A great amount of biodiversity has been lost and replaced with physical structures and human activities. Such dramatic change in the riparian ecosystem has had profound effects on both the physical appearance and ecological health of riparian zones and their rivers.

The potential role of riparian zones in ensuring better water quality objectives has been widely established through scientific research studies carried out in various countries including USA, United Kingdom and Malaysia. Recent studies on urban planning conducted in the river basin including (Karisa, 2002; Mburu, 2007; and Menya, 2008) as well as those concerned with water quality including (NRBP, 1999; & Kahara, 2002) have only focused on water pollution issues disregarding the need for proper determination, use and management of riparian zones.

In reality, riparian zones have been encroached by formal and informal urban land uses (Kimani *et al.*, 2009). This raises fundamental questions as to why such encroachments are taking place yet there is a policy and institutional framework in place to protect them. Policy and institutional factors are examined in chapter six.

This questions the influence of existing policy and institutional factors which are meant to ensure proper planning of land use and enforcement of development control along rivers. Table 1.2 presents the number of informal structures and corresponding population estimated from scenes of a 2003 Quickbird Satellite image with a resolution of 0.6 metres (Kimani *et al.*, 2009).

Table 1.2: Number of Informal Structures and Population within Riparian Zones in Nairobi

Sample Areas	30m Buffer		50m Buffer		100m Buffer	
	No. of Structures	Population	No. of Structures	Population	No. of Structures	Population
Kibera	1,245	37,350	2,278	68,340	4,681	140,430
Sinai	859	25,770	1,553	46,590	3,430	102,900
Mukuru Kwa Njenga	207	6,210	632	18,960	2,255	67,650
Mathare	1098	32,940	1,983	59,490	3,820	114,600
Museum/Race Course	41	1,230	140	4,200	569	17,070
Kyambio	43	1,290	209	6,270	1,018	30,540
Gikomba	528	15,840	784	23,520	1,258	37,740
Museum to Race Course Road	26	780	35	1,050	105	3,150
Mlango Kubwa	109	3,270	213	6,390	423	12,690
TOTAL	4,156	124,680	7,827	234,810	17,559	526,770

Source: Kimani et al. (2009). Rehabilitation and Restoration of Nairobi Rivers' Basin: Riparian Reserve Population Census and Structures Survey, DRSRS

Encroachment and degradation of riparian zones by urban land uses adversely affects social, economic and ecological aspects of terrestrial and aquatic ecosystems (Lehigh Valley Planning Commission, 2011). Pollution of rivers adversely affects downstream communities who depend mainly on untreated river water for their domestic needs.

The cost of restoration of riparian zones and cleaning the rivers in Nairobi River Basin is an unwarranted expense that possibly would have been avoided (NRBP, 2009). NRBP estimated that Kenya Shillings 16 billion was required to restore and rehabilitate the polluted river ecosystem. At the 2009 exchange rate, one US dollar was equivalent to 85 Kenya shillings.

1.1.4.2 Stakeholders of Nairobi River Basin

Guthiga and Makathimo (2010) have indicated that there is a wide range of actors with stakes in the use and management of ecosystems of Nairobi Rivers. These include the Ministry of Environment and Mineral Resources whose role is delegated and mandated to the National Environment Management Authority (NEMA), the Department of Nairobi River Basin Restoration and Rehabilitation and the Department of Resource Surveys and Remote Sensing (DRSRS). Other stakeholders include Water Resources Management Authority (WRMA) and City Council of Nairobi. Additional stakeholders include Departments of Lands, Surveys and Physical Planning in the Ministry of Lands.

There are also some non-state actors including land users and professionals who are also meant to play a part in the determination, use and management of riparian zones. Land users in the context of this study include public and private land owners, developers, and users who have occupied the 30 metre space on each side of the river from the river bank either legally or through illegal invasion.

Guthiga and Makathimo (2010) argue that all these stakeholders have different and often conflicting objectives on the management of Nairobi River Basin. However, the conflicts extend beyond management to the determination and use as established in equally different and conflicting policy and legal instruments.

Riparian zones have four distinctive qualities that make stakeholder responses to their conservation weak. First, because of their nature as interfaces between terrestrial and aquatic systems, the zones create management challenges due to multiple roles, perceptions, behaviour and interests of stakeholders (Home, 2004). Second, stakeholders in Nairobi River Basin have ignored the functions of the zones (Kahara, 2002).

Third, the zones are seen as sources of free land for building of structures and dumping of wastes (Mburu, 2007). Finally, the mainstream urban land use planning discourse has failed to ensure proper planning (Mwangi, 1994) and development control (Ayonga, 2008) through proper determination, use and management of riparian zones. Henceforth, determination, use and management of riparian zones without impairing their physical existence and ecological quality form the central premise of this study.

1.2 Statement of the Research Problem

Riparian zones are vegetated strips of land located on each side of a perennial or seasonal watercourse or adjacent to a stationary water body. The zone forms a distinct interface between terrestrial and aquatic ecosystems. Ideally, the attributes of a functional riparian zone should include uninterrupted continuum of vegetation cover along a profile of a watercourse, appropriate vegetation structure and composition, and appropriate lateral spatial dimensions (width) where ecological, social and economic functions should take place.

In reality, despite their importance as urban landscape elements, riparian zones are facing pollution, encroachment and degradation from urban land uses in Nairobi River Basin. This is arising out of improper determination, use and management. The implications of

this stated problem include failure to filter polluted surface run-off, riverbank erosion, increased incidences of flooding and soil erosion, and death of aquatic and terrestrial ecosystems that depend on riparian vegetation for survival. The cost of this problem to Kenya as a nation is monumental.

Practically, the physical width and ecological condition of the zone is dependent on the longitudinal continuity of riparian vegetation, composition and structure of riparian vegetation, the lateral spatial dimensions of the river channel and the riparian space. It is also dependent on the implications of land use types such as residential, commercial and industrial.

The zone is also a factor of land administration variables such as land tenure and cadastral data. The prevailing biophysical variables including slopes, soils and the purpose/function to which the zone is utilized are also important aspects that play a critical role in the determination of functional riparian zones. Hence, failure to consider these elements accounts for their encroachment and degradation.

From a theoretical perspective, theories that underlie conservation of riparian zones have been examined in two distinct theoretical frameworks yet the zone is not mutually exclusive from its underlying factors. Based on this theoretical gap, land use factors are explained in terms of social and economic discourses that are advanced without regard for environmental issues.

Conservation theories have mainly advanced preservation of the zones where blame is apportioned to the development discourse. In reality, there exists a comparative advantage of development over conservation discourses in the basin. Urban land use models, on the other hand, as advanced by neo-classical land rent theories, behavioural and institutional theories as well as public and private enterprise theories, though important in explaining specific dimensions of the problem, fall short of the philosophy of explaining riparian zones as vital sites for better urban land use environments and river ecosystems.

In addition, rational planning theories and urban design principles, though expected to be more integrative, have also not holistically resolved the problem. The research problem has been blamed on lack of development space, poverty and high land values without any theoretical understanding of the relationship. The problem is also attributed to innovations in technology that today make it easier to change the riparian landscape.

These theoretical perspectives give opposing views on the causes of the problem but fail to holistically bridge the research gap. However, the systems theory of planning appears more integrative and is adapted as the proponent theory of the study.

Empirically, limited priority and academic attention has been given to riparian zones in Nairobi River Basin for a long time. In reality, the main concern in permitting the use of the zones or the land adjoining them is the highest and best economic gain from the land at the expense of conservation. Consequently, the biophysical form of riparian zones in the basin has transformed into disorganized and incongruent human settlements, and designated solid and wastewater disposal sites among others.

The problem is clearly manifested in the Kenyan policy documents which have multiple definitions of riparian zone and are a source of confusion to stakeholders. The policies are inadequate in ensuring proper determination, use and management of the zones because they merely give generic riparian zone measures.

The standards are too general and are not based on any scientific assessment of site characteristics such as soils, slopes and width of water courses among others. Moreover, the generic measures do not take into account implications of the adjoining land uses and functions that could account for variable widths and conditions of the zones.

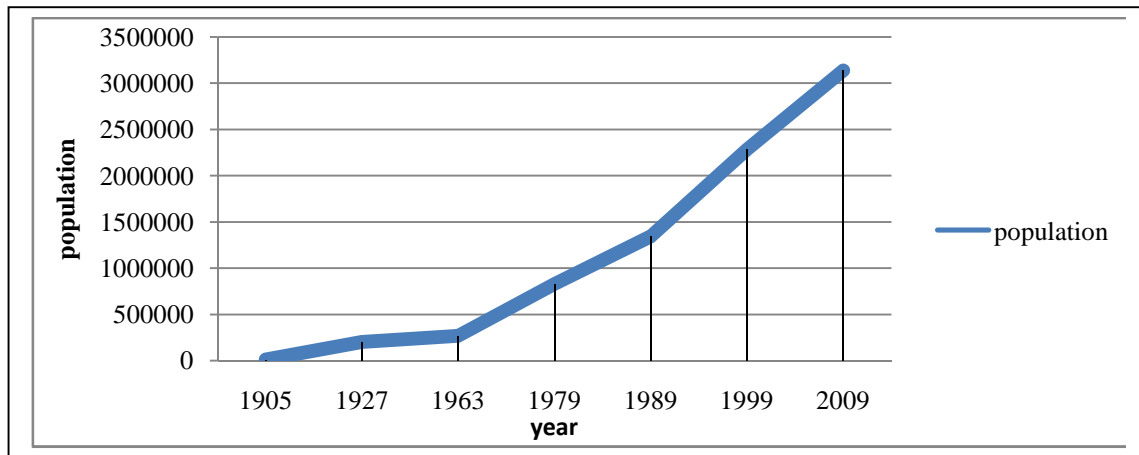
In addition, policies are not fully enforced, monitored and evaluated. Besides, professional practices in Kenya as evinced in subdivision plans, building plans, and survey and deed plans show use of the centre line of rivers as the most predominant property boundaries. This ignores the potential threats posed to the zones by the adjoining properties.

Pointedly, Nairobi has one of the highest urban population growth rates in Kenya due to its population births and in-migrations from rural areas. As the population continues to increase, the natural environment is progressively encroached and degraded because of a weak policy and institutional environment, limited roles and varied understanding and behaviour of experts and land users.

In addition, with a mainly rising poverty and unemployment rate (Kenya, 2010b), encroachment and degradation of riparian zones has been on the rise too. It is, therefore, important to properly determine the use and efficiently manage riparian zones before they

are completely transformed. Figure 1.2 presents the trends in population growth in the city of Nairobi.

Figure 1.2: Trend in Population Growth in the City of Nairobi



Source: Compiled from Kenya National Bureau of Statistics (2010b:20), Mitullah (2002:2)

Five inter-related reasons appear to explain challenges faced in the determination, use and management of riparian zones in Nairobi River Basin. First, residents of the city of Nairobi have a culture of competitive land uses based on highest and most profitable use of land. The competition largely ignores consequences of land use on the natural environment. Therefore, since the riparian zone is used as an alternative land for development, researchers cannot afford to ignore the problem and the many facets associated with the underlying issues.

Second, there is an assumption by stakeholders of a harmonious co-existence of urban land uses and riparian zones in as far as there are development control instruments in the urban planning framework of the city. In this connection, there are limited activities focusing on formulation and implementation of policies and laws which would ensure effective determination, use and management of riparian zones.

In the absence of effective controls, private interests would tend to override public good. This is the case in Nairobi River Basin. There is, therefore, need to examine whether policies and institutional factors influence the physical existence and ecological quality of riparian zones. This will effectively have theoretical, practical and policy significance in the way the zones are defined, determined, used and managed.

Third, urban land use and biophysical factors have been shown to have dramatic adverse effects on riparian zones. However, there has been limited analysis of their effects on the

zones in Nairobi River Basin. Research studies conducted in Nairobi River basin have mainly addressed how anthropogenic pollution affects water quality, but have not considered riparian zones as potential intervening variables which promote better water quality objectives. In fact, the zones are not thought out as vital elements that promote ecological and socio-economic integration of river ecosystems and urban human environments. It is important to examine riparian zones in relation to their underlying factors.

Fourth, land use planning and development controls are not implemented through involvement and coordination of all stakeholders in the basin. The role of non-state actors, their perceptions and behaviour towards conservation of riparian zones although important, has been ignored. Finally, there is lack of a coherent framework for determination, use and management of riparian zones that would integrate the role of stakeholders in the basin. As a result, it leaves land users to maximize their land utility with serious negative outcomes on the physical and ecological character of riparian zones.

This study has taken a dialectic approach to synthesis the problem of encroachment and degradation of riparian zones as guided by the systems theory of planning. In search for a comprehensive solution to a worsening state of riparian zones, this theoretical scheme forms the basis of holistically assessing internal and external structures of the key elements that characterize the problem.

1.3 Research Questions

The overall question of the study concerned whether existing policy and institutional factors, land use and biophysical factors, as well as professional and land users' factors, influence conservation of riparian zones in Nairobi River Basin. The four specific questions that emerged for the study were:

1. Are Kenyan laws and policies on riparian zones informed by scientific research and best practices?
2. Do existing policy and institutional factors in the city of Nairobi influence the determination, use and management of riparian zones in the study area?
3. Do specific land use and biophysical factors have implications on the determination, use and management of riparian zones in the study area?

4. What are the roles, perceptions and behaviour of professionals and land users towards the determination, use and management of riparian zones in the study area?

1.4 Objectives of the Study

The study aimed to achieve one overall objective and four specific objectives.

1.4.1 Overall Objective of the Study

The overall objective was to assess factors that influence the determination, use and management of riparian zones in Nairobi River Basin. The main focus was to examine the influence of existing policy and institutional factors, implications of land use and biophysical, and evaluate the role, perception and behaviour of professional and land users towards conservation of riparian zones. This was with a view of developing an integrated model for proper determination, use and management of riparian zones.

1.4.2 Specific Objectives of the Study

The study was guided by the following four specific objectives.

1. To examine the influence of existing policy and institutional factors in Nairobi on the determination, use and management of riparian zones in the study area;
2. To establish the implications of specific land use and biophysical factors on the determination, use and management of riparian zones in the study area;
3. To evaluate the roles, perceptions and behaviour of professionals and land users in relation to the determination, use and management of riparian zones in the study area; and
4. To develop an integrated model for determination, use and management of riparian zones

1.5 Assumptions of the Study

The assumptions of the study were based on the goal of ensuring proper determination, use and management of riparian zones in the study area. The following specific assumptions therefore guided the study.

1. Existing policy and institutional variables have not influenced the determination , use and management of riparian zones;
2. Some land use and biophysical variables negatively affect the functional properties of riparian zones;

3. Professionals and land users have not positively influenced the determination, use and management of riparian zones; and
4. Isolated approaches to determination, use and management of riparian zones negatively affect their functional properties.

1.6 Justification of the Study

The study was designed to answer questions regarding improper determination, use and management of riparian zones in Nairobi River Basin. The urgency of resolving the challenges of encroachment and degradation of riparian zones in the basin, therefore, transcends from mere observation of water quality issues. It is important to conserve nature: plants, animals and rivers. It should not be forgotten that human beings are part of nature. Therefore, residents, scholars and policy makers of the city of Nairobi and other urban areas experiencing similar challenges should be enlightened through this study so as not to take advantage of the very nature they depend on.

Issues related to riparian zones are complex and are intertwined in various land, land use, water and policy issues, as well as in group interests (Home, 2004). It is, therefore, important that the concept of riparian zone in relation to its main underlying factors be further developed through research so as to re-define and improve its spatial, legal and institutional meanings.

Riparian zones as river ecosystem elements have received limited academic attention from a planning perspective in Nairobi River Basin. A few planning research studies on the subject area have been conducted in the basin such as the ones by Karisa (2002), Mburu (2007) and Menya (2008). However, they do not deeply deal with the issues of determination, use and management of the zone and have methodological limitations.

The studies have mainly focused on the challenges facing the zones from the perspective of pollution. These studies also lack holistic assessment of the problem as manifested from various issues. A study of the evolution of riparian zones requires analysis of various issues using multiple types of land uses, multiple policies and regulations that exist as well as a good number of stakeholders involved.

On the other hand, studies and principles cited from other countries though important as sources of concepts and principles need to be tested locally. Such global studies and principles require re-examination because the local context has different historical

circumstances, physical and ecological site-characteristics, socio-cultural and socio-economic environments among others.

Additionally, land use planning and land administration processes in Nairobi River Basin have on one hand, promoted urban development at the bank of watercourses. On the other hand, environmental management imperatives have focused more on improving water quality and less on the potential role of riparian zones in ensuring the integrity of river ecosystem. Encroachment and degradation of riparian zones in the basin, therefore, provides a good case to examine the research problem.

Finally, this study is expected to contribute to the methodology of determining, using and managing riparian zones in the basin. In addition, it will increase the understanding of existing practices, policy and gap in the theory of planning as well as functional uses of riparian zones in the city of Nairobi.

1.7 Scope of the Study

The study was conducted along Nairobi Rivers as defined by the 1963 administrative boundaries of the city of Nairobi. The study was limited to riparian zones of three major rivers namely Nairobi, Ngong and Mathare and two smaller rivers namely Kirichwa Kubwa River and the canalized Kibagare Stream. The scope was further limited to areas confined in the 30 metre belt on each side of the river, measured at right angles from the riverbank at selected study sites where data was collected.

The focus of the study was organized around the characteristics of physical structures, activities and solid and waste water disposal systems which are related to the physical extent and ecological character of riparian zones. The study was, therefore, designed to address issues of definition, determination, use and management of riparian zones. Three different sample areas involving institutions, study sites and professionals were selected based on the need to respond fully to the research questions.

1.8 Definition of Terms

- 1) **Best Practice:** This is a technique or methodology that through experience and research has proven to reliably lead to a desired result (Comerford et al., 1992).
- 2) **Development:** This is the making of any material change in the use or density of any buildings or land or the subdivision of any land (Kenya, 1996).

- 3) **Encroachment:** Any entry into an area not previously occupied through trespass, violation, usurpation, intrusion, and invasion or entering (Oxford Advanced Dictionary, 2010). To encroach is to advance beyond proper or formal limits (Ibid, 2010).
- 4) **Environment:** It includes physical and biological factors of the surrounding of human beings such as land, water, atmosphere and climate among others (Kenya, 1999a). It is the totality of nature and natural resources including cultural heritage and infrastructure essential for socio-economic activities (Enger & Smith, 2000)
- 5) **Environmental Planning:** This is the process of facilitating decision making to carry out development with due consideration given to the natural environmental, social, political, and economic and governance factors (Catanese & Snyder, 1988).
- 6) **Formal Developments:** These are physical developments, which are considered legal and conform to official plans and standards (Kenya, 1996).
- 7) **Geo-reference:** Means the reference of an object using a specific location on, above or below the earth's surface (Kenya, 2012a; & 2012c).
- 8) **High water mark:** This means the historically recorded point of the highest level of contact between the water and the shore or bank of a water body (Kenya, 1961).
- 9) **Informal Developments/Settlements:** These are developments, which are spontaneous or unplanned, and do not conform to official plans and standards (UNHABITAT, 2009).
- 10) **Land use:** This is the sustainable accommodation in space of man's activities and natural resources on land and the way in which land surface is adapted or could be adapted to meet the needs of present and future generations (Njogu & Dietz, 2006).
- 11) **Land use transformation:** The alteration, modification or extension of existing land use or development (Ayonga, 2008). It could be altered either vertically or horizontally.
- 12) **Local Authority:** In this study, the term specifically refers to the City Council of Nairobi and its departments (Kenya, 1998a).
- 13) **Local Physical Development Plan:** it is a plan prepared with reference to any government land, trust land or private land within the area of authority of a city, municipal, town or urban council or with reference to any trading or marketing centre (Kenya, 1996).
- 14) **Natural Resources:** These include land, air, water, animals and plants and their aesthetic qualities (Kenya, 2010a).

- 15) **Policy:** These are principles, rules and guidelines formulated or adopted by an organization to reach its long-term goals and typically published in a booklet or other form that is widely accessible (Mwangi, 1994).
- 16) **Procedures:** These are formal and specific methods employed to express policies in action in day-to-day operations of an organization (Mwangi, 2008).
- 17) **Preservation:** This is as a management tool defined as regulatory or management measures taken to ensure selection of natural resources or infrastructure such as unique biological formations, fragile ecosystems and endangered or threatened species (Enger & Smith, 2000).
- 18) **Professionals:** These are persons specialized in various fields and include planners (Kenya, 2008). and other professionals with responsibility of determination, use and management of riparian zones
- 19) **Riparian Zone:** Ordinarily it is a vegetated strip of land adjoining a water body (Frietag *et al.*, 2008). A working definition of 30 metre from the river bank at right angle to one side of the river channel was used to conduct the research. Riparian condition was implied by presence or absence of a vegetation cover as an indicator of good conservation.
- 20) **Riparian Zone Conservation:** This is the determination, use and management of riparian zones without impairing their physical existence and ecological quality for the interest of present and future generation (adapted from Njogu & Dietz, 2006).
- 21) **River:** A body of natural surface stream of water of considerable volume permanently or seasonally flowing in a defined channel (Kenya, 2002a).
- 22) **River bank:** The rising ground from the highest normal water mark, bordering or adjacent to a river in the form of rock, mud, gravel or sand and in cases of flood plains includes the point where the water surface touches the land, that land not being the bed of the river (Hawe and Smith, 2005).
- 23) **Stakeholder:** A person, group of persons or institution(s), bodies with demonstrable interest on an issue and whose situation/condition may be impacted upon negatively or positively by a planning intervention/action (Kenya, 2008).
- 24) **Standard:** The International Standards Organization defines the term standard as a document established by consensus and approved by a recognized body that provides for common and repeated use, rules, guidelines or characteristics for activities or their results, aim at the achievement of the optimum degree of order in a given context.

- 25) **Sustainable Development:** is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UN, 1992)
- 26) **Wetlands:** These are defined by Ramsar Convention (UN, 2006) as areas permanently or seasonally flooded by water where plants and animals have become adapted. Wetlands include swamps, areas of marsh, peat land, mountain bogs, banks of rivers, vegetation, areas of impeded drainage or brackish, salt or alkaline; including areas of marine water the depth of which at low tide does not exceed 6 meters. It also incorporates riparian and coastal zones adjacent to the wetlands.

1.9 Organization of Thesis

There are ten chapters in this thesis report. Chapter 1 covers the introduction of the study. The chapter contains background information, statement of the research problem and research questions. The chapter also outlines objectives, assumptions, and justification, and scope of the study. Chapter 2 is on literature review and deals with the concept of a riparian zone and its underlying factors. Studies on the subject have been critically reviewed drawing largely from USA, United Kingdom, Malaysia, New Zealand, Australia and Benin in Western Africa.

Chapter 3 covers further review of the literature focusing on the theoretical background of conservation of riparian zones. The chapter contains an important exposition of the theoretical grounding of the study. The study is located in theories drawn from various epistemologies including theories of conservation, land use, rational planning theories and urban design principles. These theories explain although partially, some aspects of the research problem. The systems theory of planning is as a result, advanced as the proponent theory. Finally, the chapter ends with an exposition of empirical and theoretical gaps identified from the literature leading to the conceptual framework of the study.

Chapter 4 makes a case for research methodology and has discussed theoretical perspectives of the research design and the study methods employed. The chapter has further described data needs, sampling methodology, methods of data collection, analysis and presentation based on each objective of the study. Chapter 5 has presented the growth dynamics of the city of Nairobi that forms the background to the study.

Result of data analysis of policy and institutional factors through which the determination, use and management of riparian zones has occurred in Nairobi is in chapter 6. Chapter 7

has presented the results of data analysis on implications of specific land use and biophysical factors on the determination, use and management of riparian zones.

Chapter 8 presents an analysis of the roles, perceptions and behaviour of professionals and land users in relation to the determination, use and management of riparian zones. Chapter 9 presents the development and operationalization of the integrated model of determination, use and management of riparian zones. In this chapter, results from the analysis of data in chapters 6, 7 and 8 are used to answer specific questions that aim at achieving the objectives of the study. Chapter 10 focuses on the summary of findings, conclusion and recommendations.

CHAPTER 2: RIPARIAN ZONE CONSERVATION AND ITS UNDERLYING FACTORS

2.0 Introduction

This chapter reviews the literature on the concept of riparian zone conservation and its underlying factors in selected countries including Kenya. The chapter begins with an exposition of the concept of riparian zone conservation before describing the importance of the zones. The definition of land use and land tenure then follows. The chapter thereafter examines the impacts of land use on riparian zones, best practices in conservation of riparian zones and the policy and institutional framework within which conservation of riparian zones and its underlying factors have evolved in Kenya.

2.1 Concept of Riparian Zone Conservation

The concept of a riparian zone as given in other countries is an important gauge for evaluating the Kenyan definitions. The concept of conservation is also crucial in understanding the determination, use and management of functional riparian zones.

2.1.1 What is Riparian Zone Conservation?

Njogu and Dietz (2006) have defined conservation as “*management of human use of the biosphere so that it may yield the greatest sustainable benefit to the present generation, while maintaining its potential to meet needs and aspirations of future generations*”. Njogu and Dietz further argue that conservation is positive, embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the natural environment.

Conservation is, therefore, an act of using and protecting resources properly or as a preservation or restoration from loss, damage or neglect. Conservation is also protection of resources for future use through stopping reckless exploitation, preventing the wasteful use of non-renewable resources and providing more efficient exploitation methods (Enger & Smith, 2000).

From these perspectives of conservation, river ecosystem requires a continuum of uninterrupted riparian vegetation that essentially assists in performing various functions (Vannote *et al.*, 1980). However, urban developments in Nairobi River Basin have interrupted the riparian vegetation continuum by occupying spaces meant for riparian zones (Kimani *et al.*, 2009).

Conservation, therefore, implies moral and rational use of resources (Enger *et al.*, 2000). Morally, the argument is that human beings have no right to cause depletion/extinction of species and environments (Ibid, 2000). Rationally, conservation advocates extension of resources for the use of future generations as explained in the concept of sustainable development (UN, 1992).

Conservation permits wise use where the environment is not significantly affected and total preservation for ecologically fragile areas like riparian zones (UN, 2006). The definition of conservation of a riparian zone adopted in this study is the determination, use and management of riparian zones without impairing their physical existence and ecological quality at present and in the future.

2.1.2 Why Conserve Riparian Zones?

Riparian zones provide natural and effective means of protecting watercourses. The riparian strips of grass, shrubs and/or trees along banks of rivers and streams provide a range of environmental benefits (Lehigh Valley Planning Commission (LVPC), 2011). Connecticut River Joint Commissions (2000) in the USA suggests that protection of riparian zones would be the most important action to ensure long-term quality of rivers and watershed resources.

Protected “healthy” riparian zones appear as ribbons of green vegetation along rivers (Smith, 2010). River waters of conserved zones have, therefore, low sediment load. Damaged riparian zones on the other hand are inundated by periodic flooding and have muddy waters in the rivers (Ibid, 2010). In populated watersheds, the main function of riparian zones is to reduce direct encroachment of humans on the river ecosystem (Murphy, 2000; and Saint-Laurent Vision, 2000). A vegetated riparian zone decreases riverbank erosion, dumping of refuse and degradation by preventing human intrusion. Another function of the zone is to protect sensitive species from unnecessary disturbance and distraction from human activities (Murphy, 2000).

According to LVPC (2011), riparian zones serve as filters for polluted runoff, stabilizes riverbanks, reduce soil erosion, store flood waters and provide a transition zone between water and land use. In addition, the zones are complex ecosystems that provide habitat for wildlife and improve health of watercourses (Ibid, 2011). Freitag and McGinley (2008) have noted that although the actual area covered by riparian zone is relatively small, the

zones are extremely important components of terrestrial and aquatic ecosystems because they perform a variety of biophysical functions.

Connecticut River Joint Commissions (2000) also observes that the zone acts as a buffer between land and water, enhances property values, reduce property loss from excessive erosion and flooding and protects water quality. The zones also enhance wildlife habitat, contributes to the natural beauty of the land besides dissipating noise from traffic on roads and nearby properties. Finally, the zones provide privacy, screens unsightly views and enhance scenic views and beauty (Ibid, 2000).

In conclusion, LVPC (2011) has indicated that riparian zones work best when they contain a diverse mixture of native plants. Therefore, “*the effectiveness of pollutant removal will vary by plant type, as well as pollutant type*” (Ibid, 2011). According to LVPC, the more diverse the vegetation, the more the zone will catch polluted runoff before it enters watercourses. In particular, grasses are more effective in terms of sediment and chemical removal compared to trees (Ibid, 2011).

The main purpose of determining and managing riparian zones is to achieve specific goals and objectives. Smith and Prichard (1992) maintains that the four general management strategies are (i) maintenance of existing riparian conditions; (ii) improvement of degraded riparian conditions; (iii) recovery of lost riparian areas; and (iv) development of new riparian areas. These management strategies have, however, not been generally observed in Nairobi River Basin where encroachment and degradation are rampant (NRBP, 1999; and Kimani *et al.*, 2009).

2.1.3 Implications of Biophysical Factors on Riparian Zones

The roles of riparian vegetation and width and other biophysical variables inherent in a riparian zone are discussed.

2.1.3.1 Role of Riparian Vegetation

The presence of vegetation along a river is an important feature in the functioning of riparian zones (Vannote *et al.*, 1980). Specifically, riparian vegetation is the single most important component of upstream headwaters (Vannote *et al.*, 1980; and Collier *et al.*, 1995). Rivers with established riparian zones have sediment pollution control in the form of vegetation and intricate root system which help to stabilize the bank and prevent soil erosion (Ibid, 1980). In contrast, clearing of vegetation exposes the zone to soil erosion

(Murphy, 2000). In addition, zones with vegetation are homes or ecosystems that provide food and habitat for plant and animal species (Ibid, 1980).

Riparian vegetation acts as filters, transformers and sinks for harmful nutrients and pollutant including nitrogen and phosphorous from fertilizers and pesticides (Hawe & Smith, 2005). Riparian plants also slow sediment-laden runoff. Depending on riparian width and extent of vegetation cover, the zones may partake 50 to 100 percent of sediments, nutrients and pollutants in stream water (Broadmeadow & Nisbet, 2004).

When surface water runoff is filtered by the riparian buffer approximately 80 to 85 percent of phosphorus is captured and Nitrogen and other pollutants are transformed by chemical and biological soil activity into less harmful substances (Broadmeadow and Nisbet, 2004). A grass riparian zone has a high efficiency in sediment trapping and filtration of sediments, nutrients, microbes and pesticides and flood conveyance while trees and shrubs have high efficiency in reducing river bank erosions (Hawe & Smith, 2005).

Vannote *et al.* (1980) have further argued that forested buffers improve habitat quality. They provide shade that cools water temperatures. Cooler temperatures enhance the capacity of stream water to dissolve oxygen that is used in turn to support life for fish and aquatic animals. Woody debris from shrubs and trees in vegetated zones provides food and cover for more wildlife species (Ibid, 1980). Larger vegetated zones are directly used as screens along waterways, protecting privacy of riverfront landowners and blocking views of unsightly development (LVPC, 2011). Forested buffers facilitate hiking and camping opportunities and allow outdoor enthusiasts to enjoy undertaking environmental friendly activities on riparian zones (Ibid, 2011).

For this reason, removal of riverside vegetation primarily for development purposes results “*in degraded water resources and diminished value for human consumption, recreation, and industrial use*” (Murphy, 2000). Overall, riparian zones, therefore, helps to control water pollution as vegetation in these riparian zones function as filters for water flowing downstream and storm water runoff before it reaches streams and rivers (Hawe & Smith, 2005). Table 2.1 presents the relationship of vegetation type in relation to the effectiveness of riparian zone.

Table 2.1: Relationship of Vegetation Type to Effectiveness of Riparian Zones

	Benefit of Riparian Zone	Vegetation Type		
		Grass	Shrubs	Tree
1	Stabilize bank erosion	Low	High	High
2	Filter sediments	High	Low	Low
3	Filter nutrients, pesticides, microbes	N/A	N/A	N/A
4	Sediment bound particle removal	High	Low	Low
5	Aquatic habitat	Low	Medium	High
6	Wildlife habitat	N/A	N/A	N/A
7	Range/pasture/prairie wildlife	High	Medium	Low
8	Flood protection	Low	Medium	High
9	Water temperature	Low	Low	High

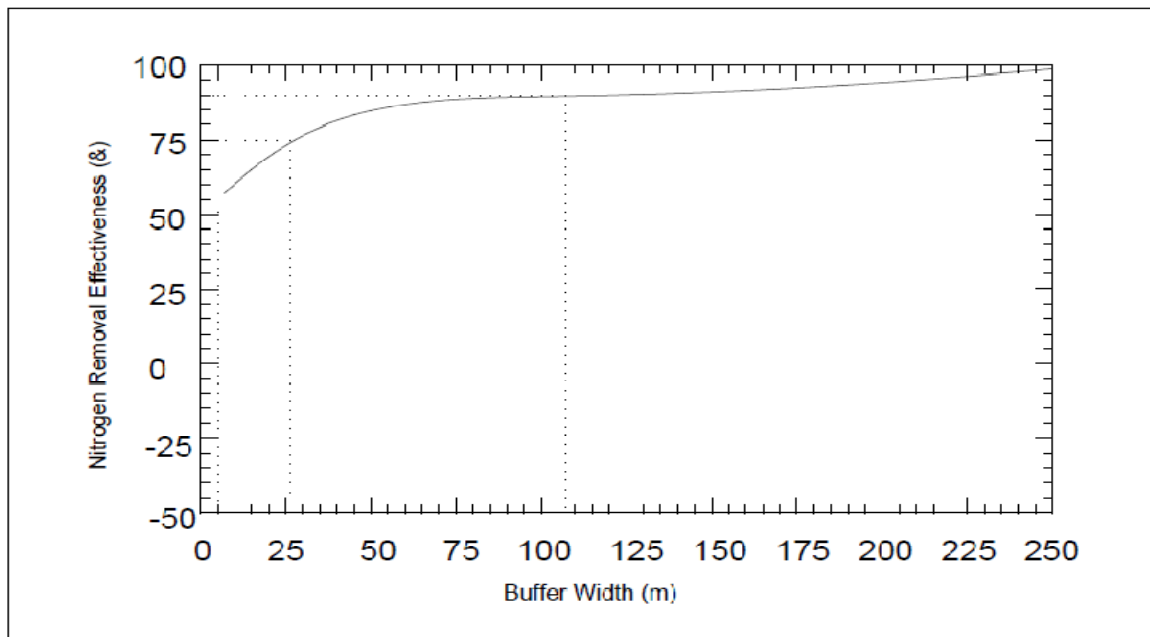
Source: Hawe and Smith. (2005). Riparian Buffer Zones: Functions and Recommended Widths. Natural Resource Conservation Service,

2.1.3.2 Determinants of Riparian Width

Lehigh Valley Planning Commission, LVPC (2011) indicates that the width of the zone depends on its purpose and what can be practically enforced as well as on natural factors such as slope, soil type and rainfall. LVPC concludes that there is not a single generic riparian width that will keep the river clean, stabilize riverbank, protect fish and wildlife and satisfy human demands on land. Therefore, most decisions on determining riparian widths will be a compromise between ideal widths based on environmental goals including wildlife corridors, riverbank stabilization and water quality protection and concerns of landowners and economic constraints (Ibid, 2011).

Many studies have been conducted over the past three decades on the effectiveness of riparian zones and their widths and type of vegetation (LVPC, 2011). The findings indicate that the effectiveness of a riparian zone is largely dependent on width and type of vegetation in the zone (Ibid, 2011). There are also site-specific variables that must be taken into account such as the need for wider riparian zones where slopes are adjacent to watercourse and the need to reduce velocity of surface run-off (Ibid, 2011). Soil factors such as depth of the water table, permeability, texture, chemistry and organic matter content may also affect infiltration of runoff and filtration of nitrogen and other contaminants (Mayer, Reynolds, Canfield & McCutchen, 2005). Figure 2.1 shows the relationship between the width of riparian buffer width and its effectiveness in removing Nitrogen from runoff (Ibid, 2005).

Figure 2.1: Riparian Buffer Width Verses Nitrogen Removal Effectiveness



Source: Redrawn from Mayer et al. (2005). Riparian Buffer Width, Vegetation Cover and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations

Figure 2.1, indicates that a 25 metre riparian width is capable of removing nitrogen up to the level of 75 percent. A width of 25 to 100 metres can remove about 90 percent of Nitrogen from the surface runoff. After 100 metres, the riparian width has no ecological effects in the removal of Nitrogen from the surface run-off. The implications of these results are twofold. First, riparian widths of up to 25 metres are adequate for removal of Nitrogen. Second, the riparian zone is not indeterminate and effort should be made to establish optimal maximum widths for different functions.

2.1.4 Methods of Delineation of Riparian Zones

There are mainly two ways of regulating the width of riparian zones. These are the fixed and variable width methods.

2.1.4.1 Fixed Width Methods

Various studies have defined fixed width riparian zones as a standard distance on each side of the river measured at right angle from the riverbank. Palik, Tang and Chavez (2004) have explained the uncertainty from cumulative lack of data on extent, type and use of riparian resources. This makes it difficult to determine the level of riparian protection required, the extent of change of riparian land use/land cover over time and social and economic benefits that can accrue from different types of riparian land use (Ibid, 2004).

Palik *et al.* (2004) argues that fixed width methods are more common in delineating riparian zones. However, the approach is questionable because delineated borders have no functional relationships to the actual riparian areas. The areas vary naturally in width among and within systems (Ibid, 2004). Murphy (2000), on the other hand, has used the concept of standard setting. This is defined as an area extending from the riverbank to some landward fixed point boundary.

In Kenya, a riparian width of 30 metres is set as the maximum in most legislation. Policy makers have considered this as the legal widths (Kimani *et al.*, 2009) when assessing encroachment.

In advancing a fixed width method, Murphy (2000) observes that scientific research has not disputed the adequacy of utilizing 30 metre buffer zones to protect riparian corridors and to ensure that there is no significant alteration of riparian functions. However, scientific information points towards maintaining riparian zones that would be at a minimum of 30 metres in width.

However, this is disputable where rivers are too small. This argument is supported by the State of Victoria Department of Natural Resources and Environment (2002) who observed that administrative definitions of riparian land in Victoria were defined as a fixed width generally between 20 and 60 m alongside the river.

Murphy (2000) has indicated that in Connecticut Inland Fisheries Division: *Policy on Riparian Corridor Protection*, a 30 metre buffer zone is utilized as a minimum setback along perennial streams, but suggests that adoption of such a policy could be controversial. According to Murphy, whether 30 metre is sufficient to protect or is overly protective of riparian zones would be the basis of doubts by developers and natural resource professionals.

Standard setting methods are easy to delineate and administer. They save time because the methods do not determine site-specific buffer zones along every watercourse. Given this fact, the exact sources of dispute emanating from recommendations vary from as little as 7.5 metres to as wide as 90 metres (Murphy, 2000).

The 30 metre buffer is used in Connecticut by numerous public agencies as appropriate minimum setback in regulating riparian zones. In Kenya, the Survey Act is the only

legislation that uses 30 metres as the minimum width. Other laws use widths ranging from two to a maximum of 30 metres.

2.1.4.2 Variable Width Methods

Site-specific or ecological methods, define riparian zone widths according to the character and sensitivity of adjacent riverside lands (LVPC, 2011). The widths, therefore, vary depending on natural or built features adjacent to watercourses. However, the method requires measurement of slopes, identification of natural features by surveyors or other qualified persons.

These methods consider physical site characteristics such as slope, soil type and vegetation cover (Murphy, 2000). The advantage of this approach is that the width of the riparian zone is designed based on site-specific characteristics and not on arbitrary predetermined width. Variable width methods, therefore, utilize formulae to calculate riparian zone width.

Ohio Department of Natural Resources (2006) has designated riparian zone width based on stream setback area of the “2006 Rainwater and Land Development Manual” which is defined as $RZ \text{ (in feet)} = 147 * (DA)^{0.38}$ where, RZ is the riparian zone width in feet and DA is the drainage Area of water course in square miles. This formula determines the width as approximately equal to ten times the width of the watercourse channel and considers the minimum width on either side of the watercourse as equal to the width of the channel or eight feet whichever is greater.

Although there is no one universally accepted formula or model, Murphy (2000) observes that most formulae depend on the degree to which sediment can be removed or filtered by natural vegetation. There is, therefore, an emphasis on the role of vegetation in sediment control. Broadmeadow and Nisbet (2004) examined studies that derived an equation to define effective buffer widths based on sediment particle size, slope, surface roughness and run-off flow rates in coastal forests of Maryland in the USA. The studies show a nonlinear relationship, so that on a two-degree slope, the buffer width doubles from 30 to 60 metres to increase sediment removal from 90 to 95 percent.

One limitation of site-specific techniques is the evaluation of all areas on a case-by-case basis. Simpler models account for slope only where it is common to set a fixed buffer width and apply 0.6 metres percent slope (Hawe & Smith, 2005).

Many models exclude impervious surfaces or areas of a steep slope during determinations. Some models recommend exclusion of slopes greater than 15 percent and all slopes over 25 percent because, as slope increases, vegetation becomes less effective in controlling surface run-off (Hawe & Smith, 2005). The implication of use of quantitative models is that any subjectivity in different methods would lead to the creation of inadequate buffer widths.

From the foregoing, variable widths appear more effective in protecting the watercourse. However, fixed widths seem easier to administer and, therefore, explains why most regulations are based on the latter approach. However, neither approach has been consistently applied in Nairobi River Basin where laws and policies prescribe conflicting measures and experts use less than optimal widths that do not promote conservation of riparian zones.

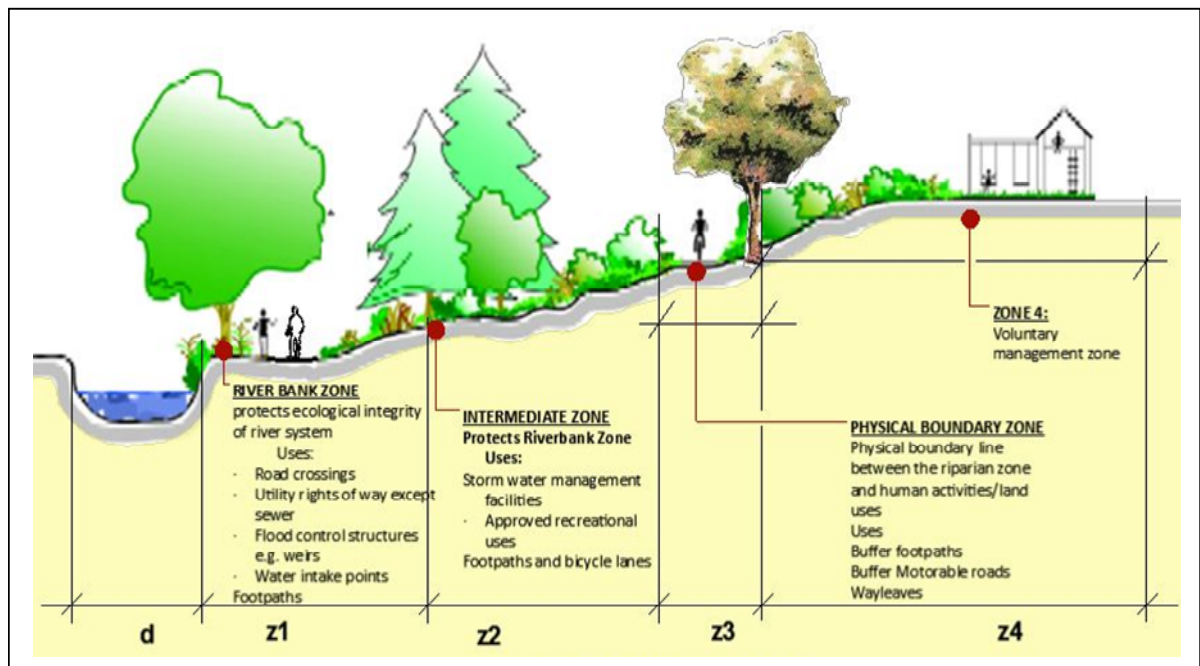
2.1.4.3 Multi-Zone Models

According to Dosskey, Shultz, and Isenhardt (1997), a multi-zone model has different small zones. Each sub-zone has a specific function in filtering run-off and in interaction with adjacent aquatic and terrestrial systems. Maryland Cooperative Extension (1998) has used three sub-zones to depict a riparian zone. Sub-zone one adjoins the river bank whereas sub-zones two and three follow in that order.

Sub-zone one absorbs the least contaminants because sub-zones 2 and 3 eliminate most. The main function of sub-zone one is to shade the water at upper reaches and acts as riverbank stabilizer. In this sub-zone, there are large natured trees that grow fast on this zone (Maryland Cooperative Extension, 1998). Sub-zone 2 provides the necessary habitat for wildlife and acts in slowing and absorbing contaminants missed in sub-zone 3.

Sub-zone 2 is an important transition between grassland and forest usually with native shrubs. Sub-zone 3 is important as the first line of defense against contaminants. The zone consists mainly of native grasses. It serves primarily to slow water run-off and absorbs contaminants before they transit through other zones (Maryland Cooperative Extension, 1998). Figure 2.2 presents a multi-zone riparian zone model.

Figure 2.2: Idealized Multi-zone Riparian Zone Model



Source: Modified from Superior Watershed Partnership, Michigan (2003:6).

The relationship between the riparian width and its capability to perform various functions has not been explored in Nairobi River Basin. Rather, most studies including (NRBP, 1999; and Kahara, 2002) have concentrated on anthropogenic pollution of water quality in rivers without analyzing the importance of riparian zones.

2.1.5 Research Studies on Determination and Management of Riparian Zones

Research studies conducted in the United Kingdom, USA, Malaysia and Benin in Western Africa are discussed to draw specific experiences that can inform the determination, use and management of riparian zones in Nairobi River Basin.

2.1.5.1 Studies in United Kingdom

Broadmeadow and Nisbet (2004) in their study on *“The effects of riparian forest management on freshwater environment: a literature review of best management practice”* argue that natural forests and water guidelines require establishment of riparian buffers to protect freshwater environment from disturbance by silvicultural operations on adjacent land. Silviculture is the art and science of controlling the establishment of growth, composition, health and quality of forests (Ibid, 2004).

The study assesses how functions of riparian zones and improvement of landscape quality is affected by the design and management of riparian forest zone. The functions include sediment removal; erosion control; protection of water quality; and moderation of shade

and water temperature; maintenance of habitat structural diversity; and ecological integrity and diversity (Vannote et al., 1980). The study focuses on width of the zone, the structure of vegetation and choice of vegetation species. It is, therefore not possible to specify a definitive riparian zone width which would protect freshwater environment from every potential threat (Ibid, 2004).

The influence of a riparian zone on river habitat and physical functions will depend on its widths, structure, species composition and management of vegetation (Broadmeadow & Nisbet, 2004). Dimensions and effectiveness of the zone are strongly influenced by extent of the riparian zone as dictated by site topography, soil type and physical structure of vegetation, particle size and velocity of run-off.

According to Broadmeadow and Nisbet (2004), “*zones that are too narrow are likely to provide inadequate protection. On the other hand, if they are too wide, they reduce the area of land use.*” Forestry agencies in United Kingdom, usually recommend widths between 10 and 30 metres (Ibid, 2004). Structure and species of vegetation have the greatest benefits where riparian vegetation replicates native riparian woodland with an open canopy of mixed species.

The authors argue that the roots of trees and herbaceous vegetation stabilize riverbanks and regulate the flow of sediments and nutrients. The canopy of trees and shrubs helps to moderate riparian microclimate and primary productivity of the river (Ibid, 2004).

The vegetation, therefore, produces leaf litter and coarse woody debris which enhances the quality of wildlife habitat (Vannote *et al.*, 1980). In Britain, control of erosion is considered to be one of the main functions of the riparian zone. This is based on the notion that riparian vegetation acts as a barrier to soil disturbance caused by land use activities (Ibid, 2004). Forest and Water Guidelines in Britain recommend average riparian widths on each side of a watercourse.

Swift and Norton (1993) have demonstrated that riparian zones of coarse grass and heather are effective in reducing velocity of run-off flow and decreases deposition of suspended solids released after pre-planting ploughing and drainage operations in Southern Scotland. They estimated that 50 percent attenuation in suspended load was achieved across a zone 60-70 metres wide on mineral soils, when vegetation was growing actively. However, the

study found out that efficiency was likely to be greatly reduced on slopes above four degrees because vegetation was flattened by surface run-off during heavy rainfall.

Table 2.2 presents recommended riparian widths in Britain based on size of a watercourse. The Guidelines further advises doubling width of the riparian zone on every erodible soil (Ibid, 2004).

Table 2.2: Recommended Riparian Widths in Britain Based on Size of Watercourse.

	Width of Watercourse Channel (Metres)	Recommended Riparian Width (Metres)
1	≤1	5
2	1-2	10
3	>2	20

Source: Compiled from Broadmeadow & Nisbet, 2004: The Forests and Water Guidelines

Broadmeadow and Nisbet (2004) concluded that a management plan is necessary to address riparian zones across the entire forest or catchment. The plan should be prepared in consultation with adjacent land owners and water conservation and fisheries authorities (Ibid, 2004). Results of a review of six studies by Broadmeadow and Nisbet are presented in Table 2.3 to summarize the main highlights.

Table 2.3: Summary of Findings of Studies on Effective Riparian Width

No.	Study	Findings
1	Xu et. al.(1992)	Found that soil nitrate concentrations fell in 764mgN Kg ⁻¹ soil to 0.5mg N kg ⁻¹ soil within the first 10m of the riparian area
2	Pinay et al., (1993)	30m buffer removed nitrate in less than detection levels after flowing through a riparian forest by the river Garonne in France
3	Haycock and Pinay (1993)	Demonstrated that 99 percent of the nitrates in waters draining from arable fields across a poplar floodplain in England during the winter was retained within the first 5m of the riparian area
4	Swift and Norton (1993)	Demonstrated that a 50m wide riparian width was effective at reducing total phosphorous concentrations in drainage waters from 10mg PI ⁻¹ to < 1mg PI ⁻¹ as long as flow rates were not high
5	Hubbard and Lowrance (1994)	Observed that a 7m forested buffer was effective at removing nitrate through plant uptake and denitrification
6	Castelle et al. (1994)	Concluded that the minimum riparian width to protect rivers and wetlands should be 15 to 30m in most circumstances

Source: Broadmeadow & Nisbet (2004:288): Review of Literature on Best Practices

Broadmeadow and Nisbet (2004) concluded that it is important to analyze sensitive sites and areas of high ecological value or potential after planning. This is in order to allow the

main functions of the site to be identified. The functions include water quality objectives, maintaining ecological integrity and landscape improvement (Ibid, 2004). Table 2.4, shows that one cannot merely prescribe minimum and maximum widths as is provided in laws and policies in Kenya without linking them with site conditions.

Table 2.4: Studies on Riparian Width Guidelines

N	Country	Reviews
1	Swedish Guidelines	Sets widths of 10-30m depending on site sensitivity
2	Irish Forest and Water Quality Guidelines	<ol style="list-style-type: none"> 1. Recommend minimum widths of 10-20m for moderate and very steeply sloping ground. 2. Recommends 15-25m for highly erodible soils
3	USA Guidelines	Out of 49 States, Forest Guidelines show that: <ol style="list-style-type: none"> 1. Just less than two-thirds of the states specify widths of 7.5-15m 2. 25 percent set widths in the range of 15-30m

Source: Broadmeadow & Nisbet (2004:288): Review of Literature on Best Practices

2.1.5.2 Case of Ellidaa' and Ytri-Rangaa' Rivers in Iceland

A study by Fualing (2009) on “*Riparian ecosystem management: A case study of the Ellidaa' and Ytri-Rangaa' rivers in Iceland*” assessed the prevailing biophysical conditions of riparian zones of Ellidaa' and Ytri-Rangaa' Rivers in Iceland. The study identified management strategies in place, gaps and challenges faced in the management of River Ellidaa.' The study also established possible strategies for restoration of the riparian zone of River Ellidaa.'

The methods used in the study included observation and acquisition of data from different sectors involved in the management of River Ellidaa' and Ytri-Rangaa'. Questionnaires and GIS mapping were also employed. Categories of respondents were selected from different sectors with specific respondents being: three fisheries biologists, one Director of Fresh-Water Fisheries Department, one municipality Mayor, one Urban Planner, one Environmental Health Inspector, one person from Reykjavik energy, one representative of private Fisheries Company, two representatives of Fishing area Land Owners Association, and one GIS specialist.

The study mainly focused on Ellidaa' River in order to illustrate human impact on riparian ecosystem. River Ytri-Rangaa' was chosen as a reference area to contrast with Ellidaa' River. The study found out that River Ellidaa' was much more affected by human activities than Ytri-Rangaa' River. The management measures in place were similar in both rivers. However, Ellidaa' River was faced with management gaps including limited

public awareness, weak enforcement of existing laws on riparian zones, limited funding and lack of prioritization for the Ellidaa' riparian zone management, lack of collaborative management and urbanization.

The study recommended strategies for effective management of Ellidaa' riparian zones focusing on measures to increase public awareness and education, measures to increase stakeholder participation, enforcement of existing legislation on riparian zones, collaborative management, compliance, inspection and monitoring, prioritization of funding for restoration projects, political support and political will.

2.1.5.3 Studies in USA

Determination of riparian widths in the USA has mainly been based on their effectiveness to protect the chemical quality of river water from nutrients, pesticides and other pollutants in surface run-off. The removal of these is achieved through enhanced deposition of particulate matter, plant uptake and soil microbial processes (Hawe & Smith, 2005).

Composition of vegetation cover has a strong influence on the effectiveness of the zone to retain sediments in run-off water (Phillips, 1989). Phillips used a detention-time model to evaluate effectiveness of pollution control of 19 riparian forests in North Carolina in the USA. The model predicted that, with a continuous tree canopy and sparse undergrowth, the zone would have to be 28 percent wider than one with dense undergrowth for it to be effective as a control for sediment losses. However, the riparian width would require an adjustment in vulnerable areas to account for variation in slope and density of vegetation cover. Table 2.5 presents summary of results of various studies and specific widths that are recommended for different functions of riparian zones.

Table 2.5: Width of Riparian Zones Based on Purpose/Function

Study By		Width in Feet of Riparian Zone Based on Purpose/Functions							
		Bank stabilization	Nutrients	Wildlife habitat	Erosion control	Stream temperature	Pesticides	Pollution	Litter and debris
1	Vermont	-	-	150	-	-	-	75	-
2	New Hampshire	10	16 -164	33 -164	30 -98	30	49 -328	30 or greater	10 -328
3	U.S. Army Corps of Engineers	10-40	30 - 140	45 - 255	50 - 160	-	-	-	-
4	United States Forest Service	10 -40	30 - 140	45 - 255	50 - 160	-	-	-	-
5	Wenger 1999	-	50 - 100	220-574	82 - 328	33 - 98	> 49	-	50
6	Army Corps 1991	49 - 98	52 - 164	30 - 656	33 - 148	33 - 68	49 - 328	-	66-102
7	Fisher and Fischenich 200	30 -66	16.4-98	98-1,640	30-200	-	-	-	10 - 33
8	Broad meadow and Nisbet 2004	-	16.4-98	-	49 - 213	49 - 230	49 - 230	-	82 - 328

Source: Compiled from Studies including Broadmeadow & Nisbet, 200; & Hawe & Smith, 2004

2.1.5.4 Studies in Malaysia

Guidelines for rivers and riparian reserves produced by the Department of Irrigation and Drainage in Malaysia are a key consideration in determining riparian widths in the country. The widths are specified to a maximum of 50 metres depending on the width of the river. The guidelines are mainly for riverbank stabilization.

These guidelines have advised that riparian zones require greater widths because they are sites for biodiversity, habitats, and corridors of wildlife migrations and improvement of water quality. Table 2.6 presents guidelines for widths of riparian zones as recommended in Malaysia.

Table 2.6: Guidelines for Riparian Widths in Malaysia

No.	River Width (m)	Width of Riparian Zone (m)
1	>40	50
2	20-40	40
3	10-20	20
4	5-10	10
5	<5	5

Source: Ministry of Natural Resource and Environment Riparian Guidelines (2009)

In Sabah region of Malaysia, establishment of riparian zones is provided under Sabah Water Resources Enactment Legislation of 1998. The law states that:

Riparian zones are to be established on land which is within 20 metre of the top of the bank of every river including its estuary where the channel is not less than three metres

Riparian zones may also be established along channels less than three metres upon recommendation of Sabah Water Resources Council (SWRC). The aim of establishing riparian zones under the law is to protect the volume of flow of water in water bodies and to prevent degradation of the quality of water resources and damage to the aquatic environment.

According to Malaysia Ministry of Natural Resource and Environment (2009), legal and management perspective, allows for fixing of width of the riparian zone along fixed or variable principles. The fixed width zones are easier to gazette, enforce and administer but, they fail to provide for most ecological functions.

Variable width zones, on the other hand, are designed to perform specific functions at different sections of rivers taking into account site specific conditions and requirements. Other laws are used to establish specific riparian zones specifically for purposes of protecting wildlife habitats.

The Malaysian Guidelines resonates well with those of United Kingdom and USA. The guidelines aim at ecologically protecting the watercourses. On the other hand, the maximum width is not indeterminate as is the case of the Survey Act (Kenya, 1961). The guidelines also relate the riparian widths to the actual widths of the watercourses.

Malaysian guidelines differ with the other Kenyan laws including the Physical Planning Act (Kenya, 1996) which prescribe widths without specific concern.

2.1.5.5 Studies in Benin, West Africa

Natta, Sinsin, and Van der Maesen (2003) conducted a study on “*riparian forests and biodiversity in Benin, West Africa.*” The study focused on the importance of forests along waterways and found out that riparian forests are important in the functioning of river ecosystems and protection of bio-diversity. These forests include woodland along riverbanks and streams (Ibid, 2003). The forests protect river waters and habitat for various species.

The research study found out that human activities and poor planning threatened the very existence of ecology in forests of Benin. Many decades of human influence are the main causes of reduced riparian forests in terms of size and complexity of vegetation cover. The function of riparian forests as routes for movement of or migratory routes for wildlife has been compromised.

Natta *et al.* (2003) concluded that it is important to conserve biodiversity through implementation of preservation programmes to secure productive forest ecosystems along rivers. The study emphasized on partnership and involvement of different stakeholders dealing with bio-diversity.

2.1.5.6 Studies in Nairobi River Basin

In Kenya, the practice has often been to remove riparian vegetation and to replace with rural and urban land use (Kenya, 1972; 2004; & Lelo *et al.*, 2005). This orientation reveals that Kenya has not taken full responsibility of riparian biodiversity conservation as provided in the 1972 Government Report to UN Conference in Stockholm.

A study by Karisa (2002) on “*A conservation ethic for sustainable Urban Communities in Kenya: Southern Nairobi Integrated River Basin Management Strategy*” was informed by this inadequacy. The study focused on human settlement perspective to integrated river basin management for the city of Nairobi. Specifically, it investigated effects of space and time on Nairobi River Basin ecosystem from ongoing urban development. However, the main focus of this study is on urban design issues.

The study found out that existing policy, laws and organizations for management of drainage basins have not checked the deterioration of riparian zones. The study established that the government and relevant public agencies remain apathetic on prevailing situation. The study concluded that management strategies work best where they are linked to community development components that relate to the improvement of human livelihood.

The study recommended the adoption of correct land use and institutional capacity building among others. This study is important as an initial basis for profiling the problem from one land use perspective. However, a methodology that involves multiple policies, land uses and stakeholders in an integrated manner would provide a better understanding of the problem of conservation of riparian zones in Nairobi River basin.

Another study by Mburu (2007) on “*A land use framework for solid waste management at the Nairobi Riverfront corridor between Globe Cinema and Racecourse Roundabouts*” in the City of Nairobi found out that different land uses are located very close to riverbanks of Nairobi River. The land uses generate solid waste that is dumped into the river or on open sites next to the river.

Menya in a study conducted in 2008 focused on “*Challenges facing riparian use and management in Mukuru Kwa Reuben in Nairobi*”. The study found out that existing conditions of the riparian zone are connected to socio-economic, institutions and other factors related to lack of effective urban planning and environmental design. The riparian zones are improperly used leading to lack of vegetation cover, encroachment by housing and commercial buildings, disposal of solid and human waste and industrial effluent.

Menya (2008) attributes the problem to a weak enforcement of development control and lack of proper guidelines and standards for environmental control in the zones. The study also established lack of awareness of the importance of riparian zone. It also attributed the problem to the lack of coordination of institutions to ensure proper management of resources on riparian zone.

2.1.6 Riparian Zone Management Models

Public and private ownership, as well as public regulation tools, are important instruments for managing riparian zones.

2.1.6.1 Public Ownership and Management

This perspective vests control of the riparian zone on the state and its agencies (McAuslin, 1980; & Mwangi, 1994). However, the national government in Kenya, in the post independent era particularly in the 1990s demonstrated a high degree of non-committal in certain environmental issues, half heartedly administering conservation of some areas such as urban parks and neglecting others like forests and riparian zones (Kenya, 2004).

Proponents of public ownership and management would argue that maintaining riparian zones as public goods for public interests provides the widest range of environmental protection (Wanyande, 1981). Normatively, the capacity, competency and resources of government agencies should be adequate in order for the agencies to meet their mandate (Karisa, 2002). In any case, their objectives should correspond to statutory duties of the institutions. However, in Kenya, institutional activities have largely not ensured proper determination, use and management of the zones (Kimani *et al.*, 2009).

2.1.6.2 Private Ownership and Management

Private ownership and management is the voluntary cooperation of non-state actors to protect and conserve riparian zones (McAuslin, 1980). These may be applied in covenants running with the land as part of grant deeds enforceable by property owners (Ibid, 1980). In practice, private ownership and management is often prompted by the need to ensure that riparian zones serve private interest (Baumol, 1983).

However, private legal action, under nuisance and trespass theories could enjoin or restrain some practices with adverse effects on riparian zones (McAuslin, 1980). Private initiative can also take the form of riparian protection associations of land owners and interested persons, possibly with contractual commitment to preservation objectives (Kenya, 2002a). Private associations may also provide legal information and assistance for a variety of land use activities.

The Water Resources Users Associations (WRUAs) prescribed in the Water Act (Kenya, 2002a) is a practical example of private participation in water resources management. However, private control is often misinterpreted as private ownership where land owners expropriate part of public land adjacent to ones land for personal use. This phenomenon is common in Kenya where developers cordon off sections of beaches and riparian areas (Kihagi, 2000).

2.1.6.3 Public Regulatory Tools

Public regulation involves formulation and implementation of laws and regulations that ensure control of development that could negatively impact on riparian zones (McAuslin, 1980). Regulation can take many forms but require permits as a pre-condition for activities that might disturb riparian ecosystems. Physical development plans (Kenya, 1996), zoning regulation (Kenya, 1965b), erosion and drainage control and other development control measures (Kenya, 2002a) can offer different levels of riparian protection in terms of river-side setbacks, zones where drainage channels, soil and vegetation are not to be disturbed.

Government subsidies may include tax deductions that are used to finance conservation of the zones. The government may also offer cash payment to landowners aimed at encouraging specific land and water management practices (LVPC, 2011). According to LVPC, the government may offer technical advice and assistance to landowners concerning on-the-ground practices. In Kenya, specific riparian protection guidelines are found in different laws that lack harmony in their provisions and application.

2.2 Implications of Land Use Factors on Riparian Zone

The manner in which the concepts of land and land use are defined determines how the riparian zone is defined, used and managed. When the zone is seen in the context of land for development or ignored as a unique land use in its own right, then it faces challenges of encroachment and degradation as is the case of Nairobi River Basin.

2.2.1 Concept of Land

Land is generally defined from an economic perspective as all natural resources over which people obtain specific rights and which may be used to yield income (Njogu & Dietz, 2006). It includes agricultural lands and building space, forests, rivers and lakes, as well as resources freely supplied by nature that help to produce what is required to meet human needs and aspirations (Ibid, 2006). From a legal perspective, land is regarded as a single resource to many rights among them public, private and customary (Kenya, 2010a).

Land in Kenya like in other parts of the world means different things to different people. However, multiple meanings affect the control and access to land. Kenya Land Alliance (KLA), (2002) indicated that land developers consider land as space that provides goods and services required for their welfare and prosperity. In the view of KLA, conservationists, on the other hand, consider land as a fragile, ecological entity resulting from initial workings of living and non-living things on the surface of the earth.

Perceptions by different people, generally translates into different and often competing interests in land that have impacts on the land policy. Colonial policy of racial segregation and post independent Kenyan policy of income differentiation evinces this argument (Njogu & Dietz, 2006). As a result, the Kenya Land Alliance (2002) argues that no single definition can adequately explain the divergent perceptions.

However, article 260 of Constitution of Kenya (2010a), defines land as “*the surface of the earth and the subsurface rock, any body of water on or under the surface, marine waters in the territorial sea and exclusive economic zone, natural resources completely contained on or under the surface and the air space above the surface.*” This definition attempts to define land from an economic and natural resource perspective.

2.2.2 Land Use Defined

According to Briassoulis (2001) human use of land resources gives rise to land use which varies with the purpose it serves whether they be food production, provision of shelter, recreation, extraction or processing of materials and the biophysical characteristics of the land itself.

Briassoulis (2001) further indicates that land use is shaped by two broad sets of forces: human needs as well as environmental features and processes; neither of which is static. Briassoulis therefore defines land use change as follows:

Changes in the uses of land occurring at various spatial levels and within various time periods are the material expressions, among others, of environmental and human dynamics and of their interactions which are mediated by land. These changes are at times beneficial; at times have detrimental impacts and effects.

The magnitude of land use change varies with the time period being examined as well as with geographical area where assessment depends on the source, definitions of land use, the spatial groupings and the data sets used (Briassoulis, 2001). To this end, Briassoulis argues that it is difficult to assess changes in land use due to definitional and data problems.

According to Briassoulis, in the last 300 years, the impacts of land use change have increasingly assumed from significant to threatening proportions. In this respect, desertification, eutrophication, acidification, climate change, sea level rise, greenhouse gas

effects and loss of biodiversity are mainly a consequence of human activity (Briassoulis, 2001). At stake, is the human vulnerability to say floods, food insecurity, health and safety which makes it necessary to study land use in relation to environmental changes (Ibid, 2001).

Enger and Smith (2000) also observed that most of the land surface has been changed by human activity. The change has occurred without evaluating and determining the most logical use of land (Ibid, 2000). Enger et al. concludes that most land use decisions are made based on economic consideration.

Land values for specific uses can be increased or decreased by changing use. Change of use is, however, constrained by the fact that each parcel of land has a unique set of characteristics which make the land suitable for limited types of use (Kihagi, 2000). Land use types are also limited by land ownership regimes and /or access arrangement (KLA, 2002).

The concept of space takes centre stage in the appropriation of land for different activities. Catanese and Snyder (1988) have suggested that space is a contested terrain when treated as a concept or a discrete place on earth. In urban areas, the concept of contested space is common and would often include sites of conflict. Contested spaces may include riparian zones, urban recreation spaces such as open spaces, forest reserves and even undeveloped lands whether public or private.

Despite the potential contestation, an ideal location is where there is orderly spatial relation between urban land use activities and natural environmental resources from an urban planning context (Hall, 2002). Land uses in close proximity may likely show varying degrees of compatibility (Kihagi, 2000). However, (UNHABITAT, 2009) observes that the lack of effective planning, weak development control and misuse of riparian zones in developing countries has hindered their proper functioning. The concept of land use adopted for this study is:

Sustainable accommodation in space of man's activities and natural resources on land and the way land surface is adapted or could be adapted to meet the needs of present and future generations.

The working definition aims to embrace sustainable wise use and management of riparian zones without impairing their physical extent and ecological character.

2.2.3 Land Use in Selected Parts of the World

The use of land in Australia, Europe, USA and Kenya are reviewed.

2.2.3.1 Land Use in Australia

The Australian Natural Resource Atlas, ANRA (1997) show that land use practices have a major effect on natural resources because of their impacts on water, soil, nutrients, plants and animals. The Atlas defines land cover as the physical surface of the earth, including various combinations of vegetation types, soils, exposed rocks and water bodies as well as anthropogenic elements such as agriculture and built environments.

Land cover classes are appropriately discriminated land identified by characteristic patterns using remote sensing techniques. Land use on the other hand, means the purpose to which land cover is committed. For example, some land uses, such as agriculture, have a characteristic pattern of land cover which usually appears in land cover classifications in Australia (ANRA, 1997). Other land uses, such as nature conservation, are not readily discriminated by a characteristic land cover pattern. For example, where land cover is woodland, land use may be timber production or nature conservation (Ibid, 1997).

ANRA further show that land capability assesses limitations to land use imposed by land characteristics and specific management options. Land suitability, on the other hand, which is assessed as part of the process of land evaluation, is the fitness of a given type of land for a specific kind of use (ANRA, 1997).

Consequently, an understanding of the use of land and management practices in one particular land use category provides valuable information about the reasons behind change in condition of natural resources (ANRA, 1997). The Atlas shows that the information it contains can be used in strategic planning and development. It can also be used to optimize land use, assessment of suitability, enhancing productivity and ultimately achieving sustainable management practices.

Finally, ANRA (1997) shows that most intensive land use in Australia is the built environment, which occupy about 2.4 million hectares, or 0.3 percent of the country. More than 80 percent of Australia's 19 million people lived in this land as at June 30, 1999 (Ibid, 1997). The Atlas shows that change in land use and intensity is most prevalent in the built up areas. Within urban areas, the pressure to increase density of housing with smaller block sizes, multiple dwellings and inner city apartment is most prevalent (Ibid, 1997).

The high densities found in the built environments, in Australia are also replicated in urban areas of Kenya (Kenya, 2010b). However, the problem in Kenya lies in the management of land use in relation to the natural resources. There is no proper national atlas and the rivers have not been classified as required by the Water Act (Kenya, 2002a).

2.2.3.2 Land Use in Europe

According to Dimas and Gabriel (2008), the current patterns of land use in Europe represent historical developments rather than optimal placement. Hence, land use is rarely strategic. The different approaches that countries have adopted in the use of land reflect many national variables, including planning systems, institutional structures, socio-cultural characteristics, population pressure and environmental management (Ibid, 2008).

In a fixed area of land, changing the way land is used can cause disproportionate effects on the availability of land for other purposes (Dimas & Gabriel, 2008). For example, expansion of urban areas has significant implications for the rural environment and often on high quality agricultural land (Ibid, 2008). The changes can be direct, occurring where one land use is substituted for another or indirect where substituted land use is displaced to a less valuable use (Kretschmer *et al.*, 2010).

Economic value, therefore, plays a significant and complex role in land use changes driven largely by productivity (Dimas & Gabriel, 2008), or its potential for development. Changes in the use of land is reversed where land or certain commodities become less profitable leading to abandonment, change in crop type, or change in use. Economic factors involved in the change have wide ranging consequences especially for the natural environment, which despite recent efforts to apportion value based on services provided by biodiversity (Ibid, 2008).

According to Dimas and Gabriel (2008), the economics of ecosystems and biodiversity (EEB) remain largely unvalued by commodity markets. These include habitat loss, isolation of species populations, over use of natural resources such as water in response to predicted increases in demand for energy and food.

Consequently, Dimas and Gabriel (2008) have further suggested that in, Europe, idle or marginal lands have been considered areas to expand production. Although these areas appear unproductive, they are nevertheless working and, therefore, being used, delivering 'services' such as biodiversity protection, water filtration, and recreational space. For

example, across Europe many nature reserves owe their existence to their inaccessibility for agricultural production. Bringing marginal land into production can involve considerable investment and lower average yields, while possibilities of incurring social and environmental costs are enormous (Ibid, 2008).

In Europe, policy interventions are used to counteract negative consequences of land use change, such as protection of designated areas to avoid conversion into areas of intensive agriculture, or compensation of farmers in less favourable areas to avoid land abandonment and depopulation (Verburg *et al.*, 2010). However, despite these interventions, increasing demands for land based products and services in Europe are causing land use patterns to change.

The change is causing concern over abilities to deliver environmental management targets as well as those of achieving sustainable production (Dimas and Gabriel, 2008). This pattern of land use change is driven by increasing world-wide demand due to increasing integrated nature of commodity markets. Consequences of demands in the developed world, particularly the European Union, are felt on a global scale (Ibid, 2008).

In developing countries, the concept of wild nature is quickly losing its meaning. The scramble for every space for economic gain remains the most obvious goal of the developers (Kiamba, 1986). However, the economics of ecosystems and biodiversity as perceived by Dimas & Gabriel (2008) also remains unvalued in Kenya. The trajectory of the decline of Kenya's natural resource base is well documented (Kenya, 1972). The decline has affected both rural and urban areas. The trend is also the same in terms of encroachment and degradation of riparian zones of urban areas particularly in the city of Nairobi (NRBP, 1999).

2.2.3.3 Land Use in USA

According to Enger and Smith (2000), about 5 percent of the land in the USA is used intensively by people in urban areas and as transportation corridors, 45 percent is forests and natural areas and about 47 percent of the land is used for crops and livestock. Waterways provided original colonists the primary method of transportation which allowed for exploration and development of commerce in the early North America (Enger & Smith, 2000). Towns with good transportation could receive raw materials and distribute manufactured goods (Ibid, 2000). Essentially, these towns grew into large industrial and trade centres.

Enger and Smith (2000), therefore, observe that early North American towns were built near rivers, lakes and oceans. In addition to transportation, water bodies provided drinking water, power and waste disposal from growing urban areas. Enger et al., therefore, argues that, without access to water, Montreal, Chicago, Detroit, Vancouver and other cities would not have developed.

Development of land adjoining water bodies has destroyed many natural areas that people had long enjoyed (Enger & Smith., 2000). Accordingly, most of the alterations of landscapes occurred without considering how they affected the lives of residents. Enger and Smith further notes that industrial activities continued to be concentrated near water bodies in the city centres. The direct relationship between water bodies and urban land use provides a platform to assess implications to riparian zones. Despite many urban areas and cities being located next to water bodies, there have been limited efforts in terms of assessing the nature of their relationship.

2.2.3.4 Land Use in Kenya

Similar to the European land use patterns, land use patterns in urban areas of Kenya, represent historic colonial development patterns rather than optimal placements (King'oriah, 1980). In this respect, the upsurge of population in urban areas more often than not represents in-optimal placement of land use (Ayonga, 2008). This is particularly, so in relation to riparian zones (UNHABITAT, 2009).

There are implications of land use and land tenure systems to conservation of riparian zones (Njogu & Dietz, 2006) In order to restore and maintain riparian zones in Kenya, there is the need to develop a clear interface between individual land use and land tenure (Ibid, 2006) on one hand, and riparian zones as public land on the other (Kenya, 2004).

Otherwise, where land use and land tenure systems appear to conflict with riparian zones and other natural resources, it leads to their physical destruction through encroachment and/or degradation (Murphy, 2000). Consequently, it is important to protect these resources with secure individual tenure to enhance a sense of ownership. This is as opposed to free, idle, or common land mentality advanced with regard to riparian zones in Kenya (Lelo *et al.*, 2005).

The Constitution of Kenya on its part has noted that land in most communities of Kenya is the most important of natural resource required for of wealth (Kenya, 2010a).

Consequently, land ownership, allocation, distribution and utilization are of great importance to most Kenyans (Kenya, 1991).

However, existing laws and institutions governing land tenure, land use and methods of acquisition and disposition of land rights that were applicable during colonial times are sources of tensions, strife and litigation in land matters (Ibid, 1991), As a result of these activities, riparian zones are continually encroached on where acquisition of public land has for instance been nicknamed “*land grabbing*” (Kenya, 2004). These encroachments are neither a preserve of the rich nor exclusively a problem of landlessness and poverty (Ibid, 2004).

2.2.4 Impacts of Land Use on Riparian Zones

The main negative impacts of land use on riparian zone are as a result of the development of structures, blockage of the drainage systems, and disposal of solid and waste water, urban agriculture and mining in the riparian zones. However, recreation parks have positive co-existence with the riparian zones.

2.2.4.1 Development of Physical Structures

Urban land uses close to water courses have an adverse effect on riparian zones (Collier *et al.*, 1995). As water catchments urbanize and contribute more run-offs, downstream areas are affected by flooding and longer duration of flows. Even at low levels of urbanization, of 5 to 10 percent, surface ground imperviousness and capacity of river ecosystems begin to rapidly decline (Murphy, 2000).

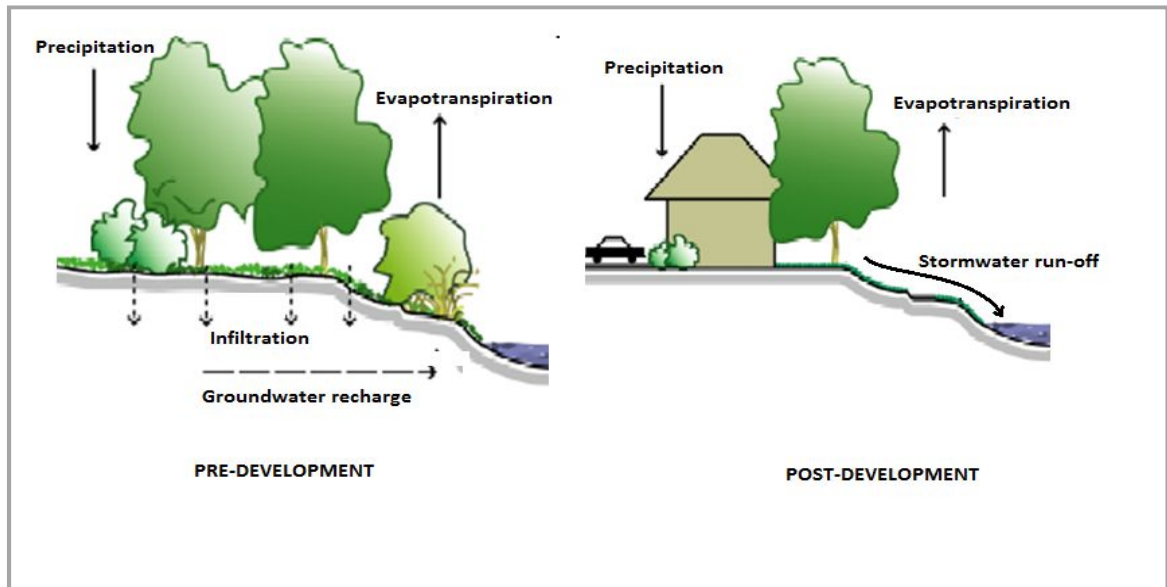
Physical structures in urban areas are developed for various purposes including housing, commercial and industrial activities. Apart from producing solid and waste water that affect the river ecosystem, the structures are known to replace riparian vegetation, increase surface run-off and reduce infiltration of water into underground aquifers (UNHABITAT, 2005). Water quality in rivers is as a result, adversely affected because of limited capacity for self-purification due to high levels of pollutants.

The effects of commercial developments on river ecosystems emanates mainly from poor solid waste management (Mburu, 2007). Kahara (2002) also observes that industrial and commercial developments have the most pollutants in sections of Nairobi River Basin. These developments are in the main industrial district, in Southern Nairobi and informal

industries scattered in major informal and low-income areas. Commercial areas include informal retail markets at Gikomba and Marigu-ini.

Consequently, Kahara (2002) indicates that these developments coincide with location of high levels of river pollution. Figure 2.3 illustrates the riparian zones before and after their development has taken place.

Figure 2.3: Effects of De-vegetated and Vegetated Riparian Zones



Source: Adopted with Modification from Murphy (2000), Utilization of 100 Foot Buffer Zones to Protect Riparian Areas in Connecticut, Inland Fisheries Division in USA.

Urban development induces major changes in runoff precipitation, by changing the configuration of natural drainage channels. This is because hard road surfaces, pavements, car parks and buildings, reduce infiltration of runoff (Murphy, 2000). As a result, polluted runoff flows directly into water courses (Ibid, 2000).

Drainage channels of Nairobi River Basin have been altered leading to increased flooding and reduced recharge into the aquifer. The main zone of urban development with large areas of structures in the 30 metres riparian zone is the informal settlements (Kimani *et al.*, 2009).

2.2.4.2 Water Supply and Drainage System

Increasing urban population has led to allocation or invasion of river ecosystems in Nairobi (Kenya, 2004). Water supply was initially from Nairobi River, with an intake at the Hotel Boulevard area, in the earlier phase of the development of the city of Nairobi. The river is today heavily polluted is not economically feasible trying to purify their

waters for human consumption (NRBP, 1999). Demand for water for the city population currently outstrips the supply (City Council of Nairobi, 1998). The city later relied on water supply from Kikuyu springs, Ruiru Dam, and presently Sasumua and Thika dams.

In Nairobi River Basin, attention has remained on water quality. Since 1969, water quality testing has been carried out consistently (Kithiia & Ongwenyi, 1997). Bacteria testing, analysis to determine levels of Nitrogen and Phosphorus nutrient and measurement of suspended sediment concentration to determine turbidity have been the most frequently conducted studies (Ibid, 1997). However, the studies have not attributed the rivers apparent water quality vulnerability to the limited capacity of riparian zones to protect water quality in the basin.

2.2.4.3 Solid and Wastewater Disposal Systems

In Nairobi, organic materials, paper, plastics, textiles, glass, metals, and ash and grit are the main types of solid waste (Mburu, 2007). In 2002, the per capita generation of solid wastes in Nairobi stood at between 0.5 kg/day to 4.0 kg/day in low and high income areas respectively (Karisa, 2002). These levels of solid waste generation can only have increased more than 10 years at the current size of increased urban population and enlarged functional area of the city.

Studies including by Kahara (2002) and Mbui *et al.* (2010) show high concentration of suspended solids and metal residues in rivers that traverse through the city. The water has a high level of Biochemical Oxygen Demand (BOD) which affects the quality of water. According to these studies, the main anthropogenic sources of pollution in the city of Nairobi are household, industrial and commercial wastes.

On the other hand, UNHABITAT (2005), show that raw sewage is mainly discharged from informal settlements that are not connected to the sewer line. Research studies also show that middle and lowland reaches of rivers are the most affected by pollution. There are several sewer treatment works in the city of Nairobi (CCN, 1998). The sites include Dandora, Kariobangi, Kahawa west, General Service Unit Camp, Karen and Lenana School. The Dandora site is the main treatment works with a design capacity of 30,000m³/day (Ibid, 1998). The Nairobi Water Master Plan estimated that the total sewer networks cover only a third of the total city population (Ibid, 1998).

2.2.4.4 Urban Agriculture

According to UNHABITAT (2005), surface run-off has two adverse consequences: first, water discharged from agricultural land carries with it soil and dissolved chemicals, crop residues, animal waste and manures. Second, the chemicals that are used in farming especially fertilizers and pesticides percolate into the soils. Finally, where the soil has been cultivated and without vegetation cover, runoff discharges into the watercourse, which affects the quality of water.

Farming in urban areas is associated with increased surface runoff, use of sewage, and eventual drainage of wetlands along the basin (UNHABITAT, 2005). According to Karisa (2002), less than 30 percent of cultivators in Nairobi River Basin practice irrigation agriculture which is only suitable in the middle and lower reaches of rivers. The affected areas include Langata, South B, South C, Kasarani, Pumwani and Embakasi (Ibid, 2002).

2.2.4.5 Mining and Quarry Wastes

Effects of quarrying in Nairobi River Basin are mainly evident at the lower stream areas. These are on Ngong River in Southern Nairobi and Embakasi-Kayole areas, and Gatharaini, Rui Ruaka, Mathare and Nairobi Rivers (Kimani et al., 2009). Active quarries generate dust which pollutes the river environment (UNHABITAT, 2005).

2.2.4.6 Recreation

Rivers and wetlands have for many centuries, provided sites for social functions of recreation (Kaplan, 2004). Poor management and construction of structures near rivers and wetlands result to fragmentation of ecosystem habitats, destruction of endangered species and destruction of water-retention function (Vannote *et al.*, 1980).

A direct relationship between rivers and recreation in Nairobi River Basin is illustrated by rivers flowing through the city's network of parks including Nairobi arboretum, the National Museum botanical gardens, the City Park and the Nairobi National Park (Kahara, 2002). This confirms that riparian zones could be used and at the same time, retains their ecological functions.

2.3 Riparian Zone and Land Administration Factors

The concepts of land management, land administration and land tenure are defined before briefly identifying the land administration principles. The way the riparian zone is held influences how it is determined, used and managed.

2.3.1 Concepts of Land Management and Land Administration

Land management involves activities that enhance productivity of land as a resource from an environmental and economic perspective (UN, 1996). These activities include among others spatial planning of towns and countryside, development and management of utilities and services, and regulation of land use including riparian zone (Ibid, 1996).

Land administration, on the other hand, is the process of determining, recording, storing and disseminating information about ownership, value and use of land (UN, 1996). Land administration is, therefore, a public sector activity that assists the process of alienation, survey, valuation, registration, transfer, development and use of land (Mwangi, 2008).

2.3.2 Concept of Land Tenure

According to Njogu and Dietz (2006), land tenure specifically refers to rights that are held on land and some resources on it that may be freehold ownership or leasehold. Land tenure may have a major influence on land use in the long term.

2.3.2.1 Land Tenure in Africa

The conceptual framework used to explain land use and land tenure in Africa usually paint a picture of simple subsistence modes of production based on communal, egalitarian land tenure systems (Kajoba, 2009). Kajoba observes that subsistence production and communal land tenure systems are still prevalent in many parts of Africa especially in sub-Saharan Africa (Ibid, 2009). However, land use has evolved in certain regions from simple subsistence and shifting cultivation to sedentary or permanent types in which individual control and ownership are emphasized and dominant (Ibid, 2009).

Kajoba (2009) outlines a number of land tenure systems that have evolved in Africa including, societies where an individual obtained land rights by residence without allocation. This type was prevalent in pre-colonial Africa. Under this tenure system, individual families within a village acquired land by clearing virgin bush, through transfer or by inheritance. The acquired land was protected by the community and it reverted to the community when not in use.

The second land tenure system was through land holding under the control of lineage. According to Kajoba (2009), access to agricultural land was exclusively reserved for use of the members who traced their heritage from a common ancestry. The third land tenure system involved societies in which Chiefs exercised direct control over the allocation of

land with a descending hierarchy of estates. This system, according to Kajoba, was associated with the emergency of centralized pre-colonial states or kingdoms. This system was a semi-feudal land tenure system that made members of the aristocracy very powerful.

The fourth system of land tenure that has evolved in Africa is the feudal system with landlords and tenants. Kajoba (2009) has cited the Bunyoro in Uganda and the “*Mailo*” system in Buganda as typical examples. In this system, the emperors granted lands to the military commanders, the aristocracy, the nobility and the church through leasing, mortgaging or sale (Ibid, 2009).

The fifth tenure system is the individualized land tenure under commercial production. This system was created in Africa after imposition of colonial rule in sub-Saharan Africa. This led to land alienation and settlement of European commercial farmers especially in Kenya, Malawi, Zimbabwe and Zambia (Kajoba, 2009). In this system, individuals were granted individual freehold and leasehold tenure on what became crown or state land.

There is an implication of land tenure for scholars and policy makers. Land use and land tenure are dynamic and often turbulent concepts. As a result, they can be transformed over the passage of time due to internal dynamics of population increase and differential control of resources by emerging rural or urban groups (Kajoba, 2009).

Kajoba (2009) also attributes this to the introduction of money economy and forces of modernization which have introduced new technologies. Specifically, there are examples of technologies applied in developing areas that were earlier perceived as difficult or impossible. For example, changes in building technology in Kenya, has led to the construction of structures very close to rivers (Kimani *et al.*, 2009).

2.3.2.2 Land Tenure in Kenya

The study by Njogu and Dietz (2006) has examined the nature and origin of rights, roles of rights and how they relate to a multitude of resources on that land. From this perspective, land tenure defines methods by which one person or group of persons acquire, hold, transfer or transmit land or specific rights over certain resources on it (Ibid, 2006).

Changes in land tenure are perhaps one of the driving forces of land use in riparian zones, in Nairobi River Basin. Whereas some locations in urban areas reflect land ownership according to individual form of legal ownership, informal areas are a contrast. Informal

land tenure does not reflect individual ownership or customary land tenure, in accordance to African traditional norms, standards and rules.

Informal land tenure system is mainly found in un-committed government and in some cases on private land which reflects squatter land holding and ownership of property (Kiamba, 1986). There are three attributes of this tenure system: land is unequally accessed compared to formal land use, land is seen as a commodity in an economic sense and is chiefly governed by spontaneous ownership and development (Ibid, 1986).

2.3.3 Land Administration Principles

Land administration tools include land policy, land tenure, cadastral systems, and spatial data infrastructure. Williamson (2000) observes that the nature of land administration strategies used, depend on the relationship of people to land. These include cities and urban areas where active land markets operate in the open market, informal settlements, forests reservation and other special uses of land.

However, the relationship is influenced by global factors of urbanization, operations in the market system, population and technological capacity (Williamson, 2000) Therefore, specific strategies adopted for land administration offer institutional, legal, technical and administrative solutions (Ibid, 2000). Best practices in land administration include implementation of land policy, land tenure and spatial data storage and retrieval systems (Ibid, 2000). It, therefore, requires laws that govern procedures and record keeping.

However, land tenure and cadastral systems can no longer rely on manual procedures and practices in record keeping and communication (Williamson, 2000). These include stand-alone or isolated approaches that support individual purposes where data and processes are maintained separately (in data silos), such as land valuation, land titling and management of state lands and forests, are not sustainable. Rather, they should allow the rights to be traded efficiently, simply, fast, securely and at low cost with no opportunity for political interference, ad hoc government decision making and corruption (Ibid, 2000).

Digital land information systems (LIS) supported by new geospatial engineering technologies including satellite positioning, photomaps, topographic mapping and simple cadastral maps offer better solutions in land administration (Kauffman, 2008). The applications support government guaranteed titles, deed registration systems, individual and group land ownership.

These depend on whether (i) titles or deeds and cadastral maps are computerized or held as paper records or (ii) whether the internet can be used to access land records or (iii) whether institutional arrangements are decentralized, de-concentrated or centralized (Williamson, 2000). In Kenya, land administration processes have remained manual with land surveying, mapping and land recording systems generally failing to adapt to modern technologies.

Other applications include spatial data infrastructure (SDI) regard spatial data as an essential component where cadastral and layers of land tenure can be integrated. Other layers include topographic layer, which indicates areas such as riparian zone.

2.3.4 Land Administration Policies

In Pennsylvania State of USA, Lehigh Valley Planning Commission (2011) argues that municipal riparian zone regulation should be based on scientific research. Regulations are outcomes of balancing scientific research on the benefits of riparian zones against political realities at the local level (Ibid, 2011). In preparation of the model regulations, LVPC considered expansive amount of research on the subject of riparian zones and acknowledged local concern, issues and history of riparian zone regulation in the Lehigh Valley.

Therefore, riparian zone regulations should be viewed as planning tools, rather than as an absolute approach to water-shed management (LVPC, 2011). The Commission used professional expertise in drafting model regulations for consideration by Lehigh Valley Municipalities (Ibid, 2011). Similar approaches in using research findings to formulate policies have been used in the states of Ohio, and New Jersey in the USA. Ireland, United Kingdom and Malaysia are other countries that have formulated development and regulatory policies for riparian zones after extensive research (Broadmeadow & Nisbet, 2004).

Other instructive studies on policies include the one by Hawe and Smith (2005) on “*Riparian Buffer Zones: Functions and Recommended Widths.*” The study has explained the importance and levels of riparian corridor protection needed and has cited extensive research done on riparian corridor protection. According to Hawe and Smith (2005), every community would adopt a river protection overlay zone for all perennial streams and rivers in the Eightmile River Watershed.

The Massachusetts River Protection Act established in 1996 requires a 200-foot resource protection area along all perennial streams in the state (except for 14 highly urbanized communities where the area is reduced to 25 feet).

The Farmington River Protection Zoning Overlay District adopted in 1992 established a 100-foot setback area along the Wild and Scenic Farmington River in four communities, in Connecticut; the new CT River Gateway Standards established a 50-foot no-activity zone and a 100-foot no-structure area along water bodies in the Gateway Zone.

2.3.5 Evaluation of Public Institutions in Land Administration

The concept of evaluation and the methods used in the evaluation of land administration processes and procedures are described.

2.3.5.1 Concept of Evaluation

The objective of public sector in rendering land administration services is not profit making (Modubu, 2009). Rather, policies in the public sector are not always strictly defined due to a host of factors like political will, loyalty and social interests (Ibid, 2009). These have a major influence in the way public sector activities are performed. As a result, there are challenges of measuring performance of public sector using standard indicators (Mwangi, 2008). In this connection, institutions should have clear mandates and structures that allow them to function efficiently and free from political pressure (Ibid, 2008).

Evaluation, according to Mwangi (2008), is the measurement of performance of a particular process and is a prerequisite for improving productivity (output), efficiency (time) and performance (process). This confirms the adage that one may not improve what is not measurable and if one does not measure, one cannot manage (Ibid, 2008). Based on this observation, the current study argues that one cannot protect the riparian zone if its variables are not properly defined for measurement, monitoring and evaluation in during land administration functions. It has been difficult to determine judicial cases in Kenya due to challenges of determining the extent and points of measurement as a result of confusion in legislation.

Performance measurement approaches like management by objectives (MBO), benchmarking, and total quality management (TQM) are recommended because these are useful in the evaluation and, therefore, in improving performance (Mwangi, 2008). Evaluation helps organizations to mirror themselves against best practices enabling them

to have a global outlook to issues. This is not common practice in Kenya where riparian zones issues are determined based on obsolete colonial laws that are marred with confusion (Lelo et al., 2005).

In another line of argument, Mwangi (2008) observes that public institutions in least developed countries (LDCs) are bogged by general unwillingness of being evaluated. She has cited the Ministry of Lands in Kenya, where land administration processes are performed in high level secrecy. As a result, the functions of land administration services are treated with suspicion. Access to information on land is considered more of a privilege than a right (Ibid, 2008).

The challenges encountered is evinced by obstacles when doing simple transactions including missing files and torn pages, taking too long to get results, being tossed from one officer to another and poor reception and hostility from officers (Mwangi, 2008). This according to Mwangi illustrates difficulties in evaluating land administration systems.

2.3.5.2 Methods of Evaluation of Land Administration Processes

There are many ways of evaluating land administration systems. Management by objective (MBO) recommends a clear definition of outputs or objectives achieved through a well defined road map (Mwangi, 2008). Guthiga and Makathimo (2010) have used this method to evaluate land use policies and natural resources management in Nairobi River Basin. The results of MBO methods are monitored through feedback systems which are used to identify loopholes so as to take preventative measures (Ibid, 2008). The MBO method may be used as long as outputs are identified, time defined and a route map put in place to realize the deliverables (Ibid, 2008).

The logic framework analysis, (LFA) method, is another approach that is used to investigate and evaluate projects in the field of development assistance. LFA has been used by development organizations such as the World Bank (Mwangi, 2008). LFA method, apply by way of structuring the main elements in a project, highlighting linkages between intended inputs, planned activities and expected outputs (Ibid, 2008). There are many versions of LFA, but Mwangi notes that the basic method consists of a four by four matrix which breaks down project units into measurable components including inputs resulting into activities, output, immediate objective or project purpose and wider organizational objectives or project goals.

Kaufmann (2008) has also used the cadastre form of a book-keeping or accounting system for land issues. Cadastre is an official register showing details of ownership; boundaries and value of real property in a district or a region (Ibid, 2008). Components of a cadastre are very easy to measure because they act as evidence of a regularized tenure. The cadastre is, therefore, an output in the administration of land registration.

It is possible to formulate objectives of each department and identify clear output in their measurable units, time taken to deliver and quality of service given (Mwangi, 2008). However, Kenya measure poorly in all indicators for land administration processes (Ibid, 2008).

Pointedly, Mwangi (2008) observes that the time taken is indeterminate; procedures are too many while costs are unregulated leading to exclusion of most of the people from formal property markets. Worse still, the completion rate of land administration processes is 8.3 to 18 percent (Ibid, 2008). These findings are indicators of the problem of riparian zones because allocation of riparian zones, are seemingly as a result of poor land administration practices next to river ecosystems (Kenya, 2004).

More simplified procedures for land administration including removal of repetitive functions at City Council of Nairobi and Director of Physical Planning, centralization of the plan approving agency as proposed in the national land policy (NLP), separation of technical processes from policy making especially where the Ministry of Lands approves development applications are the measures recommended by (Mwangi, 2008).

Other recommendations include change of organizational behaviour and culture. The focus should be on poor work culture in land administration. To do this, development of group norms with standards of behaviour that is enforced by the management is needed. Second, the norms that apply in enforcing the standards would play an important role in the reduction of corruption (Mwangi, 2008).

2.4 Best Practices in Riparian Zone Conservation

Groffman *et al.* (2003), using the case of Baltimore Ecosystem Study (BES) indicated that riparian research has become an integrative topic. Groffman *et al.* (2003) indicated how changes in hydrology associated with urbanization have altered soil, vegetation and microbial processes, and the history of human use and abuse of riparian ecosystem. In this

respect, urban riparian ecology is a topic that requires further studies across the globe (Ibid, 2003).

Accordingly, there are diverse research studies on riparian ecology focusing on among others the analysis of habitat requirements of rare plants and animal species. Other studies have focused on prevention of pollution movement from uplands and urban development to rivers, regulation of stream temperature and physical structure (Groffman *et al*, 2003).

Majority of the studies have concentrated more on agriculture land and forested watershed where emphasis is on capacity of riparian zones to prevent movement of nitrates and phosphates from agricultural uplands (Groffman *et al.*, 2003). Letsinger (2004) has also noted that riparian zones would be more effectively managed by coordinating land uses, human and naturally induced problems connected to land uses (Water and Rivers Commission, 2000).

2.4.1 Case of Thames Estuary Partnership in Britain

Thames Estuary Partnership (TEP) in Britain is one of the best practices in estuary management on lower Thames River (Home, 2004). The partnership was initiated in 1993 as a response to challenges of coastal zone management at the time. Home treated Thames Estuary Partnership (TEP) as a partnership a process and a planning mechanism.

According to Home (2004), the concept of partnership evolved to bring together a variety of stakeholders. Partnerships involve national agencies, local authorities, communities, landowners; the private sector and voluntary groups. In addition, partnership was a tool for articulating projects and mobilizing resources for urban development and regeneration after environmental issues and concerns were elevated into public policy agenda in the 1990s (Ibid, 2004).

The concept of partnership is a politically convenient substitute for structured public sector interventions, at times an ideological commitment to liberal, free-market and inclusion of environmental issues (Home, 2004). In this respect, TEP attempted a new approach to partnerships, which limited use of statutory authorities, local authority involvement and a wide range of potential partners in an unusually complex political and environmental matrix (Ibid, 2004).

Partnership as a process has borrowed heavily from formalized process of the statutory plan making in the preparation of management guidance (Home, 2004). As a planning mechanism, TEP devised a set of management guidelines and an agreed list of potential projects. TEP represented an imaginative approach seeking to involve diverse interests and achieved among others a statement of management guidelines (Ibid, 2004).

2.4.2 Case of Middlebury River Watershed Partnership in USA

Middlebury River Watershed Partnership (MRWP), in partnership with Creek Natural Resource Conservation Service (CNRCS), conducted an assessment of riparian zones along Middlebury River. The project aimed to inform and educate land owners on the benefits of programs and projects designed to improve riparian zones.

According to the partnership, riparian widths of between 50 to 150 feet with vegetation on each side of the river channel are necessary. Landowners with property in certain riverine habitats would be eligible for federal assistant programs that created cost-sharing relief to improve the health and vitality of riverbanks.

Conservation Reserve Enhancement Program (CREP) and Conservation Reserve Program (CRP) allowed the government to work with individual farmers with erosion and water quality problems on croplands, marginal pastures and other environmentally sensitive areas. US Fish and Wildlife service assisted landowners with habitat restoration practices such as riparian zone improvement and wetland restoration.

2.4.3 Case of Nairobi River Basin Programme

Nairobi River Basin Programme (NRBP) was established on a partnership model involving the Government of Kenya, multinational agencies and civil society organizations. The programme was spearheaded by UNEP, UN-HABITAT, UNDP, the private sector and the civil society. The main focus of NRBP was a restored riverine ecosystem with clean water and healthier environment to residents of the city of Nairobi (NRBP, 1999). Specifically, the objective of the programme was to rehabilitate, restore and manage the river ecosystem in order to among others enhance biodiversity.

Since its inception in 1999, the programme has conducted awareness and clean up campaigns, publicized database on the river basin especially thematic maps on the status of pollution of the rivers. The Department of Resource Surveys and Remote Sensing (DRSRS) developed a thematic map of the system focusing on geographical, socio-

economic and pollution data from the source along the basin's three main rivers of Ngong, Nairobi and Mathare.

Protection of targeted sensitive ecosystems along rivers, reduction of pollution from raw sewage, industrial and domestic sources and enhancement of public participation and communication has been the main focus of the programme.

Olago and Aketch (2000) observed that the key solutions to environmental problems are knowledge and a shared understanding. However, knowledge recorded about riparian zones in Nairobi is fragmented and spread across many different institutions and agencies (Ibid, 2000).

According to Olago and Aketch (2000), Nairobi River Basin had pristine waters in the early part of the 20th Century. However, anthropogenic impacts began to be felt from the 1960s and greatly increased in the 1970s through the 1990s. Population increase, urbanization, industrial growth, increase in agriculture and use of agrochemicals, decreased vegetation cover, growth of large informal settlements along rivers, poor disposal systems and treatment of sewage are the main challenges (Ibid, 2000).

Studies carried out to assess water quality are inadequate as a source of information for an integrated and sustainable management of Nairobi River Basin (Olago & Aketch, 2000). The studies have concentrated more on site effects and they cover only a small area with few samples and they measured only a few pollution indicators (Ibid, 2000).

One of the variables consistently ignored in these studies is the potential role of riparian zones to ensure ecological, social and economic benefits of river ecosystems and human environments. Moreover, mapping of the river basin based on point-source pollution rather than to heed in the determination of the physical extent and ecological quality of riparian zones only serves to ignore the root cause of the problem.

In addition, the mapping venture failed to analyze the riparian zone in relation to its underlying factors which would have enabled assessment of the reasons for encroachment and degradation of riparian areas. This would be a sure way of minimizing future encroachment and degradation of water resources since a better understanding would ideally translate to better planning and development control.

2.5 Environmental Management and Development Planning Policy in Kenya

The exposition of the evolution of environmental management and development planning discourses in Kenya lays the foundation for improving the understanding of the genesis of the problem that face encroachment and degradation of riparian zones in Nairobi River Basin.

2.5.1 Overview of the State of Human Environments in Kenya

The overall state of the human settlement in Kenya deteriorated over the years since independence in 1963 (Kenya, 1972). At the UN General Assembly held at Stockholm in 1972, Kenya presented a strong case for planning of the process of development to improve the state of human settlements (Ibid, 1972). The Report suggested establishment of an authority within government to take full responsibility for the health of human settlement environment. However, it took the Government more than 30 years to establish the National Environment Management Authority in 2002.

The Report to the UN Conference (Kenya, 1972) demonstrated that the human settlement problems in Kenya were related to demographic trends, patterns of population distribution, inadequate supply of housing units by the public sector and degradation of the environment by unregulated urban development. In addition, the Report observed that rural land use planning required concerted public policy action. Arising from serious challenges facing human settlements in Kenya, the government in 1978 also published the Human Settlement Report (Kenya, 1978). However, the challenges facing human settlements continued unabated.

The role of the state in environmental management changed for the worse in 1990s (Kenya, 2004). Extensive destruction of gazetted forests, agricultural land and urban environments, took place on a large scale (Ibid, 2004). Corruption and political patronage were the main causes of these challenges (Kenya, 1999a; 2004). The clearing of forests for human settlements, led to serious water shortages, shrinkage of areas covered by lakes, polluted and disappearing rivers. Food insecurity due to degraded agricultural land and diminishing water resources is one of main adverse effects of the problem (Kenya, 1999a).

The net sum effect of the rural environmental challenges has been the mass migration to urban areas especially to the city of Nairobi (KNBS, 2010b). As a result, there has been conflict between development and environmental quality in urban areas (Kenya, 2011a; & UNHABITAT, 2009). Consequently, spontaneous and unplanned human settlements and

unsustainable land use along river valleys and other environmentally fragile areas have further worsened the state of the built environment in towns (UN-HABITAT, 2003).

Kenya (1972) concludes that the concept of indivisible environment in managing the environment is important. This is because the current environmental problems have resulted from the lack of coordination of interventions on environmental programmes.

2.5.2 Environmental Management Policy in Kenya

The Stockholm Conference, led to a period of enacting environmental laws in many countries. However, this was not the case in Kenya where earlier policies of the Government focused on extraction and exploitation of natural resources. However, high rates of population growth and increased demand for settlement land were threat to natural resources including land for food production and affordable energy (Kenya, 1972).

In addition, existing judicial institutions and procedures of enforcing compliance with environmental management were weak in dealing with escalating threats to environmental sustainability and natural resources (Okidi, Kameri-Mbole & Aketch, 2008).

After the Stockholm Conference in 1972, Kenya established the National Environmental Secretarial (NES), to coordinate technical resolutions to emerging natural resource use and environmental degradation challenges. Later in 1978, the Government published the Human Settlement Report (*Purple Book*) and a strategy for managing rural and urban development to avoid the pitfalls of unplanned development including environmental degradation (Kenya, 1978).

The National Environmental Secretariat (NES) was a formal body responsible for environmental management after 1972. The Secretariat was the clearing house and a coordination centre for environmental matters (Okidi *et al.*, 2008).

On the seventh day of February 1974, the Secretariat was transferred to the office of the president and for the first time, a section on environment and conservation was created in the 1974-1978 National Development Plan (Okidi *et al.*, 2008). The five year plan also established a national working committee that would act as a watchdog on environment.

In 1980, the Secretariat moved to the newly created Ministry of Environment and Natural Resources. However, its role remained administrative and not legislative. NES, therefore, lacked requisite regulatory and enforcement powers in environmental management. The

transfer took place at the middle of the 1979-1983 National Development Plan that had a section on environmental management policy. The Plan emphasized on prevention of harmful environmental effects, which are less costly than their subsequent correction. It added that environmental exigencies must be built into development planning and management to ensure sustainable development with a healthy environment.

The Plan included the need for Environmental Impacts Reports (EIR) for all new projects and heralded the requirement for Environmental Impact Assessment (EIA) as part of environmental policy. The role of NES in the coordination of environmental issues and actions were recognized as part of the policy process in Kenya (Okidi *et al.*, 2008). However, riparian zone environmental concerns were not embedded in the mandates of the Secretariat.

Kenya enacted the Environmental Monitoring and Coordination Act (EMCA) in 1999. This was many years after the 1972 Stockholm Conference. It is a broad based law that involves public participation as required in principle 10 of the 1992 Rio de Janeiro declaration of principles (UN, 1992).

2.5.3 Development Planning in Kenya

National Development Plans, District Development Plans, Sessional papers and ad hoc programmes and projects of the Regional Development Authorities (RDAs) are the main planning and policy instruments that have guided development in Kenya.

2.5.3.1 National Development Plans

Since the formulation of the famous Sessional paper No. 10 of 1965 on “*African Socialism and its Application to Planning in Kenya*, (ASAPK)” five year national development plans (NDPs) were made consistent and periodic official document on development. The plans were to guide and promote economic and social development. The creation of Ministry of Economic Planning and Development in 1964 marked the seriousness of the new government and its focus on development planning.

Principles set in the Sessional paper guided the NDPs by advocating a more centralized government to direct the development process along African socialism lines. Following this, the planning process of the state was expected to be efficient and responsive. The process was also expected to equitably distribute economic and social benefits through regional development.

However, development planning by the state failed to achieve integrated development and regional equity. Development remained skewed and resources were even expropriated by a hegemonic elitist group (Kiamba, 1986; Leys, 1975). One of the outcomes of skewed development was illegal and irregular allocation of ecologically fragile land areas including riparian zones (Kenya, 2004).

Subsequent development plans failed to link development planning with natural resource management and environmental protection. For example, although the 1970 to 1974 plan provided for natural resource management and environmental protection, the plan failed in implementation.

The Plan for 1979 to 1983 period acknowledged that a majority of Kenyans were still very poor and lacked social services at levels commensurate with the expectations of the people. The plan also failed to link poverty with challenges facing the environmental sector. From then on, development priorities of the country lacked relevant and appropriate strategies for environmental management.

The central theme of the 1984 to 1988 Plan was structural adjustment programmes (SAPs) which advanced cost sharing. Cost sharing was introduced when majority of Kenyans were poorer as a result of strained land resources (Kenya, 2011a). The 1989 to 1993 Plan introduced the concept of public participation.

However, planning and implementation failed to integrate decentralized development administration with popular involvement of people in public policy formulation. Linking development planning with environmental management also failed. Pointedly, public participation in policy formulation and implementation in Kenya failed because Kenya lacked a model of democratic practice in public spheres, including planning and implementation.

Formulation of the 1994 to 1996 Plan happened when the country was undergoing major political changes. The plan removed the government from entrepreneurship so that it would become more of a facilitator. The plunder of public land by the political class (Kenya, 2004), disregarded the potential and real consequences of their actions on the state of the natural resources and the environment.

The 1997 to 2001 Plan focused on government commitment to alleviating poverty and unemployment through an integrated development approach. The plan aimed to employ agriculture and industry as engines of development. It was, therefore, adopted as a strategy for economic growth. However, the role of government in the provision of agricultural extension services for crop and livestock production failed. The plan also failed to implement policies and strategies formulated in the Sessional Paper No. 2 of 1996 on “*Industrial Transformation to the year 2020.*”

Notably, not all these plans failed to link development with good environmental stewardship. The 2002 to 2008 Plan aimed at effective management for sustainable growth and poverty reduction. The plan ushered in environmental management into development planning. The coming into power of the National Rainbow Coalition (NARC) government in 2003 led to the abandonment of the 2000 to 2008 Plan. In its place, the Economic Recovery for Wealth and Employment Creation (ERSWEC) strategy was formulated in 2003 and implemented from 2003 to 2008 (Kenya, 2003).

In 2007, the government launched a long term development blue-print, Kenya Vision 2030 (Kenya, 2007a). The five year plan of 2008 to 2012 was also launched as the first phase in the implementation of vision 2030 (Ibid, 2007a). It is important to note that ERSWEC, Vision 2030 and 2008-2012 national development plans contain strategies for environmental management and sustainable development.

2.5.3.2 Vision 2030 in Relation to the Environment

According to Vision 2030, Kenya aims to be a nation of clean, secure and sustainable environment by 2030. The Vision stands on three pillars of (i) social, (ii) economic and (iii) political. Each of these pillars has environmental dimensions. In this regard, the objectives of the 2008-2012 plan are (i) to increase forest cover from less than 3 percent at present to 4 percent, and (ii) to lessen by half all environment-related diseases (Kenya, 2007a).

Specific strategies include promoting environmental conservation in supporting economic pillar flagship projects, improving pollution and waste management through the design and providing economic incentives and commissioning of public-private partnerships (PPPs) to improve efficiency in water and sanitation (Kenya, 2007a). Kenya will also enhance disaster preparedness in all disaster-prone areas and improve capacity for

adaptation of global climatic change. Finally, the country will harmonize environment-related laws for better environmental planning and governance (Ibid, 2007a).

Vision 2030 has proposed specific flagship projects for the environment sector in Nairobi. These include rehabilitation of heavily polluted and degraded Nairobi River ecosystem. The Vision also proposes water catchment management initiative (WCMI) focusing on securing wildlife corridors and migratory routes and effective solid waste management in towns.

Finally, Vision 2030 has land cover and land use mapping Initiative (LCLUMI) which aims at comprehensive mapping of land use patterns in Kenya. This last initiative is relevant in mapping of land uses in riparian zones which could be used in monitoring, evaluation and decision making.

2.5.3.3 District Development Plans

In line with the five year national development plans (NDPs), district development plans (DDPs) have been prepared since 1988. District planning and management units were established to implement DDPs. The plans are instrumental in the actualization of goals in key national development blue prints.

DDPs were expected to achieve district development and resolve economic challenges in sustainable development. However, the plans were not fully implemented to achieve their goals because of lack of financing. The plans generally lacked legislative backing and were supervised by government administrative officials through authoritative processes.

2.5.3.4 Regional Development Authorities' Programs and Projects

Regional Development Authorities (RDAs) cover large areas drained and bounded by watersheds. RDAs in Kenya are as follows: Tana and Athi River Development Authority (TARDA); Coast Development Authority; Ewaso Ng'iro North Development Authority; Ewaso Ng'iro South Development Authority; Lake Basin Development Authority; and Kerio Valley Development Authority.

Nairobi River Basin is part of Tana and Athi River Basin. The basin is covered by TARDA under a law enacted in 1974. The Act provides for the establishment of an authority to advise the national government and to coordinate development projects in the two river basins.

TARDA is also expected to prepare long-range development plans for the region. Other functions include, carrying out studies, implementing programmes of monitoring performance of projects and collection of data, and creating data management systems for protection and utilization of water resources in the region.

The main challenge facing TARDA to date is the duplication of its mandates with water resources management authority (WRMA) and other development agencies. TARDA has, however, failed to effectively address environmental problems in the region least of all initiating programmes such as tree planting in the upper catchment zones of the basin. The role of the Authority appears peripheral in urban areas and cities. In addition, TARDA lacks programmes for human settlements and planning as part of environmental improvement especially in riparian zones.

2.5.3.5 Sessional Papers

Sessional papers are official policy statements on broad areas of concern in national, regional sectoral and local development in Kenya. These policy papers also spell out strategies that the government of Kenya uses to address concerns enunciated in the policies.

a. Paper No. 10 of 1965 on African Socialism and its Application to Planning

The Sessional Paper has articulated two African traditions that form the basis for planning in the context of African Socialism (Kenya, 1965a). These are political democracy and mutual social responsibility.

Political democracy stands for each member of society having equal political rights. That is, no individual or group may exert undue influence on the policies of the state for one's advantage. However, on-going degradation of the environment and encroachment of riparian zones as a result of selfish individuals negates these tenets. Political leaders and powerful individuals have on the contrary, abrogated themselves residual powers and rights to allocate land including riparian zones (Kenya, 2004)

The second pillar is on social mutual responsibility (SMR), which is an extension of African family spirit to the nation as a whole, with the hope that ultimately the spirit can be extended to ever-larger sections of society (Kenya, 1965a). It implies mutual responsibility in society among its members, to do their very best for each other with full

knowledge and understanding that if society prospers its member will share in that prosperity (Ibid, 1965a).

SMR is premised that society cannot prosper without full co-operation of its members. Accordingly, this premise suggests that the state has an obligation to ensure equal opportunities for all its citizens concerning resource use. According to Kenya (1965a), under African socialism, the power to control resource use resides with the state.

However, while the riparian zone is public land, there are titles, survey plans and deed plans showing that some riparian zones are, in fact, under private ownership (Kenya, 2004). Consequently, political democracy and SMR have not informed individual rights as well as appropriate uses and ownership of critical public resources including riparian zones.

It is logical that the heritage of future generations will depend on adoption and implementation of policies designed to conserve resources and promote livable physical and social environment. In fact, thoughtless destruction of forests, vegetation, wildlife, and productive land as it took place in the 1990s, is an indicator of the future towards self-destruction. Efforts by the National Government including formulation of a national land-use policy in 2009 have not brought the problem under control.

b. Paper No. 2 of 1996 on Industrial Transformation to the Year 2020

The main purpose of the paper was to set out national policies and strategies for structural transformation. The main goal of the paper was to enable Kenya join the league of newly industrialized countries by the year 2020. Partnerships between government and private sector would achieve the goal of industrialization. For its part, the government would be committed to political and social stability as well as continuity in economic policy and to facilitate private sector on a collaborative industrialization enterprise.

However, the goals of this paper were not achieved. The majority of small-scale industries still operate without the necessary support of the state in terms of financing and technical improvement. Also, industrial land use lacks the requisite regard for the environment. Oftentimes, it promotes poorly paid up jobs that degrade the environment (Kenya, 2011a). In fact, the existing policy framework for industrialization ignores housing for its employees especially casual low-income workers who end up living in informal

settlements constructed in riparian zones and other hazardous sites and locations in towns (Karisa, 2002).

c. Economic Recovery Strategy on Employment and Wealth Creation (2003-2008)

The third major strategy is the Economic Recovery Strategy on Employment and Wealth Creation (ERSWEC) which was launched for implementation from 2003 (Kenya, 2003) on the need to review policies and laws on biodiversity. The strategy takes into account existing policies particularly documents with special consideration of poverty reduction strategy paper (PRSP) of 1999 and launched in 2001 (Kenya, 1999a).

Good governance and rule of law are advanced as elements in economic recovery. Capacity building through financing and technical support in production is also relevant. The paper considers that the poor may not afford current costs such as rental of small scale businesses and, therefore, ends up on road reserves and riparian zones.

The other area of policy is the need to establish a favourable environment for growth of small and medium scale enterprises (SMEs). These were to have the capacity to produce high quality products and to create requisite employment. Financing, technical support and management capacity support are required to enhance the sector, for it to generate growth and jobs.

However, poverty worsened with adverse effects of deteriorating environment, itself a useful indicator of the economy on a declining path. Increased number of uncontrolled habitation of environmentally sensitive areas including riparian zones and dwindling resources such as surface and underground water resources evinces that ERSWEC was undermined by government indecision and lack of political will to enforce environmental laws and regulations.

The main conclusion from these three policy papers is that the past development perpetuated regional development imbalances. The policies did not generally promote nor effectively address income inequalities. The policies did not also properly guide conservation of vital environmental resources such as riparian zones.

2.5.4 Evolution of Land Administration Policy in Kenya

Existing land administration policy in Kenya has evolved in three distinct phases. These are pre-colonial, colonial and post-independence phases. Each phase is discussed to provide a context for understanding how the policies apply to the conservation of riparian zones in the city of Nairobi.

2.5.4.1 Pre-Colonial Period

Mwangi (1994) and Okoth-Ogendo (1999) have shown that most land in Kenya belonged to various ethnic communities before colonialism. In African customary conservation ethic, there is no separation of people from nature. Customary rules governed land use and land rights were mainly informally recorded but well structured in pre-colonial period.

In the pre-colonial era, community land use and environmental management were integrated (Lelo *et al.*, 2005). This is where nature and people co-existed harmoniously without elaborate distinction that is common today. Small nucleated settlements were also common although urban and rural areas in Kenya were at their infancy at the time.

2.5.4.2 Colonial Phase

The 1902 Crown Lands Ordinance (CLO) followed formal accession of the Kenyan territory to the status of British protectorate. Following this, the protectorate government embarked on implementing racial segregation policies. The Crown Land Act was enacted in 1915 to make further and better provision for regulating the leasing and other disposal of government land. The crown land was directly translated into Government Land Act after independence.

Under the CLO, the colonial government under the British protectorate implemented its policy of European settlement in the Kenya Highlands and initiated the process of racial segregation in and around the towns of Kenya. The Act also provided for the establishment of reserves “for the use and support of members of the native tribes of the protectorate.” The reserves were defined and proclaimed in 1926 but remained vested in the crown for administration and management.

The establishment of the reserves failed to curtail suspicions and fears of the African population. In order to allay the fears, the concept of “trust land” was enshrined in land administration practices after the recommendations of the Kenya Land Commission

(*Carter Commission*) of 1933. From that time, trust land evolved as a different category of land tenure from the crown land.

The Crown Lands Act (CLA) of 1915 empowered the Governor to grant, lease or alienate land from Africans. The Governor was further empowered to draw covenants, agreements and conditions for land tenure on behalf of the British Government. The CLA also created the office of Commissioner of Lands and authorized the Commissioner to administer conveyances and leases on behalf of the Governor. Section 15 of the CLA provided as follows:

The Commissioner of Lands may cause any portion of a township plot which is not required for public purposes to be divided into plots suitable for the execution of buildings for businesses or residential purpose and such plots may from time to time be disposed of in the manner thereafter described.

Section 18 of the CLA further empowered the Governor to issue orders on sale of plots by auction. The Act disallowed public land from allocation to private developers and gave the Governor discretion to change the method of land allocation. These provisions disadvantaged Africans when acquiring land while favoring the newly settled Europeans. These changes set in motion, the factors that led to urban and rural landlessness in Kenya.

2.5.4.3 Post-Independent Phase

In the post-independence era, natural resource conservation in Kenya followed a system of reservation where one was not permitted to take away or leave anything inside the reserve or park without permission unlike in the pre-colonial time. Privatization of land and racial segregation policies of the colonial era and post independent concept of income differentiation were the main reasons advanced (Leys, 1975).

However, the colonial and post-independent era policies seem not to have helped. Persons who pollute and encroach on riparian zones or destroy forests continued to do so without much formal restraints. The Government Land Act and Land Registration Acts are the two main laws that reflect legal and policy bias in land issues including land use planning in the early post-independent phase.

a. Land Registration Process in Kenya before Constitution of 2010

Land registration in Kenya happened under the Registered Land Act (RLA), Registration of Titles Act (RTA) and Government Land Act as well as the Land Titles Act (LTA) which was applied at the 10 mile strip along the Kenyan coastline.

In the RLA and RTA, a registered title could not be challenged even in a court of law unless there was substantive evidence that the title deed was obtained through fraud. Under Section 27 of the RLA, once a person is registered as the proprietor of a parcel of land, the proprietor is deemed to be the absolute owner of that parcel of land and enjoys all the rights and privileges entered in the land register. The rights and privileges cannot be defeated as provided in Section 28.

Under Section 69 of the GLA, the registered proprietor was entitled to hold and enjoy such rights and privileges without interruption by the grantor or lessor or any other person. Under Section 23 of RTA, the certificate of title issued by the principal registrar of title based in Nairobi *“shall be taken by all courts as conclusive evidence that the proprietor named therein is the absolute and indefeasible owner thereof and the title shall not be subject to challenge except on the grounds of fraud or misinterpretation to which the proprietor is proved to be a party.”*

Fraud as inferred in the RTA refers to the action of a person who obtains registration including approved knowledge of the existence of an unregistered interest on the part of some other person whose interest he knowingly and wrongfully defeats by that registration. Title deeds once issued, are cancelled by the High Court on the grounds of fraud, misinterpretation or error.

It is clear that if titles are issued, even within riparian zones, it would be an uphill task under these laws to cancel them leave alone to evict those who have encroached on the zones. However, the Land Registration and Land Acts of 2012 have since repealed these laws.

b. The Government Land Act

At Independence, land in Kenya was classified into three categories for administrative purposes. The first category is government land administered under the Government Land Act. The land was vested in the Government by virtue of sections 204 and 205 of the old Constitution. This is also provided in Schedule 2 of the Kenya Independence Order in

Council of 1963 and Sections 2, 22,25 and 26 of the Constitution of Kenya (Amendment) Act of 1964. Article 260 of the new Constitution (Kenya, 2010a) has re-defined land to include the natural resources on, below and above the ground.

The second category is the trust land, which applied in the rural areas or native reserves before 31st May 1963 and had been vested in the Trust Land Board. Trust lands included areas known as special areas, temporary special reserves, special leasehold areas and special settlement areas. The land was vested in the areas of jurisdiction of local authorities. The third category is private land held by members of the public including private limited companies and cooperative societies. Private land is either held on freehold or leasehold basis.

The Government Land Act (GLA) dealt with the disposal of government land within townships and government agricultural land. The law permitted the Commissioner of Lands on behalf of the Republic of Kenya, to grant leases subject to terms and conditions of town plots for any term not exceeding 99 years and agricultural land for 999 years The Constitution of Kenya (Kenya, 2010a) has since reduced the maximum term to 99 years for all land uses.

According to GLA, the Commissioner of Lands could cause any portion of a township that is not required for public purposes, to be divided into plots suitable for erection of buildings for businesses or residential purposes.

c. Procedure for Alienation of Government Land

According to GLA, the Government or Local Authority identified land to be alienated. The Director of Physical Planning and Director of Surveys were then requested to prepare Part Development Plans (PDPs) and to survey the land respectively. Ideally, the resultant plots were expected to be auctioned after advertising in the Kenya Gazette and newspapers with national circulation.

Applicants for advertised plots were selected by plot allocation committees formed throughout the country. Successful applicants were issued with letters of allotment following their eligibility. The applicants were required to pay legal fees demanded within a period of 30 days failure which led to withdrawal of the offer.

The Gazette notice stated the number of plots, site and general area of each plot, the standard premium at which the lease of each plot would be sold, survey fees to be paid for each plot, term of lease and land rent payable in respect of each plot. The notice also indicated building conditions and special covenants, if any, to be included in the lease granted in respect of any plot. Issuance of letters of allotment, survey plan, and registration of new owners and issuance of title deeds concluded the process (Kenya, 1991).

The GLA indicates that, on receipt of deed plans or Registry Index Maps (RIMs), the Commissioner of Lands would proceed to prepare grants or leases based on terms and conditions contained in the letters of allotment. Section 9 of the GLA gave the Commissioner of Lands powers to vary the method of disposal of land under the Act.

In 1994, the government published a Gazette Notice No. 35, Kenya subsidiary legislation of 1994 on government land. The notice authorized sale of undeveloped land and opened a period of widespread land speculation. It was during this period that the indiscriminate allocation of institutional land, public utility land-road reserves, and riparian zones to politically powerful individuals took place (Kenya, 2004).

2.6 Chapter Summary

The chapter has confirmed and highlighted numerous challenges faced by riparian zones in relation to their underlying factors. A review of the literature has highlighted the use of the findings of research studies to address the challenges facing riparian zones (Murphy, 2000; and Broadmeadow & Nisbet, 2004). The findings are then applied to formulate policies that are used during implementation, monitoring and evaluation, and management (Fualing, 2009).

Research studies have suggested that the influence of riparian zones on river ecosystems is dependent on the width of the watercourse, longitudinal continuum of vegetation cover (Vannote *et al.*, 1980), structure and composition of plant species (Collier *et al.*, 1995) and the adjoining land uses (Hawe & Smith, 2005). Studies have further suggested that the topography and soils of a given site along a river have a strong influence on the lateral spatial dimensions of the zone (Gonzalez del Tanago & Garcia de Jalon, 2006). For example, riparian zones that are too narrow offer inadequate protection, while if too wide, they reduce useful land which has no ecological value (LVPC, 2011).

Most studies that were reviewed have focused on the determination of the main variables of the zone. However, the variables have not been replicated in the Kenya context where socio-economic, historical and biophysical circumstances of settlements are different. In addition, Kenyan policies and laws have not defined riparian zones in relation to the effects of adjoining urban land uses, prevailing biophysical conditions and in terms of functions to which the zones are intended. Consequently, policies and stakeholders have not overcome the challenges faced in the definition, determination, use and management of the zones in Kenya.

There are inherent challenges faced in the definition of riparian zones in relation to its underlying factors, in Kenya. The concerns relate to removal of vegetation cover and reduction of the riparian width to accommodate urban developments. These issues would only be addressed with a relevant theoretical discourse that links all the elements holistically. The next chapter focuses on the theoretical background to the conservation of riparian zones as a preamble to the theoretical and conceptual frameworks of the study.

CHAPTER 3: THEORETICAL BACKGROUND TO CONSERVATION OF RIPARIAN ZONES

3.0 Introduction

This chapter examines the theoretical background to conservation of the riparian zone with a view of filling the missing research gaps identified in chapter two. The theoretical background draws from conservation, land use, rational planning theories and urban design principles which partially explains the theoretical gap. Finally, the systems theory of planning provides an overarching theoretical framework that holistically contextualizes the riparian zone issues. The theory is discussed to encapsulate the concepts that are advanced to holistically explain the research gaps.

3.1 Theoretical Underpinnings of Conservation of Riparian Zones

The concept of a river continuum and theoretical constructs of conservation engender useful perspectives in understanding, identification, demarcation and management of riparian zones. The concept of the river continuum describes physical processes that include geology and climatic elements outside of the river which affect biological processes in vegetation and even animals. These external processes, in turn, affect the physical and biological processes within a river in respect of temperature, nutrients and other elements. The river continuum concept as put forward by Vannote *et al.* (1980) states that:

Producer and consumer communities become established in harmony with the dynamic physical conditions that include width, depth, velocity, flow volume and temperature of a river.

Vannote *et al.* (1980) argues that a river ecosystem is a single continuum that flows ceaselessly from its source to mouth. On this account, ecological factors that include topography, soils, as well as amount, type duration and intensity of rainfall and other climatic elements are known to have major influence on the river ecosystem (Ibid, 1980).

The ecosystem comprises of different river ecosystem elements including flood plains, wetlands, river channel, riverbanks and the adjoining land and land uses. Changes in land and vegetation, clearance of riparian forest, change in agricultural crops and urban development, have fundamental negative effects on the functioning of the river ecosystem (Vannote *et al.*, 1980).

3.1.1 Theoretical and Philosophical Foundations of Conservation

Theoretical constructs that underlie conservation are described. Specifically, Philosophical approaches to conservation are discussed as they embody the determination of riparian zones. The link between riparian zones and conservation theories is finally described.

3.1.1.1 Theoretical Constructs of Conservation

Mitchell *et al.* (2009) conducted a study on “*Conservation theory and forest Management: Foundation, utility, and research needs.*” The study found out that conserving biodiversity is increasingly raising concern to forest and natural resource managers and many stakeholders. The study has advanced the view that theoretical underpinnings of biodiversity and conservation practice has not attracted much research attention (Ibid, 2009).

Mitchell *et al.* (2009) aimed to answer three questions: The first, questioned how robust conservation theories are in predicting patterns and processes. The second is question concerned with the extent to which conservation theories guide conservation actions. How conservation theory should be advanced to gain more strength and utility is the last question. The study sought to answer the questions by organizing conservation theories into four groups.

The first group dealt with conservation reserve and matrix-based approaches. These involve allocating land for preservation through passive or active management. The second group was premised on diversity begets diversity. Using nature’s template involved undertaking a diversity of forest management programmes against mimicking patterns created by natural disturbance regimes to achieve desired results.

The third construct entailed fine filters, meso-filters, coarse filters and hotspots. This group focuses on species, ecosystem elements and areas of high species richness. The last construct involves patchworks, networks and gradients. These are mainly models of landscape configuration.

According to Mitchell *et al.* (2009), conservation theories primarily advance ecological principles focusing on niche, population, regulation and disturbance theories. The theories also encompass broader scientific underpinnings such as chaos and hierarchy. In this regard, conservation theories may be linked to niche theory and natural selection which suggests a strong linkage between conservation biology, biodiversity and species

competitive dynamics (Ibid, 2009). The theories are also linked to succession and boundary theory in ecological systems.

The methodology of the study by Mitchell *et al.* (2009) entailed assessing utility of conservation theory. Ten (10) forest management and conservation programs from across continental USA were evaluated. These case studies represented a range of scales including size, forest types, management organizations and management objectives. Evaluation involved interviews of one to three representatives who happen to be from each program. The interviews entailed a standardized set of questions that were asked the interviewees with the goal of assessing the relative importance of conservation theories that guide planning and implementation.

The study found out that most planning efforts make extensive use of conservation theory and that the theories are often used in combination to form conservation approaches. All the theories received high utility scores. Coarse Filter (CF) emerged as the leading theory followed by Matrix Management (MM) and Fine Filter (FF).

The study also established that conservation practitioners did not generally view the theories as contrasts to each other. The theories within conservation management models which underlie diversity beget diversity and using nature's templates and landscape configuration which underlie patchworks; networks and gradients groups were consistently viewed as complementary.

The study by Mitchell *et al.* (2009) provides lessons on the need to examine different theoretical approaches in conservation of riparian zones. Whereas, land users, practitioners and policy makers may view different riparian zones issues in contrasting ways, the factors which underlie the riparian zone should be examined holistically rather than in an isolated stand-alone manner as is the case in Nairobi River Basin.

3.1.1.2 Philosophical Approaches to Conservation

Mitchell *et al.* (2009) argues that there are two alternative geographical and philosophical approaches to conservation of biological diversity. These are the establishment of conservation reserves and management of unreserved portions of the landscape or matrix. These two are land protection or preservation and natural resource management approaches. Conservation reserves are generally large areas in which maintenance of native *biota* and natural ecosystem processes are the main management objectives

(Mitchell *et al.*, 2009). According to Mitchell *et al.*, conservation reserve approach to preserving *biota* has a long history and deep philosophical roots and dates back to several centuries.

In the study, the theoretical basis for reserve-based strategies revolve around island biogeographic theory and recently, on meta-population dynamics (Mitchell *et al.*, 2009). The island biogeographic theory connotes “islands” of suitable habitats surrounded by “seas” of unsuitable terrestrial landscape habitats (Ibid, 2009). Consequently, efforts are focused on creating large reserves.

Meta-population dynamics as a theoretical construct builds upon the concept of habitat islands but is focused on specific species or population interacting through individual movement between them (Mitchell *et al.*, 2009). However, the intervening areas between suitable habitat matrices are treated as unsuitable ignoring their potential role. This theoretical construct of conservation is significant in understanding the challenges of conservation of riparian zones in Nairobi River Basin where focus has been on highest and best economic use of riparian land (Kiamba, 1986) ignoring the functional benefits of riparian zones.

In the USA, modern preservation programs began with the establishment of national parks, wildlife refuges and wilderness areas on federal lands (Mitchell *et al.*, 2009). As a result, reserves are the dominant paradigm of modern conservation biology aimed to protect fully the existing habitat and populations from direct human modification (Ibid, 2009). The reserves are viewed as “known qualities” with regard to their ability to provide suitable habitat for native *biota*: the reserve capture known elements of biodiversity and ecosystem processes and reserves function as reference sites (Ibid, 2009).

The Kenyan national and game reserves have been created along the USA model where one is not allowed to bring in or take out anything without authorization (Lelo *et al.*, 2005). However, the concepts of reserves as introduced in Kenya appear to contradict African traditional settings where nature harmoniously co-exists with people (Mwangi, 1994). As a result, people have difficulties in understanding why they cannot co-exist with nature as land matrices.

Based on the foregoing, Mitchell *et al.* (2009), notes that reserves have major limitations as the only tools for conserving biological diversity. To fully protect *biota*, a reserve

system would have to be comprehensive, adequate and representative and replicated. This is difficult to achieve using most credible scientific standards because of lack of sufficient total area, inadequate representation of natural ecosystems and pervasive influence of human society (Ibid, 2009).

In terms of area, a common preservation goal is 10 to 15 percent of total land area of a country (ANRA, 1997). The goal of representativeness is difficult to achieve as most productive lands have already been converted to other land uses (Dimas and Gabriel, 2008).

3.1.2 Linking Conservation Theories to Riparian Zones

Conservation reserves are the main theoretical constructs of riparian zones in Kenya, but they are generally utilized as land use matrices (Kenya, 2004). This is where property boundaries are considered as centre line of rivers. Following this, there is a gap that needs to be filled through appropriate definition, determination, use and management of riparian zones in relation to rural and urban land use.

The concept of riparian reserve used in Kenya at the moment, seemingly, fails to meet most conditions outlined in the theoretical construction of conservation reserves. Instead, there are developments which have mushroomed in reserves of lakes and along watercourses in Kenya (Kihagi, 2000).

The priority in defining and setting aside riparian reserves under Kenyan laws seems to be influenced by the need to protect the reserves from modification by land use activities. However, the priorities are apparently weak as there is consistent failure to enforce effective boundaries between the reserves and other adjoining land uses. This makes adverse environmental effects from adjoining land uses to continue undermining the ecological worth of these reservations.

The new Land Act of 2012 enacted under the new Constitution (Kenya, 2010a) has not improved the situation either. The new Act has retained the definition of a riparian zone in the Survey Act (Kenya, 1961) which has definition in relation to tidal rivers only. The non-tidal rivers appear the most affected.

3.2 Theories of Development and Underdevelopment

Theories of development and underdevelopment are explained from the perspective of poverty hypothesis and theories of land use change. Finally, a link between riparian zones and land use models is described.

3.2.1 Poverty Hypothesis

The level of development in a country depends on the capacity to create wealth and provide social goods (Faille, 2009). This is why socio-economic progress is part of the debate on alleged social and economic backwardness of African countries. Leys (1975), Ochola (2007) and Faille (2009) have noted that, in the 1960s, economic conditions of the majority of Sub-Saharan African countries were more favourable than in South East Asia. However, during the last 40 years, South East Asian nations have achieved economic “miracles” while Sub-Saharan Africa stagnated and, in fact, lost earlier economic gains (Ochola, 2007; & Faille, 2009).

Several theoretical perspectives have emerged to explain disparities in social and economic development in African countries. These include core-periphery theories, theories of unequal economic exchange and dependency. However, these theoretical perspectives have focused more on historical circumstances that underlie poverty. The theories to some extent offer part explanation for encroachment and degradation of riparian zones in Nairobi River Basin because they deal with broader development issues including land use planning and development.

Leys (1975) and Ayonga (2008) have explained underdevelopment in Kenya from the perspective of dependency, dualism and core-periphery. Dualism theories in particular have categorized countries as developed or underdeveloped, urban or rural, rich or poor with different sets of policies for each. The central theme in core-periphery, on the other hand, is that development spreads out or diffuses from a core region with modern economic sectors, towards peripheral regions which are in the first or pre-industrial stage of development (Friedman, 1987; and Briassoulis, 2001).

Connected to these perspectives, is the view that poverty is considered the main cause of overdependence on natural resources in emerging economies. Accordingly, wetlands, forests and other natural resources are overused and their productive capacities grossly undermined in these economies (Okpala, 2000; & UN-HABITAT, 2003).

In Kenya, colonial policies of racial segregation and post independent state policies of income differentiation were based on these underdevelopment theories. In the city of Nairobi, for example, Western and Northern neighbourhoods were reserved for European and Asian races. Lack of investment in infrastructure and services followed to support this segregation especially in African settlements in Eastlands neighbourhood. The main consequences of racial differentiation included extensive construction of slums which are today a dominant feature of urban land use (UN-HABITAT, 2009).

Although Kenya presented a strong case on the country's commitment for planned settlements, to the UN Conference in Stockholm in 1972, successive national development plans have failed to achieve expected results (Mwangi, 1994). The general hypothesis in formulation of national plans is that the economic improvement planned through centralized planning and policies would translate to poverty alleviation and achieve improved standards of living.

However, poverty has leapfrogged 50 years after independence (Kenya, 1999a; and Kenya, 2010b). The poor are seen as both agents and victims of environmental degradation. But, it remains a point of policy debate whether the poor are the main culprits in encroachment and degradation of riparian zones (UNHABITAT, 2003).

The urban poor, who cannot afford the high cost of housing, construct shanty settlement in riparian zones (Menya, 2008). In addition, they have also encroached in other reserves including road and railway reserves. However, these are better protected through appropriate policies and laws. There is also evidence of allocation of riparian land to high income earners (Kenya, 2004). It appears that the urban poor and the rich would encroach on any land they perceive as vacant where policies and laws are not clear and where there is weak enforcement.

3.2.2 Theoretical Approaches to Land Use Change

Theories of land use change, neoclassical land rent theories, behavioural, and structuralist/institutional and planning traditions are examined.

3.2.2.1 Theories of Land Use Change

Briassoulis (2001) has noted that theories of land use change are applied with a view to understanding the “what” and the “why” of land use change. The view advanced is that

land use change is an outcome of processes that include consumption patterns, lifestyles, technological change, population growth and urbanization (Ibid, 2001).

The “why” aspect would lead to better understanding and, therefore, change what people do. Briassoulis has clarified that the “why” in human-nature relations is best understood through the social side of the equation. Understanding the nature of individuals and societies that create the “what” of that change simplifies the explanation of land use change (Briassoulis, 2001).

3.2.2.2 Neoclassical Land Rent Theories

The neoclassical approach is one of the positivist paradigms which seek to establish generalization of the spatial structure in the organization of phenomenon (Odero, 1997). Fundamental to this approach is the continuing search for generalizations and laws that explain and predict phenomena by emphasizing spatial distribution and interaction of land use.

According to Nzau (2003) and Odero (1997), Von Thunen advanced in 1826 the view that the location of agricultural land use that offers greatest rent will make the highest bid for land and will, therefore, displace all others. The theory by Von Thunen assumes that land has homogeneous fertility, productivity and transportation costs which are constant in all direction from a monocentric market place (Nzau, 2003). The theory advances the crop model concept that explain a zonal organization of crops around a market as well as an intensity model concept which explain that land use densities would decline with distance from that market.

Following Von Thunen, the urban land market theory by Alonso in 1964 (Nzau, 2003) described the spatial structure of an urban area from the perspective of behaviour of households in residential housing. The main concept is bid-rent of a household which Alonso viewed as the maximum rent that can be paid for a unit of land for a household to maintain a given level of utility of that land. Alonso’s theory also assumes a mono-centric flat, continuous and uniform urban area.

In studying urban land use in relation to riparian zones, the land use intensity model appears better placed to explain the problem. Using the intensity model, relationship between the distance from central business district (CBD) and encroachment and degradation of the zone can be examined. The theory would postulate that the highest level

of encroachment and degradation of the riparian zone would be more intense in the city centre, declining farther away from the centre.

However, from satellite imagery of the city of Nairobi (DRSRS, 2003; 2008), encroachment appears less intense near the CBD probably because of strict enforcement of policies. There appears to be more spatial concentration and spread of land use in the 30 metre farther from the CBD (Kimani *et al.*, 2009). In Nairobi River Basin, it seems that CBD and distance factor are not the main factors that contribute to spatial encroachment and degradation of riparian zones as explained in the Von Thunen model.

In the city of Nairobi, there are areas where land uses are well laid far from the riparian zone despite the high land values including Nairobi Arboretum, Kamukunji open public grounds (Kimani *et al.*, 2009). There are also schools, churches and major hotels situated next to the river, but, do not encroach and degrade the zone. It appears that the nature of land use plays a critical role in encroachment and degradation of riparian zones and not its relationship with the central place.

The two theories though important in explaining the spatial distribution of different land uses, fail to take into account contributions of policies and public institutions, implications of land use and prevailing biophysical factors and opinions of actors in determining the use of the zones. The theories also disregard historical circumstances, political realities and effects of technological changes.

Land rent theories also present a prisoner's dilemma for the urban poor who cannot afford high transportation costs away from work places. Studies have shown that as transportation costs increases, ability of the poor to pay for transport costs decreases. On the other hand, the poor cannot afford high values of land close to central places (Nzau, 2003). The consequences are encroachment of illegal and dangerous areas such as riparian zones (UNHABITAT, 2003). This is especially the case where policies are not properly formulated and enforced.

Critics of the neoclassical and human ecological theories attribute land use patterns and processes to poor policy and institutional environment (King'oriah, 1980). Theories of human ecology include concentric zone, central place, multi-nuclei and sector theories.

Seemingly, the nature of land use, effectiveness and clarity of policy measures, enforcement of development control, attitudes of land users are non-linear across board which rule out generalizations using quantitative linear equations. Clearly, this is a limitation of neoclassical theories which advance the use of linear equations (Odero, 1997). The theories though significant in explaining broadly, spatial patterns of land use adjacent to rivers, fail to integrate complex dimensions of the problem in dealing with space and time.

3.2.2.3 Behavioural Approach

The approach argues for cognition, information processing and attitude formation concerning behaviour. It is applied in inductive investigations of behaviour while trying to discover generalizations (Odero, 1997). According to Odero, behavioural approaches are centred on a wide range of variables including motives, values, preferences, perceptions and opinions. The approach is useful in understanding attitudes, information flows and motives behind encroachment and degradation of riparian zones.

Unlike explanations from neoclassical theories that focus on spatial patterns of land use, behavioural approaches illuminate on the process that create spatial variations in land use. In applying behavioural theory in the study, the main concern of land users would be on how far land use should extend in relation to riparian zones and why. Policy makers on their part would be concerned with reasons for encroachment and degradation of riparian zones despite existence of policies and institutions mandated to safeguard them.

The concern of professionals would be on how much land to allocate the riparian zone to protect the river and the criteria that would apply in determining riparian zones. The decision making process by land users, professionals, policy makers and public institutions, therefore, raises important concerns because the spatial environment created by their decisions have to ameliorate riparian zone conditions lest they lead to incongruent land uses.

Different land use models have emerged concerning location and distribution of land uses. According to Odero (1997), decision makers do lack perfect information for making location choices. Secondly, decisions and choices that are often made rarely optimize leave alone maximize profits (Ibid, 1997). Behavioural approaches, therefore, advance the theory that entrepreneurs tend to satisfy multiple goals other than profit-maximization.

These include the security maximization, risk minimization, self preservation and satisfaction (Ibid, 1997).

Using the theory in the study as applied by Odero (1997), a land owner/user along the riparian zone could be influenced by factors such as income levels, levels of education, land tenure type, availability and affordability of housing, land values, type and nature of land use, biophysical characteristics of land, clarity and effectiveness of policy measures. Others include roles of institutions including enforcement, monitoring and evaluation of policies, information flows from institution including awareness creation and education and boundary conditions of riparian zones.

Odero (1997) has further suggested that it is possible to have entrepreneurs or land users in different locations who make decisions differently. It is also possible to have two land users in the same location reacting in contrasting ways to one stimulus and, therefore, lead to different decisions. These explanations are quite useful in the study.

It is true there are possibilities for different land users in different locations who would make decisions on whether or not to encroach and degrade the riparian zones. At the same time, there would be different land users within the same location who respond differently with regard to riparian zones. In addition, while most formal land uses undergo the same land administration procedures, there could also be different land uses reacting in contrasting ways despite there being similar policy stimuli.

For example, there are situations where different land users are defiling or conserving riparian zones at one location. Notably, those defiling include the new residential flats opposite the Nairobi Arboretum, Gikomba market versus Kamukunji grounds. Those conserving include Nairobi National Museum and Hotel Boulevard.

Eight factors which affect land users' decision-making have been identified by Odero (1997). These include personality, ability, age, education, environmental perceptions, information, nature of land use units and wider cultural setting, processes and objectives. Odero concludes that many factors that affect land use decisions are interrelated and this makes it difficult to measure the significance of any one factor in isolation (Ibid, 1997). There is also a presumption that information and other processes are dictated by roles, attitude and responsibilities of institutions as well as policy measures in place (King'oriah, 1980).

Values of individuals and motives are not always consistent with the behaviour of individuals (Odero, 1997; and Briassoulis, 2001). The focus of analysis around the behaviour of an individual fails to account for factors such as the role of institutions and their policies, the nature of land use and technological changes. In addition, there are practical difficulties connected to generalizing to the behaviour of an individual due to the plurality of behaviour. To go round these difficulties, studies of smaller groups of individuals are done to mitigate the challenges (Ibid, 1997).

3.2.2.4 Structuralist-Institutional Approach

Institutional theory focuses on the roles of norms, symbols, myths, belief systems and informal arrangements that constitute culture of organizations (Garson, 2008). As a result, institutions require establishing legitimacy where their influence on human behaviour is by established rules and norms (Ibid, 2008).

Hall and Taylor (1996) have identified the following three broad traditions of institutionalism, namely: (i) rational choice theory that includes public choice model and decision-making model of self-interested optimizers; (ii) principle-agent theories and (iii) liberal market theories. Institutional theory in the study, concerns the behaviour of public institutions that have roles on riparian zones and their underlying factors. The roles include allocation, planning, surveying, development control, monitoring and evaluation, environmental and resource management.

The theory places a lot of emphasis on political and economic conditions that influence decisions that are made which point to the role of the state in development (Ochola, 2007). Problems, constraints and issues in politics are encapsulated in the theory. The role and behaviour of institutions is an aspect that affects formulation, application, implementation, monitoring and evaluation of policies (Wanyande, 1981) concerned with the determination, use and management of riparian zones.

3.2.2.5 Public and Private Enterprise Theories

Public enterprise theorists assume that the government seeks to maximize economic welfare of a country and, therefore, advances the best interest of the public (Modubu, 2009). Modubu further suggests that public enterprise is constrained by four challenges. These are: (i) displacement of social objectives by political objectives; (ii) tendency for direct political intervention in public managerial decisions; (iii) internal inefficiencies in bureaucratic arrangements; and (iv) inefficient bureaucratic activities.

Similarly, Baumol (1983) has suggested that one of the reasons why state-owned enterprises fail in cost minimization is lack of clearly stated profit-making objective which is the overriding goal in private enterprises. Private enterprises happen not to be weighed down by the four challenges in public enterprise theory stated above which make profit maximization their main goal (Ibid, 1983). This explains why profit maximization of private enterprise is a single track objective.

First, it is not possible to state which of the two is more appropriate in resolving the problem of riparian zones. Second, the zone should be a public good that protects the river and enhances livable urban environment. However, the state has failed to secure the zones in the city of Nairobi (Kimani *et al.*, 2009).

Third, private enterprises are better placed to manage riparian zones, but it is imprudent to give them up to these enterprises because it is a public good (McAuslin, 1980). Finally, questions abound on whether the government should transfer riparian zone management functions to private enterprises without giving up ownership. Therefore, it appears that none of the two theoretical approaches is alone suited in all situations. It appears blending of the two into an appropriate partnership is a better option (Home, 2004).

3.2.3 Linking Poverty and Theories of Land Use Change to Riparian Zones

An understanding of the concept of a riparian zone and its underlying factors is complex. It involves the understanding of the changes of land use in response to poverty, neoclassical economic and land use models, behavioural and structuralist- institutional perspectives. It also involves the perspective of public and private enterprise theories.

In a river basin, there could be diverse land use and biophysical variables, multiple behaviours and perceptions of land users and professionals, and many policies and institutions with often conflicting roles that require a holistic structure. In the studies reviewed, the explanation of poverty hypothesis appears weak as the reason for encroachment and degradation of riparian zones.

Scientific studies have already suggested that set minimum prescriptions involving the width and condition of the riparian zone are necessary towards realization of better, protected and functioning riparian zones. Experiences, roles, behaviour and opinions of stakeholders including land users, public officers and professionals are also important in achieving this.

It appears from the foregoing, that different theoretical schemes are used to interpret differently the situations that present in the river basins. However, different places point to different circumstances that would dictate a case-by case determination. Therefore, to overcome the challenges faced, it requires a search for more integrative approaches.

3.3 Rational Spatial Planning Theories

Theoretical schemes discussed in the foregoing sections only partially address the research problem. The schemes fail to offer an integrated understanding of the problem. An examination of planning theories is searched as an alternative theoretical approach.

3.3.1 Concept of Spatial Planning

Sedogo (2002) has defined planning as the means of helping decision-makers decide how to use land by systematically evaluating alternative pattern of land use, choosing the use that meets specific goals and drawing up policies and programmes for the use of the land. It is clear from this definition that planning is a discipline at the centre of decision-making.

Agenda 21 calls for an integrated and more land users-centred approach to planning (UN, 1992). However, land use planning adjacent to rivers has not promoted best use of riparian areas in Nairobi River Basin and has for many years, continued to ignore riparian zones as important urban landscape elements (Menya, 2008).

3.3.2 Theoretical Underpinnings of Planning

Planning as a concept has evolved from the times of the industrial revolution from around 1850 to 1915. There are various planning models based on top-bottom and bottom-up approaches including master planning, structure planning, strategic structure and participatory planning which have been applied in specific times, in the history of planning.

Thomas and Healey (1991) observed that, until 1970s, the planning field was least concerned with questions of values, ethics and legitimacy. The main concerns were reconciling competing claims for land in an orderly manner, providing good or better physical environment, and designing a physical basis for better urban program, as part of a broader social policy. Since that time, the philosophy and methodology of planning have evolved in four distinct but interlinked rational planning theories. These are (i) substantive theory; (ii) procedural theory; (iii) Marxist theory, and (iv) democratic concepts in planning theory.

3.3.2.1 Substantive and Procedural Theories

Substantive theories support a better understanding of the landscape as an interface of natural and cultural processes (Friedman, 1987). They articulate the ideology, purpose and principles of sustainable landscape planning and are mainly descriptive and/or prescriptive (Friedman, 1987). The theories are particularly relevant when planning focuses on biodiversity, conservation or restoration (Ibid, 1987).

According to Faludi (1973), procedural theories, on the other hand, provide recommendations for putting substantive theories into practice and therefore focus on methodological issues. Faludi, therefore, argued that planners draw on substantive theories for information and guidelines but use procedural theories as a framework to organize information in a form that readily permits more direct application of information in addressing planning problems (Ibid, 1973).

Andreas Faludi, a Dutch planning theorist, labeled procedural and substantive theory as theory-of-planning and theory-in-planning respectively (Thomas & Healey, 1991). The distinction is controversial, with many scholars and practitioners arguing that one cannot study process without an understanding of substance, and vice versa (Ibid, 1991).

The typology of the procedural theory advanced by Faludi (1973), posits that procedures or means are the business of planning and planners. Hence, based on distinctions between substantive and procedural theories, systems and rational approaches have dominated planning.

Paris (1982) later argued that the procedural approach advanced by Faludi (1973), assumed that planning is a political and technical. Substantive-procedural distinction remains a popular typology in part due to a symbiotic relationship between rational and systems planning theories and their dominance of academic literature and planning practice (Thomas & Healey, 1991).

This distinction has not fundamentally helped planning in the developing countries. Planning is neither working as a substantive nor a procedural discipline. In Kenya, for example, it is on record that more than 60 percent of urban dwellers in the city of Nairobi live in slums (UNHABITAT, 2003). In fact, Mwangi (2006) argued that “*planning in Kenya is at a blink of the precipice*”, signifying failed planning.

3.3.2.2 Marxist Theory

Public sector planning in the 1950s focused more on nation building through political, economic, and social modernization (Thomas & Healey, 1991). By the end of the 1970s, the paradigm of modernization through accelerated industrialization and urbanization had started to lose its initial appeal (Ibid, 1991).

Neo-Marxist emerged after criticisms that planning had become too centralized, bureaucratic, elitist and non-participatory. With steadily growing urban unemployment and squatter housing, city planners began to question the efficacy of economic modernization model and its static master plans (Hall, 2002). Neo-Marxists blamed the control of the state apparatus, including its planning functions by exploitative capitalists, underscoring complete loss of state autonomy (Leys, 1975; & Kiamba, 1986).

Neo-Marxist theory asserts that the position of individuals within a class hierarchy is what determines their role in the production process. Consequently, class position determines political and ideological consciousness (Leys, 1975). According to Leys, within the Marxian class theory, the structure of the production process forms the basis of class construction.

Pointedly, the neo-Marxist theoretical position appears also weak in terms of resolving planning challenges of developing countries like Kenya. The class position of individuals in the class hierarchy has not determined political and ideological decisions or production processes (Ochola, 2007). To a larger extent, it is an emerging “*petit-bourgeoisie*” who has dictated the outcomes of planning decisions in developing countries for a long time (Kiamba, 1986; & Kenya, 2004).

3.3.2.3 Democratic Concept in Planning Theory

Structural adjustment policies, market liberalization and privatization efforts of the 1980s, collectively constituted the paradigm of neo-liberalism. This shifted the focus of attention to markets as key forces for economic transformation (Ochola, 2007). Goals of public sector planning were redefined drastically, reducing the regulatory, developmental and distributive functions of planning agencies (Ibid, 2007).

In applying the neo-liberal approach, there was institutional shift in the 1980s where planning shifted from traditional city planning offices to those of newly created development Corporations. Semi autonomous government agencies (SAGAs) in Kenya

dealing with regional development issues, water, roads, and environment undertook specific planning endeavors in total disregard of the roles of local authorities. However, this approach failed to cushion the poor who had to invade ecologically fragile and dangerous areas like riparian zones.

Participatory planning also emerged in the 1990s as a vehicle for empowering those who participated in making decisions and choices. In Kenya, new approaches were advanced through enactment of legislation including the Physical Planning Act (Kenya, 1996), Environmental Management and Coordination Act (Kenya, 1999b) and later the Water Act (Kenya, 2002a). The democratic space was further expanded through promulgation of a new Constitution (Kenya, 2010a) and new legislation. The Constitution elevated spatial planning to the national level in anticipation of a participatory environment.

Despite, the new status of planning in Kenya, it has not systematically integrated development planning and environmental management discourses. Physical Planning and Environmental Management and Coordination Acts still operate without much coordination. The riparian zones and other environmental resources are still not properly defined in relation to their underlying factors. Issues of commoditization of urban space have continued to promote land use in designated riparian zones.

In most cases, urban areas and cities in Kenya have no strategic integrated urban development plans. As a result, the spatial layout of land use is organized to direct run-off into rivers without consideration of riparian zones as filters of what goes into the rivers. Yet, the heritage of such urban areas and cities happens to be the river ecosystem which prompted their initial settlements.

It is rather unfortunate that formal planning has confined the rivers at the fringe of physical developments where it is difficult to enforce development controls. Planning has, not adequately responded to the forces of urbanization that has continued to degrade the natural environment.

3.4 Urban Design Principles

Urban design is defined as that part of town planning and architecture that determines the order and form of the city with special emphasis on aesthetics (Catanese and Snyder, 1988). Rapoport (1977), on the other hand, defines urban design as organization of space, time and communication or meaning.

From these two perspectives, urban design is the organization of built space at the scale of its use for different purposes and according to different rules that reflect the needs, values and desires of the beneficiary groups (Rapoport, 1977). Taking this understanding further, Rapoport describes urban design as a complex interrelationship between all elements of the built and un-built space in towns and cities.

The City of San Diego General Plan (2008), states that “*urban design describes the physical features that define the character or image of a street, neighborhood, community or the city as a whole.*” In this respect, urban design consists of visual and sensory relationship between people, built and natural environment. Whereas the built environment includes buildings and streets, the natural environment includes features such as riparian zones and urban parks which shape and are incorporated into the urban environment (Ibid, 2008).

Urban design evolved after the split of planning and architecture in the 1960s (Gosling and Maitland, 1984). According to Gosling *et al.*, planning focused more on land use patterns and socio-economic issues, while architecture on the design of buildings. The design of public spaces became a gap that was bridged by urban design.

From an urban design angle, the question is whether there is a need for design of urban riparian spaces. Opponents of design of riparian zones argue that the zones are primarily natural resources that should be shaped by river ecosystem ecology rather than the forces of planning and urban design (Enger & Smith, 2000). For this reason, the form of the city is ever changing, and it is prudent to prevent land use from closing onto the riparian zones because “*development is evil.*”

Proponents of design of riparian zones including Broadmeadow and Nisbet (2004) on the other hand, argue that the myriad of urban problems is the main cause of environmental woes created by poor structure and form, poor distribution of population, land use and skewed transportation systems. Consequently, they argue that development is good but must be guided into forms that protect the natural environment. This is because of their poor manifestation in spatial forms

Therefore, to safeguard the identity of riparian zones, then some rules and patterns have to be introduced in the form of urban design framework founded on ecological principles (Murphy, 2000). In this respect, the criteria for urban design should be the functions of

riparian zones and quality of the adjoining urban human environment (Hawe & Smith, 2005).

According to the City of San Diego (2008), there are several design principles and co-values relating to existing city form in terms of achieving a compact and environmentally sensitive pattern of development. These include natural environment, open spaces, natural habitat, unique topography and a compact, efficient and environmentally sensitive development. Therefore, the link between urban design and site planning would make it possible for a systematic identification and definition of riparian zones (Ibid, 2008).

It appears that the present goal of urban design in Nairobi River Basin is not a built environment that respects the natural environment (Kimani *et al.*, 2009). The initial physical form of the city was connected with a system of natural open spaces that were characterized by rivers, riparian forests and other vegetation (NRBP, 1999). Over time, urban structures replaced natural spaces that were worsened by failure of institutions to distinguish riparian zones as unique natural urban environments.

Urban design would, play an important role in minimizing encroachment and degradation of riparian zones. Following this, location of urban physical forms would be influenced by imperatives which are sensitive to designated open spaces including riparian zones (City of San Diego, 2008).

However, urban design alone would not possibly ameliorate the challenges facing riparian zones due to complexities related to the legal and policy, multiple institutions, land administration procedures, land use, conservation and planning issues. All these require to be integrated for urban design principles to be effective.

3.5 Systems Approach to Conservation of Riparian Zone

The systems approach to planning and conservation of riparian zones is built from numerous concepts and laws. The approach is considered in the study as significant to the achievement of properly conserved riparian zones. The concept of systems approach is described after reflecting on the integrated resource management concept and the laws of ecology.

3.5.1 Integrated Resource Management Concept

River basins often transcend villages, districts, provincial and oftentimes national boundaries. However, there are attempts to restrict management of water resources within administrative and institutional boundaries rather than to design institutions that reflect the actual coverage (Guthiga & Makathimo, 2010). Large-sized basins often require integration in terms of planning and management.

Integration is simply the design of strategies and programmes for development in large areas including river basins (Hanna and Slocombe, 2007). Integrated resource management concept was a planning and decision making process in the coordination of resource use with a view of optimizing long term sustainable benefits (Ibid, 2007).

The ecosystem approach was developed under the sustainable development concept and convention of biodiversity. The approach recognizes that ecosystems must be managed as whole entities with protected areas serving as reservoirs of wildlife biodiversity (Mc Neely & Scherr, 2001). Mc Neely and Scherr further suggested that biodiversity protection in an ecosystem calls for a coordinated strategy with clear objectives, goals and investments. It encourages protected areas and integrates them fully within planning framework including land use and development plans, national wetlands protection strategies and action plans (Ibid, 2001).

3.5.2 Laws of Ecology

The primary aim of integration revolves around four basic laws of ecology (Enger & Smith, 2000). The first law states that everything is connected to everything else. Based on this law, Ohio Department of Natural Resources, ODNR (2006) in the USA notes that “*riparian protection keeps people out of the danger zone*”. In this respect, every building that suffers flood damage or is in danger of being undermined by stream bank erosion is considered to be located on riparian zone (Ibid, 2006).

The second basic law which is borrowed from physics states that “*matter is indestructible and can only be converted from one form to another*” (Enger & Smith, 2000). Applying this law in the study would imply that riparian zones can be transformed into other forms of land cover. The forms would constitute the use of riparian zones as either land for development or areas for ecological functions.

The third law states that; “*nature knows best*” (Enger & Smith, 2000). The implication here is that the best innovations or technology ought to be as much concomitant with nature. Conservators argue that natural environmental systems have the requisite capacity to serve human beings if properly used and protected (Ibid, 2000).

The fourth law states “*every gain is won at some cost.*” The law introduces the concept of sustainable development where anything that is used by human beings must be replaced (UN, 1992). In this respect, conservation of riparian zones is one of the most important steps in the protection of river ecosystems (ODNR, 2006). This is because green riparian vegetation enhances ecological qualities of rivers while in tandem enhancing the value of adjoining properties (Ibid, 2006).

Based on the foregoing, compliance with land use regulations including policies and laws would provide the requirements and standards necessary to protect sensitive areas including wetlands and riparian areas (ODNR, 2006). It would also maintain or increase open spaces for use by people. It would further provide buffers, to minimize impervious surfaces and disturbance of soils and vegetation along sensitive water bodies (Ibid, 2006).

3.5.3 Concept of Systems Approach

According to Saleemi (2009), a system is “*an assembly of procedures, processes, methods, routines or techniques united by some form of regulated interaction to form an organized whole.*” Systems tend to follow basic rules whether natural, physical or biological (Ibid, 2009). Interaction of a system with its external environment could qualitatively acquire new properties where their elements would consist of inputs, processes and outputs (Mugenda, 2009).

McLoughlin (1969) observes that the system is actuated by a control device, supplied with information about its actual state compared with intended state. McLoughlin identifies four common features of all systems. These are: (i) the system to be controlled; (ii) the intended state or states of the system; (iii) a device for measuring the actual state of the system; and (iv) an appropriate technology for correcting external influences and to dissipate “stress on the system.

In a multi-sectoral approach to issues of the riparian zone, methods and theories tend to be biased towards specific interests. Land users, environmental conservators, development planners, water engineers and architects have varied interests, perceptions and concerns.

For example, nature conservators perceive the zone as an area for preservation while city planners are concerned with optimal use of land (Ayonga, 2008). On the other hand, policies and institutions advance different interpretation of the zones to meet government/political programmes. These disciplinary boundaries create challenges that face riparian zones.

The systems approach considers the basic elements of the system as sub-systems (Wilson, 1968). According to Wilson, the approach leads to the study of each sub-system in details, in the context of interrelationship and interaction with other sub-systems and within the system as a whole.

The systems approach as applied in this study provides a unifying concept of the disciplinary barriers with respect to the definition, determination, use and management of the riparian zone. In this way, the systems approach would assist in the removal of imaginary boundaries and, give a holistic understanding.

The systems theory emerged after World War II to address compartmentalization of knowledge. In recent years, “the theory has broadened to include techniques of studying systems holistically and to supplement more traditional reductionist methods where the theory is considered by some scientists as a humanistic extension of natural sciences” (Mugenda, 2009).

Information is an important factor in the systems approach. According to Wilson (1968), information is used in three ways. First, it is identified with data banks and storage systems. Second, information is used in the literal sense and many theories in different disciplines use the notion that individuals and organizations behave according to information available to them and as is understood by them. Finally, the theory of information is closely related to the general systems theory.

Wilson (1968) also observed that accounting and the environment are related to the general systems and information theories. Accounting frameworks have been developed in economics in relation to techniques of input-output analysis. The study of a specific sub-system using the systems approach forces consideration of internal and external environment of such a system. The relationship between accounting and environment with systems approach suggest the need to account for the riparian zone and its underlying environmental factors.

In this study, the systems theory of planning is deemed to provide the missing link because it is concerned with relationships, structures, and interdependence of the riparian zone and its environment. The theory can be used to investigate principles common in complex entities and models (Mugenda, 2009).

3.6 Research Gaps

The research gaps identified in chapter two revealed that the riparian zone should be distinguishable by a continuum of uninterrupted riparian vegetation cover (Vannote *et al.*, 1980) for the zone to ensure that river ecosystems function properly. Hence, the riparian vegetation and width are paramount variables of the riparian zone due to their many functions.

However, this natural continuum of vegetation cover is seriously affected by incompatible physical structures and activities in Nairobi River Basin. The problem is blamed on the emergence of settlements and urban development coupled with the lack of solid and wastewater disposal systems (Karisa, 2002) as elsewhere observed by Broadmeadow and Nisbet (2004) in United Kingdom and Fualing (2004) in Iceland.

As a result, there is limited maintenance of riparian vegetation, no improvement of the degraded zones and no recovery of lost riparian areas. In addition, there is no appropriate policy that guides land use and other underlying factors in relation to riparian zones in Nairobi River Basin.

Definitions of the riparian zone reviewed particularly those of Ohio State Department of Natural Environment (2006) and New Jersey State Department of Natural Environment (2008) are based on different attributes that affect the riparian zones including implication of land use and biophysical factors. In addition, the widths of watercourses have been used in the United Kingdom and Malaysia to give a basis for determining the most appropriate riparian width.

However, despite availability of a lot of literature on the subject, these definitions have not been replicated in Kenya. There has been no attempt to test the definitions to accustom them to the local setting where the local conditions and circumstances are different. Hence the relationship between riparian zones and their capability to perform various functions has not been explored in the basin. In fact, the concept of riparian reserve commonly used

in Kenya denotes a conservation reserve yet in reality urban land uses with adverse effects on riparian zones are operating in the zones.

In Kenya, the Survey Act provides the high water mark as an important basis for referencing the determinations (Kenya, 1961). The Physical Planning Handbook (Kenya, 2008) also defines the zone as land on either side of a watercourse that is also important to avoid property owners laying claim to riparian zones that should remain public land. Provisions in the Physical Planning Act of 1996 and other laws are supposed to be applied to regulate land use in riparian zones. However, the laws are weak, and private land rights are exercised in contravention of regulations that govern occupation and use of riparian zones.

The challenge is that most studies conducted in the basin have concentrated on water quality issues. Furthermore, the manner in which the concepts of land, land tenure and land use are defined undermines how the zones are defined, used and managed in the basin. These variables are not considered during the determination of riparian zones.

Studies have also shown that fixed and variable width delineation methods have been used in other countries to delineate the zones. Opponents of fixed width approaches, including Palik *et al.* (2004), argue that boundary limits delineated using fixed width approaches have no functional relationships to the actual riparian areas on the ground. However, proponents including Murphy (2000) argue that the scientific research has not disputed the adequacy of utilizing a 30 metre buffer zone to protect riparian corridors and ensure that there is no significant alteration of riparian functions.

On the other hand, proponents of variable width approach argue that they are more effective in protecting watercourses compared to fixed width methods. However, the high cost of analyzing site characteristics has been considered the main disadvantage of the variable width method. The predicament is that the definition of the riparian zone in Kenya is not based on findings of scientific research.

Based on the foregoing, it is clear that the main research gap relates to an isolated theoretical structure that fails to holistically link these key variables. As a result, there is the improper definition, determination, use and management of riparian zones in the basin. The main issues that relate to the research gap include weak policy and institutional

framework, failure to consider the implication of land use and biophysical variables and challenges of different roles, perceptions and behaviour of professionals and land users.

In order to address these research gaps, the current study focuses on Nairobi River Basin as an urban area requiring urgent research attention. In fact, UNHABITAT (2003) had long established that the basin is the most polluted in Kenya.

3.7 Conceptual Framework

The conceptual framework is moulded from the conceptual and operational definitions of the riparian zone and other key variables synthesized from the literature.

3.7.1 Conceptual Definition of Riparian Zone

The differences between Kenyan definitions and those of other countries notwithstanding, most literature point to a riparian zone being public land next to water bodies. The main differences are in the physical extents and ecological conditions that apply in different situations that present in a river basin at different times. The zones require commensurate physical size in terms of width as well as ecological conditions that will make them functional landscape elements.

An appropriate conceptual definition should combine aspects that are critical in ensuring proper determination, use and management of riparian zones without impairing their physical properties and quality. The conceptual definition of riparian zone in this study is as follows:

Strip of land defined on each side of a watercourse (perennial or seasonal) or adjacent to a stationary water body, containing natural or adapted (planted) vegetation cover, appropriately sized in width and ecological condition maintained to perform social, economic and ecological functions. Specifically, it should be determined from the high water mark where its physical extent should vary according to prevailing biophysical factors, and effects of adjoining or anticipated land uses and on its intended functions or purposes.

Ordinarily, appropriate riparian vegetation could also be implemented in areas affected by human activities. The zone may have grass, shrubs, trees or a mix of the three components. A zone with a mix of trees, shrubs and grass has capability of achieving most functions compared to when it has one or two components. Trees have ecological, social and economic values if naturally situated or established next to the riverbank. Similarly,

studies reviewed have shown that grass has more efficiency in filtering polluted urban runoff.

3.7.2 Key Determinants of the Conceptual Definition

The conceptual definition of the riparian zone is based on four main factors that are used in the development of the theory in this study. The factors include policy and institutional, land use and biophysical as well as those related to professional and land users.

In Nairobi River Basin, riparian zones provide alternative “free” source of land for urban development. Land use factors are grouped on the basis of the type, density and land administration aspects of land tenure and cadastral information. Spatial concentrations and spread of land use in the 30 metres are useful indicators of the implication of specific land use type in terms of waste and incompatible development and activities.

Land tenure and ownership variables are negative externalities that have implication on riparian zones. Specifically, tenure determines likelihood of the land user to construct structures in riparian zones. This is the situation where the boundary of the zone is not clearly defined in relation to private property rights or the boundary is stated as the centre line of the river.

On the contrary, insecurity of land tenure promotes the building of temporary structures. Overall, continued occupation of land that is set aside or considered as riparian zone undermines the ability of the zone to perform its ecological and physical functions. The public is also hindered from accessing the zone for recreation and other compatible uses.

There are three implications of land tenure on the riparian zone. First, riparian condition is undermined through use of land that results to the removal of riparian vegetation cover. Second, properties and life of people on the floodplain are exposed to risks. More importantly, the government does not guarantee ownership by other users because it also lays claim over the 30 metre riparian zone.

Biophysical factors are categorized on the basis of the width of the watercourses, the width and condition of riparian zones, slopes and soils. These factors have implications in the conservation of riparian zones.

Policies and institutions currently in place also determines land tenure, the types of land use, densities as well as solid and wastewater disposal systems that service development.

Policy and institutional environment also influence types of guidelines in performing roles, in perception and behaviour of public officers as well as land users and land development professionals. Effective formulation and implementation, monitoring and evaluation of relevant policies by the national and county governments in Kenya are important so as to promote appropriate institutions for land use planning and environmental management.

Efficiency, effectiveness and quality of land administration processes is another area that has influence on responsiveness and performance of public organizations in defining and enforcing actions in the management of riparian zones.

3.7.3 Choosing a Working Definition of Riparian Zone

The conceptual definition of the riparian zone adopted for the study is difficult to test unless it is operationalized to enable extraction of its features/variables. From the conceptual definition, two main variables were extracted namely: ***riparian condition*** and ***riparian width***.

3.7.3.1 Riparian Condition

The riparian condition is a qualitative measure in this study operationalized in terms of presence or absence of vegetation cover, presence or absence of solid or wastewater, presence or absence of incompatible structures and activities within the zone. Presence of vegetation cover represents good conservation whereas presence of these other conditions is considered an indicator of poor conservation.

Riparian vegetation is the trees, shrubs and grasses existing in their natural state or planted to ensure the zone meets its ecological needs. Vegetation excludes agricultural crops that leave the zone bare after harvest. In this study, the zone is considered as healthy when there is ample vegetation cover and unhealthy where there are incompatible uses and structures as well as solid waste and wastewater.

3.7.3.2 Riparian Width

The riparian width is an element of the zone that ensures an adequate riparian space. The width is a creation of laws and policies which stipulate various aspects of the zone. The width is also a creation of land users, professionals and public officers, who apply their discretion to determine, use and manage the zones. The width is also a creation of nature that determines a unique vegetation structure along the river profile.

Many definitions and methods of delineation of riparian zones make it difficult to know what width to use for different situations that present in the river basin. Fixed width and variable width approaches have been developed in other countries such as USA, United Kingdom, Iceland and Malaysia. However, these require to be examined in relation to local conditions and contexts. Other definitions obtained from Kenyan laws mainly involve multiple legal prescriptions and institutional guidelines that are confusing.

3.7.4 Justifying the Choice of a 30-Metre Working Definition

A standard width is essentially easier to delineate using spatial buffering techniques compared to variable widths. The question is which standard width is appropriate to test the conceptual definition? The choice lies between applications of minimum or maximum widths as stipulated in Kenyan laws. The multiplicity of lower minimum widths in legal instruments in Kenya, poses some challenges. On the other hand, applying any minimum width would leave out other widths that go up to 30 metres.

Hence, this leaves out 30 metres as the most plausible width in the Kenyan legal perspective. In any case, reviewed research studies also indicate that 30 metres are an optimal width that ensures protection of the river ecosystems from pollution and erosion (Murphy, 2000). The use of a 30 metre width on one side of the river from the river bank would, be a standard quantitative measure that can generate and test the variables of the study. The 30 metres would also form a plausible reference for examining riparian condition and width in relation to roles, behaviour and opinion of land users, professionals and policy makers.

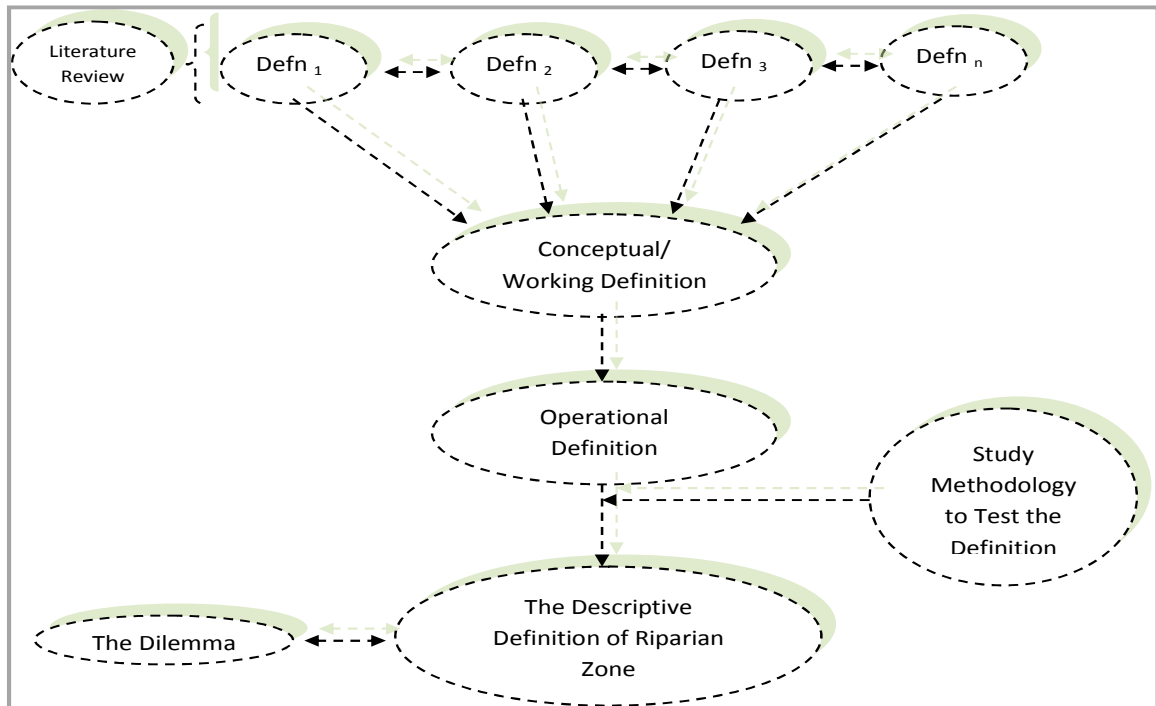
In all fairness conservation is about optimization. It should be a middle ground between total preservation and total development. Fundamentally, land is a scarce resource and, a contested space. A width of 30 metres may be unnecessary for streams because such a significant standard measure would lead to waste of land that may be considered as riparian yet has no ecological value to it. A width of 30 metres might also be inadequate for wider rivers as it would also not perform functions that require wider widths.

For example, 30 metres may not take care of worst case scenario as presented in heavy manufacturing or to accommodate large animal corridors. It might also not protect flood plains and wetlands that extend beyond it. In addition, best case scenarios such as recreational parks may not require any width at all as it is identical with the character of

the zone. This unfolding scenario points towards a variable descriptive definition of the riparian zone.

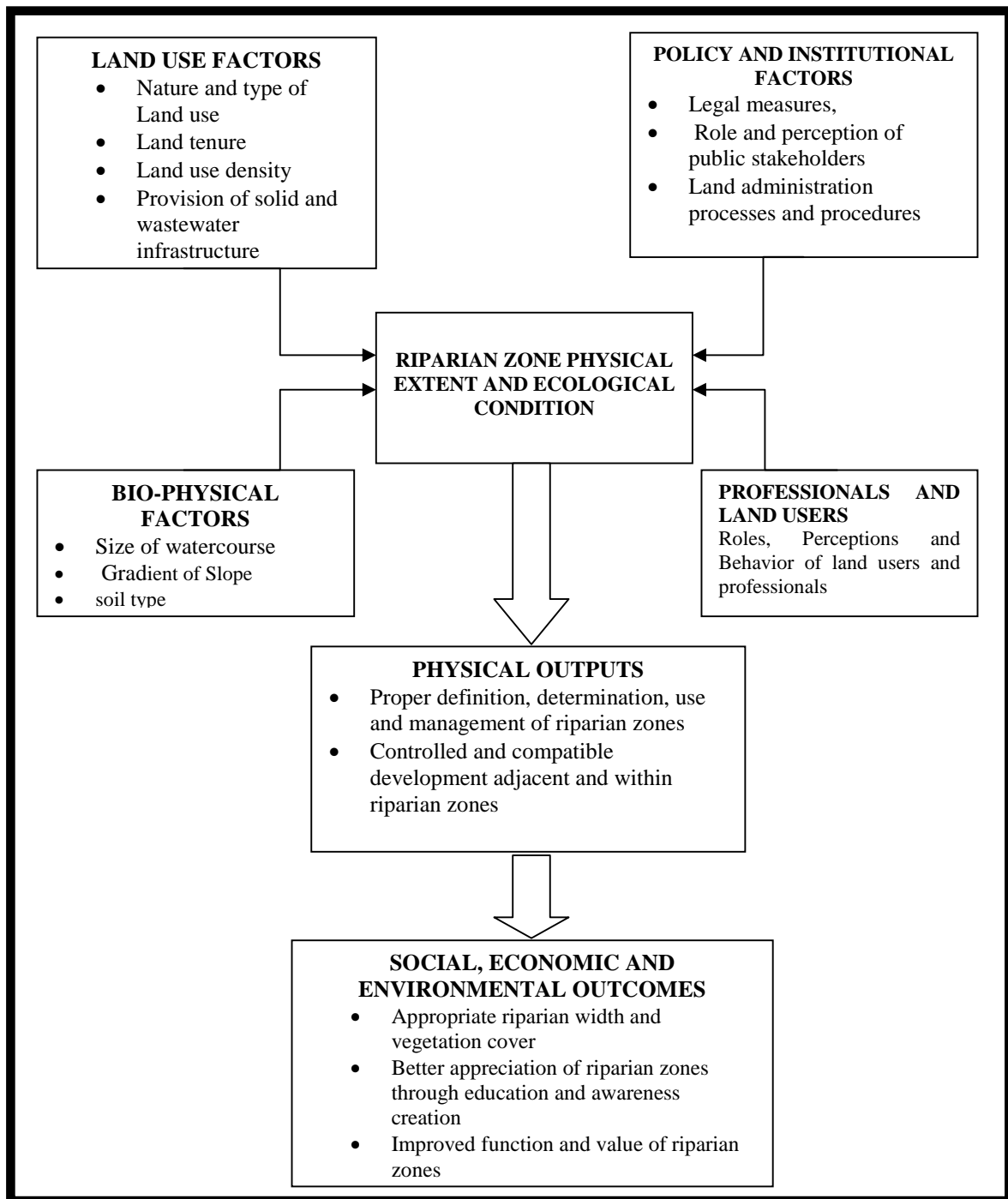
Figure 3.1 presents the critical path that should be followed to arrive at a descriptive definition of riparian zones in a changing urban land use environment of Nairobi River Basin.

Figure 3.1: Critical Path for a Descriptive Definition of the Riparian Zone



The linkage between the riparian zone and its underlying factors is best presented in a conceptual model. Figure 3.2 presents the conceptual model of the study which shows that policy and institutions, land use and biophysical as well as professional and land users' factors interrelate through interactions in the use of riparian zone resources. The relationships not only lead to physical outputs such as changes in the location of ecological boundaries of the zone, but also it is a process that leads to socio-economic and environmental outcomes that have positive or negative implications at large.

Figure 3.2: Conceptual Model for Conservation of Riparian Zones



3.8 Chapter Summary

The chapter has presented various theoretical schemes seeking to explain the definition of the concept of the riparian zone in relation to its underlying factors. In the absence of a specific theory that holistically links conservation of riparian zones with these main factors, the study has narrowed down to the systems theory of planning as the main proponent theory. Chapter four that follows discusses the research methodology adopted for the study.

CHAPTER 4: RESEARCH METHODOLOGY

4.0 Introduction

The primary objective of this research was to assess factors affecting determination, use and management of riparian zones in Nairobi River Basin. The research sought to answer the question of whether existing policy and institutional factors, land use and biophysical factors as well as professional and land users' factors influence conservation of riparian zones in Nairobi River Basin. This was with a view of proposing an integrated model for determination, use and management of riparian zones.

This chapter begins with a description of theoretical perspectives and epistemological positions that informed the research design and research methods applied in the study. The chapter also describes data needs, sampling methodology and methods of data collection, analysis and presentation in an objective-based logic.

4.1 Theoretical Perspectives behind the Study Methods

The research study sought to build a body of knowledge that would give reasons for encroachment and degradation of riparian zones in the urban setting of Nairobi River Basin. There are many epistemological perspectives that accompany philosophical positions (Mugenda, 2009). Epistemology concerns questions of what is regarded as acceptable knowledge in a discipline (Bryman, 2008).

Gray (2004) argues that an epistemological perspective is important in a study, because it helps to clarify issues of research design and provides an overarching structure of the research. This applies especially on the evidence being gathered, from where and how it is interpreted. According to Gray, epistemology provides a philosophical background for deciding what kinds of knowledge are legitimate and adequate (Ibid, 2004). Epistemology is, relevant to research designs and methods that are chosen for the study.

According to Gray (2004), the choice of a research method is influenced by the research methodology chosen, which is in turn influenced by the theoretical perspective adopted. The theoretical perspective is in turn, influenced by the researcher's epistemological position.

In addition, knowledge of research philosophy helps to decide on which design will work for a given set of objectives (Ibid, 2004). The two frequently advanced epistemological divides are positivism and interpretivism.

Positivism is an epistemological position that focuses on the application of methods of natural sciences to study social reality (Bryman, 2008). The positivist theoretical perspective is an important epistemological paradigm in this study because it is based on the premise that the inquiry should be embedded on scientific observation and, on empirical inquiry. This is as opposed to a speculative study.

Gray (2004) argues that this approach gives a study, a logical and methodological position that deal with the fact and not value. The positivist paradigm assumes that there is a single, tangible reality fragmentable into quantifiable variables and processes (Mugenda, 2009). According to Mugenda, the concept of measurement is central to investigations under the positivist epistemology.

Bryman (2008) further notes that interpretivism is a perspective that contrasts the positivist epistemology. The paradigm advances culturally-derived and historically situated interpretations of the social world (Gray, 2004). In this perspective, there are multiple, intangible realities which can only be studied holistically (Mugenda, 2009).

Mugenda (2009) further argues that constructions that mediate human behaviour are not clearly observable realities in the sense that physical scientists view objects. However, these are abstractions that exist only in the minds of people in different form and levels. For example, when dealing with realities such as riparian zone, there could be several perspectives of the same reality including free land, private land or public land. Multiple realities imply divergent views and, different methods as advocated in this study.

4.2 Research Design

Quantitative and qualitative approaches were applied in the study as advanced by the two theoretical foundations to answer different research questions. The social reality under study did not only entail observation of the natural world, but also the interpretation of aspects that were unique, individual and qualitative. In this connection, a mixed method approach was preferred for the study.

Deductive approach was necessary to test hypotheses to confirm or refute assertions about surrogates that explain the concept of the riparian zone in relation to land use and other underlying factors. Induction, on the other hand, was used to interpret patterns that emerged which suggested relationships between the zone and other factors as experienced and lived by stakeholders. The result of both deductive and inductive reasoning was used to construct relationships and generalizations in the study.

The research methodology of the study was therefore influenced by a combination of factors including the need to observe biophysical characteristics of the zone. It was also important to apply an interpretive perspective to explore multiple roles, perceptions and behaviour of key actors in their natural setting. A descriptive research design was therefore considered most appropriate. However, the design could not be pre-specified as observed by Punch (2005), but emerged or unfolded during the research process.

The process of determination, use and management of riparian zones is complex. The process involves policies, stakeholders and other interests. Oftentimes, each of these interests has different objectives. Other interests include government agencies, professionals in land administration and planning, county governments, county land management boards and urban management boards. In this regard, use of more than one method to analyze issues involved yielded better results.

Other studies including Mwangi (1994) and Fualing (2009) have used mixed methods to collect and analyze data. The study by Mwangi for instance, employed various methods to assess and compare alternative questions that yielded qualitative and quantitative data. The use of multiple methods also focused at enhancing the validity and reliability of data used in the study.

4.3 Understanding the Study Variable Scope

The study was guided by the following four specific objectives. To examine the influence of existing policy and institutional factors, to assess the implications of specific urban land use and biophysical factors and to evaluate the roles of professionals and land users, their perceptions and behaviour towards the determination, use and management of riparian zones in the study area. Finally, the study was to propose an integrated model of determination, use and management of riparian zones in the city of Nairobi.

Following the conceptual framework, the variables that emerged relate to clarity of policy measures and institutional roles and perceptions. The variables also include land use types, spatial concentration of land use, and land administration variables such as land tenure and cadastral datasets. Biophysical variables included widths of rivers, widths of the riparian zone, riparian vegetation, riparian slopes and soils. Other variables related to roles, perception and behaviour of professionals and land users towards conservation of the zones.

4.4 Understanding the Study Geographical Scope

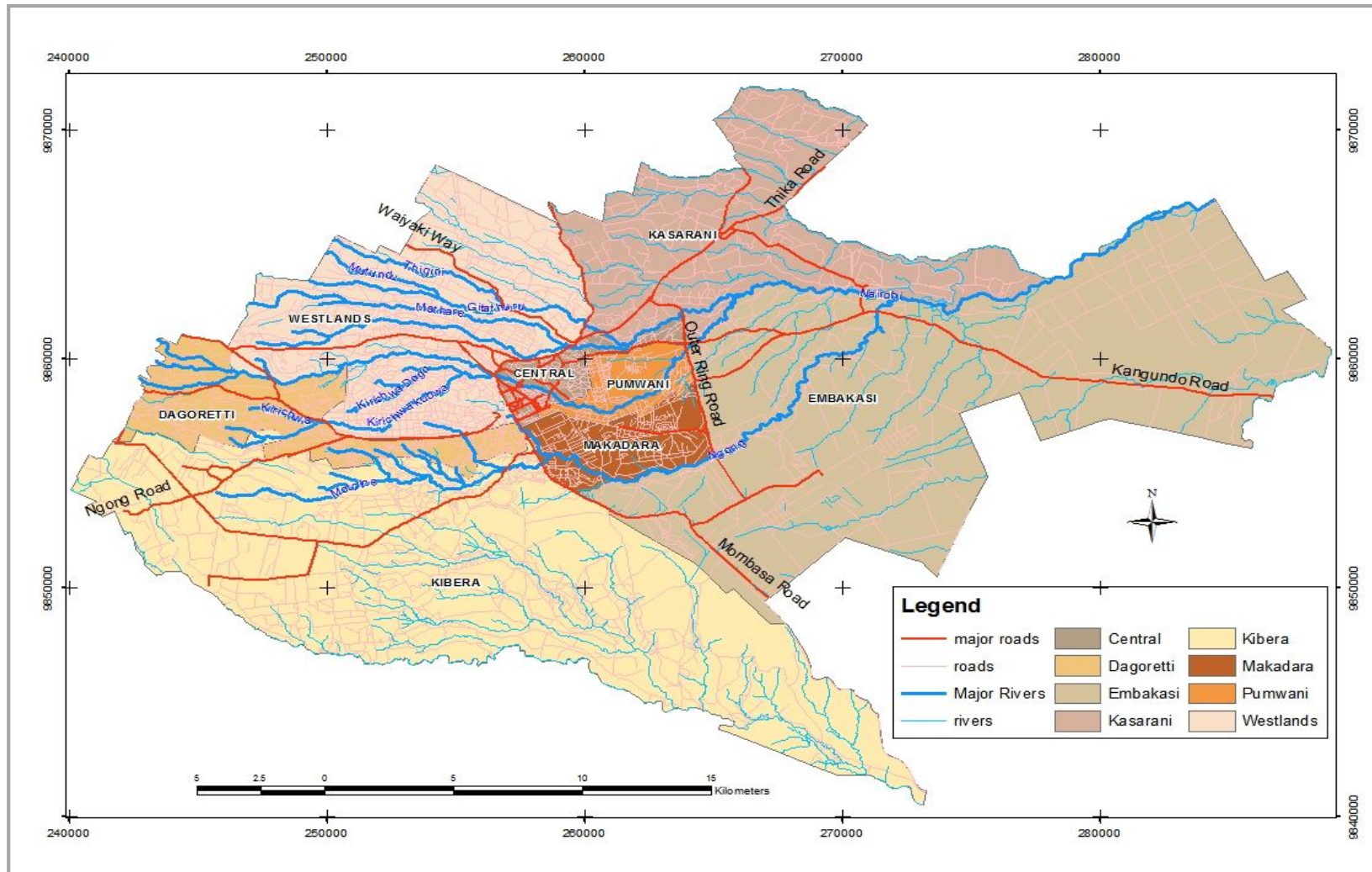
The rivers of Nairobi River Basin and specific study sites where data was collected are described.

4.4.1 Description of Rivers in Nairobi River Basin

The study area is in Nairobi River Basin. The Basin is part of the larger Athi River Basin which drains the Southern part of the Tana and Athi Rivers. The Athi River, drain into the Indian Ocean at Mamburi, North of Malindi Town in Northern Coast of Kenya. The Athi River system has three distinct bio-regions of fertile forest hills of Southern Kiambu, undulating upland savannah grassland of Athi and Kaputei plains and extensive semi-arid midlands (Kahara, 2002).

Nairobi River Basin is important in Kenya's urbanization process because of its influence on the Nairobi Metropolitan Region which is the largest urban region in East and Central Africa. The rivers that form the Nairobi River Basin traverse many rural and urban land uses. In the past 20 years, the riparian zones of the Nairobi River and its tributaries underwent rapid change and transformation from settlements to accommodate the ever-growing population. Figure 4.1 presents the city of Nairobi and its rivers.

Figure 4.1: Map of City of Nairobi and its Major Rivers



Source: Compiled from Topographical Maps of the Department of Surveys

The main rivers that traverse the city of Nairobi are; (i) Nairobi, (ii) Ngong which is also called Motoine in upstream areas and (iii) Mathare. Nairobi River is a major watercourse that crosses the city in a North-South direction. The River has numerous small tributaries. The main tributaries are Ruiru, Kamiti, Ruaka, Karura, Gitathuru, Mathare, Kirichwa and Motoine-Ngong.

In the basin, upstream of the city, the rivers are fast flowing and have steep banks. Farming is the predominant land use in the valleys. Riverbanks are encroached which causes siltation in the river channels. At the mid-stream, the rivers flow through highly urbanized locations with commercial, institutional, slum settlements, trade, industrial and recreation land uses.

The lower reaches of the rivers have gentle slopes. The rivers flow at low speed carrying suspended sediments and erosion materials which are deposited in the floodplain. The rivers are highly polluted with raw sewerage and industrial effluent (Kahara, 2002).

4.4.2 Profile of Land Uses Adjoining Nairobi Rivers

There are various land uses in the 30 metre riparian zone along Ngong River. There are many informal settlements including Kibera, Mukuru Kayaba, Mukuru Reuben, Mukuru Njenga and Sinai villages which encroach on the zone. Other land uses include low income residential areas of Kayole. The riparian zone is also dominated by industries, urban agriculture and quarry mining activities some located at the edge of the river.

There are several informal settlements along Mathare River including Kosovo, Mathare 3A, 3B, 4A and 4B. Downstream of the river is Mathare North, Kariobangi North and Baba Ndogo slums which are located close to the riverbank. Kibagare stream has mainly formal developments registered during colonial times including parcels of land where Nakumatt Ukay Hypermarket and Oshwal religious centre are located. Car parks for Nakumatt Westgate close to Nakumatt Ukay Hypermarket are also on riparian zone.

Upstream of Nairobi River, are two tributaries of Kirichwa Kubwa and Kirichwa Ndogo that have low density residential housing along river valleys. The area is fast transforming into high density urban development following review of the zoning policy on zones 3, 4, 5 by the City Council of Nairobi. Residential flats have been constructed on the riparian zones in this area. The centre line of the river is used as the property boundary following subdivision of land that includes the 30 metre riparian zone.

Along Nairobi River, informal businesses at Gikomba market, informal housing at Kitui village, Kyambio, Korogocho and at Kariobangi light industries, have encroached on and degraded the riparian zone. There are also garages at Uhuru estate along Rabai road. The riparian zone also has institutions including University of Nairobi, Nairobi National Museum, Hotel Boulevard, Kamukunji secondary school and Moi Forces Academy among others that have not encroached or degraded the riparian zone.

The rivers underlie consistent pattern of encroachment by formal and informal residential, business, industries, urban agriculture and quarry mining. Scenes of Quickbird satellite images of 2003 and 2008 obtained from DRSRS confirm that most sections of the riparian zone in the basin are covered with built structures.

On the other hand, public and private institutions including Kamukunji secondary school, Moi Forces Academy, University of Nairobi, Nairobi National Museum, Hotel Boulevard, and religious ones, are noted to have left more than 30 metres from the riverbank. Most have plenty of vegetation cover within the riparian zones. This is also replicated by urban parks and public recreation grounds (Arboretum, Kamukunji grounds).

4.4.3 Selection of Rivers for the Study

Sampling of rivers was judgmental based on the 2008 Quickbird satellite image. The image shows concentration of land uses along rivers in the city of Nairobi.

4.4.3.1 Selection Process

Selection of rivers for study depended on specific factors including their lengths as measured in the satellite image. The other criterion was concentration of land use units in the 30 metres from the existing river bank as observed after GIS buffering of the satellite image.

The satellite image shows less encroachment of the 30 metre riparian buffer at the periphery of the city especially along Gatharaini, Rui Ruaka, and Gitathuru Rivers. As a result, despite their physical length, these rivers were less likely to answer the research questions. Other rivers, upstream of the city including Motoine, Karura, Thigiri and Mutundu were also observed to have relatively less encroachment of the 30 metre buffer by urban land uses.

Nairobi, Ngong and Mathare Rivers have a diverse mixture of forest land, farms and extensive land uses within 30 metres from the riverbank. The rivers are developed with formal and informal residential housing, commercial and industrial activities among other land uses.

Nairobi River has characteristic vegetation cover as well as a mixture of urban land uses. The main land uses observed in the 30 metre buffer of the Quickbird Satellite image of 2008; and subsequent field observations were institutional, formal residential, informal residential, informal businesses, garages and urban open recreational ground. However, Nairobi River has no heavy manufacturing industries which were mainly observed along Ngong River.

From the foregoing, Nairobi River was chosen for institutional, informal businesses and garages while Ngong River was chosen for industries, urban agriculture and quarry mining study sites. Kirichwa Kubwa River was chosen for high income residential sites. Informal residential areas were observed virtually in all the three major rivers of Nairobi, Ngong and Mathare. However, to ensure wider representation, informal settlements within 30 metres along Mathare River were selected for the study.

Nairobi, Ngong and Mathare Rivers did not have high income residential land uses in the 30 metres which were observed in other rivers including the Kirichwa Rivers. In other high income residential estates including Muthaiga and Karen, there were fewer encroachments compared to the Kirichwa Rivers. Therefore, Kirichwa Kubwa River was selected ahead of Kirichwa Ndogo because it is longer and was observed to have more land use units in the 30 metre belt compared to Kirichwa Ndogo River.

Quarry mines and extensive urban agriculture were observed in the lower reaches of Ngong River, particularly at Mukuru Kwa Reuben and Mukuru Kwa Njenga areas. The canalized section of Kibagare stream was observed to exhibit unique land uses located in the 30 metre riparian zone. The uses include Nakumatt Ukay hypermarket at Westlands. Proximity of these land uses to the river predisposed them as useful sites for data collection to interrogate the research problem.

4.4.3.2 Sample Size

Study sites on each river in Nairobi River Basin, were selected using purposive sampling technique. Table 4.1 shows the main rivers that traverse the city of Nairobi and their

estimated length. The number of selected rivers represents about 38 per cent of the total number of the major rivers that traverse through the city.

Table 4.1: Nairobi Rivers and their Lengths

No.	Name of River	Length (km)	Whether River was Selected for the Study?
1	Nairobi	49	Yes
2	Ngong	27	Yes
3	Gatharaini	20	No
4	Mathare	19	Yes
5	Rui Ruaka	17	No
6	Gitathuru	13	No
7	Kirichwa Kubwa	12	Yes
8	Motoine	11	No
9	Karura	11	No
10	Thigiri	8	No
11	Kirichwa Ndogo	5	No
12	Mutundu	5	No
13	Kibagare Canalized	11	Yes

Source: compiled from Scenes of Quickbird satellite of 2003 and 2008

4.4.4 Selection of Study Sites in the 30 Metre Buffer

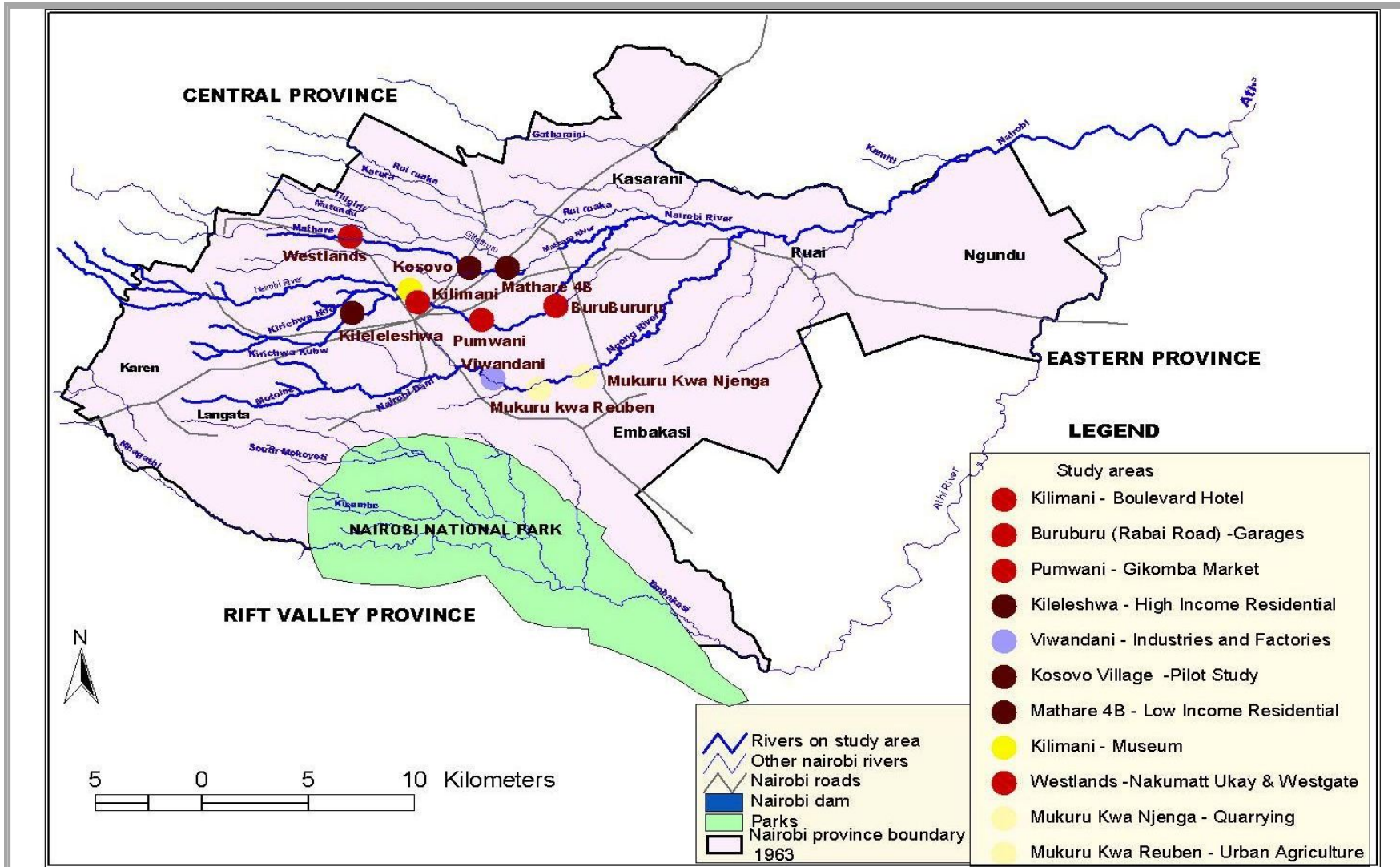
The choice of study sites was based on the fact that riparian zones are always in association with water bodies. Therefore, the land next to watercourses in the city of Nairobi was the primary consideration. The next step involved buffering of existing satellite imagery to delimit the working definition of 30 metres on one side of the river from the river bank.

The next criteria were based on the urban land use, their spatial concentration and spread within the 30 metres. Bad practice was based on encroachment and degradation including removal of vegetation cover, pollution and development of structures and carrying out of activities in the 30 metre buffer. On the other hand, best practice was based on land use units with spread of vegetation cover in the 30 metre zone. It was also defined by lack of the above conditions that represent encroachment and degradation. Biophysical characteristics of the river profiles in upper, middle and lower reaches also dictated the distribution of study sites. Some sites were selected in the upper, middle or lower reaches of the rivers as defined in the 1963 city boundary.

The study focused at concept development and, needed both qualitative and quantitative data. In this respect, sampling of study sites was done with a purpose in mind where one or more specific pre-defined land uses were sought. Therefore, judgmental or purposive sampling assisted in reaching out the targeted sample quickly. The target population transcends boundaries of the administrative units because it is distributed along rivers. Hence, census data was not useful as a basis of determining the sample sizes. However, probabilistic sampling was done to select land use units within some study sites that had multiple sub- units.

The main reason of choosing multiple land uses was essentially to eliminate bias and improve on reliability, internal and external validity of the study. In this respect, testing the conceptual definition using different land uses ensured that generalizations could be made to similar land uses in other locations, in the basin. Figure 4.2 shows the location of the study sites in relation to rivers that traverse the city of Nairobi.

Figure 4.2: Location of Study Sites



Source: Compiled from Scenes of Quick bird Satellite image of 2008

4.5 Research Procedures

The research process started with location of the problem in empirical and theoretical perspectives. Review of empirical and theoretical literature illuminated critical aspects that informed the theoretical framework of the study. This led to the construction of a conceptual framework for choosing dimensions of the problem that were explored. In this regard, the conceptual framework of the study was treated as part of data.

Theoretical and methodological perspectives were important contextual tools in the delineation of the scope for clarifying the nature of data for the study. Overall, this strategy helped to link key concepts with the physical realities with regard to the determination, use and management of riparian zones in the basin.

Design of data collection tools, pilot study to pre-test the tools, training of research assistants, research authentication and authorization and issues of data management and ethical considerations are important milestones that preceded the research.

4.5.1 Data Collection Tools

A data collection tool refers to an instrument used for collecting data (Mugenda, 2009). Data collection instruments were developed to collect both qualitative and quantitative data based on the objectives of the study. Mugenda and Mugenda (2003) indicated that data collection instruments could be questionnaires, interview schedules, observational forms and standardized tests.

To ensure reliability and validity of data gathered, methods including observation and key informant interviews were conducted alongside administration of questionnaires. Observation schedules were designed to capture data on the physical extent and ecological quality of riparian zones. Finally, document analysis was used to collect secondary data.

4.5.2 Research Management and Ethical Considerations

Research authentication and authorization, training of research assistants, pilot study and ethical considerations were the tools and procedures necessary to ensure that the research was objective. The period within which the research was conducted is also described.

4.5.2.1 Research Authentication and Authorization

Pursuant to research authorization and ethics as required by the Laws of Kenya, the researcher met the requirements in Form-A (Revised 2009) “*Application for Authority to*

Conduct Research in Kenya.” This was done at the Ministry of Higher Education, Science and Technology, in the Department of National Council for Science and Technology. The researcher was hence granted permission to conduct the study. See Appendix 2 for the Research Authorization Letter and Permit.

4.5.2.2 Training of Research Assistants

Three research assistants were trained in advance to enable collection of the data needed for the study. The wide geographical and variable scope of the study required not just the participation of the researcher, but more personnel to collect the data. The research assistants were initially engaged to correct data from the pilot study site. The exercise was used to check consistency amongst the assistants and their understanding of the research questions.

4.5.2.3 Pilot Study

Kothari (2004), states that a pilot study is a replica and rehearsal of the main survey and establishes weaknesses of questionnaires and the survey techniques. In this study, a pilot study was conducted at Kosovo village along Nairobi River. The relevance of Kosovo as a location for pre-testing the questionnaires depended on the village having similar characteristics as those of informal settlements and businesses. The village also underwent some planning effort to improve the layout of the settlement and residents have some land allotment letters. The settlement also has some characteristics of formal land use.

The pilot study permitted preliminary pre-testing of the initial propositions of the study. A preliminary questionnaire was designed and pre-tested by picking at random 10 respondents whose housing structures are located in the 30 metre riparian zone.

The pilot study enabled amendment of some research questions which were replaced with new ones that could best represent the reality. The pilot study provided insights on information that was not available at the start of the study. It also provided the researcher an opportunity to evaluate the usefulness of data in relation to the research problem. The pilot study therefore enabled decisions to be made on whether to continue with the study or to explore other alternative questions.

4.5.2.4 Ethical Consideration

According to Kothari (2004) and Punch (2005), a number of key phrases describe the system of ethical protections that contemporary social research establishment has created

to try to protect rights of their research participants. The study upheld to the principle of voluntary participation that requires that people are not coerced into participating in research. The study sought the involvement of participants through informed consent. Essentially, this meant that the prospective research participants were fully informed about the procedures and risks involved in the research and gave their consent to participate.

Ethical standards also require that researchers not put participants in a situation where they might be at risk of harm as a result of their participation. Harm can be defined as both physical and psychological. The study applied two standard practices in order to help protect the privacy of research participants.

Firstly, the research guaranteed the participants confidentiality by assuring that information was not made available to anyone who was not directly involved in the study. Secondly, by applying a stricter standard in the principle of anonymity, essentially the participant remained anonymous throughout the study.

4.5.2.5 Research Period

Data was collected from study sites and professionals in the months of March, April and May 2011. In order to validate the findings of the study sites, more data was later collected from senior officers in selected public institutions in the months of September and October 2011. After the data collected from study sites and professionals was cross checked with the institutions, another visit was made to the study sites in April 2012 to clarify on issues that remained unclear. Data analysis and report writing took place between January 2012 and August 2012.

4.5.3 Monitoring and Quality Assurance

Oso and Onen (2009) observed that it is important to ensure that a research project is well-regulated in terms of its execution from the beginning to the end. To ensure internal validity and reliability of the study results, it was prudent that inferences/conclusions made from the study depicted the reality on the ground in terms of the conceptual definitions. The data collection exercise, data entry, analysis and interpretation, were systematically checked and followed a logical sequence to ascertain clarity and coherence of facts.

Random sampling techniques were applied during sampling of multiple land use units to reduce cases of subjectivity and biasness. Secondary and primary data were gathered using various data collection methods. These included archival, observation, questionnaire and

interview methods. In the questionnaire, some questions were asked differently to check on the convergence of facts. In addition, to ensure that the research could be generalized beyond the limitations of the study, multiple sources of data were corroborated to establish their convergence.

Multiple study sites involving different land use types and different rivers spread at the core of the city were selected. The findings of the study can be generalized with replicable contexts to other similar cases.

To ensure that the referencing was consistent throughout the thesis report, the *Publication Manual of the American Psychological Association* (American Psychological Association, 2010) was used to reference cited literature.

4.6 Objective-Specific Methods

Data needs, methods of data collection, sampling techniques and techniques of data analysis are described for each objective of the study.

4.6.1 Influence of Existing Policy and Institutional Factors

The first objective of the study was to examine the influence of existing policy and institutional factors on the determination, use and management of riparian zones in the study area.

4.6.1.1 Data Needs

The data needs to achieve this objective included policy and institutional data. The main types of data and their sources are described as follows:

i. Policy and legal Data

Policy data included riparian width and ecological condition as provided for in relevant laws and regulations. The laws included Water Act (Kenya, 2002a), Physical Planning Act (Kenya, 1996), Survey Act (Kenya, 1961), the Agriculture Act (Kenya, 1986a), and the Environmental Management and Coordination Act (Kenya, 1999b). Other laws included the Public Health Act (Kenya, 1986b) and Acts of respective Regional Development Authorities. Laws enacted under the new Constitution (Kenya, 2010a) are the Land Registration and Land Act, Cities and Urban Areas Act and the National Land Commission Act.

Information was also compiled from regulations in legal notices. These included Water Resources Management Rules (Kenya, 2007b), Physical Planning Regulations in Legal Notice No. 140 (Regulation 15c) of 13th July 1998 (Kenya, 1998b). Other Regulations included Environmental Management and Coordination Act (Wetlands, Riverbanks, Lakeshores and Seashore Management Regulations (WRLSMR), Legal Notice No. 19 of 13th February, 2009 (Kenya, 2009a) and the National Land Policy (Kenya, 2009b). The Physical Planning Handbook (Kenya, 2008) developed by the Physical Planning Department and local physical development plans (LPDPs) of the city were also a source of policy data.

Literature from published journals, studies, laws and regulations from other countries were also sources of best practices on policies on determination, use and management of riparian zones.

ii. Data on Institutions

Institutional data was collected from the City Council of Nairobi (CCN), National Environment Management Authority (NEMA), Water Resources Management Authority (WRMA) and Departments of Lands, Physical Planning and Surveys in the Ministry of Lands. Data was also collected from the Departments of Resource Surveys and Remote Sensing (DRSRS) and Department of Nairobi River Rehabilitation and Restoration Programme (NRBP) in the Ministry of Environment and Mineral Resources.

Interviews were conducted to collect primary data from key informants in these institutions. Existing records on riparian zones and their underlying factors was obtained from the officers. Data was also collected on roles and application of policies, perceptions, challenges faced in determination and management of riparian zones and suggestions of officers on appropriate strategies for effective determination, use and management of riparian zones. To examine the effects of specific land use on riparian zones, officers were further requested to state their opinion on the effects of specific urban land use on riparian zones. A scale developed for the purpose was used as a basis of ranking opinions.

4.6.1.2 Sampling of Key Informants

The main consideration in the identification of key informants from each institution was the specific nature of responsibility discharged. The officers who were selected were regarded as having control over most information required for the study. Only in very few

cases did junior officers responsible for a specific aspect of the issue participate in the study.

The study leaned more towards a descriptive qualitative approach; hence *purposive* sampling was preferred as the initial sampling technique. In this methodology, sampling is done with a *purpose* in mind, where one or more specific pre-defined groups are sought. The technique was very useful because it was important to reach the targeted sample quickly. Table 4.2 presents specific officers interviewed in sampled public institutions.

Table 4.2: Officers Interviewed in Sampled Public Institutions

<i>Respondent – (Designation of Respondent)</i>	<i>Institution</i>	<i>Justification – (Roles and Responsibility)</i>	<i>Number of Respondents</i>
Director of Enforcement Officer in Charge of Wetlands	NEMA	- Environmental compliance, inspection and monitoring	2
Sub Regional Coordinators	WRMA	- Monitoring, regulation and management of water resources	2
City Planners-Forward Planning, Development Control and Environment	City Council of Nairobi	- Forward planning, development control and environmental management issues	6
Assistant Commissioner of Lands, Principal Administration Officer and Senior Land Officer	Department of Lands	- Allocation of land, registration of land	3
Senior Assistant Directors of planning	Department of Physical Planning	- Land use planning and policy making - Supervisory role on local government	2
Senior Assistant Directors-Cadastral and hydrographic surveys	Department of Surveys	- Surveys for registration of land - Preparation of survey plans and maps	3
Director of NRBP, Environmental Planner	NRBP	- Restoration and rehabilitation of Nairobi River ecosystem	2
GIS Specialist	DRSRS	- Establishment of encroachment on riparian zones using GIS	1

4.6.1.3 Methods of Data Collection

In order to achieve the first objective of the study, secondary and primary data were collected. The data sets focused on the influence of policy and institutional factors on the determination, use and management of riparian zones.

i. Secondary Data

Archival method was used to collect secondary data. The method involved review of secondary data in existing documents and records as indicated in the research design. The main advantages of the method are convenience and cost-effectiveness. In addition, documents and records were readily available. However, the data obtained from this

method could not fully answer the research question on policy and institutional factors and more data was collected from primary data sources.

ii. Scheduled Interview Method

Scheduled interview method was used to collect data from key informants in public institutions (*See Appendix 5*). Structured interview schedules were used to shed light on various roles and opinions of senior officers in public institutions. The interviews helped to elicit and compare information collected earlier from the 12 study sites. The interviews also augmented data obtained from land users and professionals. The interview method built on observations and allowed the interviewer to build on individual responses. The method restricted data collection to formal questions in the interview schedule. The method was time saving compared to questionnaire administration.

4.6.1.4 Data Analysis

The study relied on desktop qualitative and statistical analysis. Qualitative data was analyzed using the technique of content analysis. Qualitative data was presented in a narrative form. On the other hand, quantitative data was processed using SPSS. Quantitative data was summarized in percentages and presented in graphical form including tables and charts to provide a visual relationship between variables.

4.6.2 Implications of Specific Land Use and Biophysical Factors

The second objective set out to examine implications of specific urban land use and biophysical factors on the determination, use and management of riparian zones in the study area. Data needs, sampling design, methods of data collection and data analyzes techniques to achieve this objective are described.

4.6.2.1 Data Needs

Data on land use, land use densities/spatial concentration, land tenure, riparian zone and biophysical characteristics of the riparian zone were collected.

i. Urban Land Use Data

The main surrogates of urban land use studied were residential, commercial, industrial, institutional, urban agriculture and quarry mining. Other types were urban open grounds and parks. Residential and commercial land uses were further categorized as formal and informal for purposes of data analyzes. Formal residential areas were disaggregated into high, medium and low income sub-categories. It was deemed important to select the two extremes in the three sub-categories to give the biggest variation in terms of implication

on the riparian zone. The assumption was that the implication of middle income groups to the riparian zone would fall in-between.

Industrial land use was disaggregated into manufacturing industries and informal garages. Land used by institutions was disaggregated into public and private institutions. The purpose of disaggregation was to make it easier to examine the contribution of public and private enterprises operating next to rivers to the research problem. Nakumatt Ukay Hypermarket site, which is in the riparian zone, was used to examine implications of commercial land use while at the same time the case was used to interrogate application of technology in modifying the riparian zone and river channel.

The main sources of land use data used in the study were building codes and the Physical Planning Handbook (Kenya, 2008). Scenes from Quickbird satellite imageries of 2003 and 2008 with spatial resolutions of 0.6 metres were also sources of land use data on the 30 metre riparian zones. Subdivision plans; parts development plans (PDPs) and office records of the Departments of Lands, Surveys and Physical Planning were the other sources of land use data.

Data on land use was also collected from the Department of Nairobi River Basin Rehabilitation and Restoration Programme in the Ministry of Environment and Mineral Resources, City Council of Nairobi and United Nations Environmental Programme (UNEP). Field inspection of the study sites was conducted as part of ground-truthing of secondary data and information from these sources. Finally, interviews of respondents further provided more information on land use.

ii. Spatial Concentration/ Land Use Density Data

Mathare 4B informal settlement and low density residential estate of Faddville at Kileleshwa was used to establish land use densities in terms of the number of persons per unit area covered by each parcel of land. In Mathare 4B, the density was determined in terms of the number of persons per unit structure. The data that was required to evaluate the densities in these two areas was population in each parcel/structure and size of the parcel/structure. The information was obtained through administration of a questionnaire and field observation.

In the other study sites, the spatial concentration/spread was determined in terms of the number of land use units per unit area of the 30 metre buffer zone. In this study, one unit

area is equivalent to one square metre. In the informal business site, the spatial concentration was determined by the number of business units per unit area. On the hand, in the informal garages, the spatial concentration was determined in terms of the number of garage units per unit area. This was also repeated for agricultural farm units and quarry mine units.

For public and private institutions, the spatial concentration entailed the number of structures in the 30 metres. In the case of formal business at Nakumatt Ukay Hypermarket, the spatial spread of the structure in the 30 metre buffer was used to determine the spatial concentration. The source of data on the spatial concentration was obtained from existing survey plans in the case of formal land use and through buffering the satellite image for informal. Field observation through measurement determined the actual area of land use unit in relation to the 30 metres.

iii. Land Administration Data

Land administration data included both land tenure and cadastral datasets.

a. Land Tenure

Data on formal land tenure was obtained from existing survey plans which indicated the land registration numbers. Data on informal land use was obtained from maps compiled by the Department of Resource Surveys and Remote Sensing (DRSRS and through field inspection.

b. Cadastral data

Cadastral information included dimensions, shape and size of each parcel of land as presented in authenticated survey plans obtained from the Department of Surveys. This information was important as it showed boundaries of parcels of land in relation to the rivers. Cadastral plans that indicated that the boundary is centre line of the river were interpreted to mean that the riparian zone was not isolated as a unique parcel of land as stipulated in the Survey Act. In addition, boundaries of parcels of land defined with a straight line or series of monuments away from the river bank defined unique riparian zone independent of private properties.

iv. Biophysical Data

The width of watercourses, riparian width and ecological condition indicated by presence of vegetation cover, soils and slopes are described as important biophysical factors that influence determination of riparian zones.

a. Width of the Watercourse

The width of the river or stream was for purposes of this study determined from one physical riverbank to the opposite one. The width of the river has a direct relationship with the width of the riparian zone. Bigger rivers carry more volumes of water that cause flooding. Hence wider riparian zones can protect life and property. Smaller streams may not necessarily require very wide riparian zones because their area of influence is smaller.

b. Riparian Width

The width of the zone is the distance measured on one side of the watercourse starting from the riverbank and ending at an estimated position of physical structures or activities incumbent in a sampled land use-unit. The river bank was preferred as point of measurement because other points of reference cited in laws including the high water mark were difficult to establish on the ground.

Data on the width of the riparian zone was obtained by way of GIS buffering of the 30 metre zone using Quickbird satellite image of 2003 and 2008. The riparian width was assessed at the start of an estimated position of the riverbank that extended for 30 metres at the right angle from the river. For this reason, a 30 metre buffer containing vegetation cover, determined on one side of the river and measured with equidistant monuments from the riverbank was an indication of the proper determination, use and management as adopted in the working definition of the study.

c. Riparian Condition

Data on ecological condition covered surrogates that included presence or absence of vegetation cover, solid waste and wastewater and incompatible physical structures and human activities in the 30 metre buffer. Riparian vegetation cover was further classified into three sub-categories of (i) trees, (ii) shrubs, and (iii) grass. Presence of any of the three sub-categories was observed and recorded on an observation schedule. The data on ecological condition was collected through observation and supplemented by photography.

d. Soils

Soil type and its permeability formed part of the physical data that was required. Soil samples were collected after excavating a one-metre deep trial pit at each study site. The soil characteristics in specific study sites were tested by Materials Testing, and Research Department of the Ministry of Roads (*See Appendix 6*) to establish type and permeability characteristics.

e. Slopes

Slopes were calculated from contours plotted at two metre intervals. This topographical data was obtained from a recent LiDar mapping of the city. LiDar is a recent remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. LiDar is used to make high resolution topographical maps. The profile of the cross-section of the riparian zone was prepared at right angles to the course of the river and slope calculated as ratios and percentage.

The slope at each study site was classified into gradient based on criteria developed by the Institution of Surveyors of Kenya (ISK) and published in their practical guidelines on non-title surveys of 2006. The objective of this site analysis was to show variability of different study sites with respect to slope characteristics and therefore limitations of a uniform or fixed riparian width along a river profile.

4.6.2.2 Sampling Design

Multiple techniques were employed in sampling the target population to achieve this second objective of the study. At the initial stages, the study relied heavily on judgmental sampling based on what was shown in the satellite image and based on discussions with key informants and initial reconnaissance survey. Depending on what was shown in the images, subsequent sampling techniques were hinged on whether it was formal or informal.

The sampling frame was developed for formal and informal land use as sampled at different rivers in Nairobi. For formal land uses, the study adopted simple random sampling and was guided by Mugenda and Mugenda, (2003) who stated that, for descriptive studies, a sample size of 10 percent of the accessible population is enough to give valid data. For informal land uses, the study adopted systematic sampling technique as guided by Kothari (2008). The k^{th} value for the systematic approach was every second informal land use in the site blocks.

i. Sampling of Land Use Units

The target population for this study was distributed along rivers found within the 1963 city of Nairobi administrative boundary limits. It was not possible to sample land uses based on national census data which is organized in administrative units. This is because the target population falls in the 30 metre riparian zone which transcends administrative units.

The only available data was from DRSRS (2009) who had enumerated the population in the 30 metres from the riverbank.

However, the enumeration by DRSRS focused mainly on informal land uses and did not take into account all major land uses required to answer research questions for this study. Given the wide scope of encroachment and degradation of riparian zones by formal and informal land uses, it was important to sample land uses based on their capability to answer research questions.

It was necessary to select multiple sites because no single site could fully answer all the research questions of the study. Different land uses were considered more appropriate to show variations in the determination, use and management of riparian zones. The characteristics of each study site in relation to the 30 metre working definition were deemed to provide different pictures evolving in riparian zones.

The study sites were selected using purposive (judgmental) sampling technique to provide variability in terms of the major urban land uses. Selection of these sites based on random sampling techniques would have omitted some important land uses. One advantage of purposive sampling was that sites that did not meet the requirement were excluded. In addition, less time was spent because locations or elongated sections of the rivers that did not meet the criteria were not considered.

Selection of each sub-units of analysis in the study sites was based on parametric techniques for sites with more than one sub-unit. In this scenario, simple random technique was used to select each sub-unit in the formal land uses and systematic random sampling technique for the informal land uses.

For sites with one land use unit like Nairobi National Museum, Hotel Boulevard, Nairobi Arboretum, Kamukunji public open grounds and Nakumatt Ukay Hypermarket, a census was taken. These five cases were important for the study because they are typical cases next to the rivers.

ii. Sampling Process

For formal sites with registered parcels of land in the 30 metre riparian setback, land reference numbers and registered parcel numbers in survey plans and registry index maps (RIM) formed the sampling frame.

a. Steps in sampling the formal sites

1. *Satellite image to identify the land parcels in 30 metres from the river bank*
2. *Survey plans to identify the land reference numbers of the selected sites*
3. *Land parcels with one land use units were purposively selected. These included Nairobi National Museum, Hotel Boulevard, and Nakumatt Ukay Hypermarket, Arboretum, and Kamukunji public open grounds.*
4. *Specific land use sub-units within a study site with more than one sub-unit were selected using simple random sampling techniques. All land reference numbers were written in small pieces of paper, rolled into tiny balls and put inside a basket.*
5. *From the basket, the researcher picked the balls without replacing so as to give every other land parcel an equal chance of being selected for observation.*

The study sites in informal settlements and developments lacked formal registration documents and exhibited informal characteristics. The structures in the 30 metre buffer were identified in a Quickbird satellite image of 2008. Later, the researcher visited the sites to verify the structures. The structures/sheds/farms were later numbered systematically to create the sampling frame.

b. Steps in sampling the informal sites

1. *A 30 metre buffer was shown at each selected study site in the Satellite image.*
2. *The buffer line was then used to identify informal land uses such as (houses, garages, urban agriculture) that were in the 30 metre buffer.*
3. *In sampling informal land uses, the study administered a systematic sampling technique (Kothari, 2008). The k^{th} value for the systematic approach was every second informal land use unit in the site blocks. The k was 2.*

iii. Sample Size

Twelve study sites were selected to examine the implication of land use and biophysical factors on the riparian zone. Table 4.3 presents the sample sizes for both formal and informal study sites.

Table 4.3: Sample Sizes for both Formal and Informal study sites

No.	Study Site	River	Determining factor	Total Units per Site	No. of Sampled Units
1	Faddville high income residential estate	Kirichwa Kubwa	L.R No.	25	14
2	Mathare 4B Informal settlement-	Mathare Getathuro	Structure units	70	35
3	Viwandani Industries	Ngong	L.R No.	10	7
4	Westlands Nakumatt Ukay hypermarket	Kibagare	L.R No	1	1
5	Gikomba Informal Businesses	Nairobi	Shed/space unit	60	30
6	Uhuru Estate informal garages	Nairobi	Garage units	28	14
7	Mukuru Kwa Reuben Urban Agriculture	Ngong	Farm units	14	7
8	Mukuru Kwa Njenga quarries	Ngong	Quarry unit	5	3
9	Nairobi National Museum	Nairobi	L.R No.	1	1
10	Hotel Boulevard	Nairobi	L.R No.	1	1
11	Arboretum Recreational Park	Kirichwa Kubwa	L.R No.	1	1
12	Kamukunji grounds	Nairobi	L.R No.	1	1
Totals (53%)				217	115

Source: compiled from Quickbird satellite image obtained from DRSRS (2003, 2008)

4.6.2.3 Methods of Data Collection

Data sets were collected using secondary and primary data sources.

i. Secondary Data

Archival method was employed in the study to collect secondary data. The method involved review of secondary data in existing documents and records. The main advantages of the method are convenience and cost-effectiveness. In addition, documents and records were readily available. However, data obtained using this method was not up-to-date and more data was collected from primary data sources. In addition, there was limitation of secondary data since it was not collected with the research problem in mind and, lacked the depth and breadth needed.

ii. Primary Data

Field observation method was used to assess the physical width and ecological quality of riparian zones in the selected study site. Site visits and inspections were used to establish actual width and condition of the zone at each study site. Observation of absence of vegetation cover, presence of solid and liquid wastes in the 30 metre zone was interpreted as degradation. On the other hand, presence of built structures in the 30 metres from the riverbank was interpreted as encroachment.

Riparian widths were determined using a measuring tape. The width was also confirmed by taking GIS measurements of Quickbird satellite image of 2008. In some sites with thick riparian vegetation, it was difficult to measure the width from the image because the river channel was invisible. Photography was also used to capture pictorial information on ecological quality of the zone.

The observation method had one major advantage. Data collected by this method was not dependent on the opinion of land users as it existed in its natural state. However, the method could not be used to explain encroachment and degradation of the zone. This weakness justified the use of other methods to support this method.

4.6.2.4 Data Analysis

The study relied on desktop qualitative and statistical analysis with verifications being conducted on any questionable data. Qualitative data was analyzed by describing the conditions and width of the zone as observed on the study sites and as taken using photography.

Statistical analysis involved test of the hypothesis at 5 percent level of significance using *t-test* and *chi-square* for riparian width and condition respectively. This was to confirm the significance of Kenyan policies on the determination, use and management of riparian zones in the study area. Some of the results of statistical analysis were summarized in percentages while others were presented in graphs and tables to provide a visual relationship between variables.

However, GIS spatial analysis was carried out to establish the link between the zone and adjoining land uses, and, therefore, the influence of policies in the determination, use and management of riparian zones. Measurement and buffering of the satellite image was used to analyze the width and condition of the zone in relation to the 30 metre. Areas where the width was narrower than the 30 metres signified encroachment. On the other hand, where the width was found to be 30 metres or more, it showed a good conservation ethics.

Spatial techniques also enabled analysis of areas without vegetation cover and where structures covered the zone. Some activities like urban agriculture were also possible to analyze in terms of the extent but required further ground truthing to establish the type farming that was taking place.

Spatial data analysis techniques were also applied during the assessment of elongated sections of the river to quantify the vegetation cover and nature of land use encroaching onto the 30 metre space. The technique was also used to determine the width of selected rivers at specific locations. Overall, spatial data analysis proved advantageous in analyzing riparian widths and conditions.

4.6.3 Roles, Perception and Behavior of Professionals and Land Users

The third objective of the study was to evaluate the roles of professionals and land users, their perceptions and behaviour towards the determination, use and management of riparian zones.

4.6.3.1 Data Needs

Data on personal profile, roles, behavior and perceptions of land users and professionals regarding current land use, and land tenure, physical infrastructure, compliance with policies and laws and involvement and participation in protection and conservation of the zones were collected. Data needs also involved gaps in existing management strategies and possible strategies for managing the zones in the future.

Professionals who participated in the study included physical planners, land surveyors, architects, land valuers, civil engineers, and environmentalist and land administrators. There were public and private land users who participated in the study. The users were mainly those represented in selected major urban land uses, in the city of Nairobi.

4.6.3.2 Sampling of Professionals and Land Users

The sampling methodology includes the sampling frame and sampling process and size.

i. Sampling Frame

The sampling frame for professionals was based on a list of those who are registered in respective professional bodies and government boards of registrations. Physical planners and surveyors were considered in the study to form the most basic and critical group of professionals who have a direct role in the determination of the riparian zone of any river.

Architects, land valuers, environmentalists, engineers among others form level two of such professionals and, therefore, the information acquired from them was meant to triangulate what physical planners and land surveyors said about the subject matter. Physical planners and

surveyors were therefore sampled using proportionate sampling methods while the other group of professionals was purposively sampled.

ii. **Sampling Process and Sample Size**

To sample planners and surveyors, the study adopted proportionate sampling methodology while at the same time taking note of the size of the sample where Mugenda and Mugenda, (1998) state that, for descriptive studies, a sample size of 10 percent of the accessible population is enough to give valid data.

There were 150 registered planners and 95 licensed land surveyors in Kenya. Out of the 150 planners and 95 land surveyors, 106 and 75 are located in Nairobi respectively. The list kept by respective registration boards formed the sampling frame for each profession based on their physical address.

Ten percent of 181 professionals give a sample of 18 for the study. Getting a proportionate figure for each sample group, the proportionate sample for planners and surveyors are as follows.

1. *Planners - 106 out of 181 multiply by 100 is 58.6%. 58.6% of the 18 is approximately 11 planners; and*
2. *Surveyors – 75 out of 181 multiply by 100 is 41.4%. 41.4% of the 18 is approximately 7 surveyors*

The 11 planners and seven surveyors were randomly picked using simple random sampling technique. The other professionals including architects, environmentalists, engineers, land administrators and land valuers were sampled purposively by picking at least three per profession giving a total of 15. A total number of 33 professionals were sampled for the study.

4.6.3.3 Methods of Data Collection

Data from professionals and land users was collected through questionnaires. Data was also captured from secondary sources.

i. **Secondary Data**

Secondary data relevant to the study in the custody of professionals and land users including local development plans, allotment letters showing allocation of the zone and permits from local authority authorizing activities in the zone was collected through archival method. The

method involved review of secondary data in existing documents and records. The main advantages of the method were convenience and cost-effectiveness because the records were readily available. However, secondary data was not conclusive and required further collection of data through a survey.

ii. Questionnaires

Questionnaire, as a general term, include all techniques of data collection in which each person is asked to respond to the same set of questions in a predetermined order (Mugenda, 2009). In choosing this method, care was taken to ensure that the instrument was able to collect precise data that was required to answer the set research questions.

Questionnaires were designed and standardized by the researcher to fit the research questions and the target population. Using questionnaires, enabled research participants to be asked precisely the same questions in an identical format and responses recorded in a uniform manner. Standardizing of the questions was meant to increase reliability of the instrument through consistency of the measurement.

Attitudes and opinion of land users and professionals was sought and a questionnaire was the right instrument for this process. Its purpose was to collect much information over a short period which fitted the situation of this research. The use of the questionnaire was justifiable since the target population in the city of Nairobi is literate and therefore required information could be easily described in writing thus saving time.

Questionnaires were administered to land users (See Appendix 3) to capture their opinions, perceptions and attitudes towards conservation of riparian zones. The instrument collected data on levels of functions on existing land use regulations and institutional framework as well as levels of appreciation of the use of riparian zones. A questionnaire was also administered to professionals to capture roles and opinions on determination, use and management of riparian zones.

4.6.3.4 Data Analysis

In analyzing opinions of professionals and land users, both quantitative and qualitative techniques were employed.

i. Quantitative Data

Quantitative data was coded and entered into a designed data entry frame. The data was then cleaned and checked for consistency, validity and reliability before it was analyzed using Statistical Package for Social Scientist (SPSS) computer software. Determination of frequencies and cross-tabulation were used to analyze data from ` professionals.

The main advantages of quantitative data analysis using SPSS lie in the capability to analyze large volumes of data and present the result summaries. The main disadvantages were noted: First, the techniques lacked the requisite capacity for in-depth analysis. Second, the analysis using the techniques missed capturing qualitative aspects of the objectives. Tables, charts and graphs were used to present results of the analysis.

This analysis focused on professional opinion towards conservation of riparian zones. The rating of opinions of the respondents on the effects of each land use type on the riparian zones was sought using a ranking scale of 5 points. Scores were in terms of the extent to which a particular professional felt riparian zone had changed from its natural state. All opinions of professional respondents were not weighted because the outcomes of professional decisions were deemed homogeneous. This is because professionals work under organizational and institutional environment determined by the same policies and laws.

ii. Qualitative Data

This type of analysis dealt with data collected through discussions with key informants land users and professionals. The analysis involved data organization, creation of data categories, themes and patterns and ranks. These were then organized in relation to the third objective of the study. Qualitative data analysis methods helped to understand better why and how riparian zones are encroached and degraded. The method, however, proved to be tedious because each dataset had to be organized into categories before performing the analysis tasks. Also, the results of data analysis had to be corroborated with field observations, secondary data sources and interviews of public officers.

4.6.4 Integrated Model for Determination, Use and Management of Riparian zones

The fourth objective of the study was to develop an integrated model for determination, use and management of riparian zones. Data needs for this objective were obtained from the results of

data analysis of the three preceding objectives. The data sets focused on the development and operationalization of the integrated model. Therefore, specific data on policy and institutional variables, land use and biophysical variables as well as roles, perceptions and behaviour of land users and professionals were synthesized to generate the integrated model.

4.7 Limitations of the Study

The study encountered three main limitations as follows:

1. The first limitation of the study was as a result of inherent use of a descriptive study design which is considered to undermine the objectivity: instead of a purely inferential statistics with its assumption of the standard distribution in the sample population. Potential bias and subjectivity which would affect reliability of results of data analysis and therefore conclusions were overcome by employing a mixed strategy involving qualitative and quantitative methods of data collection and analysis;
2. Second, some respondents working for public institutions were not willing to voluntarily give information in aspects such as illegal land allocations on riparian zones. This limitation was overcome by corroborating limited information from respondents by using multiple sources of data that triangulated the data; and
3. Finally, questionnaires that were mailed to professionals had a response rate of 84 percent. In this regard, only 28 questionnaires out of 33 standard questionnaire responses were returned. This number of respondents hindered use of statistical techniques applicable to the standard distribution of both sample and true populations. However, since the training and work environment of professionals is relatively homogenous, responses from the sample were considered adequate. Professionals implement similar policies under same institutional environment.

4.8 Chapter Summary

This chapter has described in detail the methodology used in data collection and analyzes. Chapter five that follows discusses the growth dynamics of the city of Nairobi that culminates with a description of the background of the study area.

CHAPTER 5: GROWTH DYNAMICS OF THE CITY OF NAIROBI

5.0 Introduction

The spatial and economic growth of the city of Nairobi has been dictated by the governance and spatial planning endeavors since its creation in 1896 as a railway depot. These factors have played a major role in the manner in which environmental management and development planning decisions are made in the city.

5.1 Governance of Nairobi in Perspective

The spatial growth of the city of Nairobi presents serious governance problems especially in terms of spatial planning and distribution of land uses. Poor planning and development control are a direct outcome of poor governance of the city. For example, failure to allocate adequate spaces for environmental resources such as river ecosystems and wetlands during development planning is a good example of poor governance.

5.1.1 Governance in the Colonial Era

The city of Nairobi is the administrative and political capital of Kenya. The city is located at a place where a plain meets the highland. To the South East of the city are the low-lying Athi and Kapiti plains. The highlands extend Northwards and Westwards and cover the rich agricultural lands of the Kiambu County. The Kenya-Uganda railway and the trans-Africa international trunk road pass through the city.

The city of Nairobi was built first as a transport depot during the construction of the Kenya-Uganda railway in 1896. The Nairobi Township Committee formed in 1900 with six members was the first local government for Nairobi. Obudho (1997) described the location to have been a grazing and watering point for livestock but had no permanent African settlements. The place was a common grazing and watering point for Maasai and Kikuyu communities. The name “*Nairobi*” therefore is a Maasai word “*Enkare uaso Nairobi*” which means “*the place of cool waters.*”

Adequate and reliable water supply from Nairobi Rivers and presence of the low-lying and drier Athi plains offered a suitable location for stop-over and suitable site for a railway station. According to Nzau (2003), the site was considered to provide ample flat land for laying railway

tracks and sidings. Elevated and cooler highlands to the west provided suitable land for residential housing construction. The railway administration alienated land for this purpose that was the first step in the establishment of Nairobi.

In 1905, the colonial administration was moved from Machakos to Nairobi and later in 1906, the township was upgraded to an administrative and commercial headquarter of the colonial government. The new town had a population of 10,000 people in an area of 18 square kilometers (Nzau, 2003). By 1909, the internal structure of Nairobi particularly the road network was established but there were still drainage and health problems which plagued the new township. A municipal council for Nairobi was established in 1919 to address these problems and manage the growing township.

However, there were no efforts to provide services for Africans before 1920. Africans who were not employed were treated as surplus that posed health, law, and order menace. This means township planning ignored a large part of the population. Racial segregation was implicit in the earlier plans with separate zones for railway employees, European and Asian traders as well as Asian and African laborers. The 1940's was a period of consolidation of European settler political and economic power by the colonial government and laying the foundation for industrial expansion in the colony.

5.1.2 Governance in Post Independent Era

The City Council of Nairobi, the Nairobi City Commission, the Ministry of Nairobi Metropolitan and presently the Nairobi County Government underlie the governance of the city in the post independent Kenya era.

5.1.2.1 Nairobi City Commission (1981-1993)

The City Council of Nairobi was dissolved in 1981 and replaced with a Commission. The Commission, however, was riddled with serious allegation of corruption (Kiamba, 1986). The city, as a result, suffered serious water shortages, poor solid and sewerage disposal, poor road infrastructure and increasing formation of slum and squatter settlements. This resulted to the "Nairobi We Want Convention" that took a participatory approach with citizens giving their views. The Commission was, however, disbanded in 1993 after public outcry and the management of the city reverted to the City Council.

5.1.2.2 Ministry of Nairobi Metropolitan Development

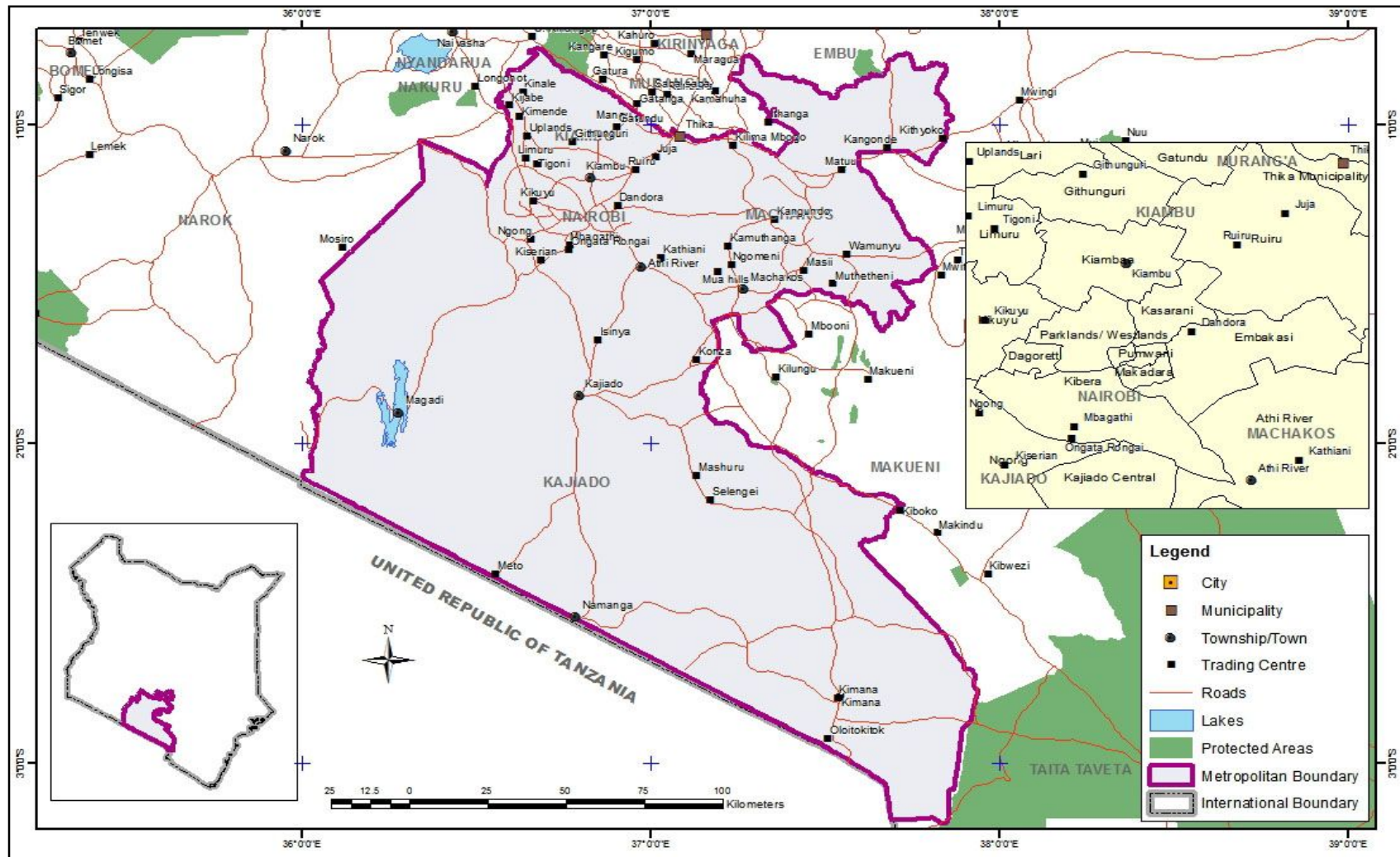
The Ministry of Nairobi Metropolitan Development was established by the Presidential Circular in May, 2008, pursuant to the Kenya Vision 2030. The 1973 Metropolitan Growth Strategy had expired in 2003. Planning and development control discourses in the city have since been implemented on an ad hoc basis. The Ministry of Nairobi Metropolitan was therefore established to handle strategic issues in the greater Nairobi Metropolis.

The ministry was mandated to develop integrated roads, bus and rail infrastructure and efficient mass transport system in the metropolitan area. The Ministry was also expected to replace slums with affordable low cost residential housing. It was also to provide adequate housing, develop and enforce planning and zoning regulations, prepare spatial plans, ensure efficient water supply and waste management, promote infrastructure and promote investment in utilities and services. The overall goals of these mandates were to transform Nairobi into a competitive global city. This Ministry has since been abolished, and its functions taken up by the Nairobi County Government.

5.1.2.3 Nairobi County Government

Nairobi is one of the 47 counties in the newly devolved system of Government. One of the challenges of Nairobi Metropolitan Region is to integrate development over four counties of Nairobi, Kiambu, Machakos and Kajiado which have different administrative structures. There are efforts to involve stakeholders to develop a strategic city development plan, but with low institutional capacity and other management and administrative challenges, it remains to be seen how issues of encroachment and degradation will be handled by the county government. Figure 5.1 represents the geographical boundary extents of the Nairobi Metropolitan Region as sourced from the Ministry of Nairobi Metropolitan, 2011.

Figure 5.1: Map of Nairobi Metropolitan Region



Source: Ministry of Nairobi Metropolitan, 2011

5.2 Spatial Planning Endeavors in the City of Nairobi

Spatial segregation of the City of Nairobi is traced to the capitalist mode of production and historical colonial policies (Leys, 1975; and Kiamba, 1986). The colonial policies of racial segregation and post independent policies of income segregation through spatial zoning of the city are pointers to the environmental changes.

The city of Nairobi has had two major formal city plans since the city was established as a municipal council in 1919. The first plan was the Nairobi Master Plan for a colonial capital. The plan was published in 1948 and led to the elevation of the city into a chartered municipal corporation under the British colonial laws. The second plan was the Nairobi Metropolitan Growth Strategy (NMGS) of 1973. The strategy was a formal policy that sought to guide the physical growth of the city and investments in services and infrastructure for a period of thirty years, from 1973 to 2003 (Mbogua & Ng'ang'a, 1973).

5.2.1 Spatial Planning in the Colonial Era

The planning for a railway town, settler town and later colonial town form the main spatial planning focus in the colonial era.

5.2.1.1 Nairobi Plan for a Railway Town of 1898

The Nairobi plan for a railway town (1898), divided housing within the railway boundary into two residential areas. It laid out an area for Europeans and Asian traders. However, the areas were in accordance to the status of the employees of the railway. There was no provision for Africans in the so called European and Asian settlements.

5.2.1.2 Nairobi Plan of 1927 for a Settler Capital

In the Nairobi plan for a settler capital (1927), considerable attention was paid to residential areas of Europeans and upper class Asians. The attention paid to middle, and lower class Asians and Africans was restrictive in nature.

5.2.1.3 Nairobi Plan of 1948 for a Colonial Capital

The 1948, Nairobi Master Plan was prepared to underline the use of the city as a colonial capital. The municipality had grown as a railway station and later had administrative, commercial and industrial functions. Subsequent years were an era of economic expansion and further growth of settler political and economic power. The town underwent physical expansion because it served as a centre for commerce in the East African territories. In addition, it was the judicial and administrative headquarter of the Kenya colony. This

development translated to planning challenges caused by congestion in African residential areas and at the railway station. In fact, the full grown central business district (CBD) required redevelopment to revitalize commerce and trade. In 1950, Nairobi became a chartered city.

The 1948 Master Plan created the following six land use divisions including (i) the Central Business District (CBD); (ii) industrial area; (iii) public and private open spaces; (iv) public land; (v) residential areas; and (vi) undeveloped land (Obudho & Aduwo, 1988). The plan was formulated on the lines of the “Garden City” concept.

The garden city concept is a method of urban planning initiated by Ebenezer Howard in 1898 in the United Kingdom. Garden cities were inspired by utopian ideas and were intended to be planned as self-contained communities surrounded by greenbelts and parks and containing proportionate residential, industrial and agricultural areas.

However, residential areas were segregated into neighbourhood along racial lines. In the plan, Europeans were settled on the Western suburbs while the lower and middle income Africans and Asians were segregated to the Eastern suburb areas of Ngara, Parklands and Pangani.

The master plan was prepared when the population of Nairobi was only 100,000 people. The projected population was 250,000 people in the next 25 years up to the year 1973. The plan was, however, weak on transportation planning that led to its failure to manage population densities and create the appropriate forum for public participation.

5.2.2 Spatial Planning in Post Independent Era

The Nairobi Metropolitan Growth Strategy (NMGS) and the creation of the Nairobi Metropolitan region are the key milestones that underlie the spatial planning of the city of Nairobi.

5.2.2.1 Nairobi Metropolitan Growth Strategy of 1973

Following the independence of Kenya in 1963, the city underwent capitalist expansion along income segregation lines. However, the city lacked coordinated planning during the first decade of independence with sectoral plans prepared to guide implementation of water sewerage, industrial and housing development.

Rapid rural to urban migration that set in at independence led to informal settlements to meet the housing needs and operational spaces for informal businesses. The formal sector failed to meet housing and employment needs of the migrants and led to the escalation of informal urban sectors. In 1973, the existing water supply for the city could not meet the needs of increasing city population. This followed the preparation of Nairobi metropolitan growth strategy (NMGS) by the Nairobi Urban Study Group (NUSG).

Kiamba (1986) points out that the 1948 Master Plan, guided planning and development in Nairobi throughout 1960s. However, the development of the city after 1973 changed to ad hoc interventions amid political interests of the council and central government. Several committees and commissions were formed to study specific aspects of growth of the city and recommend interventions (Mbogua & Ng'ang'a, 1973).

The Nairobi Metropolitan Growth Strategy (NMGS) is the most elaborate of the interventions proposed. NMGS was sponsored by a partnership of international and local capital and formulated sectoral programmes and projects into metropolitan structural growth strategy. The 1973 strategy had comprehensive proposals for different land uses including highways, public transport, central business district (CBD), housing and employment. The overall aim of the strategy was to harmonize sectoral programs and projects within the overall urban framework for development (Mbogua and Ng'ang'a, 1973). The operational time-line of the strategy was 30 years, from 1973 to 2003. The immediate concerns of the plan were the looming water shortage.

One of the main proposals of NMGS was to decentralize industry to new four industrial locations away from the main industrial area east of the CBD. The four areas were: Kariobangi, Dandora, Ruaraka and Kasarani. Decentralization of the industrial areas has never taken place, and more industries have squeezed in between the rivers and the already existing ones thus affecting the physical extents of riparian zones.

The strategy also aimed at integrating work and housing areas and alleviation of transport problems of the time. However, failure to integrate housing with workplaces resulted in the formation of slums next to rivers. NMGS further recommended the creation of a planning department in the City Council which became operational eight years later in 1981. NMGS, however, lacked the necessary legal backing for planning and implementation.

The 1970s also saw construction of urban infrastructure and facilities to match the needs of the projected population (Kenya, 1974). The City Council of Nairobi received large loans and credit to expand water supply and services and to build infrastructure for large-scale site and service housing schemes (SSHS) and core housing projects.

However, mismanagement of these funds led to financial and political crisis in the Council in the early 1980s (Kiamba, 1986). Problems in the site and service schemes were due to cost increases, delays and political interferences. These problems became endemic and led to the suspensions of the Council that was replaced with a Government appointed Commission.

Abolition of the graduated personal tax (GPT) in 1973 also led to financial problem because GPT was a major source of revenue for the Council. Revenue from water and rental income from City Council houses was not adequate for the Council's expanding financial obligations (Kiamba, 1986).

5.2.2.2 Nairobi Metropolitan Region from 2007

Nairobi Metropolitan region was formally recognized after Nairobi Metropolitan Regional Concept Plan was launched by the Ministry of Nairobi Metropolitan Development in 2008. The study covered six local government units. The 2008 Nairobi Metropolitan Bill was formulated after the expiry of the 1973 plan to give the Nairobi Metro 2030 legitimacy. The Bill aimed to amend the Local Government Act to bring together all Local Authorities within the Metropolis.

The Nairobi Metro 2030 Strategy projected that the population of the Nairobi Metropolitan Region (NMR), which stood at 6.1 million in 2007, would double to 12.1 million by 2030. The region extends to cover 15 local authorities (Kenya, 2010a). The metropolis traverses four provinces of Eastern, Central, Rift Valley and Nairobi covering an area of 32,000 km².

The strategy laid emphasis on the capacity of the metropolitan region to cope with the demands of the population. The Metropolis aimed to consolidate the pull factors from other urban centres of Mavoko, Kiambu, and Kitengela, Limuru, Ngong, Kikuyu and Ruiru. However, the strategy was overtaken by the devolved system of governance that created County Governments.

5.2.3 Challenges of Spatial Planning of the City

The Nairobi Metropolitan Growth Strategy (NMGS) of 1973 did not advocate for segregation but condoned it (Kiamba, 1986). The low-income settlers in Nairobi constitute over 60 percent of the urban population, yet they occupy a dismal 20 percent of the urban land (Matrix Consultants, 1993).

Poor planning and development control have further exacerbated encroachment and degradation of natural resources in the city of Nairobi. Spatial planning has not informed proper determination, use and management of environmental resources. The spatial growth of the city as the primate city in the metropolitan region poses serious threats to these resources unless proper interventions are made.

5.3 Demography, Land Administration and Land Use Dynamics

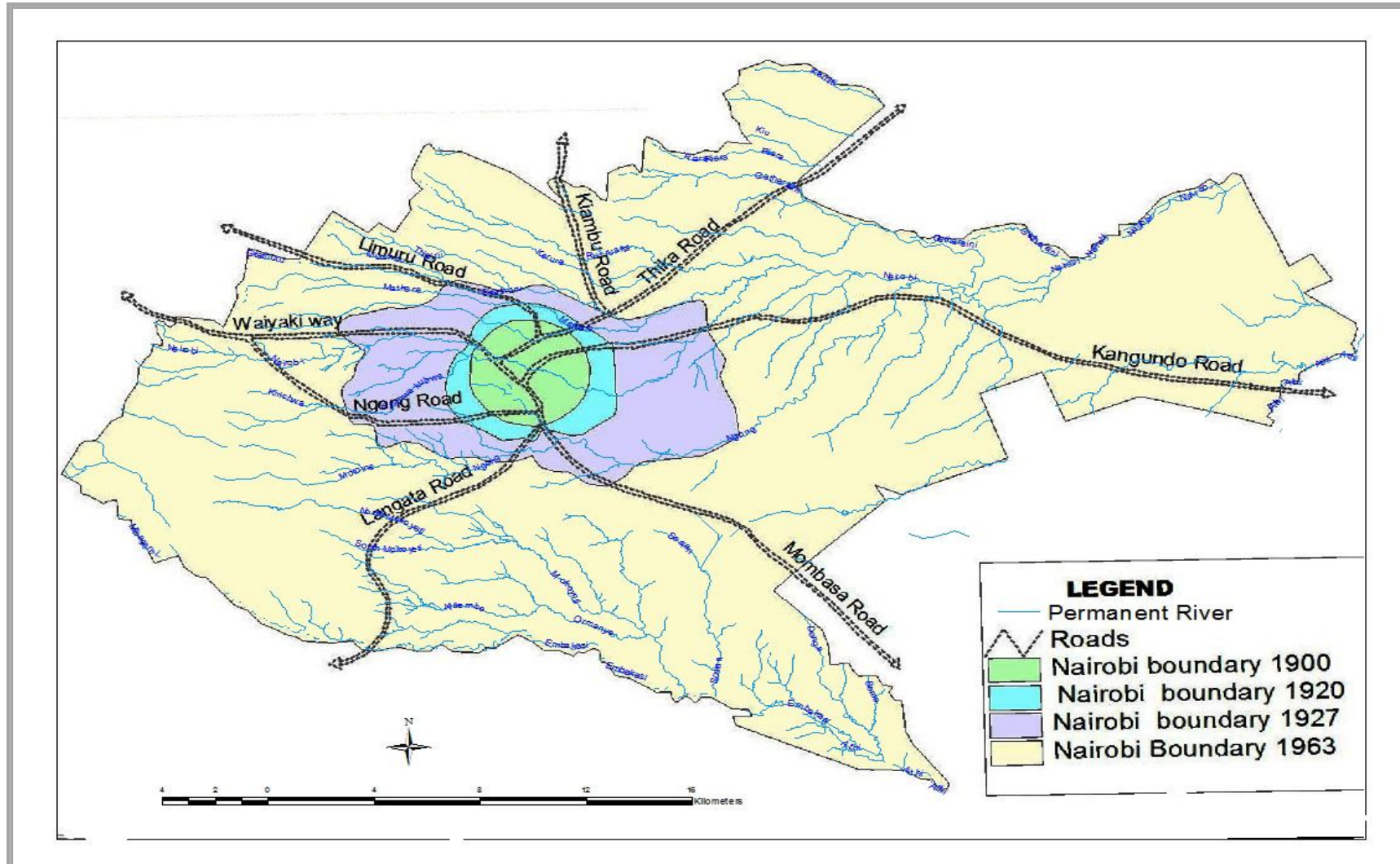
The city of Nairobi has 3.4 million people (Kenya, 2010b). The high rate of population growth coupled with poor land administration practices have exerted pressure on the natural environment in Nairobi River Basin.

5.3.1 Demography

The population of the city during colonial administration was typically low because of its containment policies. African settlements were restricted to areas marked as native reserves and Africans lived in the city on condition that they were employed (Kamau, 2005). After independence in 1963, the population increased due to rural to urban migration.

Figure 5.2 shows the boundary changes of the city of Nairobi. The boundary of Nairobi changed three times during the 68 years of European domination and colonial administration in Kenya from 1895 to 1963. The changes occurred in 1905, 1920 and 1950 and were responses to increasing urban population (Nzau, 2003). The size of the city was increased in the same year from 8,315 to 68,945 hectares. This was a 729 percent increase that enjoined rural areas of Dagoretti, Karen and Langata, as well as Nairobi National Park to the city.

Figure 5.2: Nairobi Boundary Changes Since 1900



Source: Modified from Mitullah (2002:3)

Table 5.1 presents the trend of population growth and changes in the area coverage of the city.

Table 5.1: Trends in population growth in the City of Nairobi

Year	City Coverage (ha)	Population	Density(persons per ha)
1906	1 813	11 512	6.35
1928	2537	29 864	11.77
1931	2 537	47 919	18.88
1936	2537	49 600	19.55
1944	2537	108 900	42.92
1948	8315	118 976	14.31
1963	68 945	342 764	4.97
1969	68 945	509 286	7.39
1979	68 945	827 775	12.01
1989	68 945	1 324 570	19.21
1999	68 945	2 143 254	31.09
2009	68 945	3 138 369	45.52

Source: Kenya National Bureau of Statistics (2010:20), and Mitullah (2002:2)

5.3.2 Land Administration Issues

The Kenyan law evolved from English common law of torts or civil rights and contract. In 1930, all land occupied by Africans were declared native reserves for use and benefit of African natives of the colony forever (Kenya 1991). This was the first time towards categorization of land use based on racial occupation. As a result, it introduced inequalities in the distribution of land, in Kenya where three categories of land tenure emerged. These are government land; trust land and private land.

According to Kamau (2005), 55 percent of the land in Nairobi is controlled by private sector, 40 percent of the land is government land and 5 per cent is under the City Council of Nairobi. Kamau further notes that although the City Council of Nairobi is the planning authority in the city, its control over land owned by the national government and private sector is very weak. At the same time, data on land ownership in the city is accessed at the land registry of the Ministry of Lands where availability of the same information is also weak (Mwangi, 2008). As a result, multiple allocation of land is quite evident in the land registries (Kenya, 2004).

Kiamba (1986) further observed that land allocated for middle and low-income housing in Karen-Langata area ended up as low-density high-income area. In 1972, the government compulsorily acquired Villa Franca Farm located off the Ngong River and another, North

of Nairobi International Airport for low-income housing development (Ibid, 1986). The land measured 463 Hectares. However, the land was irregularly acquired and subdivided. The two cases cited by Kiamba, do explain the misallocation of urban land resulting to invasion or conversion without proper planning and development control policies.

5.3.3 Land Use Distribution and Zoning in the City

The main land use zones in Nairobi are residential, commercial, industrial, institutional, recreational and agricultural. Riparian zones as urban open space systems are not considered distinct land uses that warrant inclusion in the zoning plans of the city.

5.3.3.1 Distribution of Urban Land Uses in Nairobi

Existing pattern of land use distribution in the city of Nairobi reflect colonial polices of racial segregation and weak post independent policies of income differentiation rather than formations based on economic land use models of cities in developed countries (King'oriah, 1980). Table 5.2 summarizes land use changes in the city as captured in satellite images of 1990, 2000 and 2010.

Table 5.2: Distribution of Land Use Types in the City of Nairobi

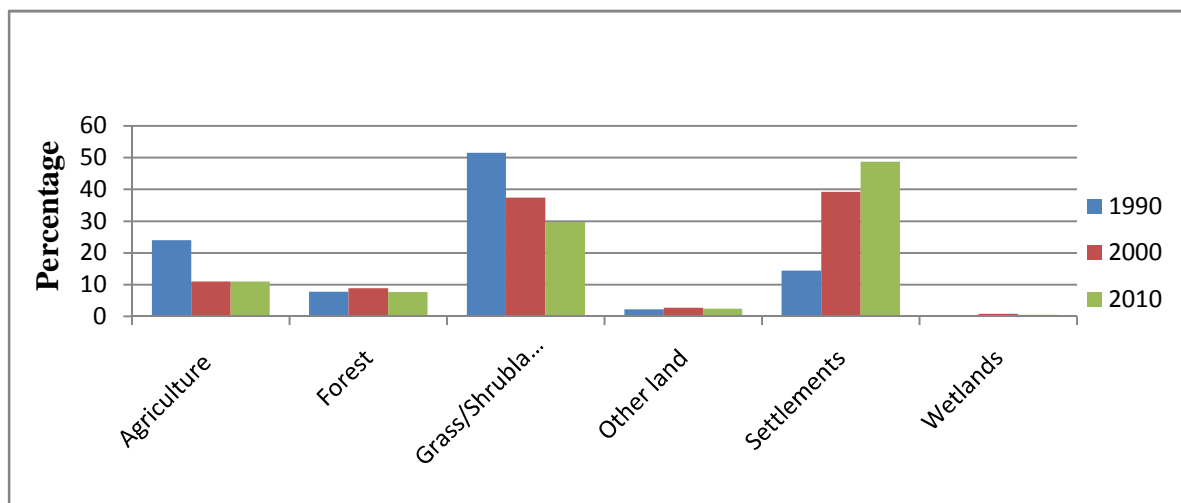
Land use Type	1990		2000		2010	
	Area (ha)	(%) of Total	Area (ha)	(%) of total	Area (ha)	(%) of total
Agriculture	17001.652	24	7786.749	11(10.99)	7765.074	11(10.97)
Forest	5488.890	7.8	6317.463	8.9	5468.678	7.7
Grassland and Shrubland	36486.595	51.5	26469.433	37.4	21021.561	29.7
Otherland	1544.503	2.2	1895.615	2.7	1711.369	2.4
Settlement area	10230.961	14.4	27733.417	39.2	34463.513	48.7
Wetlands	53.026	0.1	602.948	0.8	375.430	0.5
Totals	70805.627	100	70805.625	100	70805.625	100

Source: Compiled from Satellite images of 1990, 2000 and 2010 obtained from DRSRS

Table 5.2 shows a significant increase in the area under urban settlements over the years from 14.4 percent in 1990 to 48.7 percent of the total area in 2010. On the other hand, the area under agriculture reduced rapidly over the three periods as a result of more urban population occupying more urban spaces. Studies including Ayonga (2008) have shown that peri-urban areas are also rapidly transforming into urban land uses. These are converting riparian areas with little guidance of urban policies.

Figure 5.3 presents the trends in land use areas for 1990, 2000 and 2010 in percentage of the total area. Figure 5.3 shows that while grass/bushland was the most predominant land use in the city in 1990, the proportion decreased rapidly to less than 30 percent in 2010. The remaining bushlands are areas which include the Nairobi National Park, Karura and Ngong forests. Urban settlements are on the rise and continue to threaten open spaces, wetlands and other ecologically fragile areas including riparian zones (Kenya, 2004). According to Kenya (2004), most of the planned land parcels were grabbed and had residential and commercial buildings constructed.

Figure 5.3: Land Use Changes in the City of Nairobi



Source: Compiled from Satellite images of 1990, 2000 and 2010 obtained from DRSRS

Table 5.3 presents the number of planned public parcels of land that were irregularly and illegally alienated in the city of Nairobi.

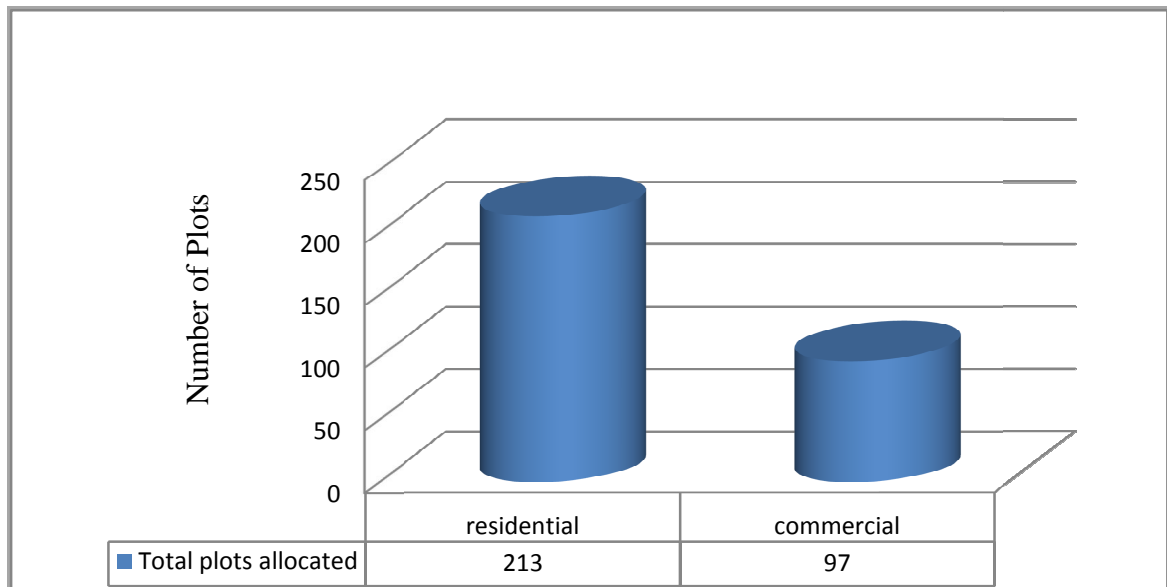
Table 5.3: Planned Public Plots Irregularly and Illegally Allocated in Nairobi

No.	Original User	Number of Plots that Changed to Residential	Number of Plots that Changed to Commercial	Total Number of Converted Plots
1	Open spaces /recreation	123	38	161
2	Public Purpose ¹	49	41	90
3	Public Utilities ¹	5	3	8
4	River Beds, Riparian Reserve	8	1	9
5	Foot Paths and Road Reserves	27	13	40
6	Water Boreholes	1	1	2
	Total	213	97	310

Source: Report on the irregular and illegal allocation of land (Kenya, 2004)

Table 5.3 and Figure 5.4 show that there are far more conversion of public land to residential than to commercial use. The figure shows the need for more formal housing to meet the ever increasing demand for shelter. This shows that threats to riparian zones and other public open spaces by residential and other competing land uses are real.

Figure 5.4: Planned Public Plots Irregularly and Illegally Allocated



Source: Compiled from the Report on the irregular and illegal allocation of land (Kenya, 2004)

5.3.3.2 Land Use Zoning in Nairobi

Zoning is the most widely used tool for urban design and spatial planning. Zoning consists of legal and administrative prescriptions and interventions as well as a map showing specific land uses for the area. Building codes are partly guidelines for implementing zoning regulations and administration. Zoning is presented in the form of maps showing segregated areas of land into residential, commercial, industrial, recreational, institutional and many more.

The overall objective of zoning is to regulate the use and development of land. Development control by way of plan approval enforces zoning regulations. Financial penalties and/or jail terms for non-compliance are also ways of enforcing zoning regulations. According to the Physical Planning Act (Kenya, 1996), zoning is a legal measure to ensure that use and development of land is in accordance with coordinated and approved land use plans. In this regard, the city of Nairobi is divided into 20 major city development zones.

However, the development zones are too broad to recognize important resource zones. The Department of Physical Planning in the Ministry of Lands and the City Council of Nairobi are responsible for preparation and implementation of local physical development plans (LPDPs) respectively. In the new devolved governance system, the Nairobi City County has a mandate to implement the planning law as from March 2013. However, the Physical Planning Act needs to be reviewed to re-align it with the Constitution.

The greatest challenge to enforcement of development control as required by the PPA is continued freehold tenure and ownership of land within the city. This form of land tenure is not subject of land administration processes and therefore residents continue to develop their parcels of land as if development control regulations are not a requirement. Therefore, the administration of farmlands that fell in the city through boundary extension is not subjected to the zoning regulations of the city of Nairobi.

5.4 Background to the Study Sites

The study sites are described based on the selected rivers. The sites include formal and informal land uses.

5.4.1 Study Sites along Mathare River

Mathare 4B informal settlement is a study site sampled to examine the implication of informal housing on the riparian zone. The settlement is located on the North Eastern part of the city of Nairobi, approximately three kilometres from the central business district (CBD). The village is located at the confluence of Mathare and Gitathuru Rivers, and it is one of the informal settlements stranding the 30 metre riparian zone of Mathare River. The topography of the confluence is a floodplain which makes it dangerous for settlement (Karisa, 2002). Sites of quarry mining for building stones are also scattered in the area that contributes to localized steep riverbanks.

According to Kiamba (1986), the Mathare Valley area was acquired primarily by Asians between 1910 and 1920 for quarrying purposes. By the end of 1930's, unauthorized African settlements had started. By late 1960's there were nine villages with an estimated population of between 50,000 and 60,000 people (Ibid, 1986). The entire settlement occupies an area of approximately 73.7 hectares and comprises of smaller settlements including Mathare 3B -3C, Kosovo, Mabatini and Mashimoni Village, Kiamutisya and Gitathuru.

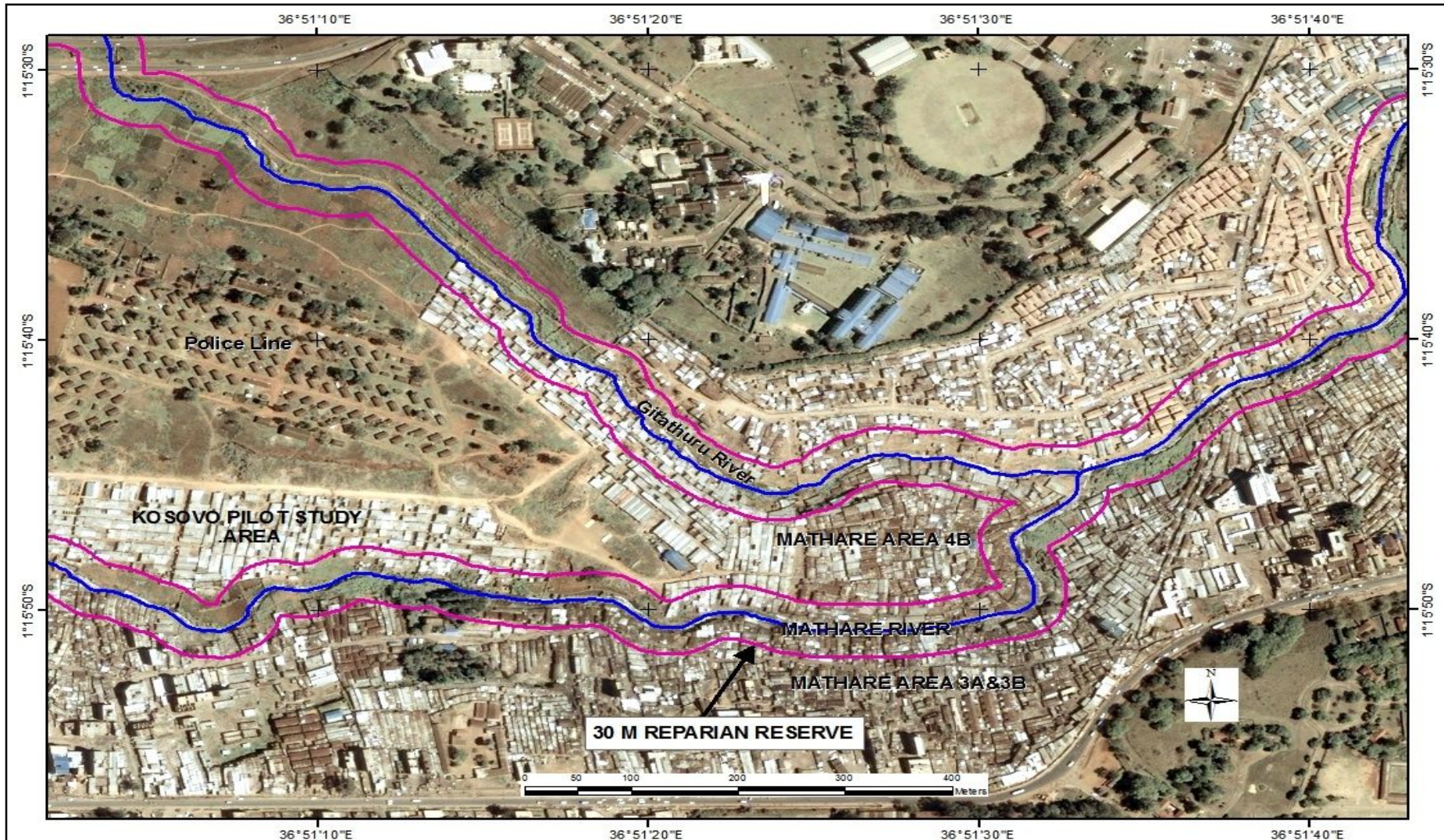
With political backing, Mathare squatter community has grown with almost de facto rights over the land. The government later granted leasehold to a board of trustees established on behalf of the community. The Kenyan Government and the Catholic Archdiocese of Nairobi with support of the Federal Government of Germany embarked on upgrading the settlement in 1992 which started the first slum-upgrading programme in Nairobi. The upgrading project later halted due to escalating violence and hostilities aggravated by former owners and local area politicians.

According to Mitullah (2002), Mathare Valley informal settlement is famous for its uncontrolled urban settlements in the city with population densities of 1,250 people per hectare in 1980. The area has spontaneous squatter settlements which are home to low-income intra-city migrants from areas of rising cost of living, shortage of accommodation, high rents and overcrowding (Ibid, 2002).

The area occupied by Mathare 4B informal settlement is approximately four hectares that are about 5.5 percent of the land. The settlement is located on a relatively steep section of the entire Mathare valley settlement. Most built structures measure about 10 square metres. Enumeration exercise conducted by Pamoja Trust in 2008 show that the settlement has a population of over 9,000 people. Pamoja Trust is a non-governmental organization (NGO) involved in the improvement of slums.

Measurement using satellite image of the village show that it covers about 4 hectares. The current population is 9000 people (KNBS, 2010). This gives a population density of 2250 people per hectare (900 people per acre). Figure 5.5 represents encroachment of the Mathare River by Mathare 4B informal settlement.

Figure 5.5: Encroachments by Informal Settlements along Mathare River



Source: Compiled from Scenes of 2003 Quickbird Satellite image

5.4.2 Study Sites along Nairobi River

The study sites along the Nairobi River include two informal sites and three formal sites. The garages in between Uhuru 1 and Buruburu phase one estate and informal business sheds at Gikomba market are the informal sites. Formal sites include Kamukunji public open grounds, Nairobi National Museum and Hotel Boulevard.

5.4.2.1 Informal Garages at Uhuru Estate

Informal garages at Uhuru Estate on Rabai road were selected to interrogate the implication of informal industries on the riparian zones. The garages are located about 10 kilometres to the North East of the city centre. The garages fall between Nairobi River and Rabai Road and across the river opposite the garages is the Kyambio slums.

The City Council of Nairobi allocated the riparian zones to garage operators in the year 1995, despite unstable riverbank prone to landslides during the rainy season. The garage operators had been evicted from Mworoto site along Jogoo Road after that site was allocated to private developers. Garage operators initially operated in the location where Rikana supermarket is currently located along Jogoo Road.

5.4.2.2 Gikomba Market Informal Businesses

Gikomba informal market site was selected to examine the implication of informal businesses on the riparian zone. The market is located along Nairobi River, East of the central business district of Nairobi. The topography is flat terrain. The provincial government administration and city council officials allocated business spaces and authorized informal business operators to construct their business sheds in the 1960s.

Gikomba market occupies extensive areas of the riparian zone from the country bus station to Kamukunji open public grounds. The study site is located at the shoe market which is directly opposite Kamukunji open public grounds.

5.4.2.3 Kamukunji Public Open Grounds

Kamukunji public open ground was a study site sampled to examine the implication of public open grounds on the riparian zone. The ground is a historical site located to the East of the city centre. The ground was established in 1960 as a meeting place for agitation of independence by native Africans.

After independence, the grounds continued to be the venue of political meetings and were a popular venue in the agitation for multi-party democracy of 1992 and 1997. The grounds are public land that covers an area of about four hectares. The grounds have maintained the riparian zone by planting of indigenous trees. There are also areas for recreation set in the riparian zone with furniture under tree shades.

5.4.2.4 Nairobi National Museum

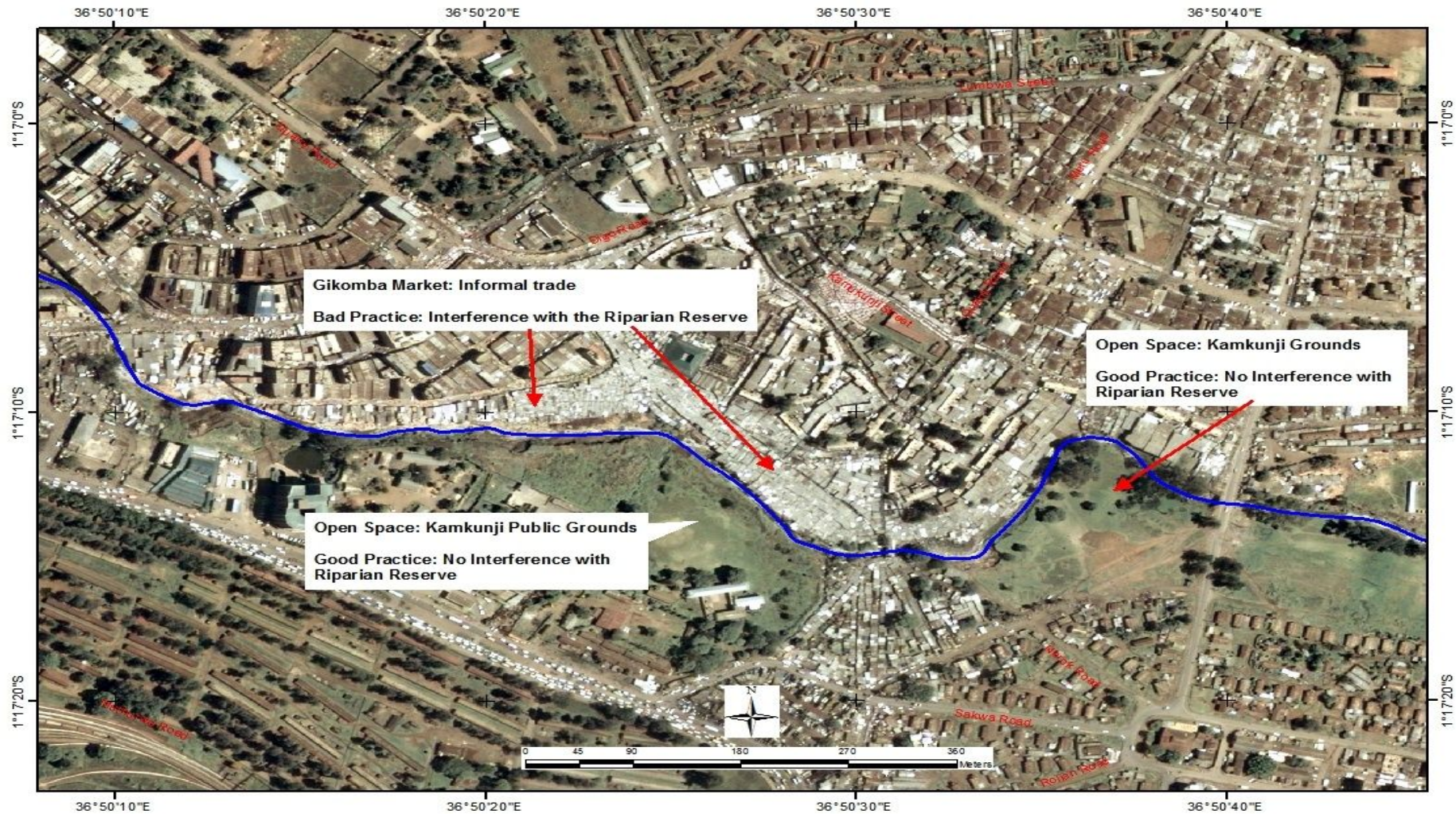
The Nairobi National Museum is a study site which was selected to interrogate the implication of public enterprises on the riparian zone. The Museum is a public repository of Kenya's historical heritage materials. It is located on the riverbank across Hotel Boulevard and the Museum hills. The institution sits on 20 acres of land that was allocated in 1962. Physical developments within the Museum are well organized in relation to the riparian zone. The museum has respected the natural riparian vegetation and has botanical gardens that blend well with furniture for public viewing of the river.

5.4.2.5 Hotel Boulevard

Hotel Boulevard was selected to examine the implication of private enterprises on the riparian zone. The hotel was established in 1973 and is situated at the end of Harry Thuku road on the Western edge of the central business district. The hotel occupies about 4.2 acres of lush gardens flowers that slope gently into the banks of Nairobi River. The hotel has maintained riparian vegetation cover and has not put up structures on the riparian zone. This is an indication of good practice in the use and management of the riparian zone.

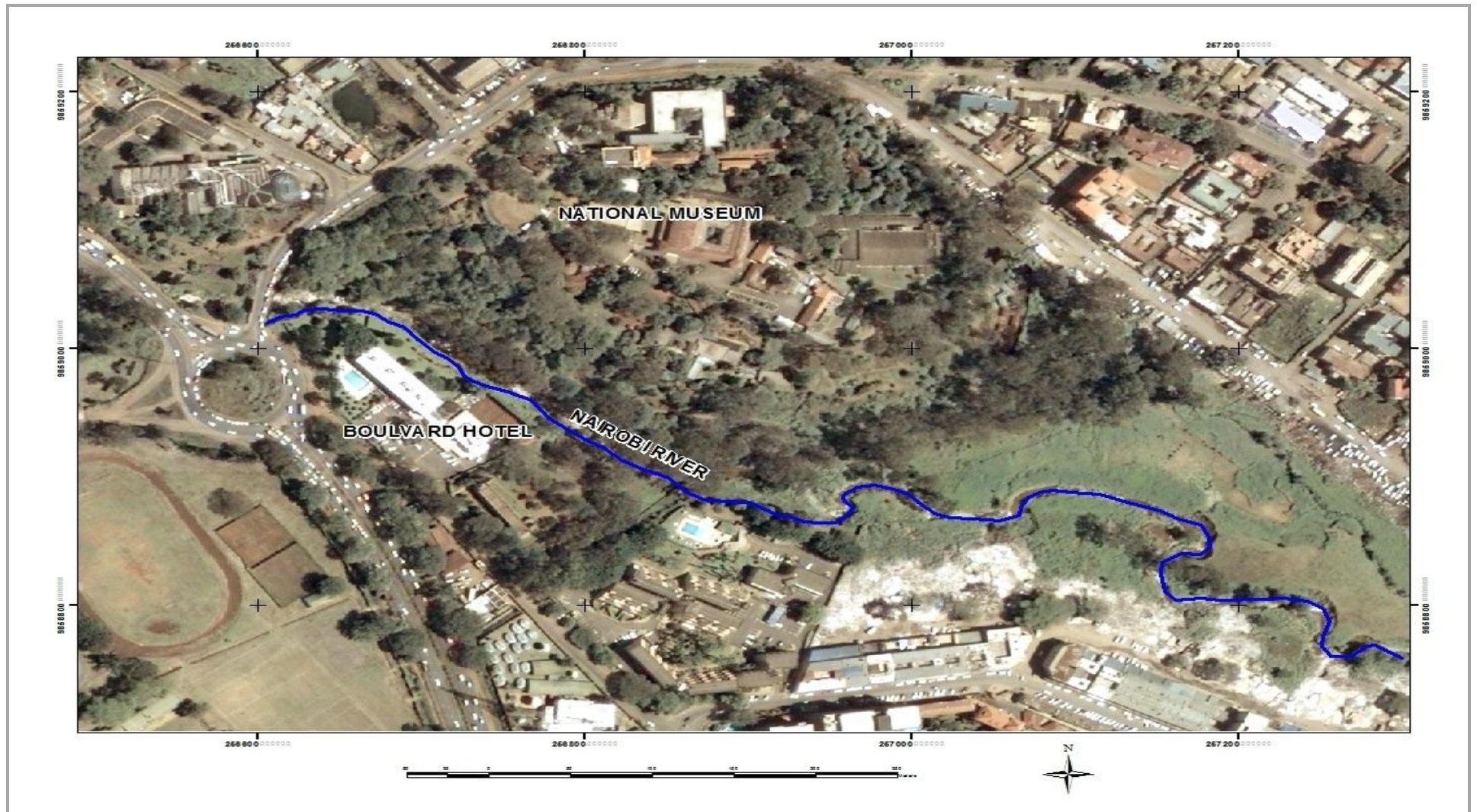
Figure 5.6 shows the location of informal businesses situated at Gikomba market, and the Kamukunji open grounds in relation to Nairobi River. Figure 5.7 shows the location of Nairobi National Museum and Hotel Boulevard in relation to Nairobi River.

Figure 5.6: Informal Businesses and Public Open Grounds along Nairobi River



Source: Compiled from Scenes of 2003 Quickbird Satellite image

Figure 5.7: Public and Private Institutions Along Nairobi River



Source: Compiled from Scenes of 2003 Quickbird Satellite image

5.4.3 Study Sites along Ngong River

The sites sampled along Ngong River include one formal and three informal land uses. The formal land use is the manufacturing industries at Viwandani area whereas informal land uses are urban agriculture practiced at Mukuru Kwa Reuben and quarries at Mukuru Kwa Njenga. It is observed that whereas the initial quarry mining activity was a formal land use, existing quarries are now disused and are informally used for dumping of urban wastes.

5.4.3.1 Viwandani Industrial Land use

Viwandani area located along Ngong River was selected to examine the implications of industrial land uses on the riparian zone. The industrial land at the study site along Ngong River was allocated between 1970 and 1977. The earlier allocations are more than 30 metres from the riverbank. However, subsequent land allocations done in the 1990s are on the riparian zone. The new industrial plots adjacent to the riparian zone have areas ranging from half to two acres. There are slums located in the riparian zone close to industries. The informal settlements are mainly housing for people who provide labour in the industries.

5.4.3.2 Mukuru Kwa Reuben Informal Agriculture

Mukuru Kwa Reuben was sampled as a study site selected to examine implications of urban agriculture on the riparian zone. The informal settlement is located about seven kilometres to the South East of the city centre. The settlement is in Imara Daima sub-location, Njenga location in Embakasi Division of the city of Nairobi. Establishment of the settlement dates back to 1962. The settlement acts as a dormitory residential housing for people who work in adjacent industrial area and was earlier on, an industrial waste dump site. Initial settlers were dumpsite scavengers sorting out recyclable waste from the dumpsite (Menya, 2008). The first settlers built carton shanties along Enterprise Road, which served as stores for sorted out waste and shelter (Ibid, 2008). The land belongs to the national government.

As the number of dumpsite scavengers increased, more shanties were built along Ngong River. According to Menya, the name “*Reuben*” is that of a European who owned the land while the name “*Mukuru*” is a Kikuyu word meaning a valley hence the name Mukuru Kwa Reuben which translates to Reuben’s valley. The settlement is characterized by poor drainage because of black cotton soils with which overlay the land along the river valley.

5.4.3.3 Quarries at Mukuru Kwa Njenga Informal Settlements

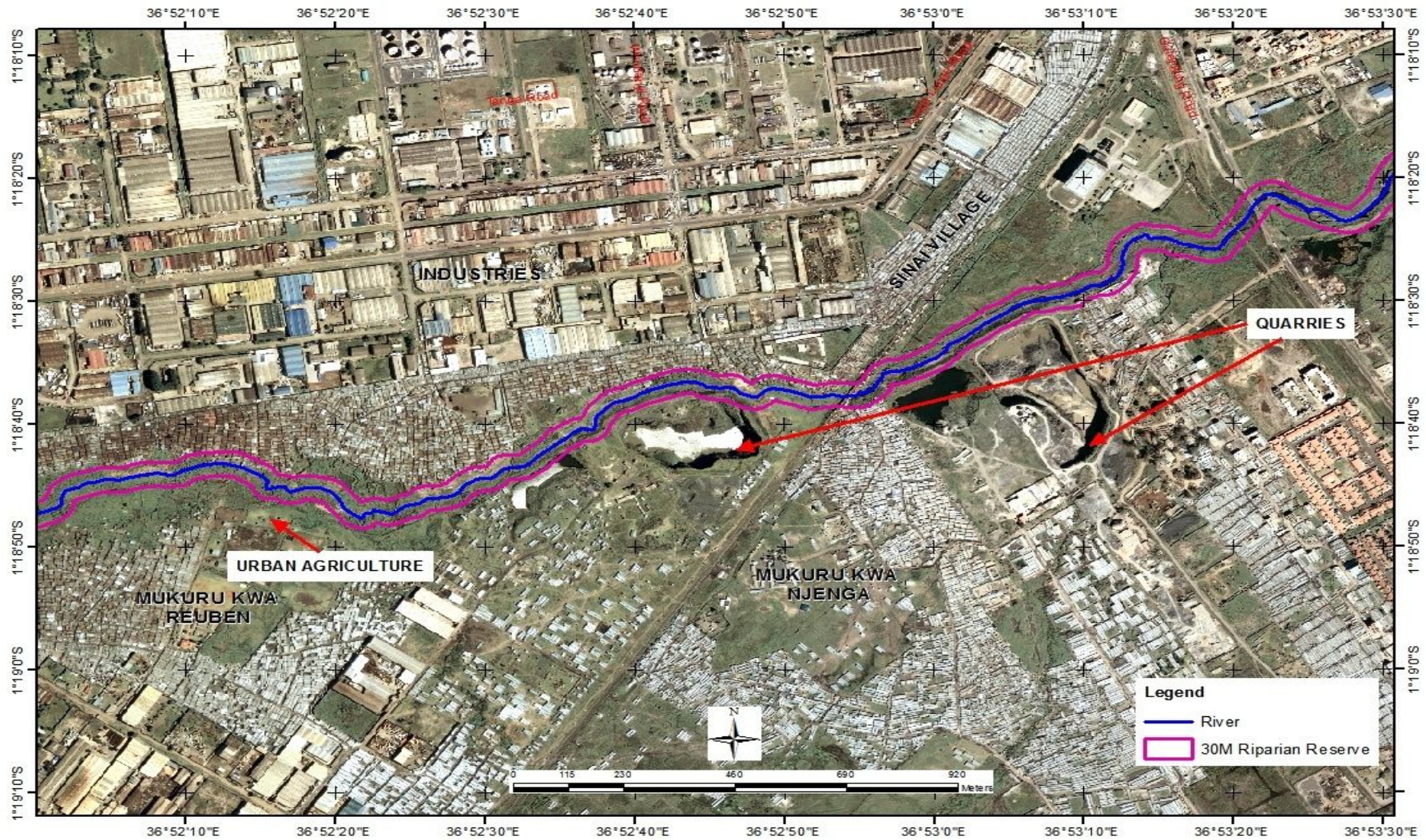
Mukuru Kwa Njenga is a slum about 10 kilometres South-East of Nairobi city centre, in the industrial area. It covers an area of 32 hectares of land. The settlement was selected to interrogate the implications of quarry mining. In the 2010 census report, Mukuru Kwa Njenga had a population of 75,000 (KNBS, 2010). This means that the slum houses 2300 people per hectare. The settlement is named after the first settlers called Njenga who had many houses for rental in the area. The slum is sandwiched between Kenya pipeline estate and Imara Daima estate and is accessed from either Mombasa road or Outer Ring Road.

Mukuru Kwa Njenga slum sits on land that was once part of farmland owned by white settlers and was first established in 1958 to house farm labourers. Later, the slum housed urban poor who built makeshift homes. With increased urbanization, more people settled in the area, and the population of the poor in Mukuru Kwa Njenga increased after the departure of European settlers. Most residents of Mukuru Kwa Njenga slum today, fall in the low-income bracket with some earning less than a dollar a day.

The land occupied by the settlement is owned by the national government, but some households have squatted on private land. This has caused difficulty for people who had previously settled in the area, as they have no legal security of tenure whatsoever. Private owners demolished some settlements in 1996, which met stiff resistance from the slum's residents and human rights organizations. In 1999, the government officially handed the residents a formal eviction notice which slum dwellers have continued to defy.

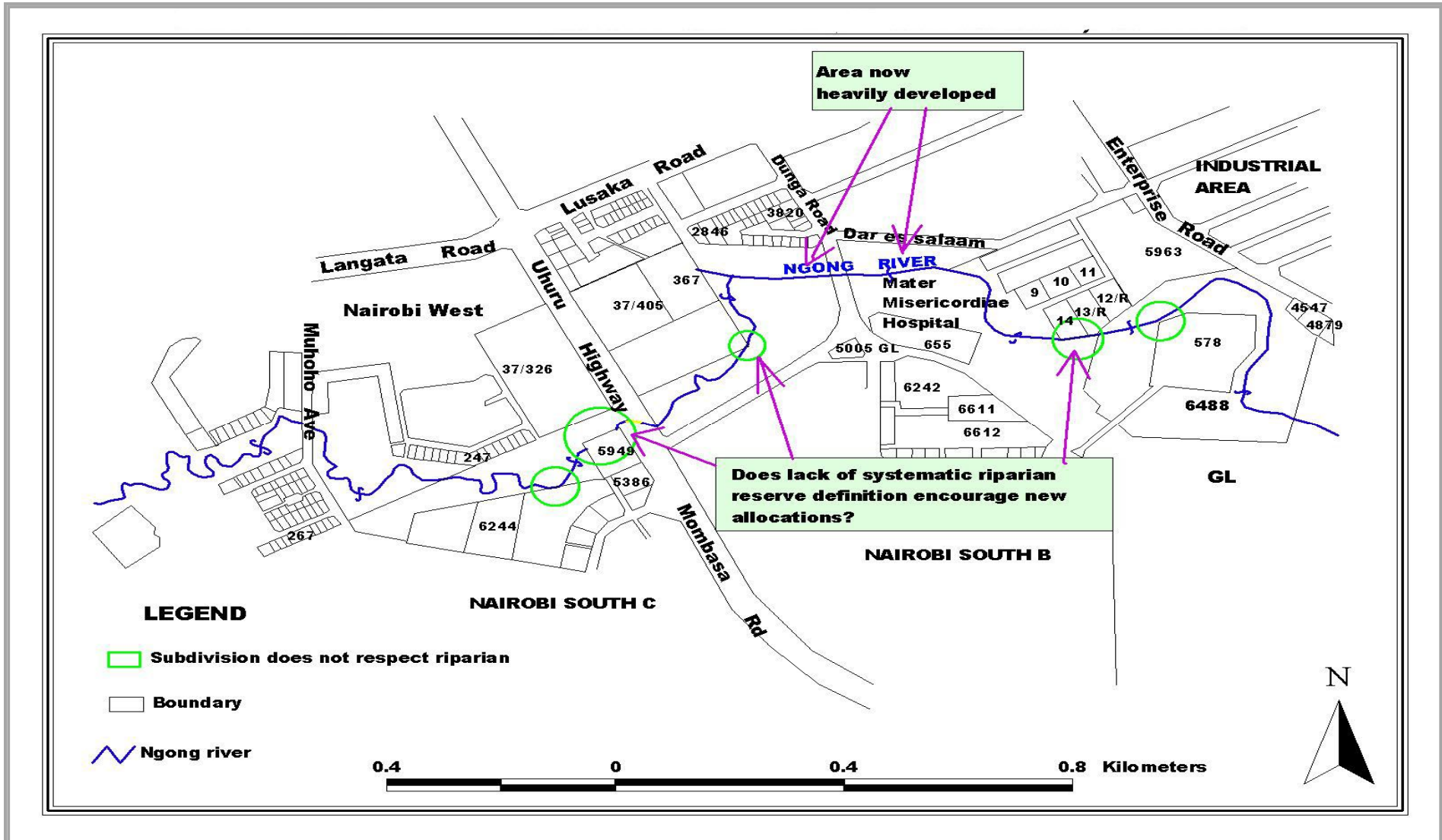
Overall, Mukuru Kwa Njenga slum is home to people of mixed ethnic backgrounds. Like most unplanned settlements, the settlement lacks basic infrastructure and sanitation facilities are also lacking. The slum has poor drainage system with overflow of sewers and illegal tapping of electricity is common which cause outbreak of fire and heaps of garbage in the vicinity of corroded iron-sheets houses. The slum is also plagued by industrial waste dump site, which pollutes the physical environment. Figure 5.8 represents urban agriculture at Mukuru Kwa Reuben and quarry mining at Mukuru Kwa Njenga Ngong River. Figure 5.9 further illustrates boundaries of industries encroaching on riparian zones along Ngong River.

Figure 5.8: Urban Agriculture and Quarry Mining along Ngong River



Source: Compiled from Scenes of 2003 Quickbird Satellite image

Figure 5.9: Industrial Land Use Boundaries and Riparian Zone along Ngong River



Source: Compiled from Cadastral Plans from Department of Surveys, Nairobi

5.4.4 Study Sites along Kirichwa Kubwa River

The sites selected along Kirichwa Kubwa River are both formal. They include residential housing at Faddville Estate and the Nairobi Arboretum which is a public recreation park.

5.4.4.1 Faddville Estate at Kileleshwa

Faddville estate was selected to examine the implication of residential land use on the riparian zone. The estate is developed on land that was purchased by the teaching and non-teaching staff members of the faculty of architecture design and development (FADD) of the University of Nairobi in the early 1980s.

Faddville estate is located about five kilometres to the West of the city centre and is a high income residential area. It is a gated community of low-density development. The residents of the estate set aside a 30 metre riparian zone during subdivision of their parcels of land in 1987. However, the riparian zone was re-planned and re-allocated to private developers in early 1990s. Presently, there are residential flats along the riparian zone. The flats are very close to the river bank and have removed the natural riparian vegetation. Some of the new parcels of land are not yet developed and have no proper access.

5.4.4.2 Nairobi Arboretum Recreation Park

The Nairobi Arboretum was selected to examine the implication of recreational parks on the riparian zone. The colonial government established the Nairobi Arboretum in 1907. The total area of land under the arboretum is about 30.4 hectares and is under the administration of Kenya Forest Service (KFS) and Friends of Nairobi. The Arboretum has forest up to the edge of Kirichwa Kubwa River and presents best practice in conservation of the riparian zone. However, the immediate neighbourhood across the river has towering high-rise residential apartments some located right at the edge of the river-in contrast to land use practice on the Arboretum land.

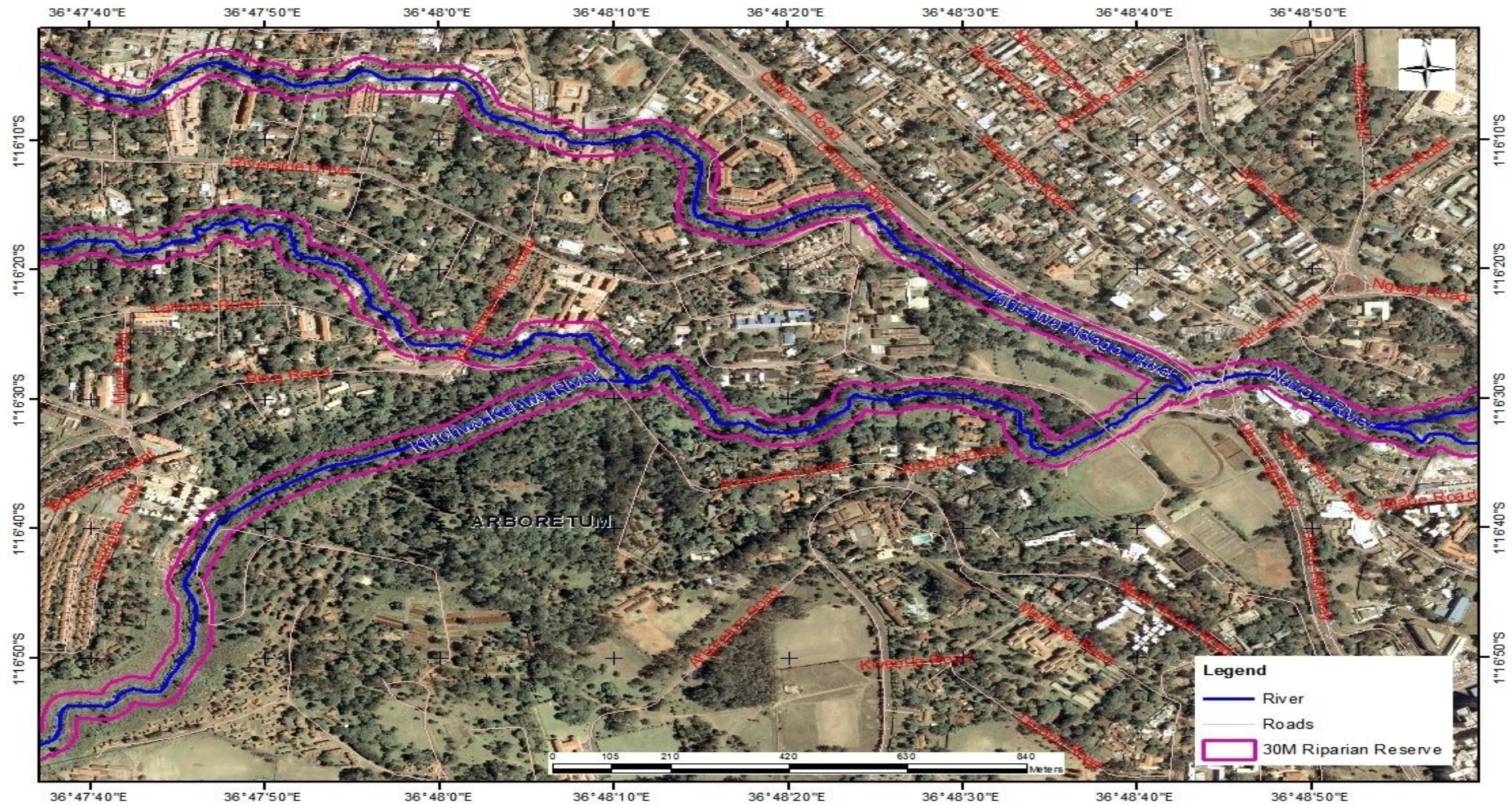
Figure 5.10 illustrates the encroachment of riparian zones by high income residential developments. On the other hand, Figure 5.11 represents good practice at the Arboretum. However, figure 5.12 illustrates spontaneous manner of determination of riparian zones.

Figure 5.10: Encroachments by Residential Housing along Kirichwa Kubwa River



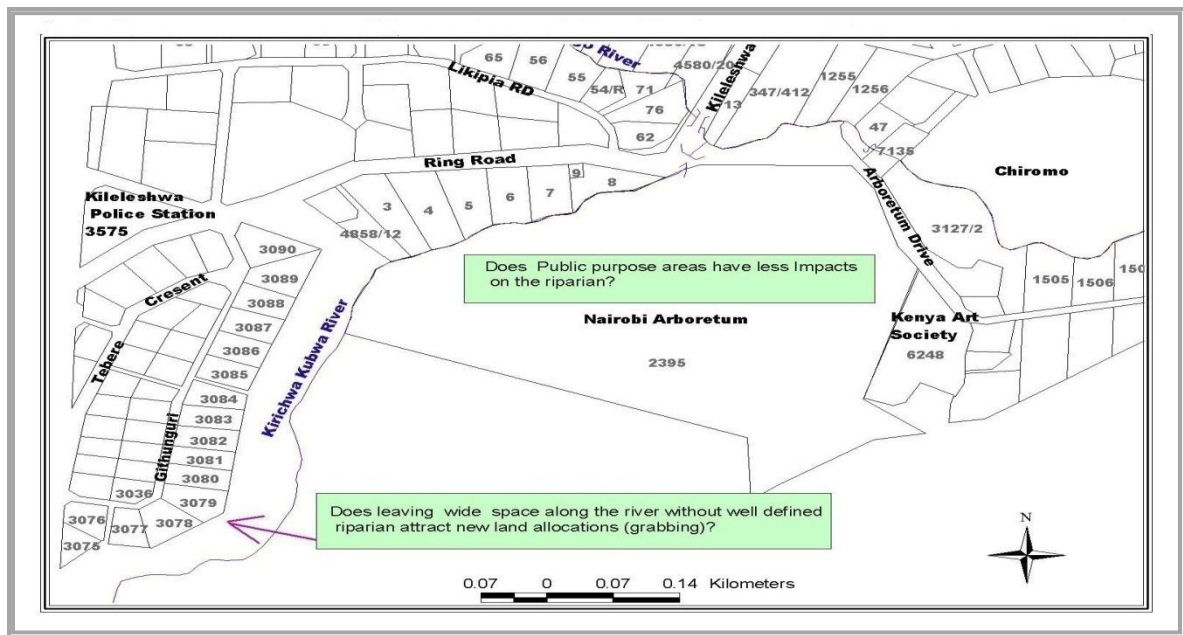
Source: Compiled from Scenes of 2014 Google Maps

Figure 5.11: Riparian Zone at Arboretum along Kirichwa Kubwa River



Source: Compiled from Scenes of 2003 Quickbird Satellite image

Figure 5.12: Residential Land Use Boundaries along Kirichwa Kubwa River



Source: Compiled from Cadastral Plans of the Department of Surveys, Nairobi

5.4.5 Study Sites along Kibagare Stream

Nakumatt Ukay Hypermarket was selected to examine the implication of commercial land use on the riparian zone. The hypermarket is located about five kilometers to the West of the city centre. Allocation of land for this controversial shopping mall was done by the colonial government in 1955. The parcel of land measures about one acre. However, its construction was controversially approved by the city council in the post independent period despite the development occupying the entire riparian zone of the canalized Kibagare stream. It therefore shows that the City Council of Nairobi failed to approve and enforce appropriate zoning codes including plot coverage rules.

The National Environment Management Authority (NEMA) went to court to challenge the development after complaints were raised by residents of Westlands, but the court has failed to make any material change to save the riparian zone.

5.5 Chapter Summary

This chapter has revealed the underlying policy and institutional framework as among areas that are a source of challenges facing proper determination, use and management of riparian zones in the study area as described. Chapter six assesses the policy and institutional factors that relate to land use and conservation

CHAPTER 6: ANALYSIS OF POLICY AND INSTITUTIONAL FACTORS

6.0 Introduction

The chapter examines existing policy and institution framework for the determination, use and management of riparian zones in the city of Nairobi. The goal is to examine whether the existing policy and institutional factors influence conservation of riparian zones in Nairobi River Basin.

6.1 Existing Policy Framework for Conservation of Riparian Zones

Existing laws that have guided the determination, use and management of riparian zones in relation to its underlying factors, in Nairobi River Basin are discussed. These laws require urgent review to align them with the new Constitution. The laws that are already repealed include the Local Government and Government Land Acts. Cities and Urban areas Act replaces LGA. The Land and Land Registration Acts replaced GLA, RTA, and RLA. The legislation is henceforth briefly discussed.

6.1.1 Existing Laws on Conservation of Riparian Zones

The laws include the Survey Act, Physical Planning Act, Water Act 2002, Environmental Management and Coordination Act and Agriculture Act. Other important laws are Local Government Act, Public Health Act and Land Registration Acts.

6.1.1.1 Survey Act

The Survey Act is an Act of parliament enacted in 1961 before independence. The law has provisions for determination of the riparian width for tidal rivers but lacks provisions for non- tidal rivers. It also has provisions for surveys, geographical names and licensing of surveyors Section 111 of the Act shows that:

On all tidal rivers, a reservation of not less than 30 metres in width above high water mark shall be made for Government purposes. Provided that, if the interests of development require, the Minister may direct that the width of this reservation shall be less than 30 metres in special cases (Kenya, 1961).

The riparian reserve as defined in this Act is for public purposes and has no provision for private use. However, the law does not specify under what circumstances the Minister may direct that the width should be less than 30 metres. Consequently, without clear guidelines on when to reduce or even increase the width, the provisions have been grossly abused.

Section 113 of the Act provides a further definition of the reservation boundaries as follows:

When surveying the reservations, a surveyor may make each boundary a straight line or a series of straight lines at a distance approximating closely to the specified distance from the feature for which a reservation is needed (Kenya, 1961).

Based on this definition, it is inevitable that the individual land holdings ought to be separately surveyed to leave riparian zones as distinct areas. However, records of survey plans and deed plans from the Department of Surveys reveal “*the boundary is centre-line of river.*” Nonetheless, this practice is not stipulated in the Survey Act. Rather, the Survey Act recommends a minimum of 30 metres from the high water mark. This means that the width of the zone would progressively increase as the floodplain widens.

To interpret the provisions in the Survey Act, it means that, along a V- shaped valley where the high water mark is close to the riverbank, the riparian width would be 30 metres because the floodplain may be non-existent. In areas where the floodplain begins to form, the high water mark would tend to be further away from the riverbank, meaning the riparian width would be $X + 30$, where X is the width of the floodplain. As the floodplain widens down the river profile, the width according to the Act would be $Y + 30$, where Y is the wider floodplain.

This implies that the determination of the width of the riparian zone has to vary depending on the physical form of the river valley from source to lowest point of the valley. For practical purposes, it would even be more interesting where the variation of riparian zone width is dependent on purpose for which it is intended with respect to human land use activities.

For example, in Arboretum, the effects of land use would be insignificant, and there may be no need of restricting recreational land use. However, for land uses like high density residential, commercial or industrial development it would be desirable to locate these further away from the riparian zones which would imply a greater width.

In the entire river profile, appropriate riparian vegetation structure has to be maintained. However, the Survey Act lacks provisions that would enhance vegetation cover as an appropriate ecological attribute of the zones. In addition, uniform widths used in land

administration and cadastral practices in Kenya contravene requirements of a variable width implied in the Survey Act.

Two survey methods are used to define boundaries on land in Kenya. One method establishes mathematically-derived marks to define boundaries consisting of straight lines that connect consecutive marks. This is the method of survey used in registration of titles under the repealed Land Titles Act, the Government Land Act and the Registration of Titles Act. The surveys are conducted under the provisions of the Survey Act and Regulations that govern the application of fixed boundary surveys.

The second method is the adoption or creation of contiguous physical features that are recognized to constitute boundaries. An area where the Registered Land Act applies under general boundaries adopts the physical features.

These two methods have advantages and disadvantages. The unifying attribute of the two methods is that parcels of land in the register must be clearly and uniquely defined, and each system must be accurate and economical. It is worth noting that fixed surveys are accurate, but general boundary surveys are mere approximations that lead to errors in the determination of riparian zone size. The bottom line is that land surveys have accurately to define riparian zones, but this is not the case in Nairobi River Basin where property boundaries extend to the riverbank.

6.1.1.2 Physical Planning Act

The Physical Planning Act (PPA) has provisions for preparation of local and regional physical development plans as well as an array of action plans. These action plans include part development plans (PDP), zoning plans, subdivision plans and subject plans. The plans provide a coordinated basis upon which planning agencies may develop their respective programmes of work with respect to their needs in the local area over a period of say 20 to 30 years.

Physical plans show transportation and communication networks in an area, and presents concerted direction for compatible, orderly, coordinated and progressive development of the area. In addition, the plans show organized land classification in tune with land use organization in terms of density of development, areas for conservation of nature and recreation among others. The Physical Planning Act through Legal Notice No. 140 of 13th July 1998 (Kenya, 1998b), rule 15(c) states that:

Way leaves or reserves along any river, stream or watercourse shall be provided of not less than 10 metres in width on each bank, except in areas where there is an established flooding

However, the Physical Planning Handbook (PPH) (Kenya, 2008) has contradicted this regulation by defining the riparian zone as:

Land defined on each side of the watercourse; has a minimum of 2 metres or equal to the full width of the river as measured between the banks of the river course up to a maximum of 30 metres for both seasonal and perennial rivers.

From the foregoing, the minimum width of 10 metres set in the Planning Regulation seemingly is not based on any demonstrated scientific derivation that is informed by principles and functions of the zone. On the other hand, the Handbook provides for a minimum of 2 metres and a maximum of 30 metres so that planners have multiple, yet subjective discretion to choose any width within this min-max model of $2 \leq \textit{riparian width} \leq 30$.

As the min-max model show, planner's discretion in the model has near indefinite number of riparian width permutations at any one particular point along the river valley. The model completely ignores important factors such as effects of types of soil, vegetation types, and gradient of riverbanks, types of human activity and wildlife types at the point of riparian zone determination. It seems that the Physical Planning Act and Handbook merely serve to promote land use for human activities leaving limited room for ecological conditions.

6.1.1.3 Agriculture Act

The Agriculture Act aims at promoting and maintaining stable agriculture and provides for the conservation of soil and its fertility. The Act advocates for soil conservation and protection of water catchment areas, regulating or control of afforestation and re-afforestation of land, protection of slopes and catchment areas and drainage of land including repair of natural or artificial infrastructure and removal of vegetation that contravenes the provisions of the Act.

The Agriculture (Basic Land Usage) Rules (Kenya, 1965b) prohibit certain land use practices likely to cause soil erosion. The rules strictly regulate cultivation of land abutting

watercourses where the gradient is between 12 and 35 percent because this enhances soil erosion. Specifically, the rules stipulate that:

Cultivation, destruction of soil, cutting down of vegetation or de-pasturing livestock on land within 2 metres of a watercourse are permissible only if done with a written consent of an authorized officer.

Pointedly, a minimum width of two metres would appear inadequate to protect the river, considering that the slopes near the river bank are often steep. In situations where agricultural chemicals are in use, any composition of riparian vegetation within two metres would fail to filter fertilizer residues such as nitrates and phosphates. The regulations also underplay the function of riparian width in urban agriculture practices which use highly polluted water from sewer effluents.

6.1.1.4 Water Act 2002

The Water Act (Kenya, 2002a) is the law for management, conservation, use and control of water resources as well as acquisition and regulation of rights to use water. The law also provides for the regulation and management of water supply and sewerage services. The Act established the Water Resources Management Authority (WRMA) to enforce protection of water resources including riparian zones.

The law aims at integrated water resources management framework although it lacks legal provision for stakeholder consultation. In particular, the Act does not provide for consultation with physical planners and surveyors who are necessary for the determination of riparian zones.

Water resources are classified in the Act according to types, location and geography. However, rivers are yet to be classified in Kenya. In the Water Resources Management Rules (Kenya, 2007b), the riparian zone is defined as:

Land in respect of which management obligations are imposed on the owner by the Water Resources Management Authority due to its proximity to the water body.

This definition imposes obligations to land users through officially written orders. However, the nature of freehold land tenure permits landowners to carry out activities without requiring a written order. After all, the capacity of WRMA sub-regional offices which have expansive coverages to enforce the orders is limited. Moreover, the local

authority often grants development permission without necessarily consulting institutions like PPD (Mwangi, 1994) and WRMA.

The Water Management Rules have not provided for a clear distinction between the riparian zone and private property but merely imposed management controls on the use of land next to the river. Unless otherwise determined by a water inspector, the riparian land on each side of a watercourse is defined in the rules as:

A minimum of 6 metres or equal to the full width of the watercourse up to a maximum of 30 metres on either side of its banks.

Notice again, the infinite number of riparian width permutations expressed as $6 \leq \textit{riparian width} \leq 30$. According to the Act, measurement of the riparian zone has to begin from the top edge of the bank of a watercourse for both seasonal and perennial watercourses. However, reference to the edge of the river is subject to variations of the width of the zone due to natural and artificial alterations of riverbank positions.

Tillage or cultivation, clearing of indigenous trees or vegetation, building of permanent structures, disposal of waste, excavation of soil or quarry mining, planting of exotic trees that could have an adverse effect on water resources or any other activity that may degrade the water course are prohibited under the Act.

Accordingly, the Act indicates that WRMA may instruct by an order, a riparian landowner or user, at his or her cost to develop and implement a soil and water conservation plan. The challenge, however, is that the Act provides for conservation measures without any obligatory criteria for the determination of appropriate riparian width.

6.1.1.5 Public Health Act

The Public Health Act (PHA) (Kenya, 1986a) borrows its legal basis from the common law doctrine of nuisance and seeks to resolve the problem of sanitation and related public health hazards. The doctrine of nuisance makes it an offence for any landowner or occupier to allow nuisance or any other condition liable to injury and danger to health to prevail on land. The Act provides for inspection of buildings for their sanitary conditions, construction standards and ventilation of buildings, drainage of land and keeping of animals. Section 118 and 129 of the act defines nuisance in a broad manner and includes any act that leads to pollution of water source.

Drainage of toxins, sewage waste and garbage into Nairobi Rivers constitutes an act of nuisance and the court can require a person committing such an offence to rectify and failure to do so, the authorities are required to charge any expenses on the owner of the proprietor or person committing the nuisance. However, rampant pollution, encroachment and degradation challenges that face riparian zones in the city of Nairobi questions the level of enforcement of the Public Health Act.

6.1.1.6 Local Government Act

The Local Government Act (LGA) (Kenya, 1998b) was repealed by the County Government Act of 2012 and Urban Areas and Cities Act of 2011 after Kenya transitioned into devolved system of government on 4th March 2013. However, the Act has had a profound influence on planning, development and evolution of land use activities since independence in 1963.

The Act has provisions for environmental health requirements. Under these requirements, local authorities are expected to provide and maintain sanitary services, sewerage and drainage facilities, control or prohibit industries, factories and businesses that emit smoke, fumes, chemicals, gases, dust, discomfiting smell or annoyance in a neighbourhood. The Public Health and Local Government Acts have been critical in the control of adverse effects from development close to riparian zones.

Land use zoning and subdivision regulation in the Act aim to enhance compatible development by leveraging development control in land use. Zoning segregates parcels of land into broad classification of compatible uses such as commercial, residential, industrial, educational, institutional, recreation and so on.

Subdivision regulations, on the other hand, are legal codes applied to ensure that development and use of land are in tandem with well-coordinated approved plans. The city of Nairobi is zoned into 20 broad urban development zones. However, weak institutions, poor governance and lack of political will by the city politicians have led to the failure in implementation of the zoning framework.

6.1.1.7 Environmental Management and Coordination Act (EMCA)

The Environmental Management and Coordination Act (EMCA) (Kenya, 1999b) focus on appropriate legal and institutional framework for management of the environment. The law has created a comprehensive institutional and organization system for administration

and enforcement of compliance in environmental management. Towards this, the law advances the principle that sustainability on the environment is the foundation for social, economic, cultural and spiritual advancement.

The law established the National Environment Management Authority (NEMA) and its statutory committees. These are the Standards and Enforcement Review Committee; National Environmental Action Plan Committee; Environmental Impact Assessment-Technical Advisory Committee; Provincial and District Environmental committees.

In addition, two independent committees: the national environmental tribunal (NET) and public complaints committee (PCC) with official mandates to investigate complaints or allegations against any person or conduct of NEMA officials were established. The tribunal largely hears technical disputes as well as administrative decisions in regard to environmental issues taken by NEMA.

With respect to environmentally sensitive areas, EMCA prohibits erection, reconstruction, placing, altering, removal or demolition of any structure or part of any structure in, or under the river, lake or wetland, excavation, drilling, tunnelling or disturbing the river, lake or wetland and depositing any substance in a lake, river or wetland, or in, on, or under its bed, if that substance would or is likely to have adverse environmental effects on the river, lake or wetland.

The law also provides for the management, protection, or conservation measures in respect of any area at risk of environmental degradation and for the development of an overall environmental management plan for the lake, river, wetland or coastal area taking into account relevant sectoral interests; contingency plans for prevention and control of all deliberate and accidental discharge of pollutants into the sea, lakes or rivers and plans for protection of wetlands. Finally, the law has special guidelines for access to and exploitation of living and non-living resources in continental shelf, territorial sea and exclusive economic zone.

6.1.2 Constitution of Kenya of 2010 and New Laws

The Constitution (Kenya, 2010a) and the laws enacted after it came into force have specific provisions for environmental management and land use planning.

6.1.2.1 Constitution of Kenya of 2010

Article 2 of the constitution (Kenya, 2010a) declares its supremacy and binds all citizens and all state organs at the national and county levels of government. Under Article 3(1), every person is obliged to respect, uphold and defend the constitution. Article 2 (4) states *“any law, including customary law, which is inconsistent with the constitution is void to the extent of the inconsistency, and any act or omission in contravention of this constitution is invalid.”*

The preamble point out that Kenyans will aspire for “ a government based on essential values of human rights, equality, freedom, democracy, social justice and rule of law” as well as respect for the environment. Article 10 spells the national values and principles of governance including patriotism, national unity, sharing and devolution of power, rule of law, democracy and participation of the people.

The article also provides for human dignity, equity, social justice, inclusiveness, equality, human rights, non-discrimination, and protection of the marginalized. It further aspires to ensure good governance, integrity, transparency and accountability as well as sustainable development.

The Constitution, under Article 43 (d) states that every person including residents of Nairobi River Basin have a right to clean and safe water as well as a healthy environment. The Constitution is in agreement with Section 11(3) of the Water Act 2002, which provides that the national water resource management strategy (NWRMS) shall prescribe principles, objectives, procedures and organizational arrangements for the management, protection, use, development, conservation and control of water resources.

6.1.2.2 National Land Commission Act No. 6 of 2012

The National Land Commission Act (Kenya, 2012b) is an Act that created and outlined the functions and powers of the National Land Commission (NLC) as well as qualifications and procedures for appointments to the Commission. The Act gives effect to the objects and principles of devolved system of land management and administration and for connected purposes.

The functions and powers of the Commission are outlined in Article 67(2) and include management of public land on behalf of the national and county governments, to recommend a national land policy (NLP), to advise the national government on a

comprehensive programme for the registration of titles in land throughout Kenya and to conduct research related to land and the use of natural resources and make recommendations to appropriate authorities.

The Commission has taken over powers and functions formerly exercised by the Commissioner of Lands and the President. The power to allocate public land by President and/or Commissioner of Lands is contrary to the new constitution and Land Act 2012. Before, these powers were exercised arbitrarily which led to loss of environmental value in land resources (Kenya, 2004).

The practice of transferring undeveloped leaseholds contrary to the law was most prevalent in the 1990s (Kenya, 2004). These transfers were not mere aberrations of procedures: they were a deliberate mechanism of facilitating illegal and irregular allocations of public land by the Commissioner of Lands. Under the new Constitution, the National Land Commission will take over all matters on public land. The Commission has powers to revoke title deeds acquired in an unlawful manner. It remains to be seen whether the commission will recognize the riparian zones as important urban landscapes.

6.1.2.3 Land Registration Act No. 3 of 2012

The Land Registration Act No. 3 (Kenya, 2012a) is an Act of Parliament and aims to revise, consolidate and rationalize registration of titles to land, to give effects to the principles and objects of devolved government in land registration, and for connected purposes.

In this Act, the concept of geo-referencing means the reference of an object using a specific location either on, above or below the earth's surface. In the context of this study, it means relating the boundaries of a parcel of land to the riparian zone.

In the spirit of this Act, cadastral maps should be prepared and maintained with properly geo-referenced riparian zone boundaries for every registration unit in the river basin. In this connection, it is prudent that the riparian land is maintained as distinct parcels of land in the registers.

6.1.2.4 Land Act of 2012

This is an Act of Parliament to give effect to Article 68 of the Constitution, to revise, consolidate and rationalize land laws, to provide for the sustainable administration and

management of land and land based resources. In the Land Act of 2012, land has the meaning assigned to it in Article 260 of the Constitution. From this meaning, the riparian zone is also considered as land and is defined as:

Land adjacent to the ocean, lake, sea, rivers, dams and watercourses as provided under the Survey, Cap 299 Act or any other written law (Kenya, 2012a).

In this Act, a geo-referenced boundary means reference to the boundary of a parcel of land to a specific or unique location on, above or below the earth's surface as defined in the survey Act, Cap 299. However, the definition of riparian reserve in the Survey Act refers to tidal rivers only. Hence, this still introduces inconsistency in the Land Act since other written laws also have their limitations.

6.1.2.5 County Government Act No. 17 of 2012

Under Constitution (Kenya, 2010a), Article 6 and the first Schedule have emphasized on devolution and decentralization of powers and resources at the national level to 47 counties.

The county government Act (Kenya, 2012c) states that county planning shall integrate among others, environmental and spatial planning. The principles of planning shall take into consideration future generations and shall protect and align natural resources in a manner that aligns national and county governments' policies as stipulated in sections 102 and 103.

This Act of Parliament has a specific of protecting designated areas and groundwater conservation areas as per the new Constitution. The county governments have a critical role in ensuring better management of water resources in their jurisdiction.

6.1.2.6 Urban Areas and Cities Act No. 13 of 2011

The Urban Areas and Cities Act No. 13 (Kenya, 2011b) give effect to article 184 of the Constitution. The Act provides for the classification, governance and management of urban areas and cities to provide for the principle of governance and participation of residents and for connected purposes. All urban local authorities under the old Act, including City Council of Nairobi will be managed by boards created in the Act.

The functions of the board of a city or municipal is (i) to oversee the affairs of the city or municipality; (ii) to develop and adopt policies, plans, strategies and programs; (iii) to

formulate and implement an integrated development plan; (iv) to control land use, land sub-division, land development and zoning by public and private sectors for different land uses; (v) to promote and undertake infrastructure development and services in the city; and (vi) to promote safe and healthy environment.

6.1.3 Challenges Facing Policy and Legal Framework

The laws on the determination, use and management of riparian zones are apparently too many and are fragmented. The problem is that the laws prescribe varying measures of the riparian width on the same river and also determine the zone from different points of reference. For example, Water Resources Management Rules stipulates that the river bank should be the point of measurement while the Survey Act prescribes the high water mark.

The Constitution and new laws are fairly recent and are expected to address limitations in existing policies and laws. However, the Land Act of 2012 appears to be repeating the mistake of benchmarking its provisions on the Survey Act and other existing laws. Existing laws still have inconsistencies in as far as the determination, use and management of riparian zones is concerned.

6.2 Institutional Framework for Conservation of Riparian Zones

There exists an elaborate institutional framework for land use, planning and conservation of riparian zones in Kenya for both the old and new constitutional dispensation.

6.2 Institutional Framework for Conservation of Riparian Zones

Institutions under the old and new constitutions are described.

6.2.1 Existing Institutions before New Constitution

The main institutions responsible for conservation of riparian zones in the old constitutional order include Physical Planning Department (PPD), Department of Lands, Department of Surveys, City Council of Nairobi (CCN), National Environment Management Authority (NEMA), and Water Resources Management Authority (WRMA).

6.2.1.1 Physical Planning Department

The department is in the Ministry of Lands and is headed by the Director of Physical Planning. As provided in the Physical Planning Act Cap 286, the department is charged with developing a national land use policy, a national land use development plan,

preparation of short and long term physical development plans and preparation of metropolitan plans.

The department is also charged the responsibility of assisting in the implementation of a national land-use information system and ensuring full implementation of the Physical Planning Act. Some of the mandates of this department are, however, taken over by the county governments who have created a position of county planner who reports to the county governor. As a result, the PPA requires to be urgently reviewed to conform to the new constitutional order.

6.2.1.2 Lands Department

The department is also in the Ministry of Lands and was responsible for the administration of land in the country before promulgation of the new Constitution. The department also enforced the repealed Government Land Act, Cap.280, Registered Land Act, Cap.300 and Registration of Titles Act Cap. 281. The Commissioner of Lands headed the department. The post of the Commissioner of Lands was abolished after repeal of the Government Land Act that was replaced by the Land Act No. 6 of 2012.

The core functions of the department were alienation of Government land and Trust land, development control, preparation and issuance of titles and registration of land transactions and other legal documents, generation and collection of revenue and custody and maintenance of land records. Other functions were provision of advisory and technical services on land matters, preservation of public utility land and fragile ecosystem and resolution of boundary and land disputes.

The department had three technical divisions and one administrative division. These were Land Administration Division, Land Registration Division, Land Valuation Division and General Administration Division. All functions of the department except land registration have been transferred to the National Land Commission at the time of completion of this report.

6.2.1.3 Department of Surveys

The department of Surveys is also within the Ministry of Lands. The department has been placed under the Cabinet Secretary in charge of land under the Land Act No. 6 of 2012. The department is responsible on all functions of land surveys and mapping. The department was formed in 1903 and enforces its outputs under the Survey Act Cap. 299.

Specifically, the main functions of the department are (i) to provide and maintain plans for property boundaries supporting land registration throughout the country and (ii) to provide all kinds of topographical and thematic maps covering rural and urban areas of the country for use by other government departments and the general public.

The Department of Surveys is expected to relinquish some of its functions to the National Land Commission. There is possibility that the department will continue to perform the mapping function. However, it is important for the department to review the Survey Act to align it with the Constitution (Kenya, 2010a).

6.2.1.4 City Council of Nairobi

The City Council of Nairobi which was since 4th March 2013 replaced by Nairobi County Government is a local authority under the Ministry of Local Government. The Council was in charge of planning and development control in the city and enforcing the repealed Local Government and Public Health Acts, which have provisions for regulating drainage and sewers, prevention of pollution and prosecution of polluters. The new Nairobi County Government will perform these functions under Urban Areas and Cities Act No. 13 of 2011 and County Government Act No. 17 of 2012.

6.2.1.5 National Environment Management Authority

The National Environment Management Authority (NEMA) is headed by a Director General responsible for supervision and coordination of all matters on environment. NEMA is charged with enforcing environmental monitoring and coordination Act (EMCA). Section 9(2) of the Act stipulates that the mandates of NEMA are (i) coordination of environmental management activities of lead agencies; (ii) promoting the implementation of environmental development policies, plans, programs and projects; (iii) enhancing environmental education and public awareness about the need for sound environmental management publish, and (iv) to disseminate manuals, codes and guidelines for environmental management.

Another broad area of mandates for NEMA is to advice the government on legislative measures for the management of the environment and implementation of relevant international conventions, treaties and agreements in the field of environment, advising the government on regional and international environmental conventions, treaties and agreements to which Kenya is a party, mobilizing and monitoring the use of financial and

human resources for environmental management and lending advice and technical support to local grass root institutions.

6.2.1.6 Water Resources Management Authority

Reforms in the water sector were initiated in 1999 after the national water policy (NWP). This led to the establishment of Water Resources Management Authority (WRMA). WRMA was until the elections of 4th March 2013, under the Ministry of Water and Irrigation.

The mandates of WRMA are to develop principles and procedures for allocation of water resources, to monitor the national water resource management strategy, to determine and process applications for permits for water use, to regulate and protect the quality of water resources and to manage and protect water catchments.

WRMA has formed catchment area advisory committees (CAACs) to support its function at the regional level and water resources users associations (WRUAs) as a medium for cooperative management of water resources and conflict resolution at sub-catchment level and communities.

6.2.2 Institutions Created by the New Constitution

The National Land Commission and Nairobi County Government are discussed.

6.2.2.1 National Land Commission

Chapter five of the Constitution (Kenya, 2010a) has articles on land and environment. Article 67(1) has established the National Land Commission. The main functions of the Commission are to manage public land on behalf of national and county governments. The Commission has a mandate to recommend national land policy to the national government as well as advising the national government on a comprehensive programme for registration of land title throughout the country.

The Commission is also mandated to conduct research on land and the use of natural resources. Other roles of the Commission include initiating investigations on its own initiatives or complaint, into present or historical land injustices and recommending appropriate redress. The Commission is empowered to use traditional dispute resolution mechanisms in land conflicts. Finally, the Commission will also assess tax on land and

premiums on immovable property in any areas designated by law as well as monitor and discharge oversight responsibilities on land use planning throughout the country.

6.2.2.2 Nairobi County Government

Nairobi County Government (NCG) is one of the 47 counties in Kenya that were created by the new Constitution. NCG has clearly defined structure of government, elected governor, county assembly and wards which are the lowest levels of political representation in the county.

Article 174 of the Constitution, states that the objectives of devolved government are to promote democratic and accountable exercise of power, to foster national unity by recognizing diversity, to give powers of self-governance to the people and to enhance the participation of people in the exercise of powers of the state and to make decisions that affect them. The county government has a role in the protection of riparian zones.

6.2.3 Challenges Facing the Institutional Arrangement

The review of institutional roles indicates overlaps of mandates. The consequences appear to be duplication of roles across public agencies. For example, WRMA has the mandate to control pollution of water resources that also appears to be the mandate of NEMA. In addition, WRMA has the mandate to determine and peg out the riparian zone which is also the role of the Department of Surveys. The Physical Planning Department has the role of preparing Physical Development Plans yet; WRMA has mandates on soil and water conservation plans.

These roles of public institutions are conflicting to the extent that land users and professionals working under their guidance would suffer from the institutional bottlenecks. The agencies have not established a realistic riparian zone policy that can be universally applied nor have they established an appropriate platform for consultation, collaboration and coordination of their functions to secure functional riparian zones.

6.3 State Interventions in Conservation of Riparian Zones

The government of Kenya has implemented a variety of interventions to protect public land. The formation of the Njonjo Commission (Kenya, 2002b) and the Ndung'u Commission (Kenya, 2004) to probe into irregular and illegal allocation of land including those on riparian zones are some of the interventions.

In addition, the Nairobi River Basin Programme was designed in 1999 to rehabilitate polluted rivers. The National Land Policy (Kenya, 2009b), accented to the new Constitution in 2010 (Kenya, 2010a) and repeal of old land laws by enacting the Land Act No. 6 of 2012 and the Land Registration Act No. 3 of 2012 are milestone interventions by the government.

6.3.1 Njonjo Commission of Land Inquiry of 2002

The goal of the Njonjo Commission appointed in November 1999 (Kenya, 2002b) was to inquire into the land law system in Kenya. The main objective of the Commission was to undertake a broad review of land laws in Kenya. Specifically, the Commission was to recommend the main principles of a land policy framework by undertaking an analysis of the legal and institutional framework of land tenure and land use in the country.

The Commission was also to recommend programmes of legislation that would give effect to such policies as well as to recommend guidelines for a basic land law and complimentary subsidiary legislation. These were to focus on land tenure systems that are appropriate for the country, system of land ownership and control, system of acquisition and disposition of land rights whether inheritance or otherwise, among others.

The Commission established that the land issues were constitutional in nature and that meaningful reforms required relevant constitutional changes. The Commission suggested that broad principles on land should be set out which formed the basis of establishing an institutional framework for ownership, administration and management of land. The Commission proposed the establishment of legislation entrenched in the Constitution and the creation of a National Land Authority and District Land Authorities to administer land professionally. The National Land Authority and the District Land Authority would manage the land on behalf of the citizens of Kenya.

The Njonjo Commission also proposed amendment of the Constitution to address grievances of past historical injustices over land at the Coast and Rift valley Provinces, as well as the creation of Land Claims Tribunal (LCT) to investigate ancestral land claims and disputes. The tribunal would be a quasi-judicial body that was to conduct public hearing in compliance with rules of fair and just hearings as required by the constitution and common law, among others.

The Constitution would provide ownership and protection of natural resources including minerals, wildlife, forests, fisheries, marine resources and water, among others. The main shortcoming of the Commission is that its recommendations were not implemented. However, the recommendation of the Njonjo Commission appears to form a major input in the new Constitution especially the creation of the National Land Commission.

6.3.2 Nairobi River Basin Programme

Nairobi River Basin Programme (NRBP) is a multi-stakeholder initiative launched in 1999 focusing on restoring riverine eco-system with clean water for the capital city and a healthier environment for the people of Nairobi. The objectives of the Programme are to rehabilitate, restore and manage Nairobi River ecosystem.

It is expected to improve livelihoods of people, enhance biodiversity and ensure a sustainable supply of water for domestic and industrial and recreational uses in the city. The programme was also expected to address problems such as pollution, waste management and greening of urban spaces, promote community participation in city policy processes and create public awareness on environment and advocate laws governing the use of the rivers in Nairobi River Basin.

NRBP was implemented in three phases. Phase one consisted of situation assessment of water quality, a preliminary public awareness and education campaign and capacity building amongst stakeholders. Phase two aimed at capacity building amongst key grassroots stakeholders.

The third phase aimed at promoting the concept of integrated river basin management through a number of activities, outputs and outcomes. It targeted among others development of environmental management and planning systems, environmental conservation and sustainable utilization of resources and sustained public awareness of and participation in environmental issues directly affecting Nairobi River Basin.

The main weakness of the programme is its focus on an informal sector ignoring the formal land uses located in the riparian zones. The programme attributes cause of river pollution in the basin to poor planning of settlements along rivers and water bodies. However, the programme has failed to reveal the real cause of poor planning and especially in relation to the location of these in riparian zones.

6.3.3 Ndung'u Commission

The Commission was formed to inquire into illegal/irregular allocation of public land (Kenya, 2004). The objectives of the Ndung'u Commission were to inquire into allocation of public land dedicated or reserved for a public purpose to private individuals and corporations, to collect and collate all evidence and information available relating to the nature and extent of unlawful or irregular allocations of such lands and to prepare a list specific to particulars of the land and of the persons to whom they are allocated; to identify the persons whether individual or corporate bodies to whom such allocations were made and the identity of any public officials involved in the allocation.

According to the Report, several factors led to illegal and irregular allocation of public land. These included abuse of land allocation process due to political interference, land speculation, corruption and lack of professional ethics, poor planning and record keeping. Complete disregard for established regulations by concerned institutions exacerbated abuse of laid down rules and procedures in land allocation.

The Commission also found out that many methods were used irregularly and illegally to acquire public land by powerful government officials, politicians and people who supported them. Specifically, there were glaring abuse of laws, rules and regulations on land allocation and registration by the President and/or Commissioner of Lands. The President and Commissioner of Lands authorized direct allocations contrary to the procedure laid down by the law.

The most affected public land included land belonging to state ministries, corporations and public institutions such as schools, bus parks, road reserves, forestry department and local authorities, illegal allocation of riparian zone land for urban development was also rampant. These illegal allocations of land in riparian zones were mainly made to private religious institutions of all faiths (Kenya, 2004). Some parties were allocated public land as an inducement or reward for mobilizing political support (Ibid, 2004).

The diplomatic missions also acquired public land illegally contrary to the Vienna Convention on Diplomatic and Consular Relations. The Commission concluded that widespread irregular/illegal land allocations took place due to abuse of power by the President and Commissioner of Lands.

The Commission recommended nullification and restoration of the land to the purpose for which it was reserved. It also recommended revocation of all current letters of allotment, issued for illegal allocation of public land. Finally, the Commission recommended investigation and prosecution of public officials who facilitated or participated in the illegal allocation of public land.

The Commission, however, failed to address issues of sanctity of title deed by securing land ownership for the land acquired legally. According to land registration Acts at the time, revocation of title deeds could only be on grounds of fraud established by the high court. However, judgments made by courts of law have often failed to establish encroachment due to lack of clear legal guidelines on what constitutes the point of reference and the width of the riparian zone. Like the Njonjo Commission Report, the Ndung'u Commission Report also remained largely unimplemented.

6.3.4 Technical Advisory Committee on Riparian Zone Determination

The Technical Advisory Committee (TAC) was an inter-ministerial taskforce spearheaded by NEMA in 2011 to implement among others, laws on riparian zones. The Committee aimed at providing a common and harmonized approach in the implementation and enforcement of laws on riparian zones. It was expected that stakeholders would adopt and implement the findings of the committee that included guidelines for determination of riparian zones for all water bodies in Kenya.

The committee was tasked to identify different laws on riparian zones and to determine suitable widths for riparian zones. The Committee was further to prepare a report and make recommendations on suitable riparian width for different water bodies. Members of the committee agreed the following criteria in determining riparian zones (i) size that is width of the river, (ii) point of measurement, either the highest or lowest water mark for a particular water body, and (iii) approved Part Development Plans (PDP) where available.

The report recommended a minimum riparian zone width of 6m to be retained or equal to the average full width of the river measured from the highest water mark, whichever is higher, up to a maximum of 30 metres for all seasonal and perennial rivers. As extensively discussed in this chapter, generic criteria would appear to offer limited or no protection to the river ecosystem. This is particularly so, when very small widths are preferred by professionals and policy makers. The criteria for determination adopted by the committee

appeared more concerned with the protection of property rights rather than the riparian zone and other river ecosystem elements.

6.3.5 Judicial Interventions

Two court cases are discussed to illuminate the challenges of determination, use and management of riparian zones.

6.3.5.1 “We Care about Nairobi Do It” and Another versus NEMA and Another

The case was held before the Environmental Tribunal in Nairobi (Appendix 10). In this case “*We Care about Nairobi Do IT and Kyuna and Shanzu Road Residents*” took NEMA and *M/S Houses and plots limited* to court challenging the initial approval by NEMA of Environmental Impact Assessment Report (EIA) for the proposed construction of 23 houses without approved architectural and structural plans. *We Care about Nairobi Do It and Shanzu Residents*, who were the appellants, argued that the land is steep with houses under construction very close to Kibagare stream where the developer, *Houses and Plot limited* had cut trees.

The main issues that were raised in the court included a protestation against the way EIA was carried out without proper public participation and due notices availed on site and in the media. Among the concerns of the appellant was that a wetland had been interfered with, trees had been cut and appropriate distances from highest water mark ignored given some houses were under construction too close to the river.

In contention, were whether or not the riparian zone was respected and whether the zone had been observed and whether it is known in law? The court observed that the riparian reserve was one of the conditions given by NEMA and has been a condition given consistently in developments alongside rivers. The appellant argued that the zone had not been respected and that four houses were set in the zone. The appellant further argued that firm ground inside the riparian area would mark the end of the zone from the highest water mark.

On the other hand, the developer argued that the six metre rule was only a guideline and therefore not legally binding. The developer further argued that NEMA officials had placed pegs showing that the two constructed houses were outside the six metre area as measured from the middle of the river.

Arising from considerations of arguments from both sides, the tribunal unanimously ordered among others that proponent takes measures in carrying out the construction to ensure that there is no encroachment on the riparian zone. This judgment in a way is generic and is not capable of protecting the riparian zone.

6.3.5.2 Faraday Limited versus National Environment Management Authority

In this court case, Faraday Limited went to court to challenge the cancellation of its license No. 000152 dated 20th July 2007. This is after NEMA had sought specific orders to stop construction of the housing development on plot LR No. 209/11946 along Ring road, Kileleshwa Nairobi claiming that the development was in the riparian zone.

The judge ordered joint reports from NEMA and WRMA after surveying the riparian reserve area. NEMA and WRMA were to indicate whether the project had interfered with the aforesaid reserve, and the developer was not to develop the area of suit land along the riparian reserve. In this case, the judge ruled in favour of Faraday as the development was beyond the six metre zone. The travesty of justice is that Faraday Limited development is in the 30 metre strip left out to cater for the riparian zone by residents of Faddville Estate during subdivision of their land in 1987.

6.3.5.3 Implication of Judicial Interventions

There are important lessons that can be drawn from the two cases, with regard to, encroachment of riparian zones. First, it shows that the law was followed to change the use from the riparian zone to residential development through the planning process. It appears allocation was done without seeking the opinion of the residents of Faddville estate who surrendered the riparian land. Second, factors such as gradients of river banks and the nature of land use were not considered when allocating the riparian zone land. Finally, it appears that there are no clear guidelines on how to determine the width of the riparian zone.

Water Resources Management Rules of (2007) provides a blanket of 6 to 30 metres that is applied by NEMA and WRMA. In such circumstances, the court is at pain to determine whether it would be 6 metres or any other width. Measurement of riparian width requires land surveying principles and techniques.

In addition, use of the riverbank as point of reference causes confusion because riverbanks are rough and erode and change with time. Developers would also shift the riverbank to

avoid being penalized. All these factors were not taken into account when delivering judgments. Unfortunately, it is the riparian zone that continues to face the consequences of land use.

6.4 Role and Opinion of Officers in Public Institutions

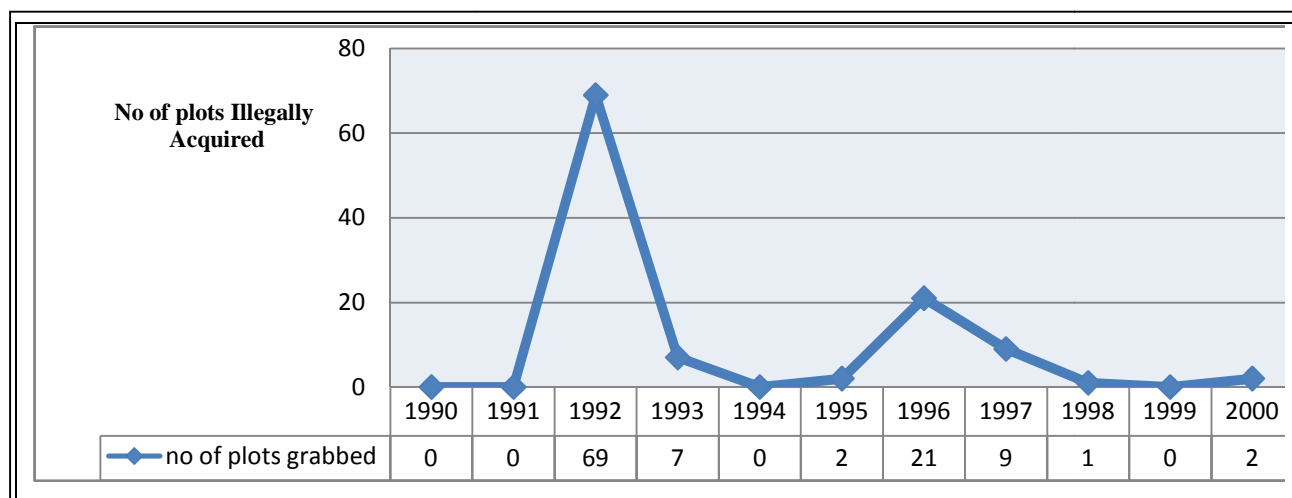
This part discusses results of data analysis on determination, use and management of riparian zones by concerned institutions. Structured interviews were used to collect the data from five institutions that included (i) City Council of Nairobi; (ii) National Environment Management Authority (NEMA); (iii) Water Resources Management Authority (WRMA); and (iv) Ministry of Environment and Natural Resources where data was collected from the Department of Resource Surveys and Remote Sensing (DRSRS), and (v) Ministry of Lands. The Departments of Lands, Physical Planning and Surveys, are the units of analysis of data sources in the Ministry of Lands. Interviews were conducting with senior officers from these institutions.

6.4.1 Allocation and Occupation of Riparian Land

According to the Departments of Lands, Physical Planning and Surveys, it was routine before the 1990s to draw up Part Development Plans (PDPs) on existing survey records and plans to avoid duplication and double allocation. However, in the 1990s, there were much duplications and double allocations of public land (Kenya, 2004). Most illegal and irregular allocations were done just before the general elections of 1992, 1997 and 2002. These allocations targeted valuable open spaces in urban areas including riparian zones.

The findings from the Ministry of Lands confirm those of the Ndung'u Commission Report on illegal and irregular acquisition of public land (Kenya, 2004). The Report show that land set aside for conservation areas was re-allocated in 1992 and 1997 electioneering years. Figure 6.1 presents the number of conservation parcels of land that were illegally and irregularly alienated in Kinale Settlement scheme between 1990 and 2000 in Kiambu County. The county borders the city of Nairobi.

Figure 6.1: Illegally Re-allocated Wetland Plots in Kinale Settlement Scheme



Source: Compiled from Kenya (2004): The Ndung'u Commission Report on the Inquiry into Illegal/Irregular Allocation of Public Land. Nairobi: Office of the President

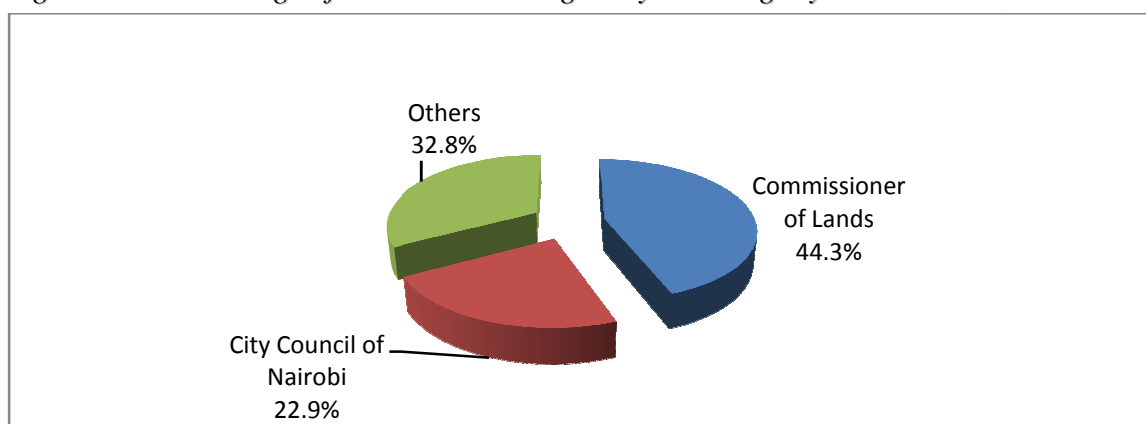
Table 6.1 and Figure 6.2 present findings of the Ndung'u Commission on the number of public parcels of land irregularly and illegally allocated by different land allocating authorities.

Table 6.1: Public Plots Irregularly and Illegally Allocated in Nairobi

No.	Allocating Authority	No. of Plots Allocated
1	Commissioner of lands	244
2	City Council of Nairobi	126
3	Others	181

Source: Compiled from Kenya (2004): Report of the Ndung'u Commission on the Inquiry into Illegal/Irregular Allocation of Public Land. Nairobi: Office of the President

Figure 6.2: Percentage of Public Land Irregularly and Illegally Allocated



Source: Compiled from Kenya (2004): Report of the Ndung'u Commission on the Inquiry into Illegal/Irregular Allocation of Public Land. Nairobi: Office of the President

Respondents in each sampled institution blamed officers in other public institutions for the allocation of riparian land. Officers of the City Council of Nairobi felt that it was the Ministry of Lands and the Provincial Administration that sanctioned the allocations. The Department of Lands, on the other hand, indicated that it was the City Council of Nairobi who allocated the land. Finally, WRMA and NEMA blamed City Council of Nairobi and the Ministry of Lands for the allocations.

The reasons given for the allocation included corruption and economic motives around land speculations. Lack of effective land use planning and political interference created fertile conditions for these factors. Table 6.2 summarizes the opinions of public officers concerning who allocated riparian land to private developers.

Table 6.2: Public Officers Opinion on Allocation of Riparian Zones

Institution	Department	Institution Reported to have Allocated Public Land Irregularly/ Illegally	Reasons Given for Allocating Public Land
City Council of Nairobi	Environment	<ul style="list-style-type: none"> • City Council of Nairobi • Ministry of Lands • Provincial Administration 	1 Corruption 2 Business purpose 3 Human settlement
City Council of Nairobi	City Planning	<ul style="list-style-type: none"> • No response 	1 Political interference
City Council of Nairobi	Development Control Section	<ul style="list-style-type: none"> • No response 	1 No response
Ministry of Lands	Department of lands	<ul style="list-style-type: none"> • City Council of Nairobi • Provincial Administration 	1 Landlessness 2 Economic motive 3 Poor planning
Ministry of Lands	Department of Surveys	<ul style="list-style-type: none"> • City Council of Nairobi 	1 Corruption 2 Political pressure
Ministry of Lands	Physical Planning	<ul style="list-style-type: none"> • City Council of Nairobi • Provincial Administration 	1 Lack of housing 2 Economic motive 3 Poor planning
WRMA	Nairobi Sub-regional Office	<ul style="list-style-type: none"> • Department of Lands 	1 No response
NEMA	NEMA	<ul style="list-style-type: none"> • City Council of Nairobi • Ministry of Lands 	2 Political Interference

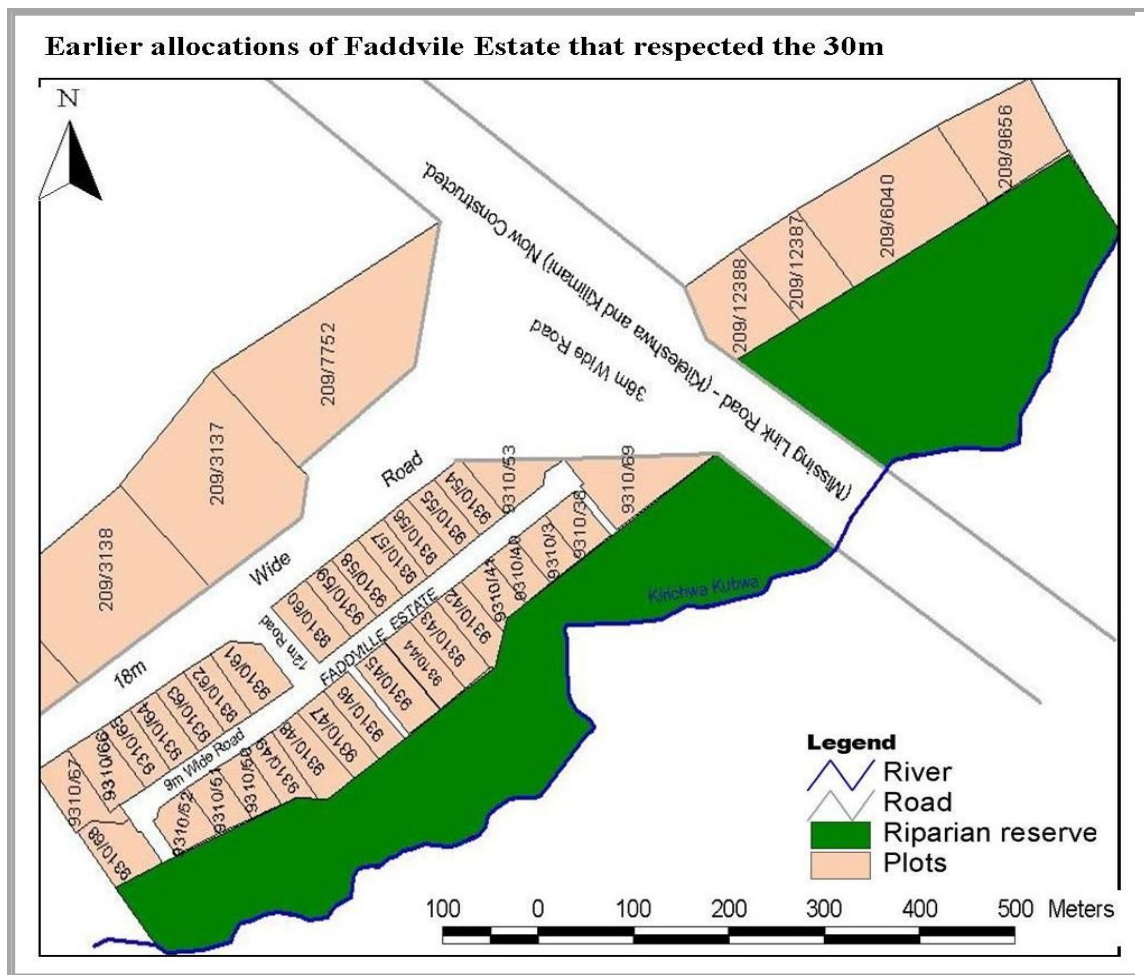
According to officials of the Department of Lands, the repealed Government Land Act stipulated that plans would be prepared before parcels of land are allocated for

development. However, they opined that the new policy and administrative changes were introduced in 1989.

The change authorized public officers in the Department of Lands, Physical Planning and Department of Surveys to plan, survey and allocate land directly without first preparing subdivision plans. As a result, in some cases, Part Development Plans (PDPs) were not prepared to enable allocation of land as required in the Government Land Act.

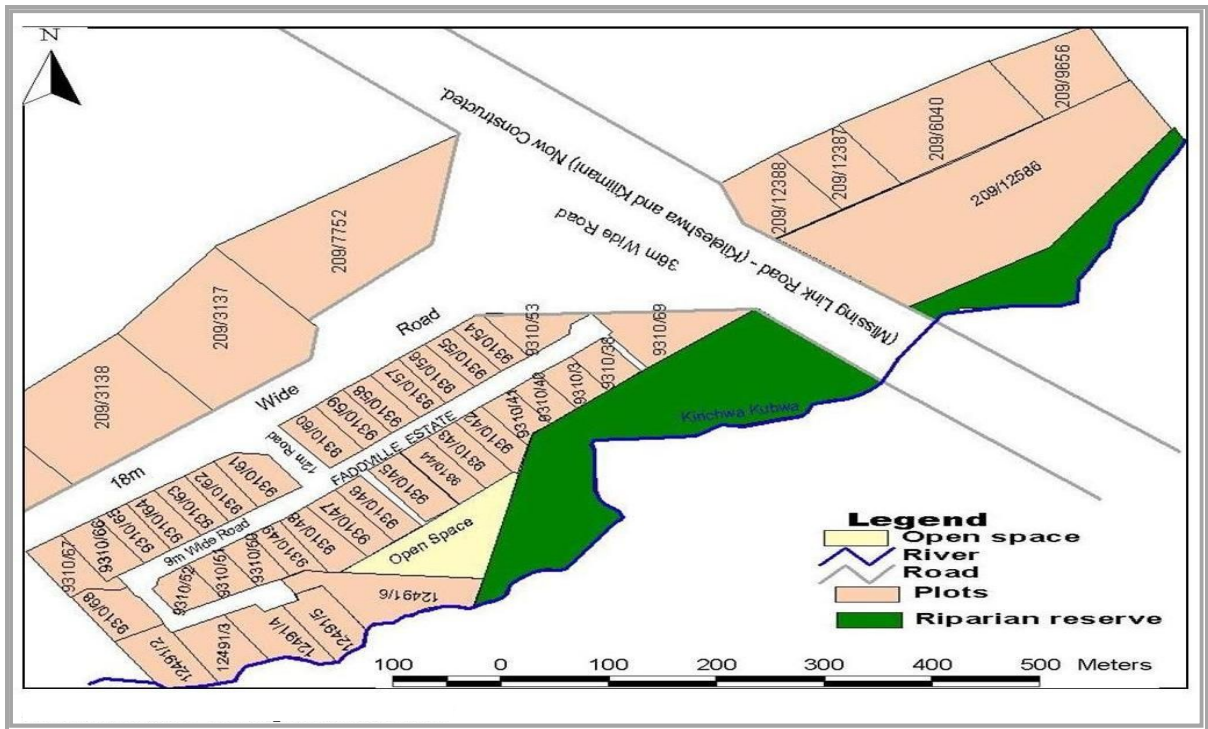
Figures 6.3, 6.4 and 6.5 show the changes that took place on riparian zone adjoining Faddville Estate after it was allocated and redeveloped into residential flats in 1987, 1994 and 2012.

Figure 6.3: Riparian Zone after Subdivision of Faddville Estate in 1987



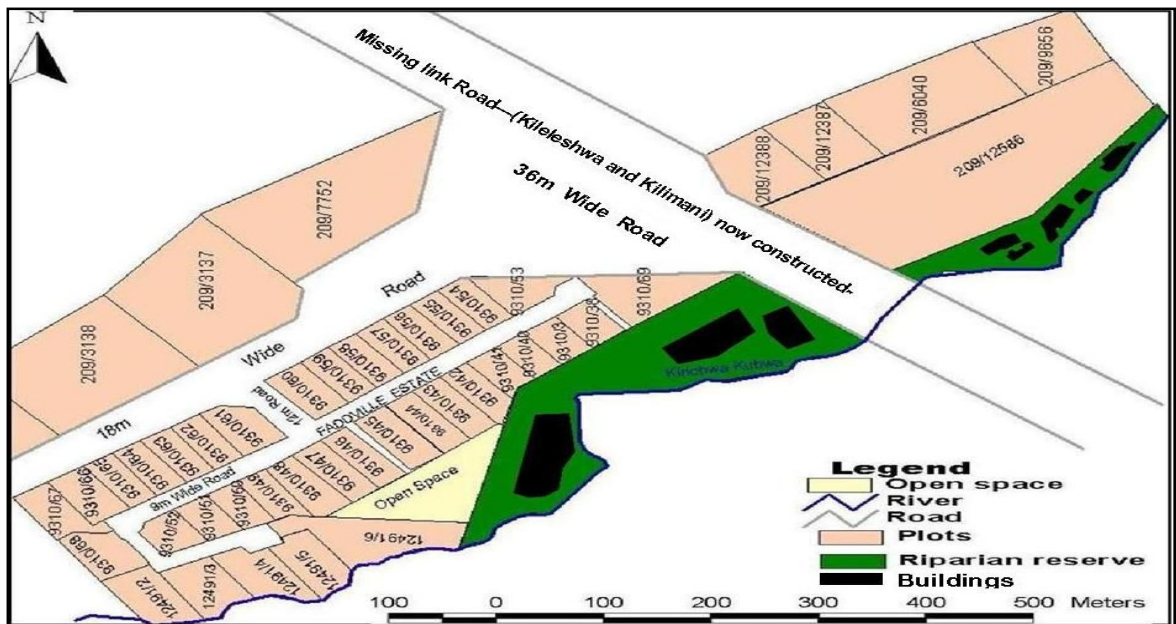
Source: Compiled from survey plans from department of Surveys and Quickbird satellite image of 2010 from DRSRS

Figure 6.4: Re-Allocation of Riparian Zone at Faddville Estate in 1994



Source: Compiled from survey plans from department of Surveys and Quickbird satellite image of 2010 from DRSRS

Figure 6.5: Developments on Riparian Zone at Faddville Estate in 2012



Source: Compiled from survey plans from department of Surveys and Quickbird satellite image of 2010 from DRSRS

Figures 6.3, 6.4 and 6.5 show the changes on riparian zones as a result of irregular and illegal allocations. The changes have resulted in reduced width of the zone and removal of vegetation cover. The new developments on riparian zones have also blocked the natural lights of old residential houses contrary to the building code that requires a minimum distance to be left between buildings. Some of the new parcels of land on the riparian zone have no proper access and use a 3 metre sanitary lane contrary to subdivision regulations that require a minimum of 9 metre road reserve.

6.4.2 Determination and Management of Riparian Zones

Officials were asked to state whether the determination, use and management of riparian zones were mainstreamed in their respective organizations and if so, to state specific roles of their organizations.

Officials from the City Council of Nairobi indicated that riparian zones were mainstreamed in the functions of the Council. The roles of the Council were formulation and review of policies and regulations, enforcement, formation of partnership with relevant stakeholders in the management and maintenance of riparian zones.

Officials from Water Resources Management Authority (WRMA) also indicated that management and protection of catchments including riparian zones are among the main functions of the institution. WRMA uses catchment area advisory committees (CAACs) to support these functions at the regional level. The organization also uses water resources users associations (WRUAs) as a medium for cooperative management of water resources and conflict resolution at sub-catchment level.

National Environment Management Authority (NEMA) regulates development on riparian zone using Water Resources Management Rules (2007). NEMA also has a section that deals with coastal marines and fresh water (CMFW). Officials in the section liaise with Water Resources Management Authority to identify riparian zones and to advise developers on appropriate activities on riparian zones. In this regard, difficulties are encountered in enforcing, the rules because it is not clear when to use 6 or 30 metres.

Officers of NEMA indicated that it is necessary to formulate regulations that will guide determination of the width based on the premise that the wider the river, the wider the zone. Finally, NEMA officials strongly felt that differences in land use should be taken into account in determining the width of the riparian zone.

Respondents from the Department of Lands also confirmed that the determination, use and management of riparian zones are mainstreamed in the functions of the department. They stated that the roles of the department include reserving adequate land for riparian zones during land allocation, conservation of fragile ecosystems and ensuring that such land is not allocated to private developers. They also indicated that they review building plans before approval to ensure that the plans do not encroach on the zones. The officers also attend liaison committee meetings with the City Council of Nairobi on the management of the Nairobi River Basin.

The officers of the Department of Physical Planning indicated that the department prepares physical development plans (PDPs) and advises local authorities on good land use practice. According to the officers, local authorities are responsible for implementing physical development plans and for enforcing development control in their areas of jurisdiction.

The officers further indicated that the City Council of Nairobi executes development decisions without strict adherence to and consultation of Physical Planning Department. On the other hand, they indicated that the department lacks the capacity to monitor and enforce land use regulations on developments located close to the riparian zone once plans are approved.

Officials at the Department of Physical Planning also responded that the riparian zone is not shown on land use plans. In addition, they indicated that the functions of the department and those of the Department of Surveys are not coordinated to ensure the proper determination of size and boundaries of riparian zone in relation to land use. In this regard, only hatched lines are drawn to indicate proposed riparian boundaries in land subdivisions. Boundaries of riparian zones are not shown in subdivision plans, deed plans or registry index maps (RIMs). Deed plans and RIMs are used as land transaction instruments.

Officers of the Department of Surveys responded that riparian zones should be demarcated with a series of beacons to show fixed boundaries in accordance with Survey Regulations. The officers further stated that, in areas that are mapped using general boundaries under the repealed Registered Land Act (Chapter 300 of Laws of Kenya), physical boundaries up to the centre of river are unnecessary. This makes it difficult for planning to curtail encroachment and to implement conservation programmes in riparian zones.

Officers in the Department of Surveys also responded that re-mapping could remove land boundaries that extend into the rivers and people sensitized on the need to conserve riparian zones. The officers suggested that a paradigm shift by the Government towards educating citizens on other means of utilizing available land resources and restraining from encroaching on fragile areas such as riparian zones. In this way, land development would lead to maximization of use of available land through construction of high-rise apartments for low income housing.

6.4.3 Monitoring and Evaluation of Riparian Zones

Officers in NEMA responded that the institution lacks a framework for monitoring the use of riparian zones. For example, in cases of sewer bursts, NEMA has to report to Nairobi Water and Sewerage Company (NWSC) for action and later monitor to find out if NWSC has repaired the sewer line.

NEMA also uses complaints received from people on encroachment and effluent discharge before its officials verify at the sites of reported incidents. The Authority also conducts periodic inspections to monitor and evaluate sections of riparian zones along rivers. Although NEMA has geographic information system (GIS), the Authority has not used it to monitor riparian zones.

NEMA blames these problems of the riparian zone to prevailing ideology of land ownership up to the centre of river. According to the Authority, it is difficult to challenge this ideology because land owners have valid land ownership documents. Indeed the land is apparently theirs since they hold title deeds and nobody has marked the riparian zones to indicate otherwise.

Another challenge is encroachment into the riparian zone after long spell of dry period. In the absence of effective enforcement of urban land use planning regulations, informal and formal land use activities were assimilated into extensive riparian zone areas. In addition, enforcement of 30 metre riparian zone width was hindered by politicians who used unaccountable political moves to legitimize unauthorized informal developments on riparian zones. Unclear and often conflicting legal provisions in the Survey Act, Physical Planning Act and the Government Land Act have also contributed to the formalization of encroachment by approved subdivision and building plans.

According to NEMA, any development close to a wetland should have an environmental impact assessment (EIA) conducted. The EIA report should propose guidelines for development to ensure that the ecology of the river is secured. In addition, NEMA is well organized at their headquarters, county, district and location levels. There are officers at the headquarters, County Directors, District Environment Committees and Chief's *Barazas* which form a structured hierarchy of enforcing environmental regulations. However, this hierarchy is not effectively integrated with other sectors.

6.4.4 Opinions of Public Officers

According to the City Council of Nairobi officials, the factors that have led to encroachment and degradation of riparian zones are (i) poor governance and corruption, (ii) lack of enforcement of existing laws, (iii) lack of coordination between ministries and other government agencies, (iv) pressure on land, (v) weak legal and institutional framework, (vi) weak enforcement of plot coverage, and (vii) lack of enforcement of approved building lines. The Council officers explained that high densities of developments led to poor disposal of domestic solid and sanitation waste because requisite facilities are not provided.

These are in turn due to lack of enforcement of building rules, regulations, and illegal land allocations and fences that run to the river channel. Litigation where developers file injunctions to challenge enforcement of building codes and land use approved plans are also factors that contribute to the challenge of riparian zone conservation.

Finally, poor surveillance because of a small number of professionals to police the riparian zone and illegal developments, as well as interference by powerful politicians supporting their electorate in informal settlements including the ones located in the riparian zones. This is in line with findings from Lands Department, the National Environment Management Authority and the Report of Ndung'u Commission. They also complained of political interference in informal settlements

City Council officials suggested the harmonization of laws on administration of riparian zones to secure common understanding among responsible institutions. The officers also suggested the harmonization of guidelines and regulatory rules. The Council officials also proposed community sensitization and participation in riparian zone conservation to make

people fully aware that the riparian zone is public land that serves multiple functions such as ecological protection and management of floods among others.

According to WRMA officials, encroachment on riparian zones led to degradation and deterioration due to weak legal provisions in existing laws that cover riparian zones. Other causes are haphazard disposal/dumping of wastes, non-compliance with land use planning regulations, impunity on the part of politically powerful and well connected developers and weak institutional capacity to police and undertake surveillance of urban development

Enactment of Water Resources Management Rules of 2007, conducting awareness creation campaigns and collaboration with line departments and/or organizations are strategies the Authority uses to ensure conservation of riparian zones.

WRMA collaborates with NEMA in prosecuting culprits in court as in the case of NEMA versus Nakumatt Ukay and NEMA to file cases in court against Nakumatt Ukay in the case "*NEMA versus Nakumatt Ukay*" and "*NEMA versus Faraday Limited.*" WRMA and NEMA lost the cases because judgments found that existing policies and laws on riparian zones conservation and determination prescribed conflicting actions, guidelines and rules.

On their part, officials from the Department of Lands have blamed scarcity of readily available land, weak institutional capacity, rapid growth of urban population and failure to design strong public management processes and procedures for encroachment and degradation of riparian zones.

6.4.4.1 Factors Affecting Biophysical Functions of Riparian Zones

Biophysical functions of the riparian zones are affected by (i) informal settlements; (ii) motor repair garages; (iii) urban farming; (iv) poor land use management; and (v) lack of strategic urban planning; (vi) weak enforcement of land use and building regulations and policies; (vii) non-compliance to existing laws, and (viii) high urban population density.

The officials of responsible institutions proposed the following measures/ strategies to restore and maintain biophysical functions of the riparian zone (i) enforcement of rules and regulations; (ii) strict compliance with existing rules; (iii) conducting corruption-free inspections by officials; (iv) review of existing rules and regulations; (v) strategic urban planning; (vi) involvement of stakeholders in the management of riparian zones; (vii) planting trees and grass to improve riparian vegetation cover, (viii) restricting

development to permitted areas only; (ix) construction of culverts where necessary; and (x) reclaiming riparian zone areas and sites as provided in the Water Act, 2002. These 10 strategies would effectively curtail causes of biophysical degradation of the zones in Nairobi River Basin.

The following were listed as negative implications of urban land uses adjacent to the river: (i) environmental pollution of the rivers; (ii) encroachment and degradation of riparian zones; (iii) erosion of the riverbank; (iv) erosion during long rains; (v) internal displacement of persons during rainy seasons; (vi) loss of business in the informal sector; and (vi) pollution of rivers.

6.4.4.2 Land Uses Permitted within and Adjacent to Riparian Zones

Majority of public officials interviewed regard urban parks and open recreation spaces, public and private institutions and high income residential development as the best suited land uses at sites adjacent to the riparian zones as presented in Table 6.3. However, they all agreed that only urban parks and open recreational spaces should be located within riparian zones.

Given the results in Table 6.3, it is surprising that this expression of perceptions of the officials is not reflected in the practices of urban land use planning and administrative practices of the officers. Neither do these reflect the multiple goals and objectives reflected in laws, rules and regulations governing the functions of institutions for which the officials work.

Table 6.3: Opinions of Public Officers on Permitted Land Uses in Riparian Zones

Institution	Department/Section	Land Uses that should be Permitted Adjacent to Riparian Zones	Land Uses that Should be Permitted in Riparian Zones
City Council of Nairobi	Environment	<ul style="list-style-type: none"> • High income residential • Private Institutions • Public institutions • Formal businesses 	<ul style="list-style-type: none"> • Open recreational Grounds
City Council of Nairobi	Forward Planning	<ul style="list-style-type: none"> • No response 	<ul style="list-style-type: none"> • Open recreational Grounds • Urban Parks
City Council of Nairobi	Development Control Section	<ul style="list-style-type: none"> • Recreational facilities • Forestry • Recreational Facilities 	<ul style="list-style-type: none"> • None
Ministry of Lands	Department of Lands	<ul style="list-style-type: none"> • High income residential 	<ul style="list-style-type: none"> • Urban Parks
Ministry of Lands	Department of Surveys	<ul style="list-style-type: none"> • Open Recreational Grounds • Urban Parks 	<ul style="list-style-type: none"> • None
Ministry of Lands	Physical Planning	<ul style="list-style-type: none"> • High income residential • 	<ul style="list-style-type: none"> • Urban parks
WRMA	Nairobi Sub-regional Office	<ul style="list-style-type: none"> • Public Institutions • Urban Parks • Open recreational Grounds 	<ul style="list-style-type: none"> • None
NEMA	Enforcement	<ul style="list-style-type: none"> • High income residential, • private and • public institutions, 	<ul style="list-style-type: none"> • Open Recreational Grounds • Urban Parks

6.4.4.3 Land Uses that Should Be Restricted From Riparian Zones

Public officers suggested the following to be used in allowing or disallowing land uses along riparian zones (i) application of polluter-pay principle; (ii) assessing the potential of proposed development to pollute and degrade the environment by conducting environmental impact assessment (EIA); (iii) strict enforcement of business licensing and regulation and rules for those locating adjacent to riparian zones

From Table 6.4, public officers rated informal settlements, informal businesses, motor vehicle repair garages and industries as land uses that must be restricted from locating close or adjacent to the zones. There was a high level of sensitivity on the part of the officials with respect to undesirable land uses close to riparian zones.

Table 6.4: Opinions of Public Officers on Restricted Land Uses in Riparian Zones

Name of Institution	Department/Section	Land use to be restricted adjacent to riparian zones
City Council of Nairobi	Environment	1. Informal settlements 2. Quarry Mining 3. Urban agriculture 4. Informal markets 5. Heavy industries 6. Motor Vehicle Garages 7. Sewer Lines
City Council of Nairobi	Forward Planning	1. No Response
City Council of Nairobi	Development Control	1. All physical developments
Ministry of Lands	Department of Lands	1. Informal settlements 2. Garages
Ministry of Lands	Department of Surveys	1. Informal settlements 2. Quarry Mining 3. Informal Businesses 4. Heavy industries 5. Sewer Lines
Ministry of Lands	Physical Planning	1. Informal settlements 2. Informal markets 3. Motor Vehicle Garages
WRMA	Nairobi Sub-regional Office	Informal settlements, quarrying, garages, Heavy industries
NEMA		1. Informal settlements 2. Quarry Mining 3. Urban agriculture 4. Informal markets, 5. heavy industries, 6. Motor Vehicle Garages 7. Sewer Lines

6.4.4.4 Challenges in Enforcement of Policies and Procedures on Riparian Zones

The City Council of Nairobi faces challenges of blatant disregard of laws and standards by developers. Developers disregard conditions attached in approved land use and building plans by implementing their developments on riparian zones contrary to granted approvals. Kenya Law Review Judicial Reports have documented cases where developers have been taken to court on violating conditions attached to the approved plans (Appendix 5).

The factors that are considered important in determining riparian zones include (i) size of the river channel; (ii) size of parcel of land; (iii) population density; and (iv) types of development. Use of signboards with warning messages to potential violators of the riparian zone, publicizing of the riparian areas and policing patrols to manage these three factors was also suggested. Clearly marked boundaries of the zones and planting of vegetation would secure effectiveness in these three management measures. Table 6.5,

summarizes the challenges public officers face in conservation of riparian zones in the basin.

Table 6.5: Challenges Faced by Institutions in Conservation of Riparian Zones

Name of Institution	Department/Section	Challenges Faced	Strategies for Overcoming the Challenges
City Council of Nairobi	Environment	<ul style="list-style-type: none"> • Lack of capacity by enforcing agencies • Weak legal framework • Lack of coordination among relevant agencies • Lack of political goodwill 	<ol style="list-style-type: none"> 1. Strengthen both institutional and legal frameworks 2. Coordination of activities among agencies 3. Urban planning
City Council of Nairobi	City Planning	<ul style="list-style-type: none"> • Uncoordinated regulatory bodies • Impunity 	<ol style="list-style-type: none"> 1. Strict enforcement of the law
City Council of Nairobi	Development Control Section	<ul style="list-style-type: none"> • Law-breaking developers • Illegal discharge into riparian zones • Understaffing of enforcement officers 	<ol style="list-style-type: none"> 1. Proper signage to warn law breakers 2. Gazettement of Riparian zones 3. Thorough patrol and inspection by officers 4. Employment of professionals in the relevant fields
Ministry of Lands	Department of Lands	<ul style="list-style-type: none"> • Corruption • Lack of enforcement by CCN 	<ol style="list-style-type: none"> 1. Cancellation of titles through a court process 2. Creating public awareness and Sensitization of officers 3. Gazettement of Riparian zones
Ministry of Lands	Department of Surveys	<ul style="list-style-type: none"> • No Response 	<ol style="list-style-type: none"> 1. No Response
Ministry of Lands	Physical Planning	<ul style="list-style-type: none"> • Lack of enforcement by CCN 	<ol style="list-style-type: none"> 1 Sensitization of land users and officers 2 Gazettement of Riparian zones
WRMA	Nairobi Sub-regional Office	<ul style="list-style-type: none"> • Legal ownership documents held by the developers 	<ol style="list-style-type: none"> 1 Ensuring that riparian zones are not allocated to developers 2 Enactment of relevant legislation (Water Act & Water Rules) 3 Awareness creation
NEMA	Development Control	<ul style="list-style-type: none"> • Lack of enforcement by CCN 	<ol style="list-style-type: none"> 1 Strengthen both institutional and legal frameworks 2 Coordination of activities among agencies

6.4.4.5 Laws and Criterion for Determining Width of Riparian Zone

Multiple statutes are used in the determination of riparian zones. These statutes are a major source of conflict in the process. Specifically, the statutes provide for different ways and results of determining the zones. Experts who use the statutes to determine and manage the zones interpret the statutes differently that makes the matter worse in deciding different official widths of the zones. Table 6.6, summarizes this problem.

Table 6.6: Opinion of Public Officers on Riparian Zones Laws

Name of Institution /Department	Number of Respondents	Applied Statutes/ Regulations	Criteria
City Council of Nairobi	4	<ul style="list-style-type: none"> • Physical Planning Act • EMCA • City Council By-laws • Physical Planning Regulations of 1996 	1 Zoning of urban areas and land use
Department of Lands	3	<ul style="list-style-type: none"> • Physical Planning Act 	1 Volume of the river 2 International standards 3 Highest watermark 4 Centre line of the river
Physical Planning Department	2	<ul style="list-style-type: none"> • Physical Planning Act • Physical Planning Regulations of 1996 • Physical Planning Handbook, 2005 and 2008 	1 Local Physical Development Plans 2 Survey Plans
Department of Surveys	2	<ul style="list-style-type: none"> • Survey Act 	1 High Water Mark
WRMA	2	<ul style="list-style-type: none"> • Water Act 2002 • Harmonized version of all laws 	1 Edge of the river (Urban setting), 2 Highest flood mark (rural setting)
NEMA	3	<ul style="list-style-type: none"> • Water Resources Management Rules (2007) 	1 6 to 30 metres from the edge of the river

Other important factors that would be influential as criteria for determination of the zones are velocity and volume in the river, permanence of the river flow, nature and characteristics of adjoining land uses, topography and groundwater recharge zones. Table 6.7 is a summary of the opinion of public officers on the factors that should be taken into account in the determination of riparian zones.

Table 6.7: Suggested Factors for Determination of Riparian Zones

Name of Institution	Factors to Consider in the Determination of Riparian Zones	Number of Respondents	Percentage
City Council of Nairobi	1 Water velocity 2 Volume of the river flow 3 Permanence of the river 4 Soil type 5 Nature of adjacent developments	4	44.44
Ministry of Lands	1 Topography of the land 2 Adjacent land uses	3	33.33
WRMA	1 Slope of the river bank 2 Ground water recharge zones	2	22.22
Total		9	100

6.4.4.6 Technical Human Capacity in Institutions

On account of respondents from public institutions, lack of technical capacity is a major institutional weakness which hinders effective determination, use and management of riparian zones. Table 6.8 presents results of data analysis on this aspect.

Table 6.8: Technical Personnel within Public Institutions

Name of Institution	Planners	Environmentalists	Enforcement Officers	Architects	Surveyors	Draftsmen
City Council of Nairobi	No Response	10	28	No Response	No Response	No Response
Min. of Lands	No Response	No Response	No Response	No Response	No Response	No Response
WRMA	0	0	4	0	0	0
NEMA	No Response	No Response	No Response	No Response	No Response	No Response

6.4.4.7 Land Survey, Land Use Planning and Land Administration Technology

Of the three institutions sampled including the City Council of Nairobi, Department of Lands and Water Resources Management Authority (WRMA), none has an operating geographic information system (GIS) in land and water resource management.

In WRMA, GIS is not used at all while, in the City Council of Nairobi, GIS is sparingly applied in simple land use planning and land survey assignment. The Department of Lands is not computerized for its land records while the Department of Surveys has no geo-referenced database to support land transactions adjacent to rivers. In fact, the most used land survey method relies on manual measurements of distances and angles.

Boundaries that join the river channel at right angle or any other direction prolong the boundary right to the centre line which is a theoretical boundary position. This makes it practically impossible to locate the position of the beacons at a later date.

6.4.4.8 Institutional Policies on Riparian Zones

Each of the institutions that were part of this study has its policy on riparian zone. The policies that were discussed in chapter six were found to advocate conflicting measures. This finding makes it necessary and urgent to have unified institutional policies on determination, use and management of riparian zones. Table 6.9 shows a summary of the opinion of public officers on riparian zone policies of their institution.

Table 6.9: Institutional Policies for Riparian Zones

No.	Name of Institution	Existence of a Policy on Riparian Zone	Relevant Aspect of the Policy
1	City Council of Nairobi	Yes	1 By-laws to manage the riparian Zones 2 By-laws to enforcement the Act
2	Department of Lands	Yes	1 No allocation on riparian zones
3	Physical Planning Department	Yes	1 Physical Planning Act of 1996 2 Physical Planning Handbook (2008)
4	Department of Surveys	Yes	1 Survey Regulations
5	Water Resources Management Authority	Yes	1 Embedded in the Water Act, 2002 2 Water Resources Management Rules of 2007
6	National Environment Management Authority	Yes	1 Environmental Management and Coordination Act of 1999
7	Department of Resource Surveys and Remote Sensing	Yes	1 Environmental Management and Coordination Act of 1999

6.4.4.9 Policy Formulation, Determination and Management of Riparian Zones

From the above discussion on institutions, the study has established that there is the absence of consultations and partnerships among stakeholders on policy concerning conservation of riparian zone. Allocation and land administration processes by the city Council of Nairobi and the Ministry of Lands rarely involve WRMA and other main actors in the land sector.

Also, institutions operate without established criteria and policies to guide planning, surveying and allocation on land on riparian zone. Some land uses adjacent to rivers have left a reserve of more than 30 metres of the zone while others are at the edge of the river channel. Table 6.10 has a summary of opinions of public officers on collaboration between public institutions.

Table 6.10: Opinions of Public Officers on Collaboration among Public Institutions

No.	Name of Institution	Institutions Collaborated With	Nature of Collaboration
1	City Council of Nairobi	<ul style="list-style-type: none"> • NEMA • Ministry of Environment 	<ul style="list-style-type: none"> • Formulation of regulations and enforcement
		<ul style="list-style-type: none"> • Nairobi Water and Sewerage Company Ltd. 	<ul style="list-style-type: none"> • Maintaining sewer systems and clean water provision
		<ul style="list-style-type: none"> • Provincial Administration 	<ul style="list-style-type: none"> • Enforcement
		<ul style="list-style-type: none"> • Ministry of Lands 	<ul style="list-style-type: none"> • Allocation of land
2	Department of Lands	<ul style="list-style-type: none"> • Kenya Forest Service • NEMA 	<ul style="list-style-type: none"> • No Response
3	WRMA	<ul style="list-style-type: none"> • NEMA 	<ul style="list-style-type: none"> • Enforcement
4	NEMA	<ul style="list-style-type: none"> • WRMA 	<ul style="list-style-type: none"> • Formulation of policies • Enforcement of policies •

6.4.5 Suggested Model for Managing Riparian Zones

Public Private Partnerships (PPP) were identified as the most effective strategies for managing riparian zones in Nairobi River Basin. The model was highly rated for its effectiveness and inclusive management of the zones. The model is especially favorably considered for looping in the private sector actors who are also considered as the main violators of riparian zone ecological sustainability, for example, through pollution of rivers.

There is extensive duplication of mandates and functions of public institutions which, may be lopped in the model as well as institutional conflicts that duplication brings about. This is a weak point in the model for institutions currently responsible for riparian zones in Nairobi River Basin. For example, NEMA performs its functions parallel to WRMA with regard to encroachment and degradation of water resources.

These functions have significance to the role of Department of Surveys in determining boundary conditions. In view of these facts, WRMA officials felt strongly that NEMA should harmonize existing legislation, policies and regulations to enhance transparency in enforcing conservation on riparian zones and manage conflicts at the zones.

6.4.6 Institutional Weaknesses

The mandates of most institutions surveyed are well laid down in the laws that established them. However, there is inadequate technical capacity in the institutions to implement the mandates. The number of environmentalists, spatial planners and surveyors involved in

enforcement of policy is glaringly low. The institutions have also not embraced modern technology such as GIS as better options for monitoring and evaluation of encroachment and degradation of the zones.

6.5 Linking Policy and Institutional Factors to Riparian Zones

Existing policies and laws discussed in this chapter are inadequate in addressing the challenges facing predictable determination, use and management of riparian zones. The inadequacies are mainly on account of multiple and fragmented policies and legislation, overlaps in institutional mandates, poor coordination and collaboration between institutions, low technical capacity in public institutions and failure to embrace geo-information technology in decision making.

Accordingly, there are weaknesses in enforcing compliance, in the implementation phase of the policies. In addition, the confusion in policy coupled with a weak institutional framework have further exacerbated abuse and misuse of public offices and power that is engrained in the institutional functions.

These weaknesses reveal an over-reliance on unusually wide discretionary policies in decision making in land administration, implementation and rules. This further confirms weaknesses in existing model of riparian zone determination which is devoid of scientifically derived parameters. Integration of these laws will require the establishment of a more appropriate policy and legal framework that incorporates views of stakeholders.

6.5.1 Policy Factors

The first objective of this study was to examine the influence of existing policy and institutional factors on the determination, use and management of riparian zones in the study area. Field inspection, direct measurements and data collected through interview of public officers revealed that existing policy and institutional factors have not significantly influenced the conservation of riparian zones in the study area.

6.5.1.1 Lack of Clarity in Policy Measures

Water Resources Management Rules of 2007 and the Physical Planning Act of 1996, reference the determination of the riparian zone from the river bank and therefore fail to address natural and physical erosion of the river channel. The Physical Planning Regulations (1998) use the end of the flood plain which also varies with season. The Survey Regulations, on the other hand, use the high water mark. The mark is difficult to

establish without following scientific research methods and mapping. As indicated in authenticated survey plans, practitioners apply the centre line of the river as point of reference in measuring riparian zone widths contrary to provisions of the survey regulations.

In most laws reviewed, the 30 metre (100-foot) riparian zone limit appears to be a conservative maximum limit because most regulations except the Survey Act recommend widths below 30 metres. In any case, the recommended widths are not in any way linked to the functional variables: land use, vegetation, slopes and soils of the riparian zone.

In addition, there is no evidence in policies and legislation to show that the definitions are based on scientific research where implications of site-specific environmental characteristics, effects of adjoining land uses and functions of riparian zones have been determined objectively. In addition, the practice by professionals in Kenya as evinced in subdivision, building, survey and deed plans that show use of the centre line of rivers as property boundaries is a clear indication of the weakness of the policies and institutions to ensure appropriate riparian zones.

Although the Survey Act provides 30 metres as its minimum width from the high water mark, the law appears to only stipulate riparian zones for tidal rivers. Nairobi, Ngong and Mathare Rivers and other rivers that are subject of the current study are not tidal in nature. The Survey Act does not also specify the nature of the activities that should take place within the 30 metre.

Ideally, the zone should be reserved for nature and biodiversity conservation. The law is also limited in terms of giving the maximum riparian width that should be provided. In reality, the riparian zone should not extend indefinitely because land is also a contested space with other legal, social and economic interests playing a part.

First, 30 metres would be too wide for small streams. Second, a 30 metre width is too narrow for wide rivers traversing areas of steep slopes. Third, the width fails to secure conservation of sites with impermeable soils or traversing wetlands. Fourth, the 30 metre is inadequate for protecting rivers from pollution-generating land uses. Fifth, the width would be insufficient for riparian zones in low-lying river valleys such as floodplains while it would still fail to secure and accommodate riparian zone areas that would function as a wildlife corridor and habitats including wildlife parks and conservation areas.

From the above discussion, riparian zone conservation is justified by other functions, in addition, to the well known ones that include aesthetics as recreational areas, ecological functions and pollution control and management. Functions that include wildlife corridors and biodiversity conservation are equally important grounds for search of more encompassing methods of determination, use and management of the zones along the length of rivers.

Maintenance and retention of appropriate vegetation is an important feature in secured riparian zones. This is because removal and replacing vegetation with built structures increases potential for erosion of riverbanks. It also increases chances of channel migration, fragmentation of riparian ecosystem and diminishes plant and animal habitat diversity in riverine and riparian zone ecosystems.

The need to determine appropriate riparian width as advocated above is resonates well with findings that the riparian zone loses its ecological capacities beyond certain widths. Studies in USA reviewed have indicated that, beyond 94 feet, the riparian zone loses most of its ecological abilities. This means that very wide riparian zones may not necessarily be useful for ecological functions.

However, such wide widths could be important for other functions such as wildlife corridors. Flat areas adjoining rivers have no definite slope to help determine the high water mark. In such situations, beyond 30 metres, engineering technology including construction of dykes is acceptable so long as the functional properties of the zone are not negatively affected.

Insofar, the Survey Act and other existing laws in Kenya, provide for static or fixed widths of the riparian zone. These laws will remain ineffective and irrelevant as a legal basis of enforcing rules for determination, use and management of riparian zones. The situation is made worse by contradictions inherent in some of the laws that also promote duplication of roles and functions of institutions.

For example, EMCA (Wetlands Rules of 2009) have replicated Water Resources Management Rules of 2007 instead of providing for synergy. The new Land Act 2012 has retained the meaning of the riparian zone in the old Survey Act which has serious weaknesses outlined.

The theoretical implication of the findings is that the reviewed Kenyan policies lack clarity on definition and determination of riparian zones. Legislations on land use and conservation of riparian zones are full of contradictions that cause confusion and misinterpretations in their applications. This is in agreement with previous studies that explain the uncertainty in policies on the extent, type and use of riparian resources.

This limitation makes it difficult to determine the level of protection required for riparian zones, allowable change on riparian land use and social and economic benefits that could accrue from different types of riparian land uses. Observations underlie the importance of policy and legal actors in the determination, use and management of riparian zones. However, the policies and laws governing establishment and management of riparian zones need to be clear and without contradictions.

6.5.2 Institutional Factors

The actors in public institutions surveyed perceive and indeed propose better ways riparian zones may be secured and managed to benefit communities that live in neighborhoods close to the zones, as well as the city of Nairobi as a whole. However, the actions of different public actors and their roles do not promote proper conservation of riparian zones in their day to day work in land use planning, land survey, land administration, environmental and water resources management.

The Department of Lands, City Council of Nairobi, Physical Planning Department and Surveys are meant to protect riparian zones but have instead allocated, planned and surveyed them as private land allowing developments at riverbanks without reprimanding the culprits. Through errors of commission or omissions some of the developments have no proper access roads, infrastructure to dispose of human wastes or spaces to dispose solid waste and leaves the riparian zone and rivers as the main conduit of the wastes.

Institutions have not properly interpreted and defined riparian zone in relation to the implications of its underlying factors. In addition, they are not coordinated to ensure proper implementation, monitoring and evaluation of the situation in relation to existing policies. They have also not encouraged broad-based partnerships that include the private sector, land users and voluntary groups. The institutions have no integrated policy framework that would take care of the riparian zone.

NEMA and WRMA have not ensured proper protection of the riparian zone, have no proper monitoring and evaluation systems and have therefore remained reactive to the problem of encroachment and degradation. The City Council of Nairobi is poorly prepared to ensure that proper planning and development control mechanisms take place due to corrupt practices, political impunity and low technical capacity. This reveals that public authorities and bodies have failed to advance and secure public interest.

Political interference was cited as a problem to the smooth operation of institutions involved. However, this is mainly as a result of a weak policy and institutional environment and lack of technical capacity and political support. In the context of previous research, public institutions fail on account of political interference in managerial decisions, internal bureaucratic inefficiencies due to structural weaknesses in organizational arrangements and inefficient work performance. The underlying point here is that efficiency and effectiveness rank low in the determination, use and management in Nairobi River Basin.

These findings confirm that an effective institutional framework is an important factor in the conservation of riparian zones. An enabling policy and institutional framework must, therefore be taken into account in the determination, use and management of riparian zones. These findings agree with the views of Home who indicated that partnerships are necessary for the success of programmes and projects.

In fact, extensive encroachment and degradation of riparian zones in Nairobi River Basin has repudiated whether legislation has meaning on conservation of riparian zone. Even if these provisions were to be applied, they would still not be effective because of inherent contradictions.

6.6 Chapter Summary

The chapter has confirmed a deep-seated riparian zone problem arising from the policy and institutional factors. Chapter seven that follows is on implications of land use and biophysical factors on the determination, use and management of the riparian zone. Empirical facts derived from the next chapter will confirm or refute the hypotheses on whether the policy and institutional factors have influenced the conservation of riparian zones.

CHAPTER 7: IMPLICATIONS OF SPECIFIC LAND USE AND BIOPHYSICAL FACTORS

7.0 Introduction

This chapter has presented results of the analysis of data that was collected from the study sites. The units of analysis entail data from 12 study sites. The results of data analysis are presented from the following seven physical development sites (i) Faddville residential estate along Kirichwa Kubwa River in Kileleshwa, (ii) Mathare 4B informal residential housing along Mathare River, (iii) Viwandani industries along Ngong River and (iv) Gikomba Informal businesses along Nairobi River, (v) Nakumatt Ukay hypermarket along Kibagare canalized the stream, (vi) Nairobi National Museum along Nairobi River, and (vii) Hotel Boulevard along Nairobi River.

The results were also interrogated from the following five physical activities (i) Mukuru Kwa Njenga quarry mines, (ii) Mukuru Kwa Rueben urban agriculture along the Ngong River, (iii) Uhuru estate garages along Nairobi River, (iv) Nairobi Arboretum Recreation Park and (v) Kamukunji open public recreation grounds. Data on solid and waste water facilities collected using interviews and questionnaires, direct observation and photography at study sites is also analyzed and the results presented.

7.1 Land Use Variables

Specific land use types located in the 30 metre buffer, their spatial concentration/densities and spread along the zone are the main land use variables studied.

7.1.1 Distribution of Land Use Types in 30-Metre Riparian Zone

Results of data analysis on the distribution of land use types using remote sensing data is presented in table 7.1. As shown in the table, bushland and grassland cover the largest area of land that is 302.04 hectares out of a total of 732.348 hectares or 41 percent. The area occupied by planted trees is the second largest area of 180.626 hectares or 25 percent of the 30 metre riparian zone. These two uses show a high proportion of land use types that are not directly influenced by human activities. However, combined land use types that have development activities namely commercial (17.198 ha), formal settlements (17.674 ha), informal settlements (78.243 ha), agriculture (58.071 ha), industrial 91.3 ha) and institutional (1.6 ha) reveal that the direct land use by urban development activities on riparian zones have more influence on the 30 metre zone. These take up a total of 174.086

or 20 percent. Table 7.1 presents the area of land uses in the 30 metre riparian zone, in the city of Nairobi.

Table 7.1: Riparian Areas Occupied by Different Land Uses in Nairobi

Land Use	Area of Different Land Uses in Hectares	Percentage of Total Area
Agriculture	58.071	7.93
Bushland/Grassland	302.041	41.24
Commercial	17.198	2.35
Formal Settlement	17.674	2.41
Industrial	1.3	0.18
Informal Settlement	78.243	10.68
Institutional	1.6	0.22
Other Land	17.059	2.33
Planted Trees	180.626	24.66
River Bed	58.536	7.99
Total	732.348	100

Source: Compiled from the Department of Resource Surveys and Remote Sensing, 2012

Two observed cases can be compared at this point; industrial land use (Viwandani) and the formal settlement (Faddville Estate). Industrial structures have been built right at the edge of the riverbank. Pipes and open concrete drains empty the effluents on riparian zone and into the river channel. Such land uses have totally ignored any sound environmental management practices. Figure 7.1 shows factories at the edge of the canalized Ngong River.

Figure 7.1: Industrial Buildings on Canalized Ngong River.



Some land uses have, however, tried to factor in a number of environmental considerations as demonstrated in figure 7.2 which presents two sections of the conserved riparian zone at Faddville estate.

Figure 7.2: Conserved Riparian Zone at Faddville Estate



7.1.2 Land Use Spatial Concentration/Densities

The spatial concentration and density of land use are key variables of encroachment and degradation of riparian zones. Densities in particular relate to population and area. Land use densities and spatial concentration could only be analyzed in relation to residential, urban agriculture, informal businesses and informal garages. The determination of the spatial concentration in relation to other sampled land uses was not obvious because it was difficult to establish the average number of persons per unit area.

For example, in Gikomba informal businesses, there was on the average one person doing business per business shed, yet in reality there are many persons who visit the shed daily. The occupancy rate in Faddville Estate and Mathare 4B is one household of five persons per housing unit. This agrees with KNBS (2010) who showed that one household has on average 5 persons. However, the average size of the housing unit in Mathare 4B is 10 m². This shows high densities and overcrowding as shown in Table 7.2.

Table 7.2: Land Use Densities in 12 Study Sites

No	Study Site	Type of Land Use	Average Size of Land Unit (Ha)	Number of Persons per unit in 30m	Number of Persons per Hectare
1	Mathare 4B	Informal Housing	0.01	5	500
2	Faddville Estate, Kileleshwa	Low Density Residential	0.04	5	125
3	Arboretum	Recreation Park	30.4	N/A	N/A
4	Kamukunji	Public open grounds	4.0	N/A	N/A
5	Nairobi National Museum	Public Institution	8.1	N/A	N/A
6	Hotel Boulevard	Private Institutions	1.7	N/A	N/A
7	Mukuru Kwa Reuben	Urban Agriculture	0.1	1	10
8	Nakumatt Ukay Hyper Market	Commercial	0.45	N/A	N/A
9	Mukuru Kwa Njenga	Quarry Mining	0.4	N/A	N/A
10	Viwandani Industries	Industrial	0.1	N/A	N/A
11	Gikomba Market	Informal Businesses	0.001	1	1000
12	Uhuru Estate along Rabai Road	Informal Garages	0.05	20	2000

The high densities generate more solid and sanitation wastes and lead to congestion that pushes people towards the river. The Implications of these densities may be understood against limited solid and wastewater disposal systems which have led to degradation of riparian zones

7.1.3 Solid and Wastewater Infrastructure

Provision of adequate water supply is panacea to better wastewater disposal systems. A proper solid waste disposal system also has a bearing in the way riparian zones are conserved.

7.1.3.1 Water Supply Systems

Access to adequate water supply helps in on-site wastewater disposal. Sewerage systems require adequate water supplies. Residents of Mathare 4B have limited access to reliable water supply, communal taps and water vendors being the most dominant means of accessing water.

In addition, urban agriculture in Mukuru Kwa Reuben depends on polluted river water and sewerage to irrigate food crops in farm units on riparian zone. This is due to lack of

adequate water supply for irrigation. Table 7.3 summarizes the main water supply and uses in six study sites.

Table 7.3: Water Supply System at Study Sites

No.	Name of Study Site	Number of Respondents	Main use for water	Water source			
				NWSC-communal tap (%)	NWSC-individual tap (%)	Venders (%)	Sewage (%)
1	Mathare 4B Informal settlements	35	Domestic	91	9	N/A	N/A
2	Faddville residential estate	14	Domestic	N/A	100	N/A	N/A
3	Hotel Boulevard	1	Hotel operations	N/A	100	N/A	N/A
4	Mukuru Kwa Reuben Urban Agriculture	7	Irrigation	N/A	N/A	N/A	100
5	Viwandani Industries	7	Industrial Processes	N/A	100	N/A	N/A
6	Gikomba Informal Market	30	Business	37	N/A	63	N/A

7.1.3.2 Wastewater Disposal Systems

Along Mathare River, respondents of Mathare 4B informal settlement lack access to proper sanitation. According to respondents, the settlement is not connected to the city sewer system and lacks storm water drains. For human waste disposal (waste water), 55.1 percent of the residents of Mathare 4B do direct injection into the river and 38.8 percent use sewer line. However, for the one's using the sewer line, the case is even more alarming. They simply open up the sewer line by either vandalizing a section or they use an open manhole for this purpose.

Table 7.4 presents a comparison between Mathare 4B and Faddville Estate with respect to provisions and access to sanitation system for disposal of human waste. The Table show that Faddville is 100 percent provided while Mathare 4B is just nominally provided.

Table 7.4: Human Waste Disposal Systems in Mathare 4B and Faddville Estate

Study Sites		Human Waste Disposal Systems			
Name of Study Site	Types of Land Use	Number of respondents	Sewerage		Pit latrines (%)
			Private facilities (%)	Communal facilities (%)	
Mathare 4B	Informal settlements	35	N/A	20	80
Faddville Estate	Low Density Residential	14	100	N/A	N/A

Respondents of Gikomba informal businesses along Nairobi River reported problems of hygiene caused by existing human waste disposal system. The main source of the problem was attributed to overcrowded communal toilets built by the city council of Nairobi. The Cost of toilet per visit and location of facilities far from businesses were cited as other two problems. Lastly, the toilets lack water and are not connected to sewer lines. This makes the toilets a sanitation nightmare during the rainy season. In Uhuru estate along Rabai Road, oil spills were observed on the ground. It was observed that regulations for disposal of these kinds of discharges of oil spills are not enforced.

Mukuru Kwa Reuben and Mukuru Kwa Njenga informal settlements situated along the Ngong River are also not connected to the sewer system. The residents use pit latrines that are rarely enough for the population and open riparian areas to relieve themselves. This has also contributed to the degradation of the zones.

Viwandani area where industries are located is connected to the sewer line but lacks proper disposal systems for industrial effluents. Oftentimes, industrial effluent is discharged into the sewerage through manholes close to informal settlement structures. This action complicates the facts that the sewage is used for urban agriculture by residents of Mukuru Kwa Reuben. This exposes the families living in Mukuru Kwa Reuben and Mukuru Kwa Njenga to hazards of industrial effluent pollution contrary to Public Health Act. Figure 7.3 shows a drain discharging effluent into a canalized section of Ngong River.

Figure 7.3: Direct Discharge of Industrial Effluent into Ngong River



The Nairobi Arboretum, Kamukunji public open grounds, Nairobi National Museum and Hotel Boulevard are the sites which, on the other hand, did not have any wastewater in the riparian zone.

7.1.3.3 Solid Waste Disposal Systems

Majority of Faddville Estate respondents have their solid waste collected by private companies. However, some respondents reported that leaking sewer and dumping of solid waste are the main environmental problem they face. However, Faddville Estate has no problem with solid waste in the riparian zone because residents have organized solid waste disposal systems. In the informal settlement of Mathare 4B, the data indicates that 54.2% dispose off their solid waste by dumping into the river and 10.4% dump next to the river. Table 7.5 shows how solid waste is disposed off by residents of Mathare 4B and Faddville Estate.

Table 7.5: Solid Waste Disposal by Residents of Mathare 4B and Faddville

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Incineration	3	6.1	6.3	6.3
	Collection By Council	1	2.0	2.1	8.3
	Collection By Private Companies	13	26.5	27.1	35.4
	Dumping Next To The River	4	8.2	10.4	43.8
	Dumping Into The River	26	53.1	54.2	100.0
	Total	48	98.0	100.0	
Missing	No Response	1	2.0		
Total		49	100.0		

Gikomba informal businesses, Uhuru Estate garages, Mukuru Kwa Reuben urban agriculture area, Mukuru Kwa Njenga quarry sites are the other sites found with solid waste in the riparian zone. However, the main source of the solid waste in the de-commissioned quarry was dumping from other places in the city. Again, the Nakumatt Ukay Hypermarket did not have solid waste mainly because it covers the whole riparian area.

The Nairobi Arboretum, Kamukunji public open grounds, Nairobi National Museum, Hotel Boulevard and Viwandani industrial area, are the sites which, on the other hand, did not have any solid waste in the riparian zone.

Implementation of better policies on riparian zone, periodic repair to improve waste disposal functions of the sewerage system and restricting the zones from construction of building were suggested as better ways of managing and maintaining riparian zones.

7.2 Land Administration Variables

Land ownership within 30 metre riparian zone is an important aspect of this study because it determines the use of land that also determines the physical extent and ecological quality of riparian zones. The analysis of land tenure, cadastral systems and other land administrative procedures is, therefore, important to the conservation of riparian zones.

7.2.1 Cadastral Data

Legal and institutional framework discussed in chapter six indicated lack of clarity in policy prescriptions. For example, cadastral data kept by the Department of Surveys show the demarcation of parcels of land based on boundaries established from centre of the river. These boundaries fail to treat the riparian zone as an independent land unit. Consequently, landowners have fenced and developed the land to the edge of the river.

7.2.2 Land Tenure

Respondents in study sites indicated different forms of land ownership. This confirmed that there is multiple land tenure operating within the 30 metre riparian zone. These include public, private and informal. Land tenure appears to dictate the location of structures in the 30 metre riparian zone. It was observed that land uses with fairly permanent buildings have formal land tenure documents, whereas those with temporary structures are informal in nature.

In order to illustrate the differences between formal and informal physical developments in the 30 metre riparian zone, Table 7.6 presents a typology of housing from respondents' interviewed in Mathare 4B and Faddville estate.

Table 7.6: Housing Typology in Residential Sites

Land use	Number of Respondents	Housing Typology			
		Temporary tenements (%)	Permanent tenements (%)	Maisonettes and Bungalows (%)	Flats (%)
Informal settlement- Mathare 4B	35	94.1	5.9	N/A	N/A
High Income Residential – Faddville Estate	14	N/A	N/A	44.4	55.6

The predominant structures in the 30 metre riparian zone in Mathare 4B informal settlement is temporary structures. On the other hand, Gikomba informal businesses and Uhuru Estate garages have temporary sheds.

Based on the fact that informal settlement dwellers are squatters on riparian zone, they opt to use temporary construction materials. In this regard, mud and iron sheets are used to avoid heavy losses in the event of eviction. Table 7.7 presents the quality of housing in Mathare 4B and Faddville estate to further illustrate the kind of investments used as a result of type of land tenure.

Table 7.7: Housing Quality Information in Residential Sites

Land Use	Number of Respondents	Floor Type		Walls	
		Concrete (%)	Mud (%)	Stone (%)	Iron Sheets (%)
Informal settlement- Mathare 4B	35	61.8	35.3	8.8	91.2
High income residential-Kileleshwa	14	66.7	N/A	100	N/A

The fact that about 91 percent of respondents in Mathare 4B use iron sheet to construct walls of their housing structures reveal poor quality of structures and, therefore, less cost of investment. In informal areas, the housing structures that are built close to the river valley are exposed to destruction risks related to floods and landslides. Plate 7.4 shows

dilapidated structures occupying the riparian zone of Mathare River at Mathare 4B. The placement of structures at the river bank is a living manifestation of the dangers inherent as a result of flooding and landslides as it happened in May 2012 in Mathare 4B.

On the other hand, Faddville Estate, Viwandani industries and Nakumatt Ukay Hypermarket have permanent structures in the 30 metre riparian zone. This is attributed to access to land title deeds which are formal land tenure documents. These are formal private enterprises whose aim is to maximize their profits through use of the riparian zone as explained by the private enterprise theory. The only exception in this group of land uses is Hotel Arboretum that has no permanent structures in the 30 metre zone. However, this should not be construed to mean disinterest in profit but, the hotel still has ample land and the riparian area next to the hotel floods during heavy rains. In any case, the riparian zone is also used exclusively for paid up recreational purposes.

The Nairobi National Museum, Kamukunji public open grounds and the Nairobi Arboretum also have formal land ownership documents. However, they have not built structures in the 30 metre riparian zones. This resonates well with the public enterprise theory that argues that public institutions aim at public good.

In other sampled land uses such as urban agriculture, quarrying, public recreation grounds, and parks, land tenure also dictates how the riparian zone is used. In the urban agriculture and decommissioned quarry mining land uses, informal users do not seek approval from the local authority because they have no land ownership documents. On the other hand, formal recreational parks are well maintained.

Encroachments of formal and informal settlements into the 30 metres underline lack of appreciation of the functions of the riparian zone in Nairobi River Basin. Informal settlements also occupy land areas set aside for designated 30 metre riparian zone without legally binding ownership documents such as letters of allotment and title to the land. Respondents of informal study sites reported having no formal land ownership documents. Therefore, they would not construct permanent structures for fear of eviction. Other respondents claimed they are tenants who rented the structures for housing. This group could not give information on land tenure

Kenyan laws show that the riparian zone is public land. However, formal land uses have title deeds that show the boundary is the centre line of the river. The survey plans of these

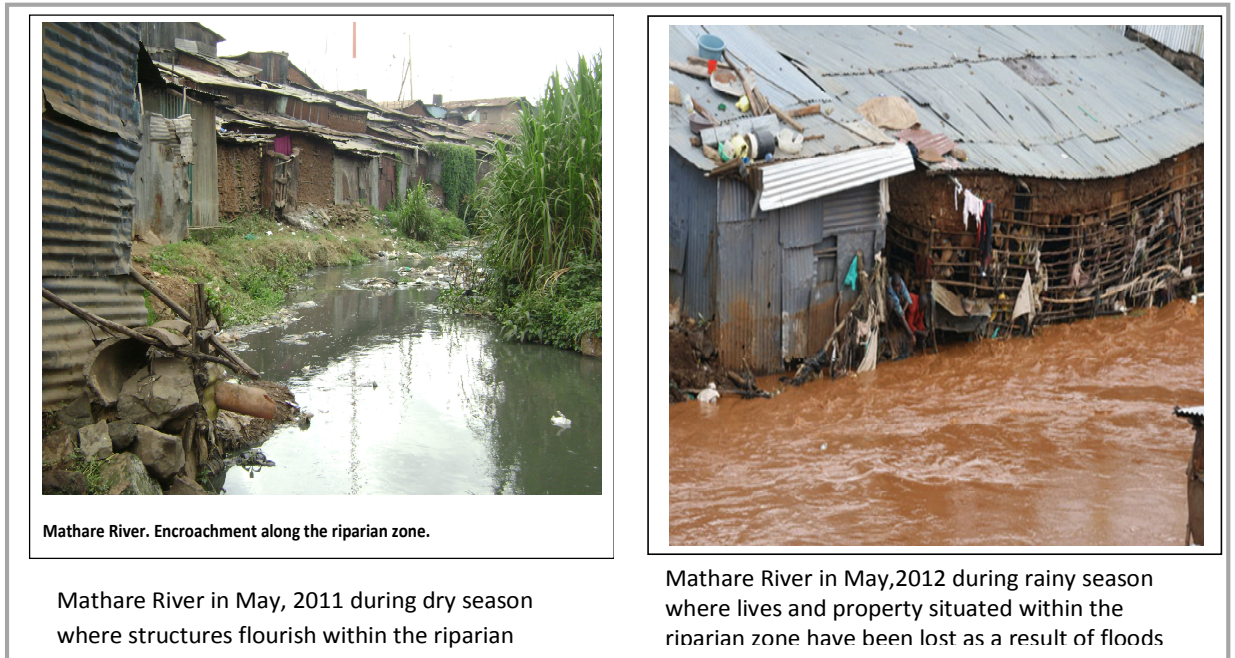
properties confirm this. The allocations were sanctioned by the colonial and post independent era governments. Table 7.8 presents land tenure for 12 study sites and the years when land was acquired and occupied.

Table 7.8: Land Tenure in Riparian Zones and Year of Acquisition/Occupation

No.	Study Site	Total Built Structure Units	Number of respondents	Percentage of Total Number of Respondents	Ownership Status of 30m Buffer from River Bank	Year when land was acquired /Occupied
1	Mathare 4B Informal settlements	70	35	50	No official ownership documents	1980's
2	Faddville residential estate	25	14	56	Leasehold title	1994-1995
3	Arboretum recreation park	1	1	100	Leasehold title	1907
4	Kamukunji open grounds	1	1	100	Government reservation	1960
5	Nairobi National Museum	1	1	100	Leasehold title	1962
6	Hotel Boulevard	1	1	100	Leasehold title	1913
7	Mukuru Kwa Reuben Urban Agriculture	14	7	50	No official ownership documents	1980's
8	Nakumatt Ukay Hyper Market	1	1	100	Leasehold title	1942
9	Mukuru Kwa Njenga Quarries	5	3	60	Quarrying license	1980's
10	Industries	10	7	70	leasehold title	1972 – 1985
11	Gikomba Informal Market	60	30	50	No formal ownership documents	1990- 2002
12	Uhuru Rabai road Garages	14	7	50	No formal ownership documents	1980's
			6	43	Allotment letter from City Council of Nairobi	
			1	7	Leasehold title	

Figure 7.4 shows informal structures dangerously located at the riverbank of Mathare River. There were reported people killed by floods and landslides in May 2012.

Figure 7.4: Structures in Riparian Zone at Mathare 4B



7.3 Bio-Physical Variables

The effects of biophysical factors on the width and condition of the riparian zone were assessed at the 12 sampled study sites.

7.3.1 Widths of Rivers

The Physical Planning Handbook, (PPH) of 2008 stipulates that the riparian zone should be twice the width of the river channel. The Handbook further stipulates that the riparian width should be between 2 and 30 metres measured from the river bank. However, as shown in Table 7.8, different reaches of the river have different widths of rivers. This is an indication that no single location has the same river size that warrants application of uniform width of the riparian zone. The data also reveal that remote sensing measurements agree quite closely with distances obtained through field inspection.

The implication of these findings is that determination of a generic riparian width without considering the width of the river is untenable. In addition, the application of two metres is inappropriate considering that most rivers are wider than this measure as they traverse the city. Use of such small widths may not secure the river from land uses that exhibit negative consequences on the river ecosystem.

Table 7.9 shows the average widths of the river channels as sampled from the upstream, mid waters and lower reaches of the rivers. The upstream sections extend from sources of the rivers to James Gichuru Road in the case of Nairobi River. It also covers the source of Motoine River to Nairobi dam for Ngong River. The upstream of Mathare River covers mainly the Muthaiga area.

Table 7.9: Average Widths of Main Rivers in Nairobi

River	Up Stream		Mid Stream		Lower Stream	
	Average width of river	Expected Width of Riparian Zone	Average width of river	Expected Width of Riparian Zone	Average width of river	Expected Width of Riparian Zone
Nairobi	0.892	1.784	6.7	13.4	14.893	29.786
Ngong	1.867	3.734	6.133	12.266	9.243	9.243
Mathare	2.3	4.6	4.433	8.866	7.367	7.367

Source: Compilation from Quickbird imagery of resolution 0.4m from DRSRS (2012)

More measurements of the width of the river were taken in the field and compared with data obtained using GIS mapping methods. The findings of direct field observation and GIS and remote sensing data indicated that the results of high resolution remote sensing data can be relied upon in determination of riparian zones.

The findings further confirmed that the widths of rivers are not uniform across board. These findings further supported the argument that a generic riparian width should not be determined because the rivers are not uniform in width, and the land uses have heterogeneous characteristics in relation to the river ecosystem. Table 7.10 presents the average widths of rivers at different study sites.

Table 7.10: Average Widths of Rivers at the Study Sites

No.	Study Site	Average River Width(m)				Comments
		Field Inspection		Measurement Via G.I.S	Discrepancy	
		Measured widths	Average			
1	Mathare 4B Informal settlements	7, 6.8, 7.4, 8.3, 7, 7, 8.4	7.4	7.6	-0.2	
2	Faddville residential estate	4.2, 3.5, 3.5, 3.0	3.6	N/A	N/A	Challenging to measure via GIS (thick riverine vegetation)
3	Arboretum recreation park	7, 6, 6, 8	6.8	N/A	N/A	Challenging to measure via GIS (thick riverine vegetation)
4	Kamukunji open grounds	20, 15, 18, 12	16.2	15	1.2	
5	Nairobi National Museum	6.5, 7, 6, 6.8	5.3	6.1	-0.8	
6	Hotel Boulevard	6.5, 7, 6, 6.8	5.3	6.1	-0.8	
7	Mukuru Kwa Reuben Urban Agriculture	8, 11, 10, 9, 9	9.4	10.2	-0.8	
8	Nakumatt Ukay Hyper Market	2, 3.4, 1.9, 1.9	2.3	N/A	N/A	Canalized stream
9	Mukuru Kwa Njenga Quarries	10.3	10.3	11.7	-1.2	
10	Viwandani Industries	8, 11, 10, 9, 9	9.4	10.2	-0.8	
11	Gikomba Informal Market	20, 15, 18, 12	16.2	15	1.2	
12	Uhuru Rabai road Garages	7, 8, 9	7.3	9	-1.7	

7.3.2 Test of Hypothesis on Widths of Riparian Zones

Field inspection was used to corroborate through ground truthing, the GIS results. The inspection also gave credence to results of quantitative data analysis.

7.3.2.1 Field Inspection of Riparian Widths

Field inspection of riparian zones was carried out on the following rivers: Nairobi, Ngong, Mathare, Kirichwa Kubwa and Kibagare which signified multiple study sites. Inspection included taking of photographs and making direct measurements. That is, the distance was taken on one side of the river, from the riverbanks to physical structures or sites of

activities that corresponded to segments of sampled land use unit. Quickbird satellite data of 2003 and 2008 was used to countercheck riparian widths that were measured. Table 7.11 shows the average widths of riparian zones from edge of the river for the 12 study sites. Several measurements of the width were taken at each study sites.

Table 7.11: Average Riparian Widths at Study Sites

No.	Study Site	Average Riparian Width (m)			
		Field Inspection		Measurement Using G.I.S	Discrepancy
		Measured widths	Average		
1	Mathare 4B Informal settlements	2, 2, 1.4, 0, 1.3, 2.2, 3.5	1.8	1	0.8
2	Faddville residential estate	6, 5.8, 3.8, 5.7	5.3	3.8	1.5
3	Arboretum recreation park	N/A	N/A	487	N/A
4	Kamukunji open grounds	N/A	N/A	167	N/A
5	Nairobi National Museum	N/A	N/A	107	N/A
6	Hotel Boulevard	25	25	26	-1
7	Mukuru Kwa Reuben Urban Agriculture	0	0	0	0
8	Nakumatt Ukay Hyper Market	0, 0, 0	0	N/A	N/A
9	Mukuru Kwa Njenga Quarries	9, 11, 8.6, 13, 10	10.3	11	-0.7
10	Viwandani Industries	N/A	Some 10 Others >30	Some 9.4 Others >30	0.6 N/A
11	Gikomba Informal Market	2, 2, 3, 2, 0	1.8	2.5	-0.7
12	Uhuru Rabai road Garages	0.5, 0, 0	0.2	0	0.2

7.3.2.2 Effects of Policy Measures on Width of Riparian Zone

In the context of this study, policy measures taken with respect to width and conditions of the riparian zone are as stipulated in legislation. The definition of the riparian zone given in the policies and how the zones are determined affect the location of land use.

There are four sets of minimum widths provided by the law. These are 2, 6, 10 and 30 metres. The two metre minimum width is established by the Physical Planning Handbook of 2008 and the Agriculture (Basic Land Usage) Rules of 1965. The minimum width of six metres is established in the Water Resources Management Rules (WRMR) of 2007. On

the other hand, the 10 metre one is stipulated in the Physical Planning Act through Legal notice No. 140 of 13th July 1998, rule 15(c). Finally, there is provision of 30 metre minimum riparian width in the Survey Act of 1961(revised in 1989).

From the four sets of minimum riparian widths, the two metre one is considered inadequate as a basis of assessing and evaluating the width of the riparian zone given that the study has established that rivers traversing the city are far much wider than two metres.

In order to test the influence of specific policy measure that is prescribed, on the width of the riparian zone, the first assumption of the study was stated as follows:

Existing policy and institutional variables have not influenced the determination, use and management of riparian zones in the study area.

This assumption would be about policy measure that prescribes riparian widths of two metres, but this is not evaluated on account of irrelevance to the reality of wider widths of rivers in Nairobi River Basin. Henceforth, the prescription of at least six metre width is tested in the study. To test the results at 5 per cent level of significance, the minimum widths of 6, 10 and 30 were used to establish whether or not the policy measures have significantly influenced determination of riparian zones in Nairobi River Basin. In this regard, the null and alternative hypotheses were formulated to test this assumption as follows.

H₀: Riparian widths observed in the study area are the same as the minimum widths in policies

H₁: Riparian widths observed in the study area are less than minimum widths in policies

The observed group mean of the recorded measures was compared with the minimum width of 6 metres set in Water Resources Management Rules (WRMR) of 2007. It was assumed that the mean standard deviation of the minimum width in the policy is zero because what is stipulated as minimum widths must be respected when determining the width of the zone. Appendix 1 presents results of t-test statistical analysis that was performed to test the hypothesis on the influence of policy measures on the width of riparian zones.

Data on actual measurement of the width that is, observed width (x_i) of 28 measurements was used to calculate group mean (\bar{x}) and variance $(x-x_i)^2$. The t -test statistical model was

selected because of the small size of the sample of 28 which is lower than 30 for a standard normal distribution.

The results of the t -test gave a mean observed width of 3.39 metres and standard deviation of 3.80 which translate to a t -test value of -3.569. The negative sign is ignored, and its modulus used when applying the statistical tables. The critical value of t at 27 (28-1) degrees of freedom is 1.706. The calculated value of t is, therefore, greater than the table value.

Since the observed value is greater than the table value at 5 per cent level of significance, the null hypothesis is rejected and the alternative one accepted meaning that the observed widths are less than the minimum width stipulated in the WRMR.

When observed widths were further analyzed using 10 and 30 metres, the observed t -test value were even greater than the table values which further supported the assumption that policy and institutional variables in the study area have not significantly influenced the determination of appropriate riparian zones. Institutions have mandates of ensuring appropriate widths are formulated, implemented, monitored and evaluated

These results are further supported by responses of land users, public officers and professionals which were recorded in questionnaires. The overall results of the analysis reveal that the trend has maintained very small riparian width, as opposed to the 30 metre width advocated by the government.

7.3.3 Test of Hypothesis on Ecological Condition of Riparian Zones

The functional definition of the riparian zone includes reference to vegetation at the interface of watercourse and terrestrial ecosystem. However, this aspect in the meaning of the zone appears to be downplayed in Nairobi River Basin. In this regard, the hypothesis concerning the presence or absence of vegetation on the 30 metre width of riparian zone was tested.

7.3.3.1 Conditions of Riparian Zones at Study Sites

Functional riparian zones contribute to better social, economic and ecological outcomes. Wider riparian widths provide adequate space for location of vegetation types. However, from field observations, five study sites that were sampled have no riparian vegetation despite its importance. Instead of vegetation, the riparian zones have built structures and

other incompatible activities. There are activities including dumping of solid and human wastes and brewing of illicit brews especially “*chang’aa*.” *Chang’aa* is an illegal traditional alcoholic brew in Kenya

In flood-prone low-lying areas that are not suitable for locating structures, the main uses are urban agriculture and dumping of wastes. Figure 7.5 shows structures constructed at the edge of Mathare River in Mathare 4B.

Figure 7.5: Structures Constructed at the Edge of Mathare River in Mathare 4B



However, in some study sites such as Nairobi Arboretum, the riparian zone is well maintained with a mix of trees, shrubs and grass. This shows unlimited attempt to protect the zone. Table 7.11 shows that a homogeneous riparian zone a well maintained vegetation cover has not been maintained in the study sites. Some sites have maintained limited riparian vegetation. Other study sites are completely bare with built structures and activities replacing the riparian vegetation cover. Table 7.12 shows the condition of the riparian zone at each study site as at the time of field visits in April and May, 2011.

Table 7.12: Riparian Vegetation Cover at 12 Study Sites

	Study Site	Trees	Shrubs	Grass	Current use
1	Mathare 4B Informal settlements	No	No	No	Structures, urban agriculture and toilets
2	Faddville residential estate	Yes	No	No	Urban agriculture Residential apartments
3	Arboretum recreation park	Yes	Yes	Yes	Public recreation park
4	Kamukunji open grounds	Yes	No	Yes	Public open grounds
5	Nairobi National Museum	Yes	No	Yes	Public picnic site
6	Hotel Boulevard	Yes	No	Yes	Private grass lawn
7	Mukuru Kwa Reuben Urban Agriculture	No	No	No	Urban agriculture like maize and sukuma wiki.
8	Nakumatt Ukay Hyper Market	No	No	No	Commercial building Parking lot
9	Mukuru Kwa Njenga Quarries	No	No	No	Quarries
10	Industries	No	No	No	Sewers, informal settlements, pipes/trenches
11	Gikomba Informal Market	No	No	No	Stalls and sheds
12	Uhuru Rabai road Garages	No	No	No	Vehicle shells, toilets

7.3.3.2 Significance of Riparian Vegetation

A Chi-square test was performed to establish the presence of different types of vegetation and land uses in the 30 metre riparian zone. The goal of the test was to establish the significance of vegetation cover in the riparian zone, in the sampled study sites. The null and alternative hypotheses were formulated as follows:

H_0 : *There is no significant vegetation cover to secure riparian zones in relation to adjoining land use types in Nairobi River Basin*

H_1 : *There is significant vegetation cover to secure riparian zones in relation to adjoining land use types in Nairobi River Basin*

From Table 7.12, the vegetation and whether or not the vegetation is in the 30 metre riparian zone was cross tabulated as presented in Table 7.13. “Yes” in Table 7.12 was a field inspection code showing that there was particular vegetation on the riparian zone. An indication of “No” implied lack or limited presence of vegetation on the zone. The code “No” also implied the presence of other undesirable attributes. Table 7.13 presents observed and expected frequencies as computed from Table 7.14.

Table 7.13: Observed and Expected Frequencies for Chi-square

Condition of the Zone	Trees	Shrubs	Grass	Total
Zone with vegetation	5 (3.33)	1(3.33)	4(3.33)	10
Zone without vegetation	7 (8.67)	11(8.67)	8(8.67)	26
Total	12	12	12	36

The Chi-square model that was used as presented in Table 7.13 is:

Chi-square = sum of [observed frequency - Expected frequency] / Expected Frequency
 where expected frequency = column total x Row total / grand total

Table 7.14: Calculation of Chi-Square

Group	Observed frequency (O)	Expected Frequency (E)	(O-E)	(O-E) ²	(O-E) ² /E
1	5	3.33	1.67	2.7889	0.8375
2	1	3.33	-2.33	5.4289	1.6303
3	4	3.33	0.67	0.4489	0.1348
4	7	8.67	-1.67	2.7889	0.3217
5	11	8.67	2.33	5.4289	0.6262
6	8	8.67	-0.67	0.4489	0.0518
					$\sum(O-E)^2/E = 3.6023$

The degrees of freedom in this test were computed from the expression $(r-1)(c-1) = (2-1)(3-1) = 2$. Letter c represents columns while r represents rows. The table value of Chi-square for 2 degrees of freedom at 5 per cent level of significance is 5.991. The calculated value of Chi-square (3.602) is less than the table value. The null hypothesis is accepted.

This means that there is no significant vegetation cover to secure riparian zones against adjoining land use types in Nairobi River Basin. In this regard, it is clear that the removal of vegetation cover in the riparian zone at the study sites is an indicator of the degradation of the zone.

This statistical test also confirms the first assumption that policy and institutional variables in the study area have not significantly influenced the determination of appropriate riparian zones. This finding agrees with the enumeration of settlements within 30 metre riparian zone that confirmed physical developments and activities within the 30 metre riparian zone. This further supports presence of limited vegetation cover in sections of riparian zones in Nairobi River Basin.

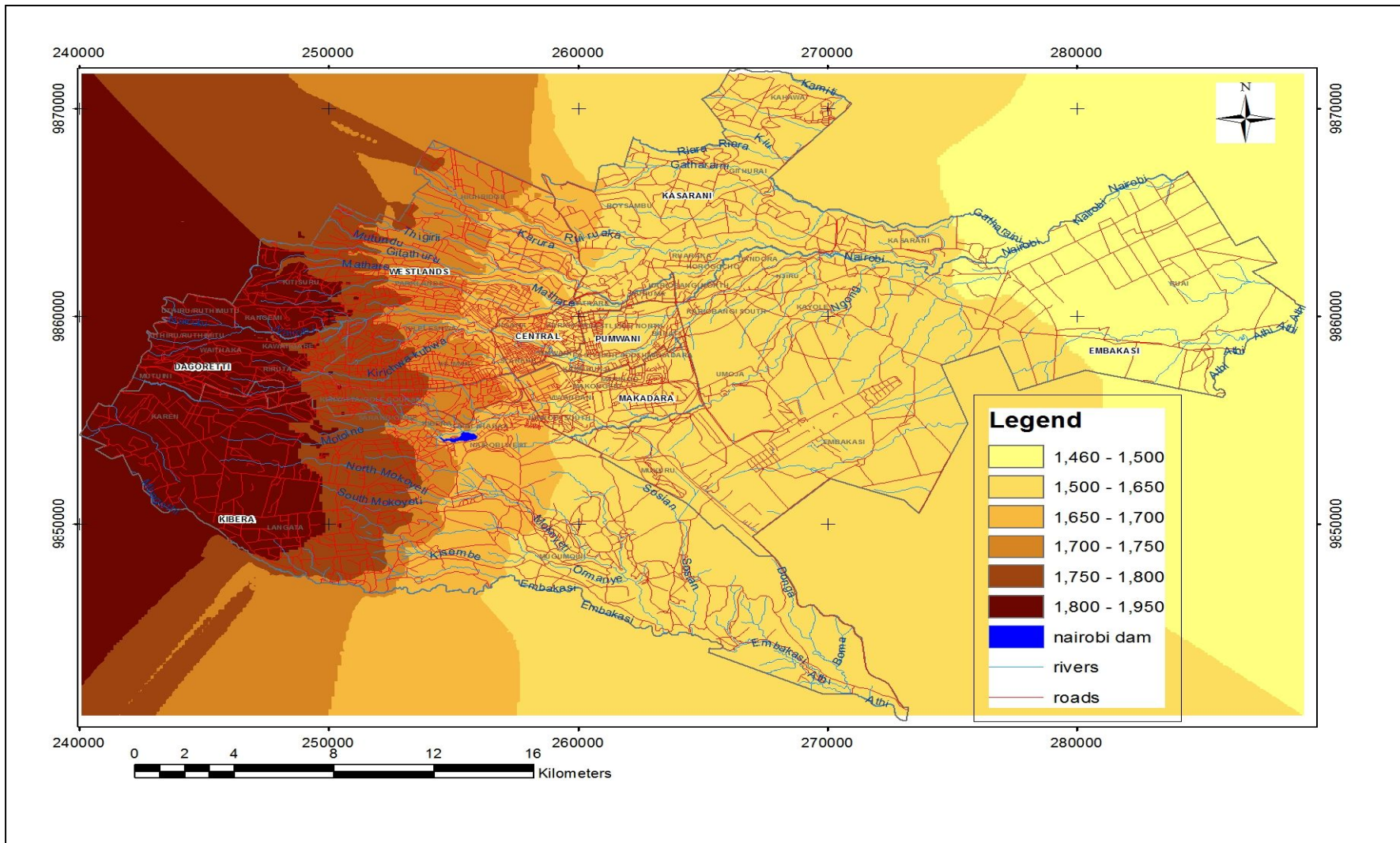
7.3.4 Riparian Slopes

The study area was analyzed in relation to elevations based on topographical data compiled from existing maps of the Department of Surveys. The data is presented in categories representing a 100 metre height difference. The highest zone has elevations ranging from 1800 to 1900 metres above the mean sea level. The lowest category ranges from 1400 to 1500 metres in the lower reaches of the city. The highest and lowest elevation category represents a 400 metres drop. The elevations are indicators of varying topography along the profiles of rivers.

The study further established that the slopes are not homogenous even within specific study location. The riparian slopes vary from very steep to flat gradients. Study sites including Faddville Estate, Nairobi Arboretum and Nairobi National Museum have very steep riparian slopes. Study sites including Mathare 4B, Gikomba Hotel Boulevard and Uhuru Estate garages have steep slopes. Study areas including Kamukunji open grounds, Mukuru Kwa Njenga, and Viwandani industrial area have gentle slopes. Finally, Mukuru Kwa Reuben and Westlands Nakumatt Ukay have flat terrains.

These findings show that the gradient of the riparian zone is not dependent on the location of the site in relation to upstream, mid-waters and lower reach categorization. Rather, some similar locations such as Nairobi National Museum and Hotel Boulevard have different gradients yet they are opposite each other. Similarly, Westlands Nakumatt Ukay is in the upstream areas yet it is in a flat area. Another implication from these findings is that the slopes should be used to determine the high water mark as a benchmark for determining riparian zones. Otherwise, any encroachment onto the flood plains has known consequences to both the river ecology and human settlements. Figure 7.6 shows the elevation map of the study area.

Figure 7.6: Elevation Map of the Study Area



Source: Compiled from the Department of Surveys Topographical Maps of 1978

The gradient at specific site is classified into categories based on Institution of Surveyors of Kenya (ISK) Practicing Guidelines for Non-Titles Surveys (ISK, 2006). Table 7.15 presents the average slopes of riparian zones at each study site.

Table 7.15: Average Slopes of Riparian Zones at Study Sites

No.	Study Site	Average Riparian Slope (%)	Comments
1	Mathare 4B Informal settlements	6.8	Steep
2	Faddville residential estate	15.5	Very Steep
3	Arboretum recreation park	17.21	Very Steep
4	Kamukunji open grounds	3.56	Gentle
5	Nairobi National Museum	20	Very Steep
6	Hotel Boulevard	8.6	Steep
7	Mukuru Kwa Reuben Urban Agriculture	1.5	Flat
8	Nakumatt Ukay Hyper Market	1.4	Flat
9	Mukuru Kwa Njenga Quarries	3.4	Gentle
10	Industries	4.42	Gentle
11	Gikomba Informal Market	5.5	Steep
12	Uhuru Rabai road Garages	5.96	Steep

Note Slopes of 0-5 is gentle, 5-15 is steep, >15 are considered as very steep in the ISK guidelines

Table 7.15 shows that there is significant slope variability across sites in different rivers, in the basin. The flatness of the riparian zone played a part in the flooding of this Hypermarket in 2010. The Hypermarket sits on top of the riparian zone. In this regard, variable and not uniform width of the riparian zone appears to be the more plausible approach in riparian width determination.

Steeper slopes have more velocity generated by surface runoff into the river. In steep slopes with little or limited vegetation cover, polluted surface runoff quickly empties into rivers undermining water quality. Therefore, the steeper the slope, it appears important to design wider riparian widths to enable the vegetation cover to slow down the surface runoff. However, as is evident from the riparian widths established in this study, there appears to be no relationship between the riparian width and the gradient of slopes in the study sites.

7.3.5 Types and Characteristics of Soil

Soil samples were collected from the study sites and tested at the Ministry of Road's laboratory (See Appendix 6). The aim was to investigate the soils that exist in different

study sites. The soil was an indicator of permeability that is important in the determination of riparian widths as shown in the literature. Table 7.16 presents results of the soil tests.

Table 7.16: Types of Soils Sampled at the Study Sites

No.	Study Site	Soil Type
1	Mathare 4B	Greyish Dark Clay
2	Arboretum, Nairobi National Museum, Hotel Boulevard	Dark Red Clay
3	Faddville Estate, Kileleshwa	Dark Red Clay
4	Kamukunji, Gikomba Market	Black Cotton Clay
5	Uhuru Estate Rabai Road Garages	Dark Black Cotton Clay
6	Nakumatt Ukay, Westlands	Dark Red Clay
7	Viwandani, Mukuru Kwa Reuben, Mukuru Kwa Njenga	Black Cotton Clay

Source: Materials Testing and Research Department, Ministry of Roads (May, 2013)

The results of soil analysis indicate that the study sites have different soil types. Red or black clay soils are dominant. The results of soil analysis show that they have low permeability. Secondary data obtained from the literature showed that soils of low permeability hinder the infiltration of surface runoff and therefore affected the quality of water in rivers.

The implication of these findings is that soil permeability should be considered when determining riparian widths. However, the soils sampled from different sample sites located in different areas of the city were either black or red clay. This implies that they have nearly the same soil permeability values. Therefore, the soil as a variable may not affect site specific determinations in the basin. However, a homogeneous distance value to cater for the soil type can be established in the basin.

7.4 Implications of Land Use and Biophysical Factors

The second objective of the study, aimed at examining the implications of specific land use and biophysical factors on the determination, use and management of riparian zones in the study area. Data on land uses and biophysical variables at specific study sites confirmed that some urban land use and biophysical factors influence the determination, use and management of riparian zones in Nairobi River Basin. This finding confirms the views of Broadmeadow and Nisbet who indicated that the determination of riparian width should be based on different factors that affect the zones.

7.4.1 Land Use Types

Location of land uses very close to the riverbank results to encroachment and degradation of riparian zones. Some physical structures have led to the dumping of solid waste, discharge of wastewater and industrial effluents, and removal of riparian vegetation cover and erosion of the zone. These findings confirm that the type of land use adjoining the riparian zone is a critical factor that influences conservation of riparian zones. Hence, the land use must be taken into account in developing a model for determination, use and management of riparian zones.

Based on the land uses that were sampled, informal housing and business, informal garages, urban agriculture and quarry mining, formal industries and commercial land uses as well as formal high income residential housing have all interfered with the riparian zones. They have led to a reduction of the riparian width and degradation of its ecological quality. Human activities that come along with such developments include indiscriminate cutting of vegetation, construction of structures, conducting business activities and dumping of solid and liquid waste, manifest the problem clearly.

These findings corroborate views advanced by NRBP that a significant concentration of chemicals and metals in Mathare; Ngong and Nairobi Rivers is as a result of residential, commercial, industrial, informal garages, urban agriculture and quarry mining close or on riparian zones. These activities reduce the capacity of riparian zones to filter pollutants in surface run-off and to curtail riverbank erosion.

The findings of the study reveal the degradation of riparian zones where there is no effective solid and wastewater disposal systems particularly in informal settlements. These findings show that availability and condition of solid and wastewater disposal systems are essential for effective conservation of riparian zones. This finding is in agreement with UNHABITAT (2005) who showed that raw sewage from informal settlements is discharged in the zone and the river channel.

The study further established that public and private institutions, open recreation grounds and public parks have not encroached and degraded riparian zones. These set of land uses have also allowed access by the public. This agrees with the public enterprise theory that public institutions aim to promote public good/interest.

In addition, the study also established that private institutions including hotels, schools and religious institutions have maintained adequate riparian widths and riparian vegetation in the zone. However, they have restricted the use of the zone exclusively for their clients who patronize the institutions. This is in agreement with private enterprise theory that private firms aim at profit maximization.

The implication of these findings is that, in situations where the riparian zone is poorly defined, and the system for enforcing development control is weak, the zone is open to over-exploitation, misuse and mismanagement with devastating environmental consequences. This is the condition that Hardin described as the “tragedy of the commons” in the author’s classical study on natural resource use, in the USA.

Another implication of the findings is that identification of land uses that should be allocated to sites close and in the riparian zones is useful in the determination of the appropriate balance between the levels of development, relative location with respect to the position of the zones as well as the development.

7.4.2 Land Use Density/ Spatial Concentration Issues

Results of data analysis revealed high land use densities in informal settlements, informal businesses, and motor vehicle garages. This contrasts with the low land use density in the sampled formal residential settlement. These findings are in agreement with those of Kimani *et al.* that high levels of land use densities are quite prevalent in the 30 metre riparian zone in Nairobi River Basin. A high influx of population and failure to provide solid and wastewater disposal systems aggravates pollution and degradation of riparian zones.

A useful finding is, however, with respect to urban development at high income residential housing which has also encroached on the riparian zone. The settlement has adequate solid and wastewater disposal system which curbs the dumping of waste on riparian zones.

The density of built structures is, therefore, a critical factor in conservation of riparian zones. The density is directly derived from population resident in a unit parcel of land or structure. The spatial concentration referred to the intensity of land use per unit area in the 30 metre riparian zone. The result of a high occupancy rate in settlements that are under provided with infrastructure services is dumping of solid and human waste on riparian zones.

The findings also agree with the view of Dimas and Gabriel that the economics of ecosystems and biodiversity are not valued in the commodity market. This has led to the loss of riparian habitat and isolation of animal and plant species populations.

Protection of riparian resources is therefore a practical imperative that must be exercised to regulate and control consequences of changing land use. Pointedly, this would have to overcome the mentality and perception of pervading formal and informal land uses and developers that riparian zones in Nairobi River Basin are free, idle and common public property. Public education and awareness creation campaigns would be some of the most effective means of popularizing proper approaches in the determination, use and management of the zones.

7.4.3 Land Administration Issues

Land tenure encompasses a collection of rights to own, use, occupy or improve space. The zoning regulations and code show the size and configurations of land holdings. These affect the way land is used which also affects urban form. The study established that the size and configuration of parcels of land along riverfronts have not promoted desirable/optimal riparian zones in the study area. The riparian zone is, therefore, not properly geo-referenced in relation to cadastral data as a means of restricting incompatible land uses.

There are multiple land tenure and ownership of riparian zones in the study sites. These ownerships are a result of the convolution of public, private and communal land tenures. There is also informal ownership of businesses and structures on riparian zones. The overall system of land tenure on riparian zone is marked by formal or officially sanctioned developments and diffuse ownership claims by unofficial squatters. Informal housing and socio-economic activities underlie these ownerships.

These findings contradict government policies and laws that define riparian zones as public land. The findings also contradict best practices described in the literature that consider determination of appropriate riparian zones based on their functions. The findings confirm that the land tenure is a determining factor in conservation of riparian zones. The factor should be taken into account in formulating criteria for conservation of riparian zones.

It is clear from the review of policies that laws do not determine the boundaries of riparian zones based on site characteristics or effects of adjoining land uses. Whereas the laws provide a range of riparian widths that can be used, records of survey plans and deed plans in the Department of Surveys indicate property boundaries as centre line of rivers. This motivates practitioners to include riparian zones as part of private land. As a result, there is evidence of incompatible, competing and conflicting land uses in riparian zones.

The findings further confirm that issuing of title deed and allotment letters to private developers on riparian zone defeats the very essence of the existence of riparian zones. It also contradicts the notion that riparian zones should be reserved as public land. Lack of clarity on this point especially with respect to administration of riparian land underlines continued formal and informal allocation and development of riparian land.

In order to change this, institutions mandated to administer land tenure including Department of Lands, City Council of Nairobi and the National Land Commission have to come up with effective procedure and criteria for determination, use and management of riparian zones in Nairobi River Basin.

7.4.4 Bio-Physical Effects

The study results indicate that different locations of the same river have different river sizes. This does not, therefore, warrant the application of a uniform width of the riparian zone. The data also reveal that remote sensing measurements agree quite closely with distances obtained through field inspection. This implies that GIS and high resolution remote sensing data which are comparatively much cheaper than land survey methods could be used to determine riparian zones in the basin.

The results of statistical analysis using student *t-test* at 5 percent level of significance indicate that the observed riparian widths are less than the tested minimum widths in policies. The result of statistical analysis of riparian vegetation using *Chi-square* at 5 percent level of significance also established that there is no significant vegetation cover to secure riparian zones against adjoining land use types in most study sites.

The two statistical tests confirmed that the policy and institutional variables in the study area have not significantly influenced the determination of appropriate riparian zones. The overall results of the analysis reveal that the trend has maintained very small riparian width, as opposed to the 30 metre maximum width in legislation.

Riparian width and riparian vegetation are two analyzed variables that are conceptually related. However, vegetation is a function of the width, which suggests a variable riparian width. Thus, an increase in the width of the zone would imply more space for the vegetation cover and vice versa. This shows a direct relationship between the width and amount of vegetation that would be maintained in one segment of the zone

These findings contradict previous studies that suggested that appropriate width and vegetation cover are significant factors of its conservation. The riparian width and ecological conditions must, therefore, be taken into account in developing a model of conservation of riparian zones.

Riparian zone conservation is justified by other functions, in addition, to the well known ones that include aesthetics as recreational areas, ecological functions and pollution control and management. Functions that include wildlife corridors and biodiversity conservation are equally important grounds for the search of more encompassing methods of determination, use and management of the zones along the length of rivers.

It is important to observe that previous studies have shown that the riparian zone loses its ecological capacities beyond certain widths. This aspect has not been considered in the study area. In this regard, wider riparian widths would not be necessary for ecological reasons. However, wider widths are useful for functions that require wider riparian zones such as wildlife corridors. In addition, beyond 30 metres, engineering technology such as construction of dykes would be acceptable insofar as it does not adversely affect the functional properties of the zone.

The study further established that there is significant slope variability across study sites in different rivers, in the basin. In this regard, variable and not uniform width of the riparian zone appears to be a more plausible approach in riparian width determination. From these findings, it appears that the width of the river channel which widens down the river valley from source to mouth has not been considered during the determination of riparian widths. Data collected from the 12 sites corroborated this as the sites have varying river widths yet one small uniform riparian width has often been used.

After all, river channels are subject to changes due to natural and human activities and that wider zones are necessary for the lower reaches of rivers because the river meanders occur there. In low-lying areas, there would be a need for wider riparian widths to enable the

construction of dykes. In addition, the zones are a critical public space for construction of dams, weirs and water conveyor pipelines.

The study also established that the riparian slopes range from gentle to very steep in the study sites. However, there was no evidence that gradient of slopes has been considered during the determination of riparian zones in the study sites. Variation in slopes justifies moving away from relying on uniform and narrow widths. Previous studies including Collier *et al.* have observed that steep slopes require wider zones.

The result of laboratory test of soil samples also established that the basin has predominantly black and red clay soils with low permeability in the 30 metre riparian zone. Previous studies established that soil permeability should be considered when determining riparian widths. However, since the soils in the study sites are mainly clay with homogeneous soil permeability characteristics, soil type as a variable may not be significant in the determination of riparian widths in the basin.

7.5 Linking Land Use and Biophysical Factors to Policy and Institutional Factors

Field inspections, direct measurements and data collected through sampling confirmed that existing policies and institutional factors have no significant influence on the determination, use and management of riparian zones.

7.5.1 Non-Compliance to Policy Measures

In Mathare 4B, residents do not adhere to policies or follow regulations on land use that control construction in order to protect the riparian zone. It was further observed that residential houses are built on the floodplain close to the riverbank. Some temporary tenements are a mere 1.8 metre from the riverbank. Toxic and poisonous effluents from *chang'aa* brewing activities conducted at the riverbank are discharged into the river. Temporary *mabati* (iron sheet) toilets are also built on the edge of the river, and open drains empty their contents into the river.

The foregoing evidence is contrary to provisions in the Physical Planning Act, Public Health Act, Water Resources Management Rules and Environmental Management and Coordination Act which prohibit pollution of water resources

The location of Nakumatt Ukay hypermarket building contravenes existing regulations on riparian zone conservation which require maintenance of a minimum distance and

vegetation cover in riparian zones. The Kibagare stream is canalized with its width reduced to 1.9 metres in average to ensure maximum use of the zone.

One of the de-commissioned quarries in Mukuru Kwa Njenga, is located about 15 metres from the riverbank and is used as a dump site. In April, 2012, the pit was full and overflowing with litter that was being blown and deposited in the riparian zone and river channel. It is important to note that the Geology and Mines Department in the Ministry of Environment and Mineral Resources, City Council of Nairobi and the National Environment Management Authority (NEMA) had issued licenses that allowed quarry mining activities close to the river. Industrialists at Viwandani have not uniformly adhered to regulations that govern the conservation of the riparian zone. Some industrial structures have been built at the edge of Ngong River.

Urban farmers in Mukuru Kwa Reuben have flouted laws and regulations especially the Agriculture Act which prohibit cultivation close to watercourses. The farmers have planted crops up to the edge of the river. Over cultivation and grazing of livestock in the riparian zone has led to the loss of vegetation and erosion of the riverbank.

Garage operators along Rabai Road at Uhuru Estate use the zone as a dumping ground for oils, battery acid, vehicle scrap metals, repair and spraying of vehicles. Toilets are constructed in a manner to facilitate the discharge of garage wastes into the river. Flooding and landslides are constant dangers to the garage operators located at the river bank. Dumping of solid and liquid wastes at riparian zones contravenes the Water Resources Management Rules of 2007 and Environmental Management and Coordination Act of 1999.

The foregoing analysis of data on land use and field observation of biophysical characteristics of the riparian zone clearly reveal the general lack of adherence to Kenyan policies that stipulate minimum widths aimed at conservation of the zone. The smallest width provided in the policies is 2 metres but the structures are built even within this width of the zone.

The next smallest width of 6 metres provided by the Water Act of 2002 has not been adhered to either. Worse still, land users have failed to follow the provisions of the Water Act 2002 and the Physical Planning Act of 1999 which explicitly provides for the retention of riparian vegetation cover.

7.5.2 Adherence to Policies

At Kamukunji open public grounds, the riparian zone was covered with planted trees and grass. The grounds are used for recreational activities and holding public meetings. There are park furniture, pavements, litter bins and a newly built modern public toilet. These enable the users of the public ground to enjoy the view and surroundings of Nairobi River as it passes this section. This part of the riparian zone is intact and represents good practice in riparian zone usage.

Faddville high income residential estate in Kileleshwa conforms to Water Resource Management Rules of 2007 by observing a minimum width of six metres. There was evidence, however, of the fence having been moved half a metre away from the riverbank in adherence to the regulations. The riparian zone was covered with a few young trees and there was a pavement close to the fence that facilitates people to enjoy the scenery of the river. There was also evidence of some conservation-related economic activities such as the sale of potted plants.

At the Nairobi Arboretum, the riparian zone is covered with trees, shrubs and grass. There are paths provided to access and recreate close to the river. The respondents opined that the riparian zone regenerates its own natural vegetation and soils as it is left undisturbed. The only source of river water contamination is domestic waste generated from residential flats across the river channel.

Conservation and adherence to policies on use and management of riparian zones is evident at Nairobi National Museum and Hotel Boulevard. Hotel Boulevard has fenced off the zone to limit access by the public. The zone is used for recreational activities such as reception for parties at a fee. Maintenance of adequate vegetation covers and lack of solid and liquid waste on the zone implied good practice by both the Museum and the Hotel.

The main types of riparian vegetation include trees, shrubs and grass. These findings are in agreement with those of Collier *et al.* that riparian vegetation is the most important factor in riparian zones in connection to its function as filters, transformer and sink for harmful nutrients and pollutants including nitrogen, phosphorous and pesticides. By this function, riparian vegetation slows sediment-laden run-off and therefore help to control pollution and stabilize riverbanks by preventing soil erosion.

7.6 Chapter Summary

This chapter has presented results of data analysis and discussions in relation to the second objective of the study. The findings confirm that the land use, and biophysical factors constitute a complexity of issues in Nairobi River Basin. The issues have adverse implications on the environmental health of the riparian zone as well as the urban human system in the basin.

Based on the foregoing, there is no empirical evidence to suggest that riparian zones are properly determined to ensure they perform their functions. Hence, most study sites are adversely affected by competing land use and biophysical factors. This has directly affected the physical extent and ecological character of riparian zones as a result of improper determination, use and management of the zones. Chapter Eight that follows is on the role, perceptions and behaviour of professionals and land users.

CHAPTER 8: ROLES, PERCEPTIONS AND BEHAVIOUR OF PROFESSIONALS AND LAND USERS

8.0 Introduction

Data that was collected from professionals and land users was analyzed based on their opinions, roles, perceptions and behaviour in the determination, use and management of riparian zones in Nairobi River Basin.

8.1 Opinions of Professionals

Professionals expressed their opinions by stating the factors they considered to contribute to encroachment and degradation of riparian zones, impacts of different land uses on riparian zones and strategies that could lead to effective conservation of the riparian zones.

8.1.1 Response Rate

Response rate was determined based on the percentage of professionals who responded to questionnaires. A response rate of 84 per cent was found good. Table 8.1 shows the response rate of professional respondents.

Table 8.1: Response Rate of Professional Respondents

	Frequency	Percentage (%)
Response	28	84
No Response	5	16
Total	33	100

8.1.2 Factors Contributing to Encroachment and Degradation of Riparian Zones

According to the professionals, riparian zones seem to have been properly demarcated in prime (high income) areas of the city. However, they indicated with great certainty what could be the biggest challenges warranting encroachment into the zone. The reasons are grouped into four main categories of socio-economic factors, legal and policy factors, awareness level and other factors.

8.1.2.1 Socio-Economic Factors

Professionals felt that the livelihood strategies, gentrification and no-man's land are the key challenges to conservation of riparian zones.

a. Livelihood Strategies

Professionals indicated that Nairobi has one of the highest urban population growth rates in Kenya that agrees with results in Figure 1.1. This population increase is coupled with a mainly rising poverty and the unemployment rate and compounded with the lack of affordable housing for the urban poor. The urban poor also experience mass inaccessibility to land thereby opting to build shackles at the river banks. The observed urban agriculture practice along the river banks is a strong indicator of a survival strategy by the ‘owners’ of those ‘farmlands.’

b. Gentrification

Professionals also opined that urban land is rapidly being converted to more lucrative land uses at market rates. Programmes like urban renewal, slum upgrading, are cases to mention. Naturally, those who can’t afford will be required to move to less expensive areas. Most urban poor opt for undeveloped and perceived free land especially at the river banks.

c. No-man’s-land/ wasteland

Most riparian zones are considered by many as no-man’s-land; space erroneously considered to belong to no one and so easily invaded by informal and formal activities. Moreover, some people view it as a wasteland since they appear as wetlands. These perceptions have made the riparian zones in most human settled areas to bear the brunt of wanton destruction.

8.1.2.2 Policy and Legal Framework

Professionals considered that a disjointed regulatory framework, conflicting roles, weak enforcement and laissez-faire of policies were to blame for the encroachment and degradation of the zones.

a. Disjointed Regulatory Framework

There is variable and sometimes conflicting interpretation of policy, legal and institutional matters for instance the lack of clear legal boundary definition between the riparian zone and the adjacent property. Save for the ocean/seas, lakes and tidal rivers, the Department of Surveys allows property boundaries to be defined as being “the centre-line of the river” while the Survey Act is clear that all reservations are to be surveyed as self contained units at a distance equidistant from the high water mark.

On the other hand, planning and city council by laws leave the determination of the riparian zones at the discretion of the planner. This has given rise to a failure by survey records and plans to establish riparian boundaries leading to lack of clear and standard statutory width of the riparian zone.

The professionals also lamented about failure of local planning authority to enforce riparian conservation laws. They observed that in some cases the policies are unrealistic/ unclear on the width of the riparian zone to be reserved. `

b. Conflicting Roles

Every piece of legislation and policy touching on riparian zone conservation has its own understanding and interpretation of the various roles each stakeholder should play in so far as riparian zone management is concerned. This has led to unclear conservation and management regimes. For instance, one may ask if the zone is within the private property, then who has the mandate: is it City Council, NEMA, owner or Ministry of Water Resources? Some professionals talked of dysfunctional land use control bodies.

c. Enforcement

There was no designated agency responsible for ownership, monitoring, maintenance and preservation of riparian zones until recently when NEMA and WRMA were set up with specific mandates on such zone and laws addressing this entrenched in the new Constitution. Because of the conflicting roles as aforementioned, enforcement of the relevant laws is impaired. The residual effect of this is the lack of proper monitoring and controls of riparian zones.

d. Laissez-faire or Simply Impunity

Developers simply disregard zoning policies and regulations as defined by City Council of Nairobi. This is a show of impunity by the land users. These includes those settling or conducting activities in the riparian zone while knowing it is wrong but bribe their way to remain there.

Impunity is also exacerbated by those who govern. These include the local administration: chiefs and sub-chiefs; councilors and city council officials who despite knowing it is wrong, go ahead to allocate portions of the riparian zone and even develop on them and collect rent. Professionals noted that this forms the greatest cause of riparian encroachment.

8.1.2.3 Awareness Level

Professional respondents noted that there is a lack of awareness by some of the defilers of the riparian zones. This has led to, for instance, uncontrolled domestic and industrial waste disposal both solid and wastewater, occupation by squatters and other economic activities such as kiosks, garages and carwash, and the practice of urban agriculture and quarrying among others. Many land users rarely understand the plan of the areas where the riparian zone falls.

However, professionals also acknowledged that land-lords and developers close their eyes to the existence of riparian zones and overlook other related physical development standards. For instance, developers hardly adhere to the allowed plot coverage as prescribed by the zoning regulations.

8.1.2.4 Other factors

Professionals also indicated the need by land users to maximize land use once surrounding areas are fully developed. In low income areas, riparian zones initially provided sources of water. However, with time the rivers became places to dispose-off waste. Professionals also attributed the problem to rampant illegal allocations of riparian zones by the provincial administration and the vigilante groups.

8.1.3 Strategies for Conservation of Riparian Zones

Professionals proposed strategies for conservation of riparian zones in a changing urban landscape in Nairobi River Basin. The highest ranked strategy was enforcement of laws and policies to recover riparian areas. The need for clear definition and demarcation of the riparian zone was suggested by 36 percent of respondents in order to achieve long term conservation of riparian zones. Table 8.2 shows the opinion of professionals on how to ensure effective conservation of riparian zones.

Table 8.2: Strategies for Conservation of Riparian Zones

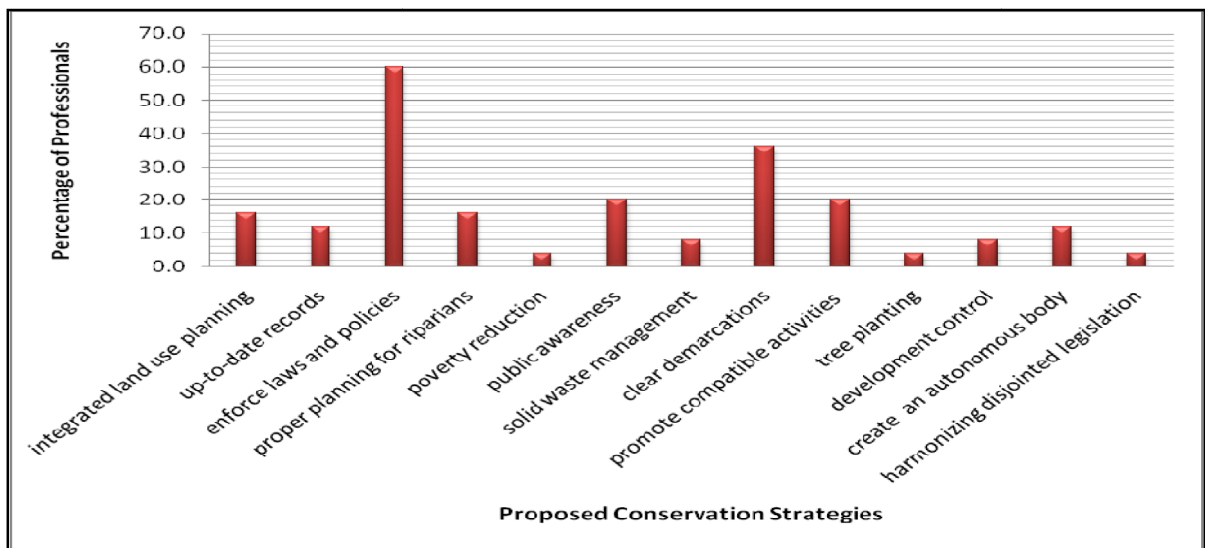
Way(s) of Conserving the Riparian Zone	Frequency	Percentage	Rank
Enforce laws and make stringent policies to recover riparian areas	15	60	1
Clear demarcation of riparian reserves	9	36	2
Promote compatible conservation activities e.g. recreation	5	20	3
Public awareness/ community sensitization	5	20	4
Proper planning for riparian reserves at different levels	4	16	5
Integrated land use planning and management	4	16	6
Create an autonomous body/ authority to manage riparian reserves	3	12	7
Development control	2	12	8
Proper solid waste management	2	8	9
Planting trees in the zone	1	8	10
Employment creation to reduce the number of urban poor	1	4	11
Harmonization of disjointed legislation	1	4	12
Total	52	100	

In Table 8.2, enforcement of laws and implementation of policies stands out as the most preferred strategies by professionals. Clear identification of riparian zones and promotion of compatible activities close and within the zones as well as effective land use planning were also suggested. The suggestions by professionals appear realistic and achievable.

The overall, overarching suggestion is a properly defined zone with clearly demarcated boundaries. However, this would only be possible if adequate scientific criteria or principles are used in the definition of riparian zones. In addition, environmental conditions of the zone including soils and gradient of slopes should be established before determination of the zones.

Other important factors that were cited include rights of landowners over registered land as well as constitutional rights of squatters who may require alternative locations for their housing and economic activities. Once land use factors are determined based on the suggestions of professionals, these would in turn inform policy formulation and institutions concerned with the determination, use and management of riparian zones. Figure 8.1 is a graphical presentation of the suggestions of professionals on conservation of riparian zones.

Figure 8.1: Strategies for Conservation of Riparian Zones



In summary, for proper conservation of riparian zones, professionals suggested the following which must be put in place:

- a. There should be a clear zoning policy framework with specifically designated land uses. This will ensure that riparian zones are set aside for conservation with specific uses such as parks, water catchment areas, cycling tracks and forested areas. These by-laws should be adequately enforced to recover lost riparian areas as well as to remove all non-complaint land uses on the zone. Landscaping of the riparian zone would be appropriate to make it more attractive for picnics and outings by city dwellers and the general public;
- b. There should be a clear legal definition of a riparian zone; its width depending on the nature of land use, relief (steepness or flat flood plain) and volume and catchment area of the river; and its nature of conservation and management, and by whom. Such endeavors should be geared towards demarcating the riparian zones and keeping them clear of settlements and other human activities that may lead to their degradation. Regular and frequent policing must also be enhanced in the area by the relevant authority;
- c. There should be strict adherence to development control regulations. Maintenance of the riparian zone to be the responsibility of the abutting property owners for protection and monitoring;

- d. There is a need to establish and embrace integrated land use planning and management by planning for riparian zones at different levels: regional (macro) and local (micro). Such integrated regimes would also be able to promote compatible income generating conservation activities in appropriate areas along these reserves. Converting the riparian zones to places for recreation could offer a good proposal to be explored by providing the necessary facilities including seats, planting of trees and flowers; and
- e. Creation and maintenance of an up-to-date database on the state of riparian zones, as well as having a monitoring system; strengthening public awareness on the role of riparian zones, setting up a land use authority with vested powers to control the development and maintenance of the riparian land and enhancing security along riparian zones.

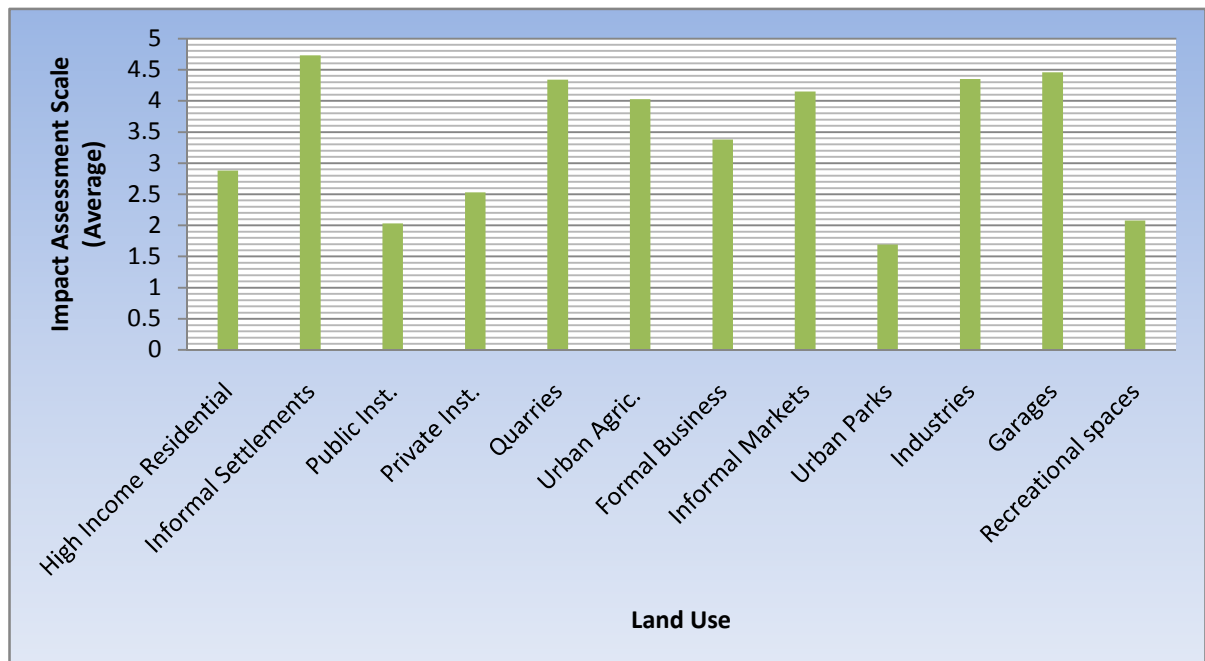
8.1.4 Impacts of Land Use on Riparian Zones

Responses of professionals on the physical impact of land uses on riparian zones were categorized and ranked on a scale of 1 to 5 as follows: rank 1(no impact), rank 2 (least impacts), rank 3 (moderate impact), rank 4 (major impacts) and rank 5 (serious impacts).

Informal settlement ranked as the land use with most serious impacts holding a mean of 4.73. Other land uses that recorded high means are (i) garages (4.46); (ii) industries (4.35); and (iii) quarries (4.34) respectively. Land uses with the lowest mean, implying that they had the least adverse impacts, were urban parks (1.69) and recreational spaces (2.08). These in fact were suggested to be compatible land use activities in riparian zones. Table 8.3 and Figure 8.2, gives a summary of professional opinions on the impacts of specific urban land uses on riparian zones.

Table 8.3: Variability of Professional Opinions on the Impacts of Urban Land Uses

	N	Minimum	Maximum	Mean	Std. Deviation
High Income Residential e.g. Kileleshwa	27	1	5	2.96	.980
Informal Settlements e.g. Mathare 4B	27	2	5	4.81	.622
Public Institutions e.g. National Museum	27	1	4	2.04	.854
Private Institutions e.g. Boulevard Hotel	27	1	5	2.48	.753
Quarrying e.g. at Pipeline Quarry village	27	3	5	4.41	.636
Urban Agriculture e.g. at Mukuru Kwa Reuben	27	2	5	4.19	1.039
Formal Businesses e.g. Nakumatt Westlands	27	2	5	3.74	1.130
Informal Markets e.g. Gikomba market	27	2	5	4.22	.847
Urban Parks e.g. Arboretum	27	1	4	1.81	.962
Heavy Industries e.g. Industrial area	27	2	5	4.63	.688
Garages e.g. along Kirinyaga road	27	2	5	4.59	.694
Open Recreational Spaces e.g. Kamukunji grounds	27	1	4	2.30	1.031
Physical Infrastructure e.g. sewers along Ngong River	27	2	5	3.78	.934
Valid N (listwise)	27				

Figure 8.2: Professional Opinions on Impacts of Land Uses on Riparian Zones

The overall emerging assessment of respondent professionals is that informal settlement land use has the most serious physical impact on riparian zone. On the other hand, urban parks and recreational spaces have the least impact on the physical character of the zones. Table 8.4 presents a Likert Scale showing the professional opinions on the suggested impacts of specific land use types on the riparian zone.

Table 8.4: Likert Scale on Professional Opinion on Impacts of Land Use on Riparian Zone

		Specific Land Use Types												
		High Income Residential	Informal Settlements	Public Institutions	Private Institutions	Quarrying	Urban Agriculture	Formal Businesses	Informal Markets	Urban Parks	Heavy Industries	Garages	Open Recreational Spaces	Physical Infrastructure
Valid % for each Likert Unit	1	3.7	0	22.2	3.7	0	0	0	0	48.1	0	0	22.2	0
	2	29.6	3.7	63.0	51.9	0	11.1	18.5	3.7	29.6	3.7	3.7	44.4	14.8
	3	40.7	0	3.7	40.7	7.4	11.1	22.2	14.8	14.8	0	0	14.8	11.1
	4	18.5	7.4	11.1	0	44.4	25.9	25.9	37.0	7.4	25.9	29.6	18.5	55.6
	5	7.4	88.9	0	3.7	48.1	51.9	33.3	44.4	0	70.4	66.7	0	18.5
Cumulative % above scale 3		66.6%	96.3%	14.8%	44.4%	99.9%	88.9%	81.5%	96.3%	22.2%	96.3%	80.3%	33.3%	85.2%
Mean Score		2.96	4.81	2.04	2.48	4.41	4.19	3.74	4.22	1.81	4.63	4.59	2.30	3.78
Relationship with the normal mean of 3		0.04 below the normal mean	1.81 above the normal mean	0.96 below the normal mean	0.52 below the normal mean	1.41 above the normal mean	1.19 above the normal mean	0.74 above the normal mean	1.22 above the normal mean	1.19 below the normal mean	1.63 above the normal mean	1.59 above the normal mean	0.7 below the normal mean	0.78 above the normal mean

8.1.5 Appropriate Widths of Riparian Zone

From Table 8.5, most professionals suggested that urban agriculture (45%) and recreational open spaces (42%) should have widths of 0-9 metres. In addition, professionals suggested that industrial (39%), commercial (37%) and informal residential housing (32%) should have widths of more than 30 metres.

Table 8.5: Professionals Opinions on Appropriate Riparian Widths

Land Use Type	Suggested Width (m)			
	0-9 (% of responses)	10-19 (%)	20-29 (%)	>30 (%)
Industrial	N/A	28	33	39
Commercial	32	10	21	37
Formal Residential	16	21	37	26
Urban Agriculture	45	11	22	22
Recreation/Open Space	42	21	26	11
Informal Residential	16	31	21	32
Infrastructure-Sewers	37	10	42	11

The results of data analysis on the widths suggested in Table 8.5 show that professionals recommend variable widths for riparian zone in relation to specific land uses. However, these findings are based on professional experience and are subjective. It is necessary to carry out more detailed sectoral studies to establish the most appropriate riparian width for each type land use.

8.2 Socio-Economic Profile of Land Users

Levels of education and income were employed as measures for socio-economic status of the residents in Nairobi River Basin. These are indicators of poverty that have been used to discount poverty as one of the underlying reasons that explain encroachment and degradation of riparian zones.

8.2.1 Education and Income Levels of Households

The highest level of education obtained by 60 per cent of respondents in Mathare 4B is primary school. Approximately 34.3 percent have attained secondary school level while only 5.7 percent attained tertiary level of education. Tertiary education in Kenya is acquired in the university and other post secondary education institutions

In contrast, 80 percent of respondents from Faddville Estate have tertiary level education. About 11 per cent have secondary school level of education while only 9 percent of respondents have primary level of education. The 20 per cent respondents with primary and secondary education in Faddville may be attributed to either the number of relatives or workers of owners of the residential units.

Table 8.6 presents levels of education and income of respondents interviewed in Mathare 4B and Faddville estate.

Table 8.6: Education and Income Levels of Households

Name of Study Site	No. of Respondents	Education Level			Income Level	
		Primary (%)	Secondary (%)	Higher Level (%)	Monthly Income (Kshs)	Percentage of Respondents
Mathare 4B Informal settlement	35	60	34.3	5.7	< 10,000	71.4
Faddville High Income Residential Estate	14	9	11	80	> 30,000	64

In Mathare 4B, the highest proportion of respondent which is 71.4 per cent earn income of less than Kenya shillings 10, 000 per month. In contrast, a similarly high percentage at 64 per cent of residents in Faddville earns more than Kenya shillings 30,000 per month. This suggests a direct relationship between levels of education of respondents and levels of income. In this regard, the higher the level of education, the more likely will a respondent earn a higher income in the future and vice-versa.

It is worth to note that respondents live in two areas with extreme differences in terms of social and economic life but have equally encroached on the riparian zone. However, the higher level of provision of services and infrastructure at Faddville reduces the level of degradation of the zone but only at a minimum.

8.2.2 Emerging Socio-economic Issues

The study examined socio-economic status of land users in relation to the physical extent and ecological character of the riparian zone with the aim of assessing their implication. Formal and informal land users of high and low income groups respectively have

encroached and degraded riparian zones. The study findings have not confirmed poverty as the main reason for encroachment and degradation of riparian zones in the study area.

Instead, the study confirmed economic/ profit motive as an indicator of encroachment and degradation of riparian zones. The study established that the majority of the structures in the 30 metre riparian belt in Mathare 4B are rented. This is in agreement with Menya who established that over 70 percent of structures in Mukuru Kwa Reuben were rented. This finding underscores the fact that although the poor may justify encroachment to locate housing and livelihood activities, they certainly use the poverty label to advance their economic motive.

Based on the foregoing, the poor and rich would encroach and degrade riparian zones as long as they are not properly determined, used and managed. This explicitly means that the size of the physical area and ecological quality of the zone would suffer socio-economic consequences of land development as well as solid and wastewater which are generated.

8.3 Roles, Perception and Behaviour of Land Users

Results of data analysis show that the land users have very limited roles in the conservation of riparian zones. In fact, they have perceptions that influence their behaviour towards defiling the zones. Some similar land uses in formal and informal residential and formal and informal business areas in the study sites are as a result of bad decisions to encroach and degrade the zones.

On the other hand, there are land uses as in the case of the recreation park versus high-income residential areas, public open grounds versus informal business that are located close to the river but merely behave differently. For example, Nairobi Arboretum along Kirichwa Kubwa River has conserved the zone. However, the high-income residential flats directly across Nairobi Arboretum are built at the riverbank.

The riparian zone of Kamukunji open public ground has well maintained riparian vegetation but across Nairobi River, Gikomba business sheds are located at the riverbank. Table 8.7 presents a summary on perceptions and behaviour of respondents at the study sites.

Table 8.7: Roles, Perception and Behaviour of Land Users

	Study sites	Roles	Perceptions	Behavior
1	Mathare 4B Informal settlements	None	Idle land free land	Mainly informal residential houses, toilets and solid waste disposal.
2	Faddville residential estate	Limited	Government land for planting trees and recreation	Used for planting trees, flowers for economic use and residential apartments
3	Arboretum recreation park	Protection of the riparian zone	Public reserve land for recreation	Zone covered with trees, grass and shrubs and is used for public recreation
4	Kamukunji open grounds	Protection of the riparian zone	Recreation area and public arena	Zone covered with trees and grass and is used for recreation
5	Nairobi National Museum	Maintenance of the riparian zone	Government riparian reserve	Botanic gardens, trees and grass
6	Hotel Boulevard	Maintenance of the riparian zone	Private property with title deeds	Zone fenced off, with private grass lawn used for paid up recreation
7	Mukuru Kwa Reuben Urban Agriculture	None	Free and idle land	Crop farming, animal keeping, residential houses, toilets
8	Nakumatt Ukay Hyper Market	None	Private property with title deeds	Commercial building and Parking lot
9	Mukuru Kwa Njenga Quarries	None	Free and idle land	Zone used for quarry mining and dumping of waste
10	Viwandani Industries	None	Planting trees, flood control, minimizing pollution of the river	Industries at the edge of river while those far away use pipes to drain effluents to the river
11	Gikomba Informal Market	None	Idle land free land	Market sheds
12	Uhuru Rabai road Garages	None	Idle and free land, government land, Others perceive it to be own private land	Zone used for storage of vehicle shells, repair of vehicles and space for toilets

Table 8.7 shows that some land users have limited roles in conservation of riparian zones. Perceptions about riparian zones are so diverse with land users perceiving the zones as idle and free land. Others perceive the zone as private property while others still perceive it as public land.

These diverse perceptions which are the genesis of the prevailing utilization of the land on riparian zone do generate conflict, now dominant in the behaviour towards the development and fact use of the zones in Nairobi. Encroachment and degradation of the zones is a clear manifestation of these conflicts.

The study endeavored to understand how the functions of the land adjacent to the river are perceived. There were varied responses some very positive within the context of conservation endeavors. For instance, 50 percent of the residents of the Mathare 4B

informal settlement said that the land adjacent to the river is for planting vegetation while 19.2 percent said it was for flood control, views quite in tandem with the spirit of conservation.

However for the respondents who reported no knowledge of the purposes of this land had fairly unfavorable view to the spirit of conservation. For instance, 39.4 percent of this group said this land is meant for farming, 18.2 percent said it is to be used for construction of houses and 12.1 percent had the view that this land has no use or it is idle land or just no-man's-land.

The favorable view by the affirmative respondents on what use the land should be put is contravened by what is practiced on the ground. For instance, asked about the activities that people were undertaking on the land adjacent to the river, 31.6 percent said they do farming /planting vegetables and sugarcane, 15.8 percent construction of residential houses, 14.5 percent toilets connection to the river and 13.2 percent said they use it for dumping of garbage/waste disposal.

8.4 Evaluating Professional and Land Users' Factors

The third objective of this study was to evaluate the roles of professionals and land users. Land users include public and private enterprises operating next to selected rivers. The objective also focused on evaluating perceptions and behaviour of professionals and land users towards the determination, use and management of riparian zones in the study area.

Data analysis and interpretation of questionnaire responses from land users and professionals confirmed that the roles, perceptions and behaviour of professionals and land users are influential in conservation of riparian zones. The roles, perceptions and behaviour of these actors must be taken into account in designing, formulating and implementing policies and laws for conservation of riparian zones.

8.4.1 Roles, Perception and Behaviour of Professionals

Professionals are key players in the allocation, planning, surveying and land subdivision as well as in the preparation and approval of development requests that are implemented in riparian zones. Land users, on the other hand, are critical in the proper use of the zone by not constructing building structures, conducting activities and dumping solid and sanitation wastes in the zones. Otherwise, their roles would potentially affect the riparian width and ecological condition.

The existing planning practice in Nairobi River Basin has two challenges. First, it is based on multiple provisions in legislation on conservation of riparian zones. As a result, this creates confusion and conflicts to land users, professionals and policy makers with interests and responsibilities at the river front. This has resulted in professionals particularly planners making incompatible land use plans next to rivers, policy makers and city managers approving any development next to rivers. Planning without coordination contributes to poor management especially where land development is not integrated into the existing planning framework.

The behaviour of professionals in the study area seems to be influenced by their values, preferences and perceptions towards conservation of riparian zones. In most cases, it appears that professional preferences relate more to achieving highest economic use of the riparian zone as demonstrated by subdivisions that set aside very small riparian width setbacks. Economic perspectives are quite influential on attitudes of professionals. Information flow as provided in survey plans and subdivision schemes does not appear to give professions the right motives of conserving riparian zones.

Therefore, what size and sites of the zones to earmark for protection and what criteria they employ in the determination of riparian zones has remained subjective. There are appears no useful methodologies in developing common norms to support the practice of professionals and minimize misinterpretation of concept application in policies.

8.4.2 Roles, Perceptions and Behaviour of Land Users

Data analysis revealed that the land users have limited or no role at all in conservation of riparian zones. They also have varied perception about the zone. They perceive the zone as private land, idle, free land or public land. Land users have behaved differently and acted in contrasting ways in their use of the riparian zone. Some have opted to encroach and degrade the zones while others have maintained a good conservation ethic.

These findings underline the importance of roles, perceptions and behaviour of land users as factors in the conservation of riparian zones. The findings are in agreement with views of Lelo *et al.* whose study on managing the river Njoro watershed in Kenya established that a free access mentality had developed in relation to the riparian zone leading to its degradation.

Pointedly, the decision of professionals and land users depend on their roles, perceptions and behaviour. The manner in which these stakeholders respond helps to conserve or otherwise encroach and degrade the riparian zones.

8.4.3 Technology Innovation by Land Users

Canalization of Kibagare stream involved reducing and deepening the river channel and reducing the riparian zone so as to create space for construction of buildings such as the Nakumatt Ukay Hypermarket. Construction work to canalize the river channel as a river management tool focuses on maximizing the economic use of riparian zones. Proponents of urban development in the riparian zone suggest that technology is used in other parts of the world to avail riparian zones for urban development. Such is common in South East Asian Countries

However, the use of technology to lay the basis for urban development in riparian zones ignores the benefits that conserved zones provide to a greater majority of the urban communities. This study posits that use of technology to facilitate urban development of the magnitude of Nakumatt Ukay Hypermarket on the riparian zone is nothing but facilitation of free market capitalism that curtails long term sustainable river ecosystem.

In fact, the use of modern technology to modify fragile ecological areas that riparian zones happen to be negates the very essence of environmental sustainability and biodiversity conservation and goals of livable urban habitats. However, use of technology to enhance conservation and sustainability of river ecosystem while monitoring social and economic development would go a long way in the protection and conservation of riparian zones.

8.4.4 Need for Private Public Partnerships

Data analysis has shown that partnerships between professionals, land users and public institutions are weak. Coordination of the main actors in conservation of riparian zones is also weak. Stakeholder involvement in urban land use planning and conservation of riparian zones is more effective and better achieved through strong partnerships of public and private agencies. This finding agrees with those of Home, Muketha and Menya.

8.4.5 Linking Professional and Land Users' Factors to Riparian Zones

Based on the foregoing analysis, it appears that the riparian zone has both economic and legal meanings. The economic meaning emerges from the fact that riparian zones are perceived by land users as a livelihood asset in form of places to obtain income, food and

shelter. The legal meaning of the zone underscores legitimization of right (s) to access and occupy it as a public and private entity supported by public and private law as well as in terms of customary practices of the rights to land.

Contemporary perception of the riparian zone as space revolves around its role to locate uses such as residential, industrial and recreational. These uses of the zone are, however, constrained in that each riparian space has a unique set of biophysical characteristics that would make it suitable for some and not other types of land use. Previous studies underscore this fact as the basis of differentiated characteristics of the riparian zone as land that is contested whether it is treated as a concept or a discrete place on the surface of the earth.

8.5 Chapter Summary

This chapter has evaluated the roles, perceptions and behaviour of professionals in relation to conservation of riparian zones in the study area. Professionals and land users have limited, or no role at all in conservation of riparian zones. They have different and oftentimes, negative perceptions and behaviour towards the conservation of riparian zones. These attributes have adverse implications on the physical extent and ecological quality of riparian zones. Chapter Nine that follows uses the result of data analysis in chapter six, seven and eight to develop and operationalize an integrated model for conservation of riparian zones.

CHAPTER 9: INTEGRATED MODEL FOR CONSERVATION OF RIPARIAN ZONES

9.0 Introduction

Chapters six, seven and eight have presented results of data analysis and discussions in relation to the first three objectives of the study. The findings and discussions confirm that the policy and institutional factors, land use and biophysical factors, professional and land users' factors constitute multitude of issues that influence the determination, use and management of riparian zones in Nairobi River Basin. The issues have adverse implications on the functional attributes of the riparian zone ecosystem and urban human environment in the basin.

The main actors in the interplay of these factors include expert officials of public institutions, professionals and land users. They perceived and indeed proposed better ways riparian zones may be secured and managed to benefit communities that live in neighborhoods close to the zones, as well as the city of Nairobi as a whole.

However, the same actors have not promoted conservation of riparian zones in their day to day work. Therefore, land use planning; land surveying; environmental and water resources management imperatives in the basin have not resolved the looming problem. This chapter focuses on the development and operationalization of an integrated model for determination, use and management of riparian zones. From the results, the riparian zone appears to be a function of spatial and non-spatial factors.

9.1 Spatial and Non-Spatial Determinants of Riparian Zones

Spatial determinants include land use and biophysical factors inherent in the riparian space.

9.1.1 Spatial Determinants

The spatial determinants of riparian zone include land use and biophysical factors. The riparian width and ecological condition are also important surrogates of the riparian zone.

9.1.1.1 Land Use and Biophysical Factors

Land use factors that emerged as the main determinants of riparian zones are specific land use types, spatial concentration, and land administration variables of land tenure and cadastral boundary data. Biophysical factors including longitudinal continuity of

vegetation, and lateral width of the watercourse, riparian slopes, and type and permeability of soils were found to be the main attributes of a functional riparian zone.

The study findings have established that existing land use and biophysical characteristics of the river ecosystem are completely ignored in the existing distorted practices and multiple policies in Nairobi River Basin. The existing practices are *ad hoc*, disjointed and at most conflicting. To address these shortcomings, riparian widths that meet specific functions of the zone should be determined. It also requires proper ecological condition that consists of requisite vegetation cover.

9.1.1.2 Riparian Width and Vegetation

The riparian width is dependent on the nature of the prevailing environment and urban land uses. Some land uses were found to transform the zone through removal of vegetation cover and dumping of wastes especially where there is a lack of appropriate solid and liquid infrastructure system. Land uses with high spatial concentration in the 30 metres have also played a role in its encroachment and degradation.

The width of the zone would, depend on the width of the watercourse because wider rivers require wider riparian spaces to accommodate among others, high incidences of floods. On the other hand, smaller rivers would require smaller riparian widths since areas of influence of the zones are also restricted to near the riverbank. However, there should be a minimum threshold for the width of the zone below which the riparian width should not be determined irrespective of the width of the river.

The riparian width is also dictated by the high water mark where a clear flood plain exists. The maximum width of the zone, on the other hand, should be dictated by the prevailing biophysical conditions and implication of specific land use types. Biophysical conditions influence the capacity of the zone to perform its functions. Steeper slopes increase the velocity of the surface run-off and therefore require wider riparian widths. Impermeable soils such as clays require wider riparian widths because they reduce infiltration of polluted run-off leading to poor water quality.

Implications of specific urban land uses, such as industrial land use plants require bigger riparian width than a low density residential zone to mitigate effects of industrial effluents. In addition, recreation parks would require no width at all because the nature of this land use resonates well with the conservation of the zone. However, where existing

developments are already close to the river, specific management measures or demolitions would be the solution.

The riparian zone ideally should comprise of uninterrupted vegetation cover along the river profile with different composition and structure to ensure maximum efficiency. Different vegetation mix including trees, shrubs and grass have different capacities and perform different functions related to the protection of the river ecosystem. The vegetation cover should be unique to a particular ecological zone since presence of appropriate vegetation type helps conserve the river ecosystem. Interruption of the vegetation continuum through urban development or scant vegetation would expose the river ecosystem to the adverse effects of land use.

9.1.1.3 Linking Riparian Width and Vegetation Cover

The riparian width and vegetation cover have been discussed independently for purposes of simplification. In reality, the two variables of a riparian zone complement one another since at specific locations of the river; the width determines how much vegetation can be accommodated. Therefore, since the lateral dimensions of the river channels, slopes and type and permeability of soils as well as urban land uses are not uniform along a river profile, it would be necessary to design variable riparian widths to accommodate enough vegetation cover and to perform functions/purposes that are required.

In determining the riparian zone, the first step should entail site analysis to establish the environmental factors such as width of watercourse, soils, slopes and implications of adjoining land uses. The selection of vegetation type should be dictated by the local plant species that would best adapt to the area. It should also be dictated by the preferred management objectives. For example, if the intention is to control pollution, then obviously a grass belt is more effective whereas, for a wildlife corridor a mix of trees, shrubs and grass are better.

The concept of multi-zone variable model reviewed in the study captures the profile of the zone at right angles to the river channel. Based on a variable multi-zone approach in determining riparian zones, the width of the zone should be a function of many variables including vegetation structure that is the most influential factor. In this regard, different widths are for accommodating different types of vegetation and accounting for biophysical factors and effects of adjoining land uses. Therefore, the functional point of reference in a multi-zone riparian system should be the high water mark. This point should be

determined through mapping and classification of rivers as provided in the Water Act of 2002.

The high water mark as a reference point for variable and multi-zone riparian widths is not easy to determine because it requires topographical mapping and hydro-geological surveys. In undertaking these tasks, specialized geospatial engineering works such as LiDar mapping and geographical information system (GIS) have to be undertaken. The mapping work has to be geo-referenced with the existing cadastral boundary data to enable establishment of their spatial extents.

Maintenance of appropriate riparian widths and vegetation cover is primarily considered in this study as conservation. Appropriate riparian zones have the ability to protect property values since the properties will not be susceptible to flooding. Moreover, removal of the riparian vegetation cover causes loss of the functionality of the riparian zone and subsequently increases liability as it exposes communities to more polluted water and floods. The spatial variables therefore require appropriate policy standards and guidelines for policy makers, land users and professionals to comply with.

9.1.2 Non-Spatial Determinants

The spatial model alone may not resolve the research problem because it requires clear policy guidelines and laws as well as policy formulators and implementers. In any case, every section of the river is unique and would require different approaches. Non-spatial factors that emerged from the findings were qualitative descriptions of the zone as prescribed in policies and enforced by institutions, land users and professionals.

It is important to assess the contribution of non-spatial factors towards conservation of riparian zones in a river basin. Understanding these variables would facilitate ecological sustainability, social acceptability and economic viability of the river and the adjoining terrestrial ecosystems in line with goals of sustainable development.

Ecological sustainability is achieved through the protection of the river and its water quality from pollution, riverbank stabilization, and control of soil erosion, flood control and provision of food for both aquatic and terrestrial plants and animals. Socially, the riparian zone is important as a recreation area. Riparian vegetation could also be a source of building materials and fruits for human consumption.

9.1.2.1 Policy Factors

The role of non-spatial factors especially the policy and institutional factors are to ensure that the spatial model is properly implemented. Development control and enforcement of policies as well as plan-making are critical to the proper determination, use and management of riparian zones.

Land tenure and cadastral boundary information are land administration variables that determine how the zone is utilized in the basin. The riparian zone in the basin has not been used in ways that conserve its physical extents and ecological qualities. Therefore, in situations where the zone has been used to accommodate a mix of land uses, the riparian vegetation cover is not the most predominant element.

The riparian width and ecological condition are dependent on measures as stipulated by the policy guidelines. A common policy position with regard to riparian width has not been well spelt out in Nairobi River Basin. Enforcement of policy guidelines and laws has also not been effected under the guidance of one institution.

Lack of clarity and multiple policies have encouraged chances of duplication of institutional functions and therefore conflict in the determination of the extent and condition of the zone. There is an urgent need to formulate and implement a riparian zone policy based on the principles developed in relation to the width and condition of the zone.

9.1.2.2 Institutional Factors

The mandates of various institutions and the perceptions of their senior officers play an important role in the determination, use and management of riparian zones. High levels of conflicts observed in the study are because of unclear institutional responsibilities and a plethora of institutions dealing with the same riparian zone issues. In the absence of a strong institution to ensure proper planning and development control, land use in relation to riparian zones is unregulated thus adversely affecting the functional properties of the zones.

Under the circumstances where different points of reference and different widths of the zone are specified for the same locations in laws, courts are not useful in resolving conflicts. In this respect, little would be achieved without effective area-wide coordination through preparation of appropriate policies and plans.

Another institutional factor is created by limited long-term investment in technical expertise and public resource mobilization for riparian zone programs. Limited number of planners to ensure proper planning and enforcement of policies was identified as a serious problem. On the other hand, regulatory tools such as laws and regulations are not reliable where public apathy prevails as this reinforces the problem.

The situation worsens in areas where there are incentives in place to encourage the development and use of the riparian zone for economic reasons. For example, this is common in sections of the river basin where residents are politically encouraged to build their residential housing and to conduct economic activities that are incompatible with riparian land use. However, there have been consequences of serious flooding and landslide tragedies.

The solution to the problem would possibly lie in higher degrees of public ownership and regulation as in the Nairobi Arboretum. This is the situation that places greater emphasis on institutional intervention through strict regulations and enforcement. However, all along since the problem became endemic in the 1990s, very little has been achieved from the perspective of the public ownership and management model. This would therefore point to a public-private partnership which would infuse an ideology of participation in riparian zone issues.

9.1.2.3 Professional and Land Users' Factors

The roles, perceptions and behaviour of professionals and land users towards riparian zones are as a result of a weak policy and institutional framework. To have a common understanding of the determination of the width and ecological condition of the zone, professionals and land users should be included in a negotiated framework for policy formulation, implementation, monitoring and evaluation.

9.2 Integration of Spatial and Non-Spatial Factors of Riparian Zone

The two sets of factors combined are fundamental to proper conservation of riparian zones. Indeed, whether spatial or non-spatial factors exist, a wetland has to be present for the riparian zone to exist. In this regard, the riparian zone should always be associated with a water body whether visible, permanent or seasonal. In addition, other than the prevailing biophysical characteristics including width of the watercourse channel, slopes and soils which are inherent in a riparian zone, the riparian width and condition are the two main surrogates that are often manipulated by human activities.

9.2.1 Proposed Integrated Model

In a systems approach, the variables established in the study should not be determined or perceived in isolation. Rather, these attributes are parts of a whole where the riparian zone and its underlying factors are its main components. The development of an integrated model for determination, use and management of riparian zones therefore should aim to bring together in an integrated manner, different elements that define and determine the riparian zones in a changing and often turbulent urban land use environment.

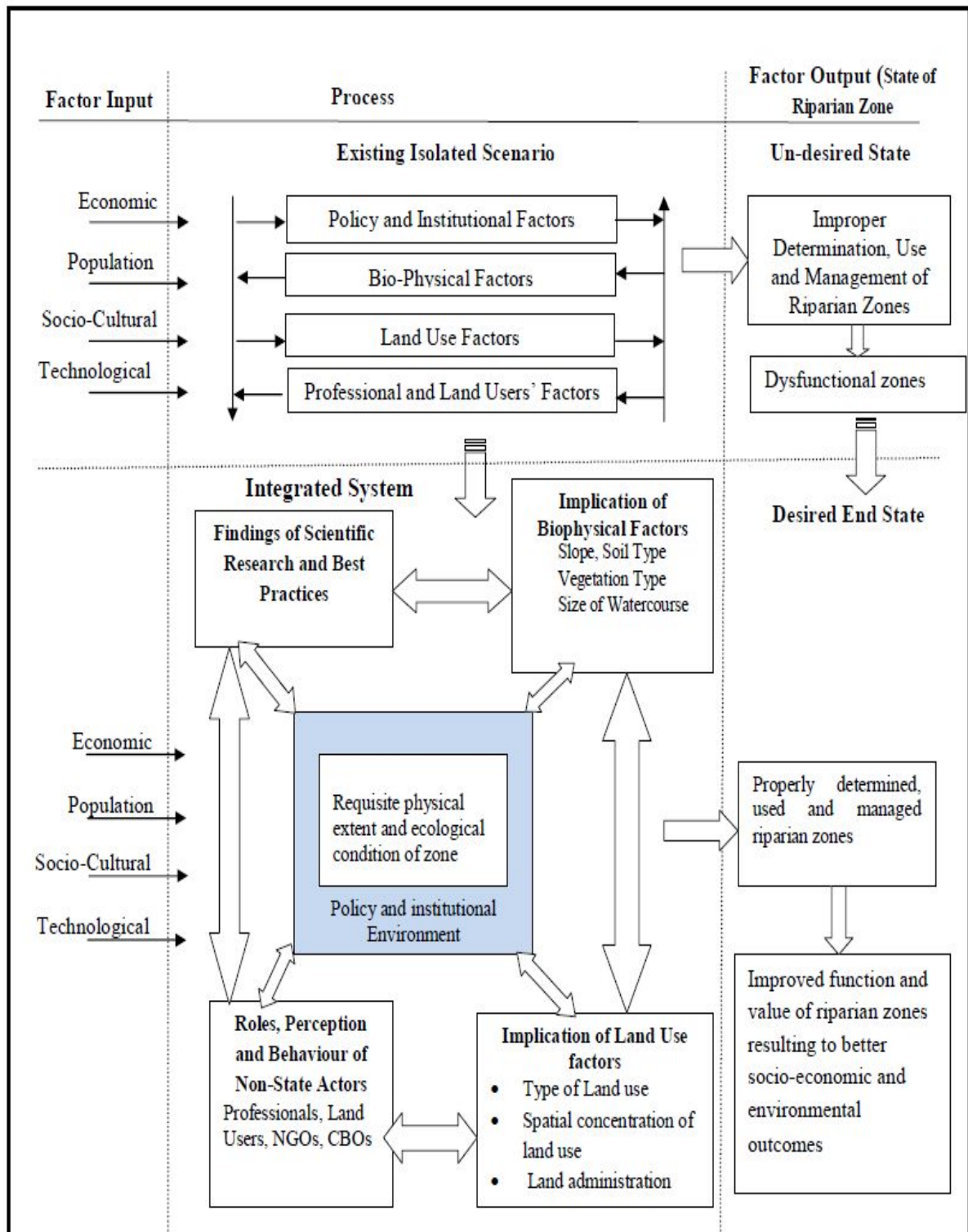
The spatial and non-spatial attributes of the zone, therefore, become the main inputs of the integrated model. Under the existing situation in the basin, the factor inputs find a disjointed stand-alone environment. The existing policy, legal and institutional framework in Nairobi River Basin operates in a disjointed manner whereas the implications of land use and biophysical factors are not taken as important factors in the determination, use and management of the zones.

Additionally, the roles, perceptions and behaviour of professionals and land users are not considered during formulation, implementation, monitoring and evaluation of policies by actors. The overall net outcome of this stand-alone approach is improper determination, use and management of riparian zones in the basin without proper feedback mechanisms.

Ideally, specific attributes in a systems approach are designed to link the factor inputs through a process that synchronizes them in a common platform. In this respect, proper definition, determination, use and management of riparian zones is informed by an appropriate policy and institutional framework which is in turn based on findings of research studies and best practices in the subject area, local biophysical factors, land use factors as well as roles, perceptions and behaviour of non-state actors among them professionals and land users.

Based on the foregoing, an integrated structure is a prerequisite to conservation of riparian zones because it spells out the requisite physical extent and ecological conditions that will be maintained. The output of such a process would be proper determination, use and management of riparian zones. This would result to improved value and functions of riparian zones. Well conserved riparian zones would be expected to have better ecological, social and economic outcomes. Figure 9.1 has summarized this into an integrated model for the determination, use and management of riparian zones.

Figure 9.1: Integrated Model of Conservation of Riparian Zones



9.2.1.1 Operationalization of the Integrated Model

The first step in operationalizing the integrated models would be through properly defined riparian zones in spatial plans and statutes. In addition, a negotiated framework involving stakeholders to determine the underlying factors such as land uses that should be allowed or restricted in the zone and the point of reference of the zone would be very crucial.

Table 9.1 summarizes highlights of the operation of the main factors of conservation of riparian zones under integrated model.

Table 9.1: Main Input-Output Factors for Conservation of Riparian Zones

Level	Input	Process	Output	Feedback/Control
Land Users	Public opinion and values	Participation, representation and advocacy	Positive attitude and appreciation of riparian zones	No. of new cases of encroachment and degradation
	Policy and Regulations	Compliance	Appropriate width and vegetation cover	No. of culprits reprimanded, Penalties and demolitions
	Information from Public stakeholders	Advocacy, coordination and cooperation	Partnerships and joint ventures	Level involvement and awareness by land users
Policy	Legislations	Formulation, Enforcement, Monitoring and Evaluation	Effective planning, use and management of zones	Actual situation in harmony with intended- as in policies
Institutions	Organizational Structure, Personnel.	Staffing, coordinating and directing	Efficiency and motivation	Level of performance
	Funding	Budgeting and allocation	Services rendered	Accounting, transparency and audits
	Implementation of mandates	Research, Planning, Mapping, Implementation and Reporting	Properly defined, used and managed zones	Level of achievement of riparian function/ purpose
Professional Practitioners	Client needs, Practitioner's expertise	Assessment, consultation and advise	Change in perception and behavior of client (land user)	Riparian zone in tandem with spatial plans and policies
	Spatial plans of land-use and riparian zone	Research, mapping of existing situation before determination of zones	Geo-referenced coordinates of riparian boundary based on high water mark and functions	Periodic review and revision of riparian management plans
	Theory, new technology, professional values and ethics	Practice informed by theory, technology, values and ethics	Effective, Economical and Ethical services	Zero tolerance to allocation, approval of building plans within riparian zones through registration and discipline

9.2.1.2 Assumptions of the Integrated Model

The integrated model is based on six assumptions. First, it assumes that the property boundaries would not be determined from the centre line of rivers, but from the high water mark as provided for in the Survey Act. Under the assumption, land users would only have user rights and not tenure rights on riparian zones. The second assumption is that the riparian land will be surrendered on conclusion of land administration transactions to the National Land Commission for issuance of title deeds. Third, it is assumed that stakeholders will construct physical barriers such as footpaths and roads to secure riparian zones as largely recreational land.

The fourth assumption is that the zones would be designated in local physical development plans (LPDPs) as conservation spaces for recreational parks, greenways and utility corridors. Fifth, riparian zone management plans would be prepared through popular participation. Finally, it is assumed that public education will be conducted to sensitize and create awareness among stakeholders for effective compliance with regulations and guidelines for utilization of riparian zones.

9.2.2 Application of the Integrated Model

The integrated model is intended for application in formal developed areas, informal areas and newly urbanizing areas.

9.2.2.1 Replication of the Model in Formally Developed Areas

Densely built formal development, located on riparian zones seemingly came into existence as a result of an ineffective development control system in the city of Nairobi. Attempts to reverse these developments and restore the zone would attract protracted legal suits while compulsory acquisition would lead to high compensation payouts. In this regard, the model would apply in these areas selectively only as remedial rather than a reversal of existing level of encroachment and degradation of the riparian zone.

Remedial measures that are feasible include giving property owners inducements or incentive to improve vegetation cover of their river frontages, maintenance of sewer and solid waste infrastructure and by way of property rate rebates. Public campaigns to educate and create awareness on ecological and recreational functions of the zones are also important remedial measures.

9.2.2.2 Replication of the Model in Informally Developed Areas

Most developments in informal areas have encroached and degraded riparian zones through illegal occupation. This notwithstanding any attempt to evict households residing there and demolish their structures without alternative sites for resettlement would lead to hostile and possible violent resistance.

The recommended strategies for implementation in the context of the model are (i) public education and awareness creation; (ii) relocation and resettlement; (iii) implementing environmental improvement programmes on recovered riparian sites and in resettled sites; and, (iv) provision of sewer and solid waste disposal infrastructure systems.

9.2.2.3 Replication of the Model in Open Sparsely Developed Areas

Riparian zones are least encroached and degraded in undeveloped urban areas and urbanizing agricultural areas. The spatial model would therefore fully apply in these areas. It is recommended that policy makers and professionals in Nairobi City County government implement the model in all sections of riparian zones along main rivers of Nairobi, Ngong and Mathare and other rivers in Nairobi River Basin.

The first step would be to map out riparian zones using new surveying mapping techniques like LiDar mapping. The second step would be to implement a programme for zoning and preparation of land use plans for the riparian zone and properties that border it. Finally, it would be necessary to design land development guidelines for the zones and bordering properties to ensure strict enforcement of development control.

9.2.3 Linking the Integrated Model to the Objectives of the Study

The results of data analysis revolve around the first three objectives of the study that are (i) to examine the influence of existing policy and institutional factors (ii) to assess the implications of specific urban land use factors and (iii) to evaluate the roles of professionals and land users, their perceptions and behaviour towards the determination, use and management of riparian zones in the study area.

9.2.3.1 The Main Linkage

Overall the first three objectives of the study have been achieved in the context of the assumptions that (i) existing policy and institutional variables have not influenced the determination, use and management of riparian zones in the study area; (ii) some urban land use and biophysical factors have negatively affected the functional properties of

riparian zones; and (iii) professionals and land users have not positively influenced the determination, use and management of riparian zones.

Objective one that has quantitative and qualitative aspects have further been supported in the context of the hypotheses that observed riparian widths in the study area are less than minimum widths in policies. It has further been supported by the hypothesis that there is no significant vegetation cover to secure riparian zones in relation to adjoining land use types in Nairobi River Basin. The discussions have interpreted the findings of the study in the context of previous similar studies to underscore the uniqueness of the findings of this study.

Four general but critical issues have merged in relation to ineffective conservation and protection of riparian zones. First, formal and informal land uses, rich and poor in Nairobi River Basin have encroached on the zones. These two categories of “developers” need to be checked. Poverty alone cannot be the only reason that forms the ground for encroachment of riparian zones because well to do members of the society have also invaded the zones.

Second, the riparian vegetation is necessary for the sustainability of the zones and continued functioning as necessary agents in riverine conservation. Finally, demand for land for urban development to meet the needs of a rising urban population need not be met by excision, encroachment and invasion of fragile riparian ecosystems of Nairobi, Ngong and Mathare Rivers and other rivers. Rather, laws, rules and development control mechanisms should be enforced to curb encroachment and degradation of riparian zones.

9.2.3.2 Influential Factors Connected to the Linkage

Four influential factors are interlinked or connected to the emerging issues. The first one concerns the spread or coverage of land use types that occupy the riparian zones. It was found that indeed informal housing, formal housing, and urban agriculture by the poor low income groups, informal economic activities mainly selling of goods and services consumed by low income groups at informal markets and large industrial firms and supermarkets are the main culprit in encroaching and degrading the zones.

The second factor concerns land administration attributes like land tenure and cadastral boundary information. Whereas the riparian zone is public land, continued expropriation of this land into private ownership and use is a widespread phenomenon in the basin. It

appears that the perception that tenure or ownership of land in riparian zones is free land for acquisition by those who have no alternative land is deeply engrained in the public psyche about the riparian zone in the basin.

The third factor concerns lack of a common operational definition of the riparian zone that is determined by land users, professionals and policy makers. This has left these categories of actors in land use, planning, administration and policy to apply different operational definitions of riparian zones with grievous results to the ecology of these fragile riverine areas. In any case, a uniform application of 30 metres or any other smaller generic width to the zone in different situations of the basin falls short of any scientific logic.

Lastly, provision of infrastructure and services for solid and wastewater disposal systems is restricted to only a third of the city. These are mainly areas covered by formal residential and commercial development. Many other sites with developments including informal housing, garages, and informal markets lack the requisite facilities for safe waste disposal. Developments in these areas are sources of pollutants to the riparian zones ecosystems. In addition, industrial land uses have sewers but lack requisite facilities to dispose-off industrial effluents.

9.3 Theory Development

Given the foregoing, the assumption that existing policies have failed to influence conservation of riparian zones is affirmed. The three main explanations for the failures are as follows. The first one is a lack of clarity in policies that were designed to secure the zones from encroachment and degradation. At the same time, existing laws have prescribed conflicting definitions whereas policies have ignored site-specific factors including soil types and their permeability characteristics, gradient of slopes and width of the river channel. In addition, actions of land users and professionals have not helped either.

Furthermore, a weak institutional capacity and operational inefficiency has led to widespread failure to enforce laws and administrative decisions on the use of riparian zones. Location of incompatible land uses in the zones, inability to control the density of activities located in the zones and indiscriminate dumping of waste are now common practices in the use of the zones. The two reasons underlie the fact that riparian zones in Nairobi River Basin are no longer distinguished as public land or uses that serve the public purpose. Economic motives of private developers have instead taken over the zones.

The third explanation which is intertwined with the second above revolves around roles, perceptions and behaviour of land users and professionals towards riparian zones. Some land users and professionals perceive the zones to be legally acquired land because land ownership documents show that boundaries of their land extend to the centre line of the river channel. Others perceive the riparian zone to be idle or free land to be occupied and used at will because it has no claimant. Still, there are others who correctly perceive the land as public good that must be conserved and protected.

Based on the foregoing, policy and institutional, land use and biophysical attributes as well as roles, perceptions and behaviour of different non-state actors, are factors that should determine better use and management of the zones. However, the main challenges facing riparian zones are as a result of an isolated structure that lacks a common platform for integration of these main issues. The study henceforth culminates in an inductive generalization that:

Specific land use and biophysical factors should inform policy and institutional factors which should effectively guide professional and land users' roles, perceptions and behaviors resulting to integrated determination, use and management of riparian zones

9.4 Chapter Summary

The descriptive explanation of the integrated model apparently should provide the most consistent understanding of the looming problem of riparian zones in Nairobi River Basin. The last chapter that follows is on the summary of findings, conclusion and recommendations.

CHAPTER 10: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

10.0 Introduction

This is the final chapter of the study which culminates with the summary of the main findings, conclusion and recommendations. The policy implications of the conclusion and contributions of the study are also detailed in the chapter.

10.1 Summary of Findings

The main findings of the study fall within the following three categories. These are (i) weaknesses in policy and institutional framework; (ii) adverse implications of land use and biophysical factors; and (iii) conflicting roles, perceptions and behaviour of professionals and land users.

10.1.1 Influence of Policy and Institutional Framework

Weaknesses in existing policies are with respect to laws that provide for securing riparian zones through land use planning and control including land surveying. Policy prescriptions that are legislated in law provide two, six, 10 and 30 metres as minimum riparian widths. These were found to be a major weakness that undermines the essence of conservation of riparian zones.

These multiple prescriptions give wide discretion among actors who make day-to-day decisions concerning the utilization of riparian land resources. As a result, strategies geared towards the protection, conservation and enforcement of riparian zone standards are grossly undermined because of multiple public institutions with multiple mandates. The institutions rarely cooperate between themselves and have limited technical capacities. Institutions also suffer from political interference in their operations and are ineffective in terms of stopping new encroachments or evicting defilers of riparian zones.

In addition, the study established that there are no clear land administration guidelines and procedures for riparian zones. This has created room for developers of adjacent land to construct structures and conduct activities which are not compatible with long term sustainability of the physical and ecological factors of the zones. Weak land administration processes in the basin have, therefore, led to indiscriminate allocation of riparian zones that further undermines the ecological integrity of the zones.

Finally, land use planning is weak in securing the zones and the natural state of riparian vegetation and river channel. Subdivision planning specifically would be an effective tool for enforcing established widths and conditions of riparian zones, but has totally failed. Zoning and enforcement of development control regulations are the other two sets of land use planning instruments which have also failed to secure the integrity of the zones.

10.1.2 Implications of Land Use and Biophysical Factors

The study established that some urban land use and biophysical factors influence the determination, use and management of riparian zones in Nairobi River Basin.

Some land uses have led to dumping of solid waste, discharge of wastewater and industrial effluents, and removal of vegetation cover. These include formal and informal residential, formal and informal commercial, industrial, informal garages, urban agriculture and quarry mining. These land uses have led to a reduction in the width and degraded the ecological quality of riparian zones. However, public and private institutions, open recreation grounds and public parks have not encroached and degraded riparian zones.

The land uses deemed to have the most effects on riparian zones in a descending order are as follows (i) informal settlements, (ii) garages, (iii) industries, (iv) quarries, (v) informal businesses, (vi) urban agriculture, (vii) formal businesses, (viii) sewers, (ix) high income residential, (x) private institutions, (xi) open recreation spaces, (xii) public institutions, and (xiii) urban parks in that order. This order could be translated into future interventions in the protection of riparian zones.

The density of built structures is a critical factor in conservation of riparian zones. The result of high densities and spatial concentrations of settlements that are under provided with infrastructure services is dumping of solid and human waste on riparian zones. Protection of riparian zones is, therefore, not a practical imperative that is exercised to regulate and control consequences of changing land use in the river basin.

There are multiple land tenure and ownership of riparian zones in the study sites. The size and configuration of parcels of land along riverfronts do not promote desirable/optimal riparian zones. The records of survey plans and deed plans in the Department of Surveys show property boundaries as centre line of rivers. This means that the riparian zone is not properly defined in cadastral data to restrict incompatible land uses. These findings contradict government policies and laws that define riparian zones as public land.

The study results further revealed that different locations of the same river have different widths of the river. As a result, it does not warrant the application of a uniform width of the riparian zone. The results of statistical analysis using student *t-test* at 5 percent level of significance established that the observed riparian widths are less than the tested minimum widths in policies.

The result of statistical analysis of riparian vegetation cover using *Chi-square* at 5 per cent level of significance also established that there is no significant vegetation cover to secure riparian zones against adjoining land uses in the study sites. These two statistical tests confirmed that the policy and institutional variables in the study area have not significantly influenced the determination of appropriate riparian zones.

The study further established that there is significant slope variability across study sites in different rivers, in the basin. Therefore, variable and not uniform width of the riparian zone appears to be a more plausible approach in riparian width determination. The result of laboratory test of soil samples indicated that the basin has predominantly black and red clay in the 30 metre riparian zone. However, since the soils in the study sites are mainly clay with near homogenous soil permeability characteristics, soil type as a variable may not be significant in the determination of riparian widths in the basin.

In conclusion, every unit of the riparian zone has site characteristics that directly relate to natural features of the landscapes. These uses of the zone are, however, constrained in that each riparian space has a unique set of biophysical characteristics that make it suitable for some and not other types of land use.

10.1.3 Roles, Perceptions and Behaviour of Professionals and Land Users

Professionals as well as public and private land users have not played their respective roles of ameliorating continued indiscriminate invasion and ecological deterioration of riparian zones in the study sites. It was established that professionals and land users in the basin have very limited roles or none at all in securing riparian zones.

Professionals are caught between implementing ecologically functional boundaries of riparian zones against weak policy and institutional framework on the one hand. In addition, they are under pressure to accommodate and allow indiscriminate invasion of the zone by a galaxy of incompatible urban land uses. Apparently, professionals have given into the latter.

Land users have also abused riparian zone because their perceptions of the zones as free and idle land that has no assigned “ownership” pervades the society in Nairobi River Basin. This is further compounded by multiple land tenure and uses including dumping of solid and wastewater as well as discharge of industrial effluents. It is also affected by very high land use densities that have been allowed in riparian zones.

10.1.4 Integrated model for determination, use and management of riparian zones

The study established that there is an isolated structure that lacks a common platform for integration of the main factors inherent in the conservation of riparian zones. The integrated model developed in the study would, provide a better opportunity for proper and holistic determination, use and management of riparian zones in relation to their underlying spatial and non-spatial factors.

10.2 Conclusion

From the summary of findings, the study concludes that there is improper determination, use and management of riparian zones in Nairobi River Basin. Following this, the areas that physically and ecologically ought to be riparian zones, are encroached and degraded by urban land uses. Based on the main findings of the study, the following specific conclusions are made:

- 1 Existing policies and laws have not influenced proper determination, use and management of riparian zones in the study area.
- 2 Existing institutions have also not influenced proper determination, use and management of riparian zones in the basin.
- 3 Some urban land use and biophysical factors influence the determination, use and management of riparian zones in Nairobi River Basin.
- 4 Roles of professionals are weak and ineffective while perceptions and behaviour of land users towards riparian zones adversely affect rather than secure the zones. This has undermined effective determination, use and management of riparian zones.
- 5 Sectoral approaches to the determination, use and management of riparian zones are not effective models for sustainable riparian zones and instead, an integrated approach to conservation of riparian zones offers more effective alternatives.

The implications of the five conclusions are that riparian zones in Nairobi River Basin are under serious threat from encroachment and degradation by urban land uses.

A weak policy and institutional framework have undermined resolute determination, use and management of riparian zones. Provisions for determination, use and management of riparian zones as stipulated in Agriculture Act, Survey Act, Physical Planning Act and Water Resources Management Rules of 2007 prescribe contradicting actions in the conservation of riparian zones. The laws and policies require urgent harmonization.

Institutions have unnecessary overlap of functions and mandates; they rarely cooperate between themselves, and have limited technical capacities. The institutions also suffer from political interference in their operations and are ineffective in terms of stopping more encroachment and degradation of riparian zones.

Some urban land uses have encroached and degraded riparian zones adversely affecting their functional properties. High land use densities adjoining riparian zones without concomitant solid and wastewater disposal systems have led to pollution and degradation of the zones. Land tenure and cadastral data, widths of rivers, riparian width and vegetation cover, slopes and soils are the other factors that influence the determination of riparian zones.

As a result, multiple and competing land uses and land tenure that have conflicting claims on riparian zones are converting these ecologically fragile riverine lands into highly degraded urban landscapes. Riparian zones should offer better spaces for recreation and conservation amid built up urban neighbourhoods as represented in the logical framework shown in Appendix eight.

Other challenges facing effective determination, use and management of riparian zones without risks of degradation are ineffective urban land administration and land use planning. These implications call for designing of better criteria for determining land use types that should be permitted in riparian zones. It also helps to determine those that should have limited presence and those that should be entirely excluded. Guidelines to be used in the reconstruction of degraded sections of the zones as well as creating up the database for Nairobi River and its tributaries should also be formulated.

Another implication from the conclusions is that participation of professionals and land users in effective determination, use and management of riparian zones are necessary and inescapable for sustainable zones. In addition, the use of four different fixed minimum widths of 2 metre, 6 metre, 10 metre and 30 metre at the discretion of different professionals to determine the width of the zone distorts the functions of the zones that least promotes their ecological sustainability.

Instead, the practice should be the establishment of variable riparian zone areas and boundaries that reflect the changing profile of the river valley and channel. Both awareness through public education and effective enforcement of zoning and development control, rules and regulations would secure sustainability of riparian zones.

These implications from conclusions question the existing spirit of planning theory and practice. The theory and practice have failed to secure a functional riparian zone in connection to boundaries that prevent encroachment by urban development and create conditions for resilient vegetation cover. The role of planners as custodians of public interest is grossly undermined which makes them irrelevant not only to the development planning discourses but environmental management too.

10.3 Recommendations

The study has recommended several interventions to address the identified research gaps in determination, use and management of riparian zones in Nairobi River Basin. Contributions of the study and areas for further research are also outlined.

Strategies will be implemented to support the proposed integrated model of riparian zone determination, use and management. The strategies are (i) to secure and regulate use of riparian zone; (ii) land use planning; (iii) land surveying of the zones; (iv) land registration; (v) environmental impact mitigation; and (vi) stakeholder involvement in conservation

10.3.1 Secure and Regulated Access to Riparian Zones

This strategy will focus on identification and zoning of land uses adjacent to riparian zones in the study area. It is important to maintain natural biophysical characteristic of the zone in terms of a longitudinal continuity of riparian vegetation. This strategy will, therefore, seek to conserve a belt of natural or adaptive vegetation comprising of a mix of

trees, shrubs and grass. The study should also seek to ascertain the applicability of different riparian widths that will achieve various management objectives.

In this regard, a policy to support the application of an integrated model in securing the full extent of variable riparian zone down the river valleys is recommended. The variation of the width should take into account corresponding variations of the river along its longitudinal profile while in tandem maintain its lateral spatial dimensions. This implies smaller widths in exceptionally narrow rivers, in upstream areas and wider zones of exceptional river widths down the river profile.

10.3.2 Planning and Management of Riparian Zones

The main objective of planning and managing riparian zones should be to achieve specific management goals and objectives. For this reason, where riparian zones have not been encroached and degraded, it is imperative to at least maintain the existing physical extent and ecological conditions. Secondly, in places where the zones are encroached, there should be projects and programs to recover them.

Thirdly, there should be efforts geared towards the improvement of the already degraded riparian areas to enable achievement of their ecological and socio-economic objectives. Finally, there is also need to develop riparian zones of undeveloped areas based on principles of an integrated model developed in the study.

The strategies for planning and managing the zones should be properly defined, and quantified into appropriate standards and guidelines. These should also be subsequently institutionalized into principles that form a norm in the determination, use and management of riparian zones. The outcome of such a coherent approach should be appropriate result-oriented management based on set objectives. For example, if the intended management objective of conserving the zones is to achieve adequate physical width and vegetation cover, then the zone should be monitored and assessed based on these characteristics and not on the basis of political influence and will.

It is, therefore, imperative to formulate and implement a riparian zone policy that is backed by spatial land use plans for areas or properties adjacent to the outer boundary of riparian zones, as well as the zones themselves. The plans should be prepared and made accessible to relevant public agencies, professionals and land users to form a common source of information on area/size of the zones, urban land uses permitted in the zone,

densities or spatial concentration of land use in the zones and riparian zone tenure. The plans should be the basis of development control enforcement and conservation of the zones.

10.3.3 Land Surveying

Geo-referenced riparian zone boundaries would help minimize conflicts and uncertainties with the adjoining private land. This in a way is also beneficial to property owners whose land would normally extend to the centre of the river yet, they are not allowed to develop beyond the zone.

Also, the extent of riparian zones should be secured from the high water mark, and future land administration practices should discard cadastral practices that fix property boundaries at the centre line of river channels. Geo-referenced boundaries for small streams and non-tidal rivers should be based on the principles developed in the study of the determination of riparian width and vegetation structure.

Henceforth, riparian zone procedures, standards and regulations should be formulated and implemented based on geo-referenced boundaries. Mutation surveys that are not geo-referenced indicate approximate situations as represented by approximate boundaries. These surveys would not reliably and accurately help in the identification of the actual physical extent of the zones.

This strategy should focus on enforcing cadastral surveying principles clearly to show riparian zones and parcels of land in the areas that are adjacent to the zone. In this regard, riparian zone boundaries should be geo-referenced to existing cadastral boundary coordinates.

10.3.4 Registration of Riparian Zones

This strategy seeks to have riparian zones registered like other parcels of land in respective land registers as kept by the Ministry of Lands or the National Land Commission. The goal is to secure public ownership of riparian zones. In addition, this strategy should be a source of information on the status of a particular section of the zone that is of specific interest. It is also vital to document information on changes that are implemented. Finally, the strategy should document ownership of particular parcels adjoining the riparian zones to assist in managing the encroachment of the zones.

10.3.5 Environmental Impact Mitigation on Riparian Zones

This strategy should involve carrying out periodic inspection of riparian zones to monitor intensities and location of land uses on riparian zones. Geographic information system (GIS), remote sensing or any appropriate strategies and technology should be used to monitor and evaluate ecological status of the zones. These should be conducted as part of the mitigation of environmental impacts.

10.3.6 Stakeholder Involvement in Conservation

A strategy on stakeholder involvement in conservation of riparian zones is necessary for the successful application of an integrated model. This strategy should involve implementing a programme of public education to sensitize and create awareness on ecological importance as well as socio-economic benefits of riparian zones. This will respect and uphold regulations and development control requirements on development in and adjacent to riparian zones.

The strategy should also strengthen the partnership between public agencies and bodies entrusted with the conservation of riparian zones. In addition, it should also strengthen partnerships between land users and neighbourhood communities in promoting consumptive use of the zones while in tandem, conserving and protecting the physical and ecological integrity of the zones.

10.4 Policy Implications

In this study, a generic quantitative riparian width applicable for all situations has not been determined and recommended. This is because the river profiles entail a changing biophysical and urban land use environment with varying implications to policy. Different land uses have different compatibility requirements and therefore different implications on the river ecosystem. Therefore, one uniform and static riparian zone would not be appropriate to ameliorate consequences of the nine major urban land uses in Nairobi River Basin.

It therefore requires determination of variable and functional widths on a case by case basis as dictated by various factors including implication of each land use and biophysical factors inherent in each site. However, the final adaptive quantitative measures or definitions of the zones in various sections of the river would be those negotiated by experts and other actors through a participatory approach.

It is important to appreciate that there should be a minimum distance to represent the high water mark regardless of the land use bordering the river. For example from the literature review, Ohio has determined six metres; New Jersey uses eight metres as minimum riverbank widths. In Malaysia and United Kingdom, riparian widths are determined in categories based on widths of river channels.

This distance is important to protect the flood plains or river banks. In places of the river without a defined flood plain, particularly in the V-shaped valleys, the distance should be at least equivalent to the width of the river channel to protect the riverbank from erosion. The best approach to the determination of requisite widths and conditions of the zones would be through involvement of different experts including scientists, biologists, hydro-geologists, planners and surveyors among others.

10.4.1 Methodology for Conservation of Riparian Zones

The study is recommending the integrated model as an entry point to conservation of riparian zones. Principles developed in the study underlie a universal way of ensuring functional riparian zones. Site-specific analysis and area-wide zonal planning should be the main approaches. It is important to ensure harmony and compatibility of land use. Topographical mapping and delimitation of boundaries as well as assessment of the river flow regimes to assist in the establishment of the high water mark is equally important. As a result, appropriate ecological standards such as vegetation should be set.

The final widths and conditions depicted in land use plans should form the basis of whether or not to approve development beyond predetermined boundary limits. This will only be possible if the riparian zone boundaries are in the same coordinate system as the cadastral boundaries. Such a system would enable detection of physical developments and activities that extend way into the prescribed riparian zones.

10.4.2 The Dilemma

Many urban areas and cities in Kenya are located next to water courses and stationary water bodies. Historically, rivers were sources of water supply and will continue to attract more urban communities. The question is what will happen to all rivers and, therefore, the water needs of Kenyans in terms of quality and quantity in 50 years to come? On a lighter note "*We should cut this suit according to the size and needs of the wearer.*" The suit is

the width and condition of a voiceless, dying riparian ecosystem. The riparian zone should live ceaselessly to provide insensitive mankind with a lifeline.

Conservation is surely proper definition of the riparian zone followed by proper determination, use and management. Everyone is warned that if one messes around with “*Mother Nature*”, she is very unforgiving. Wise stewardship of riparian zones is a sure way of protecting the river ecosystem and the neighbouring communities.

10.5 Contribution of the Study

The study has restricted its research scope to the determination, use and management of riparian zones. There are important areas in Nairobi River Basin which have over time undergone ecological and physical changes due to unregulated and unplanned invasion by human activities: both formal and informal. These invasions reflect the ferociousness of environmental degradation in these important urban landscapes.

Through literature review and analysis of secondary and primary data on an array of land uses (both formal and informal) that have located on riparian zones on selected sites of Nairobi, Ngong, Mathare, Kirichwa Kubwa Rivers and Kibagare stream, the study has demonstrated that indeed, riparian zones in Nairobi River Basin are highly encroached and degraded which has undermined ecological sustainability of these important zones. Also, the zone has limited recreational and economic values to communities who live next to them.

Pointedly, the study has established that planning theory and indeed planning practice are not relevant and effective to ameliorate continued encroachment and degradation of riparian zones in the basin. At the same time, land use planning, land administration, land surveying as well as environmental surveillance by public agencies have failed to secure riparian zones areas as distinct and sustainable land uses.

Development planning and land surveying in particular have taken place with no strict guidelines on the size or extent of riparian zones. Therefore, many permutations of riparian widths based on different minimum and maximum prescriptions in policies and laws are implemented by planners and used by environmentalists to assess encroachment and degradation thereby compounding the problem of a unified professional and expert solution.

This state of affair hinders formulation of one set of guidelines that would be applied by professionals, policy makers and land users in the determination, use and management of riparian zones. In this regard, the study has developed an integrated model and its operational strategies and assumptions as an ultimate solution to these problems.

10.6 Areas for Further Research

Further research is suggested in the following areas to build on the contribution of the study:

1. Empirical research is recommended to establish optimum riparian widths that would apply to different land use and biophysical factors in urban areas;
2. The study found out that vegetation cover is necessary for conservation of riparian zones. A study to determine localized plant species (trees, shrubs and grass) that are adaptive or suitable for lost riparian zones is recommended;
3. A study that focuses on modeling on riparian zones in order to generate a predictive model for the relationship between riparian zones and their underlying factors established in this study is recommended. A predictive model would provide specific contribution of every variable to the problem of riparian zones.; and
4. It is finally recommended that a study that focuses on the relationship between demand of land for urban development at sites adjacent to the zones and within the zones proper give more insights into types of policy measures that would be implemented to curtail land speculation at the zones and adjacent land uses. This would go a long way in supporting land administration and management processes and procedures.

REFERENCES

- American Psychological Association. (2010). *Publication Manual of the American Psychological Association*. (4th ed.). Washington, DC: Author
- Australian Natural Resource Atlas. (1997). *National land and water resources Audit, Australia 1997-2002*.
- Ayonga, N. J. (2008). “*Land use conflicts and in-optimal spatial patterns in peri-urban areas of the city of Nairobi, Kenya*”. Unpublished PhD thesis, University of Nairobi.
- Baumol, W.J. (1983), Toward operational models of entrepreneurship. In Ronen, J. (ed.). *Entrepreneurship*. Lexington Books, Lexington, MA.
- Booth D. B., Karr J. R., Schauman, S., Konrad, C. P., Morley, S. A., Larson, M. G., & Burges, S.J. (2004). *Reviving urban streams: Land use, hydrology, biology, and human behavior*.
- Brian, A. (2008). *Social research methods*. USA, New York: Oxford University Press.
- Briassoulis, H. (2001). *Analysis of land use change: Theoretical and modeling approaches*. Regional Research Institute, West Virginia University, USA.
- Broadmeadow, S. & Nisbet, T.R. (2004). *Effects of riparian forest management on the fresh water environment: Review of best management practice*. UK.
- Castelle, A.J. & Johnson, A.W. (2000). Riparian vegetation effectiveness. *National Council for Air and Stream Improvement, Research Triangle*. Technical Bulletin No. 799. Park, NC, USA.
- Castelle, A.J., Johnson, A.W., & Connolly, C. (1994). Wetland and stream buffer size requirements: A review. *Journal of Environmental Quality*, USA.
- Catanese, A.J., & Snyder, J.C. (1979). *Introduction to urban planning*. USA: McGraw-Hill Book Company Ltd.
- Catanese, A.J., & Snyder, J.C. (1988). *Urban planning* (2nd ed.). New York: McGraw-Hill Book Co. Ltd.
- City Council of Nairobi. (2007). *Nairobi environmental outlook*: Nairobi: Government Printers.
- City of San Diego General plan. (2008). *Mayor Jerry Sanders city planning and community investments*. Retrieved from www.sandiego.gov. Resolution No. R-303473.
- Coastal Environmental Services. (1994). *Development of a riparian buffer zone*. Developed for Montgomery Township Environmental Commission. Princeton, New Jersey.
- Collier, K.J., Cooper, A.B., Davies, R.J., Rutherford, C.J.C., Smith, C.M., & Williamson, R.B. (1995). *Managing riparian zones: A contribution to protecting New Zealand's rivers and streams*. Vol.1 Concepts, July 1995.
- Comerford, N., Mansell, R., & Neary, D. (1992). *The effectiveness of buffer strips for ameliorating offsite transport of sediment, nutrients, and pesticides from silvicultural operation*. NCASI Tech. Bull. No. 631.

- Connecticut River Joint Commissions. (2000). *Introduction to Riparian Buffers: Living with the River*. Series No. 1. Charleston, NH. <http://www.crjc.org/>
- Department of Resource Surveys and Remote Sensing. (2003). *Quickbird satellite image of 2003*.
- Department of Resource Surveys and Remote Sensing. (2008). *Quickbird satellite image of 2008*.
- Dimas, S., & Gabriel, S. (2008). *The Economics of Ecosystems and Biodiversity*. Interim Report of the European Communities, Cambridge, UK.
- Dosskey, M., Shultz, D., & Isenhardt, T. (1997). *Riparian Buffers for Agricultural Land*: (<http://digitalcommons.unl.edu/agroforest/notes/2/>). Agroforestry notes, No.3, January 1997. National Agro forestry centre, USDA Forest service, Lincoln, NE.
- Enger, E.D., & Smith, B. F. (2000). *Environmental science: A study of interrelationships*. (7th ed.). Western Washington University, USA: McGraw-Hill Higher Education.
- Faille, D.D. (2009). "Development and underdevelopment: A critical examination of contemporary theories". (Unpublished).
- Faludi, A. (1973). *Planning theory*. Oxford: Pergamon Press.
- Friedman, J. (1987). *Planning in the public domain: From knowledge to action*. New Jersey: Princeton University Press.
- Frietag, A., McGinley, M., & Tollner, E. (2008). Riparian Zone. (Retrieved http://www.eoearth.org/article/riparian_zone on 23/4/2010 at 6.02pm).
- Fualling, D. (2009). *Riparian ecosystem management: A case study of the Ellidaa' and Ytri-Ranga rivers in Iceland*. Land Restoration Training Programmen, Keldnaholt, 112 Reykjavik, Iceland
- Garson, D. (2008). Institutional theory. (Retrieved from <http://faculty.chass.ncsu.edu> on 19th March 2010 at 8.59 p.m.)
- Gonzalez del Tanago, M. & Garcia de Jalon, D. (2006). Attributes for assessing the environmental quality of riparian zones. *The ecology of the Iberian inland waters: Homage to Ramon Margalef: Asociacion Espanola d Limnologia*, Madrid, Spain, ISSN: 0213-8409. E.T.S Ingenieros de Montes Universidad Politecnica de Madrid.
- Gosling, D., & Maitland, B. (1984). Urbanism London: In *Architectural Design Publications*. (ed.). Concepts of urban design. London: Academy.
- Gray, D.E. (2004). *Doing research in the real world*. London: SAGE Publications Ltd.
- Groffman, P. M., Bain, D.J., Band, L. E., Belt, K.T., Brush, G.S., Grove, J. M., Pouyat, R. V., Yesilonis, I. C., & Zipperer, W. C. (2003). Down by the Riverside: Urban Riparian Ecology. *The Ecological Society of America*. (Retrieved from www.frontiersin ecology.org on 10th August 2010 at 11.00am)
- Guthiga, P., & Makathimo, M. (2010). "Land use policies and natural resources management in Kenya: The case of Nairobi River Basin". (Unpublished).

- Hall, P. (2002). *Urban and regional planning* (4th ed.). London: Routledge.
- Hanna, K.S., & Slocombe, D.S. (eds.) (2007). *Integrated resource and environmental management: Concepts and practice*. Toronto: Oxford University Press.
- Hawe, E., & Smith, M. (2005). *Riparian buffer zones: Functions and recommended widths*. Yale School of Forestry and Environmental Studies for the Eightmile River Wild and Scenic Study Committee.
- Haycock, N.E., & Pinay, G. (1993). Groundwater nitrate dynamics in grass and popular vegetated riparian buffer strips during the winter. *Journal of Environmental quality*.
- Home, R. (2004). Partnership, processes, and planning in estuary management: The case of the lower Thames. In Deakin, M., Dixon-Gough, and Mansberger, R. (2004) (eds.): *Methodologies, models and instruments for rural and urban land management*. England: Ashgate Publishing limited.
- Hubbard, R. K., & Lawrence, R.R. (1994). Riparian forest buffer system research at the Coastal Plain Experiment Station. *Water, Air Soil Pollution*, 77, 409-432.
- Institution of Surveyors of Kenya. (2006). "Practicing guidelines for non-title surveys". Unpublished practising manual. Nairobi.
- Kahara, S.N. (2002). *Characterizing anthropogenic sources of pollution for tropical urban river management: A proposed case study of the Nairobi River Basin*. Project Advisor (Monitoring and Assessment), Nairobi River Basin Project. Nairobi, Kenya.
- Kajoba, G.M. (2009). *Land use and land tenure in Africa: Towards an evolutionary conceptual framework*. Curso de Africa, 25th February, 2009, University of Zambia.
- Kamau, P.K. (2005). Factors that affect self-build housing in Nairobi, Kenya. Published PhD dissertation, University of Tsukuba.
- Kaplan, M. (ed.) (2004). *The rivers of Israel: Policy and planning principle*. Ministry of the Environment, State of Israel.
- Karisa, C. (2010). "A negotiated framework for rehabilitation of riparian zones in Nairobi city: the case of Mathare river valley". Paper presented at the 46th ISOCARP Congress held in Nairobi.
- Karisa, C.D. (2002). "A conservation ethic for sustainable urban communities: Southern Nairobi Integrated River Basin Management Strategy". Unpublished MA in Planning thesis. University of Nairobi.
- Kaufmann, J. (2008). The boundary concept: Land management opportunities for sustainable development provided by the cadastre 2014 approach. Integrating Generations, *FIG Working Week 2008, Stockholm, Sweden*, 14th -19th June 2008.
- Kenwick, R.A., Shammin, R., & Sullivan, W.C. (2009). Preferences for riparian buffers. *Landscape and Urban Planning Journal*. 91 (2009)88-96, Elsevier B. V, USA.
- Kenya Land Alliance. (2002). *Land use in Kenya: The case for National Land Use Policy*. Land Reform Vol.3.Nakuru: Printfast Kenya Limited.

- Kenya Republic of. (1966). *National development plan 1966/70*. Nairobi: Government Printer.
- Kenya Republic of. (1972). *Kenya's national report to the United Nations on the human environment*. Nairobi: Government Printer.
- Kenya Republic of. (1965a). *African socialism and its application to planning in Kenya*. Nairobi: Government Printer.
- Kenya Republic of. (1965b). *Agriculture Act: Basic management rules*. Nairobi: Government Printer.
- Kenya Republic of. (1974). *National development plan, 1974/79*. Nairobi: Government Printer.
- Kenya Republic of. (1979). *National development plan, 1979/83*. Nairobi: Government Printer.
- Kenya, Government of. (1961). *Survey Act: Cap. 299 laws of Kenya (revised Edition 1989)*. Nairobi: Government Printer.
- Kenya, Government of. (1963). *Registered Land Act: Cap. 300 laws of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (1978). *Human settlements in Kenya: A strategy for urban and rural development*. Physical Planning Department, Ministry of Lands and settlements.
- Kenya, Republic of. (1982). *Registration of Titles Act: Cap 281, laws of Kenya (Revised Edition)*. Nairobi: Government Printer.
- Kenya, Republic of. (1984a). *Government Land Act: Cap 280, laws of Kenya (Revised Edition)*. Nairobi: Government Printer.
- Kenya, Republic of. (1984b). *National development plan, 1984/88*. Nairobi: Government Printer.
- Kenya, Republic of. (1986a). *Agriculture Act: Cap.381, laws of Kenya (revised Edition)*. Nairobi: Government Printer.
- Kenya, Republic of. (1986b). *Public Health Act: Cap.242, laws of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (1989). *National development plan, 1989/93*. Nairobi: Government Printer.
- Kenya, Republic of. (1991). *Handbook on land use planning, Administration and development procedures*. Ministry of Lands and Housing, Nairobi.
- Kenya, Republic of (1994). *National development plan, 1994/96*. Nairobi: Government Printer.
- Kenya, Republic of. (1996). *Physical Planning Act: Cap 286 laws of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (1997). *National development plan, 1997/2001*. Nairobi: Government Printer.

- Kenya, Republic of. (1998a). *Local Government Act: Cap. 265 laws of Kenya (revised Edition)*. Nairobi: Government Printer.
- Kenya, Republic of. (1998b). *The Physical Planning Act: Legal notice No. 140 of 13th July 1998 rule 15(c)*. Nairobi: Government Printer.
- Kenya, Republic of. (1999a). *National poverty eradication plan, 1999-2015*. Office of the President, Department of Development Co-ordination. Nairobi: Government Printer.
- Kenya, Republic of. (1999b). *Environmental Management and Coordination Act: Laws of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (2002a). *Water Act 2002: Laws of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (2002b). *Report of the commission of inquiry into the land law system of Kenya on principles of a national land policy and new institutional framework for land administration*. Njonjo Report of 20th November 2002. Nairobi: Government Printer.
- Kenya, Republic of. (2003). *Economic recovery strategy for wealth and employment creation 2003-2007*. Ministry of Planning and National Development.
- Kenya, Republic of (2004). Report of the commission of inquiry into the illegal/irregular allocation of public land. Ndung'u Report of June, 2004. Nairobi: Government Printer.
- Kenya, Republic of. (2007a). *Kenya Vision 2030*. Nairobi: Government Printer.
- Kenya, Republic of (2007b). *Water resources management rules*. Nairobi: Government Printer.
- Kenya, Republic of. (2008). "Physical planning hand book". Unpublished report of the Department of Physical Planning. Ministry of Lands. Nairobi
- Kenya, Republic of. (2009a). *Environmental management and coordination (wetlands, river banks, lake shores and sea shore management regulations)*. Legal notice No. 19 of 13th February, 2009. Nairobi: Government Printer.
- Kenya, Republic of. (2009b). *National Land Policy*. Nairobi: Government Printer.
- Kenya, Republic of. (2010a). *Constitution of Kenya*. Nairobi: Government Printer.
- Kenya, Republic of. (2010b). *Kenya population and housing census: A population distribution by administrative units*. Kenya National Bureau of Statistics, Vol. 1. Nairobi, Kenya.
- Kenya, Republic of. (2011a). "Environmental concerns in cities and urban areas". Paper presented at World Town Planning day. Ministry of Environment and Natural Resources. 8th November, 2011, Kenyatta International Conference Centre, Nairobi, Kenya.
- Kenya, Republic of (2011b). *Urban Areas and Cities Act, 2011*. Kenya Gazette supplements No.99 (Acts No.13). Nairobi: Government Printer.
- Kenya, Republic of. (2012a). *Land Registration Act No.3 of 2012*. Kenya Gazette supplements No.33. Nairobi: Government Printer.

- Kenya, Republic of. (2012b). *National Land Commission Act No.5 of 2012*. Kenya Gazette supplements No.187. Nairobi: Government Printer.
- Kenya, Republic of. (2012c). County Government Act No.17 of 2012. Kenya Gazette supplements. Nairobi: Government Printer.
- Kenya, Republic of. (2012d). *Land Act of 2012*. Kenya Gazette. Nairobi: Government Printer.
- Kiamba, C.M. (1986). "The role of the state in the control of urban development: Urban land policy for Nairobi, Kenya". Unpublished PhD dissertation, Department of Land Economy. University of Cambridge.
- Kihagi, J. K. (2000). "Land use changes in the lake Nakuru catchment". Unpublished MA thesis in Planning. University of Nairobi.
- Kimani, J.N., Ojwala, M.A., Kibet, R.S., Anne, S., & Juma, E. (2009). "Rehabilitation and restoration of Nairobi Rivers Basin: Riparian reserve population census and structures survey". Unpublished report. Department of Resource Surveys and Remote Sensing (DRSRS). Ministry of Environment and Mineral Resources, Nairobi.
- Kingoriah, G.K. (1980). "Policy impacts on urban land use patterns in Nairobi, Kenya". Unpublished PhD dissertation. Indiana State University, Terra Haute.
- Kithiia, S.K., & Ongwenyi, G.S. (1997). "Some problems of water quality degradation in the Nairobi River sub-basins in Kenya". Paper presented at Fresh Water Contamination Proceedings of Rabat Symposium, S4, April-May 1997.
- Kothari, C.K. (2004). *Research methodology: Methods and techniques*. (2nd ed.). New Delhi: New Age International (P) Ltd. Publishers.
- Kothari, C.K. (2008). *Research methodology: Methods and techniques* (2nd Revised ed.). New Delhi: New Age International (P) Ltd. Publishers.
- Kretschmer, B., Delzeit, R., Gömann, H., Holm-Müller, K., Kreins, P, Münch, J. A., & Sonja, P. (2010). *Analyzing bio-energy and land use competition in a coupled modeling system: The Role of bio-energy in renewable energy policy in Germany*. Kiel Institute for World Economy.
- Lee, P., Symth, C., & Boutin, S. (2004). Quantitative review of riparian buffer width guidelines from Canada and the United States. *Journal of Environmental Management*, 70(2004) 165-180.
- Lehigh Valley Planning Commission. (2011). *Lehigh Valley Hazard Mitigation Plan*. Pennsylvania.
- Lelo, F.K., Chiuri, W., and Jenkins, M.W. (2005). "Managing, the river Njoro watershed, Kenya: Conflicting Laws, Legislations and Community Priorities". Paper presented at the *International Workshop on African water laws*. Plural Legislative Frameworks for Rural Water Management in Africa. Johannesburg, South Africa.
- Letsinger, S.L. (2004). *Evaluation of riparian buffer zones using GIS and remote sensing to target watershed restoration efforts*. Indiana Geological Survey and Young's creek watershed in Johnson County, Indiana.

- Leys, C. (1975). *Under-development in Kenya: The political economy of neo-colonialism*. Nairobi: East African Educational Publishers Ltd.
- Life Application Study Bible. (1986). New Living Translation (2nd ed.). Carol Stream, Illinois: Tyndale House Publishers Inc.
- Lowrance, R. (1998). Riparian forest ecosystems as filters for non-point source pollution. In Pace, M.L., and Groffman, P. (Eds.). *Success, limitations and frontiers in ecosystem science*. New York: Springer-Verlag.
- Lowrance, R., Leonard, R., & Sheridan, J. (1985). Managing riparian ecosystems to control nonpoint pollution. *Journal of Soil and Water Conservation*. 40(1) 87-91.
- Maipose, G.S. (2003). Economic development and the role of the state in Botswana. *DPMN Bulletin*: Vol. X, Number 2, April 2003.
- Malaysia Ministry of Natural Resources and Environment. (2009). *Managing biodiversity in the riparian zone*. Best Practice Series.
- Maryland Cooperative Extension. (1998). *Riparian forest buffer design: Establishment and maintenance*. University of Maryland.
- Matrix Development Consultants. (1993). *Nairobi's Informal Settlements: An inventory of Nairobi*. Housing and Urban Development Programmes, USAID.
- Mayer, P.M., Reynolds Jr., S.K., Canfield, T.J., & McCutchen, M.D. (2005). *Riparian buffer width vegetation cover and Nitrogen removal effectiveness: A Review of current Science and Regulations*. United States Environmental protection Agency, Oklahoma.
- Mbogua, J.P., & Ng'ang'a, A.J. (1973). *Nairobi Metropolitan Growth Strategy*, Volume one-Main Report. The Nairobi Urban Study Group, Nairobi.
- Mbui, D., Orata, D. O. and Kariuki, D. (2010). "Physico-chemical assessment of pollutants in Ngong River". Unpublished research paper. Department of Chemistry. University of Nairobi (unpublished).
- Mburu, E.W. (2007). "A land use framework for solid waste management at the Nairobi riverfront corridor between Globe Cinema and Racecourse Roundabouts". Unpublished Planning and Development Project for the BA in Urban and Regional Planning. University of Nairobi.
- McAuslin, P. (1980). *The ideologies of planning law*. Great Britain: Biddles Ltd.
- McLoughlin, J.B. (1969). *Urban and regional planning: A systems approach*. 3 Queen Square, London: Faber and Faber.
- McNeely, Jeffrey A., & Scheer, Sara J. (2001). Reconciling agriculture and biodiversity: Policy and research challenges of 'eco-agriculture'. *World Summit on Sustainable Development, 2002*.
- Menya, A. (2008). "Challenges facing riparian use and management in Mukuru Kwa Reuben, Nairobi". Unpublished Research Project for the BA in Urban and Regional Planning. University of Nairobi.

- Mitchell, R.J., Schulte, L.A., Hunter Jr., M.L., Franklin, J.F., McIntyre, R.K., & Palik, B.J. (2009). Conservation theory and forest management: Foundation, utility and research needs. (Retrieved from www.earth-forum.com, www.nrem.iastate.edu on 27th January, 2012 at 1.55p.m.)
- Mitullah, W. (2002). "Urban slums reports: The case of Nairobi, Kenya". Unpublished report. University of Nairobi (Retrieved from wvmitullah@swiftkenya.com on 27th January, 2012 at 3.00 pm)
- Modubu, R.J. (2009). *Private enterprise versus public enterprise theory*. In Chapter 2, Vickers and Yarrow (1989:15).
- Mugenda, A.G. (2009). *Social science research: Theory and principles*. Nairobi: ARTS Press.
- Mugenda, O.M., & Mugenda, A.G. (1998). *Research methods: Quantitative and qualitative approaches*. Nairobi: ARTS Press.
- Muketha, S.M. (2007). "Planning for sustainable water supply and sanitation infrastructure at the suburbs: A case study of Ngundu informal settlement in Nairobi, Kenya". Unpublished MA thesis in Planning. University of Nairobi.
- Murphy, B.D. (2000). *Utilization of 100 foot buffer zones to protect riparian areas in Connecticut*. Inland Fisheries Division.
- Mwangi, I.K. (1994). "Urban land development and planning law in Kenya: The case of Nairobi city and bordering urban areas". Unpublished PhD dissertation. University of Waterloo, Canada.
- Mwangi, I.K. (2006). Planning in Kenya on the brink of precipice. Nairobi: *Planning Issues Journal*. Nairobi, Kenya.
- Mwangi, W. (2008). Performance evaluation of land administration systems in Kenya, Africa Habitat review 2 (2008)81-90. *Journal of school of the built environment*. University of Nairobi
- Nairobi City Council. (1998). *Nairobi Master Plan for Sewer, Sanitation and Drainage*. Third Nairobi Water Supply Project.
- Nairobi River Basin Programme. (1999). *Save the Nairobi River*. Nairobi River Basin Programme; Nairobi: UNEP/ROA http://unep.org/roa/Nairobi_River/Webpages/
- Nairobi River Basin Programme. (2009). *Nairobi River Basin Programme, Phase III*. Resource Booklet on pollution monitoring activities. NETWAS, IUCN & UNEP
- Natta, A.K., Sinsin, B., and Van der Maesen, L.J.G. (2003). "Riparian forests and biodiversity in Benin, West Africa". A paper submitted to the XII World Forestry Congress, Quebec City, Canada
- New Jersey Department of Environmental protection. (2008). *Riparian zone model ordinance*. New Jersey, USA.
- Njogu, J.G., and Dietz, T. (2006). "Land use and tenure: entitlement rights for community-based wildlife and forest conservation in Taita Taveta, Kenya". *IDS working paper No. 542*. University of Nairobi.

- Nzau, B. M. (2003). "Modeling the influence of urban sub-centres on spatial and temporal land value patterns: Case study of Nairobi, Kenya". Unpublished Msc. thesis. ITC, Enschede, the Netherlands.
- Obudho R.A. and Aduwo. (1988). "The role of Nairobi in spatial planning in Kenya: Towards a planning alternative". *First International Conference on Urban Growth and Spatial Planning of Nairobi*.
- Obudho. R.A. (1997). Nairobi national capital and regional hub. In Carole Rakodi (ed.). *The urban challenge in Africa growth and management of its large cities*. United Nations University, New York:
- Ochola, S.A. (2007). *Leadership and economic crisis in Africa*. Kenya, Nairobi: Literature Bureau.
- Odero, K.K. (1997). "The direct and indirect effects of road quality improvement: A study of fertilizer use and potato yield in Kinangop Division, Nyandarua District, Kenya". Unpublished PhD thesis. University of Nairobi.
- Ohio Department of Natural Resources. (2006). *Rainwater and Land Development Manual* Ohio, USA.
- Okidi, C.O., Kameri-Mbote, P., and Akech, M. (2008). *Environmental governance in Kenya: Implementing the framework law*. Centre for Advanced studies in Environmental Law and Policy. Kenya, Nairobi: East African Educational Publishers Ltd.
- Okoth-Ogendo, H. W. O. (1999). "Land policy development in East Africa: A survey of recent trends". A paper presented in the "Land Rights and Sustainable Development in Sub-Saharan Africa" Workshop held at Sunnigdale Park Conference Centre, Berkshire England. 16th-19th February, 1999.
- Okpala, D. (2000). "Geomaticians' Role in Environmental Management. Paper presented to the Institution of Surveyors of Kenya, Land Surveyors Chapter. Nairobi, Kenya.
- Olago and Aketch. (2000). "Pollution assessment in Nairobi River Basin". *Pollution assessment report of the Nairobi River Basin*. Africa Water Network.
- Opiyo-Aketch and Kibe. (2000). "Mapping of the Nairobi River Basin. Report of the Nairobi River Basin". Africa Water Network
- Oso, W.Y and Onen, D. (2009). *A general guide to writing research proposal and report: A handbook for beginning researchers*. Nairobi: Jomo Kenyatta Foundation.
- Oxford Advanced Learner's Dictionary. (2010). *International student's edition* (New 8th ed.). New York: Oxford University Press.
- Palik, B., Tang, S.M., & Chavez, Q. (2004). *Estimating riparian area extent and land use in the Midwest*. General Technical Report, NC-248. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.28 pp.
- Paris, C. (1982). *Critical readings in planning theory*. Oxford: Pergamon Press
- Phillips. J.D. (1989). Nonpoint source pollution control effectiveness of riparian forests along a coastal plain river. *Journal of Hydrology.*, 110 221-237

- Pinay, G., Roques, L., and Fabre, A., (1993). Spatial and temporal patterns of denitrification in a riparian forest. *Journal of Applied Ecology*, 30. 581-591
- Postel, S. (1992). *Last oasis: facing water scarcity*. New York: Norton WW.
- Price, P, Lovett, S and Lovett, J. (2004). *Managing riparian widths*. Fact Sheet 12; Canberra: Land and Water Australia
- Punch, K.F. (2005). *Introduction to social research: Quantitative and qualitative approaches* Great Britain: SAGE publications ltd.
- Rapoport, A. (1977). *Human aspects of urban form: Towards a man-environment approach to urban form and design*. Oxford: Pergamon Press.
- Saint-Laurent Vision. (2000). *The contribution of urban activities to the deterioration of the St. Lawrence River*. Quebec, Canada.
- Saleemi, N.A. (2009). *Systems theory and management information systems simplified* (2nd ed.). Nairobi: Saleemi Publications Ltd.
- Sedogo, L.G. (2002). "Integration of local participatory and regional planning for resource management using remote sensing and GIS". Unpublished PhD thesis. ITC, the Netherlands.
- Smith, S.E. (2010). *What is a riparian zone?* Conjecture Corporation. (Retrieved from <http://www.wisegeek.com> on 23/4/2010 at 6.04 pm).
- Smith, B., & Prichard, D. (1992). *Riparian area management: Management techniques in riparian areas*. U.S. Department of the Interior Bureau of Land Management Services Centre: Denver
- State of Victoria, Department of Natural Resources and Environment. (2002): *Managing riparian zone*. (Retrieved from www.nre.vic.gov.au/vrhs on 23/4/2010 at 7.15 pm)
- Superior Watershed Partnership (2003) .*A model riparian buffer implementation plan*. Upper Peninsula of Michigan, July, 2003. A Simple Low-cost Great Lakes protection Tool.
- Swift, D. W., and Norton, R. L. (1993). "Measures for protecting upland water quality: assessment of forestry buffer strips". Final R and D report to the Scotland & Northern Ireland Forum for Environmental Research (SNIFFER) under contract SR3442/1. SNIFFER, Edinburg, UK.
- Terragis (2012). "LiDar mapping data for the City Council of Nairobi".
- Thomas, H., & Healey, P. (1991). *Dilemmas of planning practice, ethics, legitimacy and the validation of knowledge*. Alderhot: Avebury Technical.
- Thornton White, L.W., Silberman, L. & Anderson, P. R. (1948). "Nairobi Master Plan for a colonial capital". A report prepared for the Municipal Council of Nairobi. His Majesty's Stationery Office, 1948, London
- University of California Berkeley, University of Nairobi, & Pamoja Trust. (2009). "Collaborative Slum Planning and Upgrading". Unpublished planning report.

- United Nations. (1976). *Report of Habitat: United Nations Conference on Human Settlements*. Vancouver, Canada p.70.
- United Nations. (1992). *United Nations Conference on Environment and Development*. Rio de Janeiro, Brazil (June 3-14 1992).
- United Nations. (1996a). *Land administration guidelines (with special reference to countries in transition)*. United Nations publication, Sales No E.96. II.E.7 ISBN 92-1-116644-6
- United Nations. (1996b). *Bogor Declaration*. United Nations Interregional Meeting of Experts on the Cadastre Bogor, Indonesia
- United Nations. (2006). *The Ramsar Convention Manual: A guide to the convention on wetlands. Ramsar, Iran, 1971* (4th ed.). Gland, Switzerland: Ramsar Convention Secretariat.
- UN-HABITAT. (2003). *The challenges of slums: Global report on human settlements*. London: Earth Scan Publications Ltd.
- UN-HABITAT. (2005). *A Guidebook for local catchment management in cities*. United Nations Human Settlement Programme, Nairobi.
- UN-HABITAT. (2009). *Planning sustainable cities*. Global report on human settlements. United Nations Human Settlement Programme. London: Earth Scan Publications Ltd.
- Vannote, R.L, Min shall, G.W., Cummins, K.W., Sedell, J.R., & Cushing, C.E. (1980). The river continuum concept; *Canadian journal of fisheries and aquatic sciences* 37:130-137.
- Verburg, P.H., Van Berkel, D., Valbuena, D., & Willemsen, L. (2010). *Modeling the influence of land use and land cover change on landscape functions*. Institute for Environmental Studies, VU University Amsterdam, The Netherlands.
- Wanyande, P. (1981). "Management and role of public enterprises in the socio-economic development of the Kenya Tea Development Authority". Unpublished MA thesis. University of Nairobi.
- Water and Rivers Commission (2000). *Water notes for wetland management: Advisory notes for land managers on river and wetland restoration*. Government of Australia and Natural Heritage Trust.
- Williamson, I.P. (2000). "Best practices for land administration systems in developing Countries". *International Conference on Land Policy Reform*. Jakarta 25-27 July 2000, LAP-C Project.
- Wilson, A.G. (1968). "Research for regional planning". *Centre for Environmental Studies*, Working Paper. London.
- Xu, L., Gilliam, J.W., & Daniels, R.B., (eds.) (1992). Nitrate movement and loss in riparian buffer area. In *Agronomy Abstracts*. ASA Madison, WI, USA.


APPENDICES


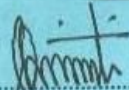
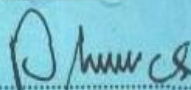
Appendix 1: Hypothesis Testing on Influence of Policy Measures on Riparian Width

S/No	Observed Width((Xi)	Group Mean(X)	Variance(Xi-X) ²
1	2	3.39	1.920204082
2	2	3.39	1.920204082
3	1.4	3.39	3.943061224
4	0	3.39	11.46306122
5	1.3	3.39	4.350204082
6	2.2	3.39	1.405918367
7	3.5	3.39	0.013061224
8	6	3.39	6.834489796
9	5.8	3.39	5.82877551
10	3.8	3.39	0.171632653
11	5.7	3.39	5.355918367
12	0	3.39	11.46306122
13	0	3.39	11.46306122
14	0	3.39	11.46306122
15	9	3.39	31.52020408
16	11	3.39	57.97734694
17	8.6	3.39	27.18877551
18	13	3.39	92.4344898
19	10	3.39	43.74877551
20	0	3.39	11.46306122
21	2	3.39	1.920204082
22	2	3.39	1.920204082
23	3	3.39	0.14877551
24	2	3.39	1.920204082
25	0	3.39	11.46306122
26	0.5	3.39	8.327346939
27	0	3.39	11.46306122
28	0	3.39	11.46306122
n=28	∑((Xi)=94.80		∑(Xi-X)²=390.5542857

Note the mean of the observed width is $X = \sum(Xi/n) = 94.8/28 = 3.39$ and the standard deviation, $O = \sqrt{\sum(Xi-X)^2 / (n-1)} = (390.5542857)/(28-1) = 3.80$. This gives a t-test value of, $t = (X-6) / (O/\sqrt{n}) = (3.39-6) / (3.8/\sqrt{28}) = -3.569$.

Appendix 2: Research Clearance Permit No. NCST/RR1/12/1/ES-011/16

<p style="text-align: center;">CONDITIONS</p> <ol style="list-style-type: none"> 1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit 2. Government Officers will not be interviewed with-out prior appointment. 3. No questionnaire will be used unless it has been approved. 4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries. 5. You are required to submit at least two(2)/four(4) bound copies of your final report for Kenyans and non-Kenyans respectively. 6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice 	 REPUBLIC OF KENYA RESEARCH CLEARANCE PERMIT
<p>GPK6055t3mt10/2011</p>	<p>(CONDITIONS— see back page)</p>

<p>PAGE 2</p> <p>THIS IS TO CERTIFY THAT:</p> <p>Prof./Dr./Mr./Mrs./Miss..... SILAS MWITI MUKETHA</p> <p>of (Address)..... UNIVERSITY OF NAIROBI BOX 30197 NAIROBI</p> <p>has been permitted to conduct research in</p> <p style="text-align: right;">.....Location,</p> <p style="text-align: right;">.....NAIROBI.....District,</p> <p style="text-align: right;">.....NAIROBI.....Province,</p> <p>on the topic..... RIPARIAN ZONE CONSERVATION IN A CHANGING URBAN LAND USE ENVIRONMENT: THE CASE OF NAIROBI RIVER BASIN.</p> <p>for a period ending..... 31ST DECEMBER, 2012</p>	<p>PAGE 3</p> <p>NCST/RR1/12/1/ES-011/16</p> <p>Research Permit No.....</p> <p>Date of issue..... 20/5/2011</p> <p>Fee received..... KES. 1000</p> <div style="text-align: center;">  </div> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div style="text-align: center;">  Applicant's Signature </div> <div style="text-align: center;">  Secretary National Council for Science and Technology </div> </div>
---	---

Appendix 3: Questionnaire for Land Users

Personal Information

- 1) Respondent's name (optional)
- 2) Respondent's age
- 3) Sex: 1) Male 2) Female
- 4) Education Background 1) None 2) primary 3) secondary 4) college 5) University Level 5) others (specify)
- 5) Marital status: 1) Single 2) Married 3) Divorced 4) Widow/Widower 5) separated 6) Other (Specify)...
- 6) Employment: 1) Civil Servant 2) Private Sector Job 3) Self-employed 4) Jobless 5) Others (Specify).....
- 7) Household Monthly Income: 1) below 10,000 2) Between 10,001-20,000 3) Between 20,001-30,000 4) over 30,000
- 8) Household monthly expenditure : 1) below 5,000 2) Between 5,001-10,000 3) Between 10,001-15,000 4) over 15,000

Demographic Trends

- 9) Place of birth: District Division.....
- 10) How long have you lived in this locality..... (Years)
- 11) Had you lived in any other estate in Nairobi before you came here? 1)Yes 2) No
- 12) If yes, which one? (Estate).....
- 13) Why did you choose to settle in this area?

Land Tenure and Ownership

14. Land Use Type	1. Residential 2. Commercial 3. Residential cum Commercial 4. Others (Specify).....
15. Ownership (Tenure) Documents by respondent	1. Freehold Title 2. Leasehold title 3. Rental 4. Share Certificate 5. Allotment Letter 6. Other (Specify).....
16. Size of land parcel/Space	M ²
17. Mode of acquisition of land/space	1. Purchase 2. Inherited 3. Allocation 4. Others (specify).....
18. Land allocated by (if obtained through allocation)	1. Commissioner of Lands 2. Provincial Administration 3. City Council of Nairobi 4. Village Chairman 5. Others (Specify).....
19. Date of acquisition	Year.....
20. Cost of Land/Space	1. During Acquisition..... 2. Current Cost.....

- 21 If you have no title to land/space, what problems do you experience in developing the land?
- 22 What do you consider to be the most probable remedies to the problems in question 21?
- 23 What was the use of this parcel of land before you occupied it?
25. Do you have any plans to change the current land use on your parcel of land/space? 1) yes 2) no
26. If your answer to 25 is yes, please explain.

Housing Type and Quality Information

Quality of House	1. Stone 2. Concrete 3. Timber 4. Iron Sheet 5. Mud/Earth 6. Tiles 7. Others (specify).....
27. Floor	
28. Wall	
29. Roof	
30. Type of House	1. Maissonnete/ Bungalow 2. Permanent Tenement 3. Temporary Tenement 4. Flat 5-Others (Specify)

31. What is the area occupied by your house:M²
32. How many rooms does your house have?
33. How many people live in your house?.....

Physical Infrastructure

34. What is your main source of water supply: 1-NWSC Individual Connection 2-Communal tap 3-river 4-borehole 5- shallow well 6- water carriers/hand carts 7- others specify
35. How far is the water source from your house: 1- within the house 2- less than 200m 3- between 200m - 800m 4-more than 800m

36. How do you dispose solid waste? 1) Incineration 2) Collection by Council 3) collection by Private companies 4) Dumping next to the river 5) dumping into the river 6) others (specify)
37. Which institutions deal with solid waste management in this area? 1) CCN 2) private companies 3) community based organizations 4) none 5) others (specify)
38. How much do you pay for solid waste collection per month?
39. How do you dispose human waste? 1) Sewer 2) ordinary Pit latrine 3) Septic tank 4) Conservancy tanks 5) VIP pit latrines 6) others (specify)
40. How is the facility in question 39 used? 1) Privately 2) Shared by other Households 3) Communal 4) Others (Specify)
41. What challenges do you face with the current human waste disposal system?
42. Given a choice, which system of human waste disposal would you prefer?

Section 2: Perceptions on Riparian Zones

43. Do you know the purpose of the land adjacent to the river? 1) Yes 2) No
44. If your answer to question 43 is Yes, in your opinion what are the major functions of the land adjoining the river?
45. What activities do people in your neighborhood undertake on the land adjacent to the river?
46. In your opinion, how far should use of your land extend to the river channel? 1) At the edge of the river 2) less than 10m 3) between 10 -20m 4) between 20-30m 5) 30m or more 6) others (specify)
47. Do you consider your land/space to be government land? 1) yes 2) no
48. If your answer to 47 is Yes briefly explain reasons for occupation
49. If your answer to 47 is No what land ownership documents do you possess?
50. What opportunities/benefits does the land adjacent to the river present to you?
51. What are the dangers of living next or very close to the river channel?
52. How do you protect the land adjoining the river?
53. In your opinion, who should be involved in the protection of the land next to the river?.
54. Are there forums between residents and government officials to protect the land adjacent to the river
1) yes 2) No
55. If your answer to 54 is Yes, who spearheads such forums?
56. If your answer to 54 is No, Who do you expect to spearhead such forum?

Existing Characteristics of Respondent's Land/Space Adjacent River

57	Distance of plot/space boundary to edge of riverMetres
58	Distance of building /structure/activities to edge of riverMetres
59	Land cover of space adjacent to river	1) Trees, shrubs, grass 2) shrubs, grass 3), grass only 4) physical structures 6) bare ground 7) others specify.....
60	Solid waste in space next to river	Type: 1) domestic waste 2) soil waste 3) none 4) others specify.....
61	Liquid waste in space next to river	Type: 1) sewerage 2) storm water 3)domestic waste water 4) Others specify.....
62	Slope of land next to river	1) Very steep (>15%) 2) steep (5-15%) 3) gentle (0-5%)
63	Soil characteristics of land next to river	1) Black cotton 2) red soils 3) clay soils 4) rock 5) murrum 6) others specify.....
64	Accessibility of land next to river	1) Open to public use 2) fenced off 3) built on up to edge of river 4) other specify
65	Physical Orientation of your structures/activities relative to river	1) Building front facing the river 2) Back of building/activity facing river
66	Width of river (bank to bank)Metres

Land Use Regulations and Building Codes

67. Do you adhere to the following regulations when carrying out activities/development next to the river?
(*Tick appropriately in the table below*)
68. Which agency ensures that development next to the river is implemented in accordance to regulations? (

Appendix 4: Questionnaire to Professionals

Name of Respondent (Optional) -----

Profession-----

Implication of Land Use on Conservation of Riparian Zones

1. In your opinion, what factors have contributed to the encroachment and degradation of riparian zones in the city of Nairobi?
2. In your opinion, how would conservation of riparian zone be achieved in a changing urban land use landscape in Nairobi River Basin?
3. In your assessment using a scale of 1 to 5 indicate your opinion of the impacts (encroachment and degradation) associated with each of the following urban land uses on the riparian zone in the city of Nairobi

URBAN LAND USE TYPES	IMPACTS ON RIPARIAN ZONE 1) No Effect 2) Minimal Effect 3)Moderate Effect 4)significant Effect 5)Major Effect
High income residential e.g. Kileleshwa	
Informal settlements e.g. Mathare 4B	
Public institutions e.g. National Museum	
Private institutions e.g. Boulevard Hotel	
Quarrying e.g. at Pipeline Quarry village	
Urban agriculture e.g. at Mukuru Kwa Reuben	
Formal businesses e.g. Nakumatt Westlands	
Informal markets e.g. Gikomba market	
Urban parks e.g. Arboretum	
Heavy industries e.g. Industrial area	
Garages e.g. along Kirinyaga road	
Open recreational spaces e.g. Kamukunji grounds	
Physical infrastructure e.g. sewers along Ngong River	

4. There being different implications of land uses on riparian zones, what widths would you suggest? Please indicate. Please indicate.

Land use	<i>I suggest a fixed width for all land uses (specify this width in metres)</i>	I suggest variable widths for different land uses (specify these widths)
Industrial		
Commercial		
Residential(formal)		
Urban agriculture		
open spaces		
Residential (informal)		
Infrastructure (sewer)		
Institutional		

Appendix 5: Interview Schedule to Institutions

SECTION A: General information

1. Are the determination, use and management of riparian zones mainstreamed in your organization?
2. If yes, what is the role of your organization/ministry/department in the determination, use and management of riparian zones in the city of Nairobi?
3. What role do you as an officer in this organization/ministry/department play in the determination, use and management of riparian zones in the City of Nairobi?
4. What factors have contributed to encroachment and degradation of riparian zones in the City?
5. What do you attribute this current trend to?

SECTION B: Bio-physical Condition (riparian vegetation and widths of zones)

6. In your own assessment and experience, is the current vegetation cover of riparian zones in the city of Nairobi incapable of supporting a functional river ecosystem?
7. If yes, what are the factors that are affecting the biophysical conditions of riparian zones in the city of Nairobi?
8. What possible management measures or strategies would restore the biophysical functions of riparian zones in the city of Nairobi?

SECTION C: Implication of Urban Land on Riparian zone

9. What are the main implications of urban land uses on riparian zone in Nairobi River basin?
10. In your assessment using a scale of 1 to 5, indicate your opinion on the impacts of specific land use on riparian zones (this is with regard to encroachment and degradation).

URBAN LAND USE TYPES	IMPACTS ON RIPARIAN ZONE 1) <i>No Effect</i> 2) <i>Minimal Effect</i> 3) <i>Moderate Effect</i> 4) <i>significant Effect</i> 5) <i>Major Effect</i>
<i>The land uses are listed in the instrument as follows:</i> High income residential; informal settlements; public institutions; private institutions; quarry mining; urban agriculture; formal businesses; informal businesses; urban parks; heavy industries; garages; open recreation grounds; and solid and wastewater disposal systems	

11. In your opinion which of the above land uses should be permitted
 - a. Adjacent to riparian zones?
 - b. In the riparian zones?
12. In your opinion which of the above land uses should be restricted
 - a. Adjacent to riparian zones?
 - b. In the riparian zones?
13. In your opinion what criteria should be used to permit or restrict land uses along riparian zones?

SECTION D: Management of Riparian Zones

14. In your opinion, are there allocations of riparian zones to private developers in the city of Nairobi? Please explain.
 - a. If your answer to 14 is yes, when did the allocation occur and when were they most rampant?
 - b. Who was involved with the allocation riparian zones in the city of Nairobi?
 - c. What were the reasons for allocation of riparian land to private developers?
15. Has this organization/ministry/department attempted to stop encroachment and degradation of riparian zones in the city of Nairobi?
 - d. If the answer to 15 is yes, what challenges did your organization/ministry/department face?
 - e. In your opinion, what steps can be taken to overcome these challenges?
16. A government agency should be given the responsibility, legislative power and funding for conservation of riparian zones. In your opinion, who should have the jurisdiction to manage riparian zones? Please explain.

SECTION E: Policies, Laws and Perceptions on Riparian Zone Conservation

17. The table below illustrates various recommended riparian widths from different legislations concerned with the conservation of riparian zones. From the table different legislation prescribes different widths. Which statute does this organization/Ministry/Department apply when dealing with riparian zone? Please explain

Statutory provisions (Kenya) on riparian width	
Statute/institution	Recommended riparian width (in metres)
Water Act (2002)	Minimum 6m and max. 30m from the river bank
EMCA	Minimum 6m and max. 30m from the river bank
Agriculture Act	2m from the
Physical Planning Act	Minimum 2m and max. 30m horizontal from edge of river
Survey Act	Minimum 30m for tidal rivers only. No mention of other smaller rivers. Measurement from high water mark
Physical Planning Regulations of 1996	Minimum of 10m from the flood level
City Council by-laws	City Council by laws put a maximum of 30m from high water mark

18. What informs the application of minimum and maximum riparian zone widths as stipulated in the legislations?
19. Different legislations recommend different reference points for determination of riparian zones. In your opinion which is the most appropriate criterion for referencing the width of riparian zones. Please explain.
20. The Survey Act stipulates the high water mark for referencing the width of riparian zone. However, the practice of cadastral surveying in Kenya shows boundaries of properties as centre lines of rivers". In your opinion why is there a difference?
21. In your opinion, is the use of the centerline of river as the boundary the root cause of the challenges that face riparian zones? Please explain.
22. In your opinion, should there be a uniform riparian zone width from the source of the river to its mouth? Please explain.
23. In your opinion, what factors should be considered when determining riparian zones in the city of Nairobi?
24. There being different implications of land uses on riparian zones, what widths would you suggest? Please indicate.

Land Use	Suggested Width
Industrial	
Commercial	
Residential(formal)	
Urban agriculture	
Recreation spaces/open spaces	
Residential (informal)	
Infrastructure (sewer)	

25. What policies are used by organization for managing riparian zones?

SECTION F: Institutional Assessment

26. Does your organization have sufficient technical human capacity to oversee effective conservation of riparian zone in the city of Nairobi? Please indicate
27. What data do you collect on when registering parcels of land adjacent to riparian zones?

Disciplines/professionals involved in riparian zone conservation	Existing number of technical human capacity	Desired number of technical human capacity	Excess /Deficit
Planners			
Environmentalists			
Enforcement officers			
Architects			
Surveyors			
Draftsmen			
Others (specify)			

28. Does your organization have a GIS system in place to aid in the determination, use and management of riparian zones? Please explain
29. Which organizations do you consult or collaborate with?

THANK YOU

Appendix 6: Soil Laboratory Test Results for Riparian Soils from the Selected Study Sites



**MINISTRY OF ROADS
MATERIALS TESTING AND RESEARCH DEPARTMENT
FOUNDATION AND DRILLING SECTION
TEST RESULTS CERTIFICATE.
MOR/QMS/MD 017**

**PROJECT NAME: STUDY SITES IN NAIROBI RIVER BANKS
CLIENT: SILAS M. MUKETHA**

8 May 2013

SAMPLE NO.	DEPTH (M)	PLASTICITY				GRADING				COMPACTION			PERMEABILITY	REMARKS
		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTIC INDEX (%)	LINEAR SHRINKAGE	GRAVEL % > 2mm	SAND % 0.006-2MM	SILT % 0.002-0.06MM	CLAY < 0.002MM	M.D.D Kg/m ³	O.M.C %	MOISTURE %	PERMEABILITY K	SPECIFIC GRAVITY
ARBORETUM	1.00M	64	35	29	14	0	40	35	25	1520	28	26	8.55×10 ⁻⁵	
MATHARE 4B	1.00M	62	26	36	19	1	39	34	23	1490	33.5	30	8.85×10 ⁻⁵	2.82
MUKURU REUBEN	1.00M	65	21	44	16	5	40	36	26	1310	31	30	8.78×10 ⁻⁵	
RABAI ROAD	1.00M	89	32	57	23	2	28	41	34	1360	30	28	8.67×10 ⁻⁵	2.71
KAMUKUNJI	1.00M	65	21	44	16	2	26	39	33	1280	29	27	8.69×10 ⁻⁵	
NAKUMATT WESTGATE	1.00M	64	35	29	14	5	31	31	33	1300	28	28	8.76×10 ⁻⁵	2.63

a/e *G. W. K.*
LOCATION: NAIROBI
ADDRESS: 10320015, Nairobi.

CHIEF ENGINEER MATERIALS
MINISTRY OF ROADS
P.O. Box 19871
NAIROBI

Appendix 7: We Care about Nairobi do it and Another versus NEMA and Another

By notice of appeal dated 29th June 2006 filed in the National Environmental Tribunal on 30th June 2006, the appellants (We Care About Nairobi Do IT – 1ST Appellant, Kyuna and Shanzu Road Residents- 2nd Appellant) entered an appeal against the Director General, National Environmental Management Authority (NEMA-1st Respondent and M/S Houses and plots limited-2nd Respondent) challenging NEMA's initial approval of Environmental Impact Assessment Report (EIA) for the proposed construction of 23 houses on Land Reference Number 7158/53 subsequently LR No. 7158/385-388) without approved architectural and structural plans and amalgamation of plots LR No. 7158/385, 386, 387 and 388) without the necessary approvals. The appellants requested the tribunal to order demolition of illegal structures. To fully appreciate issues under contention, the tribunal along with counsel of parties visited the site on 12th February 2007 and observed that the land is steep with houses under construction, there is a river (Kibagare river) at the bottom where trees had been cut and stumps spread out and only a few old trees remained standing by partly built up homes (Kenya Law Review, 2007).The tribunal was supplied by among others, interim report of local physical development plan; policy review for zones 3,4,5 (that cover zone 5 where the project was located) dated 3rd July 2006 by the Department of City planning; City Council of Nairobi.

It was observed in court that the proponent had sought approval of 23 houses but 16 were approved by the City Council in February 2005. By July 2005, another plan was approved against the same title for seven houses bringing the total number of houses to be constructed on site to 23. By enforcement notice dated 20th March 2006, the council stopped construction of the 23 houses on the grounds among others that the developer had added four masionettes contrary to the approved building plans. The developer re-submitted new building plans which resulted in an approval for construction of 20 masionettes by letter dated 21st September 2006.The challenge by residents was whether an area of 2 acres was environmentally suitable for as many as 20 houses. They also had protested against the way EIA was carried out without proper public participation and due notices availed on site and in the media. The appellant alleged that conditions set in the EIA had hardly been observed by the proponent: a wet land had been interfered with, trees had been cut and appropriate distance from highest water mark ignored given some houses were under construction too close to the river; green spaces were non-existence, in every case replaced by concrete at the estimated ground coverage of 80-90 percent (Appellants estimation). On his part, the respondents indicated among others, that the 6 metre riparian reserve underscored by NEMA's condition had been observed, as demonstrated by pegs NEMA'S District Environment Officer had planted.

There were differences of view on applicable policy in zone 5 including the number of houses that could be built on the 2 acres; plinth area, ground coverage and density applicable; whether the marshy wetlands had been interfered with, amount of green spaces available and houses constructed practically along the riparian reserve. In this case, among the issues in contention was whether or not the riparian zone was respected or not and the status of the practice; whether demolitions were to be carried out and whether there were consultations with the neighbours as required by law or not. The court in its communication questioned whether the riparian zone had been observed and whether it is known in law. The court observed that the riparian reserve was one of the conditions given by NEMA and has been a condition given consistently in developments alongside rivers.

In this case, the Appellants averred that the zone had not been respected and that four houses were set to be put in the area. According to the appellant, firm ground inside the riparian area would mark the end of the zone from the highest water mark. Of concern to the proponent, was how to first establish the zone in the circumstances of a river that had been canalized on either side of the property and that the six metre rule was a guideline and therefore not legally binding. According to the proponent, NEMA officials had placed pegs showing that the two houses constructed were outside the six metre area as measured from the middle of the river. And whatever the status of the practice may have been, it was at that time no longer an issue as Legal Notice No. 120 of 2006 (Water Quality Regulations) provided that “no person shall cultivate or undertake any development activity within full width of a river or stream to a minimum of six metres and a maximum of 30 metres on either side based on the highest recorded flood level”. Arising from considerations of arguments from both sides, the tribunal unanimously ordered among others that proponent takes measures in carrying out the construction to ensure that there is no encroachment on the riparian zone.

Appendix 8: Logical Framework for Conservation of Riparian Zone in Nairobi River Basin

Summary of Objectives/ Activities	Objectively Verifiable Indicators	Means/Source of Verification	Important Assumptions
Goal: Riparian zone conservation in a changing urban land use environment	Riparian zones determined based on scientific research, best practices and prevailing local conditions	<ol style="list-style-type: none"> 1. Relevant local authorities' minutes on approval of developments next to rivers 2. Ministry of lands physical development plans 3. Ministry of environment M and E Reports 	<ol style="list-style-type: none"> 1. Riparian zones will be treated as a distinct land use type serving a distinct function 2. Mapping of riparian zones to establish clear boundaries 3. Riparian zone management plans will be prepared
Specific Objectives: 1. To minimize implications of land use and biophysical factors on riparian zones	<ol style="list-style-type: none"> 1. Notable reduction in encroachment of riparian zones by urban land use 2. Reduced degradation of riparian zones by urban land use 3. Improved vegetation cover in the zones 	<ol style="list-style-type: none"> 1. Local authorities zoning plans with properly defined riparian zones 2. Periodic inspections using remote sensing, GIS and field inspections to review changes occurring in riparian zones 	<ol style="list-style-type: none"> 1. Riparian zones will be included in zoning plans of the city 2. Provision for solid and waste water disposal systems will be improved to prevent pollution of the zone
2. To integrate existing laws and policies in Kenya and to incorporate provisions of scientific research and best practices for effective conservation of riparian zones	<ol style="list-style-type: none"> 1. Harmonized legal and policy framework on riparian zone conservation adopted by all stakeholders 2. Development of a Kenyan based riparian zone management handbook incorporating provisions of scientific research and best practices. 	<ol style="list-style-type: none"> 1) PPA, LGA, EMCA, water Act, Agriculture Act, Survey Act will be reviewed to have the same provisions and standards on riparian zones 2) 2. One central riparian zone management Handbook used by all relevant Government actors and professionals 	<ol style="list-style-type: none"> 1. All relevant legislations will adopt a one definition of riparian zones and identify their importance 2. Riparian zone conservation policy will be based on scientific research and best practices and will incorporate local conditions.
3. To promote public awareness and education on the importance of conservation of riparian zones with the view of improving stakeholders roles, perceptions and behaviour towards riparian zones	Increased public awareness campaigns by government, CBOs, NGOs, Corporations, private Companies and environmentalists on importance of riparian zones especially to communities living close to rivers	<ol style="list-style-type: none"> 1) 1. Stakeholders' yearly calendar of events showing number of riparian zone conservation campaigns organized 2) 2. Reviews on number of communication media adverts including radio, television, and newspapers placed on a periodic basis 	All relevant organizations especially county and national governments will actively participate in creating public awareness and education on the importance of conserving riparian zones in urban and rural areas of Kenya.
Expected Outputs: <ol style="list-style-type: none"> 1) A sustainably used and managed riparian zone 2) An integrated legal and policy framework on riparian zone conservation adopted by all actors 3) A Kenyan based riparian zone management handbook on determination, use and management of riparian zones 4) 4. Informed and educated stakeholders who appreciate the value and functions of riparian zone 	<ol style="list-style-type: none"> 1) Adequately sized pollution free riparian zone characterized by ample riparian zone vegetation composition and structure 2) Harmonized riparian zone guidelines and standards in one policy 3) Adherence to regulations and rules on riparian zones by Stakeholders 	<ol style="list-style-type: none"> 1) Measurement of riparian zone widths and documentation of the riparian zone condition. 2) Published policy and law 3) Published riparian zone Management Handbook 4) Periodic surveys of stakeholders to seek their opinion on the condition of riparian zones 	<ol style="list-style-type: none"> 1) All stakeholders involved will ensure proper determination, use and management of riparian zones 2) National and County governments will spearhead formulation and implementation of appropriate regulations and by-laws

Appendix 9: Professional Opinions of the Physical Impacts of Land use on Riparian Zone in the City of Nairobi

URBAN LAND USE TYPES	IMPACTS ON RIPARIAN ZONE 1)no impact 2) least impacts 3)moderate impacts 4) major impacts 5) Serious impacts																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
High income residential e.g. Kileleshwa	3	3	4	3	3	3	2		3	3	3	3	2	4	3	2	4	2	4	5	2	2	2	5	1	3	4	2
Informal settlements e.g. Mathare 4B	5	5	5	5	5	5	5		5	5	5	5	5	5	5	4	5	5	4	5	5	5	5	5	2	5	5	5
Public institutions e.g. National Museum	2	1	2	2	2	1	2		1	1	2	2	2	2	2	2	4	2	2	3	2	2	4	4	1	1	2	2
Private institutions e.g. Boulevard Hotel	2	2	3	2	3	2	3		2	2	3	2	3	3	2	2	3	3	3	3	3	2	2	5	1	2	2	2
Quarry Mining e.g. at Pipeline Quarry village	5	4	4	4	4	5	5		4	5	4	4	5	4	5	4	5	4	4	5	3	4	5	5	3	5	5	5
Urban agriculture e.g. at Mukuru Kwa Reuben	3	5	4	5	2	4	5		5	4	2	5	5	4	3	5	5	4	4	2	5	5	5	5	5	4	5	3
Formal businesses e.g Nakumatt Westlands	2	4	5	5	3	5	5		4	5	3	5	5	5	2	4	5	4	4	3	2	3	2	4	3	2	3	4
Informal markets e.g. Gikomba market	4	4	5	5	3	4	5		4	4	3	5	5	5	4	5	5	5	3	3	4	5	4	4	2	4	5	5
Urban parks e.g. Arboretum	1	1	2	2	4	1	1		1	1	4	2	1	2	1	2	3	3	2	1	3	1	1	3	1	2	2	1
Manufacturing Industries	5	4	5	5	4	5	5		4	5	4	5	5	5	5	5	5	5	5	4	5	4	4	5	2	5	5	5
Informal Garages	5	4	4	5	4	5	5		4	5	4	5	5	4	5	5	5	5	5	5	4	5	4	5	2	5	5	5
Open recreational spaces e.g. Kamukunji grounds	2	2	3	4	1	2	2		2	2	1	4	2	3	2	1	3	4	2	2	2	1	3	4	1	2	4	1
Physical infrastructure e.g. sewers along Ngong River	4	4	4	4	2	2	3		4	2	2	4	3	4	4	5	4	5	4	5	4	3	4	5	4	4	5	4