SPATIOTEMPORAL ANALYSIS OF ENCROACHMENT ON WETLANDS: HAZARDS, VULNERABILITY AND ADAPTATIONS IN KAMPALA CITY, UGANDA

by

JOHN BOSCO ISUNJU

Dissertation presented for the degree of *Doctor of Philosophy in the Faculty of Science at Stellenbosch University*

Supervisor: Dr. J Kemp, Stellenbosch University

Co-supervisor: Prof. CG Orach, Makerere University

March 2016

Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Chapters 4, 5, and 6 of this thesis were submitted for publication in peer reviewed journals. The first author conceptualised the study, collected and analysed data and drafted the manuscripts. The co-authors provided conceptual guidance and editorial input.

Chapter	Article details	Status
Chapter 4	Isunju JB & Kemp J (2015). Spatiotemporal analysis of encroachment on wetlands: a case of Nakivubo wetland in Kampala, Uganda, *Environmental monitoring and assessment.*	Accepted
Chapter 5	Isunju JB, Orach CG & Kemp J (2015). Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda, *Environment and Urbanization.* doi: 10.1177/0956247815613689	Published online
Chapter 6	Isunju JB, Orach CG & Kemp J (2015). Community-level adaptation to minimise vulnerability and exploit opportunities in Kampala's wetlands, *Environment and Urbanization.* In press	In press

March 2016

Abstract

Wetlands provide vital ecosystem services including water purification, flood control and climate moderation, which enhance environmental quality, promote public health and contribute to risk reduction. The biggest threat to wetlands is posed by human activities that transform wetlands, often for short-term consumptive uses. Population pressure, urbanization and industrial developments, among other factors, have resulted in severe degradation of wetlands. In the face of increased climate variability, several hazards continue to emerge, affecting the vulnerable sectors of society, especially the poor. This study sought to quantify and map the extents and spatiotemporal dynamics of human activities in wetlands, taking a case of Nakivubo wetland that drains Kampala city's wastewater to Lake Victoria; assess the range of hazards, perceived vulnerabilities and associated factors among wetland communities, and assess the benefits and opportunities informal wetland communities in Kampala Uganda derive from their location in the wetland and how they adapt to minimise vulnerability to hazards such as floods and disease vectors.

In order to achieve the study objectives, a mix of methods were used. These included GIS and Remote sensing techniques for analysis of very high resolution aerial photos and satellite imagery (captured in 2002, 2010 and 2014), a survey of 551 households, four focus group discussions among wetland communities and five key informant interviews with stakeholders. Analysis of land cover in Nakivubo wetland showed a 62% loss of wetland vegetation between 2002 and 2014, which is mostly attributed to crop cultivation. Results from the survey showed floods and waterlogging as the principal hazards; however, secondary effects of floods and waterlogging such as disease vectors and diseases affect more people than the floods. Tenants were more likely to be exposed to floods, but less likely to prefer to adapt, and to perceive themselves able to afford adaptation than landlords/homeowners, and households that spend more than US$ 80 per month were less likely than households that spend less to be exposed to floods. Households that had been exposed to floods before were more likely to perceive themselves as vulnerable. Free water from spring wells and cheaper rental units topped the benefits associated with location while the main benefit associated with the wetland itself is that it supports crop farming.

However, cultivation in the buffer wetland vegetation makes it unstable to anchor to the substrate, implying that it will likely be calved away by receding lake waves as evidenced by the 2014 data. With barely no wetland vegetation buffer around the lake, the heavily polluted wastewater streams will further deteriorate the quality of lake water. Furthermore, with increased human activities in the wetland, exposure to flooding and pollution will likely have more impact on the health and livelihoods of vulnerable communities. There is a need for coordinated adaptation strategies that involve all stakeholders, and a multi-faceted approach such as ecosystem-based adaptation needs to be implemented; possibly through zoning out the wetland and restricting certain activities to specific zones so as to enhance equitable utilisation of wetland resources without compromising their ecosystem services and benefits.

Opsomming

Vleilande bied belangrike ekosisteemdienste soos watersuiwering, vloedbeheer en klimaat moderering, wat die omgewingsgehalte verbeter, openbare gesondheid bevorder en bydra tot risiko vermindering. Die grootste bedreiging vir vleilande is die transformasie daarvan as gevolg van kort termyn menslike aktiwiteite en hul verbruikende doeleindes. Bevolkingsdruk, verstedeliking en industriële ontwikkelings, onder andere, het gelei tot ernstige agteruitgang van vleilande. In die aangesig van die verhoogde klimaat variasie, kom sekere gevare steeds na vore wat die kwesbare sektore van die samelewing, veral die armes, affekteer. Hierdie studie poog om die mate en tyd-ruimtelike dinamika van menslike aktiwiteite in vleilande te kwantifiseer en te karteer, en neem 'n gevallestudie van Nakivubo vleiland wat Kampalastad se afvalwater na Lake Victoria dreineer; evalueer die omvang van gevare, waarneming van kwesbaarhede en verwante faktore onder vleiland gemeenskappe, en om die voordele en geleenthede wat informele vleiland gemeenskappe in Kampala, Uganda put uit hul nedersetting in die vleiland, te bepaal, asook hoe hulle aanpas om kwesbaarheid vir gevare soos vloede en siektes te verminder.

Om die studie se doelwitte te bereik, is verskeie metodes gebruik. Dit sluit in GIS en afstandswaarnemings tegnieke vir die ontleding van baie hoë resolusie lugfoto's en satellietbeelde (vasgevang in 2002, 2010 en 2014), 'n opname van 551 huishoudings, vier fokusgroepbesprekings onder vleiland gemeenskappe en vyf belangrike informant onderhoude met belanghebbendes. Ontleding van gronddekking in die Nakivubo vleiland het gewys dat 'n verlies van 62% van die vleiland plantegroei tussen 2002 en 2014 plaas gevind het, wat meestal toegeskryf word aan gewasverbouing. Resultate van die opname het getoon dat vloede en water deurtrokkenheid die hoof gevare is; daar is egter sekondêre gevolge van vloede en water deurtrokkenheid, byvoorbeeld siekte vektore en siektes, wat mense meer affekteer as die vloede. Huurders was meer geneig om blootgestel te word aan vloede, maar minder geneig om te verkies om aan te pas, en om hulself te sien bekostig om aan te pas as verhuurders/huiseienaars, en huishoudings wat meer as US$ 80 per maand spandeer was minder geneig as huishoudings wat minder spandeer om blootgestel te word aan vloede. Huishoudings wat blootgestel was aan vloede voorheen was meer geneig om hulself as kwesbaar te beskou. Gratis water vanaf die lente putte en goedkoper huureenhede het die

voordele verbonde aan die omgewing oorskry, terwyl die grootste voordeel wat verband hou met die vleiland is die ondersteuning van gewasverbouing.

Egter, verbouing in die buffer vleiland plantegroei maak dit onstabiel om te anker, wat impliseer dat dit waarskynlik weg gekalf sal word deur die afname van meergolwe soos blyk uit die data van 2014. Met skaars geen vleiland plantegroei buffer rondom die meer, sal die hoogs besoedelde afvalwaterstrome verder die meer se waterkwaliteit verswak. Verder, met verhoogde menslike aktiwiteite in die vleiland, sal blootstelling aan vloede en besoedeling waarskynlik ‘n groter impak op die gesondheid en lewensbestaan van kwesbare gemeenskappe hê. Daar is 'n behoefte aan gekoördineerde aanpassingsstrategieë wat alle belanghebbendes betrek, en 'n veelvuldige benadering, soos byvoorbeeld ekosisteem gebaseerde aanpassing moet geïmplementeer word; moontlik deur die sonering uit die vleiland en die beperking van sekere aktiwiteite tot spesifieke gebiede sodat die billike benutting van vleiland hulpbronne kan verbeter sonder om hul ekosisteem dienste en voordele te kompromiseer.

Acknowledgements

My sincere appreciation goes to every individual, institution and partner who contributed or supported this work in one way or another; including those I may not have listed below.

Firstly, I acknowledge my supervisors Dr. Jaco Kemp from the Department of Geography and Environmental Studies at Stellenbosch University, and Prof. Christopher Garimoi Orach from Department of Community Health and Behavioural Sciences at Makerere University School of Public Health. I am forever grateful for the time, support and intellectual guidance they offered me.

Secondly, I appreciate the bursary from the African Doctoral Academy (ADA), through the Graduate School of Arts and Social Sciences at Stellenbosch University; the PeriPeri-U project at Makerere University School of Public Health that funded my travel and part of field work. I also appreciate my Employer, Makerere University for granting me a study leave.

Thirdly, special thanks to all those people who guided or supported me in one way or another including Prof. JH van Merwe, Prof. R Donaldson, Prof. A van Niekerk, Dr. JC Ssempebwa, Assoc. Prof. W Bazeyo, Assoc. Prof. F Makumbi, Dr. J Hurvy and Mr. P Thio, as well as my colleagues Dr. R K Mugambe, S Tusingwire, A Halage, H Komakech, H Bukirwa, F, Niyonshaba B, Walyawula, R A Aogo, I Fuseini, S Adeniyi, L C Bam, L de Beyer and T M Kruger.

Fourthly, I thank my research team i.e. R Tenywa, T Mukama, T Sekamate, H Lubwama, E Atusingwize, A Kisakye and R Ndejjo.

Lastly, I am deeply grateful for the love, prayers and support from friends and family, including Dr. E Gailhofer, Magdalena and Prof. G Aigner from Austria, Mr & Mrs Steen from The Netherlands and the Stellenbosch International Fellowship (SIF).

Above all, I give the Glory to God, who always makes a way where there seems to be none!

Dedication

This thesis is dedicated to my dear parents, Mr. & Mrs. Isunju for the invaluable contribution into my life. Also dedicated to my son Daniel, daughter Daniella and my wife Daphine in appreciation of their endurance and moral support.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ADA	African Doctoral Academy
CBD	Central Business District
CCA	Community Conservation Areas
DPSEEA	Driving force-Pressure-State-Exposure-Effect-Action
DWM	Department of Wetlands Management (Uganda)
EBA	Ecosystem Based Adaptation
ETM+	Enhanced Thematic Mapper Plus
FGDs	Focus Group Discussions
GIS	Geographic Information Systems
GPS	Global Positioning System
HDREC	Higher Degrees, Research and Ethics Committee (Makerere University)
IPCC	Intergovernmental Panel on Climate Change
KCC	Kampala City Council
KCCA	Kampala Capital City Authority
KIIs	Key Informant Interviews
MWE	Ministry of Water and Environment (Uganda)
NDVI	Normalized Difference Vegetation Index
NEMA	National Environmental Management Authority (Uganda)
NIR	Near-infrared
NWSC	National Water and Sewerage Cooperation (Uganda)
OECD	Organisation for Economic Co-operation and Development
OSP	Stellenbosch University's Overarching Strategic Plan
PEAP	Poverty Eradication Action Plan (Uganda)
Periperi U	Partners Enhancing Resilience to People Exposed to Risks
REC	Research and Ethics Committee (Stellenbosch University)
RS	Remote Sensing
SANSA	South African National Space Agency
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
SVM	Support Vector Machine

UBOS	Uganda Bureau of Statistics
UGX	Uganda Shillings
UNCST	Uganda National Council for Science and Technology
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UTM	Universal Transverse Mercator
WASH	Water and Sanitation
WGS	World Geodetic System
WMD	Wetlands Management Department (Uganda)
WSSP	Wetland Sector Strategic Plan

Chapter 1: Introduction and General Background

Wetlands are well known for their role in storing, purifying and releasing water gradually, thereby controlling floods and providing water for life. Over the past decade, Uganda's capital Kampala has been experiencing problems of flooding and heavy contamination of water sources whenever it rains, which is partly attributed to encroachment on wetlands around the city. Wetlands, including water bodies, cover approximately 11% (26,600 km^2) of Uganda's total area (241,500 km^2). By 2001, about 9% (2,376 km^2) of the total wetland area had been drained, mostly for agricultural expansion and industrial development (MWE, 2001). Studies have also reported population pressure, urban development, industrial growth and failure to enforce development control as prominent drivers of encroachment on wetlands (Davis, 1993; Ahmad *et al*., 2012). This contravenes the mission of the international treaty for conservation of wetlands – the 1971 Ramsar Convention: "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar, 2010).

Dealing with the issues of encroachment on wetlands is quite complex and delicate because of several reasons including unclear boundaries and legal definition of wetlands, limited physical planning, and the need to compensate wetland titleholders. The Ugandan Ministry of Water and Environment developed a wetland boundary demarcation strategy which it recently used to demarcate the Nakivubo urban wetland in Kampala and a few other wetlands around the country (MWE, 2012). Emphasis is being put on establishment of wetland management committees, demarcation of wetland areas and recognition with respect to encroachment. The Local Authorities such as the Kampala Capital City Authority (KCCA) and the National Environmental Management Authority (NEMA) also have intensified efforts to restore wetlands from encroachers. But more often than not, the process is politicised and uses confrontational approaches, putting many livelihoods at stake. Kabumbuli and Kiwazi (2009:154) strongly advocate for "participatory planning, management and alternative livelihoods for poor wetland-dependent communities" so that wetland encroachers are not only considered part of the problem but also part of the solution.

Understanding the nature, extent and dynamics of human activities in wetlands calls for a longitudinal analysis of land cover changes (Huising, 2002). In 1972, the 'Kampala Development Plan' was developed by the then Town and Country Planning Board. The plan outlined several policies including housing, transport routes, city centre, water and sewerage as well as space for future planning. By then, issues of gazetting wetlands and monitoring encroachment were not deemed pertinent. The 1972 plan was in operation until 1994 when a new plan for the 1994 – 2000 period was made (UN-Habitat, 2007a). Much as the Kampala's planners always came up with ideas to guide urban growth, urban growth often preceded structural planning – making enforcement of development control largely futile. As observed elsewhere (Kapoor *et al*., 2004), less developed land parcels such as wetlands and land left for future planning easily get encroached upon. Many of the recently built-up areas, and large portions of informal settlements in Kampala are in wetlands (Vermeiren *et al*., 2012). These informal settlements house a considerable proportion of the urban population (Chatterjee, 2010). Flooding and contamination of water sources precipitate a range of water related diseases including cholera, malaria, dengue and yellow fever (Matthys, *et al*., 2006; Unger & Riley, 2007; Malan *et al*., 2009; Fuhrimann,, 2015).

Besides settlements, several industrial establishments in Kampala over the past couple of decades have been erected in wetlands. Without appropriate waste management practices such industries discharge gross pollution into the environment (Scheren *et al*., 2000; Kairu, 2001; Ntiba *et al*., 2001; Banadda *et al*., 2009; Wandiga & Madadi, 2009; Rana, 2011). The polluted wastewater quickly drains through the encroached wetlands with minimal purification into Lake Victoria (Kaufman, 1992; Zeng & Chen, 2011). The pollution in the lake, which is closely associated with encroachment on the wetlands has raised concerns of more severe environmental and public health consequences (Oyoo, 2009; Horwitz *et al*., 2012; Fuhrimann *et al*., 2014). Encroachers often take advantage of the dry seasons to drain soggy lands to plant crops (van Dam *et al*., 2013) and or fill waterlogged sites to erect housing structures.

Kampala city is built on gentle hills and flat bottomed valleys, with a network of wetlands covering approximately 32 km^2, which is about 16% of Kampala district (Namakambo, 2000).

According to the ministry of water and environment, all these wetlands have been grossly encroached upon (MWE, 2012). The majority of wetland encroachers live in poor quality dwellings on illegally occupied land with neither the mandate nor the ability to invest in more resilient and flood-proof housing structures (Mukwaya *et al*., 2012). The flat nature of wetland areas makes them particularly attractive to encroachers (Ahmad *et al.*, 2012). Given the current trend, the number of people occupying wetland areas will triple by the year 2030 (Vermeiren *et al.*, 2012). This implies further transformation of wetlands and increased exposure to hazards.

In addition to settlement and industrial establishments, large sections of wetland areas have been fragmented into small plots of farm land by the surrounding communities. To do so, people drain the wetland and confine the water in small ditches through which it swiftly runs into Lake Victoria, carrying with it pollution and heavy metal-laden sediment (Wasswa, 1997; Mbabazi *et al*., 2010). This not only pollutes the Lake but also increases the risk of ground water pollution (Matagi, 2002; Banadda *et al.*, 2009). Draining of wetlands for agriculture, construction or other forms of wetland modification driven by concentration or expansion of urban environments are associated with significant public health risks such as toxic food contaminants as well as infectious diseases (Patz & Olson, 2008; Nasinyama *et al*., 2010; Horwitz *et al.*, 2012; Fuhrimann *et al.*, 2014).

The current status of wetlands is linked to historical land ownership, population growth, inadequacy of space, urbanization and industrialisation (Davis, 1993). However, key aspects such as the extent and dynamics of encroachment activities, the hazards faced by wetland communities, and the adaptation mechanisms they employ to reduce vulnerability are only sparsely documented. This study has contributed to addressing a number of knowledge gaps including but not limited to, generating up-to-date spatiotemporal extents and dynamics of human activities in wetlands at a local scale (Chapter 4); providing insight into the factors associated with exposure to hazards and vulnerability to hazards among wetland communities (Chapter 5); and providing insight into preferences and ability of affected communities to adapt to hazards (Chapter 6).

1.1 Statement of the problem

There has been unprecedented encroachment on wetlands in Uganda over the past couple of decades (Huising, 2002). Lately, the capital, Kampala, is experiencing problems of flooding and heavy contamination of water sources whenever it rains. This is partly attributed to encroachment on wetlands around the city (Vermeiren *et al.*, 2012). The city is adjacent to Lake Victoria and is drained by four main wetlands which have been grossly encroached upon (MWE, 2012). These wetlands act as pollution buffer zones for the lake as well as flood attenuation zones for the city (Kaufman, 1992; Zeng & Chen, 2011). Draining of wetlands is associated with significant public health risks such as toxic food contaminants (Nasinyama *et al.*, 2010) as well as infectious diseases (Patz & Olson, 2008; Horwitz *et al.*, 2012) resulting from contamination of water sources. Flooding and flushing of sludge out of shallow pit latrines spreads pollution to water and places where children play, thus increasing the risk of helminthiasis (Fuhrimann *et al.*, 2014, 2015; Katukiza, *et al*., 2014). Waterlogging also provides breeding grounds for mosquitoes that spread malaria and yellow fever among others.

Encroachment activities include draining the wetlands for crop farming, construction of dwellings or commercial establishments and other livelihood activities (WMD-MWE, *et al*., 2009). Encroachment has subsequently triggered a range of conservation, restoration and wise use efforts from various actors (Kiwango & Moshi, 2013; van Dam *et al.*, 2013). Given the fact that urban development preceded structural planning in many parts of the city (UN-Habitat, 2007a), enforcement of development control is quite complex (Isunju *et al*., 2011).

This study assessed the spatiotemporal extent of encroachment activities using very high resolution remote-sensed data on the Nakivubo urban wetland in Kampala. In addition, based on a survey among wetland communities, the factors associated with exposure to the principle hazard of floods, perceived vulnerability to floods and adaptation mechanisms to minimize vulnerability and to exploit wetland benefits as well as their preferences and ability to adapt were assessed. Insights from previous studies and the findings of this study should inform the present and future sustainable urban wetland management and risk reduction interventions.

1.2 Research questions

Given the problem stated above, the following research questions were formulated to guide the study:

- To what extent have human activities transformed wetlands?
- What hazards are associated with encroachment on wetlands?
- What factors are associated with vulnerability to hazards?
- What benefits do communities in wetlands associate with their location?
- What factors are associated with the preference to adapt to reduce vulnerability in wetlands?

1.3 Aim and objectives

1.3.1 Aim of the study

This study aims to assess the spatiotemporal extent of encroachment on wetlands, and the associated hazards, vulnerabilities and adaptive capacity among wetland communities so as to inform risk reduction endeavours.

1.3.2 Specific objectives

1) Quantify and map at very high resolution the spatiotemporal extents of land cover in the Nakivubo wetland in 2002, 2010, and 2014.
2) Quantify and map land cover changes in the Nakivubo wetland between the periods 2002-2010, 2010-2014, and 2002-2014.
3) Assess factors associated with exposure and vulnerability to hazards among wetland informal communities in Kampala.
4) Evaluate the adaptive capacity of wetland communities to minimize vulnerability to hazards and to exploit opportunities that exist.

1.4 Research design and study area

The study applied two designs: Longitudinal spatial analysis and a cross-sectional survey. The longitudinal design quantified land cover for three dates and analysed changes over a period of 12 years, while the cross-sectional survey design applied a mix of methods, using both qualitative and quantitative techniques.

The cross-sectional survey was done in informal communities occupying four wetlands (i.e. Nakivubo, Kinawataka, Kansanga, and Kyetinda/Ggaba) that drain in the inner Murchison Bay of the Lake Victoria in Kampala, Uganda as shown in Figure 1.1 below. The Bay is the main source of water supply for Kampala city. The wetlands receive storm runoff from the extensively paved urban area. The study area lies within the equatorial belt with a moist sub-humid climate and has bi-annual rainy seasons: March to May and September to November. However, studies have reported increase in seasonal variability (Lwasa, 2010; Ide *et al.*, 2014; Nsubuga *et al.*, 2014; Tolo *et al.*, 2014; Cooper & Wheeler, 2015; Buotte *et al.*, 2016). In Uganda, given its dependence on rain-fed agriculture, critical climate-related changes are with regard to increased/reduced precipitation and increasing temperature (Orlove *et al.*, 2010; UN-Habitat, 2012; Ide *et al.*, 2014; Nsubuga *et al.*, 2014; Tolo *et al.*, 2014). The mean annual rainfall is about 1500 mm and mean temperature is about 22.7 °C. The rains are linked to the Inter Tropical Convergence Zone (ITCZ), altitude, local topography as well as the lake; with short-duration tropical thunderstorms being particularly common around Lake Victoria and Kampala area (Kansiime & Nalubega, 1999). Given the extensive paving, compacted ground and roof area in urban neighbourhood, the thunderstorms are often followed by heavy runoff and flooding in low-lying areas.

The longitudinal (spatiotemporal) analysis was limited to the Nakivubo wetland, which covers approximately 5.29 km^2 on the northern shores of Lake Victoria's inner Murchison bay in Kampala. The wetland plays a critical role; it receives most of the wastewater from Kampala city, the adjacent industrial area and the sewage treatment plant. Much of its natural vegetation has been transformed into crop fields, settlements and industrial establishments. The natural wetland vegetation in the permanently inundated part is predominantly *Cyperus papyrus* and *Miscanthidium violaceum* (Kansiime *et al.*, 2007), which serves as a natural waste water treatment system and flood attenuation zone. The wetland discharges only about four kilometres from the city's water in-take in Lake Victoria's inner Murchison bay (Banadda *et al.*, 2009). The extent used in the analysis was clipped from the imagery using the Nakivubo wetland boundary obtained from the Wetlands Department at the Ministry of Water and Environment. Further details about the Nakivubo wetland are provided in Chapter 4.

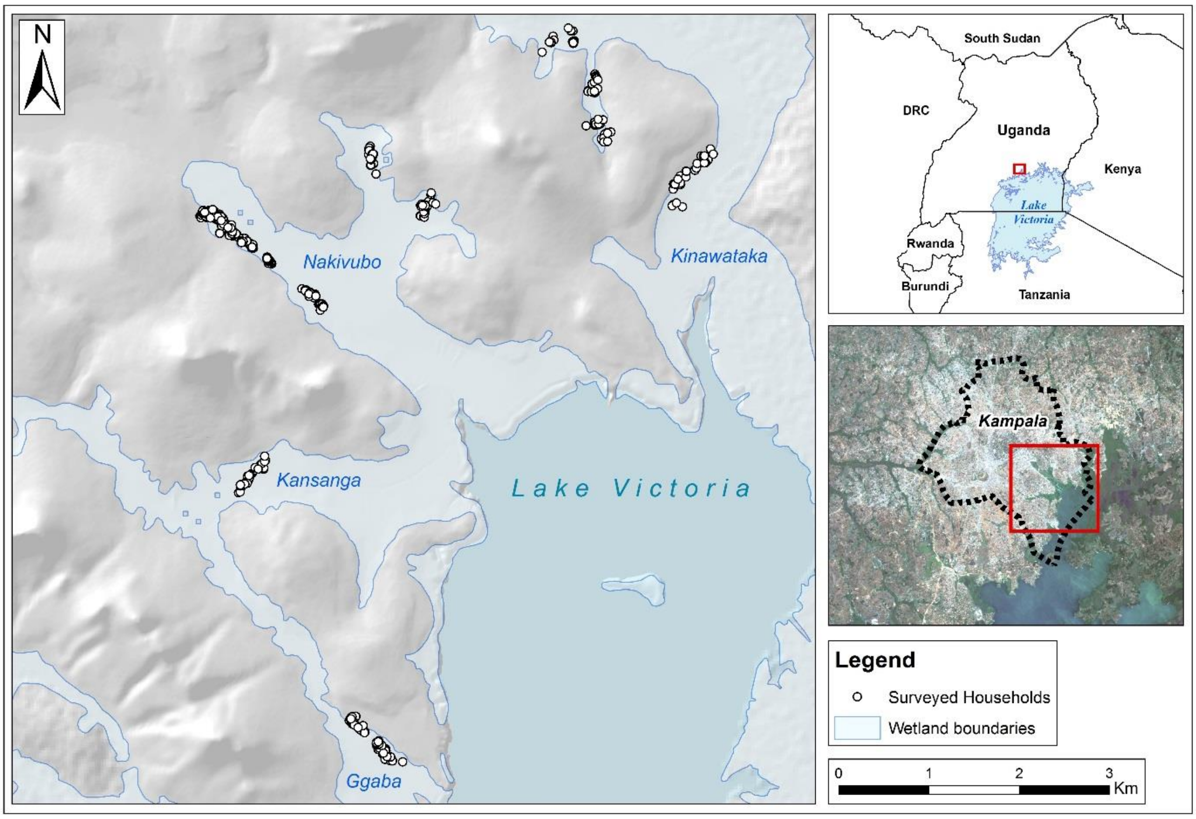


Figure 1.1 Map of study area showing sampled households and wetlands in Kampala

1.5 Thesis structure

This thesis is structured into eight chapters as summarised in Figure 1.2 below. Chapter 1, which is an introductory chapter, provides a general background to the thematic issues i.e. encroachment on wetlands, associated hazards, vulnerabilities and adaptations, and explains the local setting of the study. This chapter also conceptualises the research problem, presents the study aim and objectives, and lays out the research design. Chapter 2 provides a conceptual framework, reviews the relevant research, defines key concepts and provides an overview of wetland products, services and attributes. This is followed by a discussion of contextual drivers and pressures underlying the transformation of wetlands, and the resulting exposure to hazards and effects. In addition, the review examines the application of remote sensing to assess the status of wetlands, as well as the risks in flood-prone areas, and the theory and practice of community adaptation, highlighting critical research gaps to which this study makes its contribution. Chapter 3 provides an overview of the methods used to achieve the study objectives. The data used, and the GIS and remote sensing techniques applied for spatiotemporal analysis of land cover changes are described. Then, details of the quantitative survey and qualitative methods used as well as the ethical procedures observed are explained.

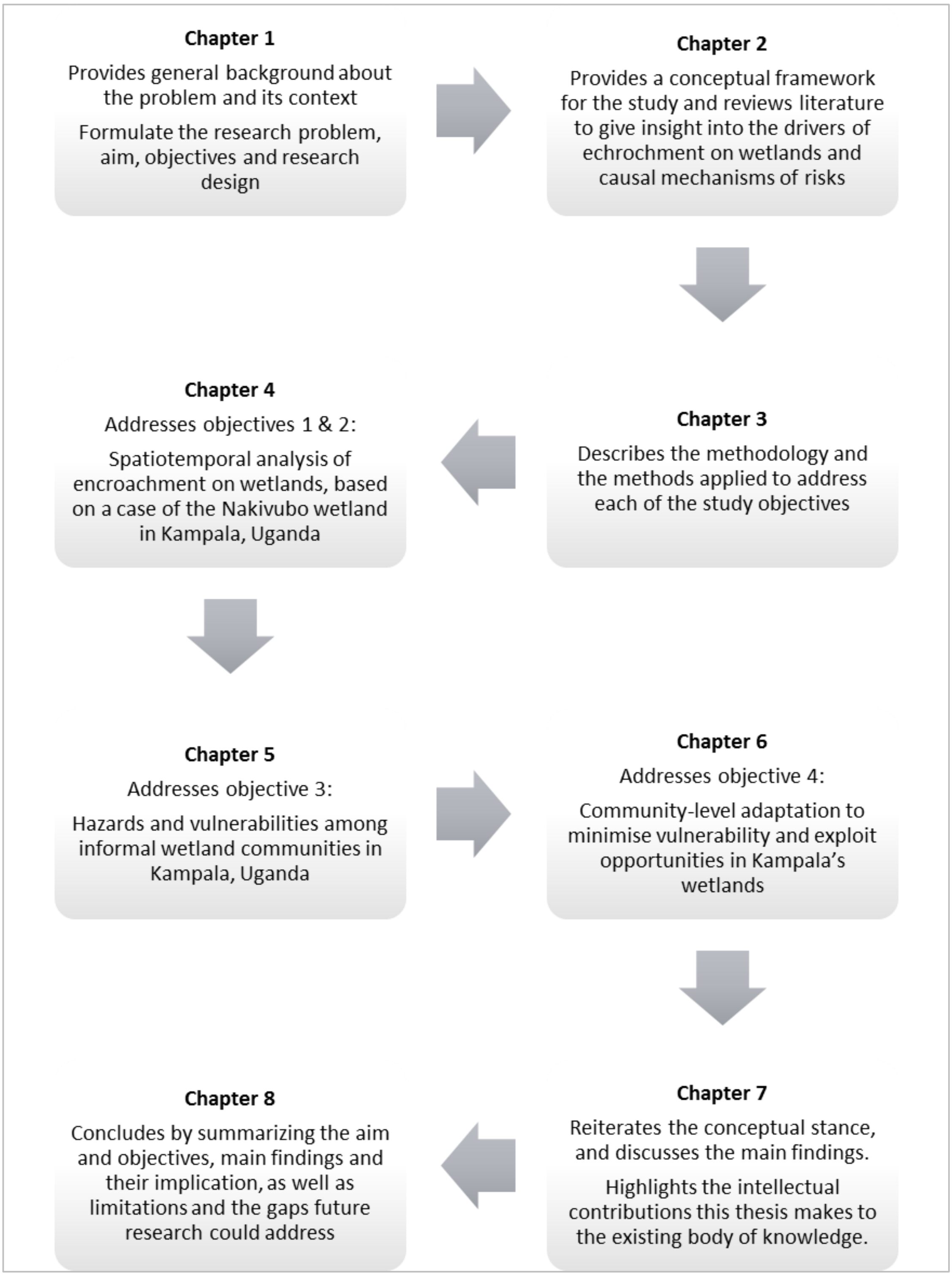


Figure 1.2 Research agenda and chapter layout

Research objectives 1 and 2 are addressed in Chapter 4, where land cover and land cover changes in the Nakivubo wetland are quantified and mapped. Spatiotemporal land cover changes are cross-tabulated and conversions from natural wetland vegetation are shown in spatially congruent land cover change maps providing a multi-temporal analysis of changes from 2002, 2010 to 2014. Objective 3 is addressed in Chapter 5, where a range of hazards, perceived vulnerabilities and associated factors among wetland communities in Kampala are analysed. Chapter 6 addresses objective 4 as it discusses benefits informal wetland communities in Kampala derive from their location in the wetland and how they adapt to minimise vulnerability to hazards such as floods and disease vectors. It focuses on the mechanisms, preferences and ability to adapt.

Chapter 7 reiterates the conceptual stance taken in this study, provides a synthesis of the results in the light of the conceptual framework and the study aim and objectives, and encapsulates the intellectual contributions this thesis makes to the existing body of knowledge and practice. Chapter 8 provides conclusions and implications of the main study findings, as well as limitations and directions for future research.

Additional materials appended to this thesis include:

a) The household questionnaire (Appendix A) used for the survey
b) The key informant interview (KII) guide (Appendix B)
c) The focus group discussion (FGD) guide (Appendix C)
d) The Letter of consent for study participants (Appendix D)
e) Approval from Stellenbosch University's Research and Ethics Committee (REC) (Appendix E)
f) Approval from Makerere University's Higher Degrees, Research and Ethics Committee (HDREC) (Appendix F)
g) Approval from Uganda National Council for Science and Technology (UNCST) (Appendix G)
h) Approvals for information sharing from Kampala Capital City Authority (KCCA) and from the Department of Wetlands Management (DWM) (Appendix H)
i) Google Earth archive imagery (Appendix I).

Chapter 2: Conceptual framework and literature review

2.1 Introduction

This Chapter provides a conceptual framework and reviews previous research relevant to the themes of interest in this study, i.e. encroachment on wetlands, associated vulnerabilities and adaptations. First, definitions of key concepts and an overview of wetland products, services and attributes are provided. Then risks associated with encroachment on wetlands are illustrated in a "Driving force-Pressure-State-Exposure-Effect-Action" (DPSEEA) framework[1] adapted from Briggs (1999). Following from these two frameworks, the rest of the discussion centres on the interaction between man and wetlands in an urban setting; highlighting some of the underlying drivers of encroachment on wetlands such as urbanisation and population growth, land tenure dynamics, the draining of wetlands for mosquito control, conversion of wetlands for agriculture, pollution and the lack of an integrated management for wetlands. In addition, the use of remote sensing data as well as limitations of resolution at a local scale are examined. The local conditions shaping the status quo; i.e. the risk of flooding in informal low-lying poorly serviced settlements, and the theory and practice of community adaptation are discussed. Finally, the review highlights the critical research gaps to which this study makes its contribution.

2.2 Conceptual Framework

Oelofse (2003) defines the environment as comprising both natural and social components. Production and socio-economic development often occur at the cost of environmental resources, as such, there exists a dialectic relationship between society and nature. Society is often engaged in practices that continually change nature (Plant, 2001). Land is a well-known factor for production. Currently, almost a half of the land surface on earth has been transformed by human action (Vitousek *et al*., 1997). The consequence of this is increased environmental

---

[1] The DPSEEA framework was developed by the WHO to illustrate connections between elements/indicators in the causal chain of environmental-related public health effects and how actions/interventions target these elements (Briggs, 1999; Schirnding, 2002; Hambling *et al.*, 2011).

risk, which is “the potential of detrimental outcome resulting from the interaction of the human and natural worlds” (Oelofse 2003: 262). Environmental risk has over time triggered increasing environmental concerns and ideological convergence towards sustainable development. Critical realist perspective on risk suggests that risk events are shaped by causal mechanisms and specific local conditions (Oelofse, 2003), hence, hazards such as floods can be reduced by understanding the environment and the forces that shape it. Human interactions with nature as highlighted by Plant (2001) and Oelofse (2003) are complex and socially embedded, but simplistically they could be viewed as a cyclic process illustrated in Figure 2.1 below. This cyclic process forms a conceptual lens through which this research proceeds. The elements conceptualised in the framework include:

(a) *Interactions:* The interaction between natural and the social components of the environment as described above. The natural component provides resource base, space and food for the social component to thrive and multiply.

(b) *Pressures:* The pressures within the social component as a result of increase in population, consumption and waste generation are vented on the natural component of the environment.

(c) *Environmental degradation:* When the ability of nature to handle the pressures from the social component is exceeded, nature is degraded, its natural state is transformed and its attributes compromised.

(d) *Hazards and vulnerability:* The degraded state of the environment precipitates exposure to hazards, which affect vulnerable components of the environment.

(e) *Adaptation and resilience:* The affected components adapt and build resilience so as to minimize their vulnerability to hazards and increase the ability to exploit the benefits and resources from nature.

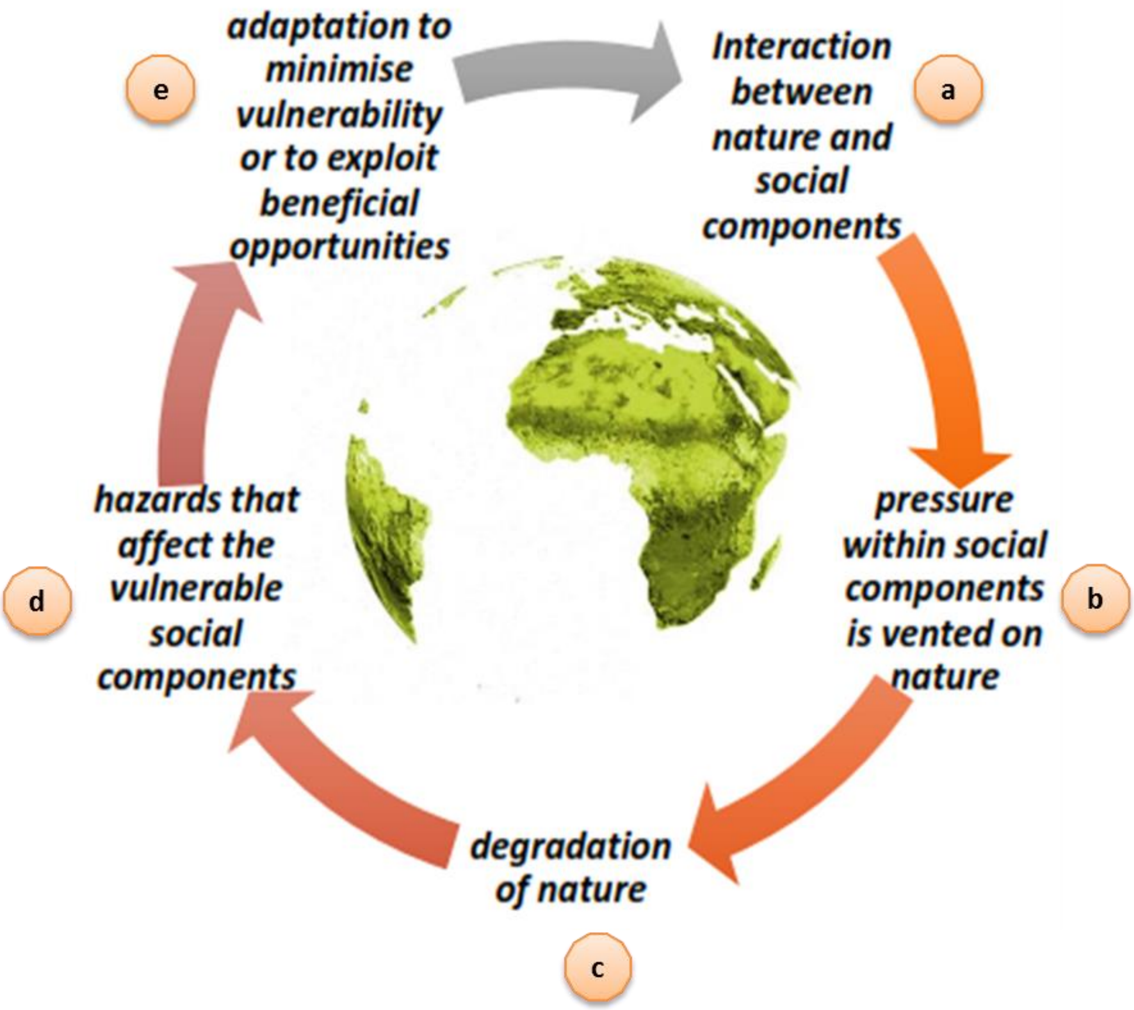


Figure 2.1 A conceptual human interaction with nature: pressure, degradation, hazards and adaptations

Following from the conceptual framework summarized above, this study focuses on human interaction with nature by analysing how wetland areas in Kampala have been transformed. Then, based on the understanding that human activities compromise the ability of the wetland to provide ecosystem services, which consequently precipitates exposure to hazards, the present study assesses exposure to hazards and vulnerability of affected communities. Finally, premising on the notion that adaptation minimises vulnerability and allows for the exploitation of benefits and opportunities, the benefits and opportunities from the wetland, the adaptation mechanisms against hazards, and the preference and ability to adapt are assessed.

2.3 Definition of wetlands

Wetlands are among the vital ecosystems under threat by human activities. The international treaty for their conservation, which is popularly known as the Ramsar Convention seeks to conserve and sustainably utilize wetlands, recognizing their invaluable ecological functions in addition to several societal benefits and products they provide. According to the Ramsar Convention, wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs (Ramsar, 2010). Depending on the context, an appropriate definition for that context is often adopted. For example, Uganda's National Policy for the Conservation and Management of Wetland Resources defines wetlands as areas where plants and animals have become adapted to temporary or permanent flooding (The Republic of Uganda, 1995).

2.4 Wetland products, services and attributes

Wetlands provide a myriad of products, services and attributes which have been widely documented (Kansiime & Nalubega, 1999; Rebelo *et al*., 2009; Rebelo, McCartney & Finlayson, 2010; WMD-MWE *et al.*, 2009; Kakuru *et al*., 2013). In Uganda for example, wetland products include but are not limited to water, food (plants, fish and wildlife), land (for farming, grazing and forage), craft and building materials, plant mulching material and medicines. Wetland services include flood attenuation, drought control, groundwater recharge, erosion and sediment control, wastewater treatment, carbon retention, climate modification, habitat function, eco-tourism, and transport. Finally, wetland attributes include biodiversity, genetic resource conservation, aesthetics and cultural heritage (MWE, 2001; Kansiime *et al.*, 2007; Kaggwa *et al.*, 2009). While many of the wetland products can be commodified for economic evaluations, it is important to note that not all the services wetlands provide can be monetarily quantified. An example here is the Nakivubo urban wetland in Kampala, which was economically valued at about USD 1.373 million per year in 2002 (Schuyt, 2005), yet its true value maybe far beyond what was quantified. Services such as water purification, flood attenuation, fish breeding, climate moderation and other hydro-ecological functions are often underestimated or not monetised at all, and are not factored in where decisions are based on direct economic returns.

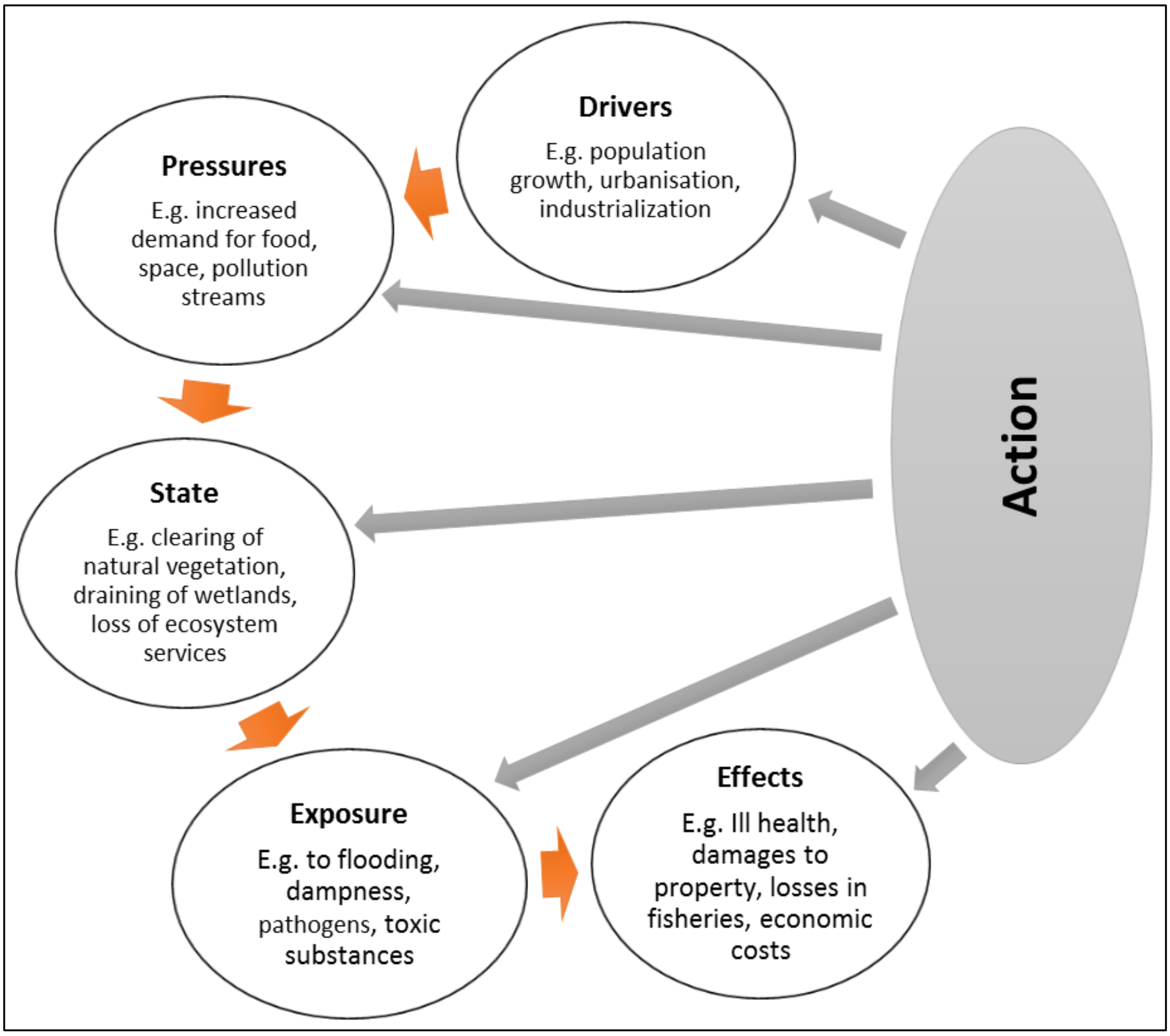
With increasing demand for their products and the opportunities they provide, wetlands are under pressure from their competing users. The rate of loss of natural wetlands has reached critical levels, let alone the complexity of restoring degraded ones (Ramsar, 2010; Lukooya *et al.*, 2013). The conversion of wetlands for agriculture, commercial developments, settlements and other immediate uses are occurring at the cost of vital ecosystem services (Namakambo, 2000; Banadda *et al.*, 2009; Kanyiginya *et al*., 2010; Lukooya *et al.*, 2013). When ecosystem services are lost, vulnerable communities and water resources get exposed to hazards, resulting in a ripple of negative outcomes, such as pollution, disease outbreaks, loss of fish productivity, increased water treatment costs etc. The Nakivubo wetland, for example, has for more than 50 years received sewage effluent and pollution-laden urban runoff, however its capacity to treat these wastewater streams has significantly dwindled (Kansiime & Nalubega, 1999). The government of Uganda, through the National Water and Sewerage Cooperation (NWSC) has been constructing wastewater treatment plants to compensate for the diminished capacity of wetlands. However, such engineered systems are costly to construct and operate.

Naturally, wetlands can purify waste water, at least to a considerable extent. This service is provided freely for natural wetlands but can be quite costly when wetlands have to be constructed or even worse when the treatment system is entirely an engineered one. While the capacity of wetlands to satisfactorily treat waste water is not absolute, a combination of engineered systems and wetlands can significantly reduce the cost of waste water treatment (Lukooya *et al.*, 2013). Furthermore, wetlands are well known for their ability to absorb, store and gradually release water thereby controlling floods and drought (Horwitz *et al.*, 2012; Munroe *et al.*, 2012).

2.5 Adapting the Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) framework for encroachment on wetlands

Ecological and societal risks associated with wetland loss are on the increase; prominent among which are flooding, pollution, and spread of Water, Sanitation and Hygiene (WASH) related diseases. Given the vast number of ecosystem services provided by wetlands, such as flood attenuation, water purification and climate moderation, wetlands help to absorb climate related shocks and stresses. In urban areas, wetlands help to counter the urban heat island effect by providing cool breezes. Wetlands also act as carbon sinks, hence contribute to lowering the air pollution. Degradation of wetlands reduces their ability to provide the above mentioned ecosystem services, which leads to exposure to hazards. Given that it is the poor and vulnerable communities who are most in touch with, and directly depend on environmental resources for their livelihoods, the impacts of hazards on vulnerable communities are ultimately more significant. As observed by Smit & Pilfosova (2001), the adaptive capacity of communities is determined by their socioeconomic characteristics and is a necessary condition for reducing vulnerability. These aspects can be conceptualised in a “Driving force-Pressure-State-Exposure-Effect-Action” (DPSEEA) framework (Figure 2.2 below), illustrating how driving forces within society generate environmental pressures, leading to alteration of the state of ecosystems, human exposure to hazards, and eventual effects. Actions, through adaptation and mitigation, can be taken at each step in the causal chain, to help manage the driving forces, and reduce negative outcomes (Briggs, 1999).

In the context of the present study the elements in the DPSEEA framework could include the following: *Driving forces* (D), such as population growth, urbanisation, and industrialization. *Pressures* (P), e.g. increased demand for environmental resources, food, space and increased pollution streams. *State* (S), refers to the transformation from the natural state of the environment such as the clearing of natural wetland vegetation, draining of wetlands, altering of wetland attributes leading to loss of ecosystem services. *Exposure* (E), with regards to the hazards associated with encroachment on wetlands including floods and waterlogging, dampness, disease vectors, pathogens and toxic substances. *Effects* (E), effects of the hazards which could range from damage to property, economic losses, high water treatment costs, ill health and in extreme circumstances deaths. *Action* (A), actions or interventions targeting each of the elements in the chain, including but not limited to wetland conservation and restoration, adaptation, hazard mitigation and resilience building as well as policy interventions.



Source: Adapted from Briggs (1999)

Figure 2.2 The Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) framework

Following from the DPSEEA framework, the subsequent sections in this review examine the *drivers* of encroachment on wetlands in the study area (Subsection 2.6), the societal *pressures* of increased demand for wetland resources and increased waste generation (Subsections 2.6.2 and 2.6.5), conversion from the natural *state* of wetlands (encroachment) (Subsections 2.6.3, 2.6.4, 2.6.6 and 2.7), *exposure* to hazards by vulnerable elements, the *effects* of hazards and *actions* to reduce risk (adaptation) (Subsection 2.8). It is worth noting here that while the DPSEEA framework may not be the most appropriate for natural hazards such as earthquakes and wide-spread severe floods, where the concept of pressure is less meaningful (Briggs, 1999), in this review, the framework has been used in the context of localized urban flooding which is largely influenced by human activities. Also, the DPSEEA framework presents a seemingly linear relationship between the elements in the causal chain, yet in reality, the various interactions are more complex and may occur at different levels (Schirnding, 2002). Despite these shortcomings, the DPSEEA framework serves to represent in a more clear way the connections between the factors affecting health and the environment (Schirnding, 2002; Hambling *et al*., 2011). Furthermore, the DPSEEA framework takes a holistic approach to the issue of environmental change, effects thereof and targets the interventions. By targeting elements in the causal chain of effects, interventions would not only improve environmental quality but reduce the ripple effects that would have resulted from the transformed state of the environment (Hambling *et al*., 2011). Unlike other models such as the Pressure and Release Model for Climate Change Hazards, which might be appropriate in disaster risk studies (Awal, 2015), the DPSEEA framework can be applied even in non-disaster scenarios as is the case in this study.

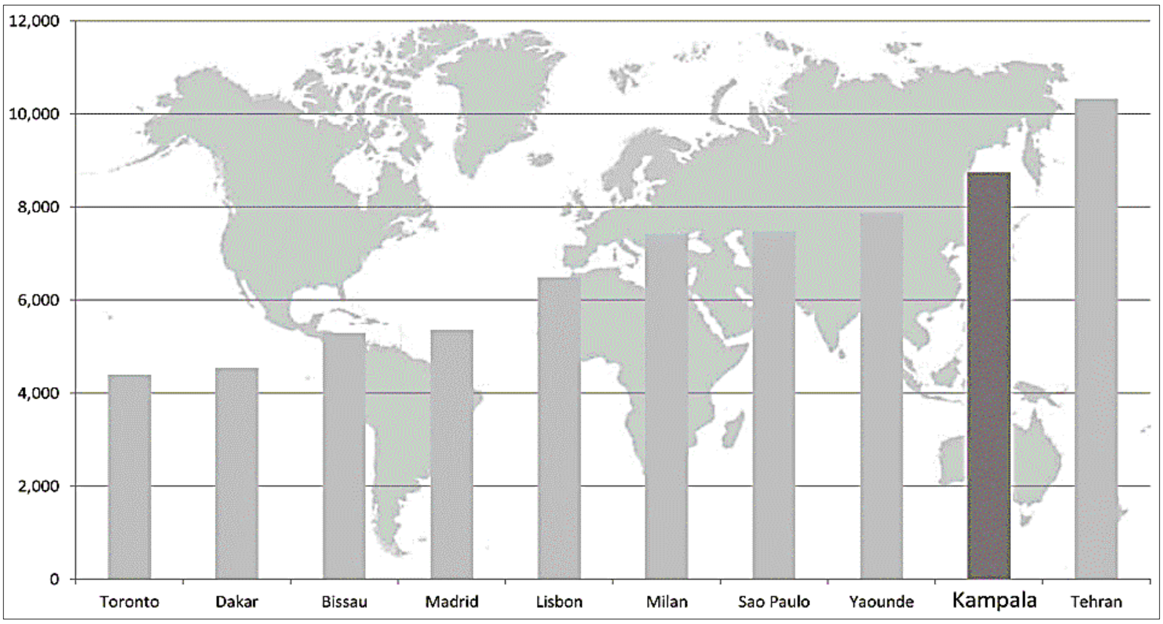
2.6 Causal mechanisms of encroachment on wetlands

This section examines the drivers of encroachment on wetlands. It highlights some generic drivers and details those contextual to the study area such as population growth and urbanization, the land tenure dynamics in Kampala, the drainage of wetlands for mosquito control, the conversion of wetlands for agriculture, the pollution of wetlands, and the lack of an integrated management for wetlands.

2.6.1 Population growth and urbanisation

Currently, more than half of the world's population live in urban areas and this figure will likely rise to 75% in the next 50 years (United Nations Department of Economic and Social Affairs Population Division, 2015). While Africa's population is still largely rural, over the last two decades, Africa has experienced the highest urban growth rate of 3.5% per year compared to rest of the world; a trend expected to continue into 2050 (United Nations 2014). According to UN-Habitat, compared to other regions, sub-Saharan Africa has the highest rate of urbanisation and an equally high rate of slum growth (UN-Habitat, 2007a). Uganda has one of the fastest growing populations in Africa; the annual population growth rate is 3.03% (UBOS, 2014). The total fertility rate (TFR)[2] is high; up to 6.2 children per woman in 2011, having declined from 6.7 in 2006 (UBOS, 2011, 2014). With nearly half of the country's population under the age of 15 years, there are challenges of low productivity, and high consumption and dependency (Baguwemu *et al*., 2013). Although the fertility rate in rural areas in Uganda is nearly three times higher than in urban areas (UBOS, 2011), the high rate of rural-urban migration, especially among the youth, leads to urban population growing much faster. And when the productive segment of the population migrate to urban areas, the elderly who remain in rural areas are too weak to produce sufficient food to feed the ever-growing urban population. Literature around food security suggest that urban agriculture is a key resilience and livelihood strategy for urban dwellers (Smit *et al*., 2001; Lwasa, *et al et al*., 2012; Gyasi *et al*., 2014; Sabiiti *et al*., 2014). Currently, Uganda’s urban population growth rate is 5.1% compared to the national population growth rate of 3.03%. Kampala city alone constitutes up to 25% of Uganda’s urban population (UBOS, 2014). Figure 2.3 below shows a snapshot comparison of Kampala’s population density (i.e. nearly 9,000 people per square kilometre) relative to other global cities. The population pressure in Kampala has resulted in overcrowding, development of informal settlements and slums, and encroachment on reserve lands and wetlands within and around the city (Nyakaana *et al*., 2007).

[2] Total Fertility Rate (TFR) is the total number of children a woman would have during her lifetime given the current observed age-specific rates.



Source: (KCCA, 2014)

Figure 2.3 Kampala's population density relative to other cities

To a large extent, rural-urban migration has been a major driver of encroachment on wetlands. The majority of Uganda's rural people are peasants[3], who try to practice similar livelihood strategies when they migrate to urban areas (Byaruhanga & Ssozi 2012). The concept of urban agriculture is gaining increasing attention as a measure of boosting food security in urban centres (Smit *et al.*, 2001; Lwasa *et al.*, 2012; Waters, 2013). The negative impact of urban agriculture is however unveiled when it is done at the expense of other vulnerable environmental resources, such as wetlands and water bodies.

2.6.2 Land tenure dynamics in Kampala

The nature of land-use is closely linked to its ownership. Land tenure in Kampala is a consequence of its traditional and colonial history (KCCA, 2014). Until the beginning of the colonial era and subsequently the signing of the 1900 Buganda Agreement, land ownership in Uganda was largely communal (Banadda *et al.*, 2009; Obbo *et al.*, 2013). The 1900 Agreement parcelled out land for development of the then Kampala town, land for the Kabaka (king of Buganda), land for colonial settlers (British Crown land) and forest and "wastelands"

[3] In the study context, peasants refers to an occupation category for small-scale or subsistence farmers

(including wetlands). Eight years later, private land ownership was enacted into law through the 1908 land Law (Banadda *et al.*, 2009). Peasants who occupied and cultivated the lands then had not been catered for until they revolted in 1927, and were then recognised as tenants (occupants) of mailo[4] lands owned by chiefs or the Kabaka. Private land ownership in Uganda was concretized in 1955 by the Royal Commission which called for land registration throughout the country. More land reforms were attempted in 1969 and 1975. The 1975 land reform radically decreed that all land in Uganda be vested in the state in trust for the people to facilitate its use for economic and social development. The decree led to the establishment of the Uganda Land Commission which became the principal authority overseeing land ownership, occupancy and registration until 1995 when the new constitution introduced new land reforms (Omolo-Okalebo, 2011).

Although wetlands like other natural resources were held in trust by government for the common good of all citizens, it was not until after the 1995 constitution that control over their use became an enforceable Act of parliament. The provisions of the 1995 constitution were to be implemented through land reforms laid out in the 1998 Land Act (Apuyo, 2006). The objectives of the 1998 Land Act included providing security of tenure to all citizens, reducing poverty, reducing conflict over land, promoting the land market, proper planning and co-ordinated development of urban areas, sustainable land-use and development throughout the country to conserve the environment, redressing historical imbalances and injustices in the ownership and control of land, and government acquisition of land in the public interest and public use, public safety, public order, public morality or public health (Rugadya, 1999). The Act equated primary (ownership) rights of the registered owners with those of the tenants (occupancy) rights, and as such gave powers of ownership to occupants who had stayed or used any land for 13 years or more. This land reform has been blamed for the significant loss of wetland areas and other reserve lands to private owners (Banadda *et al.*, 2009).

The land sector in Uganda has thus been dealing with several challenges including the failure to enforce land-use planning especially because planning has not kept pace with the rapid

[4] Mailo land tenure refers to a form of land ownership system in Uganda which was introduced by the 1900 land parcelling agreement between the British colonial government and the king of Buganda (in the central region of Uganda). The land that was appropriated to the king, his notables and local chiefs in form of square miles was referred to as “mailo land”. Over time, mailo land became subdivided and its owners were issued certificates of ownership (Rugadya, 1999; Giddings, 2009).

urbanization and population increase. Also, the task of redressing land grievances and historical injustices extending back to the colonial era, human settlement and environment conflicts, corruption, inadequate supply of serviced land for urban and industrial development among others complicate the process of resolving ownership matters (Obbo *et al.*, 2013). In an effort to attract investors, create jobs and fight poverty, the government has been reclaiming significant portions of wetlands and forest reserves to create industrial parks, road networks and more recently the plan to transform wetlands in the Kampala city into urban parks (Banadda *et al.*, 2009; KCCA, 2012a). Equally, the people who have encroached on wetlands endeavour to find justification and security of tenure. The 1995 Uganda constitution recognises four land tenure systems, i.e. customary, mailo, freehold and lease hold. In Kampala, about 60% of the land is held under the mailo-land tenure system while the remaining 40% is under customary and freehold tenure (Kiguli & Kiguli, 2004). These several land tenure systems complicate planning, especially where ownership is not by government (UN-Habitat, 2007b; Omolo-Okalebo, 2011). Lately, with renewed efforts to restore and wisely use wetlands, the parliament of Uganda has been pushing for cancellation of all land titles obtained after 1995 in wetland areas, and strict monitoring to ensure wise-use for occupants whose land titles were obtained before 1995.

2.6.3 Draining of wetlands for mosquito control

Draining of stagnant water to eliminate mosquito breeding grounds is one of the popular measures of preventing malaria and other mosquito borne illnesses. In 1914, Simpson – a public health and hygiene scholar - recommended to the colonial government anti-mosquito drainage of swamps around Kampala city and most of the urban centres in the countryside at the time. This recommendation was incorporated in the 1919 planning scheme for Kampala (Omolo-Okalebo, 2011), implemented and later laid out in the Public Health Act in 1935. With time, the drained and seasonal wetlands gradually became inhabited by the natives and rural urban migrants, who had not been included in the land parcelling during the colonial era. In addition, it was deemed unhealthy for colonial settlers to dwell closer to natives, as quoted from Simpson (1916): “a house closer to native huts is unhealthy”, and one of the measures to prevent malaria was living in a house well away from native huts and houses (Simpson, 1916). This is because the natives were perceived by the colonial imperialists to be the hosts for the malaria parasite, as such, malaria prevention strategies included isolation from the natives.

New urban immigrants needed social networks to adapt to the new environment and as such had to dwell with or close to the natives or previous immigrants in the low-lying vulnerable suburbs (Omolo-Okalebo, 2011). The reclamation of wetlands for settlement has since continued as evidenced by the number of informal settlements in wetlands (UN-Habitat, 2007b; Vermeiren *et al.*, 2012; Allen *et al.*, 2016).

2.6.4 Conversion of wetlands for agriculture

Agricultural activities are a major threat to wetlands the world over (Rebelo *et al.*, 2009; Nagabhatla *et al.*, 2010). Some of the world's most popular foods, for example rice, sugar cane, coco yams and vegetables thrive well in saturated soils and hence are largely grown in wetlands (Verhoeven & Setter, 2010). In Uganda, the increasing demand to produce more food, coupled with the dependence on rain-fed agriculture are estimated to have driven up to 30% loss in Uganda's total wetland cover between 1994 and 2009 (Turyahabwe *et al*., 2013). Climate variability in terms of reduced amounts of rainfall results in water stress or even drought due to the shrinking of water tables leading to food scarcity. To counter these effects of reduced rainfall amounts and prolonged dry seasons, farmers reclaim wetlands for crop cultivation (UN-Habitat, 2012). In cities, urban agriculture is increasingly gaining attention in the framework of sustainable cities, which argue that a sustainable city should be able to produce food internally to boost food security of its inhabitants (Smit *et al.*, 2001; Gyasi *et al.*, 2014; Sabiiti *et al.*, 2014). Due to limited space, most of the urban agriculture in Uganda takes place in wetlands. In Kampala, the moist soils in wetlands are also nutrient-rich because of the waste water discharged from the urban areas; they hence support crop farming throughout the year (Kabumbuli & Kiwazi, 2009; Lwasa *et al.*, 2012; Lukooya *et al.*, 2013; Fuhrimann *et al.*, 2014). Clearing of the natural wetland vegetation and subsequently draining the marsh for cultivation alters the unique attributes of wetlands and consequently compromises their ecological functions (Kansiime & Nalubega, 1999; Matagi, 2002; Kanyiginya *et al.*, 2010). From an ecological perspective, reclamation of wetlands in Uganda has resulted in the decimation of many wetland dependant animals such as *Sitatunga* antelope, and destruction of breeding sites for fish and birds such as the Crested Crane, which is one of Uganda's national symbols (Balirwa, 1998; Schuyt, 2005; Kansiime *et al.*, 2007; NAPA-Uganda, 2007; Turyahabwe *et al.*, 2013).

2.6.5 Pollution of wetlands

The fact that wetlands are generally located in valleys means that they receive both surface and subsurface waters from the catchments they drain (Kansiime & Nalubega, 1999). In urban areas, storm water following high intensity rains over extensively paved urban surfaces produces powerful surface runoff (Sliuzas *et al.*, 2013; Molina, 2014). With the limited drainage infrastructure; blocked drains and haphazard settlements, the frequency of flash floods in low lying areas increases (Douglas *et al.*, 2008). The runoff from Kampala city and flood waters flush a myriad of point and non-point pollutants down into the wetlands, including industrial pollutants, which increase the toxicity of surface water while others could potentially leach into ground water (Banadda *et al.*, 2009). This is in addition to the sanitation challenges of using pit latrines in areas with a high water table or worse, areas prone to flooding. The consequences of pollution from pit latrines in wetlands have been widely documented, including the spread of Water, Sanitation and Hygiene (WASH) related diseases, pollution of ground water and eutrophication of downstream water resources (Isunju *et al.*, 2011; Isunju *et al.*, 2013; Fuhrimann *et al.*, 2014, 2015; Katukiza *et al.*, 2014; Lutterodt *et al.*, 2014; Nyenje *et al.*, 2014; Nyenje *et al*., 2014). Pollution also affects growth and productivity of natural wetland vegetation. In a study carried out in Ggaba wetland close to the city's water intake, pollution was found to suppress aerial productivity of *Cyperus papyrus* (Kaggwa *et al.*, 2001). *Cyperus papyrus* and *Miscanthidium violaceum* are the dominant natural vegetation species in permanent wetlands in Kampala, and play a vital role in removal of nutrients in waste water from the city before discharging into Lake Victoria's Murchison bay (Kansiime *et al.*, 2007).

2.6.6 The lack of an integrated management for wetlands

Traditionally, communities have always protected their environment through cultural beliefs and norms. Integration of traditional environmental conservation into science and practice is however hindered by the strictness of scientific standards and rigid institutional frameworks of governments (Mercer, Gaillard, Crowley, Shannon, Alexander *et al*., 2012) as well as the time-bound projects which do not last long enough to achieve sustainable community engagement (Nakangu & Bagyenda, 2013). Ingram (2008) and Ostrovskaya *et al*., (2013:135) contend that "the success of wetland management policies may be determined more by local embedding of institutions, which is influenced by local traditions, culture, practices, and infrastructure". Some wetland products are foods, beverages and medicines. These include fruits and vegetables, roots or leaves which are locally used for treatment of various ailments such as skin rashes, snake bites, constipation, and arthritis among others. Wetlands are also a source of materials for building, making fish traps, hand crafts e.g. baskets, mats and other ornaments for sociocultural ceremonies (Chapman *et al.*, 2001). Another example is the local naming of natural resources such as the Lake Nulubaale (Lake Victoria) because it is believed to be the base for the gods of the Buganda Kingdom, and the Nakivubo wetland was named so because the name "Nakivubo" in the local language, Luganda refers to a fishing area. The Nakivubo wetland was endowed with catfish and lungfish which were 'easy meal' for the natives, but also the wetland-lake interface is a famous breeding ground for fish, especially Nile tilapia (*Oreochromis niloticus*) (Balirwa, 1998; Kansiime & Nalubega, 1999). Such benefits could potentially incentivise community-based management of the wetland. Due to the unsustainable use and increased pollution in the wetland, fishing has dwindled and is currently among the least of the Nakivubo wetland's products. As urged by Kansiime & Nalubega (1999), an integrated management strategy for wetlands needs to be adopted, taking into account all stakeholders. Also, raising awareness on conservation of wetlands as a means of adaptation against hazards. This could include putting signposts along wetland boundaries with messages of wetland benefits as has been done in Accra, Ghana (Figure 2.4 below) (Secretariat of the Convention on Biological Diversity 2012).

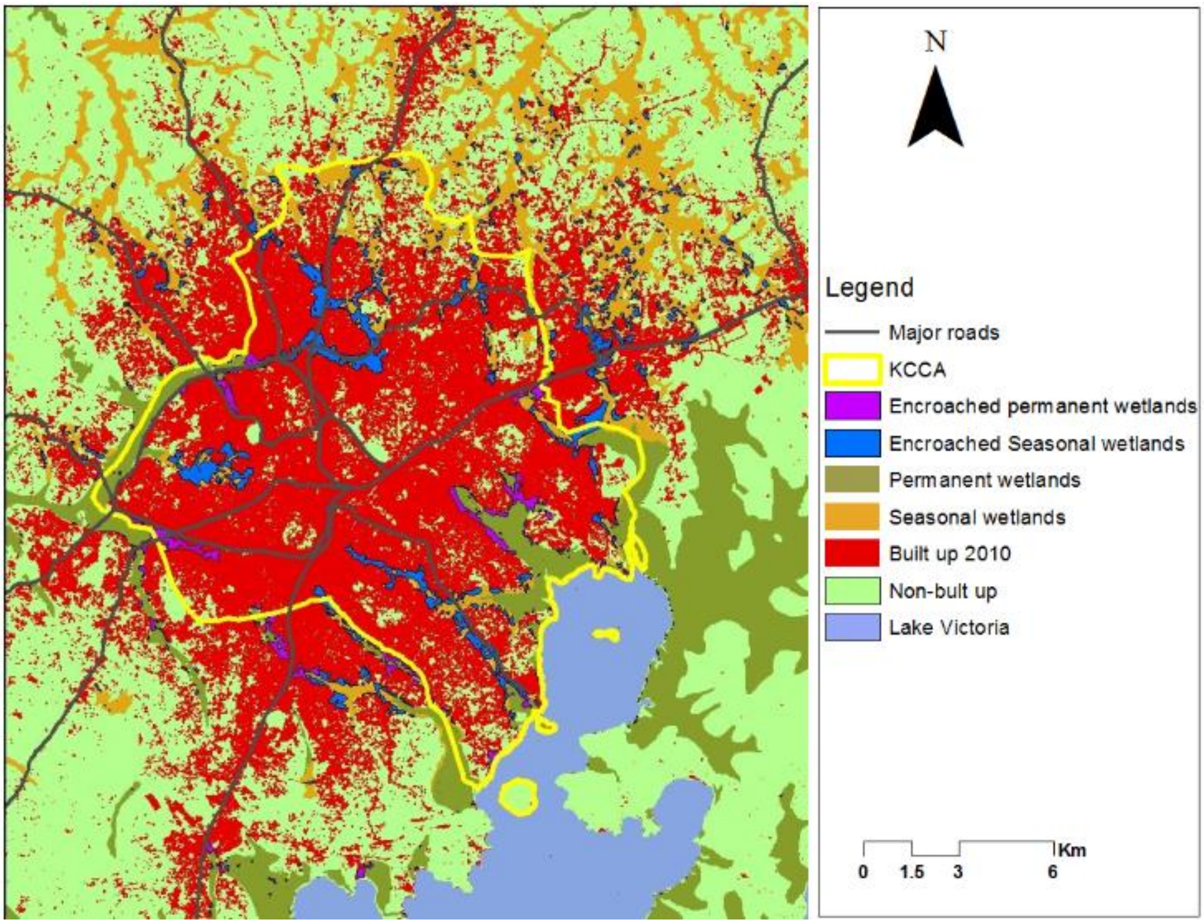
Source: Secretariat of the Convention on Biological Diversity (2012)

Figure 2.4 Raising awareness of wetland benefits in Accra, Ghana

2.7 Remote sensing of encroachment on wetlands

Remote sensing refers to the process of obtaining information about an object or scene without getting in physical contact with the source (Rebelo *et al.*, 2009; Campbell & Wynne, 2011). Remote sensing has been applied to gain information on a vast array of phenomena, though for the interest of this study we focus on assessment of land cover changes. The use of remote sensing data such as satellite imagery and aerial photos to assess land cover/use is among its most prominent and widely documented applications. Image classification simply refers to the process of assigning image pixels or groups of image pixels to certain classes (Campbell & Wynne, 2011). A combination of geographic information systems (GIS) and remote sensing (RS) techniques allows for spatiotemporal analysis and has been applied to assess status of wetlands in various studies (Huising, 2002; McCauley & Jenkins, 2005; Rebelo *et al.*, 2009; He *et al.*, 2011; Twesigye, 2011; Zhang *et al.*, 2011; Pauw, 2012; Cai & Wang, 2013).

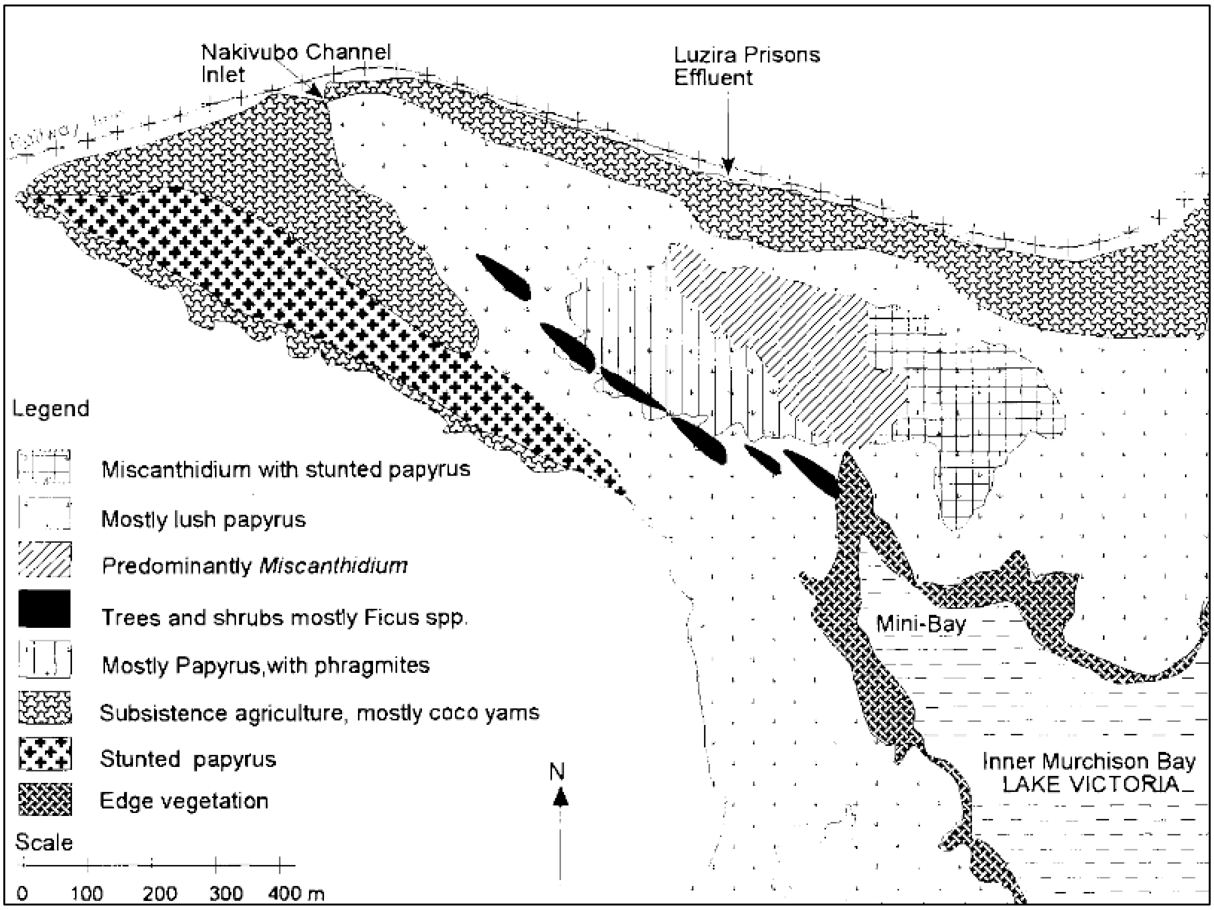
In Kampala, an attempt has been made to quantify and map encroachment on wetlands in the Grater Kampala Metropolitan Planning Area using Landsat imagery over a 21 year period, 1989-2010 (Abebe, 2013). The study quantified built-up area clipped inside wetland boundaries shape file obtained from World Resource Institute. The multi-temporal quantification of built-up area in wetlands showed that 79ha, 183ha, 878ha and 1639ha of wetland area had been built up in 1989, 1995, 2003 and 2010 respectively. Also, it was noted that seasonal wetlands were more prone to encroachment than permanent wetlands. A land cover classification based on Landsat ETM+ image of 2010 in Figure 2.5 below the purple and blue areas show encroachment of built-up area within permanent and seasonal wetlands at city-wide scale in Kampala (Abebe, 2013). However, the resolution of the data set used are too low to provide sufficient detail at a local scale. Furthermore, human activities that constitute encroachment are related to more than just built-up area. The fragmented crop fields and tiny housing units for example may not be captured from low resolution remote sensed data such as Landsat. Analysis based on very high-resolution data, including aerial photos or even preferably multi-spectral satellite imagery would provide sufficient detail of the land cover at local scales (Huising, 2002; Campbell & Wynne, 2011; Pauw, 2012).



Source: Abebe (2013)

Figure 2.5 Map showing built-up area within wetlands at city-wide scale in Kampala, based on Landsat ETM+ data 2010

Following the advent of aerial photography, the first aerial photographs in Uganda were taken in 1955 over several areas of interest to the colonial government for planning purposes. The 1955 aerial photos have since been used as reference for a number of studies including the assessment of root causes of land cover/use change (Mugisha, 2002), wetland monitoring (Huising, 2002), and as basis for topographic maps. A national biomass study conducted by the Forestry Department, in collaboration with the Department of Surveys and Mapping in Uganda also took aerial photos in 1993 (at a scale of 1:25,000) over a large part of the country (Drichi, 2002). The 1993 aerial photos have been used to guide structural planning and the drawing of the 1994 wetland boundaries. Figure 2.6 below shows the 1992 land cover map in the lower part of the Nakivubo wetland, bordering the railway to the north and Lake Victoria to the south (Kansiime & Nalubega, 1999). Also shown in the map are the main pollution streams from the Nakivubo channel and sewage from Luzira prisons. The nature of land cover in the 1992 map can be categorised into two classes: i) wetland vegetation (consisting of *miscanthidum*, papyrus, phragmites and edge vegetation) and ii) cultivated. Noticeably, the wetland vegetation is fairly intact and the cultivated area is mostly along the peripheries of the wetland but was reported to be gradually increasing. The authors in the above study concluded that human activities were continuously degrading the wetland and its ecological values, and needed to be controlled (Kansiime & Nalubega, 1999).



Source: Kansiime & Nalubega (1999)

Figure 2.6 Vegetation cover for lower Nakivubo wetland in 1992

Until this point, this review of literature has provided an overview on the *Drivers* and *Pressures* leading to the state of wetlands in the study context, in line with the element of *State* in the DPSEEA framework presented earlier. The next section focuses on the other elements in the framework, including *Exposure, Effects* and *Actions.*

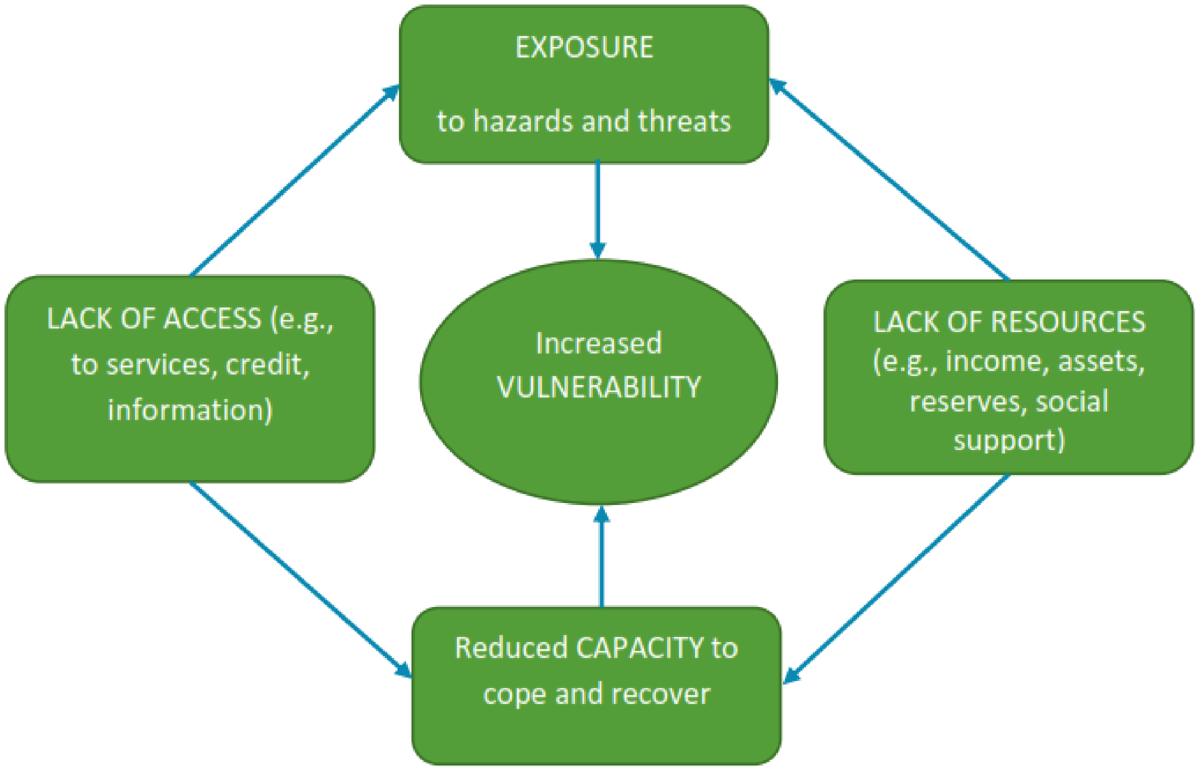
2.8 Hazards, exposure, vulnerability, impacts and adaptation in wetlands

Definitions of the terms hazards, exposure, vulnerability, impacts and adaptation agreed upon under the climate change agenda are compared here with definitions of the same agreed upon under the disaster risk agenda. This comparison is intended to provide a general understanding of these terminologies and the context of their application. The United Nations Framework Convention on Climate Change (IPCC, 2014: 5) defines a ***hazard*** as a "potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources". Similarly, the United Nations International Strategy for Disaster Reduction (UNISDR) also defines a ***hazard*** as "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (UNISDR, 2009: 17). According to IPCC, ***exposure*** refers to "the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected" and ***exposure,*** according to disaster risk literature refers to people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (UNISDR, 2009: 15). ***Vulnerability*** is defined by the IPCC as "the propensity or predisposition to be adversely affected, which also encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." Similarly, ***vulnerability*** is defined by UNISDR as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UNISDR, 2009: 30). ***Impacts*** according to IPCC are "effects on natural and human systems" while according to UNISDR, ***impacts*** may include "loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation" (UNISDR, 2009: 9). Furthermore, ***adaptation*** according to IPCC refers to "the process of adjustment to actual or expected effects" and according to UNISDR ***adaptation*** refers to "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (UNISDR, 2009: 4).

In human systems, adaptation seeks to moderate or avoid harm or exploit opportunities (Smit & Pilfosova, 2001). In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. Although the above definitions are based on climate change and disaster reduction, they have been adopted in this study because of the invaluable role of wetlands in combating climate change. In addition, the definitions are relatively universal and applicable to the hazards, exposure, vulnerability, impacts and adaptation experienced in study context, which include meteorological hazards such as floods, health hazards such as disease vectors, and environmental hazards such as pollution streams. While the concept of adaptation has gained increased attention, its realisation is still a work in progress (Smit & Pilfosova, 2001; Sperling, 2003; Lwasa, 2010; Quade & Lawrence, 2011; Munroe *et al*.., 2012; Odemerho, 2015). Nature has always adapted and will continue to adapt. Utilizing nature's adaptive mechanisms is a potentially promising approach which has until recently not been thoroughly explored. Approaches such as ecosystem based adaptation (EBA), which promote the use of natural mechanisms, such as mangroves as coastline barriers and wetlands as pollution and flood controls (Doswald & Osti, 2012; Munroe *et al.*, 2012) need to be explored for risk reduction in urban areas.

Globaly, up to 25% of the total burden of disease is attributed to environmental hazards, and this estimate is nearly 35% in sub-Saharan Africa (WHO, 1997). In Uganda, a number of studies have reported significant public health hazards associated with urban agriculture in Kampala's wetlands. The hazards could be physical, chemical, biological or psychosocial, and may include injuries from sharp objects; contact with, inhalation or ingestion of toxic substances; consumption of contaminated food, infections from disease vectors, helminths and other pathogens; and psychosocial stress resulting from insecurity due to unclear land tenure, loss of farmland, fear of theft and violence or working long hours (Cole *et al*., 2006; Nasinyama *et al.*, 2010; Fuhrimann *et al.*, 2014, 2015). In 2006, the Kampala City Council (KCC) passed an ordinance to guide urban agriculture so as to promote safe practices and healthy products and promote urban dwellers' livelihoods (Secretariat of the Convention on Biological Diversity, 2012). However, not much progress has been realised.

Settlements in wetland areas are at even greater risk from the hazards mentioned above since there are more vulnerable groups such as children involved. Vulnerability is determined by factors related to individuals, community, and geographical location; including but not limited to socioeconomic, demographic, information, presence of disease vectors and control programs and the extent of environmental degradation (McMichael & Githeko, 2001). An illustration of these interlinkage is shown in **Error! Reference source not found. Error! Reference source not found.**.



Source: Adapted from McMichael *et al*. (1996) and McMichael & Githeko (2001)

Figure 2.7 Diagrammatic illustration of vulnerability to hazards

Most of the settlements in wetlands are informal, commonly characterised by overcrowding, haphazardness and poor servicing, limited accessibility and drainage infrastructure. The reluctance of local authorities to plan and provide formal services in informal settlements can be easily explained from the interpretation of informality as illegality (Karenina & Guevara, 2014). This view of "informality" as all that happens outside of formal regulatory procedures is among the reasons for the marginalization and stigmatization of informal settlements in the urban space, which often are characterized by evictions or threats of eviction and demolitions (Roy, 2009). However, there has been a gradual shift from this interpretation towards acceptance and formalization of informality, which among other things involves legalization of land tenure through titling (Karenina & Guevara, 2014). Formalization attracts some level of servicing, infrastructural projects, and empowerment of beneficiary communities (Magalhães & Villarosa, 2012), but also presents new challenges for formality-oriented city authorities to find a middle ground given that there are situation in which some individuals or groups in the population belong to both informal and informal sectors simultaneously (Roy & AlSayyad, 2004; Roy, 2009). It is import to note that upgrading infrastructure and housing alone without building the capacity and livelihoods of communities is mare “aestheticization of poverty” (Roy & AlSayyad, 2004; Roy, 2005). In the context of this study, formalizing informal settlements in gazetted wetlands would call for first degazetting the wetlands and then legalizing land ownership, and subsequently providing all the necessary infrastructure and services in addition to upgrading peoples’ livehoods. Alternatively, it could mean restricting all other activities in wetlands except for those permitted within the National Environment Regulations for wetlands, river banks and lake shore management (NEMA, 2000).

East African cities are characterised by clustered slum settlements, most of which are located in wetland areas and as such are prone to flooding (KCC, 2002; Vermeiren *et al.*, 2012). Acceptance of this kind of informality means that city authorities have to either provide effective flood protection for these communities or relocate them whilst ensuring no further encroachment (KCCA, 2012a). Whereas micro-scale adaptive processes are important in reducing vulnerability, they are not necessarily sufficient for successful adaptation to occur (Brooks, 2003). Some constraints to adaptation reported in literature include anthropogenic land use changes which pose physical barriers to inland migration of wetlands (Feeley & Silman, 2010; Klein *et al.*, 2014), also the location and design of buildings and infrastructure, especially in urban areas influence vulnerability (Bulleri & Chapman, 2010; Jackson &

McIlvenny, 2011), while the degradation of environmental quality reduces the availability of ecosystem goods and services (Côté & Darling, 2010; Tobey *et al.*, 2010). Sustainable adaptation can only be realised through addressing the structural causal mechanism of vulnerability, such as poverty, population growth, land ownership and the failure to enforce land-use planning (Wisner *et al.*, 2003; Mimura *et al.*, 2014; Noble *et al.*, 2014).

2.9 Research gaps

Actions to address the issues discussed above will need to target each step in the causal chain as illustrated in the DPSEEA framework (Figure 2.2 above). From this review of literature, evident that most of the driving forces and pressures have been documented. However, the understanding of the spatiotemporal dynamics of the several human activities degrading wetlands is limited and not up-to-date. In addition, there is limited insight into the factors associated with exposure to hazards, self-perceived vulnerability[5] and opinions about adaptation. Because hazards are context specific, local actors play a critical role in minimizing vulnerability and building resilience against hazards. Understanding local contingent conditions is paramount for improvement of adaptive capacity and resilience against hazards (Oelofse, 2003; Uy, Takeuchi & Shaw, 2011). Lately, the Kampala Capital City Authority has recognised the need to plan for and implement hazard mitigation measures so as to reduce vulnerability of city dwellers and the environment. The Authority hopes to proactively engage local communities, community based organizations and property owners in fostering safety and resilience in the city (KCCA, 2014). From the literature review in this chapter, it is clear that wetlands are threatened partly because of their location, and the benefits and the opportunities they provide. Hence, a context specific assessment of benefits and opportunities wetland communities enjoy would give more insight into the links between pressures and exposures so as to inform appropriate remedial actions.

[5] Self-perceived vulnerability as used in this study refers to the level of vulnerability (to a specific hazard e.g. floods) uniquely perceived by those affected in the context of their circumstances.

Chapter 3: Methods

3.1 Introduction

Following from the research design described earlier (in Section 1.4), this Chapter provides an overview of the methods used to address the study objectives. The objectives are addressed in Chapters 4, 5 and 6. These chapters were structured for publication in peer reviewed journals, as such they may contain some of the material described in this chapter. To address objectives 1 and 2, spatiotemporal analysis was done, while for objectives 3 and 4, a cross-sectional household survey was conducted. These quantitative methods were complemented by qualitative methods i.e. Focus Group Discussions and Key Informant Interviews. The data used, data sources, and the methods of data collection, management and analysis are described in the subsequent sections. Finally, the chapter highlights the ethical considerations and sets the scene for the subsequent chapters.

3.2 Spatiotemporal analysis

The purpose for the spatiotemporal analysis was to quantify and map land cover and land cover changes in Nakivubo wetland, thereby, addressing objectives 1 & 2. This was done at a local scale, using very high resolution space and airborne data so as to permit identification of small scale human activities or land cover types. Based on the available cloud-free, full colour and/or multispectral data scenes and the cost of such data in comparison to the resources for the study, the extent for spatial analysis was limited to the Nakivubo wetland and to three dates, i.e. 2002, 2010, and 2014. The extent used in the analysis was clipped from the imagery using the Nakivubo wetland boundary obtained from the Wetlands Department at the Ministry of Water and Environment.

3.2.1 Remote sensing and GIS data collection

Selection of data was subject to availability of very high resolution, cloud-free data fully covering the study area. The data used includes full-colour aerial photos captured in 2010 and high-resolution multispectral satellite images captured in 2002 and 2014. Details of date, sensor, resolution, source and vendor are summarised in Table 3.1 below.

Table 3.1 Spatial data sources

Year	Sensor	Resolution	Source	Vendor
April, 2002	QuickBird	0.6m	DigitalGlobe	SANSA
July, 2010	Aerial photos	0.5m	KCCA	KCCA
December, 2014	Pleiades	0.5m	Airbus Defence and Space	SANSA

Ancillary data used includes:

- Wetland boundaries obtained from the Department of Wetland Management at the Ugandan ministry of water and environment;
- A 0.5 meter digital elevation model (DEM) and vector GIS layers for Kampala obtained from KCCA;
- Point data were collected by the research team using hand-held GPS devices to record the locality of each of the household interviews. This point data were used to create a locality map of the interviews; and
- Multi-date satellite imagery available in Google Earth (Appendix I).

3.2.2 Remote sensing and GIS data analysis

In order to obtain the desired classification output and detect changes with a sufficiently high precision, a number of data processing and analysis operations were performed as sequentially illustrated in Figure 3.1, i.e.:

Image pre-processing**:** included pan sharpening to increase the spatial resolution of the multispectral image so as to match that of the panchromatic band. This was done in PCI Geommatica 2014. In addition, all image data were terrain corrected and standard georeferenced to UTM zone 36N and WGS 84.

Sampling: Sample points for training the classifier algorithm and for accuracy assessment were selected from the images simultaneously to avoid inadvertent use of the same points for both operations. Then, half the samples per class were randomly allocated for training and half for accuracy assessment.

Segmentation: The images were segmented to create unique objects corresponding to features in the images. Segmentation was done in eCognition 9.0 and segmentation scale parameters of 50, 50, and 30 were used for the 2002, 2010, and 2014 datasets, respectively.

Classification: Object-based classification was performed on the segmented image objects by assigning the objects to real-world classes. This process involved training the support vector machine (SVM) classifier in eCognition 9.0 using the training points and subsequently executing supervised classification based on mean reflectance values of bands and Normalized Difference Vegetation Index (NDVI) values. No NDVI was computed for the aerial photos due to their lack of a Near Infrared (NIR) band.

Manual correction: The classification was inspected and misclassification were manually corrected using the paint brash tool in eCognition 9.0.

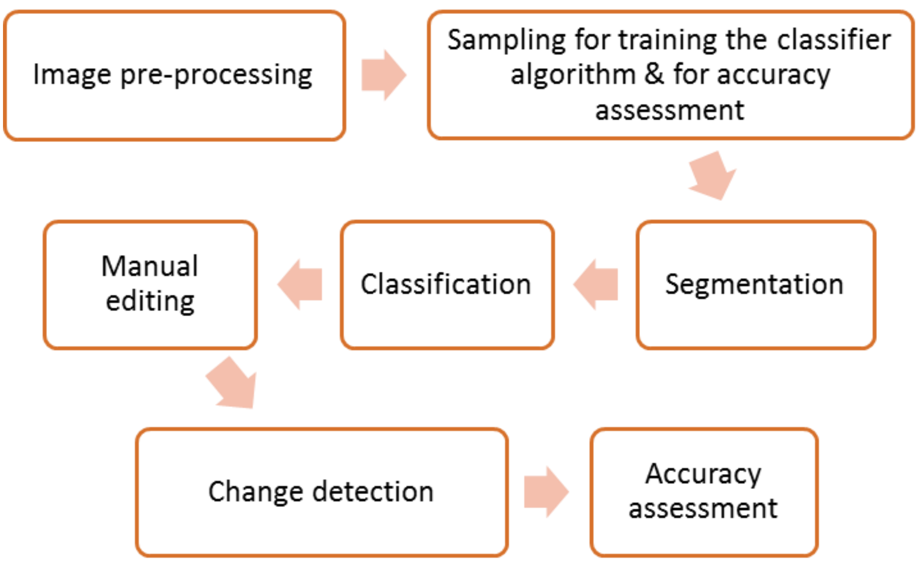


Figure 3.1 Image data processing and analysis operations performed

***Change detection*:** Classification raster outputs were converted into vector layers for analysis. Using spatial analysis tools in ArcGIS 10.2.2 the areas for the various land cover classes were computed as well as changes from one land-use class to another across different dates. Through a union operation the layers for the different years were combined into a polygon layer from which spatially congruent change-detection maps were generated. This mean that each area on the map had a complete record of occupation and change between the dates.

***Accuracy assessment*:** The level of accuracy for each of the classification outputs was assessed by generating a confusion matrix comparing sample points originally assigned to classes with the actual classification output as shown in Table 3.2 below. The shaded diagonals represent sample points that were correctly classified. All classifications yielded overall accuracies above 83%, with Kappa statistics of 0.82, 0.80, and 0.89 for 2002, 2010 and 2014 respectively. Detail on operations described above are provided in Chapter 4.

Table 3.2 Confusion matrices for accuracy assessment of the 2002, 2010 and 2014 classifications; the rows are the reference while the columns are classified points

2002								
	Bare	Built-up	Cultivated	Grassland	Trees & shrubs	Water	Wetland vegetation	Grand Total
Bare	10	8	2					20
Built-up	5	14		1				20
Cultivated			20					20
Grassland			2	18				20
Trees and shrubs			1	1	18			20
Water						20		20
Wetland vegetation				2			18	20
Grand Total	15	22	25	22	18	20	18	140
2010								
	Bare	Built-up	Cultivated	Grassland	Trees & shrubs	Water	Wetland vegetation	Grand Total
Bare	19	1						20
Built-up	2	18						20
Cultivated			20					20
Grassland			4	12			4	20
Trees and shrubs			2	4	11		3	20
Water				2		18		20
Wetland vegetation				2			18	20
Grand Total	21	19	26	20	11	18	25	140
2014								
	Bare	Built-up	Cultivated	Grassland	Trees & shrubs	Water	Wetland vegetation	Grand Total
Bare	29	1						30
Built-up	1	27		1		1		30
Cultivated			29	1				30
Grassland			1	29				30
Trees and shrubs				6	24			30
Water						30		30
Wetland vegetation				6	1		23	30
Grand Total	30	28	30	43	25	31	23	210

3.3 Household survey

This section describes the cross-sectional household survey through which quantitative data were gathered to address objectives 3 and 4. Specifically, it details sample size determination and sampling procedure, study tools (questionnaires) and data collection, and data processing and analysis as well as qualitative data collection and processing.

3.3.1 Sample size and sampling procedure

The sample size for the household survey was calculated using the Kish Leslie (1965) formula for survey sampling, which assumes considerable homogeneity within a study population to permit generalisation of findings.

$$n = \frac{Z^2 PQ}{d^2}$$

Where,

n = Sample size, number of households that were interviewed

d = Precision/margin of error, which for this study was 5%

Z = Standard normal deviation corresponding to the 95% CI = 1.96

P = 0.50 was assumed in order to obtain sufficient sample size and a high precision.
Q = 1-P

Substituting,

$$n = \frac{1.96^2 * 0.5(1-0.5)}{0.05^2} = \frac{3.8416 * 0.25}{0.0025} = 384.16 \approx 385$$

The survey was done in informal communities occupying four wetlands that drain into the inner Murchison bay in Kampala. Administratively, it was limited to five parishes in Kampala district, i.e. Bukasa, Mutungo, Ggaba, Butabika and Kansanga, which cover significant portions of informal settlements within the Nakivubo, Kinawataka, Kansanga, and Kyetinda/Ggaba wetlands as shown earlier in Figure 1.1. Given the clustered nature of these settlements and the selection criteria of being within the wetland boundary, purposive sampling was used to select samples. Sample size was proportioned according to approximate number of households within the wetland boundary in each parish (Table 3.3 below), and subsequently an appropriate sampling interval was determined. It was anticipated that respondents in the different clusters were likely to have similar characteristics, which would have caused a loss in effective sample size. In order to increase effective sample size, a design effect of 1.43 was used hence therefore, sample size $\boldsymbol{N = 385 * 1.43 = 551}$ respondents. A respondent was a head of household or responsible adult found at home at the time of visit.

Table 3.3 Study parishes and sample size

Parish	**Sample size (n)**	**%**
Bukasa	231	42
Mutungo	140	25
Ggaba	90	16
Butabika	56	10
Kansanga	34	6
Total	**551**	**100**

3.3.2 Survey tools and data collection

The household questionnaires were structured, with questions framed to gather data that would address study objectives. The main themes covered were: hazards, vulnerabilities, opportunities and adaptations, in addition to socioeconomic and demographic characteristics. First, the questionnaires gather information on a range of hazards in the area and where applicable, the frequency of exposure to the hazards identified including but not limited to floods and water logging, disease vectors, pollution, fire etc. Similarly, the questions on perceived vulnerability are posed with respect to each of the hazards already mention and so are the questions on adaptation. Later, the questions narrow the focus to the principle hazard in the area, which according to the residents and farmers is floods. To ensure good quality data, the questionnaires were drafted in both English and the local language (Luganda) and research assistants were trained in administering both. The questionnaires were pre-tested in a comparable community (in Bwaise III zone in the Lubigi wetland in Kampala) that was not part of the study area. Feedback from the pre-test was used to make necessary adjustments in the questions to attain coherence, validity and relevance. The questionnaire used is appended as Appendix A.

Entry into the study area was through community gate keepers, in this context the Chairpersons of the village/zone councils (LC 1s), who served as guides and also introduced research assistants to study participants. In each cluster, an appropriate sampling interval was computed upon establishing the layout of homes. Often, the layout of the homes was irregular due to the absence of detailed plans and enforcement of building code. Also, it was common to find one housing block with several units, with each unit occupied by a different household. The questionnaires were administered by the research assistants. To minimise recall bias, the reference period of exposure to hazards was limited to one year prior to the time the survey was done. One member was interviewed from each of the selected households. This was either the household head or any responsible adult found at home at the time of the visit. While some questions were directly addressed to the respondent, most were with reference to all the members of the household since the unit of analysis was a household.

Five key informant interviews (KIIs) were conducted with stakeholders. The KIIs were: two senior wetland officers from the Wetlands department at the Ministry of Water and Environment (MWE), the Environment and Sanitation Specialist in the Directorate of Public Health and Environment at Kampala Capital City Authority (KCCA), the Chairperson – Nakivubo Famers Association, and the Safety Manager for a non-governmental organization (NGO) – Hope for Children based in Namwongo, adjacent to Nakivubo wetland. A key informant interview guide (Appendix B) was used to gather information on the key themes mentioned above by asking the following questions:

- What in your view are the main drivers of encroachment?
- What hazards are associated with encroachment?
- What kinds of vulnerabilities exist among wetland communities and the environment?
- Who is affected and by what?
- What opportunities exist in wetland areas?
- What specific benefits do people derive from the wetlands?
- How are people adapting to minimize vulnerability to floods?
- How are people adapting against floods so as to exploit opportunities in the wetland?

- What is your role as a key stakeholder on the issue of encroachment on wetlands?
- What has been done about the encroachment situation?
- What are some of the risk reduction strategies that stakeholders have implemented?
- What are some of the major challenges encountered when dealing with issues of encroachment on wetlands?
- What do you recommend as a workable solution to the current situation?

The Focus Group Discussion (FGD) guide (Appendix C) was used to gather and compare information from the different groups in the study community (i.e. landlords, tenants, male farmers and female farmers), resonating around the same themes of hazards, vulnerabilities, opportunities and adaptations among wetland communities. In addition, participants were engaged in a pair-wise ranking exercise to identify which hazards affected more people.

3.3.3 Data processing

Data cleaning was done right from the point of data collection, through to data entry and final crosschecking. A data entry platform (.rec) was created in Epidata 3.0 based on the structured questionnaire as shown in Figure 3.2 below. In total 551 structured questionnaires were entered in before analysis. This manoeuvre permitted for entry of multiple responses. Most variables were already coded from the questionnaires, but where necessary, additional coding and recoding were done. Qualitative data from the recordings of FGDs and KIIs were transcribed. The data were then grouped into themes in line with study objectives and used to elaborate on quantitative findings in form of narratives or direct quotes where necessary.

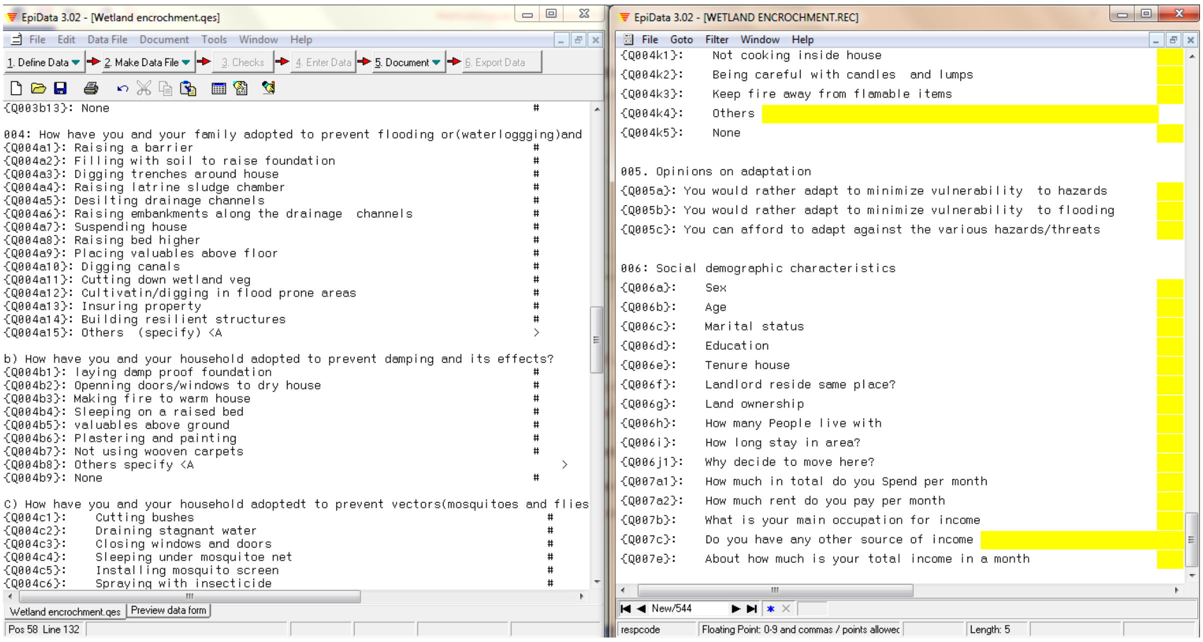


Figure 3.2 Example of Epidata .que and .rec forms used for data entry

3.3.4 Data analysis

Outcomes of interest ranged from descriptive statistics for certain variables to measures of association between outcome and independent variables. For objective 3 for example, as detailed in Chapter 5, an inventory of the hazards wetland communities in Kampala face was based on frequencies and percentages, while assessment of the factors associated with exposure to flooding and the factors associated with perceived vulnerability are based on statistical associations between independent variables and outcome variables. In this case, outcome variables were exposure to floods, and perceived vulnerability to floods. The outcomes of interest for objective 4 in chapter 6 include benefits associated with location and those derived from the wetland, adaptation mechanisms against disease vectors and floods for which descriptive statistics were generated. These were in addition to the outcome variables for the regression analysis, which were preference and self-perceived ability to adapt. For both sets of analyses, in chapter 5 and 6, the independent variables were mostly socioeconomic and demographic characteristics. Such factors have been shown to influence the exposure and vulnerability to environmental hazards (Smit & Pilfosova, 2001).

Analysis of the survey data was done using the Statistical Package for the Social Sciences (SPSS) version 19. Here, data were imported from Epidata and crosschecked for consistence and completeness. Descriptive statistics were generated and exported to Microsoft Excel 2013 to generate graphics and tables summarising the results. Ordinal responses for example where Likert scales were used were analysed for descriptive statistics, but were collapsed to binary for logistic regression analyses. Cross-tabulations and binary logistic regressions were done to generate measures of significance upon which associations were assessed. A chi-square test was used to test null hypotheses and statistical significance was considered at p-value <0.05. Only the variables that were significant at bivariate regression were included in multivariate regression. Crude odds ratios (CORs) at bivariate and adjusted odds ratios (AORs) at multivariate regressions, as well as their corresponding 95% confidence intervals (CIs) were computed.

3.3.5 Qualitative data

Qualitative data were collected from key informant interviews (KIIs) and focus group discussions. The KIIs included officials from key stakeholder institutions/organizations such as the Department of Wetlands Management at the Ministry of Water and Environment, the Directorate for Health and Environment at the Kampala Capital City Authority, a representative of the Nakivubo farmers' association, and an NGO working to promote health and environmental protection in the study area. Further details on these stakeholders are provided in Chapters 5 and 6. In total, four FGDs were held, i.e. tenants, landlords/house owners, male farmers and female farmers, each constituting of seven participants. Separate FGDs were held for men and women because gender inequality in land and property rights and decision making have been reported previously in the study area (Kiguli & Kiguli, 2004). The outputs of the quantitative analysis are summarised in graphs and tables in the results (Sections 5.3 and 6.3).

3.4 Ethical considerations

Ethical clearance for the study was obtained from the Research Ethics Committee of Stellenbosch University (REC-050411-032 – Appendix E), and the Higher Degrees Research and Ethics Committee of Makerere University (IRB00011353 – Appendix F). Approval to carry out the study was obtained from the Uganda National Council for Science and

Technology (SS 3351) – Appendix G). Wherever necessary, permission of employers was obtained before interviewing the relevant officers, e.g. written permission was also obtained from the Commissioner, Wetlands at the Ministry of Water and Environment to share information/data on wetlands in Kampala (Appendix H). Written consent was obtained from all participants who also retained a copy (Appendix D). The information collected was handled confidentially by using codes and not personal identifiers. Data in softcopy were secured with a password and hard copies were kept under lock and key.

3.5 Chapter summary

This Chapter has provided an overview of the methods used to achieve study objectives with regard to the spatiotemporal analysis, household survey and the qualitative methods used as well as the ethical considerations observed. The next three chapters constitute the main body of this thesis. As explained earlier, Chapters 4, 5 and 6 were structured for publication in peer reviewed journals, and as such, they contain sections on methods, as well as results and discussion in line with the objectives other study.

Chapter 4: Spatiotemporal analysis of encroachment on wetlands: a case of the Nakivubo wetland in Kampala, Uganda[6]

This chapter addresses research objectives 1 and 2. Based on very high resolution data, the land cover in the Nakivubo wetland in 2002, 2010 and 2014, as well as the land cover changes between the periods 2002-2010, 2010-2014, and 2002-2014 have been quantified and mapped. The Nakivubo wetland drains wastewater from Kampala city to Lake Victoria in Uganda. The analysis is based on very high resolution aerial photos and satellite imagery, focus group discussions and key informant interviews. Overall, the analysis of losses and gains in wetland vegetation showed a 62% loss of wetland vegetation between 2002 and 2014, which is mostly attributed to crop cultivation. Cultivation in the buffer wetland vegetation makes it unstable to anchor, implying that it will likely be calved away by receding lake waves as evidenced by the 2014 data. With barely no wetland vegetation buffer around the lake, the heavily polluted wastewater streams will further deteriorate the quality of lake water. Furthermore, with increased human activities in the wetland, exposure to flooding and pollution will likely have more impact on the health and livelihoods of vulnerable communities. A multi-faceted approach such as ecosystem-based adaptation needs to be implemented, possibly through zoning out the wetland and restricting certain activities to specific zones.

[6] The contents of this Chapter have been submitted in the form of a paper for publication in a peer-reviewed journal (*Environmental Monitoring and Assessment).*

4.1 Introduction

The past couple of decades have witnessed unprecedented loss of wetlands. In spite of the drive for *wise use* of wetland resources, which is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Ramsar 2010:8), not much progress has been realised. Wetlands are well-known for their ability to store, purify and gradually release water. In so doing, wetlands control floods and provide water for life (Allen *et al.*, 2016). The functioning wetlands however is often dependent on the dominant vegetation (Kansiime *et al.*, 2007). There is increasing concern about direct consumptive use of wetland resources which is occurring at the expense of essential bio-physical and hydro-chemical processes. In the quest for wetland products, humans transform wetlands by draining the marsh and clearing the natural vegetation to maximise private benefits such as land for cultivation, settlement, industrial sites, and building materials among others. In the context of this study, encroachment on wetlands refers to human modifications which compromise the ability of wetlands to perform their ecological functions. While this definition may not be fully inclusive, it provides insight into the link between wetland-use and conservation.

In Uganda, wetland communities comprehend the products they get from wetlands, so much so that for many, wetlands are the sole source of livelihood (Kabumbuli & Kiwazi, 2009; Nakangu & Bagyenda, 2013). However, the link between wetland conservation and their ecosystem services are often not well understood or are simply taken for granted (Kansiime *et al.*, 2007; Lukooya *et al.*, 2013; Nakangu & Bagyenda, 2013). Furthermore, some authorities perceive conservation of wetlands as hampering economic development, and subsequently afford it a lower priority relative to other issues (OECD, 2006; Ostrovskaya *et al.*, 2013). Encroachment activities include draining the wetlands for crop farming, construction of dwellings or commercial establishments and other livelihood activities (WMD-MWE, *et al.*, 2009). Encroachment on the Nakivubo wetland, which is the central wastewater drainage system for Uganda's Capital Kampala, is associated with significant public health and environmental risks (Fuhrimann *et al.*, 2014, 2015). Prominent among these is the increased risk of flooding, vulnerability of communities occupying wetland areas, and the pollution loads that end up in Lake Victoria, the city's main source of water supply (Banadda *et al.*, 2009; Fuhrimann *et al.*, 2015). Notably, limited capacity in government to effectively ensure wise use of wetlands is among the key limitations (Ostrovskaya *et al.*, 2013); specifically the lack of appropriate and up-to-date information for policy implementation at local levels (WMD-MWE *et al.*, 2009; MWE, 2012).

4.2 Policy and legal framework for wetlands in Uganda

Draining and conversion of wetlands in Uganda was unchecked or even promoted for purposes of malaria control (Omolo-Okalebo, 2011), cultivation, and animal grazing until 1986 when the National Resistance Movement (NRM) government through the Ministry of Environmental Protection banned further wetland conversion (Apuyo, 2006; Nakangu & Bagyenda, 2013). Although the government owned wetlands on behalf and for the good of all citizens, its control over their use was limited by inadequate legislation. Subsequently, the need to regulate wetland-use led to formulation of the National Wetlands Policy, the National Environment Statute, and the National Guidelines for Wetland Resource Developers in 1995, and later the National Environment Regulations (for wetlands, river banks and lake shore management) in 2000 (NEMA, 2000). These documents provide guidelines for sustainable use of wetland resources. But there are still challenges in regulating small-scale human activities without environmental impact assessment (EIA); activities which, collectively, have significant impacts on wetlands.

4.3 Wetland monitoring in Uganda

The need to monitor and control human activities in wetlands for the sake of ecosystem services and values has been recommended by several scholars (Kansiime & Nalubega, 1999; Kansiime *et al.*, 2007; Banadda *et al.*, 2009), however, the monitoring and control has not kept pace with the rate of encroachment. To this end there is insufficient research explicitly quantifying the spatiotemporal extents of encroachment on wetlands. According to Huising (2002) human activities in wetlands, especially agro-forestry, have been traced as far back as the colonial times, long before wetland boundaries were drawn. A number of aspects complicate the control over wetlands, including the lack of data and unclear boundaries (WMD-MWE *et al.*, 2009). The process of demarcating physical boundaries of wetland areas has dragged on for long yet the pressure to encroach on the seemingly redundant chunks of land is ever growing. The pressure arises from inadequacy of land to accommodate urban and industrial growth, rural-urban migration, growth of informal settlements, land tenure dynamics, protection of urban peasants' livelihoods and food security among others (Nyakaana *et al.*, 2007; Lwasa *et al.*, 2012; Waters, 2013).

4.4 Previous studies and research gaps

Whereas several studies have reported on human activities in Kampala's wetlands (Emerton *et al.*, 1999; Kansiime & Nalubega, 1999; Matagi, 2002; Huising, 2002; Kiguli & Kiguli, 2004; Nyakaana *et al.*, 2007; Kansiime *et al.*, 2007; Banadda *et al.*, 2009; Kabumbuli & Kiwazi, 2009; Lwasa, 2010; Nasinyama *et al.*, 2010; Omolo-Okalebo, 2011; Twesigye, 2011; UN-Habitat, 2012; Vermeiren *et al.*, 2012; Byaruhanga & Ssozi, 2012; Kirabira & Nagaddya, 2012; Abebe, 2013; Sliuzas *et al.*, 2013), explicit quantification of the spatiotemporal extents of human activities in the wetlands have not received much attention. In the few studies which have mapped land cover (Twesigye, 2011; Vermeiren *et al.*, 2012; Abebe, 2013), the low resolution of the datasets used (i.e. Landsat imagery) did not permit detailed analysis of land cover at a local scale. Huising (2002) provides a historical examination of land cover changes in the Nakivubo wetland from 1955 to 1999 and discusses the potential of using satellite imagery and aerial photos for change detection but does not spatially quantify any changes described in the study.

Explicit quantification of the spatial extents of changes in wetlands, showing human activities, is particularly vital because it provides concrete information at a local scale. A study on wastewater treatment by the Nakivubo wetland (Kansiime & Nalubega, 1999) provides 1996 estimations of the total area of the wetland covered by natural vegetation and cultivated area in the lower part of the wetland (bordered by the railway line to the north and the Marchison bay to the south). The authors compared their estimates with an earlier study (Taylor, 1991) and reported that the total area of the Nakivubo wetland covered by natural vegetation had reduced by approximately 14% in 5 years (from 2.2 km^2 in 1991 to 1.9 km^2 in 1996), while cultivated area in the lower the Nakivubo wetland had increased by more than 350% (from <0.05 km^2 to 0.225 km^2) in the same period. Their estimations of cultivated area, however, cover only part of the wetland and do not capture other forms of encroachment. These earlier studies, which now date almost 20 years back paint a clear picture of the increasing anthropogenic transformation of the wetland and certainly echo the need for up-to-date information to guide wetland conservation and risk reduction endeavours.

Given that the biggest threat to wetlands is posed by human activities (Kansiime *et al.*, 2007), it is important to generate realistic and up-to-date information. In this chapter, high resolution aerial photos and satellite imagery are used to classify and map recent land cover and provide a historical analysis of land cover change in the Nakivubo wetland over the past 12 years, 2002-2014. We discuss the drivers and implications of these changes in the light of the accelerated loss of the functional wetland vegetation, and increasing risks of flooding and pollution.

4.5 Methods

4.5.1 Study area

The Nakivubo is a gazetted wetland of prime importance located on the northern shores of Lake Victoria's Murchison bay in Uganda (Figure 4.1 below). Though it is part of a network of wetlands that drain Kampala city, the Nakivubo is the largest and receives most of the wastewater from the central business district (CBD), effluent from sewage treatment plant, stabilisation ponds and the adjacent industrial area (Emerton *et al.*, 1999; Kansiime & Nalubega, 1999). It covers an area of about 5.29 km^2 and is centrally located in close proximity to the CBD, the industrial area, and the lake where it discharges, approximately four kilometres from the intake of the city's water supply (Banadda *et al.*, 2009). It is accessible along the railway line that traverses the entire length of the wetland to port Bell (Figure 4.1). According to Kansiime *et al*. (2007), the dominant natural vegetation in the permanently inundated part of the Nakivubo wetland are *Cyperus papyrus* and *Miscanthidium violaceum*, while the seasonal wetland was dominated by grassland and shrubs which have been largely transformed into crop fields.

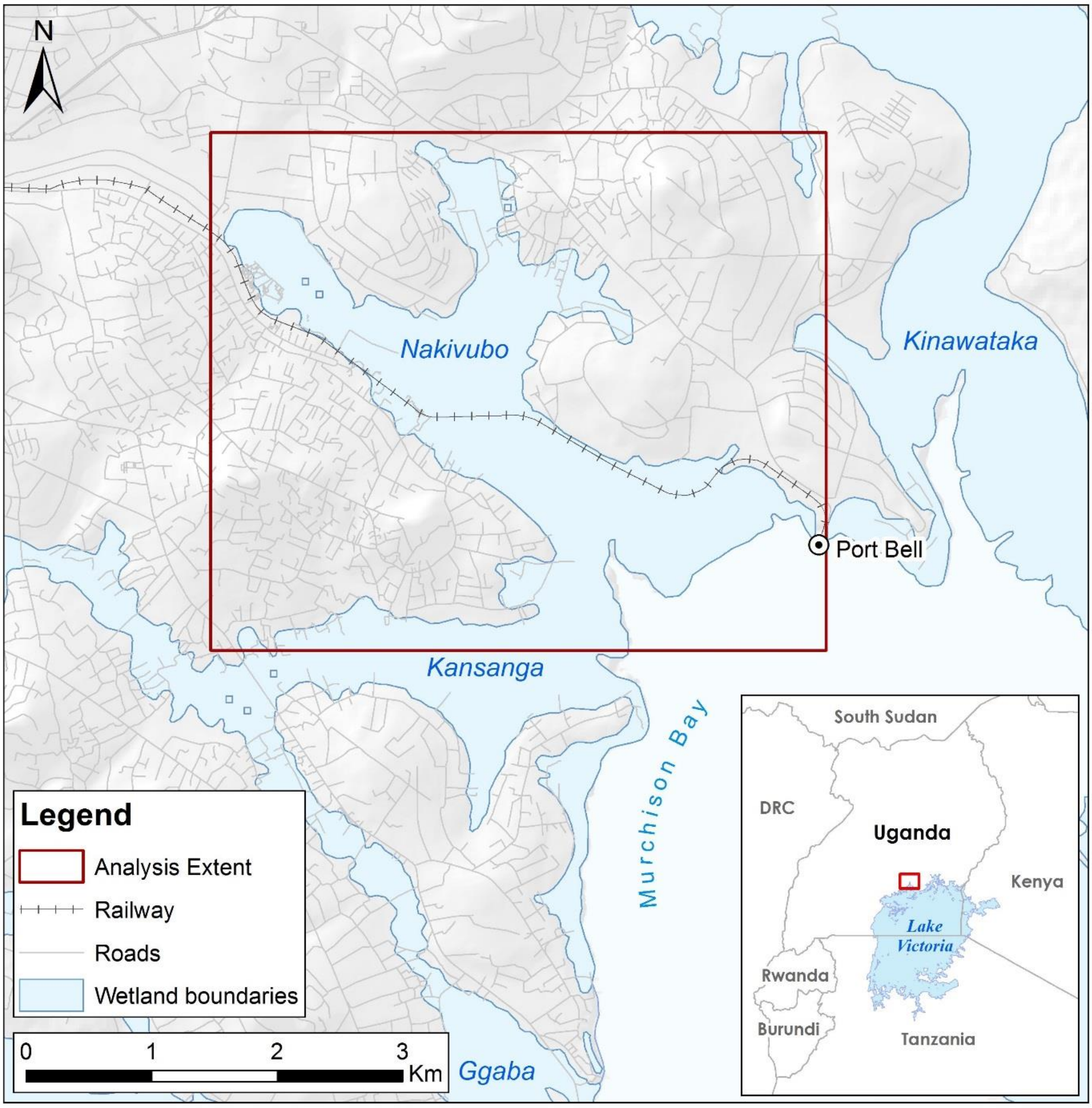


Figure 4.1: Map of the Nakivubo wetlands network as located adjacent to the Murchison Bay in Uganda

4.5.2 Data types and sources

The data used include full-colour aerial photos taken in July 2010 (0.5m resolution) from KCCA, and two high-resolution multispectral satellite images: a 0.62m Quickbird image (captured on 3 April 2002) and a 0.5m Pleiades image (captured on 5 December 2014). Both satellite images were acquired from the vendors (DigitalGlobe and Airbus Defence and Space, respectively), through the South African National Space Agency (SANSA). The image data was complemented by key informant interviews (KIIs) with stakeholders and focus group discussions (FGDs) with members of the Nakivubo wetland community including farmers, home owners and tenants.

4.5.3 Data processing and analysis

4.5.3.1 Data pre-processing

The multi-spectral satellite images were pan-sharpened with their respective panchromatic bands to improve resolution using PCI Geomatica 2014. All image data were terrain corrected and standard georeferenced to UTM zone 36N and WGS 84. The analysis was limited to the extent of the Nakivubo wetland as identified by the Wetlands Department at the Ugandan Ministry of Water and Environment. Sample points for both training the classifier algorithm and for accuracy assessment were concurrently selected in ArcGIS to avoid inadvertent use of the same samples for both purposes. The sample points were verified against ground-truthed GPS points. The classification system decided on for this study consisted of the following seven classes: Built-up, Cultivated, Grassland, Wetland Vegetation, Trees & Shrubs, Bare, and Water. These classes represented the main land cover in the Nakivubo wetland types and also were comparable to other studies on the impacts of urbanisation on wetlands (Cai & Wang, 2013).

4.5.3.2 Object-based classification

Object-based classification is the process of grouping image pixels to form objects (segmentation), and subsequently assigning the objects to real-world classes (classification) (Blaschke *et al*., 2008; Blaschke *et al*., 2014; Campbell & Wynne, 2011). Each of the image datasets was segmented in eCognition 9.0 to create unique objects corresponding to features in the images. Appropriate segmentation scale parameters of 50, 50, and 30 were used for the 2002, 2010, and 2014 datasets, respectively. Training objects were used to train a support vector machine (SVM) classifier. Classification was based on mean reflectance values of bands and Normalized Difference Vegetation Index (NDVI) values. No NDVI was computed for the aerial photos due to their lack of a Near Infrared (NIR) band. The classification was visually inspected for any misclassification of features, and where necessary, misclassifications were reclassified using rulesets based on feature information such as NDVI values and relational information e.g. distance. Extensive manual correction was performed based on expert knowledge in order to correct any further misclassifications, especially for the vegetated feature classes.

4.5.3.3 Accuracy assessment

Accuracy assessment was based on the spatial agreement between the known classes of the collected reference points and those of the classified raster datasets. For each classified raster, a confusion matrix was generated from which values for overall accuracy, Kappa, errors of omission and errors of commission could be calculated. All classifications yielded overall accuracies above 83%, with Kappa statistics of 0.82, 0.80, and 0.89 for 2002, 2010 and 2014 respectively. The accuracy assessment details for each classification are summarised in Table 4.1 below.

Table 4.1 Summary of accuracy assessment

	2002	2010	2014
Total reference samples	140	140	210
Average samples per class	20	20	30
Average User's Accuracy	85%	85%	93%
Average Producer's Accuracy	74%	83%	78%
Overall Accuracy	84%	83%	91%
Kappa	0.82	0.80	0.89

4.5.3.4 Change detection

All classification exports were converted to polygon vector layers for spatial analysis in a GIS environment. Cross-tabulation based on land cover class was performed in ArcGIS 10.1 in order to determine total area changes in classes from 2002 to 2010, from 2010 to 2014, and from 2002 to 2014. This also allowed the generation of inter-class change statistics. In order to do spatially congruent (site-specific) analyses of inter-class changes, the vector layers for all three classifications were combined through a Union operation. This allowed the generation of statistics and change maps that provide spatially referenced descriptors of changes between classes over time.

4.5.3.5 Handling of data from KIIs and FGDs

Upon transcription, qualitative findings from KIIs and FGDs were grouped into relevant themes and have been presented as narratives or direct quotes to elaborate on the patterns of encroachment on the wetland and the apparent driving forces.

4.6 Results

The results below provide spatiotemporal extents of land cover in the Nakivubo wetland (for the years 2002, 2010 and 2014), spatially congruent land cover changes (for the periods 2002-2010, 2010-2014, and 2002-2014), and the drivers of increasing encroachment on the wetland.

4.6.1 Spatiotemporal extents of land cover

The spatiotemporal extents of land cover are shown in Figure 4.2 below, while the corresponding total area and percentage covered by each of the land cover types in 2002, 2010 and 2014 are presented in Table 4.2 below.

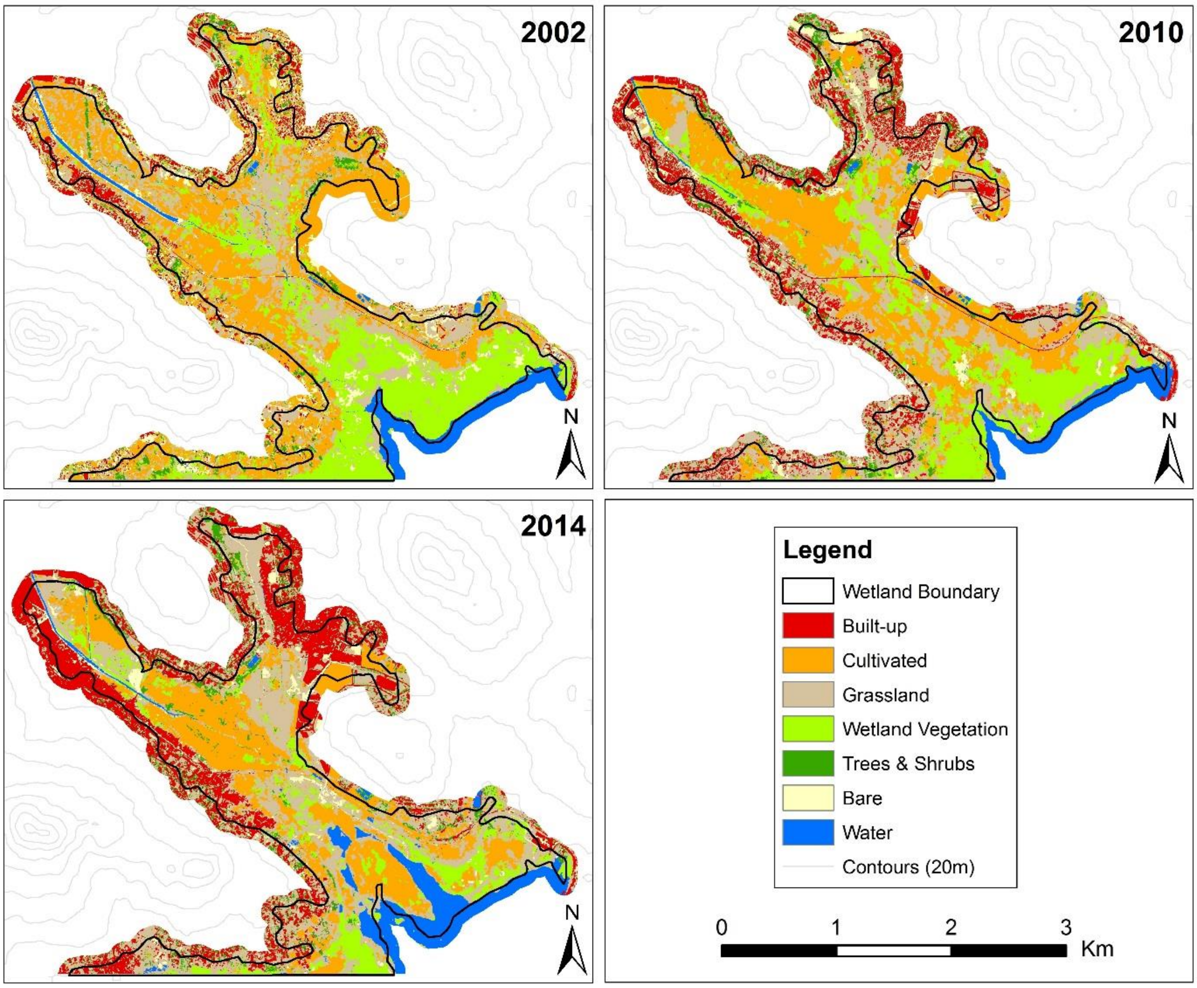


Figure 4.2 Spatiotemporal land cover in the Nakivubo wetland (2002, 2010 & 2014)

In 2002, the largest part of the Nakivubo wetland was cultivated, grassland and wetland vegetation. Analysis of land cover changes as a percentage of the total area showed that 62.7%, 53.0%, and 68.8% of the area changed to different classes over the periods 2002-2010, 2010-2014, and 2002-2014 respectively. These results show that land cover in the Nakivubo wetland is highly dynamic. Noticeably, built-up density increased along the peripheries of the wetland while wetland vegetation decreased significantly through the entire period. By 2014, most of the wetland vegetation that buffered the lake had been converted into cultivated, grassland and water, and a new road access to the lake via the wetland had been created.

Table 4.2 Total area (in m^2) and percentage per land cover class for each classification date

Land cover	2002	2010	2014
Built-up	164 556.0 (3%)	493 265.0 (9%)	827 374.3 (15%)
Cultivated	1 869 358.7 (33%)	1 808 289.5 (32%)	1 529 857.4 (27%)
Grassland	1 474 136.6 (26%)	1 673 363.0 (30%)	1 900 393.9 (34%)
Wetland vegetation	1 505 256.5 (27%)	1 168 562.3 (21%)	568 773.0 (10%)
Trees & Shrubs	141 312.2 (3%)	169 122.5 (3%)	234 317.9 (4%)
Bare	353 706.8 (6%)	255 092.3 (5%)	235 859.0 (4%)
Water	121 461.1 (2%)	66 036.5 (1%)	333 202.3 (6%)

Land cover changes within each class, including interclass conversions were a plotted as a percentage of their 2002 areas (Figure 4.3 below). Between 2002 and 2014, built-up area, water, trees and shrubs, and grassland increased by about 403%, 174%, 66%, and 29% respectively while wetland vegetation, bare and cultivated areas decreased by about 62%, 33%, and 18% respectively.

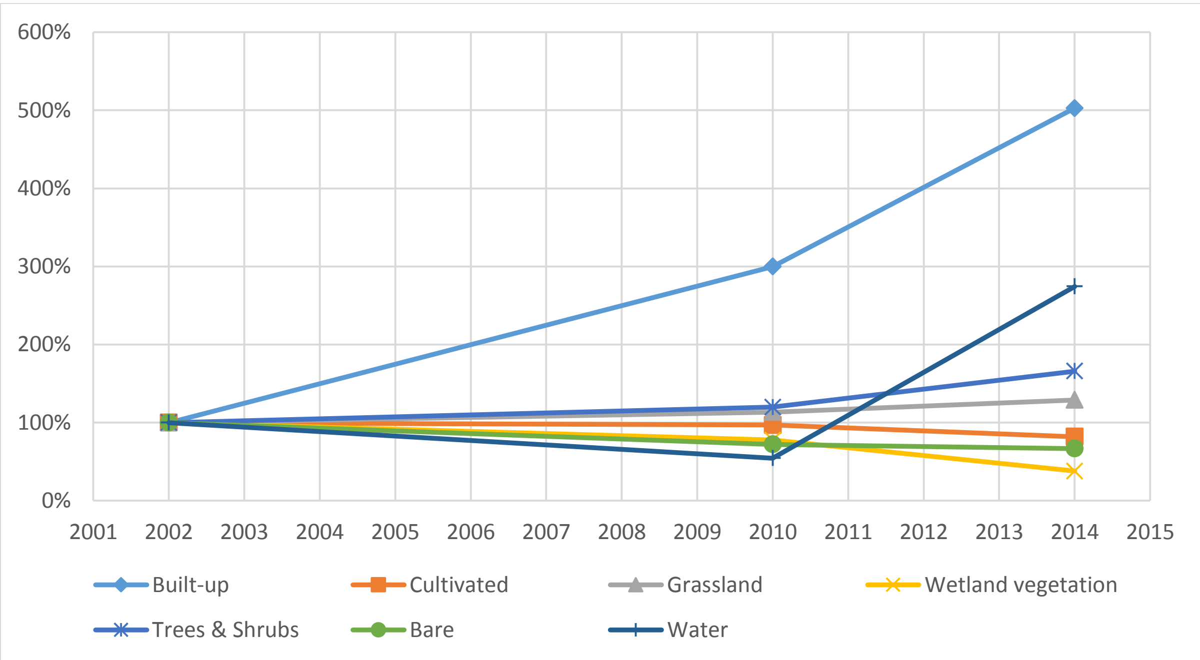


Figure 4.3 Overall change in class areas as a percentage of 2002 over time, notice the sharp increase in built-up and water classes

4.6.2 Spatially congruent land cover changes

In order to quantify the areas that changed over time, areas of inter-class conversions were calculated for the periods 2002-2010, 2010-2014, and 2002-2014, and are present in Table 4.3, Table 4.4, and Table 4.5respectively.

Results in Table 4.3 below show that by 2010, about 41.2% of the original 2002 wetland vegetation was still intact while 1.4% had been converted to built-up, 25.8% to cultivated, 26.4% to grassland, 1.3% to trees & shrubs, 3.1% to bare and 0.9% to water. Despite these conversions from wetland vegetation some areas, e.g. about 9.1% of cultivated, 17.7% of grassland, 9.9% of trees & shrubs, 17.2% of bare, 34.6% of water in 2002 had converted to wetland vegetation in 2010.

Table 4.3 Inter-class land cover changes (2002-2010), shaded diagonals indicate areas of no change

Land cover change (m²)		2010						
		Built-up	Cultivated	Grassland	Wetland vegetation	Trees & shrubs	Bare	Water
2002	Built-up	107749.4 (65.5%)	3739.3 (2.3%)	26009.6 (15.8%)	756.7 (0.5%)	5915.2 (3.6%)	20210.0 (12.3%)	175.7 (0.1%)
	Cultivated	175519.8 (9.4%)	784032.8 (41.9%)	590105.9 (31.6%)	170006.8 (9.1%)	64574.3 (3.5%)	82475.6 (4.4%)	2643.5 (0.1%)
	Grassland	89943.5 (6.1%)	537833.9 (36.5%)	485132.8 (32.9%)	261103.7 (17.7%)	38967.8 (2.6%)	54019.4 (3.7%)	7135.6 (0.5%)
	Wetland vegetation	20945.9 (1.4%)	388696.7 (25.8%)	396870.1 (26.4%)	619632.7 (41.2%)	19667.9 (1.3%)	46454.4 (3.1%)	12988.8 (0.9%)
	Trees & Shrubs	14359.0 (10.2%)	32110.2 (22.7%)	48292.6 (34.2%)	13956.5 (9.9%)	23308.9 (16.5%)	8970.5 (6.3%)	314.6 (0.2%)
	Bare	83020.0 (23.5%)	47786.4 (13.5%)	107891.3 (30.5%)	60915.2 (17.2%)	13164.5 (3.7%)	40142.5 (11.3%)	787.0 (0.2%)
	Water	945.7 (0.8%)	13181.8 (10.9%)	17464.7 (14.4%)	41985.4 (34.6%)	3192.1 (2.6%)	2713.7 (2.2%)	41977.8 (34.6%)

Results in Table 4.4 below show that by 2014, about 24.6% of the 2010 wetland vegetation was still intact while 1.1% had been converted to built-up, 26.9% to cultivated, 28.4% to grassland, 1.5% to trees & shrubs, 2.7% to bare and 14.8% to water. Conversely about 6.7% of cultivated, 7.7% of grassland, 4.1% of trees & shrubs, 3.0% of bare, 21.4% of water had converted to wetland vegetation in between 2010 and 2014.

Table 4.4 Inter-class land cover changes (2010-2014), shaded diagonals indicate areas of no change

Land cover change (m²)		2014						
		Built-up	Cultivated	Grassland	Wetland vegetation	Trees & shrubs	Bare	Water
2010	Built-up	374375.5 (75.9%)	9461.5 (1.9%)	67642.8 (13.7%)	1872.5 (0.4%)	17485.8 (3.5%)	22030.8 (4.5%)	396.3 (0.1%)
	Cultivated	38869.0 (2.1%)	831669.8 (46.0%)	634262.0 (35.1%)	121167.5 (6.7%)	54455.0 (3.0%)	65272.0 (3.6%)	62594.3 (3.5%)
	Grassland	268340.0 (16.0%)	323153.3 (19.3%)	733341.5 (43.8%)	129571.5 (7.7%)	86924.0 (5.2%)	74630.5 (4.5%)	57402.3 (3.4%)
	Wetland vegetation	12901.8 (1.1%)	314326.3 (26.9%)	332104.0 (28.4%)	287823.5 (24.6%)	17130.3 (1.5%)	30976.3 (2.7%)	173300.3 (14.8%)
	Trees & Shrubs	29173.3 (17.2%)	18884.5 (11.2%)	57595.5 (34.1%)	6865.8 (4.1%)	48765.5 (28.8%)	4595.8 (2.7%)	3242.3 (1.9%)
	Bare	102345.5 (40.1%)	30865.8 (12.1%)	62815.8 (24.6%)	7777.8 (3.0%)	9340.3 (3.7%)	36863.8 (14.5%)	5083.5 (2.0%)
	Water	2449.8 (3.7%)	1847.5 (2.8%)	14041.0 (21.3%)	14162.8 (21.4%)	654.0 (1.0%)	1603.0 (2.4%)	31278.5 (47.4%)

If we assess the overall changes from 2002 to 2014 (Table 4.5 below), we find that by 2014, only about 20% of the original wetland vegetation cover in 2002 was still intact; about 3% had been converted to built-up, 30% to cultivated, 30% to grassland, 2% to trees & shrubs, 2% to bare, and 14% to water. Gains in wetland vegetation over this period came predominantly from grassland (8.5%) bare (8.6%) and water (9.4%).

Table 4.5 Inter-class land cover changes (2002-2014), shaded diagonals indicate areas of no change

Land cover change (m²)		2014						
		Built-up	Cultivated	Grassland	Wetland vegetation	Trees & shrubs	Bare	Water
2002	Built-up	127379.9 (77.4%)	3810.2 (2.3%)	16719.1 (10.2%)	1580.0 (1.0%)	6387.1 (3.9%)	8512.2 (5.2%)	167.4 (0.1%)
	Cultivated	336381.8 (18.0%)	614625.1 (32.9%)	628668.0 (33.6%)	98163.7 (5.3%)	96005.2 (5.1%)	81592.2 (4.4%)	13922.6 (0.7%)
	Grassland	166473.4 (11.3%)	398122.2 (27.0%)	610012.8 (41.4%)	125744.4 (8.5%)	64140.1 (4.4%)	67811.0 (4.6%)	41827.0 (2.8%)
	Wetland vegetation	43336.8 (2.9%)	444705.5 (29.5%)	458213.4 (30.4%)	295646.0 (19.6%)	24133.3 (1.6%)	35266.7 (2.3%)	203954.8 (13.5%)
	Trees & Shrubs	36386.6 (25.7%)	18641.2 (13.2%)	46805.4 (33.1%)	5727.6 (4.1%)	23046.8 (16.3%)	7348.7 (5.2%)	3354.8 (2.4%)
	Bare	115682.8 (32.7%)	40372.2 (11.4%)	108674.6 (30.7%)	30468.2 (8.6%)	18537.5 (5.2%)	28725.1 (8.1%)	11243.2 (3.2%)
	Water	1733.0 (1.4%)	9581.0 (7.9%)	31300.6 (25.8%)	11443.0 (9.4%)	2067.8 (1.7%)	6603.1 (5.4%)	58732.6 (48.4%)

In order to show locations of the areas that changed as quantified in Table 4.3, Table 4.4 and Table 4.5, spatially congruent maps were generated for each year. Spatiotemporal conversions from wetland vegetation to other classes for the periods 2002-2010, 2010-2014, and 2002-2014 are shown in Figure 4.4, Figure 4.5, and Figure 4.6 respectively.

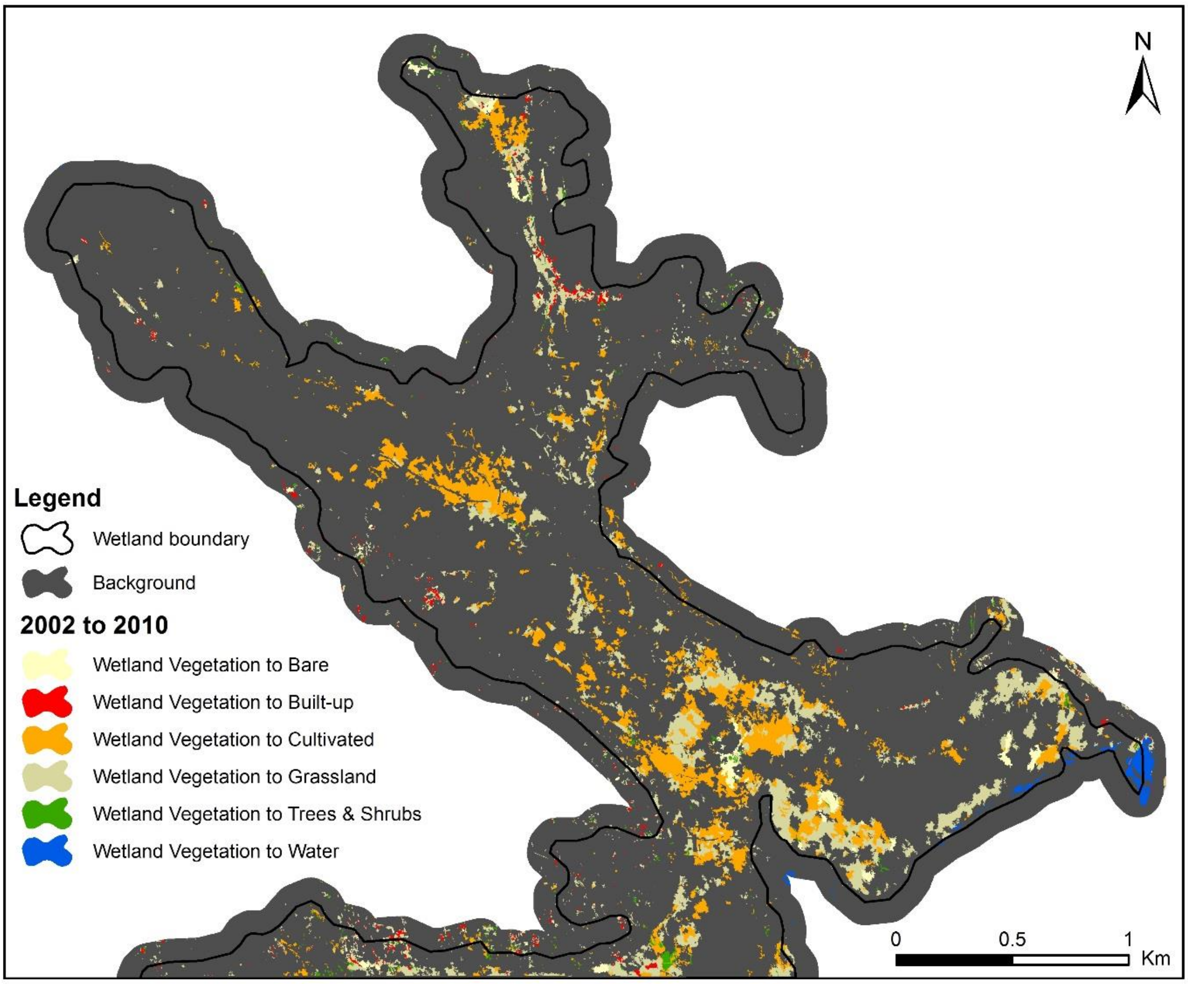


Figure 4.4 Conversions from wetland vegetation to other classes between 2002 and 2010

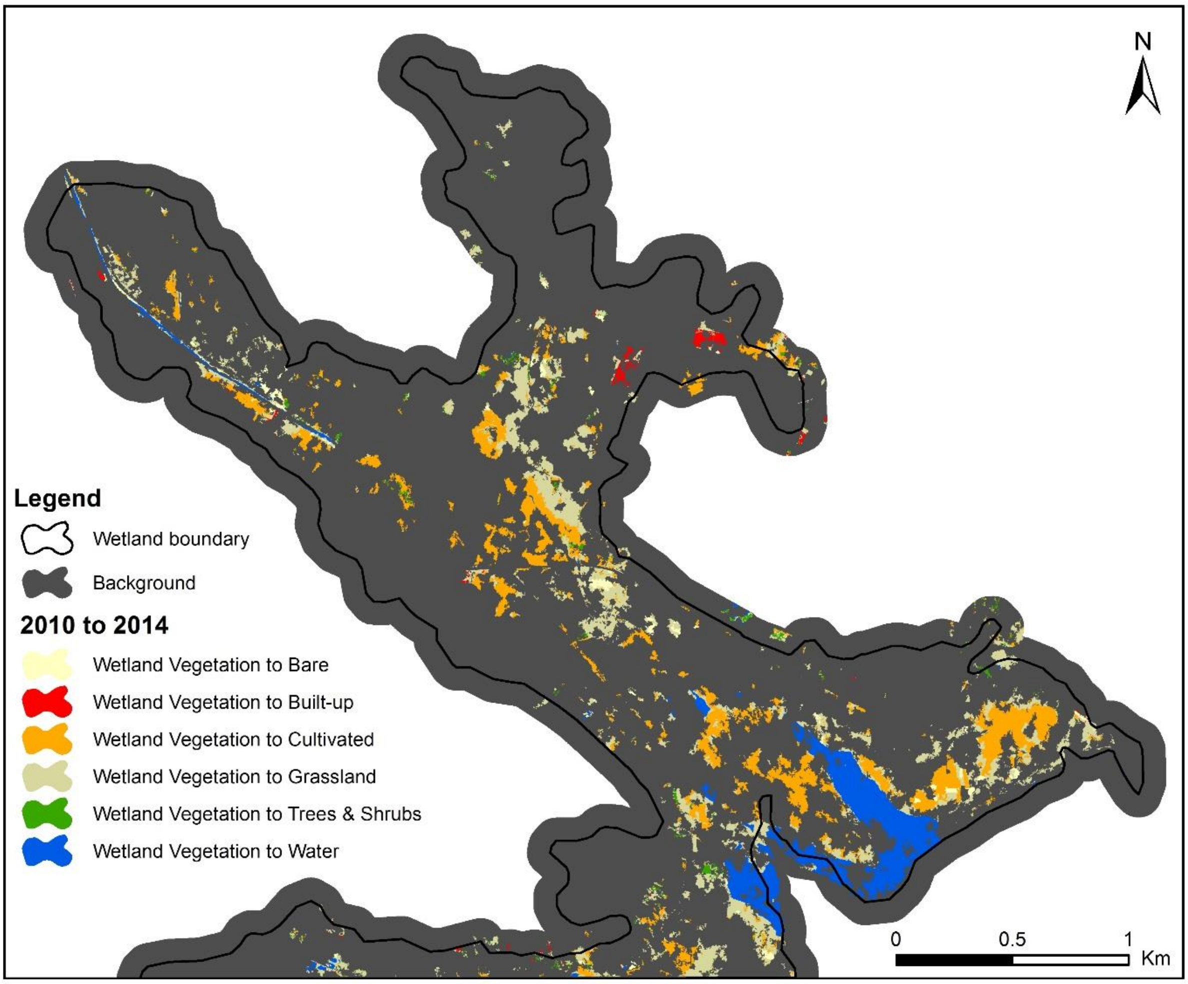


Figure 4.5 Conversions from wetland vegetation to other classes between 2010 and 2014

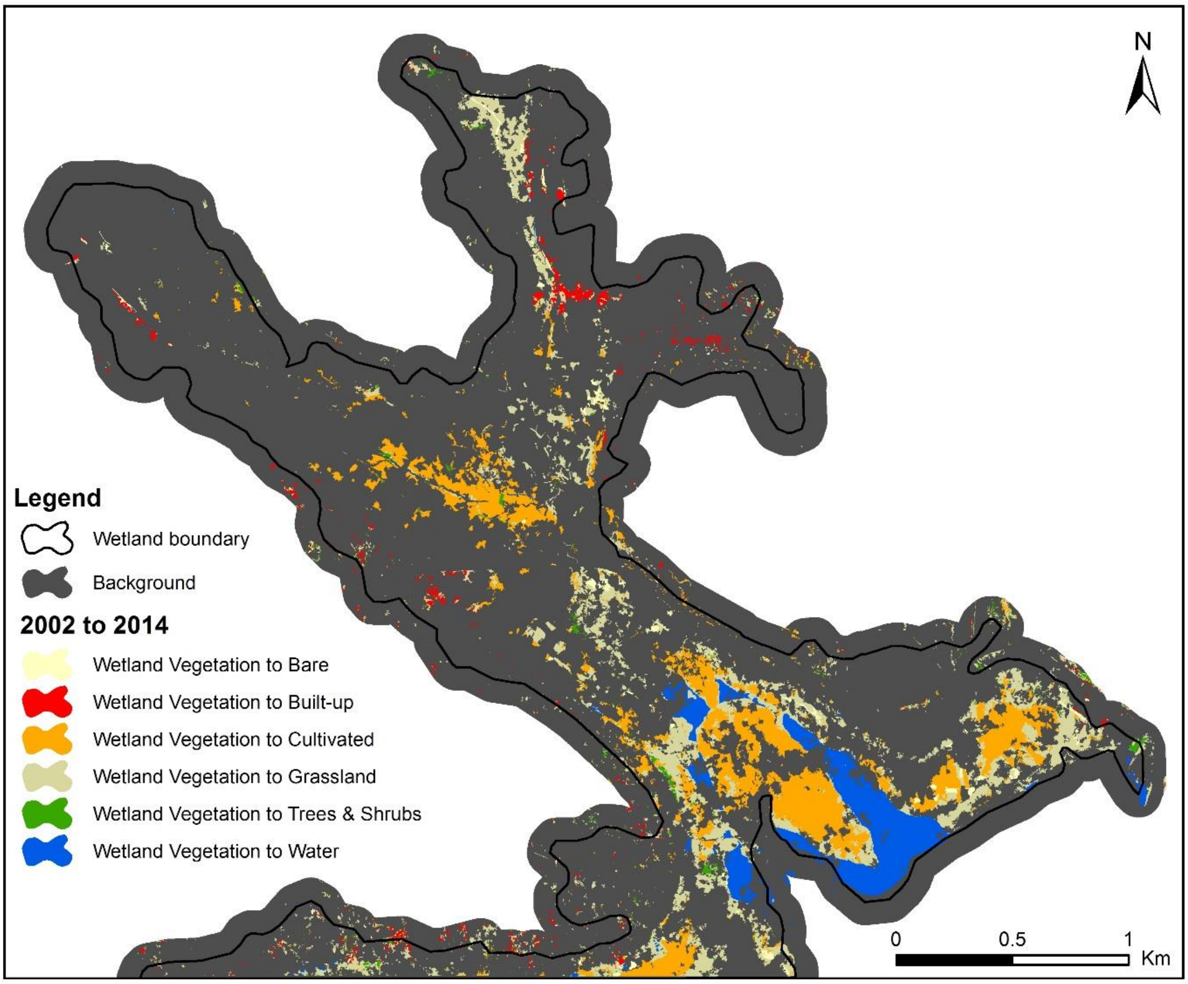


Figure 4.6 Conversions from wetland vegetation to other classes over the whole period (2002 to 2014). Note the dominance of the cultivated and grassland classes, especially towards the lake in the south-east

4.6.2.1 Rate of loss of wetland vegetation

Overall, the analysis of losses and gains shows a 62% loss of wetland vegetation between 2002 and 2014 (Figure 4.7 below). The differences between the overall and site-specific trend lines indicate the magnitude of the gains (i.e. areas that converted to wetland vegetation), expressed as a percentage of the 2002 wetland vegetation cover.

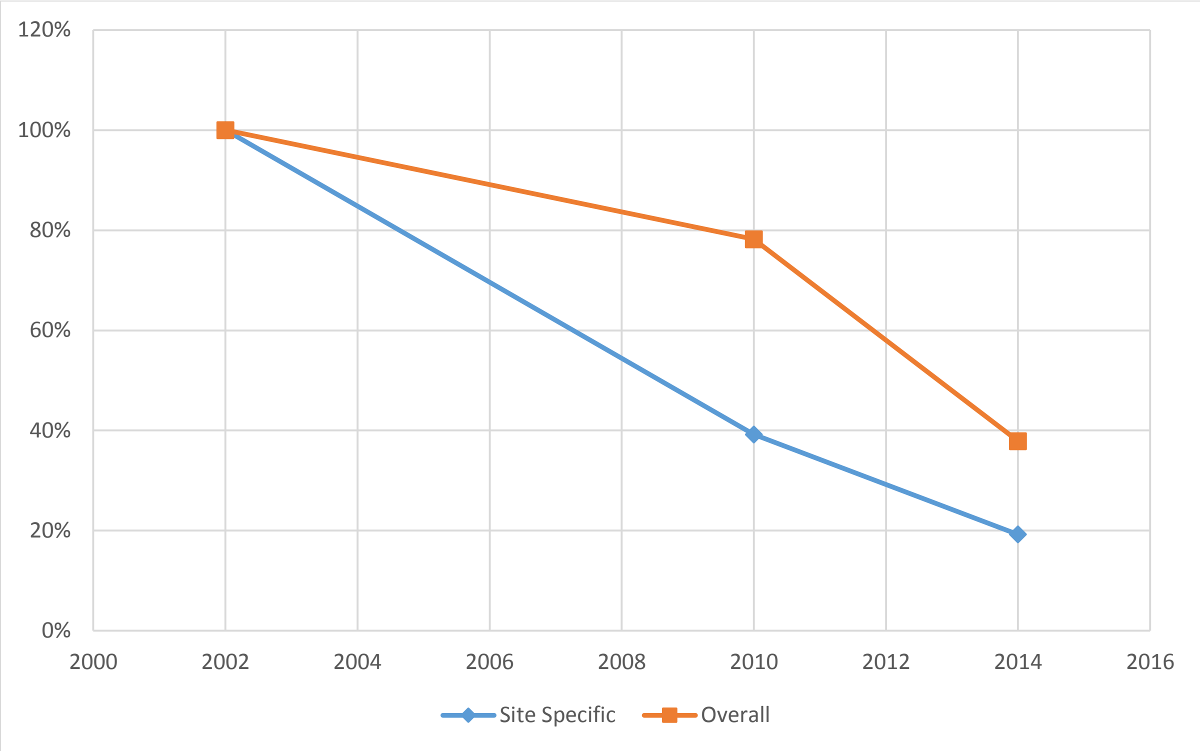


Figure 4.7 Loss of wetland vegetation as a percentage of 2002 area. The site specific curve describes the change of the original 2002 wetland vegetation areas, while the overall curve describes the total change in area of the wetland vegetation classes (including both gains and losses) over time

4.6.3 Some of the drivers of increasing encroachment on the wetland

The contextual drivers of increasing encroachment on the Nakivubo wetland that emerged prominent from FGDs and key informant interviews are presented below under three themes: land ownership, displacement of farmers and the lack of coordination among stakeholders.

Land ownership: Land ownership in the wetland area was mentioned among the key barriers limiting the local authority’s control of land-use. The 1995 Ugandan constitution recognises four land tenure systems, i.e. customary, mailo, freehold and lease hold. According to the Kampala Capital City Authority, these several land tenure systems complicate planning, especially where ownership is not by government. Some of the people who claim ownership of land in wetland areas also possess appropriated documentation to guarantee their security of tenure.

Quote:

> "*It is difficult to control what happens where you do not own or access… we are engaging land owners who claim to have land titles obtained before 1995 constitutional land reforms, which within the provisions of the law are legal, while titles obtained after 1995 are illegal. The best we can do, when owners have legal titles is to engage them to only implement projects that are within regulated activities described in the wetlands, river banks and lake shore regulations*" (KI Supervisor Environmental Management KCCA).

Displacement of farmers: Farmers explained that they are compelled to cultivate further downstream into the wetland because they are displaced from the peripheries by other investors.

Quote:

> "*…the space where the water would spread was given to an investor and he has already filled up about 35 acres with soil to displace the water; ...government does not consider a poor person, it considers a rich person, even when a rich person destroys the wetland they (government) do not mind, but for us who are poor, when we plant our yams, they consider us very bad people who destroy the wetland"* (FGD Men farmers).

Lack of coordination: Lack of coordination among stakeholders was said to be a key institutional limitation hampering sustainable wetland management. Also, political interference was said to antagonise development control by the local authority, especially when wetland encroachers claim to have been permitted by higher authorities. However, according to KCCA, efforts are being made to actively engage lead-agencies and all the stakeholders.

Quote:

> *"We are engaging lead-agencies, especially the National Environmental Management Authority (NEMA) to increase collaboration, coordination and decision-making with respect to wetland management. We are enforcing stoppage of further developments and denial of approval permits in wetlands; we do routine monitoring and inspection, and we engage parliament and cabinet who are the policy makers. This is important in*

controlling political interference" (KI Supervisor Environmental Management KCCA).

The contextual drivers of encroachment on the Nakivubo wetland presented above are however not exclusive of the underlying causes, which among others include poverty, population pressure, urbanisation and capacity constraints that have been widely documented.

4.7 Discussion

Our results have shown that there was about 80% loss and only 18% recovery of wetland vegetation in 12 years (i.e. 2002-2014). The rate of encroachment on the Nakivubo wetland, as measured by the loss of wetland vegetation, also accelerated between 2010 and 2014. As quantified in Table 4.4 above, large areas covered by wetland vegetation especially towards the lake (Figure 4.5 above), were converted for instance to cultivated, grassland, and water. Another large form of conversion observed was from grassland to built-up and to cultivated area. Earlier studies had estimated about 14% decrease in the total area covered by natural vegetation and a rapid increase of about 350% in cultivated area in the lower part of the Nakivubo wetland between 1991 and 1996 (Taylor, 1991; Kansiime & Nalubega, 1999). Our findings not only agree with the high rate of loss of natural wetland vegetation reported in earlier studies but also provide spatially congruent extents and site-specific conversions from wetland vegetation.

In our study, the explanations provided by FGDs and KIIs give insight into the dynamics of encroachment activities in the study context. The process seems to flow from clearing of the wetland vegetation and grassland, to draining for cultivation, and then where it is drier (especially the wetland peripheries), cultivated areas get gradually replaced by built-up areas and lawns. These areas then gain value faster due to their strategic location in the urban neighbourhood; settlements, commercial and industrial establishments crop up. The farmers who are displaced from the peripheries and their counterparts seeking livelihoods from the wetland reclaim new areas, often further down into the wetland. Despite the slight decreasing trend in cultivated area (Figure 4.2 above), much of the newly cultivated areas have replaced wetland vegetation, all the way down to the lake shore (Figure 4.5 and Figure 4.6).

Uganda's regulations for wetlands, river banks and lake shores require that a 200 metre buffer zone of natural wetland vegetation be maintained for shore stability, pollution and flood control, fish breeding and other ecosystem values (NEMA, 2000; Nakangu & Bagyenda, 2013). However, this is only one of many good environmental policies that barely get implemented due to competing uses, such as reclamation of wetlands for agriculture or settlement which most often are short-term and consumptive. Agriculture, food security, livelihoods and wetlands in Uganda are closely interlinked (Nakangu & Bagyenda, 2013). Many of the crops that boost food security or generate income thrive best in moist soils. Our results support the notion that such short term, consumptive uses take precedence over the long-term benefits of conserving wetlands. Human encroachment on urban wetlands has also been reported in other cities around the world with similar impacts as has been observed in this study. In Kolkata city for instance, the wetlands surrounding the city, referred to as a "natural kidney" of Kolkata because of their role in wastewater treatment have been significantly transformed by human activities (Allen *et al.*, 2016).

Analysis of the 2014 satellite imagery in this study shows development of a new road access to the lake via the Nakivubo wetland, which will attract more human activities and further degradation. Additional to our findings, a visual inspection of Google Earth archive imagery from December 2013 to February 2015 (0.29˚N, 32.64˚E) clearly shows large portions of the wetland buffering the lake which are gradually drifting away into the lake. This is likely due to a loss of structural stability resulting from the increased cultivation. Calving away of wetland vegetation can occur naturally following sudden raise in water levels. Sudden raise in water levels can detach the roots of emergent vegetation from the substrate to form rafts of floating rhizomes. Much of the papyrus and *Miscanthidium*-dominated patches in the lower Nakivubo wetland are floating (Kansiime & Nalubega, 1999). During periods of rapid water level fluctuation and stormy weather, these rafts tend to break away from stable swamp together with fringe plants and form islands of floating vegetation (Whigham *et al.*, 1993). The floating wetland vegetation on the lake-ward side of the Nakivubo wetland is frequently swayed by high speed-short duration South East trade winds of up to 60km/hr for at most two minutes from May to July (Kansiime and Nalubega 1999). The diumal on and offshore winds lead to gradual displacement of surface water northwards and receding lake seiches drift the floating vegetation islands further into the lake. While these processes can occur naturally, cultivation in to the wetland vegetation buffering the lake weakens its ability to attach to the substrate.

In light of the proposed infrastructure developments to transform the Nakivubo wetland into an urban park, in-land port, and lakefront (KCCA, 2012b, 2014), its future hangs in balance. The Ugandan Wetland Sector Strategic Plan 2001-2010 defines a *critical* wetland as one that is subject to on-going degradation that jeopardises continuation of its attributes or existence (MWE, 2001). Based on this definition, the Nakivubo is a critical wetland that needs prompt monitoring, regulation of human activities so as to prevent further loss of the natural wetland vegetation and restoration of degraded areas.

Whereas the above measures have been recommended by earlier studies (Kansiime & Nalubega, 1999; Kansiime *et al.*, 2007; Lukooya *et al.*, 2013), the big question of how to exploit opportunities as well as reduce risks society and the environment still remains unanswered. It will require a multi-faceted approach to address aspects of equity, environmental integrity as well as economic development. Limited implementation capacity as reported by Ostrovskaya *et al*. (2013) calls for coordination of various stakeholders, and engagement of wetland communities as part of the solution (Kabumbuli & Kiwazi, 2009). Community engagement would involve sensitization and empowerment of wetland dependent communities to seek alternative livelihood activities.

In view of the above, there is an apparent need for ecosystem-based approaches to adaptation (EBA) to reduce vulnerability. Ecosystem-based adaptation promotes the use of natural mechanisms, such as mangroves as coastline barriers and wetlands as pollution and flood controls (Doswald & Osti, 2012; Munroe *et al.*, 2012). Such natural mechanisms help vulnerable communities adapt against hazards whilst exploiting the multiple interlinked benefits. In the case of the Nakivubo wetland, EBA could include conservation and restoration of the natural wetland vegetation as part of an overall adaptation strategy against flooding and pollution. This might require zoning out wetlands and actively engaging communities in wetland conservation and wise-use practices, as laid out in the wetlands, river banks and lake shore regulations (NEMA, 2000). A potential approach to consider here is a community conservation areas (CCA) approach, which is achieved through 1) raising awareness of the links between wetland biodiversity and livelihoods, 2) demonstrating and implementing wise-use practices, and 3) integrating community based conservation models into policy and planning. A CCA approach has been piloted among rural wetland communities of the Lake Mburo-Nakivale and Lake Bisina-Opeta wetland systems in Uganda (Nakangu & Bagyenda, 2013), however its feasibility in an urban context such as the Nakivubo needs to be studied.

4.8 Chapter summary

Overall, our analysis showed a 62% loss of wetland vegetation between 2002 and 2014, which is mostly attributed to crop cultivation. Cultivation in the buffer wetland vegetation makes it unstable to anchor, implying that it will likely be calved away by receding lake waves as evidenced by the 2014 data. With barely no wetland vegetation buffer around the lake, the heavily polluted wastewater streams will likely further deteriorate the quality of lake water. Furthermore, with increased human activities in the wetland, exposure to flooding and pollution will likely have more impact on the health and livelihoods of vulnerable communities. A multi-faceted approach such as ecosystem-based adaptation needs to be implemented, possibly through zoning out the wetland and restricting certain activities to specific zones.

This chapter addressed research objectives 1 and 2, and the next chapter addresses objective 3 by investigating the hazards, their effects, and vulnerability among wetland communities in Kampala.

Chapter 5: Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda[7]

This chapter addresses research objective 3. Herein, a range of hazards, perceived vulnerabilities and associated factors among wetland communities in Kampala are analysed. The analysis is based on a survey of 551 households using semi-structured interviews, four focus group discussions and five key informant interviews. The study focused on communities living in four wetlands that drain the city's wastewater into Murchison bay of Lake Victoria. Results show floods and waterlogging as the principal hazards; however, secondary effects of floods and waterlogging such as disease vectors and diseases affect more people than the floods. Tenants were more likely to be exposed to floods than landlords/ house owners, and households that spend more than USD 80.00 per month were less likely to be exposed to floods than households that spend less. Households that had been exposed to floods before were more likely to perceive themselves vulnerable. Variations in exposure to hazards and perceived vulnerabilities could likely be due to differences in the capacity to resist, cope with, or adapt to minimize vulnerability.

---

[7] The contents of this Chapter have been published a peer-reviewed journal (*Environment and Urbanization*). The publication is currently online and can be cited as: Isunju, J.B., Orach, C.G. & Kemp, J. 2015. Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda. *Environment and Urbanization*. doi: 10.1177/0956247815613689.

5.1 Introduction

Our environment is comprised of two constantly interacting components: the natural and the social components (Oelofse, 2003; UN-Habitat, 2012). The theoretical point of departure in this chapter is based on this interaction where pressure within social components is vented on nature, consequently degrading it. Hazards emerge and affect the vulnerable elements in both the natural and the social components. Risk scholars have crafted conceptual approaches to estimating risk as a function of hazard and vulnerability factors (Oelofse, 2003; Taubenböck *et al*., 2008; UNISDR, 2009). According to Turner *et al*. (2003) , vulnerability studies need to address three important aspects if they are to support evidence-based policy and practice. These aspects are: a study of all the hazards affecting the system (community or environment); how the system gets exposed to the hazard; and the coping capacity of the system.

A number of studies have been done on flood risk in African cities (Ologunorisa & Abawua, 2005; Musungu *et al.*, 2012; Sliuzas *et al.*, 2013; Molina, 2014), mostly using deterministic models. The opinions of local communities, which provide contextual explanations, are often overlooked. Yet estimation of flood risk is complex and could be grossly inaccurate in cases where historical data are unavailable or where human activities have significantly influenced local hydrologic phenomena. This Chapter specifically investigates the perceptions of the local community who are faced with local hazards and have varying perceptions of vulnerability to the hazards they face. Arguments are based on the notion that, whereas exposure to a hazard is necessary for risk to occur, the capacity to resist, adapt or recover from the effects of exposure to the hazard minimises or eliminates vulnerability (UNISDR, 2004, 2009; Haque *et al.*, 2014).

5.1.1 Encroachment on wetlands in Kampala

Kampala is Uganda's capital city, with a population of nearly 1.75 million people (KCCA, 2012a), but growing at a rate of 3.7% annually (UN-Habitat, 2012). Over 60% of the population live in informal settlements (UN-Habitat, 2007b). Here, population growth, rural-urban migration, economic and industrial developments, urban agriculture, unclear boundaries, land ownership and the long-term failure of government regimes to enforce development control, among other reasons, have resulted in extensive encroachment on the city's wetland areas (Namakambo, 2000; Huising, 2002; Isunju *et al.*, 2011; MWE, 2012; Vermeiren *et al.*, 2012; Sliuzas *et al.*, 2013; Molina, 2014). These wetlands are important because they drain and purify waste water from the city before discharging it into Africa's largest fresh water lake, Lake Victoria (Kaggwa *et al.*, 2001; Schuyt, 2005; Banadda *et al.*, 2009; WMD-MWE *et al.*, 2009). The lake is not only the city's main source of water but also a major "biodiversity hot-spot" (Scheren *et al.*, 2000; WMD-MWE *et al.*, 2009). In recent years, increased pollution of the lake has led to rising water treatment costs and hence increased the cost of water supply to the city. For example, by 2008, the monthly cost of treating water, incurred by the National Water and Sewerage Cooperation (NWSC) had risen by fourfold from the 1990s (Banadda *et al.*, 2009; Kaggwa *et al.*, 2009; Oyoo, 2009).

5.1.2 Risks associated with encroachment on wetlands

Exposure to frequent flooding and waterlogging in Kampala has gradually increased as human activities advance further and further into the wetlands (Vermeiren *et al.*, 2012). Recent studies in Kampala predict that as more areas get developed, the degree of imperviousness as well as surface runoff will increase, resulting in more flooding (Sliuzas *et al.*, 2013; Molina, 2014). Although previous city plans considered wetlands as flood attenuation zones for the city (KCC, 2002), the proposed Kampala Physical Development Plan seeks to transform most of the wetland area in the city into "lively, healthy and functional urban parks"; to be used as green open space, for recreation, sports and culture (KCCA, 2012a,b). Currently, communities living in wetlands are exposed to a wide range of hazards and several vulnerability conditions. The damage caused by the hazards is diverse but mostly frustrates people's livelihoods and lowers the quality of life (Kabumbuli & Kiwazi, 2009). Except for reviews of the causal mechanisms highlighted above, there are limited empirical data on local conditions that shape risk events in this context. Understanding the range of hazards, exposure, damages and perceived vulnerabilities is an important step in risk assessment and a foundation for risk reduction strategies (IPCC, 2012).

5.1.3 Theoretical basis for the study

This study draws theoretical insights from contemporary risk-studies, including studies linked to climate variability. Most definitions of risk in literature point to the probability of occurrence of an (undesirable) event among vulnerable subjects (Brooks, 2003). Also, the disaster risk literature defines risk as a function of hazard factors and vulnerability factors, in addition to adaptive capacity, i.e. the ability to anticipate, resist, cope with, or recover from the effects of a hazard (UNISDR, 2004, 2009; Louw, 2007; Keim, 2011; Odemerho, 2015). The interactions between the factors that constitute risk are often complex but have been simplistically incorporated in the risk equation.

$$Risk = \frac{Hazard * Vulnerability}{Capacity}$$

Adapted from Taubenböck *et al*. (2008), Brooks (2003) and UNDP (2004)

From the above expression, it is clear that risk is hazard-specific; where, "hazard" refers to a threatening event or potentially damaging phenomenon, for example flood, fire, disease, etc. Vulnerability refers to the ''conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards'' (UNISDR, 2004, 2009), or intrinsic characteristics of a system, element or individual (Cardona, 2003), and should be considered in the context of the hazard characteristics in question (Birkmann, 2007). The measurement of vulnerability is however still fuzzy (Birkmann, 2006) and difficult to express as a single metric, but rather vulnerability is uniquely perceived by those affected in the context of their circumstances. Vulnerability as experienced can be assessed through perceptions of those that are vulnerable (Adger, 2006). The "perceived vulnerability" discussed in this chapter is an intrinsic characteristic and is used as a proxy expression of vulnerability. It is based on the assumption that hazards interact with psychological, social, institutional, and cultural processes in ways that may amplify or attenuate responses or perceptions of risk (Kasperson *et al.*, 1988).

The authors apply a critical realist perspective on urban environmental risk to examine the factors associated with perceived vulnerability. Critical realism assumes that risk events are shaped by causal mechanisms and specific local conditions (Oelofse, 2003). In the context of this study, causal mechanisms could include population pressure, rural-urban migration, poverty, and social-political processes, already highlighted above; while local conditions could include location, seasonality, infrastructure, land-use, tenure status, income levels, adaptation mechanisms, and social demographic factors, which have hitherto not been empirically analysed. Thus besides exploring the range of hazards and damages, the chapter analyses the factors associated with perceived vulnerability to a principle hazard: flooding.

5.2 Methods

5.2.1 Study setting, design and sampling

The study was done among communities living in four wetlands (Nakivubo, Kinawataka, Kansanga, and Kyetinda/Ggaba) that drain into Murchison bay of Lake Victoria (Figure 1.1 above), but was limited to within the administrative boundaries of Kampala district. Quantitative and qualitative data were collected using a mix of methods which included a household survey of 551 households, four focus group discussions (FGDs), five key informant interviews (KIIs), and GPS-linked field observations. The main outcomes of interest for the study were to establish the kind of hazards faced by communities living and or working in Kampala's wetlands and their perceived vulnerability to the hazards.

Purposive sampling was done in five parishes (Butabika, Mutungo, Bukasa, Kansanga and Ggaba) that cover significant portions of the four wetlands. Although encroachment activities extend beyond informal settlements, the household survey was done in informal settlements located within wetland areas. Given the clustered and crowded nature of the informal settlements within the study area, selection of samples was based on approximated population sizes of the various clustered settlements and fell within the officially demarcated wetland areas (Figure 1.1).

5.2.2 Study tools and data collection

For the quantitative data, a household survey was conducted using semi-structured interviews, translated into the commonly spoken a local language (Luganda). The Research assistants were trained and the questionnaires were pretested in a comparable community in the Lubigi wetland, which was not included in the study. The questionnaires were designed to collect data on hazards experienced by the household and perceived frequency of exposure; damages caused by the hazards; and perceived vulnerability to hazards. In addition, data on socio-demographic and socioeconomic characteristics, such as gender and age, level of education, marital status, nature of tenure, and length of stay in the area, household size, main occupation, monthly rent and household monthly expenditure were collected. Where necessary, respondents were asked to rank their degree of agreement or disagreement with statements on Likert scales.

For the qualitative data, the four FGDs held were of male farmers, female farmers, house owners/landlords, and tenants, each group consisting of seven participants. These groups were selected because; famers use the largest proportion of the wetlands for cultivation and employ many casual labours. Also, it was in the interest of the study to check perceptions of vulnerability to hazards across sex. Landlords owned rental housing units or occupied their own houses while tenants occupied rented housing units in the area. The five key informants interviewed included two senior wetland officers from the Wetlands department at the Ministry of Water and Environment (MWE), the Environment and Sanitation Specialist in the Directorate of Public Health and Environment at Kampala Capital City Authority (KCCA), the Chairperson – Nakivubo Famers Association, and the Safety Manager for a non-governmental organization (NGO) – Hope for Children based in Namwongo, adjacent to the Nakivubo wetland. Qualitative data were collected using FGD and KII guides respectively. The guides were designed to probe for participants' roles and responsibilities, actions, challenges and proposed solutions with respect to the topic. Participants were allowed to freely discuss any related issues. Note-taking and voice recording were done with participants' consent.

5.2.3 Data management and analysis

Coded quantitative data were entered in EpiData 3.0 software, cleaned and exported to SPSS 19 software for analysis. The majority of variables were binary or categorical. For household size, mean, standard deviation and range were computed. Frequencies and percentages were calculated to show exposures and perceived vulnerabilities to hazards. Ranked data from Likert scales were later collapsed to nominal levels of "agree" versus "disagree" and "vulnerable" versus "not vulnerable". Binary logistic regressions were performed for categorical variables to generate Crude Odds Ratios (CORs) (Szumilas, 2010), 95% Confidence Interval (CI) and p-values. The Pearson Chi-Square test was used to test null hypotheses, and statistical association was considered significant at $p<0.05$. In order to establish the main factors associated with exposure and perceived vulnerability, variables which were significant or near significance at bivariate analysis were incorporated into multivariate regression models to generate Adjusted Odds Ratios (AORs), 95% Confidence Interval (CIs) and p-values. Qualitative data from voice recordings were transcribed and summarised into thematic issues of interest as they emerged. Qualitative findings were compared with and used to elaborate quantitative results in form of narratives or direct quotes where appropriate.

5.3 Results

The results presented here include the social-demographic characteristics of respondents, an inventory of self-reported hazards and exposure frequency, damages or effects of floods and waterlogging, the factors associated with exposure to floods, perceived vulnerability, and the factors associated with perceived vulnerability to floods.

5.3.1 Socio-demographic characteristics of respondents

Of the 551 respondents surveyed, 55.5% were female, 67% were aged 30 years or younger, 52.4% had studied beyond primary level, 73.9% were married/cohabiting, 63% were tenants (renting), and 66.4% had lived in the area for at most 5 years as detailed in Table 5.1 below. The mean household size was 3.9 (SD=2), ranging from 1-13 people per household.

Table 5.1 Characteristics of respondents

Characteristic	Sub-category	Respondents [% (n)]
Sex	Male	44.5 (245)
	Female	55.5 (306)
Age (completed years)	≤ 20	12.0 (66)
	21-30	55.0 (303)
	31-40	25.6 (141)
	41-50	6.9 (38)
	> 50	0.5 (3)
Level of Education	None	11.8 (65)
	P1-P4	10.0 (55)
	P5-P7	25.8 (142)
	O'level	36.1 (199)
	A'level	10.9 (60)
	Tertiary	5.4 (30)
Marital status	Single	24.0 (132)
	Married/cohabiting	73.9 (407)
	Widowed	1.3 (7)
	Divorced/separated	0.9 (5)
Length of stay in the area	<1 year	24.3 (134)
	1-5 years	41.4 (228)
	6-10 years	22.9 (126)
	11-20 years	9.6 (53)
	21-30 years	1.1 (6)
	>30 years	0.7 (4)
Occupation	Peasant	10.3 (57)
	Casual labourer	27.9 (154)
	Professional	8.0 (44)
	Self-employed	39.9 (220)
	Others	13.8 (76)
Tenure status	Owners/landlords	37.0 (204)
	Tenants	63.0 (347)
Monthly rent (UGX)	Do not pay rent	37.0 (204)
	<50,000s	22.1 (122)
	50,001-100,000s	33.8 (186)
	100,001-200,000	5.3 (29)
	200,001-300,000	1.6 (9)
	>500,000	0.2 (1)
Household monthly expenditure	<50,000	1.1 (6)
	50,001-100,000	6.0 (33)
	100,001-200,000	36.1 (199)
	200,001-300,000	37.2 (205)
	300,001-500,000	16.3 (90)
	>500,000	3.3 (18)

USD1 ≈ UGX2500; O=Ordinary; A=Advanced

5.3.2 Hazards and exposure

Respondents were asked to mention the hazards their household faced in the area. In order to minimise recall bias, exposure period was limited to one year preceding the study. With reference to each hazard mentioned, respondents were further asked whether they were exposed to the hazard often or rarely. Results summarised in Table 5.2 below show that disease vectors, communicable diseases, floods and waterlogging, vermin, dampness, and poor excreta disposal top the list and majority of households were often exposed to them. Next is crime to which also, a fairly large proportion of households were often exposed. Other hazards mentioned to which more than half of households were often exposed are pollution, evictions, and subsidence/collapsing of houses. A small proportion of respondents mentioned fires as a hazard, the majority of whom said it was rare.

Table 5.2 Hazards and perceived exposure

Hazard	% exposed (N=551)	% often exposed
Disease vectors	98.5	87.8 (477/543)
Communicable diseases	85.7	72.9 (344/472)
Floods and waterlogging	84.9	69.7 (326/468)
Vermin	82.6	75.6 (344/455)
Dampness	82.0	71.5 (323/452)
Poor excreta disposal	71.9	74.7 (296/396)
Crime	70.4	58.0 (225/388)
Pollution of water, air or soil	57.5	55.2 (175/317)
Evictions	51.0	56.6 (159/281)
Subsidence/collapsing of house	47.2	59.2 (154/260)
Fires	16.7	21.7 (20/92)

Although floods and waterlogging were not experienced as often as disease vectors, vermin, poor excreta disposal, dampness and communicable diseases, they were said to play a central role in the proliferation of most of the other hazards. Furthermore, it was mentioned that during heavy rains, some people empty their latrines into tertiary drains while others dump solid waste and most frequently also plastic bottles to be swept away by storm water. Quote:

Floods spread pollution:

> "*Floods come with a lot of things including dirty water, dead bodies, faeces, dead animals, snakes...*" (FGD, tenants); "*…some people empty their latrines into the*

> *channel, others bury the contents in very shallow pits at night. When it rains, everything comes to us here in the floods; ...sometimes you smell faeces everywhere and even get difficulties in breathing because of the bad smell; ...the floods come with a lot of diseases for example from the sewage treatment plant in Bugolobi. That wastewater ends up in our houses and it usually comes at night when people are sleeping, and it spreads in the sauce pans, all the waste and maggots spread in the utensils and we do not have disinfectant to clean the utensils*" (FGD, landlords).

In addition to the hazards mentioned above, several other related issues were mentioned such as illegal and restrictive electricity connections, conflicts between residents and farmers resulting from diversion of flood waters, frequent clogging of drainage channels, insecurity, noise from bars and night clubs, and investors.

Quote:

Conflicts between residents and farmers resulting from diversion of flood waters:

> "*Farmers have contributed a lot to the flooding of this area; they put their gardens in the middle of the wetland where the main drainage channel should discharge its waters. So, they (farmers) always block this water from flooding to their gardens. One time we mobilized the community and piled bags along the banks of the drainage channel to prevent the water from flooding to our houses. But when the farmers saw that the floods had gone to their gardens they decide to remove our barrier and diverted the water back to our houses, and this is because most farmers do not stay in these flooding communities*" (FGD, landlords).

5.3.3 Effects of floods and waterlogging

The effects of floods and waterlogging on flood-exposed households (Table 5.3 below) were examined by running independent bivariate analyses. Although breeding of disease vectors was the most common effect, it was not significantly different between households who had been exposed to floods and those who had not.

Table 5.3 Effects of floods and waterlogging among flood-exposed households

Effects of floods and waterlogging	% (N=468)	COR[95%CI]	p-value	
Breeding of disease vectors	97.4 (456)	0.9[0.21-4.27]	1.000	
Flooded and damaged access roads	92.5 (433)	6.6[3.77-11.72]	<0.001	†††
Damage to houses	91.2 (427)	6.9[3.99-11.84]	<0.001	†††
Blockage of drainage channels	89.1 (417)	5.4[3.19-9.14]	<0.001	†††
Disease outbreaks	86.8 (406)	2.1[1.18-3.67]	0.018	†
Destruction of property	85.3 (399)	12.0[7.09-20.29]	<0.001	†††
Flushing of wastewater into yards and dwellings	72.2 (338)	2.3[1.43-3.71]	0.001	††
Falls	69.7 (326)	1.9[1.21-3.12]	0.007	†
Pollution of water sources	48.3 (226)	3.1[1.83-5.42]	<0.001	†††
Injuries caused by sharps objects in the mud	46.8 (219)	2.2[1.30-3.59]	0.003	††
Burying of crops	25.0 (117)	1.6[0.89-3.03]	0.124	
Low yields/ rotting of crops	20.9 (98)	1.3[0.70-2.42]	0.461	
Eroding/ sweeping away of gardens	20.7 (97)	1.3[0.70-2.39]	0.461	
Drowning in flood waters	6.0 (28)	5.2[0.70-38.89]	0.104	

COR=Crude Odds Ratio; †††=very significant, ††=significant, †=weakly significant at 95% Confidence Interval (CI)

Flooded and damaged access roads, damage to houses, blockage of drainage channels, disease outbreaks, destruction of property, flushing of wastewater into yards and dwellings, falls, pollution of water sources, and injuries caused by sharp objects in the mud were more likely to be reported among flood-exposed households than those who had not been exposed to floods.

It was noted in all the FGDs and KIIs that floods and waterlogging provided breeding sites for mosquitoes and flies, kept houses damp and structurally compromised, and polluted the area. Dampness of houses was said to be associated with upper respiratory tract complications (FGD tenants).

Solid waste and silt washed down by storm water clog drainage channels triggering flooding. Flooding was said to be a problem in the rainy seasons although several of its effects were often experienced way beyond rainy seasons. Some community members believed that floods are channelled to their settlements intentionally by government as an indirect way of evicting them. From observations during transect walks, several of the hazards and vulnerabilities mentioned by participants were confirmed (Figure 5.1 below).

Figure 5.1 Flooding situation in the flat and low-lying study area: (A) flooded access paths; (B) flood-barriers made of sand bags; (C) flooded house; (D) unprotected well prone to contamination

5.3.4 Factors associated with exposure to floods

Factors associated with exposure to floods were examined among flood-exposed households at bivariate and multivariate levels (Table 5.4 below). Tenants were more likely to be exposed to floods than house owners/landlords (COR 1.7, 95% CI, 1.08-2.76); households that spent more than UGX 200,000 (USD 80) per month were less likely to be exposed to floods than households that spent less (COR 0.6, 95% CI 0.33-0.91). Factors such as marital status, occupation, length of stay in the area, and family size were not statistically associated with exposure to floods.

Table 5.4 Factors associated with exposure to floods and waterlogging

Factors	% Exposed to floods	COR[95%CI]	p-value	
Marital status				
Single	86.4(114/132)	1.0	0.739	
Married/cohabiting	84.8(345/407)	0.9[0.50-1.55]	0.654	
Widowed	71.4(5/7)	0.4[0.07-2.19]	0.288	
Divorced/separated	80.0(4/5)	0.6[0.07-5.97]	0.689	
Occupation				
Peasant	78.9(45/57)	1.0	0.465	
Casual labourer	85.7(132/154)	1.6[0.73-3.49]	0.238	
Professional	88.6(39/44)	2.1[0.67-6.43]	0.203	
Self-employed	83.6(184/220)	1.4[0.66-2.83]	0.406	
Others	89.5(68/76)	2.3[0.86-5.98]	0.098	
Tenure status				
Owners/landlords	80.4(164/204)	1.0		
Tenants	87.6(304/347)	1.7[1.08-2.76]	0.023	†
Length of stay in the area				
≤ 5 years	84.5(306/362)	1.0		
> 5 years	85.7(162/189)	1.1[0.67-1.81]	0.712	
Family size				
≤ 4 people	85.4(304/356)	1.0		
> 4 people	84.1(164/195)	0.9[0.56-1.47]	0.686	
Monthly expenditure (UGX)				
≤ 200,000	89.1(212/238)	1.0		
> 200,000	81.8(256/313)	0.6[0.33-0.91]	0.019	†

COR=Crude Odds Ratio; †=weakly significant at 95% Confidence Interval (CI)

Some community members held beliefs that the government was not doing enough to ensure their safety and well-being. Quote:

> "*The government should construct the drainage channel; ...the government should reconstruct that bridge and put bigger culverts to eliminate the flooding; ... the government should get organizations to sensitize people on how to create income generating activities; ....government should provide us with 2-3 mosquito nets per household*" (All 4 FGDs).

5.3.5 Perceived vulnerability to hazards

Respondents were asked to rank on a Likert scale how they perceived their household's vulnerability to each of the hazards that they had already mentioned. The scale provided four (4) options: very safe, not vulnerable, fairly vulnerable, and very vulnerable. The results (Figure 5.2 below) show that majority (81.1%), and at least more than half (53.4%) of respondents perceived their households very vulnerable to disease vectors, and floods and waterlogging respectively. Nearly half (47.4%, 46.1%, and 46.1%) ranked their households very vulnerable to poor excreta disposal, dampness, and communicable diseases respectively, while more than half (55.5%) of respondents ranked their households fairly vulnerable to pollution for water, air and or soil.

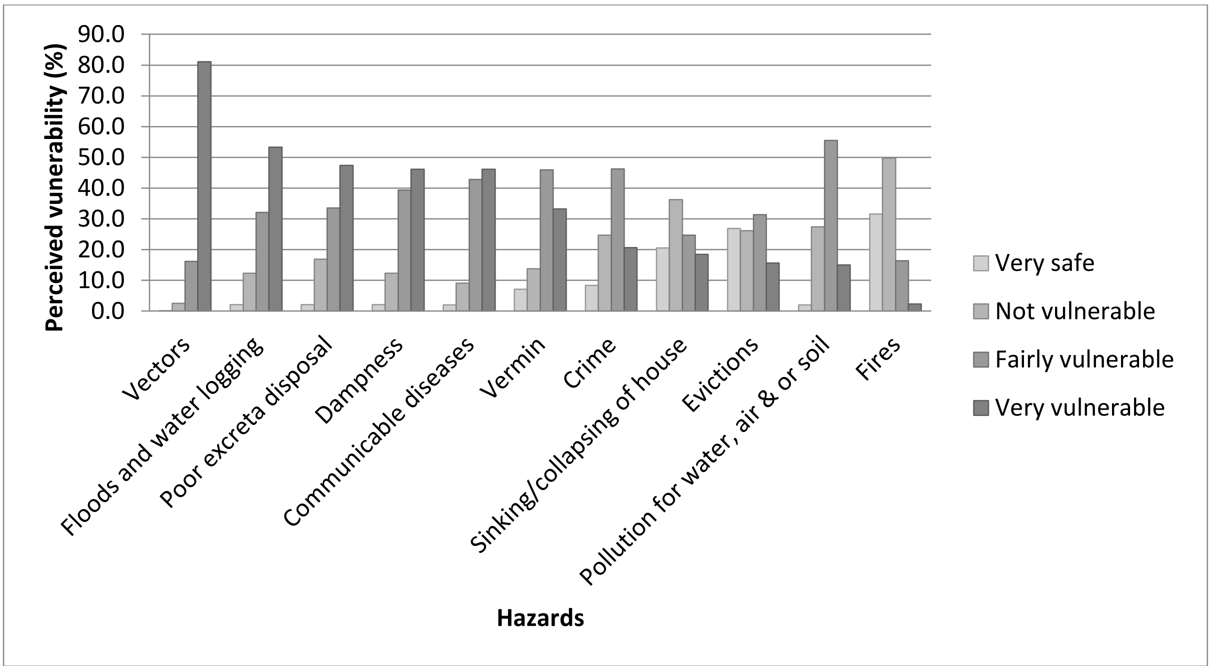


Figure 5.2 Ranked perceived vulnerability to hazards

The four categories above were collapsed into two by adding 'very safe' to 'not vulnerable', and 'fairly vulnerable' to 'very vulnerable' (Figure 5.3 below). Disease vectors, communicable diseases, and dampness, said to be secondary effects of flooding, were perceived by over 80 per cent of respondents. Also, poor excreta disposal (e.g. shallow/filled up pit latrines), vermin, and pollution were said be linked to flooding, waterlogging and the high water table.

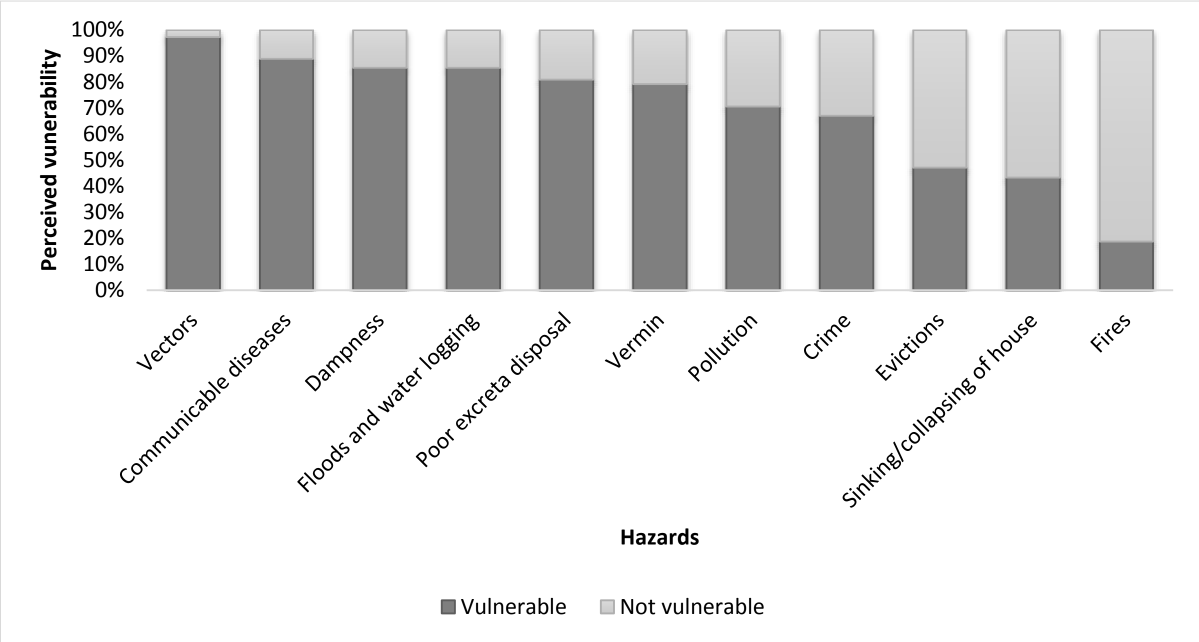


Figure 5.3 Combined perceived vulnerability to hazards

In each of the four FGDs (i.e. landlords, tenants, male farmers, and female farmers), participants were asked to list and rank hazards according to the number of people affected, which was then used as a proxy measure for vulnerability (Table 5.5 below). Landlords and tenants ranked floods first; male farmers ranked disease vectors first yet female farmers ranked disease vectors last.

Table 5.5 Vulnerability to individual hazards as ranked by 4 FGDs

Landlords	Tenants	Male farmers	Female farmers
1) Floods	1) Floods	1) Disease vectors	1) Rich people/investors
2) Disease vectors	2) Poor excreta disposal	2) Floods	2) Eviction
3) Poor excreta disposal	3) Crime	3) Poor excreta disposal	3) Floods
4) Crime	4) Dampness	4) Dampness	4) Disease vectors
5) Dampness	5) Eviction	5) Pollution	
6) Electricity	6) Disease vectors	6) Diseases	
7) Pollution	7) Electricity supply reliability	7) Eviction	

5.3.6 Factors associated with perceived vulnerability to floods

Bivariate and multivariate logistic regression analyses to assess factors associated to with perceived vulnerability to floods and waterlogging were run. Tenure status, and exposure to flood and waterlogging were significant at bivariate level of analysis (Table 5.6 below). Tenants were more likely to perceive their households vulnerable to floods and waterlogging than house owners/landlords (COR 1.7, 95% CI 1.03-2.68), while households that had been exposed to floods before were more likely to perceive themselves vulnerable to floods and waterlogging than households that had not been exposed (COR 34.8, 95% CI 18.95-63.92). Other factors such as sex, age, and marital status, occupation, length of stay in the area, family size, and monthly expenditure were not statistically significant.

Multivariate analysis showed only one factor, exposure to floods and waterlogging to be statistically significant. Households that had been exposed to floods before were more likely to perceive themselves vulnerable to floods and waterlogging than households not been exposed (AOR 34.0, 95% CI 18.46-62.45).

Table 5.6 Factors associated with perceived vulnerability to floods and waterlogging

Factors	% Vulnerable to floods	COR[95%CI]	p-value	AOR[95%CI]	p-value
Sex					
Male	86.5(212/245)	1.0			
Female	84.6(259/306)	0.9[0.53-1.39]	0.532		
Age (completed years)					
≤ 20	80.3(53/66)	1.0	0.772		
21-30	85.5(259/303)	1.4[0.73-2.87]	0.294		
31-40	87.2(123/141)	1.7[0.77-3.67]	0.196		
41-50	86.8(33/38)	1.6[0.53-4.96]	0.399		
> 50	100.0(3/3)	3.96E8[0.00-0.00]	0.999		
Marital status					
Single	81.1(107/132)	1.0	0.468		
Married/cohabiting	86.7(353/407)	1.5[0.91-2.57]	0.111		
Widowed	85.7(6/7)	1.4[0.16-12.17]	0.759		
Divorced/separated	100.0(5/5)	3.77E8[0.00-0.00]	0.999		
Occupation					
Peasant	82.5(47/57)	1.0	0.924		
Casual labourer	85.7(132/154)	1.3[0.56-2.89]	0.559		
Professional	88.6(39/44)	1.7[0.52-5.26]	0.390		
Self-employed	85.9(189/220)	1.3[0.59-2.83]	0.514		
Others	84.2(64/76)	1.1[0.45-2.85]	0.788		
Tenure					
Owners/landlords	81.4(166/204)	1.0		1.0	
Tenants	87.9(305/347)	1.7[1.03-2.68]	0.037	1.3[0.71-2.41]	0.389
Length of stay in the area					
≤ 5 years	83.7(303/362)	1.0			
> 5 years	88.9(168/189)	1.6[0.91-2.65]	0.103		
Family size					
≤ 4 people	85.7(305/356)	1.0			
≥ 4 people	85.1(166/195)	1.0[0.58-1.57]	0.862		
Monthly expenditure (UGX)					
≤ 200,000	87.8(209/238)	1.0			
> 200,000	83.7(262/313)	0.7[0.44-1.16]	0.176		
Exposure to floods					
Not exposed	33.7(28/83)	1.0		1.0	
Exposed	94.7(443/468)	34.8[18.95-63.92]	<0.001	34.0[18.46-62.45]	<0.001 †††

COR=Crude Odds Ratio; AOR=Adjusted Odds Ratio; †††=very significant at 95% Confidence Interval (CI)

5.4 Discussion

5.4.1 Floods and public health

Overall, analysis of exposure to hazards showed floods and waterlogging as the principal hazard. However, secondary effects of floods and waterlogging such as disease vectors (especially mosquitoes), communicable diseases and dampness affect more people than the actual floods. This is in line with findings from previous research on climate change-related flooding which point out the secondary impacts of flooding on health and livelihoods (Lwasa, 2010; Horwitz *et al.*, 2012). Waterlogged areas provide breeding sites for mosquitoes that spread Malaria (Kansiime & Nalubega, 1999; Unger & Riley, 2007; Horwitz *et al.*, 2012; Musoke *et al*., 2013; Ding *et al*., 2014). The increased frequency of flooding and mosquito breeding have been reported as key concerns for wetland communities around Lake Victoria in Kenya (Kairu, 2001), and also as an explanation for the upsurges of malaria in Kampala (UN-Habitat, 2012). However, it is also likely that the agricultural activities in the wetland, particularly the method of farming and the type of crops grown could provide breeding sites for mosquitoes (Boischio *et al.*, 2006; Matthys *et al.*, 2006; Horwitz *et al.*, 2012). In addition, floods have been reported to promote diseases such as foot rot, worms, respiratory infections and diarrhoea (NAPA-Uganda, 2007)

The nature of flooding experienced in the study area can be categorised as seasonal flash floods, resulting from intense short duration thunderstorms. The impact of floods occurring in the area is exacerbated by human activities such as the built up areas, blocked storm drains and culverts, compacted ground, the relatively flat profile of valleys and the high water table in low lands which limits percolation. The floods range from short-term to prolonged, depending on location (short-term in the wetland peripheries and prolonged in the lower and permanently inundated parts). Footpaths between buildings become waterlogged whenever it rains as has been observed in other low-laying informal settlements in several African cities (Douglas *et al.*, 2008). With this complex sanitation situation; decomposing waste providing breeding for flies, water sources, usually shallow wells and spring wells, are frequently contaminated by floods, a host of water and sanitation-related diseases spread far beyond flood-prone areas.

5.4.2 Vulnerability in flood-prone areas

Occupation of flood-prone areas happens in dry seasons and as such, the population there is highly transient (Isunju *et al.*, 2013). Results indicate that perception of vulnerability to floods and waterlogging was associated with previous exposure to the same, .i.e., households that had been exposed to floods were more likely to perceive themselves vulnerable. In addition, the vulnerabilities ranked in Table 5.5 above suggest that gender is an important factor for perception of vulnerability. The rankings show that female farmers perceived themselves more vulnerable to being displaced or evicted than their male counterparts. This is possibly due to culturally embedded gender inequalities and property rights as have been reported in other studies (Kiguli & Kiguli, 2004; Nabulo *et al.*, 2004; Simiyu, 2013). Otherwise, the variations in perception of vulnerability could be attributed to differences in adaptive capacity such that households with stronger adaptive capacity perceive themselves less vulnerable and vise versa; or increases in flood frequency and severity might have caused more households to perceive themselves vulnerable to floods, or a combination of the above.

In spite of the high risk of flooding, communities continuously endure and occupy these wetland areas because of various reasons, such as poverty, population pressure, benefits they associate with the area etc. Studies on flooding in informal settlements have reported several coping strategies including seasonal occupancy of dwellings, sleeping on raised beds, keeping valuables above ground, building resilient houses and flood barrier walls, raising embankments, raised latrines, desilting drainage channels, digging drainage around the house, psychosocial coping strategies such as alertness, early warning systems, social networks, insurance, lobbing for external support e.g. government/politicians or third party actors (Douglas *et al.*, 2008; Chatterjee, 2010; Sakijege *et al.*, 2012; Isunju *et al.*, 2013; Waters, 2013; Satriagasa *et al.*,, 2014; Odemerho, 2015). Such coping strategies minimise vulnerability. There is therefore a need to explore the coping strategies or adaptation mechanisms to the various hazards identified in this study.

The nature of tenure was crudely associated with both exposure and vulnerability to floods and waterlogging. Tenants were more likely to be exposed and or perceive themselves more vulnerable to floods than landlords/house owners. This is possibly due to the fact that house owners have invested in making their dwellings safer for which tenants do not have a mandate to do. In addition, houses in flood-prone areas are relatively cheaper for tenants hence are usually on demand in dry seasons. Studies analysing the pattern of growth for Kampala have reported that large parts of the newly built-up areas, especially slum areas, are located in wetlands (UN-Habitat, 2007b; Vermeiren *et al.*, 2012). This could be because plots in the wetlands are relatively cheaper and many owners would rather sell to a willing buyer or rent out to tenants than continue being flooded.

5.4.3 Lessons for environmental protection and risk reduction

The community places trust in the government to ensure a clean and healthy environment (Uganda Constitution, 1995: Cap. 4, Sec. 39), but there are sentiments that government is not doing enough to ensure safety and wellbeing of its people. However, it is not uncommon for vulnerable communities to blame their governments for not doing enough to guarantee their safety (Tempelhoff *et al.*, 2009). It should be noted here that not all the hazards mentioned by the community satisfy the conventional definition of a hazard according to the United Nations Framework Convention on Climate Change (IPCC) and the United Nations International Strategy for Disaster Reduction (UNISDR) literature. Most of what the community perceives as hazards have more to do with the local environmental sanitation conditions. Environmental sanitation encompasses excreta and waste management, safe water management and hygiene, drainage and vector control. The local authority, in this case Kampala Capital City Authority, should normally provide such services. However, servicing informal communities, who are occupying gazetted wetland areas, would not only imply formalizing the informal but also legalizing the illegal. The local authority would be acting contrary to its own planning. Nonetheless, these findings underpin the importance of environmental sanitation and re-emphasise the necessity for an integrated approach (Bremner & Zuehlke, 2009) in dealing with the issues of population growth, health, and the environment.

5.5 Chapter summary

This chapter has unveiled the various hazards, damages caused by the hazards, and locally perceived vulnerabilities among communities living and or working in Kampala's wetlands. The findings are contextual as experienced and perceived by the affected communities. Although the community is exposed to several hazards, principal among them is seasonal flooding and waterlogging, whose secondary effects such as vector breeding and disease outbreaks affect more people than those exposed to floods. Environmental protection and risk reduction can have competing interests, as such, interventions on either side need to be integrated. The variations in exposure to floods and perceived vulnerability floods observed in this study could likely be due to differences in capacity to resist, cope, or adapt to minimize vulnerability.

This chapter addressed research objective 3, and the next chapter addresses objective 4 by investigating community-level adaptation to minimise vulnerability to floods and exploit opportunities in Kampala's wetlands.

Chapter 6: Community-level adaptation to minimise vulnerability and exploit opportunities in Kampala's wetlands[8]

This chapter addresses research objective 4. It discusses benefits informal wetland communities in Kampala Uganda derive from their location in the wetland and how they adapt to minimise vulnerability to hazards such as floods and disease vectors. It focuses on the mechanisms, and the factors associated with preference and ability to adapt. A total of 551 households were interviewed in addition to four focus group discussions and five key-informant interviews. Free water from spring wells and cheaper rental units topped the benefits from location while the main benefit associated with the wetland is that it supports crop farming. Tenure status was significantly associated with the preference and perceived ability to adapt: tenants were less likely to prefer to adapt, and less likely to perceive themselves able to afford adaptation than landlords. There is a need for coordinated adaptation strategies that involve all stakeholders and that enhance equitable utilisation of wetland resources without compromising their ecosystem services and economic benefits.

[8] The contents of this Chapter were accepted for publication in a peer-reviewed journal (*Environment and Urbanization*). The publication is currently in press and can be cited as: Isunju, J.B., Orach, C.G. & Kemp, J. 2015. Community-level adaptation to minimise vulnerability and exploit opportunities in Kampala's wetlands. *Environment and Urbanization*. In press.

6.1 Introduction

As the world gets more urbanised, environmental resources such as wetlands are threatened (Hettiarachchi *et al.*, 2015), and vulnerable groups, especially the urban poor get increasingly marginalised (Zebardast, 2006). Governments in developing countries are grappling to find equilibrium between poverty reduction and environmental protection. The past couple of decades have witnessed unprecedented encroachment on marginal and reserve areas such as wetlands and increasing exposure of vulnerable groups to hazards (Fuseini & Kemp, 2015). Often, the poor are most affected because they directly depend on their immediate environment for livelihoods. Only resilient communities can thrive (Sapirstein, 2006). Whereas, resilience has been defined from a number of perspectives, its key elements include the ability of a social-ecological system to absorb disturbance and appropriately reorganize, learn from and adapt to minimise vulnerability (Scientific and Technical Advisory Panel, 2015). The intricate interaction between the social and natural components of our environment necessitates in-depth understanding of the factors that shape the way in which risk is perceived or experienced. Alberti (2005:169) holds that "humans depend on earth ecosystems for food, water, and other important products and services, and that changes in ecological conditions that result from human actions in urban areas ultimately affect human health and well-being".

Wetlands have been well-documented for their ability to purify and gradually release water, thereby controlling floods and providing water. While the ecological importance of wetlands is clear, for the sake of human habitation wetlands are high-risk areas; prone to flooding, pollution and several other sanitation related hazards (Alberti, 2005). Despite the hazards however, the fertile soils and abundant soil moisture in wetlands support crop farming almost throughout the year, guaranteeing food security (Turyahabwe *et al.*, 2013) and subsistence incomes for the poor among other benefits (Kakuru *et al.*, 2013). In order to exploit the benefits, minimise vulnerabilities, and improve quality of life, communities devise adaptation mechanisms against the hazards they face. However, in the process of adapting, human activities can potentially degrade wetlands, compromise their ecological benefits, or create even more hazards.

Uganda envisions managing and wisely using wetland resources in ways conducive to conserving the environment and its biodiversity while optimising sustainable benefits. Among its objectives, the Wetland Sector Strategic Plan (WSSP) seeks to promote community-based regulation and administration of wetlands resource use (MWE, 2001). The dilemma however lies with implementing wetland conservation in the framework of Uganda's Poverty Eradication Action Plan (PEAP), whose pillars among others include increased ability of the poor to raise their incomes, and increased quality of life for the poor.

This chapter focuses on the opportunities/benefits and community-level adaptations in wetlands that receive and filter wastewater from the city of Kampala, Uganda before discharging it into Murchison bay of Lake Victoria. The city is built on gentle hills and flat bottomed valleys (Kansiime & Nalubega, 1999), with a network of wetlands covering approximately 32 km^2, which is about 16% of Kampala district (Namakambo, 2000). Here, many informal settlements, with a mix of tenants and landlords (Isunju *et al.*, 2011) have cropped up in addition to reclamation of wetlands for crop farming and industrial development. Traditional farmers (peasants) and rural-urban immigrants engage in urban agriculture in the wetlands as a transfer of rural livelihood strategies into an urban environment, where a market for produce is assured and transport costs are minimal. Cultivation in Kampala's wetlands has been reported as far back as the 1950s but increased significantly in the 1990s (Huising, 2002). The farmers mostly plant sugarcane and coco yam which thrive well in waterlogged soils (Nasinyama *et al.*, 2010). More than half of the wetland area in the city has been transformed into crop fields, industrial establishments and settlements (WMD-MWE *et al.*, 2009). Increased occupancy of these flood-prone lands is associated with increased vulnerabilities and risks (Douglas *et al.*, 2008). It is important to understand how communities that derive benefits from the wetlands exploit these benefits, and how they adapt in order to minimise their vulnerability. This is necessary not only for risk reduction in these communities, but also for the judicious use of wetland resources. This chapter discusses survey findings from informal wetland settlements in Kampala. The discussion centres on the benefits that communities associate with their location and the wetland itself, adaptation mechanisms they employ to minimise vulnerability to disease vectors and floods, and the factors associated with the preference and perceived ability to afford adaptation.

6.2 Methods

6.2.1 Study setting, design and sampling

This cross-sectional study was conducted among communities living in four wetlands (Nakivubo, Kinawataka, Kansanga, and Kyetinda/Ggaba) that drain into the Murchison bay of Lake Victoria in Kampala, Figure 1.1 above. The study population constituted of informal settlements in wetlands, most of which were within a radius of eight kilometres from the city centre. A mix of qualitative and quantitative methods, including focus group discussions (FGDs), key informant interviews (KIIs), GPS-linked field observations, and a household survey were used to gather data. The study investigated benefits and opportunities that the community associated with their location and those derived from the wetland. In addition, community level adaptation mechanisms to minimise vulnerability to hazards and also to exploit benefits and opportunities were assessed. Purposive sampling was applied in five parishes, i.e. Butabika, Mutungo, Bukasa, Kansanga and Ggaba that cover significant portions of the four wetlands. Study units were households, and were selected proportionate to population sizes of zones in the wetland areas.

6.2.2 Data collection and quality control

Quantitative data from the survey of 551 households were collected using structured interviews which were administered by trained and experienced research assistants. One respondent was interviewed per household, who was either the household head or an adult household member found at home at the time of visit. To ensure good-quality data, the questionnaires were drafted in both English and the local language (Luganda) and research assistants were trained in administering both. The questionnaires were pre-tested in a comparable community that was not part of our study area. The feedback from the pre-test was used to make necessary adjustments in the questions to attain coherence, validity and relevance. To ensure completeness, accuracy and consistency in responses, cross-checking and field editing of data were done. Besides collecting demographic and socioeconomic characteristics of respondents, the questionnaires inquired about benefits and opportunities of location and from the wetland, adaptation mechanisms to minimise vulnerability, and the preference and ability to adapt.

To gain insights into the likelihood of flood-exposed households to adapt in a particular manner to minimise vulnerability to floods and waterlogging, each adaptation mechanism practiced by a household was independently regressed against self-reported exposure to floods and waterlogging. And to gain insights into the factors associated with the preference to adapt against floods and waterlogging rather than relocating to another place, respondents were asked whether they preferred to stay and adapt or relocate to another place. Also, respondents were asked whether they agree or disagree with a statement about their ability to adapt, which read as: “You can afford to adapt against the hazards that you face in this area”. “Ability to afford adaptation” was not necessarily in monitory terms but rather a holistic self-assessment, taking into consideration one’s circumstances and previous experiences.

Complementary to the quantitative data, qualitative data were gathered from four focus group discussions (FGDs), five key informant interviews (KIIs) and GPS-linked field observations. The four FGDs conducted constituted house owners/landlords, tenants, male farmers, and female farmers. It was in the interest of the study to gain insights into the preference and ability to adapt in each of the sub-groups above. Firstly, the house owners have invested in these vulnerable areas and are therefore at risk of loss in the event of hazards such as floods. Secondly, tenants occupying rental housing units in the area constitute the majority of residents and the most vulnerable. And thirdly, the farmers use the largest portion of the wetlands for crop cultivation. Separate FGDs of male and female farmers were held because of the culturally embedded gender roles and inequality in land rights (Scott, Oelefse & Guy, 2002). In the study context, men customarily have more rights over land even though women are more engaged in cultivation. An earlier study reported an anecdotal case where the man determined the type of crops the woman should grow and how to utilise the output (Kiguli & Kiguli, 2004). The five KIIs were held with representatives of key stakeholders including the Wetlands Management Department at the Ministry of Water and Environment, the Directorate of Health and Environment at Kampala Capital City Authority, Hope for Children – an NGO working to promote public health and the environment in the study area, and the Nakivubo Farmers Association.

6.2.3 Data management and analysis

Quantitative data were entered and cleaned in EpiData version 3.0 and subsequently exported and analysed in SPSS version 19. Frequencies and percentages were computed for discrete and categorical variables such as social demographic characteristics, benefits and adaptation mechanisms, and mean and standard deviation for household size. Ranked data were collapsed to binary before performing regression analyses. Binary logistic regressions were performed at bivariate and multivariate levels to generate crude and adjusted odds ratios respectively, 95% confidence intervals and p-values. A chi-square test was used to test null hypotheses and statistical significance was considered at p-value <0.05. Only variables that were significant at bivariate level were included in multivariate regression. The outputs of the quantitative analysis are summarised in graphs and tables in the results section. Qualitative data from the recordings of FGDs and KIIs were transcribed. The data were then grouped into themes in line with study objectives and used to elaborate on quantitative findings in form of narratives or direct quotes where necessary.

6.3 Results

6.3.1 Socio demographic characteristics

Of the 551 respondents surveyed, 55.5% were female, 67% were aged between 18 and 30 years, 52.4% had studied beyond primary level, 73.9% were married/cohabiting, 63% were tenants (renting) and 66.4% had lived in the area for less than 5 years. Household income, expenditure, monthly rent and occupation are summarised in Figure 6.1 below. The mean household size was 3.9 (SD=2), ranging from 1-13 people per household.

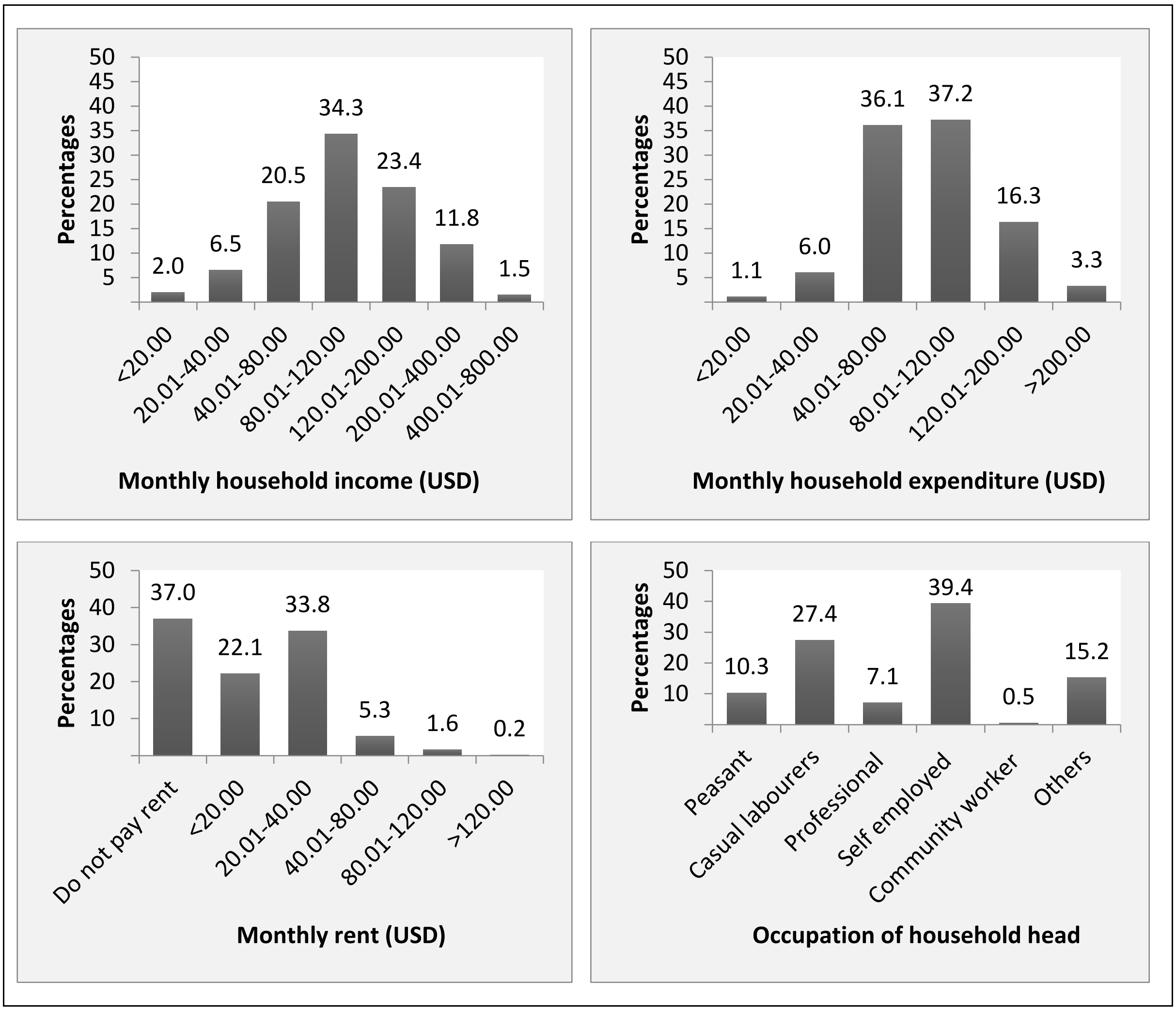


Figure 6.1 Household income, expenditure and occupation

6.3.2 Benefits associated with location

Households were asked to mention the benefits they associated with or derived from their current location (place of residence). More than half of households (53.7%) mentioned free sources of water (e.g. spring wells) and about half (49.5%) mentioned cheaper rent, while significant proportions mentioned closer proximity to the central business district (CBD) i.e. within a radius of about eight kilometres, roads, work places, places of worship, and social networks among others (Table 6.1 below). Only 3.1% mentioned reliable piped water.

Table 6.1 Benefits associated with location

Benefit/opportunity associated with location	% (N=551)
Free sources of water	53.7 (296)
Cheaper rent	49.5 (273)
Closer proximity to the central business district (CBD)	38.1 (210)
Closer proximity to roads	35.9 (198)
Closer proximity to work place	28.1 (155)
Closer proximity to place of worship	21.6 (119)
Closer proximity to social networks	21.1 (116)
Cheap food	19.4 (107)
Closer proximity to educational institutions	15.4 (85)
Others (e.g. security, electricity, quietness, recreation, beautiful view, etc.)	11.1 (61)
Cheaper plots of land	9.1 (50)
Reliable piped water	3.1 (17)

Although the house rent in these fragile areas is comparatively lower than in non-flood prone neighbourhoods, it was reported to increase with proximity to urban centres and/or road networks. Quote:

> "…*some landlords mistreat us by increasing rent almost every month because they know their houses are near town, you will not go away and rent in other places which are a distance from town*" (FGD, Tenants).

Staying closer to workplaces, markets and urban centre was strategic for the dwellers to save on transport costs. Quote:

> "…*we are near industrial area we easily get jobs and we don't pay for transport*" (FGD, Tenants).

6.3.3 Benefits derived from the wetland

Besides the benefits associated with or derived from current residential location, households were also asked to mention benefits they derived from the wetland area. Results in Table 6.2 below show that free sources of water (23.2%) still topped the list, followed by; cool breeze/temp, cheap land for cultivation, high crop-yields, and sand/clay mining. Only 1.5% of households mentioned fishing and hunting. Mud fish, which according to earlier occupants was easy meal, can now hardly be found in the Nakivubo wetland. Recreation (1.1%) was the least mentioned among the benefits derived from the wetland area.

Table 6.2 Benefits derived from the wetland

Benefits/opportunities derived from wetland	% (N=551)
Cheap/free water from springs/streams/ponds	23.2 (128)
Cool breeze/temp	19.6 (108)
Cheap land for cultivation	18.9 (104)
High crop-yields	17.4 (96)
Sand/clay mining	10.3 (57)
Clay brick laying	6.2 (34)
Papyrus for crafts	6.0 (33)
Medicinal plants	5.6 (31)
Construction materials	4.4 (24)
Others (e.g. Cheap/free food, vegetable, fruits etc.)	2.2 (12)
Fishing and hunting	1.5 (8)
Recreation	1.1 (6)

Some of the benefits the community mentioned are shown in Figure 6.2 below and include cheaper plots for construction, free water from a spring wells, an extensive sugar cane plantation, and clay and sand mining.

Figure 6.2 Some of the benefits from wetlands in Kampala: (A) cheaper plots, (B) free water, (C) farmland, and (D) clay and sand mining

6.3.4 Adaptation against hazards

Foremost among the hazards mentioned during the household survey were floods and waterlogging (84.9%) and presence of disease vectors (98.5%). Local adaptation mechanisms to minimise vulnerability to these hazards were examined and results are presented in the subsequent sections.

6.3.4.1 Adaptation mechanisms to minimise vulnerability to disease vectors

The majority of households mentioned adaptations against the hazard of malaria-transmitting mosquitoes, i.e. sleeping under mosquito nets (88.7%), spraying with insecticides (52.1%), closing windows and doors (48.3%), and draining stagnant waters (43.0%). Fewer households mentioned adaptations against the hazard of flies, i.e. cleaning latrines regularly (35.2%), covering pit latrines (25.8%), covering garbage and not storing it for long (23.4%) as summarised in Table 6.3 below.

Table 6.3 Adaptation mechanism against disease vectors

Adaptations against disease vectors	% (N=551)
Sleeping under mosquito nets	88.7 (489)
Spraying with insecticides	52.1 (287)
Closing windows and doors	48.3 (266)
Draining stagnant waters	43.0 (237)
Cleaning latrines regularly	35.2 (194)
Covering pit latrines	25.8 (142)
Covering garbage and not storing it for long	23.4 (129)
Cutting bushes	21.8 (120)
Installing mosquito screen	8.3 (46)
Using electrocutors	7.8 (43)
Others e.g. mosquito repelling coils, creams and smoke	7.1 (39)

6.3.4.2 Adaptation mechanisms to minimise vulnerability to floods and waterlogging

A large majority of flood affected households said they adapted by raising flood barriers, and a considerable majority adapted by building resilient structures. About two-thirds said they adapted by filling with soil to raise ground levels, placing valuables above the floor and digging trenches around the house, while slightly more than half adapted by desilting drainage channels as summarized in Table 6.4 below. The results of regressions, also in Table 6.4, show that households who had been directly exposed to floods and waterlogging within the last five years were more likely to adapt by raising barriers around their houses (COR 2.2, 95% CI 1.30-3.64, p=0.003); filling waterlogged areas with soil (prior to building or inside existing houses) to raise ground levels (COR 1.6, 95% CI 1.00-2.58, p=0.049); digging trenches around the house (COR 1.6, 95% CI 1.02-2.61, p=0.043); raising beds higher (COR 3.5, 95% CI 1.89-6.55, p<0.001); and placing valuable items higher above ground (COR 2.7, 95% CI 1.69-4.37, p<0.001) than households that had not been exposed to floods. Although a considerable majority of households said they had built resilient structures, the odds of building such resilient structures were significantly lower among flood exposed households compared to those who had not been exposed. It is likely that some households were exposed to floods earlier, then build resilient structures, which partly explain the high percentage of people with resilient structures among the flood exposed, while the odds ratio of 0.4 could be because resilient structures are protective against floods and waterlogging. However, this being a cross-sectional survey, we could not establish a cause-effect relationship. While building resilient structures might be protective against exposure to floods, other factors such as location, severity of floods, and construction materials could affect the level of protection. Although several households exposed to floods and waterlogging also adapted by raising latrine sludge chambers, desilting drainage channels, raising embankments along the drainage channels, digging drainage canals, cutting down wetland vegetation so that the area dries up, and cultivating/digging in flood prone areas, these adaptations were often at neighbourhood scale, and were not statistically different between flood-exposed and unexposed households.

Table 6.4 Adaptation mechanisms against floods and waterlogging

Adaptation mechanisms against floods	% (N)	COR[95%CI]	p-value	
Raising a barrier	81.8 (383)	2.2[1.30-3.64]	0.003	**
Building resilient structures	71.2 (333)	0.4[0.19-0.73]	0.004	**
Filling with soil to raise ground levels	66.7 (312)	1.6[1.00-2.58]	0.049	*
Placing valuables above floor	66.5 (311)	2.7[1.69-4.37]	<0.001	***
Digging trenches around the house	64.7 (303)	1.6[1.02-2.61]	0.043	*
Desilting drainage channels	57.3 (268)	1.1[0.67-1.72]	0.755	
Raising embankments along the drainage channels	43.6 (204)	1.6[0.98-2.63]	0.061	
Raising bed higher	39.5 (185)	3.5[1.89-6.55]	<0.001	***
Raising latrine sludge chamber	34.8 (163)	0.8[0.48-1.24]	0.283	
Digging canals	21.2 (99)	1.4[0.77-2.72]	0.254	
Cutting down wetland vegetation so that it dries up	12.6 (59)	1.6[0.69-3.56]	0.284	
Suspending house on stilts	7.5 (35)	2.2[0.65-7.18]	0.211	
Cultivating/digging in flood prone areas	6.0 (28)	2.6[0.60-11.03]	0.202	
Insuring property	0.6 (3)	0.3[0.04-1.59]	0.145	

COR=Crude Odds Ratio; ***=very significant, **=significant, *=weakly significant at 95% Confidence Interval (CI)

The nature and scale of adaptation mechanisms against floods and waterlogging varied widely from physical structures and innovations, to practices and behavioural adjustments (such as staying awake at night to watch over family members during floods). Some of the physical adaptation mechanisms observed during the survey shown in Figure 6.3 below include sand bags piled to form embankments along banks of drainage channels, bridging streams to improve accessibility, barrier walls around property, and raising ground levels.

Figure 6.3 Some of the adaptations mechanisms against floods in the Kampala: (A) embankments along banks of drainage channels, (B) locally innovated bridges on streams, (C) barrier walls around property, and (D) filling the marsh with earth to raise grounds above flood level

Some of the coping strategies were reported to be quite stressful and significantly lowered the quality of life for those affected. Quote:

"*…I have spent three nights standing because of floods*" (FGD, Tenants);

"*…at night when I am sleeping and I hear the thunderstorm I get worried and I wonder where I will put the children at that time*" (FGD, Landlords);

"*...because one time the rain came when the parents were sleeping, children were sleeping on the floor, but by the time they (the parents) realised that the floods had entered the house, one child had already died*" (FGD, Landlords).

6.3.5 Preference to adapt against floods as opposed to relocation

Overall, about 35.6% (196/551) of households said that, given the choice, they would rather stay in the wetland and adapt against hazards than relocate to somewhere else. The results of regressions in Table 6.5 below show that occupation, tenure status, family size, exposure to floods, and perceived vulnerability to floods were significantly associated with preference to adapt at bivariate level. Multivariate analysis however revealed that only tenure status is significantly associated with the preference to adapt: tenants are less likely to prefer to adapt (AOR 0.3, 95% CI 0.20-0.44, p<0.001) than house owners/landlords.

Table 6.5 Factors associated with preference to adapt against floods as opposed to relocation

Factors	% Prefer to adapt	COR[95%CI]	p-value	AOR[95%CI]	p-value	
Sex						
Male	33.1(81/245)	1.0				
Female	37.6(115/306)	1.2[0.86-1.73]	0.271			
Age (completed years)						
≤ 20	34.8(23/66)	1.0	0.284			
21-30	32.3(98/303)	0.9[0.51-1.57]	0.695			
31-40	43.3(61/141)	1.4[0.78-2.61]	0.252			
41-50	34.2(13/38)	1.0[0.42-2.25]	0.947			
> 50	33.3(1/3)	0.9[0.08-10.87]	0.957			
Level of Education						
None	30.8(20/65)	1.0	0.503			
P1-P4	41.8(23/55)	1.6[0.76-3.43]	0.210			
P5-P7	37.3(53/142)	1.3[0.72-2.51]	0.360			
O-level	34.2(68/199)	1.2[0.64-2.13]	0.614			
A-level	30.0(18/60)	1.0[0.45-2.07]	0.926			
Tertiary	46.7(14/30)	2.0[0.81-4.79]	0.136			
Marital status						
Single	31.8(42/132)	1.0	0.066	1.0	0.163	
Married/cohabiting	35.6(145/407)	1.2[0.78-1.80]	0.425	0.9[0.58-1.48]	0.749	
Widowed	71.4(5/7)	5.4[1.00-28.75]	0.050	3.5[0.57-21.47]	0.178	
Divorced/separated	80.0(4/5)	8.6[0.93-79.05]	0.058	7.0[0.69-71.38]	0.100	
Occupation						
Peasant	54.4(31/57)	1.0	0.020	1.0	0.298	
Casual labourer	33.8(52/154)	0.4[0.23-0.79]	0.007	0.6[0.33-1.26]	0.198	
Professional	43.2(19/44)	0.6[0.29-1.41]	0.265	0.9[0.39-2.12]	0.834	
Self-employed	32.3(71/220)	0.4[0.22-0.72]	0.002	0.5[0.29-1.02]	0.058	
Others	30.3(23/76)	0.4[0.18-0.74]	0.006	0.7[0.31-1.48]	0.324	
Tenure						
Owners/landlords	54.9(112/204)	1.0		1.0		
Tenants	24.2(84/347)	0.3[0.18-0.38]	<0.001	0.3[0.20-0.44]	<0.001	***
Length of stay in the area						
≤ 5 years	34.0(123/362)	1.0				
> 5 years	38.6(73/189)	1.2[0.85-1.76]	0.280			

Family size					
≤ 4 people	31.2(111/356)	1.0		1.0	
> 4 people	43.6(85/195)	1.7[1.19-2.45]	0.004	1.2[0.79-1.78]	0.420
Monthly expenditure (UGX)					
≤ 200,000	31.9(76/238)	1.0			
> 200,000	38.3(120/313)	1.3[0.93-1.89]	0.120		
Exposure to floods					
Not exposed	49.4(41/83)	1.0		1.0	
Exposed	33.1(155/468)	0.5[0.32-0.81]	0.005	0.6[0.32-1.19]	0.151
Vulnerability to floods					
Not vulnerable	46.3(37/80)	1.0		1.0	
Vulnerable	33.8(159/471)	0.6[0.37-0.96]	0.032	0.9[0.45-1.73]	0.711

USD1 ≈ UGX2500; COR=Crude Odds Ratio; AOR=Adjusted Odds Ratio; ***=very significant at 95% Confidence Interval (CI)

6.3.6 Perceived ability to afford adaptation

About 41% (226/551) of respondents said they can afford while 59% (325/551) said they cannot afford. The results of regressions in Table 6.6 below show that age, level of education, occupation, and tenure status, length of stay in the area, monthly expenditure, and perceived vulnerability to floods are significantly associated with perceived ability to afford adaptation at bivariate level of analysis. Multivariate analysis however revealed that only level of education, occupation, tenure status, and monthly expenditure were the factors significantly associated with perceived ability to afford adaptation. Respondents with at least primary one (P1) and above (except for A-level, who could have been continuing students) were more likely to perceive themselves able to afford adaptation. Also, peasants in this context were more likely to consider themselves able to afford adaptation than non-peasants. Tenants were less likely to perceive themselves able to afford adaptation (AOR 0.3, 95% CI 0.20-0.46, p<0.001) than house owners/landlords; and households who spent more than UGX 200,000 (USD 80.00) per month were more likely to perceive themselves able to afford adaptation (AOR 1.5, 95% CI 1.00-2.28, p=0.05) than households who spent less.

Table 6.6: Factors associated with perceived ability to afford adaptation

Factors	% Afford to adapt	COR[95%CI]	p-value	AOR[95%CI]	p-value	
Sex						
Male	40.4(99/245)	1.0				
Female	41.5(127/306)	1.0[0.74-1.47]	0.862			
Age (completed years)						
≤ 20	40.9(27/66)	1.0	0.015	1.0	0.158	
21-30	36.6(111/303)	0.8[0.48-1.44]	0.516	0.8[0.46-1.53]	0.574	
31-40	53.2(75/141)	1.6[0.91-2.97]	0.101	1.3[0.63-2.49]	0.513	
41-50	31.6(12/38)	0.7[0.29-1.55]	0.345	0.5[0.17-1.20]	0.113	
> 50	33.3(1/3)	0.7[0.06-8.37]	0.795	0.6[0.05-8.05]	0.726	
Level of Education						
None	30.8(20/65)	1.0	0.004	1.0	0.024	*
P1-P4	32.7(18/55)	1.1[0.51-2.37]	0.818	1.1[0.46-2.56]	0.851	
P5-P7	48.6(69/142)	2.1[1.14-3.96]	0.017	2.2[1.09-4.37]	0.028	
O-level	42.7(85/199)	1.7[0.92-3.05]	0.089	1.5[0.74-2.92]	0.271	
A-level	26.7(16/60)	0.8[0.38-1.78]	0.613	0.8[0.31-1.86]	0.538	
Tertiary	60.0(18/30)	3.4[1.37-8.31]	0.008	2.3[0.78-6.60]	0.134	
Marital status						
Single	35.6(47/132)	1.0	0.442			
Married/cohabiting	43.0(175/407)	1.4[0.91-2.05]	0.135			
Widowed	28.6(2/7)	0.7[0.14-3.87]	0.705			
Divorced/separated	40.0(2/5)	1.2[0.19-7.47]	0.841			
Occupation						
Peasant	68.4(39/57)	1.0	<0.001	1.0	0.002	**
Casual labourer	35.7(55/154)	0.3[0.13-0.49]	<0.001	0.3[0.17-0.69]	0.003	
Professional	56.8(25/44)	0.6[0.27-1.37]	0.232	0.6[0.22-1.47]	0.246	
Self-employed	34.5(76/220)	0.2[0.13-0.45]	<0.001	0.3[0.15-0.58]	<0.001	
Others	40.8(31/76)	0.3[0.15-0.65]	0.002	0.6[0.25-1.35]	0.208	
Tenure						
Owners/landlords	60.8(124/204)	1.0		1.0		
Tenants	29.4(102/347)	0.3[0.19-0.39]	<0.001	0.3[0.20-0.46]	<0.001	***
Length of stay in the area						
≤ 5 years	37.6(136/362)	1.0		1.0		
> 5 years	47.6(90/189)	1.5[1.06-2.16]	0.023	1.1[0.69-1.65]	0.765	
Family size						
≤ 4 people	38.8(138/356)	1.0				
> 4 people	45.1(88/195)	1.3[0.91-1.85]	0.147			
Monthly expenditure (UGX)						
≤ 200,000	32.4(77/238)	1.0		1.0		
> 200,000	47.6(149/313)	1.9[1.34-2.70]	<0.001	1.5[1.00-2.28]	0.05	*
Vulnerability to floods						
Not vulnerable	50.0(40/80)	1.0		1.0		
Vulnerable	39.5(186/471)	0.7[0.41-1.05]	0.079	0.8[0.45-1.28]	0.302	

USD1 ≈ UGX2500; COR=Crude Odds Ratio; AOR=Adjusted Odds Ratio; ***=very significant, **=significant, *=weakly significant at 95% Confidence Interval (CI)

6.4 Discussion

Based on the results presented above, this section provides a synthesis and discussion of the findings regarding benefits associated with location and the wetland, adaptation mechanisms, preferences towards adaptation and the perceived affordability thereof. In addition, the stance of government on the status quo is discussed as well as its implications for urban adaptation and resilience of vulnerable communities.

6.4.1 Benefits and opportunities enjoyed by wetland communities in Kampala

More than half of households in this study mentioned free water as the main benefit from the wetlands. Earlier, a national inventory of benefits from wetlands in Uganda also reported water as the main benefit in 80% of wetlands nationally (WMD-MWE *et al.*, 2009). Certainly, the high water table and the abundance of spring wells endow the community with free local sources of water. These water sources are, however, highly prone to pollution especially in urban informal settlements (Isunju *et al.*, 2013). The pollution sources, both point and diffuse such as wastewater (Fuhrimann *et al.*, 2014) and industrial effluent (Banadda *et al.*, 2009), and leachate from garbage (Nyenje *et al.*, 2014) and pit latrines (Lutterodt *et al.*, 2014) among others are associated with significantly high health risks (Katukiza *et al.*, 2014).

Another benefit mentioned by about half of households is cheaper rent (affordable accommodation). In light of the rapid urban population growth, it is likely that more and more people will seek affordable accommodation against all odds. This suggests that the growth of informal settlements in wetlands is driven by a need for low cost of living in the city. Closer proximity to the CBD, roads, work places, places of worship, and social networks were also mentioned as benefits associated with location by significant proportions of households. These findings confirm earlier research which found that proximity to previously built up area and public infrastructure are key predictors for urban expansion and encroachment on wetlands (Vermeiren *et al.*, 2012).

As human activities continue to transform wetlands in pursuit of private benefits, societal benefits and ecosystem services of wetlands gradually diminish. Sources of water get polluted, and water quality and fish productivity are sacrificed for cheap land for cultivation, high crop-yields, sand and clay mining among others. Recently, the local authorities seem to have come to terms with the complexity of restoring natural wetland vegetation due to the myriad of competing wetland-users and the grossly compromised capacity of these wetlands to treat wastewater (Mbabazi *et al.*, 2010). Focus has instead shifted towards construction of more wastewater treatment plants (Letema, 2012; MWE, 2014) and using the wetlands as urban parks for recreation (KCCA, 2012a). However, this option may not be sustainable either given the high construction and operational costs of conventional wastewater treatment plants. Rather, integrating engineered drainage and wastewater treatment systems with natural wetland ecosystems (Lukooya *et al.*, 2013) might perhaps be a more sustainable option.

6.4.2 Adaptations to minimise vulnerability and exploit opportunities

To minimise their vulnerability to malaria-transmitting mosquitoes, most of the study households sleep under mosquito nets while others spray insecticides, close windows and doors early, and drain stagnant waters. Attention to drainage might be a less frequent response because, to be effective, neighbourhood drainage requires community cohesion and a sense of ownership, which are often lacking in such multi-ethnic and tenant-dominated urban poor communities. In Kampala, in-city low-income communities were found to have lower community cohesion than those on the city-periphery (Waters, 2013). In our study context, the community is characterised by a mix of both in-city and city-periphery low-income dwellers: in-city because of its close proximity to the city centre and city-periphery because it is at the edge of the wetland. Lack of community cohesion is often accompanied by weak social resilience (Sapirstein, 2006), which in turn increases the degree to which people will be impacted by a hazard. In this context, social resilience would refer to the ability of a community to mobilize its own resources quickly and effectively, and use them to anticipate, mitigate, adapt to, recover and learn from the effects of the hazards faced.

The adaptation mechanisms against floods and waterlogging identified in this study can be categorised under two levels: household and community. Household-level adaptations such as raising barriers around houses, building flood-resilient structures, adding soil to raise house foundations, digging trenches around the house, raising beds and placing valuable items higher up, above the floor, which were found to be common among flood exposed households, have also been reported in several flood-prone urban informal settlements in Africa (Odemerho, 2015), Asia (Chatterjee, 2010; Satriagasa *et al.*, 2014) and the Caribbean (Moser & Stein, 2010). These household-level adaptations are, however, desperate and isolated efforts towards preparedness, response and recovery with very limited impact in terms of risk reduction. Raising houses on stilts and purchasing flood insurance, all reported in other studies (Odemerho, 2015), were uncommon in our study community.

Community-level adaptations such as desilting drainage channels, raising embankments along streams or digging more drainage channels were undertaken by only a few members in the community, but were also said to be a source of conflict between farmers and residents. The conflict resulted from the diversion of flood waters. It was established from the FGDs that after some community members diverted the waters away from the settlement to the wetland, which resulted in flooding of crop fields. The farmers who had been affected reacted by diverting the waters back to the settlements. Some of the residents argued that the farmers were indifferent because they did not necessarily reside in flood-affected zones (Isunju *et al.*, 2015). These findings support earlier reports that extreme events such as erratic heavy rains have increased resulting in floods destroying crop fields in wetlands and flooding adjacent settlements (NAPA-Uganda, 2007). Some pragmatic communities do desilt local drainage channels when necessary, although this is properly the responsibility of the local authority and should be done with its consent. Drainage in the Nakivubo wetland is especially contentious, in part because of different objectives and a lack of coordination among stakeholders. For example, the redesign of storm drainage to spread/diffuse it upstream to protect the inner Murchison Bay from pollution (AfDB, 2008) also increased flooding in the adjacent informal settlements. Effective adaptation cannot only be community-based but must be supported by the necessary infrastructure and institutional framework (Lwasa, 2010). In addition, the barriers and constraints to adaptation need to be minimised through creating an enabling environment for adaptation (Smith *et al.*, 2008; Endfield, 2012; Biesbroek *et al.*, 2013; Klein *et al.*, 2014).

Results indicate that only about a third of households preferred to stay and adapt against floods and waterlogging rather than relocating to another place; and tenants were less likely to prefer to adapt than house owners/landlords. These results indicate that the preference to adapt is generally low, and even lower among tenants who are the majority. This low preference to adapt could have several explanations, for example; the fear of confrontational enforcement against encroachment by government authorities, increased frequency and severity of flooding, and the limited capacity to adapt. Adaptation requires some form of investment (Lwasa, 2010). In this context, the investment would be towards improving the resilience of physical structures, building flood barriers, improving drainage (hard adaptation) and community mobilisation, raising resources, obtaining institutional support (soft adaptation). However, most people, especially tenants do not feel it is incumbent on them to take on these responsibilities.

The challenge of adapting to minimise vulnerability in order to exploit opportunities in Kampala lies heavily on households (Nyakaana *et al.*, 2007). The study examined household adaptive capacity by asking whether or not households were able to afford to adapt against the hazards faced in the area. Important to note here is that ability to afford adaptation was not necessarily in monetary terms but rather as holistic self-reported ability; on the account that ability is uniquely perceived by those affected in the context of their circumstances and previous experiences. More than half of households said they could not afford to adapt. Perceived ability to afford adaptation was associated with level of education, occupation, tenure status, and monthly expenditure. In the context of this study, peasants were more likely to consider themselves able to afford adaptation than non-peasants. Since peasants are often considered a low-income occupation group, this finding is somewhat counter-intuitive. However, the high demand for their produce places urban peasants in better financial status than their rural counterparts (Kakuru *et al.*, 2013), but also, the crops mostly grown, i.e. coco-yams and sugar cane can thrive in waterlogged areas. Furthermore, the peasants' frequent exposure to wet and muddy conditions on crop fields could be boosting their confidence, hence affecting the way they perceive their ability to afford adaptation. Results also showed that tenants are less likely able to afford adaptation than house owners/landlords. Most tenants rent accommodation in these vulnerable locations because of financial constraints. Our results confirmed this: households who spend an equivalent of more than 80 US dollars per month were more likely able to afford adaptation than households who spent less. The above paint a clear picture of the link between urban poverty, vulnerability, and the limited ability to adapt.

Uganda's National Policy for the Conservation and Management of Wetland Resources defines wetlands as areas where plants and animals have become adapted to temporary or permanent flooding (The Republic of Uganda, 1995). Additionally, the National Environment Act in Section 36 provides for protection of wetlands and prohibits any person from reclaiming, erecting or demolishing any structure that is fixed in, on, under or over any wetland. From key informant interviews it was emphasised that the authorities are not ready to bend the law to accommodate wetland encroachers. In August 2015, the Ministry of Water and Environment (MWE) launched a wetland atlas for Kampala and neighbouring districts of Wakiso and Mukono in the bid to raise awareness following a cabinet directive to cancel illegal land titles in wetlands and evict encroachers (Okanya & Nantambi, 2015). Also, the National Environmental Management Authority in collaboration with Kampala Capital City Authority and the Ministry of Water and Environment signed a memorandum of understanding and has intensified the pressure to evict wetland encroachers.

Our findings unveil gaps in community-level adaptation, which are compounded by pressures of being evicted from wetlands. As such, there is a lack of an enabling environment to support adaptation. Such an enabling environment relates to institutional support, starting with the recognition of the need to build the resilience of vulnerable communities, creating a healthy environment and subsequently laying strategies to realise these goals. A recent study (Gyasi *et al.*, 2014) suggested the promotion of urban agriculture as a means to building urban resilience. However, given that urban agriculture in Kampala is largely practiced in wetlands, we recommend that it should be limited only to wetland peripheries to permit restoration of the critical natural wetland vegetation which attenuates flooding and pollution. Also, backyard vegetable gardening as piloted in neighbouring suburbs (Sabiiti *et al.*, 2014) could be promoted through community based organisations. The fact that Uganda depends on rain-fed agriculture, climate variability, particularly prolonged dry seasons and droughts leave many peasants vulnerable. This in part explains why many peasants try to cope by reclaiming wetlands where the soil moisture is fairly reliable. Alternative copping strategies such as availing water for agriculture on arable lands through small-scale irrigation schemes need to be explored (NAPA-Uganda, 2007).

Findings in this study show that up to two-thirds of households had stayed for less than five years in the area. This implies that the population is highly transient as has been reported by other studies in informal settlements (UNDP, 2004; Isunju *et al.*, 2011; KCCA, 2014). The highly transient nature of low-income households has been reported to disrupt social networks which are necessary in building community resilience (O'Keefe *et al.*, 2015). Frequent relocation of low-income tenant households is often as a result of failure to cope with the local conditions, eviction or inability to afford the cost of housing as has been reported elsewhere (Bartlett, 1997). The Ugandan government in collaboration with the private sector needs to initiate low-cost housing projects that are not in hazard-prone areas to accommodate the rapidly growing urban population. Low-cost housing projects (UNESCAP & UN-Habitat, 2008) have been successfully implemented elsewhere (Skobba *et al.*, 2013), however, caution should be taken to avoid exploitation by middle and higher income groups as reported in Dhaka city (Nahiduzzaman, 2012).

Raising awareness on the roles wetlands play such as flood control and water purification is recommended. It could include putting sign posts along wetland boundaries with messages of wetland benefits as has been done in Accra, Ghana (Secretariat of the Convention on Biological Diversity, 2012). Equitable wetland management will require strategic consideration of all beneficiaries of wetland resources and attributes (Mugwisa, 2014) if ecological conservation gains are to be sustained (Nakangu & Bagyenda, 2013). Hence, eviction of vulnerable wetland communities will need to be integrated with community empowerment as previously recommended by Kabumbuli & Kiwazi (2009) (Kabumbuli & Kiwazi, 2009) so as to enable them seek alternative livelihoods.

6.5 Chapter summary

This chapter has presented and discussed findings on benefits informal wetland communities in Kampala associate with location and the wetland itself, adaptation mechanisms to minimise vulnerability to hazards such as floods and disease vectors, preferences towards adaptation and the perceived ability to afford adaptation. It has given insight into the intricate nature of interactions between social and natural components of the environment and the factors that shape the way in which risk is perceived or experienced. The willingness to adapt and perception of affordability cannot be separated from the immediate benefit a community derives from its location. In this context, however, the process of adaptation often occurs at the expense of the natural environment. The findings suggest a need for sustainable adaptation strategies, and a need for involvement of all stakeholders, from the grassroots through the relevant government and partner institutions. Future research could therefore explore possibilities of coordinated adaptation strategies which enhance equitable utilisation of wetland resources without compromising their ecosystem services and economic benefits.

This chapter has addressed research objective 4. The next chapter discusses how the research findings in the preceding chapters address the research aim as well as the intellectual contribution of this study to the existing body of knowledge.

Chapter 7: General discussion and contributions

This chapter reiterates the conceptual stance taken in the dissertation, revisits study objectives, key findings and discusses the implications thereof in light of the conceptual framework. Summarised here are also the contributions to knowledge and practice.

7.1 Revisiting the conceptual framework and study objectives

The study was conceptualised based on the interactions that exist between the natural and human components of the environment described in Chapters 1 and 2. These interactions seem more dialectic than mutual. The social components (humans) depend on nature from which they derive resources and livelihoods. Humans need nature to survive, yet the biggest threat to nature is posed by human actions. Pressures within the social component of our environment are vented on nature, either directly or indirectly through consumptive resource exploitation, degradation and waste loads. This arouses Spirkin's rhetorical statement and question, "The threat of a global ecological crisis hangs over humanity like the sword of Damocles; Is it not the fatal mission of man to be for nature what cancer is for man?" (Spirkin, 1983). Human actions ultimately determine his fate; when nature thrives, man thrives but when nature falters man falters (Roberts *et al.*, 2014).

Premising on the conceptualisation that human activities generally transform nature in the quest for short-term consumptive needs, and in turn precipitate increased exposure to hazards that affect vulnerable elements, this study empirically analysed these theorised concepts using the case of encroachment on wetlands in Kampala, Uganda. Here, as described in Chapter 1, unprecedented encroachment by human activities on wetlands is associated with increased risk of flooding, pollution and a host of public health and environmental hazards which the community has to either cope with or succumb to. Henceforth, as illustrated in Figure 7.1 below, the first two objectives of this study resonate around the aspect of wetland transformation, while the last two objectives deal with the associated risks and risk reduction in a transformed environment. To address objective 1, spatiotemporal extents of land cover in the Nakivubo wetland in 2002, 2010 and 2014 were quantified and mapped, while objective 2 quantified and mapped the changes in land cover between the periods 2002-2010, 2010-2014, and 2002-2014 in the same area. Objective 3 was addressed by assessing factors associated with exposure and vulnerability to hazards among wetland communities in Kampala, and objective 4 by evaluating the preferences and adaptive capacity of these wetland communities to minimize vulnerability to hazards and to exploit opportunities that exist.

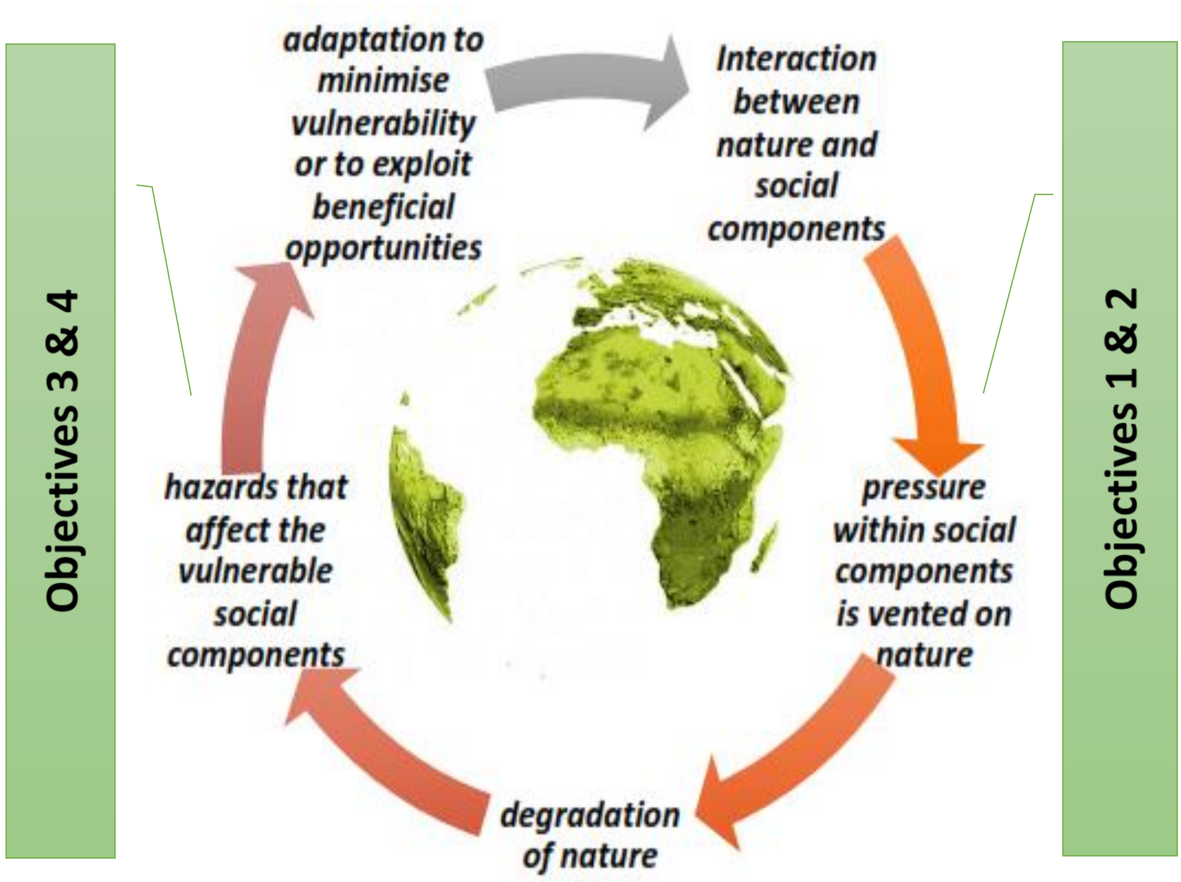


Figure 7.1 Study objectives within the conceptual framework

7.1.1 Encroachment on wetlands in light of the conceptual framework

The lack of up-to-date information to guide policy implementation towards judicious use of wetlands at a local scale was identified as a key constraint in the study context. The extent of the various human activities in wetlands and their interaction with the natural wetland vegetation (where and when transformations occur) provide important insights for strategic planning, stakeholder involvement and community-based conservation of these vital ecosystems. Objectives 1 and 2 are addressed in Chapter 4, which has provided analysis of the spatiotemporal extent of human activities in wetlands by quantifying the different land cover types and producing spatially congruent change detection maps of the Nakivubo wetland over a period of 12 years. The spatiotemporal analysis was based on very high resolution remotely sensed data so as to permit for the identification of various land cover types at a local scale. The Nakivubo wetland plays critical roles of flood attenuation and pollution buffering but also supports extensive urban agriculture on the northern shores of Lake Victoria in Kampala.

By quantifying the areas covered by each of the several land cover types such as built-up areas, cultivated areas, bare ground, grassland, trees and shrubs, natural wetland vegetation and open water, it was possible to know which human activities are dominant in the wetland. Too often, in the study context, encroachment on wetlands is perceived as or limited to built-up areas, but evidence from the Nakivubo wetland rather showed that cultivation covers much larger areas than all the other human activities. From the KIIs and FGDs, it was noted that the progression of encroachment activities often flows from clearing of the wetland vegetation and grassland, to draining for cultivation, and then where it is drier (especially the wetland peripheries) cultivated areas get gradually replaced by built-up areas and lawns. These areas then gain value faster due to their strategic location in the urban neighbourhood and settlements, commercial and industrial establishments begin to crop up. The farmers who are displaced from the peripheries reclaim new areas, often further down into the wetland.

In the FGDs, farmers in the Nakivubo wetland, who also referred to themselves as '*the poor',* expressed concerns regarding unequal land rights with industrial developers, *'the rich'*. The poor felt they were perceived by authorities as wetland degraders, yet according to them, the rich have transformed wetlands more because they have the resources and political networks. The same was noted from KIIs that political interference was key limitation in the management of wetlands resources, especially when encroachers are politically motivated. This findings support those in the Water and Environment Sector Performance Report 2014 (MWE, 2014). As discussed in Chapter 5 for example, female farmers ranked the rich as their greatest threat. Ironically, high urban poverty levels in the developing world have been hailed for keeping environmental degradation lower due to lesser consumption, resource use and waste generation (Satterthwaite, 2003). As a precautionary measure, the National Environment Management Authority (NEMA) in Uganda requires large-scale developments to undertake Environmental Impact Assessments (EIAs) and subsequently mitigate potential impacts. However small-scale activities which are not mandated to undertake EIAs are many and collectively, their effects can be significant (Apuyo, 2006; Nakangu & Bagyenda, 2013).

Land cover in the Nakivubo wetland was found to be highly dynamic; indicating intense human interaction. Analysis of the interclass conversions for the periods 2002-2010 and 2010-2014 showed more than half of wetland area would get transformed within each of the periods above. The spatial location and extent of each land cover class for the different years provided concrete evidence of which activities are compromising the wetland's ability to perform ecological functions such as water purification and flood control. The spatially congruent change detection maps clearly show where and when the wetland vegetation was cleared, especially the thick papyrus that buffered the lake in 2002, which was rapidly converted to crop fields mostly between 2010 and 2014. Overall, by 2014 the wetland vegetation had decreased by 62% of its 2002 cover. Although built-up area also increased significantly in the 12 years (over 400% of the 2002 built-up area), it was largely confined to wetland peripheries. From the FGDs, increased flooding was said to be the limiting factor that has confined built-up areas to the peripheries; the cost of construction in highly flood prone areas and the risk of flooding were said to be higher and rental returns from such dwellings were lower.

While the analysis of encroachment was limited to Nakuvubo wetland, it portrays man's interaction with nature at a local scale. Evidently, these transformations are occurring at the cost of nature's carrying capacity. The findings of this study, though local, resonate within the Sustainable Development Goals (SDGs) of the Post 2015 Development Agenda. For instance, Goal 15 seeks among other things to protect, restore and promote sustainable use of terrestrial ecosystems and their services, including freshwater resources and wetlands (ICSU & ISSC, 2015). The methods applied in this study demonstrate the possibility of precise spatiotemporal monitoring of wetland loss and/or recovery as well as the activities that ought to be regulated.

The drivers and consequences of wetland transformation interrelate with community adaptations to minimise vulnerability and to exploit benefits.

7.1.2 Hazards, vulnerabilities and adaptation in light of the conceptual framework

The household survey that provided quantitative data for objectives 3 and 4 relied on perception of those directly affected in the context of their circumstances. While this approach might appear subjective, it was contextually appropriate given that this study considered risk as a subjective calculation of those directly affected by hazards. Thus, "perceived vulnerability" discussed in this study is an intrinsic characteristic and is used as a proxy expression of vulnerability. Also, perceived ability to afford adaptation was not limited to financial terms but rather holistic self-reported ability, on the account that ability is uniquely perceived by those affected in the context of their circumstances and previous experiences.

Chapter 5 of this dissertation has addressed objective 3 of the study. An inventory of the hazards wetland communities in Kampala face has been provided and the factors associated with exposure and perceived vulnerability have been analysed. Having established that floods were the principal hazard, the subsequent analyses focused on flooding. It was in the interest of the study to understand for instance how flooding impacted the community; which factors were associated with exposure to floods, and which factors were associated with perception of vulnerability to floods. As opposed to conventional flood risk modelling approaches, in this thesis, risk is understood as a subjective calculation by those affected in the context of their circumstances (Kasperson *et al.*, 1988; Dwivedi, 1999). These aspects were deemed pertinent on the premise that perceptions underlie actions (Freeman *et al.*, 2011); people have different perceptions and therefore can have different reactions (Dwivedi, 1999).

Flooding emerged as the principal hazard because most of the other hazards were attributed to the flood waters. For example disease vectors, particularly mosquitoes that spread malaria, breed in stagnant pools of water following floods or in water that collects in discarded materials. The upsurges of malaria following floods are recurrent problem in the tropics (Ding *et al.*, 2014). Degradation of wetlands, cultivation, sand and clay mining and discarded materials provide mosquito breeding sites (Patz *et al.*, 2004; Matthys *et al.*, 2006; Malan *et al.*, 2009; Horwitz *et al.*, 2012). In addition to malaria, the high burden of water-related diseases, resulting from the contamination that is spread by floods into settlements, water sources and crop fields was reported by a large majority as has been noted in Chapter 5. A number of studies have also reported the significant public health risks among wetland communities (Nasinyama *et al.*, 2010; Fuhrimann *et al.*, 2014, 2015; Katukiza *et al.*, 2014). As recommended elsewhere (Malan *et al.*, 2009; Musoke *et al.*, 2013), wetland conservation, restoration or creation programs ought to put in place measures that prevent mosquito breeding. While, anti-mosquito drainage is meant to prevent stagnation of water which is necessary for mosquito larvae to mature (Malan *et al.*, 2009), the water should not flow too rapidly through the wetland so as to permit natural purification. On a general note, most of the hazards mentioned by the community in the context of this study were environmental health challenges resulting from the lack of municipal services in these informal settlements, as has been observed elsewhere in the developing world (Satterthwaite, 2003). Such services include storm water drainage, excreta management, solid waste management, disease vector control and housing.

The results in Chapter 5 also show that tenure and social economic status were associated with exposure to floods; tenants and households that spend less than USD 80.00 per month were more likely to be exposed to floods. From the focus group discussion with tenants, it was noted that many tenants rented vulnerable housing units either because of financial constraints or lack of affordable and safer alternatives. Housing units that were prone to flooding were said to be cheaper and habitable in dry seasons since flooding would occur in rainy seasons. The lack of, or poor quality basic public services and housing, inadequate or unstable income and risky asset base observed in this study are typically interrelated deprivations indicating absolute poverty (Oelofse, 2003; Satterthwaite, 2003). Given the rapidly growing urban population, it is likely that more tenants will continue to desperately seek for affordable accommodation within close proximity to the urban centres. This implies that even dwellings in vulnerable locations such as those discussed in this thesis will be occupied against all odds. These findings suggest that the urban poor compromise or endure their present circumstances for the sake of their future aspirations.

Results also show that perception of vulnerability to floods was associated with previous exposure; households that had been exposed to floods before were more likely to perceive themselves vulnerable. Given that risk, as described earlier, is expressed as a function of hazard and vulnerability factors, the factors associated with exposure and vulnerability to the hazards in Chapter 5, provide insight into the risks faced by wetland communities. Hence, variation in risk levels can be attributed to a number of factors that are associated with exposure, vulnerability, and differences in the capacity to resist, cope with, or adapt to minimize vulnerability.

Risk can be reduced through mitigation of hazards, reduction in vulnerability and or improving on the capacity to anticipate, resist, cope with or recover from the effects of hazards. Chapter 6 of this thesis addressed objective 4 by exploring the adaptation strategies that communities in Kampala's wetlands employ to cope with the hazards faced in light of the benefits and opportunities they derive from their location and the wetland itself. The hypothesis was that given the opportunity, a majority of community members would rather stay and adapt to minimise their vulnerability than relocate to another place. This was based on the assumption that the opportunities derived from location and the benefits from the wetland were linked to people's preference.

Top among the benefits and opportunities wetland communities in this study associated with their location and the wetlands were free water from spring wells, cheaper rental units and land for crop farming. This suggests that human occupation in these wetlands cannot be separated from the benefits and opportunities they derive from them. However, much as the settlements in Kampala's wetlands accommodate a large proportion of low-income urban dwellers, most of them live in deplorable conditions with very limited means to adapt. In this study households affected by floods and water logging in wetlands were more likely to adapt by raising barriers around their houses, filling with soil to raise house foundation, digging trenches around the house, raising beds on stilts, placing valuable items higher than non-affected households. Most of these adaptation mechanisms are rather weak and unsustainable, being desperate and isolated actions with very limited impact in terms of risk reduction.

Tenure status emerged as a significant factor from all the analyses, i.e. for land cover, exposure to hazards, perceived vulnerability to hazards, and preference and ability to adapt. The results in Chapter 6 showed that tenure status was significantly associated with the preference and perceived ability to adapt: tenants were less likely to prefer to adapt, and were less likely to perceive themselves able to afford adaptation than house owners. In all cases, tenants were more at risk than house owners, yet they do not feel it is incumbent on them to take adaptive actions. This is in line with Smit and Pilfosova's observation that the most vulnerable groups are the ones who get exposed to hazards, yet have limited adaptive capacity (Smit & Pilfosova, 2001). The results also indicated that the majority would prefer to relocate rather than trying to adapt against the frequent flooding. This explains the transient nature of tenant households reported in other studies (Bartlett, 1997; Kulabako *et al.*, 2010; Isunju *et al.*, 2013). Studies elsewhere argue that frequent relocation breaks social networks that are necessary in building community resilience (Bartlett, 1997; Waters, 2013). In light of this, measures to enhance adaptive capacity of tenants are a necessary condition to reduce vulnerability.

It is worth noting here the distinction between land tenure systems and ownership of a house. The tenure status as used in this study refers to the latter, while land tenure systems are categorizations of land ownership types emanating from the land parcelling agreement, popularly referred to as the 1900 Buganda agreement (see Chapter 2). This agreement marked the advent of private land ownership in Uganda. A number of other land reforms were made, the latest being the 1995 Ugandan Constitution which recognises four land tenure systems, i.e. customary, mailo, freehold and lease hold (Chapter 2 and Chapter 4). An inventory of the wetlands in Kampala (Namakambo, 2000) indicates that not all the wetlands are entirely owned as public land by government; several tenure/ownership arrangements exist, for example, Kansanga wetlands is owned partially under public and leasehold while Kinawataka and Kyetinda/Ggaba wetlands are owned partially under public, leasehold and mailo arrangements. As quoted from an interview with a key informant (Chapter 4), the several land ownership arrangement complicate development control, especially where ownership is not public.

Naturally, wetlands store, purify and gradually release water in the environment and as such they control floods and support life. Chapter 2 of this thesis has provided an overview of the products, services and attributes of wetlands as well as some of the underlying drivers of encroachment such as urbanisation and population growth, land tenure dynamics, the draining of wetlands for mosquito control, and the lack of an integrated management for wetlands in the study context. These drivers are no different from those in other parts of the world given that they depict general global challenges of population growth, increased demand for the finite environmental resources, the need for space to accommodate urban and industrial growth and the challenge of finding the right balance between short-term consumptive uses and maintaining environmental integrity. Evidence in literature suggests that environmental degradation exacerbates poverty (Satterthwaite, 2003). While governments in developing countries grapple to find equilibrium between poverty reduction and environmental protection, it is important to note that poverty eradication policies which do not take into account environmental limits are rather self-defeating (Melamed & Ladd, 2013).

Critical realism argues that structural factors, in this case factors such as population growth, institutions, land tenure systems etc. that were described in Chapter 2, are necessary but not sufficient to shape risk events. Structural factors are complemented by contingent local conditions (Oelofse, 2003). Structural factors are causal mechanisms which together with contingent local conditions drive environmental change and shape the way risk is perceived or experienced (Oelofse, 2003). Risk as defined in literature is a function of hazard and vulnerability factors, but is inversely associated with adaptive capacity (Taubenböck *et al.*, 2008; Keim, 2011), such that systems, communities or individuals with strong adaptive capacity are less likely to perceive themselves at risk or are less likely to experience risk.

7.2 Contributions to knowledge and practice

While this work builds on earlier studies on transformation of wetlands (Kansiime & Nalubega, 1999; Huising, 2002; Abebe, 2013), it also provides a recent assessment of encroachment based on a case of the Nakivubo urban wetland in Kampala, Uganda. Intriguingly, the very high resolution remotely sensed data used in this study permitted identification of small land cover types which together constitute significant areas. In addition, the study generated spatially congruent land cover change maps which give insight into the spatiotemporal dynamics of land cover, showing for instance the loss or recovery of the natural wetland vegetation. These findings could inform wetland managers and risk managers on the status of wetlands and the nature of transformations occurring therein. The findings can thus be used to assess the impact of wetland-restoration interventions implemented during the period covered by the study as well as to inform planning for new interventions.

The study findings on the hazards faced by wetland communities and the factors associated with exposure and vulnerability are vital for targeting risk reduction interventions. Furthermore, the insight into the adaptive capacity of affected communities provided by this study, and the links between benefits and adaptation discussed should inform policy makers as they design interventions. Interventions need to strike the right balance regarding the protection of the wetland environment by evicting encroachers, and supporting the survival strategies of the poor.

Given the above study findings, three dimensions to reducing risks associated with encroachment on wetlands are suggested: (a) the conservation and restoration of wetlands for their ecosystem services, (b) mitigation of hazards and exposure, and (c) reducing vulnerability through adaptation and resilience as illustrated in Figure 7.2 below.

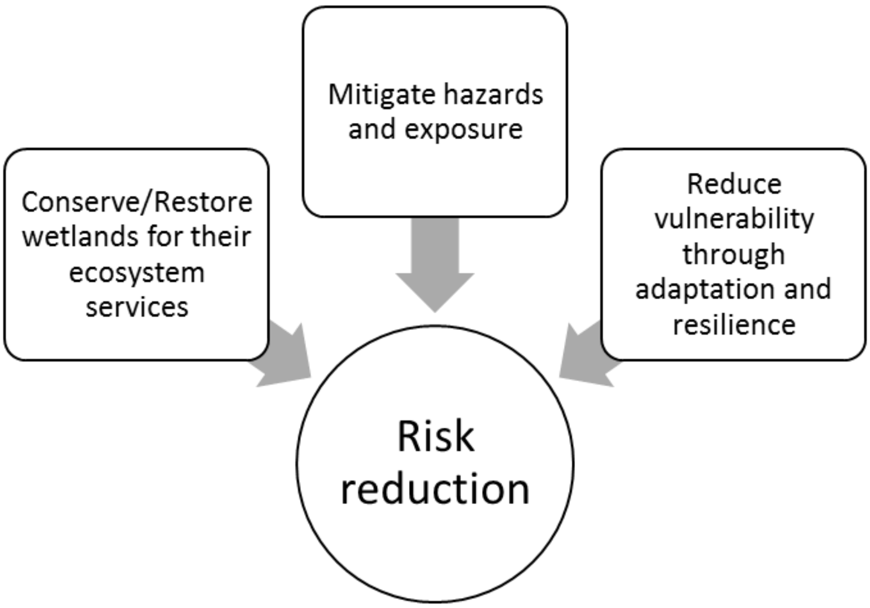


Figure 7.2 Risk reduction dimensions in wetlands

The risk reduction dimensions illustrated in Figure 7.2 above would need to be implemented within a holistic framework that addresses the causal mechanisms of risk as well as the contingent condition that shape it. Borrowing from the Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) framework presented earlier, risk reduction actions would have to target the elements in the risk causal chain.

Firstly, the driving forces will need to be addressed; including but not limited to reducing the high rates of urbanisation and population growth as well as controlling urban and industrial developments to ensure compliance with regulations preventing transformation of wetlands. In light of climate change and increased climate variability, extreme events are eminent, for example the torrential rains popularly referred to as *El Niño* that result in severe floods and disease outbreaks. The transformation of wetlands has compromised their ability to attenuate hazards such as flooding and pollution, with consequences of increased public health risks and economic costs such as the high water treatment costs.

Secondly, the pressures which arise from the driving forces highlighted above will also need to be addressed. Such pressures include increase demand for food, space, water and other services in addition to increased waste discharge into wetlands. Of prime interest in the study context is flood attenuation and waste water treatment. These might call for zoning out of the wetland and restricting certain activities to specific zones. While recent studies (Gyasi *et al.*, 2014; Sabiiti *et al.*, 2014) suggest the promotion of urban agriculture as a means to boosting food security and building urban resilience, in the context of this study, agriculture could be limited to only the wetland peripheries to permit restoration of the critical natural wetland vegetation which attenuates flooding and pollution. This would be a form of ecosystem-based approach (EBA) to minimizing the risks of flooding and pollution. In addition, backyard vegetable gardening as piloted in neighbouring suburbs (Sabiiti *et al.*, 2014) could be promoted through community based organisations as an alternative to cultivation in the wetlands.

Thirdly, flood-prone areas should be conserved as flood attenuation zones. Natural wetland vegetation should be restored in such areas as has been done elsewhere in the region (Kiwango & Moshi, 2013). Priority should be given to restoring wetland buffers zones around water bodies and protecting them against further encroachment. Awareness needs to be raised on the roles wetlands play, including flood control and water purification. This could include putting sign posts along wetland boundaries with messages of wetland benefits, as has been done in Accra, Ghana (Secretariat of the Convention on Biological Diversity, 2012). Wetland communities need to be involved in creating solutions to the risks discussed in this study so as to sustain ecosystem-based adaptations. Future research could therefore explore possibilities of coordinated adaptation strategies which enhance equitable utilisation of wetland resources without compromising their ecosystem services and economic benefits.

Last but not least, an enabling environment for adaptation needs to be created. This would entail institutional support, starting with the recognition of the need to build the resilience of vulnerable communities, creating a healthy environment and empowering them to live in such an environment. Hence, eviction of vulnerable wetland communities will need to be integrated with community empowerment efforts, as previously recommended by Kabumbuli & Kiwazi (2009) and support to enable members of these communities seek alternative livelihoods. Given that tenure status emerged as a significant factor in all the analyses, the Ugandan government, in collaboration with the private sector, will need to initiate low-cost housing projects that are not in hazard-prone areas to accommodate the current wetland settlers.

In a nutshell, the spatiotemporal analysis has provided detailed understanding of the dynamics of encroachment activities and their implications for the ecosystem services provided by wetlands. In addition, the study has established the factors associated with exposure to flooding as well as adaptive capacity of affected communities. The findings of this study are vital for urban planning, implementing wise use of wetlands, as well as urban risk reduction. In a broader context, the study contributes local insights into some of the key aspects that the Sustainable Development Goals (SDGs) seek to address; particularly SDG 11, which seeks to make cities and human settlements inclusive, safe, resilient and sustainable; SDG 13, which seeks to take urgent action to combat climate change and its impacts; and SDG 15, which seeks to protect, restore and promote sustainable use of terrestrial ecosystems, and halt and reverse degradation and biodiversity loss.

Chapter 8: Conclusions

The aim of this study was to assess the spatiotemporal extent of encroachment on wetlands, and the associated hazards, vulnerabilities and adaptive capacity among wetland communities in Kampala, Uganda. Specifically, the study objectives were: to quantify and map at very high resolution the spatiotemporal extents of land cover in the Nakivubo wetland in 2002, 2010, and 2014; quantify and map land cover changes in the Nakivubo wetland between the periods 2002-2010, 2010-2014, and 2002-2014; assess factors associated with exposure and vulnerability to hazards among wetland communities in Kampala; and to evaluate the adaptive capacity of wetland communities to minimize vulnerability to hazards and to exploit opportunities that exist. In so doing, the study has examined the spatiotemporal dynamics in the wetland, interconnected hazard profiles and provided a basis for an integrative understanding of the physical and socioecological challenges with in the transforming wetlands.

Main findings and implications

Overall, analysis of land cover changes in the Nakivubo urban wetland showed a 62% loss of wetland vegetation between 2002 and 2014, which is mostly attributed to crop cultivation as has been observed by earlier studies. Cultivation in the buffer wetland vegetation makes it unstable to anchor, implying that it will likely be calved away by receding lake waves as evidenced by the 2014 image data. With barely no wetland vegetation buffer around the lake, the heavily polluted wastewater streams will likely further deteriorate the quality of lake water. Furthermore, with increased human activities in the wetland, exposure to flooding and pollution is expected to have more impact on the health and livelihoods of vulnerable communities. A multi-faceted approach such as ecosystem-based adaptation needs to be implemented, possibly through zoning out the wetland and restricting certain activities to specific zones.

In addition, the study has unveiled the various hazards, damages caused by the hazards, and locally perceived vulnerabilities among communities living and/or working in Kampala’s wetlands. The findings are contextual as experienced and perceived by the affected communities. Although the community is exposed to several hazards, principal among them is seasonal flooding and waterlogging, whose secondary effects such as vector breeding and disease outbreaks affect more people than those exposed to floods directly. Environmental protection and risk reduction can have competing interests and, as such, interventions on either side need to be integrated. The variations in exposure to hazards and perceived vulnerabilities observed in this study could likely be due to differences in capacity to resist, cope, or adapt to minimize vulnerability.

Finally, the study has presented and discussed findings on benefits informal wetland communities in Kampala associate with location and the wetland itself, adaptation mechanisms to minimise vulnerability to hazards such as floods and disease vectors, preferences towards adaptation and the perceived ability to afford adaptation. The findings have shown the intricate nature of interactions between social and natural components of the environment and the factors that shape the way in which risk is perceived or experienced. The willingness to adapt and perception of affordability cannot be separated from the immediate benefit a community derives from its location. In this context, however, the process of adaptation often occurs at the expense of the natural environment. In general, the findings suggest a need for sustainable adaptation strategies, and a need for involvement of all stakeholders, from the grassroots through the relevant government and partner institutions.

Study limitations

While all the wetlands in the study area are encroached upon, the extent for spatiotemporal analysis was limited to the Nakivubo wetland and to three dates partly because of the cost of very high resolution data visa vie the funds available and the time to process the data sets. As such, no comparison was done regarding encroachment activities across the four wetlands. Nonetheless, the Nakivubo wetland is the largest of the four wetlands and receives most of the wastewater from Kampala city.

Directions for future research

Research is needed to identify context-specific interventions targeting the elements in the causal chain of encroachment on wetlands and associated risks. Subsequently, evaluation of impacts of proposed interventions needs to be done so as to understand where in the causal chain an intervention aimed at reducing risk would be most effective. In addition, future research could assess the potential of ecosystem-based approaches to adaptation (EBA) to reduce vulnerability; for instance, the potential of restored wetlands to efficiently attenuate flooding and pollution levels. Also, the feasibility of community conservation areas (CCA) approach in an urban context needs to be studied so as to understand how wetland communities can be part of the solution to the issues identified in this study. Finally, institutional arrangements and coordination to enhance the wise-use of wetland resources, hazard mitigation and resilience building at community level and beyond need to be evaluated.

References

Abebe, G.A. 2013. Quantifying urban growth pattern in developing countries using remote sensing and spatial metrics: a case study in Kampala, Uganda. University of Twente.

Adger, W.N. 2006. Vulnerability. *Global Environmental Change*. 16:268–281.

AfDB. 2008. *Kampala Sanitation Programme: Environmental and Social Impact Assessment Summary (ESIA)*. Kampala, Uganda: AfDB.

Ahmad, C.B., Abdullah, J. & Jaafar, J. 2012. Community Activities Around Protected Areas and the Impacts on the Environment at Krau Wildlife Reserve, Malaysia. *Procedia - Social and Behavioral Sciences*. 68(November):383–394.

Alberti, M. 2005. The Effects of Urban Patterns on Ecosystem Function. *International Regional Science Review*. 28(2):168–192.

Allen, A., Lampis, A. & Swilling, M. Eds. 2016. *Untamed Urbanisms*. London and New York: Routledge, Taylor & Francis Group.

Apuyo, R. 2006. Managing wetlands with changing times: Uganda's experience. In *International River Symposium*. Brisbane. 1–10.

Awal, M.A. 2015. Vulnerability to Disaster: Pressure and Release Model for Climate Change Hazards in Bangladesh. *International Journal of Environmental Monitoring and Protection*. 2(2):15–21.

Baguwemu, A., Onyai, F., Kaggwa, R., Kashemeire, O., Atwembembeire, J.M., Magero, S., Olemo, J.P. & Odeke, G.I. 2013. *The State of Uganda Population Report 2013*. Kampala, Uganda: Population Secretariat.

Balirwa, J.S. 1998. Lake Victoria wetlands and the ecology of the Nile tilapia, Oreochromis niloticus Linné. A.A.Balkema.

Banadda, E.N., Kansiime, F., Kigobe, M., Kizza, M. & Nhapi, I. 2009. Landuse-based nonpoint source pollution : a threat to water quality in Murchison Bay , Uganda. *Water Policy*. 11(1):93–104.

Bartlett, S. 1997. The significance of relocation for chronically poor families in the USA. *Environment and Urbanization*. 9(1):121–132.

Biesbroek, G.R., Klostermann, J.E.M., Termeer, C.J. a M. & Kabat, P. 2013. On the nature of barriers to climate change adaptation. *Regional Environmental Change*. 13(5):1119–1129.

Birkmann, J. 2006. Indicators and criteria for measuring vulnerability: Theoretical bases and requirements. In *Measuring Vulnerability to Natural Hazards: towards disaster resilient societies*. 1st ed. J. Birkmann, Ed. Tokyo: United Nations University Press. 55–77.

Birkmann, J. 2007. Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications. *Environmental Hazards*. 7(1):20–31.

Blaschke, T., Lang, S. & Hay, G.J. 2008. Object-based image analysis : spatial concepts for knowledge-driven remote sensing applications. Berlin, Germany: Springer.

Blaschke, T., Hay, G.J., Kelly, M., Lang, S., Hofmann, P., Addink, E., Queiroz Feitosa, R., van der Meer, F., et al. 2014. Geographic Object-Based Image Analysis - Towards a new paradigm. *ISPRS Journal of Photogrammetry and Remote Sensing*. 87(100):180–191.

Boischio, A., Clegg, A. & Mwagore, D. Eds. 2006. Health Risks and Benefits of Urban and Peri-Urban Agriculture and Livestock (UA) in Sub-Saharan Africa. In *Urban Poverty and Environment*. Canada.

Bremner, J. & Zuehlke, E. 2009. *Integrating Population, Health, and Environment in Uganda*. Washington, DC 20009.

Briggs, D. 1999. *Environmental health indicators: Frameworks and methodologies*. Geneva: World Health Organization.

Brooks, N. 2003. *Vulnerability, risk and adaptation: A conceptual framework*. Norwich.

Bulleri, F. & Chapman, M.G. 2010. The introduction of coastal infrastructure as a driver of change in marine environments. *Journal of Applied Ecology*. 47(1):26–35.

Buotte, P.C., Peterson, D.L., McKelvey, K.S. & Hicke, J.A. 2016. Capturing subregional variability in regional-scale climate change vulnerability assessments of natural resources. *Journal of Environmental Management*. 169:313–318.

Byaruhanga, A. & Ssozi, L. 2012. The Impact of population growth on the Ecosystems and Biodiversity of Kampala : Lessons for Sustainable Urban Development. In *Sustainable Futures: Architecture and Urbanism in the Global South*. Kampala, Uganda. 191–195.

Cai, Y. & Wang, X. 2013. Urbanization and Its Impacts on an Estuarine Wetland Area in Fuzhou City, China. In *Paving the Way Forward in Urbanization and Global Environmental Change Research*. Emerging S ed. C. Griffith, Ed. Tempe, Arizona: Arizona State University. 12–16.

Campbell, J.B. & Wynne, R.H. 2011. *Introduction to Remote Sensing*. New York: The Guilford Press.

Cardona, O.D. 2003. The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Perspective: A Necessary Review and Criticism for Effective Risk Management. In

Mapping Vulnerability: Disasters, Development and People. G. Bankoff, G. Frerks, & D. Hilhorst, Eds. London: Earthscan Publishers.

Chapman, L.J., Balirwa, J., Bugenyi, F.W.B., Chapman, C. & Crisman, T.L. 2001. Wetlands of East Africa: Biodiversity, Exploration, and Policy Perspectives. In *Biodiversity in wetlands: assessment, function and conservation*. Vol. 2. B. Gopal, W.J. Junk, & J.A. Davis, Eds. Leiden, The Netherlands: Backhuys Publishers. 101–131.

Chatterjee, M. 2010. Slum dwellers response to flooding events in the megacities of India. *Mitig Adapt Strateg Glob Change*. 15:337–353.

Cole, D.C., Bassil, K., Jones-Otazo, H. & Diamond, M. 2006. Health risks and benefits associated with UA: impact assessment, risk mitigation and healthy public policy. In *Health Risks and Benefits of Urban and Peri-Urban Agriculture and Livestock (UA) in Sub-Saharan Africa*. A. Boischio, A. Clegg, & D. Mwagore, Eds. IDRC.

Constitution. 1995. *Constitution of the Republic of Uganda*. Uganda: Parliament of Uganda.

Cooper, S.J. & Wheeler, T. 2015. Adaptive governance: Livelihood innovation for climate resilience in Uganda. *Geoforum*. 65:96–107.

Côté, I.M. & Darling, E.S. 2010. Rethinking ecosystem resilience in the face of climate change. *PLoS Biology*. 8(7).

Van Dam, A.A., Kipkemboi, J., Rahman, M.M. & Gettel, G.M. 2013. Linking Hydrology , Ecosystem Function , and Livelihood Outcomes in African Papyrus Wetlands Using a Bayesian Network Model. 381–397.

Davis, T.J. 1993. *Towards the Wise Use of Wetlands*. Gland, Switzerland: Ramsar Convention Bureau.

Ding, G., Gao, L., Li, X., Zhou, M., Liu, Q., Ren, H. & Jiang, B. 2014. A Mixed Method to Evaluate Burden of Malaria Due to Flooding and Waterlogging in Mengcheng County, China: A Case Study. *PLoS ONE*. 9(5):e97520.

Doswald, N. & Osti, M. 2012. *Ecosystem-based approaches to adaptation and mitigation-Good practice examples and lessons learned in Europe*. Bonn, Germany: Bundesamt für Naturschutz (BfN).

Douglas, I., Alam, K., Maghenda, M., Mcdonnell, Y. & Mclean, L. 2008. Unjust waters : climate change, flooding and the urban poor in Africa. *Environment and Urbanization*. 20:187–205.

Drichi, P. 2002. *National Biomass Study*. Kampala, Uganda.

Dwivedi, R. 1999. Displacement, Risks and Resistance: Local Perceptions and Actions in the Sardar Sarovar. *Development and Change*. 30(1):43–78.

Emerton, L., Iyango, L., Luwum, P. & Malinga, A. 1999. *The Economic Value of Nakivubo Urban Wetland, Uganda*. Nairobi, Kenya: IUCN.

Endfield, G.H. 2012. The resilience and adaptive capacity of social-environmental systems in colonial Mexico. *Proceedings of the National Academy of Sciences*. 109(10):3676–3681.

Feeley, K.J. & Silman, M.R. 2010. Land-use and climate change effects on population size and extinction risk of Andean plants. *Global Change Biology*. 16(12):3215–3222.

Freeman, J.B., Ambady, N., Midgley, K.J. & Holcomb, P.J. 2011. The real-time link between person perception and action: brain potential evidence for dynamic continuity. *Social neuroscience*. 6(2):139–155.

Fuhrimann, S., Winkler, M.S., Schneeberger, P.H.H., Niwagaba, C.B., Buwule, J., Babu, M., Medlicott, K., Utzinger, J., et al. 2014. Health risk assessment along the wastewater and faecal sludge management and reuse chain of Kampala, Uganda: a visualization. *Geospatial health*. 9(1):241.

Fuhrimann, S., Stalder, M., Winkler, M.S., Niwagaba, C.B., Babu, M., Masaba, G., Kabatereine, N.B., Halage, A.A., et al. 2015. Microbial and chemical contamination of water , sediment and soil in the Nakivubo wetland area in Kampala , Uganda. *Environmental Monitoring and Assessment*. 187(475):1–15.

Fuseini, I. & Kemp, J. 2015. A review of spatial planning in Ghana's socio-economic development trajectory: A sustainable development perspective. *Land Use Policy*. 47:309–320.

Giddings, S.W. 2009. *The Land Market in Kampala, Uganda and its Effect on Settlement Patterns*. Washington, D.C.

Gyasi, E.A., Fosu, M., Kranjac-Berisavljevic, G., Mensah, A.M., Obeng, F., Yiran, G.A.B. & Fuseini, I. 2014. *Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Tamale, Ghana*. J. Padgham & J. Jabbour, Eds. Nairobi: United Nations Environment Programme (UNEP).

Hambling, T., Weinstein, P. & Slaney, D. 2011. A review of frameworks for developing environmental health indicators for climate change and health. *International journal of environmental research and public health*. 8(7):2854–2875.

Haque, A.N., Dodman, D. & Hossain, M.M. 2014. Individual, communal and institutional responses to climate change by low-income households in Khulna, Bangladesh. *Environment and Urbanization*. 26(1):112–129.

He, C., Tian, J., Shi, P. & Hu, D. 2011. Simulation of the spatial stress due to urban expansion on the wetlands in Beijing, China using a GIS-based assessment model. *Landscape and Urban Planning*. 101(3):269–277.

Hettiarachchi, M., Morrison, T.H. & McAlpine, C. 2015. Forty-three years of Ramsar and urban wetlands. *Global Environmental Change*. 32:57–66.

Horwitz, P., Finlayson, C.M. & Weinstein, P. 2012. *Healthy wetlands, healthy people: a review of wetlands and human health interactions*. Gland & Geneva, Switzerland: Secretariat of the Ramsar Convention on Wetlands, Gland, Switzerland, & The World Health Organization, Geneva, Switzerland.

Huising, E.J. 2002. Wetland monitoring in Uganda. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. XXXIV:127–135.

ICSU & ISSC. 2015. *Review of Targets for the Sustainable Development Goals: The Science Perspective*. Paris, France: ICSU.

Ide, T., Schilling, J., Link, J.S.A., Scheffran, J., Ngaruiya, G. & Weinzierl, T. 2014. On exposure, vulnerability and violence: Spatial distribution of risk factors for climate change and violent conflict across Kenya and Uganda. *Political Geography*. 43:68–81.

Ingram, H. 2008. Beyond Universal Remedies for Good Water Governance: A Political and Contextual Approach. In *Rosenberg Forum for Water Policy*. Zaragoza, Spain.

IPCC. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. C.B. Field, V. Barros, T.F. Stocker, & Q. Dahe, Eds. Cambridge: Cambridge University Press.

IPCC. 2014. Summary for Policy Makers. In *Climate Change 2014: Impacts, Adaptation and Vulnerability - Contributions of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. and L.L.W. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, Ed. Cambridge: Cambridge University Press. 1–32.

Isunju, J.B., Schwartz, K., Schouten, M.., Johnson, W.P. & van Dijk, M.P. 2011. Socio-economic aspects of improved sanitation in slums: A review. *Public Health*. 125(6):368–376.

Isunju, J.B., Etajak, S., Mwalwega, B., Kimwaga, R., Atekyereza, P., Bazeyo, W. & Ssempebwa, C.J. 2013. Financing of sanitation services in the slums of Kampala and Dar es Salaam. *Health*. 5(4):783–791.

Isunju, J.B., Orach, C.G. & Kemp, J. 2015. Hazards and vulnerabilities among informal wetland communities in Kampala , Uganda. *Environment and Urbanization*. 28(1):1–19.

Jackson, A.C. & McIlvenny, J. 2011. Coastal squeeze on rocky shores in northern Scotland and some possible ecological impacts. *Journal of Experimental Marine Biology and Ecology*. 400(1–2):314–321.

Kabumbuli, R. & Kiwazi, F.W. 2009. Participatory planning, management and alternative livelihoods for poor wetland-dependent communities in Kampala, Uganda. *Blackwell Publishing Ltd, African Journal of Ecology*. 47(1):154–160.

Kaggwa, R., Hogan, R. & Hall, B. 2009. *Enhancing Wetlands' Contribution to Growth, Employment and Prosperity*. Kampala, Uganda: UNDP/NEMA/UNEP Poverty Environment Initiative, Uganda.

Kaggwa, R.C., Mulalelo, C.I., Denny, P. & Okurut, T.O. 2001. The impact of alum discharges on a natural tropical wetland in Uganda. *Water research*. 35(3):795–807.

Kairu, J.K. 2001. Wetland use and impact on Lake Victoria , Kenya region. *Lakes & Reservoirs: Research and Management*. 6:117–125.

Kakuru, W., Turyahabwe, N. & Mugisha, J. 2013. Total Economic Value of Wetlands Products and Services in Uganda. *The ScientificWorld Journal*. 2013:13.

Kansiime, F. & Nalubega, M. 1999. Wastewater Treatment by a Natural Wetland: the Nakivubo Swamp, Uganda. A.A. Balkema Publishers.

Kansiime, F., Saunders, M.J. & Loiselle, S. a. 2007. Functioning and dynamics of wetland vegetation of Lake Victoria: An overview. *Wetlands Ecology and Management*. 15:443–451.

Kanyiginya, V., Kansiime, F., Kimwaga, R. & Mashauri, D.A. 2010. Assessment of nutrient retention by Natete wetland Kampala, Uganda. *Physics and Chemistry of the Earth*. 35(13-14):657–664.

Kapoor, M., Lall, S. V, Lundberg, M.K.A. & Shalizi, Z. 2004. *Location and Welfare in Cities: Impacts of Policy Interventions on the Urban Poor*. Washington DC 20433, USA: World Bank.

Karenina, N. & Guevara, A. 2014. Informality and Formalization of Informal Settlements at the Turn of the Third Millennium: Practices and Challenges in Urban Planning. *Journal of Studies in Social Sciences*. 9(2):247–299.

Kasperson, R.E., Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X. & Ratick, S. 1988. The Social Amplification of Risk: A Conceptual Framework. *Risk Analysis*. 8(2):177–187.

Katukiza, A.Y., Ronteltap, M., van der Steen, P., Foppen, J.W.A. & Lens, P.N.L. 2014. Quantification of microbial risks to human health caused by waterborne viruses and bacteria in an urban slum. *Journal of Applied Microbiology*. 116(2):447–463.

Kaufman, L. 1992. Catastrophic Change Rich in Freshwater Ecosystems The lessons of Lake Victoria tropical ecosystem in. *BioScience*. 42(11):846–858.

KCC. 2002. *Kampala Drainage Master Plan*. Kampala: Kampala City Council.

KCCA. 2012a. *Updating Kampala Structure Plan and Upgrading the Kampala GIS Unit*. Kampala.

KCCA. 2012b. *Proposed Kampala Physical Development Plan*. Kampala: KCCA.

KCCA. 2014. *Laying the foundation for Kampala city transformation: Strategic Plan 2014/15-2018/19*. Kampala, Uganda.

Keim, M.E. 2011. Preventing Disasters: Public Health Vulnerability Reduction as a Sustainable Adaptation to Climate Change. *Disaster Medicine and Public Health Preparedness*. 5(02):140–148.

Kiguli, J. & Kiguli, L.N. 2004. Gender and Access to Land for urban agriculture in Kampala, Uganda. *UA-Magazine*. (May):34–35.

Kirabira, P. & Nagaddya, T. 2012. *Situational analysis of the health status of the slum dwelling population along the railwayline in Bukasa Parish, Makindye Division-Kampala*. Kampala, Uganda.

Kish, L. 1965. *Survey Sampling*. New York: John Wiley & Sons, Inc.

Kiwango, Y. & Moshi, G. 2013. Papyrus wetlands creation , a solution to improve food security and save Lake Victoria. *Wetlands Ecology and Management*. 21(2):147–154.

Klein, R.J.T., Midgley, G.F., Preston, B.L., Alam, M., Berkhout, F.G.H., Dow, K. & Shaw, M.R. 2014. Adaptation Opportunities, Constraints, and Limits. In *Assessment Report 5-Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. 899–943.

Kulabako, R.N., Nalubega, M., Wozei, E. & Thunvik, R. 2010. Environmental health practices, constraints and possible interventions in peri-urban settlements in developing countries--a review of Kampala, Uganda. *International journal of environmental health research*. 20(4):231–57.

Letema, S.C. 2012. Assessing sanitary mixtures in East African cities. Wageningen Academic Publ.

Louw, E.J.M. 2007. Climate Change in the Western Cape : A Disaster Risk Assessment of the Impact on Human Health. Stellenbosch University.

Lukooya, B.N., Tukahirwa, J., Busulwa, H. & Hein, T. 2013. Integrating Wetland Ecosystem Services into the Planning of Urban Landscapes in Developing Cities of East Africa: Lessons From European Riverine Wetlands and Floodplains. In *Paving the Way Forward in Urbanization and Global Environmental Change Research*. Emerging S ed. C. Griffith, Ed. Tempe, Arizona: Arizona State University. 17–22.

Lutterodt, G., Foppen, J.W.A. & Uhlenbrook, S. 2014. Escherichia coli strains harvested from springs in Kampala , Uganda : cell characterization and transport in saturated porous media. *Hydrological Processes*. 28(4):1973–1988.

Lwasa, S. 2010. Adapting urban areas in Africa to climate change : the case of Kampala. *Current Opinion in Environmental Sustainability*. 2(3):166–171.

Lwasa, S., Wahab, B., Mugagga, F., Simon, D., Fragkias, M., Griffith, C., Mukungu, D., Connors, J., et al. 2012. *The Role of Urban and Peri-Urban Agriculture in Enhancing Food Security and Climate Change Resilience in East and West African Cities*. Kampala, Uganda.

Magalhães, F. & Villarosa, F. Di Eds. 2012. *Slum Upgrading: Lessons Learned from Brazil*. Washington: Inter-American Development Bank.

Malan, H.L., Appleton, C.C., Day, J.A. & Dini, J. 2009. Wetlands and invertebrate disease hosts: Are we asking for trouble? *Water SA*. 35(5):753–768.

Matagi, S.V. 2002. Some Issues of Environmental Concern in Kampala, the Capital City of Uganda. *Environmental Monitoring and Assessment*. 77(2):121–138.

Matthys, B., Vounatsou, P., Raso, G., Tschannen, A.B., Becket, E.G., Gosoniu, L., Cissé, G., Tanner, M., et al. 2006. Urban farming and malaria risk factors in a medium-sized town in Côte d'Ivoire. *American Journal of Tropical Medicine and Hygiene*. 75(6):1223–1231.

Mbabazi, J., Kwetegyeka, J., Ntale, M. & Wasswa, J. 2010. Ineffectiveness of Nakivubo wetland in filtering out heavy metals from untreated Kampala urban effluent prior to discharge into Lake Victoria , Uganda. *African Journal of Agricultural Research*. 5(24):3431–3439.

McCauley, L.A. & Jenkins, D.G. 2005. GIS-Based Estimates of Former and Current Depressional Wetlands in an Agricultural Landscape. *Ecological Applications*. 15(4):1199–1208.

McMichael, A.J., Haines, A., Slooff, R. & Kovats, S. Eds. 1996. *Climate change and human health*. Geneva, Switzerland.

McMichael, A. & Githeko, A. 2001. Human health. In *Climate Change 2001: Impacts, Adaptation and Vulnerability*. U. Confalonieri & A. Woodward, Eds. Cambridge: Cambridge University Press. 451–485.

Melamed, C. & Ladd, P. 2013. *How to build sustainable development goals : integrating human development and environmental sustainability in a new global agenda*.

Mercer, J., Gaillard, J.C., Crowley, K., Shannon, R., Alexander, B., Day, S. & Becker, J. 2012. Culture and disaster risk reduction: Lessons and opportunities. *Environmental Hazards*. 11(2):74–95.

Mimura, N., Pulwarty, R.S., Duc, D.M., Elshinnawy, I., Redsteer, M.H., Huang, H.Q., Nkem, J.N. & Rodriguez, R.A.S. 2014. Adaptation Planning and Implementation. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. 869–898.

Molina, P.E. 2014. Modelling urban growth and flooding interactions with cellular automata in flooding interactions with cellular automata in Kampala, Uganda. University of Twente.

Moser, C. & Stein, A. 2010. *Pro-Poor Adaptation to Climate Change in Urban Centers : Case Studies of Vulnerability and Resilience in Kenya and Nicaragua*. Washington DC: The World Bank.

Mugisha, S. 2002. *Root causes of land cover/use change in Uganda: an account of the past 100 years*. (14). Nairobi.

Mugwisa, M. 2014. *The forgotten golden value of wetlands in Kampala*. Kampala. [Online], Available: http://www.newvision.co.ug/news/659306-the-forgotten-golden-value-of-wetlands-in-kampala.html [2015, August 28].

Mukwaya, P.I., Sengendo, H. & Lwasa, S. 2012. Enhancing Security and Resilience of Low-Income Communities to Climate Change in Growing Cities: An Assessment of Flood Management and Planning Regimes in Kampala City, Uganda. In *Climate Change, Human Security and Violent Conflict*. Vol. 8. J. Scheffran, M. Brzoska, H.G. Brauch, P.M. Link, & J. Schilling, Eds. Springer Berlin Heidelberg. 543–557.

Munroe, R., Roe, D., Doswald, N., Spencer, T., Möller, I., Vira, B., Reid, H., Kontoleon, A., et al. 2012. Review of the evidence base for ecosystem-based approaches for adaptation to climate change. *Environmental Evidence*. 1(1):13.

Musoke, D., Karani, G., Ssempebwa, J.C., Musoke, M.B., Ssempebwa, C.J. & Musoke, B.M. 2013. Integrated approach to malaria prevention at household level in rural communities in Uganda: experiences from a pilot project. *Malaria journal*. 12(1):327.

Musungu, K., Motala, S. & Smit, J. 2012. Using Multi-criteria Evaluation and GIS for Flood Risk Analysis in Informal Settlements of Cape Town : The Case of Graveyard Pond. *South African Journal of Geomatics*. 1(1):77–91.

MWE. 2001. *Wetland Sector Strategic Plan 2001-2010*. Kampala, Uganda.

MWE. 2012. *Water and Environment Sector Performance Report*. Kampala: Government of Uganda Ministry of Water and Environment.

MWE. 2014. *Water and Environment Sector Performance Report 2014*. Kampala, Uganda: Government of Uganda, Ministry of Water and Environment.

Nabulo, G., Nasinyama, G., Lee-smith, D. & Cole, D. 2004. Gender Analysis of Urban Agriculture in Kampala , Uganda Urban agriculture in. *UA-Magazine*. (May):32–33.

Nagabhatla, N., Wickramasuriya, R., Prasad, N. & Finlayson, C. 2010. A multi-scale geospatial study of wetlands distribution and agricultural zones, and the case of India. *Tropical Conservation Science*. 3(3):344–360.

Nahiduzzaman, K.M. 2012. Housing the Urban Poor: An Integrated Governance Perspective - The Case of Dhaka, Bangladesh. Royal Institute of Technology (KTH).

Nakangu, B. & Bagyenda, R. 2013. Sutainable management of wetland for livelihoods: Uganda's experience and lessons. In *Wetland management and sustainable livelihoods in Africa*. 1st ed. A.P. Wood, A.B. Dixon, & M.P. McCartney, Eds. Abingdon; New York: Routledge. 160–182.

Namakambo, N. 2000. *Kampala District Wetland Inventory Report*. Kampala.

NAPA-Uganda. 2007. *Climate Change: Uganda National Adaptation Programmes of Action*. Kampala, Uganda.

Nasinyama, G., Cole, D. & Lee-Smith, D. 2010. Health Impact Assessment of Urban Agriculture in Kampala. In *African Urban Harvest*. G. Prain, D. Lee-Smith, & N. Karanja, Eds. Springer New York. 167–190.

NEMA. 2000. *The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations*. Vol. XCIII date. Uganda.

Noble, I.R., Huq, S., Anokhin, Y.A., Carmin, J., Goudou, D., Lansigan, F.P., Osman-Elasha, B. & Villamizar, A. 2014. Adaptation Needs and Options. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. 833–868.

Nsubuga, F.N.W., Olwoch, J.M., DeW., C.J. & Rautenbach, O.J.B. 2014. Analysis of mid-twentieth century rainfall trends and variability over southwestern Uganda. *Theoretical and Applied Climatology*. 115(1):53–71.

Ntiba, M.J., Kudoja, W.M. & Mukasa, C.T. 2001. CASE REPORT Management issues in the Lake Victoria watershed. 211–216.

Nyakaana, J.B., Sengendo, H. & Lwasa, S. 2007. *Population, urban development and the environment in Uganda: the case of Kampala city and its environs*. Kampala, Uganda.

Nyenje, P.M., Foppen, J.W., Uhlenbrook, S. & Lutterodt, G. 2014. Using hydrochemical tracers to assess impacts of unsewered urban catchments on hydrochemistry and nutrients in groundwater. *Hydrological Processes*. 28(24):5860–5878.

Nyenje, P.M., Havik, J.C.N., Foppen, J.W., Muwanga, A. & Kulabako, R. 2014. Understanding the fate of sanitation-related nutrients in a shallow sandy aquifer below an urban slum area. *Journal of contaminant hydrology*. 164(3):259–74.

O'Keefe, M., Luthi, C., Tumwebaze, I.K. & Tobias, R. 2015. Opportunities and limits to market-driven sanitation services: evidence from urban informal settlements in East Africa. *Environment and Urbanization*. 27(6):1–20.

Obbo, D., Nanziri, M. & Ndawula, N. 2013. *Overview of Land Tenure Systems in Uganda*. Kampala, Uganda: MLHUD.

Odemerho, F.O. 2015. Building climate change resilience through bottom-up adaptation to flood risk in Warri, Nigeria. *Environment and Urbanization*. 27(1):1–22.

OECD. 2006. *The Challenge of Capacity Development: Working Towards Good Practice*. (83943 2006). Paris.

Oelofse, C. 2003. A Critical Realist Perspective on Urban Environmental Risk: a case study of an informal settlement in South Africa. *Local Environment: The International Journal of Justice and Sustainability*. 8(3):261–275.

Okanya, A. & Nantambi, A. 2015. *Kampala, Wakiso, Mukono wetland atlas out*. Kampala. [Online], Available: http://www.newvision.co.ug/news/672672-kampala-wakiso-mukono-wetland-atlas-out.html [2015, August 27].

Ologunorisa, T.E. & Abawua, M.J. 2005. Flood risk assessment: a review. *Journal of Applied Sciences and Environmental Management*. 9(1):57 – 63.

Omolo-Okalebo, F. 2011. The Evolution of Town Planning Ideas , Plans and their Implementation in Kampala City 1903-2004.

Orlove, B., Roncoli, C., Kabugo, M. & Majugu, A. 2010. Indigenous climate knowledge in southern Uganda: The multiple components of a dynamic regional system. *Climatic Change*. 100(2):243–265.

Ostrovskaya, E., Douven, W., Schwartz, K., Pataki, B., Mukuyu, P. & Kaggwa, R.C. 2013. Capacity for sustainable management of wetlands: Lessons from the WETwin project. *Environmental Science and Policy*. 34:128–137.

Oyoo, R. 2009. Deteriorating Water Quality in the Lake Victoria Inner Murchison Bay and its impact on the drinking water supply for Kampala, Uganda. In *13th World Lake Conference*. Wuhan, China.

Patz, J.A. & Olson, S.H. 2008. Land Use/Land Change and Health. In *International Encyclopedia of Public Health*. H. Editor-in-Chief: Kris, Ed. Oxford: Academic Press. 15–21.

Patz, J.A., Daszak, P., Tabor, G.M., Aguirre, A., Pearl, M., Epstein, J., Wolfe, N.D., Kilpatrick, A.M., et al. 2004. Unhealthy Landscapes: Policy Recommendations on Land Use Change and Infectious Disease Emergence. *Environmental Health Perspectives*. 112(10):1092–1098.

Pauw, T. 2012. Assessment of SPOT 5 and ERS-2 OBIA for mapping wetlands. Stellenbosch University.

Plant, M. 2001. Critical Realism: a Common Sense Philosophy for Environmental Education? In *ATEE Conference*. Stockholm.

Quade, D. & Lawrence, J. 2011. *Vulnerability and adaptation to increased flood risk with climate change — Hutt Valley household survey*. Wellington, New Zealand.

Ramsar. 2010. *Wise use of wetlands: Concepts and approaches for the wise use of wetlands*. 4th ed. Vol. 1. D. Pritchard, Ed. Gland, Switzerland: Ramsar Convention Secretariat.

Rana, M.M.P. 2011. Urbanization and sustainability: challenges and strategies for sustainable urban development in Bangladesh. *Environ Dev Sustain*. 13:237–256.

Rebelo, L.M., Finlayson, C.M. & Nagabhatla, N. 2009. Remote sensing and GIS for wetland inventory, mapping and change analysis. *Journal of environmental management*. 90(7):2144–53.

Rebelo, L.M., McCartney, M.P. & Finlayson, C.M. 2010. Wetlands of Sub-Saharan Africa: Distribution and contribution of agriculture to livelihoods. *Wetlands Ecology and Management*. 18(5):557–572.

Roberts, J., Ford, H., Spacey, K., Norton, E., Cruz, P., Redford, R. & Somerhalder, I. 2014. *Nature Is Speaking*. USA: Conservation International.

Roy, A. & AlSayyad, N. Eds. 2004. *Urban Informality: Transnational Perspectives from the Middle Eas, Latin America, and South Asia*. Lanham, Maryland: Lexington Books.

Roy, A. 2005. Urban Informality: Toward an Epistemology of Planning. *Journal of the American Planning Association*. 71(2):147–158.

Roy, A. 2009. Why India Cannot Plan Its Cities: Informality, Insurgence and the Idiom of Urbanization. *Planning Theory*. 8(1):76–87.

Rugadya, M. 1999. Land reform: the Ugandan experience. In *Land use and villagisation workshop*. Kigali, Rwanda. 1–12.

Sabiiti, E.N., Katongole, C.B., Katuromunda, S., Sengendo, H., Basalirwa, C.P.K., Atukunda, G. & Nambuubi, S.K. 2014. *Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Kampala, Uganda*. Nairobi, Kenya: United Nations Environment Programme (UNEP).

Sakijege, T., Lupala, J. & Sheuya, S. 2012. Flooding, flood risks and coping strategies in urban informal residential areas: The case of Keko Machungwa, Dar es Salaam, Tanzania. *Jàmbá: Journal of Disaster Risk Studies*. 4(1):1–10.

Sapirstein, G. 2006. Social Resilience : The Forgotten Dimension of Disaster Risk Reduction. *Jàmbá: Journal of Disaster Risk Studies*. 1(1):54–63.

Satriagasa, M.C., Nugraha, H., Riasasi, W., Ayuningtyas, E. & Rusdimi, A.U. 2014. Community-based Flood Adaptation In Vu Gia-Thu Bon Watershed , Central Vietnam. In *IJJSS 2014 : The 6th Indonesia Japan Joint Scientific Symposium*. Yogyakarta, Indonesia.

Satterthwaite, D. 2003. The Links between Poverty and the Environment in Urban Areas of Africa, Asia, and Latin America. *Annals of the American Academy of Political and Social Science*. 590:73–92.

Scheren, P.A.G.M., Zanting, H.A. & Lemmens, A.M.C. 2000. Estimation of water pollution sources in Lake Victoria , East Africa : Application and elaboration of the rapid assessment methodology. *Journal of Environmental Management*. 58(January):235–248.

Schirnding, Y. Von. 2002. Framework for Linkages between Health, Environment and Development. In *Health in Sustainable Development Planning: the Role of Indicators*. Geneva: World Health Organization. 105–120.

Schuyt, K.D. 2005. Economic consequences of wetland degradation for local populations in Africa. *Ecological Economics*. 53(2):177–190.

Scientific and Technical Advisory Panel. 2015. *Resilience Adaptation Transformation Assessment and Learning Framework*. Washington DC.

Scott, D., Oelefse, C. & Guy, C. 2002. Double trouble: environmental injustice in South Durban. *Agenda*. 52:50–57.

Secretariat of the Convention on Biological Diversity. 2012. *Cities and Biodiversity Outlook: A Global Assessment of the Links between Urbanization, Biodiversity, and Ecosystem Services*. Montreal, Canada.

Simiyu, R.R. 2013. Gendered Access to and Utilization of Land by Food Producers in Urban Kenya. 325–342.

Simpson, W.J.R. 1916. *The Maintenance of Health in the Tropics*. 2nd ed. London: John Bale Sons & Danielsson Ltd.

Skobba, K., Bruin, M.J. & Yust, B.L. 2013. Beyond Renting and Owning: The Housing Accommodations of Low-Income Families. *Journal of Poverty*. 17(2):234–252.

Sliuzas, R., Flacke, J. & Jetten, V. 2013. Modelling urbanization and flooding in Kampala, Uganda. In *N-AERUS XIV*. Enschede, Netherlands: Network-Association of European Researchers on Urbanisation in the South.

Smit, B. & Pilfosova, O. 2001. Adaptation to Climate Change in the Context of Sustainable Development and Equity. In *Climate Change 2001: Impacts, Adaptation and Vulnerability*. A. Patwardhan & J.F. Soussana, Eds. Cambridge: Cambridge University Press. 879–906.

Smit, J., Nasr, J. & Ratta, A. 2001. Urban Agriculture Yesterday and Today. In *Urban Agriculture: Food, Jobs and Sustainable Cities*. 2001st ed. The Urban Agriculture Network, Inc. With support from UNDP. 1–32.

Smith, T.F., Brooke, C., Measham, T.G., Preston, B., Gorddard, R., Withycombe, G., Beveridge, B. & Morrison, C. 2008. *Case Studies of Adaptive Capacity: Systems Approach to Regional Climate Change Adaptation Strategies prepared for the Sydney Coastal Councils Group, Sydney Australia*. Sydney.

Sperling, F. 2003. *Reducing the Vulnerability of the Poor through Adaptation*.

Spirkin, A. 1983. *Dialectical materialism: Man in the Realm of Nature*. Moscow: Progress Publishers.

Szumilas, M. 2010. Explaining Odds Ratios. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*. 19(3):227–229.

Taubenböck, H., Post, J., Roth, A., Zosseder, K., Strunz, G. & Dech, S. 2008. A conceptual vulnerability and risk framework as outline to identify capabilities of remote sensing. *Natural Hazards and Earth System Sciences*. 8:409–420.

Taylor, A.R.D. 1991. *Status of Nakivubo and Luzira swamps in Kampala*. Kampala, Uganda: Natural Wetlands Conservation and Management Programme.

Tempelhoff, J., Gouws, I. & Botha, K. 2009. The December 2004-January 2005 floods in the Garden Route region of the Southern Cape, South Africa. *Jàmbá: Journal of Disaster Risk Studies*. 2(2):93–112.

The Republic of Uganda. 1995. *National Policy for the Conservation and Management of Wetland Resources*. Uganda: Ministry of Water and Environment.

Tobey, J., Rubinoff, P., Robadue, D., Ricci, G., Volk, R., Furlow, J. & Anderson, G. 2010. Practicing Coastal Adaptation to Climate Change: Lessons from Integrated Coastal Management. *Coastal Management*. 38(3):317–335.

Tolo, C.U., Majule, E.A. & Lejju, J.B. 2014. Local and Indigenous Knowledge Systems in Subsistence Agriculture, Climate Risk Management, and Mitigation of Community Vulnerability in Changing Climate, Lake Victoria Basin: A Case Study of Rakai and Isingiro Districts, Uganda. In *Nile River Basin*. A.M.M. Setegn, W. Abtew, & G. Shimelis, Eds. Springer International Publishing. 451–473.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., et al. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America*. 100(14):8074–8079.

Turyahabwe, N., Kakuru, W., Tweheyo, M. & Tumusiime, D.M. 2013. Contribution of wetland resources to household food security in Uganda. *Agriculture & Food Security*. 2(1):5.

Twesigye, C.K. 2011. The Impact of Land Use Activities on Vegetation Cover and Water Quality in the Lake Victoria Watershed. *The Open Environmental Engineering Journal*. 4(1):66–77.

UBOS. 2011. *Uganda demographic and health survey 2011*. Kampala, Uganda.

UBOS. 2014. *National population and housing census 2014*. Kampala, Uganda: Uganda Bureau of Statistics.

UN. 2014. *World Urbanization Prospects, the 2014 Revision*. New York: United Nations.

UNDP. 2004. *Reducing Disaster Risk: A challenge for development*. New York, USA: United Nations Development Programme.

UNESCAP & UN-Habitat. 2008. *Housing the poor in Asian Cities - Low-Income Housing: Approaches to help the urban poor find adequate accommodation*. Bangkok and Nairobi, Thailand and Kenya: UNESCAP and Un-Habitat.

Unger, A. & Riley, L.W. 2007. Slum health: from understanding to action. *PLoS Med*. 4:e295.

UN-Habitat. 2007a. *State of the world's cities report (SWCR) 2006/2007*. Nairobi, Kenya: United Nations Human Settlements Programme.

UN-Habitat. 2007b. *Situation Analysis of Informal Settlements in Kampala*. Nairobi: United Nations Human Settlements Programme.

UN-Habitat. 2012. *Climate Change Assessment for Kampala, Uganda: A Summary*. Nairobi, Kenya: United Nations Human Settlements Programme.

UNISDR. 2004. *Living with Risk: A global review of disaster reduction initiatives*. New York and Geneva: United Nations publication.

UNISDR. 2009. *Terminology on Disaster Risk Reduction*. Geneva, Switzerland.

United Nations Department of Economic and Social Affairs Population Division. 2015. *World Population Prospects : The 2015 Revision, Key Findings and Advance Tables*. New York: United Nations.

Uy, N., Takeuchi, Y. & Shaw, R. 2011. Local adaptation for livelihood resilience in Albay, Philippines. *Environmental Hazards*. 10(2):139–153.

Verhoeven, J.T.A. & Setter, T.L. 2010. Agricultural use of wetlands: opportunities and limitations. *Annals of Botany*. 105(1):155–163.

Vermeiren, K., Van Rompaey, A., Loopmans, M., Serwajja, E. & Mukwaya, P. 2012. Urban growth of Kampala, Uganda: Pattern analysis and scenario development. *Landscape and Urban Planning*. 106(2012):199– 206.

Vitousek, P.M., Mooney, H.A., Lubchenco, J. & Melillo, J.M. 1997. Human Domination of Earth's Ecosystems. *Science*. 277(5325):494–499.

Wandiga, S.O. & Madadi, V.O. 2009. *Water Quality Issues in Eastern Africa*. Elsevier Inc.

Wasswa, J. 1997. Determination of Levels of Pollutants within Sediments in Water Channels from Industries and Selected Parts of Lake Victoria. Makerere University.

Waters, J.J.J. 2013. The Role of Ecosystem Services and Adaptive Capacity in the Resilience of Poor Urban Areas. University of East Anglia.

Whigham, D.F., Dykyjová, D. & Hejný, S. Eds. 1993. *Wetlands of the World I: Inventory, Ecology and Management*. Vol. 15/2. Dordrecht: Springer Science & Business Media.

WHO. 1997. *Health and Environment in Sustainable Development: Five Years after the Earth Summit*. Geneva.

Wisner, B., Blaikie, P., Cannon, T. & Davis, I. 2003. *At Risk: natural hazards, people's vulnerability and disasters*. 2nd ed. London, Routledge: Routledge.

WMD-MWE, UBOS, ILRI & WRI. 2009. *Mapping a Better Future: How Spatial Analysis Can Benefit Wetlands and Reduce Poverty in Uganda*. Kampala, Uganda: World Resources Institute, 10 G Street NE, Washington, DC 20002, USA.

Zebardast, E. 2006. Marginalization of the urban poor and the expansion of the spontaneous settlements on the Tehran metropolitan fringe. *Cities*. 23(6):439–454.

Zeng, L. & Chen, G.Q. 2011. Ecological degradation and hydraulic dispersion of contaminant in wetland. *Ecological Modelling*. 222(2011):293–300.

Zhang, W.W., Yao, L., Li, H., Sun, D.F. & Zhou, L.D. 2011. Research on Land Use Change in Beijing Hanshiqiao Wetland Nature Reserve Using Remote Sensing and GIS. *Procedia Environmental Sciences*. 10:583–588.

Appendices

Appendix A: Household Questionnaire

Hazards, Vulnerabilities, Opportunities and Adaptations among communities in Kampala's wetlands

Respondent Code		**Initials of interviewer**	
Date of Interview		**Start time**	
Parish		**Zone/Village**	
GPS Coordinates	**N**	**E**	**Z**

	Variable			**Attributes**	
001	Exposure to hazards and threats in the area (i.e. Environmental health and Socio-political). *Circle appropriately*				
	a) **Bizibu ki ku bino wamanga byemusanze mu banga el'emyaka etaano egiyise mu kitundu kino**			*b)If* ***yes,*** *how Often*	
	What hazards or threats have you/your household experienced in this area (in past 5 years)?	*1= Yes*	*2 = No*	*Rarely*	*Often*
	1. **Amataba** – [Floods (and waterlogging)]	1	2	1	2
	2. **Okutobelera/[bunnyogovu]–** [Dampness]	1	2	1	2
	3. **Obukyafu - Kazambi, kasassiro n'omwala** – [Poor sanitation (excreta, solid waste & drainage)]	1	2	1	2
	4. **Ebiwuka okugeza ng'ensiri n'enswera** – [Vectors (mosquitoes & flies)]	1	2	1	2
	5. **Bintu ki ebyonona obutonde bwensi – Mu mazzi, Ettaka n'empewo** – [Pollution (**probe** for water, soil and or air)]	1	2	1	2
	6. **Endwadde nga Kolera, Ekiddukano, Ekifuba, Lubyamira (Pnemonia), omusujja gw'ensiri –** [Communicable diseases (e.g. cholera, diarrhoea, RTIs, malaria etc)]	1	2	1	2
	7. **Ennyumba okubbira/okukka/okugwa olw'amazzi –** [Sinking/collapsing of houses]	1	2	1	2
	8. **Emmese, emisota, amakovu –** [Vermin (rats, snakes, snails etc)]	1	2	1	2
	9. **Okutiisibwa tiisibwa Okugobwa mu kitundu (okumenya n'okwonona ebintu)** [Evictions/threats (demolitions, destruction of property etc)]	1	2	1	2
	10. **Obumenyi bw'amateeka – Obubbi, obutemu, okukwata abakyala, obuwambe** [Crime (e.g. rape, theft, abduction, murder etc)]	1	2	1	2
	11. **Emiliro** [Fires]	1	2	1	2
	12. **Ebilara** [Others] (specify)..	1	2	1	2
	13. None	1	2	1	2

		Circle appropriately		
B	**Bintu ki eby'onooneddwa oba bulabe ki bwe musanze olw'ebizibu ebyogedwa ko wagulu?** [What **damages**/dangers have you faced due to exposure to the hazards above?]	Okwononeka kwamayumba oba ebintu by'ewaka. [Damage on houses dwellings]	Y	N
		Okwononeka kw'ebintu by'ewaka. [Destruction of other property]	Y	N
		Okukyafuwaza enzizi oba ebifo ebijjibwamu amazzzi [Pollution of water sources]	Y	N
		Emyala okuzibikira – [Blockage of drainage channels]	Y	N
		Okuyingilirwa amazzi agalimu kazambi – [Flushing of wastewater and sludge onto yards and dwellings]	Y	N
		Amataba okwonoona amakubo oba enguudo [Flooded and damaged access roads and paths]	Y	N
		Okwalula kw'ebiwuka ebileeta endwadde nga Ensiri n'ensweera - Breeding of disease vectors	Y	N
		Okubaluka wo kw'endwadde nga ekiddukano, kolera, lubyamira, **omusujja gwensiri nebirala-** Disease outbreaks e.g. Diarrhoea, Cholera, RTIs, malaria, etc	Y	N
		Okwonoonebwa kw'ebirime okugeza ettaka okuziika ebirime Burying of crops	Y	N
		Mukoka okwonoona ebirime Eroding/sweeping away of gardens	Y	N
		Ebirime obutadda bulungi n'ebirime okuvunda mu nnimiro Low yields/rotting of crops	Y	N
		Okugwa ebigwo Falls	Y	N
		Okubbira/okufiira mu mataba oba mu lutobazzi oba mu kitoogo. Drowning in flood waters	Y	N
		Okufumitibwa oba okusalibwa ebisongovu ng'ebyuuma, amaccupa Injuries caused by sharps in the mud	Y	N
		Ebilara Others (specify)............................	Y	N
		None	Y	N

002	Vulnerability				*Circle appropriately*
	a) Gwe oba ab'omumaka go mwetwalira nga abantu abasobola okukosebwa bino wammanga? Tugenda kukozesa ekipimo okuva kw'emu okutuuka ku nnya. [1= Oli bulungi nnyo, 2=Sikosebwa 3=Nkosebwamu 4=Nkosebwa ddala] Do you consider yourself (or any member of your household) vulnerable to any of the following hazards/threats?				
	Hazards/threats	**Oli bulungi nnyo** Very safe	**Sikosebwa** Not vulnerable	**Nkosebwamu** Fairly vulnerable	**Nkosebwa ddala** Very vulnerable
	1. Amataba – [Floods (and waterlogging)]	1	2	3	4
	2. Okutobelera/[bunnyogovu]– [Dampness]	1	2	3	4
	3. Obukyafu - Kazambi, kasassiro n'omwala – [Poor sanitation (excreta, solid waste &drainage)]	1	2	3	4
	4. Ebiwuka okugeza ng'ensiri n'enswera – [Vectors (mosquitoes & flies)]	1	2	3	4
	5. Ebintu ebyonona obutonde bwensi – okugeza mu mazzi, Ettaka n'empewo – [Pollution (of water, soil and or air)]	1	2	3	4
	6. Endwadde nga Kolera, Ekiddukano, Ekifuba, Lubyamira (Pnemonia), omusujja gw'ensiri – [Communicable diseases (e.g. cholera, diarrhoea, RTIs, malaria etc)]	1	2	3	4
	7. Ennyumba okubbira/okukka/okugwa olw'amazzi – [Sinking/collapsing of houses]	1	2	3	4
	8. Emmese, emisota, amakovu – [Vermin (rats, snakes, snails etc)]	1	2	3	4
	9. Okutiisibwa tiisibwa Okugobwa mu kitundu (okumenya n'okwonona ebintu) [Evictions (demolitions, destruction of property etc)	1	2	3	4
	10. Obumenyi bw'amateeka – Obubbi, obutemu, okukwata abakyala, obuwambe [Crime (e.g. rape, theft, abduction, murder etc)]	1	2	3	4
	11. Emiliro [Fires]	1	2	3	4
	12. Ebilara [Others] (specify)...	1	2	3	4
	13. None	1	2	3	4

003	Benefits/opportunities/resources	*Circle appropriately*	
	a) Birungi ki by'oganyuddwamu okubeera mu kitundu kino? What **benefits** do you associate **with location** (*e.g. proximity to CBD, roads, market for your produce, water source, work place, place of worship, educational institutions, to shops etc*)? P**robe indirectly**		
	Benefits associated with location	Yes	No
	Nnyumba za layisi - Cheaper accommodation (low rent)	1	2
	Kumpi n'oluguudo - Closer proximity to free roads/transport means	1	2
	Kumpi n'amazzi agakozesebwa - Closer proximity to free water	1	2
	Kumpi n'ekibuga - Closer proximity to business centres	1	2
	Kumpi ne wenkolera - Closer proximity to work place	1	2
	Kumpi n'amasomero - Closer proximity to educational institutions	1	2
	Kumpi n'esinzizo - Closer proximity to place of worship	1	2
	Kumpi n'akatale - Market for produce and merchandize	1	2
	Kumpi n'abe nganda, emikwano n'emirirwano - Social networks (relatives, friends & close neighbours)	1	2
	Poloti si za buseere - Cheaper plots of land	1	2
	Emmere ya layisi - Cheap food	1	2
	Amazzi ga taapu tegatera kubula -Reliable flow of piped water (b'se of high pressure)	1	2
	Ebilara Others (specify)	1	2
	Tewali – None	1	2
	b) Bilungi ki by'ofunye okubeera mukitundu kino ekiri okumpi n'olutobazzi? What **benefits** do you derive **from the wetland** area (*land for settlement, land for agriculture/livelihood activities, free water from springs/streams/ponds, mining sand, clay brick-making, papyrus for hand crafts/roofs/fences, medicinal plants, fishing*) **Probe indirectly**		
		Yes =1	No=2
	Ebirime bidda bulungi - High yields	1	2
	Ettaka okulimirako n'okulunda si lya buseere - Cheap land for agriculture/livelihood activities	1	2
	Amazzi sig a buseere - Cheap water from springs/streams/ponds	1	2
	Akawewo/Empewo ennungi – Cool breeze/cool temperature/fresher air		
	Okusima omusenyu/Ebbumba – Sand/clay mining	1	2
	Okukuba bbulooka ez'ebbumba - Clay brick-making	1	2
	Ebitoogo ebikola ebiwempe, okuseleka, ekikomera - Papyrus for hand crafts/roofs/fences	1	2
	Eddagala eliva mu bimera - Medicinal plants	1	2
	Okuvuba n'okuyigga - Fishing and hunting	1	2
	Ebifo ebisanyukirwamu ng'okuwuga – Recreation, e.g. beach, swimming, kayaking etc	1	2
	Ebikozesebwa okuzimba - Construction materials	1	2
	Ebilara Others (specify)	1	2
	Tewali – None	1	2

004	**Biki ebikusobozesezza okubeera mu kitundu kino**/ Adaptation mechanisms **(Probe)**	*Circle appropriately*	
	a) Osobodde otya okugumira embeera y'ebyo eby'ogeddwako ng'amataba oba okulegama kw'amazzi? How have you (and your household) adapted to prevent **flooding** (or waterlogging) and its effects?	Yes=1	No=2
	Okuzimba ekikomera/olubalaza okuziyiza amazzi - Raising a barrier wall/embankment or the veranda around the house	1	2
	Okuyiwa ettaka okuziyiza amazzi - Filling with soil to raise the foundation above flood level	1	2
	Okusima emyala/emikutu okw'etoloola ennyumba -Digging trenches around the house	1	2
	Okuzimba kabuyonjo za kaliana - Raising the latrine sludge chamber above ground (raised latrine)	1	2
	Okugogola emyala - Desilting regularly the drainage channels	1	2
	Okusitula ensalosalo z'emyala oba ewakungaanira mukoka - Raising embankments along the drainage channels/flood spots	1	2
	Okuwanilira ennyumba n'empagi - Suspending the house above water	1	2
	Okuyimusa obuliri okuva kuttaka - Raising the bed higher above ground	1	2
	Okuteeka ebintu eby'omugaso mu bifo ebili waggulu - Placing valuable items above the floor	1	2
	Okusima emyala/emikutu ejijja amazzi mu nnimiro oba mu bifo ebibelwamu - Digging canals to drain water away from the crop fields and or settlements	1	2
	Okusaawa entobazzi okugezaako okukaza ettaka - Cutting down wetland vegetation so that the soil can dry up	1	2
	Okulima oba okubeera mu bifo ebyentobazzi mu biseera eby'omusana Cultivation/dwelling in flood-prone area only during dry season	1	2
	Ebintu okubisasulira insuwa ey'amataba - Insure property against flood damages	1	2
	Okuzimba ebizimbe ebisobola okugumira embeera - Building resilient structures	1	2
	Others (specify) …………………………………………………………………………	1	2
	b) Osobodde otya okugumira oba okuziyiza embeera y'obuwewevu/obunyogovu? How have you (and your household) adapted to prevent **dampness** and its effects?		
	Okuteeka akaveera mu musinji - Laying a damp-proof foundation	1	2
	Okuggula enziji n'amadilisa okukaza mu nyumba - Opening doors/window to dry the house	1	2
	Okukuma omuliro okubugumya enju - Making a fire to warm the house	1	2
	Okwebaka ku kitanda ekiwanvu - Sleeping on a raised bed	1	2
	Okuteleka ebintu by'omuwendo waggulu - Keeping valuables above ground	1	2
	Okukuba pulasita n'okusiiga langi buli lwe kyetagisa - Plastering and painting regularly	1	2
	Sikozesa kapeti ya kyoya - Not using woven carpets	1	2
	Ekilara - Others (specify) …………………………………………………………………………………………	1	2

	c) Okola otya okuziyiza ebiwuka ng'ensiri oba enswera? How have you (and your household) adapted to prevent **vectors** (mosquitoes & flies)?		
	Okusaawa ensiko eyetolodde - Cutting bushes around	1	2
	Okujja wo amazzi agalegamye - Draining stagnant water	1	2
	Okuggala mangu ennyumba - Closing windows and doors early	1	2
	Okwebaka mu katimba ke nsiri - Sleeping under mosquito nets	1	2
	Okuteeka obutimba obuziyiza ensiri mu madilisa - Installing mosquito screens on window and louvers	1	2
	Okufuuyira nga tukozesa eddagala ly'ebiwuka - Spraying with insecticide	1	2
	Okukozesa akatimba ka masanyalaze - Use electrocuters	1	2
	Okubikka kasasiro n'obuta muteleka kiseera kinene - Covering household refuse and not storing it for long	1	2
	Okubikka ku kabuyonjo, n'okukozesa kabuyonjo eliko payipu - Covering pit latrines, using VIP latrine with effective fly-screen	1	2
	Okulongoosa kabuyonjo - Cleaning the latrine regularly	1	2
	Ebirala - Others (specify)	1	2
	Tewali – None	1	2
	d) Water pollution/Contamination of water		
	Okufumba oba okuteka eddagala mumazzi g'okunywa. Boil or chlorinate drinking water	1	2
	Okunywa amazzi ga tapu n'okukozesa amazzi g'emidumu okukola emirimu emirara. Use only piped water for drinking and spring water for other purposes	1	2
	Okukozesa amazzi gatapu gokka. Use only piped water	1	2
	Okuteka tapu mukoka/amatabi wegatatuka. Ensure that pipe water taps are located safely above flood levels	1	2
	Okuteka buloka oba obusawo obulimu omusenyu mumakubo agayitibwamu okwewala olinya mumazzi. Provide brick/sand-bag paving on walkways	1	2
	Okwambala butusi oba engatto mubigere okwewala obutalinya mumazi. Always put on footwear or other protective wear	1	2
	Okwewala okukozesa/okukwata/okulinnya mumazzi amakyafu (Okutangira abaana okuzanira mumazzi amakyafu)- Avoid contact with wastewater (also limit children from playing in dirty environment)	1	2
	Okugogola emyala - Drain the channels often	1	2
	Okwokya kasassiro ng'aweze -Burn refuse whenever it accumulates	1	2
	Okuyiwa eddagala mu kabuyonjo okuziyiza ekivundu n'okujula -Pour chemicals in the latrine to prevent the bad smell and filling up	1	2
	Okuloopa abonoona obutonde bw'ensi mu mbuga z'amateeka -Report polluters to the local authority	1	2
	Ebirala - Others (specify)	1	2
	e) Communicable diseases		
	Okunaaba engalo buli we kyetaagisa -Always wash hands with soap at all critical times (i.e. *Before preparing or handling food, After using toilet/ Latrine, Before eating any food, After cleaning child's bottom, After coming from fields/garden/market etc*)	1	2
	Obutasaasanya kazambi - Practice safe excreta disposal (*effectively separate excreta from humans, e.g. use a well maintained latrine, without flies*)	1	2
	Okunywa amazzi amayonjo -Drink clean water (*boiled or chlorinated water*)	1	2
	Endya ennungi -Maintain good nutrition (*have a sufficient and balanced diet*)	1	2

	Okuziyiza obutalumwa nsiri -Protecting against mosquitoes (*e.g. using mosquito-screens/nets/repellents/insecticides/electrocuters, closing door & window early etc*)	1	2
	Okusaanyawo ebifo ensiri mweziyalulira - Destroying mosquito breeding sites (*e.g. Clearing bushes, draining stagnant water, etc*)	1	2
	Okunoonya obujjanjabi mu bwangu ng'olwadde -Seek healthcare promptly	1	2
	Okwejjanja -Self-medication	1	2
	Ebilala -Others (specify)	1	2
	f. Sinking/Collapsing of houses		
	Okuba n'omusingi omugumu -Lay a strong foundation (filled/compacted ground, use hardcore, etc)	1	2
	Okuzimba ebizimbe ebigumu -Ensure higher structural strength (*e.g. use more cement and reinforcement*)	1	2
	Okuwanvuya ebisenge ng'ennyumba esse n'okuzaako akasolya -Keep raising the walls and roof higher	1	2
	Okuzimba ebiziyiza amazzi okuyingira munyumba -Build barriers to prevent water from entering the house	1	2
	Okudabiriza n'oddamu n'okozesa ennyumba -Repair the damage and continue to use the house	1	2
	Okumenya n'ozimba endala -Demolish the house and build another	1	2
	Okuleka ennyumba n'osenguka - Abandon it and shift	1	2
	Ebirala -Others (specify)	1	2
	g. Sharps		
	Okukozesa butusi oba engato ng'okola/ng'otambula munsiko -Use boots/other protective wear when walking/working in bush areas	1	2
	h. Vermin		
	Okuwa emesse obutwa - Poison the rats	1	2
	Okukozesa obumasu -Use rat traps	1	2
	Okuziyiza emesse obutayingira nnyumba -Prevent entry into the house (seal off openings)	1	2
	Okugoba emesse -Chase the vermin	1	2
	Ebirala -Others (specify)	1	2
	i. Evictions		
	Okugaana okugobwa mungeri yonna -Contest eviction with all possible means	1	2
	Okufuna ekyapa ky'obwananyini -Acquire land titles to get legal ownership	1	2
	Okufuna ebiwandiiko ebirala eby'obwananyini -Possession of other ownership documents (*e.g. sale agreement, documents of inheritances etc*)	1	2
	Okutunda ettaka -Sale the land to other people	1	2
	Okola entegeka okusenguka bw'oba ogobeddwa -Plan to settle elsewhere in case of eviction	1	2
	Obutakola nkulakulana ku ttaka -Not investing in the area (maintain minimal assents)	1	2
	Okufuna "Insuwa" y'ebintu -Insure property against damage	1	2
	Ebirala -Others (specify)	1	2
	j. Crime		
	Okuba omwetegefu bulikaseera- Keep alert always	1	2
	Obutatereka eby'omuwendo ewaka -Not keeping valuables at home	1	2
	Obutatambula kiro/ munzikiza wekka- Not walking at night/in dark places alone	1	2

	Okuteeka amataala g'ebweru -Installing security lighting	1	2
	Okukuba enduulu okufuna obuyambi -Making alarms (e.g. whistle, screaming for help, etc)	1	2
	Okukubiriza abaana okwewala abazzi b'emisango -Sensitize children about avoiding criminals	1	2
	Okuwa ebibonerezo eby'amannyi eri abazzi b'emisango -Heavy penalties for offenders (e.g. mob justice)	1	2
	Okufuna "Insuwa" y'ebintu ebyononedwa -Insure property against damage	1	2
	Ebirala -Others (specify)	1	2
	None	1	2
	k. Fire		
	Obutafumbira munda munnyumba -Not cooking from inside the living house	1	2
	Okubeera omwegendereza ng'okozesa emisubawa n'etaala -Being careful with candles and lumps	1	2
	Obutasembereza omuliro eri ebintu ebisobola okukwata omuliro -Keeping fire away from flammable items	1	2
	Ebirala -Others (specify)	1	2
	None	1	2

005	Opinions on adaptation	*Circle appropriately*				
	Mbulira oba okiriziganya nabino wammanga oba nedda. Please indicate the extent to which you agree or disagree with each statement	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
	a) **Wandigumikiriza nga bwoziyiza embera zino okusinga okugenda mukifo ekirara** You would rather adapt to minimize vulnerability to the hazards mentioned above than relocate to another place	1	2	3	4	5
	b) **Wandigumiikiriza nga bwoziyiza obuzibu obuva ku mataba okusinga okugenda mukifo ekirara.** You would rather adapt to minimize vulnerability to flooding and dampness than relocate to another place	1	2	3	4	5
	c) **Osobola okuziyiza/okwezzawo ebyo bye twogedde ko waggulu?** You can afford to adapt against the various hazards/threats mentioned above	1	2	3	4	5

	Variable	Attribute	
006	Socio-demographic characteristics	*Circle appropriately*	
	a) **Ekikula** –Sex	**Musajja** -Male	1
		Mukazzi -Female	2
	b) **Emyaka** -Age (in completed years)	15-20	1
		21-30	2
		31-40	3
		41-50	4
		>50	5
	c) **(Oli mufumbo?)**Marital status	**Siri mufumbo** -Single	1
		Mufumbo -Married/cohabiting	2
		Namwandu/Semwandu -Widowed	3
		Twayawukana -Divorced/separated	4
		Ebirala Others (specify)	5
	d) **(Wasoma kyenkana wa?)** Formal Education of respondent	**Saasoma** -None	1
		P1-P4	2
		P5-P7	3
		O-level	4
		A-level	5
		Ettendekero ery'awagulu -Tertiary	6
	e) **(Obwananyini bw'ennyumba)** Nature of Tenure (living house)	**Mupaangisa** -Tenant	1
		Nannyini nnyumba -Owner	2
		Ebirala -Others(specify)	3
	f) **Landiloodiwo asula wano?** Does your landlord reside at the same premises?	**Ye** -Yes	1
		Nedda -No	2
		Tekyetaagisa -Not applicable	3
	g) **Obwananyini bwettaka** - Nature of Tenure (land)-Land ownership	**Mupangisa** -Tenant	1
		Nannyini -Owner	2
		Museenze -Squatter	3
		Ebirala -Others(specify)	4
	h) **Mubeera bamekka ewakka wano ?** How many people do you live with?	**Abakulu** -Adults	
		Abato -Children	
	i) **Omazze banga ki mukitundu kino?** How long have you lived in this area (in years)?	Siweza mwaka 1	1
		Wakati w'omwaka 1 – 5	2
		Wakati w'emyaka 6 – 10	3
		Wakati w'emyaka 11 – 20	4
		Wakati w'emyaka 21 – 30	5
		Okusuka emyaka 30	6
	j) **Lwaki wasalawo okujja wano?** Why did you decide to move to here (current location/house)?	**Kumpi ne wenkolera** Because it is near your place of work	
		Kumpi n'oluguudo Because it is near the road	
		Siwabuseere ng'ebifo ebirala Because it is cheaper than other places	
		Wokka wenali nsobola okubeera It was the only available place then	
		Kumpi n'abenganda n'emikwano It closer to my family or friends	
		Kubanga wakka Because you consider it home	
		Sisasula bisale bya nnyumba I don't have to pay rent	

007	Household income and expenditure	*Circle appropriately*	
	a) **Omwezi osasanya ssente mekka?** How much in total do you spend per month	< 50,000Sh	1
		50,001-100,000Sh	2
		100,001-200,000Sh	3
		200,001-300,000Sh	4
		300,001-500,000Sh	5
		500,001-1,000,000Sh	6
		>1,000,000	7
	a) **Ennyumba ogisasulira ssente mekka buli mwezi?** How much rent do you pay per month?	**Sisasula** -Don't pay rent	1
		<50,000Sh	2
		50,001-100,000Sh	3
		100,001-200,000Sh	4
		200,001-300,000Sh	5
		300,001-500,000Sh	6
		>500,000Sh	7
		Others (specify)	8
	b) **Okola mulimu ki?** What is your main occupation for income?	**Mulimi/mulunzi** -Peasant	1
		Muchuba -Causal labourers	2
		Omulimu gw'obuyigirize Professional (e.g. teacher, nurse, etc)	3
		Nekozesa -Self-employed (e.g. trader, mechanic, boda-boda rider, driver)	4
		Akola mirimu gy'amukitundu - Community worker (e.g. local politician, VHT, etc)	5
		Ekirala Others (specify,...............................)	6
	c) **Oyina ekintu ekirala ky'ofunamu ensimbi?** Do you have any other sources of income?	Specify	
	d) **Omwezi okola ssente nga mekka?** About how much is your total income in a month?	< 50,000Sh	1
		50,001-100,000Sh	2
		100,001-200,000Sh	3
		200,001-300,000Sh	4
		300,001-500,000Sh	5
		500,001-100,000Sh	6
		1,000,001-2,000,000Sh	7
		> 2,000,000Sh	8

Appendix B: Key Informant Interview (KII) Guide

Spatiotemporal analysis of encroachment on wetlands

Hazards, Vulnerabilities, Opportunities and Adaptations among communities in Kampala's wetlands

Name of KI		**Contact details**	
Position		**Date Conducted**	
Organisation		**Name of Interviewer**	

1. Could you please give me an overview about encroachment on wetlands (e.g. extent and characteristics)
2. What in your view are the main **drivers of encroachment**?
3. What hazards are associated with encroachment?
4. What kinds of vulnerabilities exist?
5. Who is affected and by what?
6. What opportunities exist in wetlands areas?
7. What specific benefits do people derive from the wetlands?
8. How are people adapting to minimize vulnerabilities?
9. How are people adapting to exploit opportunities?
10. What is your role as a key stakeholder?
11. What has been done about the encroachment situation?
12. What are some of the risk reduction strategies that stakeholders have implemented?
13. What are some of the major challenges encountered when dealing with issues of encroachment on wetlands?
14. Finally, what do you recommend as a workable solution to the current situation?

Appendix C: Focus Group Discussion (FGD) Guide

Hazards, Vulnerabilities, Opportunities and Adaptations among communities in Kampala's wetlands

FGD Code		**Initials of interviewer**	
Date Conducted		**Start time**	
Parish		**Number of members**	

Variable	**Attributes**
1. Exposure to hazards and threats in the area (i.e. Environmental health and Socio-political).	
a) What **hazards** or **threats** do you face in this area? *In order of priority* (w.r.t Environmental health conditions)	
b) What **damages** do you (as a community) face due to exposure to the hazards above?	

2. Vulnerability

a) To which of the hazards mentioned above are **more people** vulnerable?

Pairwise ranking for Percieved Vulnerability (*based on* ***number of people vulnerable within the community*** **)**

		Floods (and water logging)	Dampness	Poor sanitation (excreta,	Vectors (mosquitoes & flies)	Pollution (of water, soil and or	Communicable diseases (e.g. cholera,	Sinking/collapsing of houses	Vermin (rats, snakes,	Evictions (demolitions,	Crime (e.g. rape, theft, abduction,	Fires	Others (specify)...	None
		A	B	C	D	E	F	G	H	I	J	K	L	M
Floods (and water logging)	A													
Dampness	B													
Poor sanitation (excreta, solid waste & drainage)	C													
Vectors (mosquitoes & flies)	D													
Pollution (of water, soil and or air)	E													
Communicable diseases (e.g. cholera, diarrhoea, RTIs, malaria etc)	F													
Sinking/collapsing of houses	G													
Vermin (rats, snakes, snails etc)	H													
Evictions (demolitions, destruction of property)	I													
Crime (e.g. rape, theft, abduction, murder etc)	J													
Fires	K													
Others (specify)...	L													
None	M													
Score														
Rank														

3	Benefits/opportunities/resources			*Circle appropriately*
	a) What **benefits** are associated **with this location**?			
	Benefits associated with location	Priority		
		High	Average	Low
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
	b) What **benefits** are derived **from the wetland** area?			

	Benefits derived from the wetland area	Priority		
		High	Average	Low
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3

4	Adaptation mechanisms			*Circle appropriately*
	a) How have people here adapted to prevent **flooding** (or waterlogging) and its effects?			
	Adaptation against flooding	Extent of measure		
		Largely	*Somewhat*	*Rarely*
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
	b) How have people adapted to prevent **dampness** and its effects?			
	Adaptation against dampness	Extent of measure		
		Largely	*Largely*	*Largely*
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3

c) What negative outcomes are associated with the adaptation mechanisms mentioned above?

....

....

004	Adaptation mechanisms			*Circle appropriately*
	a) What **other adaptation mechanisms** have people adopted **to minimise vulnerability**?			
	Other adaptations to minimise vulnerability	Extent of measure		
		Largely	*Somewhat*	*Rarely*
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
	b) How have people adapted **to exploit benefits/opportunities**?			
	Adaptations to exploit benefits/opportunities	Extent of measure		
		Largely	*Largely*	*Largely*
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3
		1	2	3

c) What negative outcomes are associated with the adaptation mechanisms to exploit benefits/opportunities?

………

………

Appendix D: Letter of Consent

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

CONSENT TO PARTICIPATE IN RESEARCH

Hello!

My name is .... I am working with Stellenbosch University and Makerere University. We are interested in learning more about experiences in this community with respect to hazards, vulnerabilities, opportunities and adaptations/coping mechanisms. We are conducting a survey to learn about the community adaptations to minimize vulnerability to hazards as well as to exploit wetland resources and benefits associated with this location. Your household has been randomly selected to participate and we would like to ask you some questions. If you decide to participate your name and address will not be recorded. Participation is completely voluntary. We expect that the interview will take approximately 45 minutes. You can decline to answer any question or stop the interview at any time. You will not receive anything for participating in this survey, but it may benefit vulnerable communities by providing information that can guide risk reduction strategies.

If you do not want to participate, you are free to decline the interview. If you have any questions about the conduct of the study or how you are being treated by the study, please feel free to contact the Principal Investigator, Mr. J.B. Isunju (isunju@musph.ac.ug; +256 772 346304), Supervisor, Dr. J. Kemp (jkemp@sun.ac.za; +27 82 3339063) or Co-Supervisor, Assoc. Prof. C.G. Orach (cgorach@musph.ac.ug; +256 772 511444). If you have any questions regarding your rights as a participant you may contact Ms Maléne Fouché (mfouche@sun.ac.za; +27 21 808 4622) at the Division for Research Development or Assoc. Prof. D. Guwatudde (dguwatudde@musph.ac.ug; +256 752 229 081) of the Uganda National Council for Science and Technology (UNCST).

__________________________________ ____________

Signature of Investigator **Date**

Appendix E: REC Approval from Stellenbosch University

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

Approved with Stipulations

New Application

19-May-2014
Isunju, John J

Proposal #: DESC/Isunju/May2014/4

Title: Spatial-temporal analysis of encroachment on wetlands: flood risk and adaptations in Kampala

Dear Mr John Isunju,

Your **New Application** received on **08-May-2014**, was reviewed
Please note the following information about your approved research proposal:

Proposal Approval Period: **16-May-2014 -15-May-2015**

The following stipulations are relevant to the approval of your project and must be adhered to:
Please make all changes on the ORIGINAL proposal using TRACK CHANGES. Furthermore, it is required that a letter be sent to the DESC, responding to each of the DESC's concerns and comments in BULLET FORMAT.

1) Ethical clearance from the HDREC of Makerere University and UNCST.
The researcher is requested to submit copies of ethical clearance letters granted by these universities. If these are still awaited, the researcher should forward these to the DESC as soon as this is obtained.

2) Informed consent form (ICF)
The informed consent form contains all the relevant information but the researcher should change the formulation to less academic language on par with what will be understandable for the participants.

Furthermore, seeing that the above will not be the only interviews that will be conducted (referring here to the so-called key informants), an example of the ICF that will be given to these participants is also needed.

3) Questionnaire
Will the questionnaires be self-administered? If so, then the question of language and comprehension applies to the questionnaires as well – (e.g. with regard to question 2: "pairwise ranking for perceived vulnerability"). If self-administered, in order to assist comprehension, should the questionnaires not also be translated into Luganda?

4) Participants
Should any participants be employees of specific key stakeholders, the researcher should obtain letters of permission by such employers before employees may be approached for participation in the research.

5) DESC application form
Finally, the DESC application form at 2(b) refers to information that will be gathered directly from companies, corporations, organizations, NGOs, government departments, etc. that is not available in the public domain. If this is the case, then the applicant needs to obtain permission to access such information. Permission should be obtained before research may begin and copies thereof should be sent to the DESC.

Please provide a letter of response to all the points raised IN ADDITION to HIGHLIGHTING or using the TRACK CHANGES function to indicate
ALL the corrections/amendments of ALL DOCUMENTS clearly in order to allow rapid scrutiny and appraisal.

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number** (**DESC/Isunju/May2014/4**) on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The
Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number

REC-050411-032. We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218089183.

Included Documents: DESC application Focus group guide Research proposal

Questionnaire

Key informant guide

Consent form_participant

Sincerely,

Clarissa GRAHAM REC Coordinator
Research Ethics Committee: Human Research (Humanities)

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1.Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2.Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use. If you need to recruit more participants than was noted in your REC approval letter, you must submit an amendment requesting an increase in the number of participants.

3.Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4.Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the continuing review report in a timely fashion to ensure a lapse in REC approval does not occur.** If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5.Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, number of participants, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6.Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouch within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch Universtiy Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7.Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC

8.Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9.Final reports. When you have completed (no further participant enrollment, interactions, interventions or data analysis) or stopped work on your research, you must submit a Final Report to the REC.

10.On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

Appendix F: HDREC Approval from Makerere University

MAKERERE UNIVERSITY

P.O. Box 7072 Kampala Uganda
Website: www.musph.ac.ug

Tel: 256 414 532207/543872/543437
Fax: 256 414 531807

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

HIGHER DEGREES, RESEARCH AND ETHICS COMMITTEE

Makerere University School of Public Health • Higher Degrees, Research and Ethics Committee •
Valid Thru:
10 DEC 2014

10th December 2013

Mr. John Bosco Isunju
Principal Investigator, Protocol (039)
PhD student – Stellenbosch University

Re: (IRB00011353) Approval of Proposal titled: Spatial-temporal analysis of encroachment on wetlands: flood risk and adaptations in Kampala district, Uganda

This is to inform you that, the Higher Degrees, Research and Ethics Committee (HDREC) has granted approval to the above referenced study, the HDREC reviewed the proposal and made some suggestions and comments which you have adequately incorporated:

Note that the initial approval date for your proposal by HDREC is 10th/12/2013, and therefore approval expires at every annual anniversary of this approval date. The current approval is therefore valid until: 09th/12/2014.

Continued approval is conditional upon your compliance with the following requirements:

1) No other consent form(s), questionnaire and/or advertisement documents should be used. The consent form(s) must be signed by each subject prior to initiation of any protocol procedures. In addition, each subject must be given a copy of the signed consent form.

2) All protocol amendments and changes to other approved documents must be submitted to HDREC and not be implemented until approved by HDREC except where necessary to eliminate apparent immediate hazards to the study subjects.

3) Significant changes to the study site and significant deviations from the research protocol and all unanticipated problems that may involve risks or affect the safety or welfare of

subjects or others, or that may affect the integrity of the research must be promptly reported to HDREC.

4) All deaths, life threatening problems or serious or unexpected adverse events, *whether related to the study or not*, must be reported to HDREC in a timely manner as specified in the National Guidelines for Research Involving Humans as Research Participants.

- Please complete and submit reports to HDREC as follows:

a) For renewal of the study approval – complete and return the continuing Review Report – Renewal Request (Form 404A) at least 60 days prior to the expiration of the approval period. The study cannot continue until re-approved by HDREC.

b) Completion, termination, or if not renewing the project – send a final report within 90 days upon completion of the study.

- Finally, the legal requirement in Uganda is that all research activities must be registered with the National Council of Science and Technology. The forms for this registration can be obtained from their website www.uncst.go.ug. Please contact Mr. Tusiime Wilson, Administrative Assistant of the Higher Degrees, Research and Ethics Committee at wtusiime@musph.ac.ug or telephone number (256)-41-543872 or +256772496136 if you encounter any problems.

Yours sincerely

Makerere University School of Public Health • Higher Degrees, Research and Ethics Committee •
Valid Thru:
10 DEC 2014

Dr. Suzanne Kiwanuka
Chairperson, Higher Degrees, Research and Ethics Committee

Enclosures:

a) A stamped, approved study documents (informed consent documents):

Appendix G: UNCST Approval

Uganda National Council for Science and Technology
(Established by Act of Parliament of the Republic of Uganda)

UNCST

Our Ref: SS 3351 **07/04/2014**

Mr. John Bosco Isunju
Makerere University School of Public Health
Kampala

Re: Research Approval: **Spatial Temporal Analysis of Encroachment on Wetlands: Flood Risk and Adaptations in Kampala**

I am pleased to inform you that on **20/12/2013**, the Uganda National Council for Science and Technology (UNCST) approved the above referenced research project. The Approval of the research project is for the period of **20/12/2013** to **20/12/2016**.

Your research registration number with the UNCST is **SS 3351**. Please, cite this number in all your future correspondences with UNCST in respect of the above research project.

As Principal Investigator of the research project, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the research protocol or the consent form (where applicable) must be submitted to the designated local Institutional Review Committee (IRC) or Lead Agency for re-review and approval **prior** to the activation of the changes. UNCST must be notified of the approved changes within five working days.
3. For clinical trials, all serious adverse events must be reported promptly to the designated local IRC for review with copies to the National Drug Authority.
4. Unanticipated problems involving risks to research subjects/participants or other must be reported promptly to the UNCST. New information that becomes available which could change the risk/benefit ratio must be submitted promptly for UNCST review.
5. Only approved study procedures are to be implemented. The UNCST may conduct impromptu audits of all study records.
6. A progress report must be submitted electronically to UNCST within four weeks after every 12 months. Failure to do so may result in termination of the research project.

Below is a list of documents approved with this application:

	Document Title	Language	Version	Version Date
1	Research proposal	English	N/A	N/A
2	Questionnaire	English	N/A	N/A
3	Key Informant Guide	English	N/A	N/A
4	Focus Group Discussion Guide	English	N/A	N/A
5	Consent Form	English	N/A	N/A

Yours sincerely,

Leah Nawegulo Omongo
for: Executive Secretary
UGANDA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

cc Chair, Makerere University School of Public Health IRC, Kampala

LOCATION/CORRESPONDENCE

Plot 6 Kimera Road, Ntinda
P. O. Box 6884
KAMPALA, UGANDA

COMMUNICATION

TEL: (256) 414 705500
FAX: (256) 414-234579
EMAIL: info@uncst.go.ug
WEBSITE: http://www.uncst.go.ug

Appendix H: Approvals for information sharing

KCCA
KAMPALA CAPITAL CITY AUTHORITY
For a better City

DIRECTORATE OF PUBLIC HEALTH AND ENVIRONMENT

Ref: PHE/KCCA/702

DATE: 17th April 2014

Mr. John Bosco Isunju

PhD Student and Assistant Lecturer

Makerere University School of Public Health

P.O. Box 7072 Kampala, Uganda

Dear Sir,

RE: REQUEST FOR KEY INFORMANT INTERVIEW FROM KCCA

This is in response to your request made on 14th April 2014 for a Key Informant Interview for your doctoral study titled: Spatial-temporal analysis of encroachment on wetlands: flood risk and adaptations in Kampala.

The Directorate of Public Health and Environment at KCCA thus grants you permission to conduct the said interview with the Environment and Sanitation Specialist who handles such issues as highlighted in your topic.

Please share with us you findings.

Dr. Okello Ayen Daniel

AG. DIRECTOR PUBLIC HEALTH AND ENVIRONMENT

P. O. Box 7010 Kampala- Uganda
Plot 1-3 Apollo Kaggwa Road
Tel: 0414 231 446 / 0204 660 000
Web: www.kcca.go.ug, Email: info@kcca.go.ug
f: facebook.com/kccaug, t: @KCCAUG

Tel. General	+256 41 4505942
Telephone:	+256 41 4505945
	+256 41 4505950
	+256 41 4220203
	+256 41 4321316
	+256 41 4221198
	+256 41 4505941
Fax:	+256 41 4505941
E-mail:	mwe@mwe.go.ug
	ps@mwe.go.ug
Website:	www.mwe.go.ug

THE REPUBLIC OF UGANDA

MINISTRY OF WATER AND ENVIRONMENT
P.O. BOX 20026
KAMPALA, UGANDA

28th February 2014

To: John Bosco Isunju
PhD Student and Assistant Lecturer
Makerere University School of Public Health
P.O.BOX 7072
Kampala, Uganda

REQUEST FOR INFORMATION ON KINAWATAKA, KABALAGALA, NAKIVUBO & LUBIJJI WETLANDS

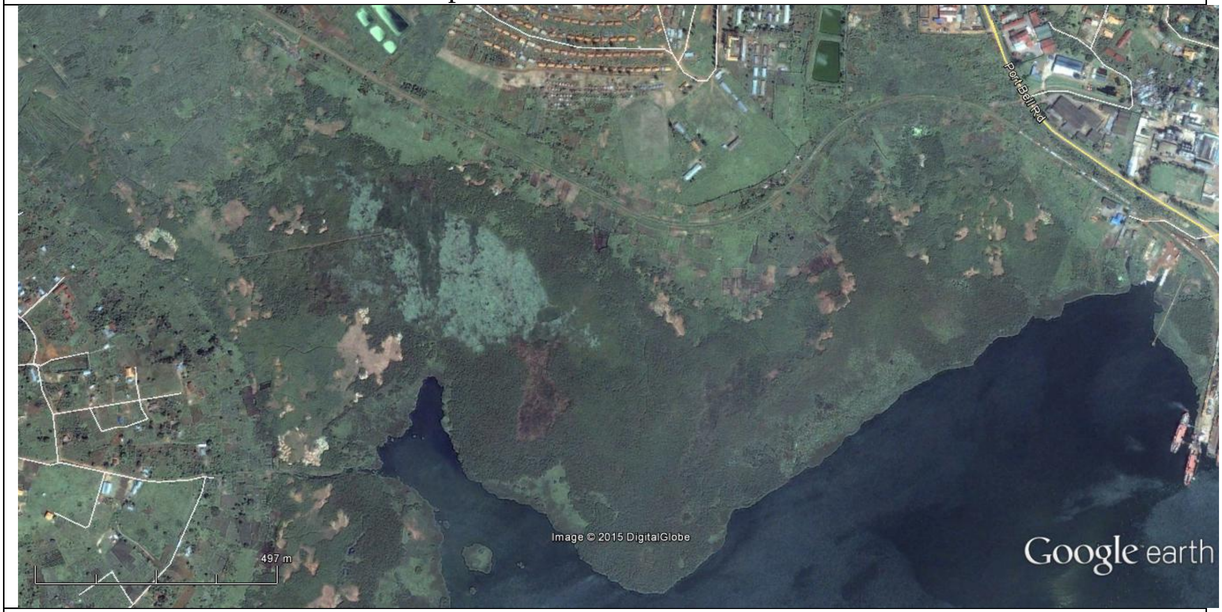
Reference is made to your communication of 5th February 2014 to Wetland Management Department, requesting for information on Kinawataka, Kabalagala, Nakivubo and Lubijji wetland system to be used for your academic research.

Wetland maps covering your areas of interest are attached for your reference. One is for the wetland boundaries according to the 1994 mapping and the other for 2008 mapping.

Oloya Collins
THE COMMISSIONER (Wetlands Management Department)

Appendix I: Google Earth Archive, 2000 - 2015

Lower Nakivubo wetland in Kampala - Location: 0°17'27.23" N 32°38'32.35" E

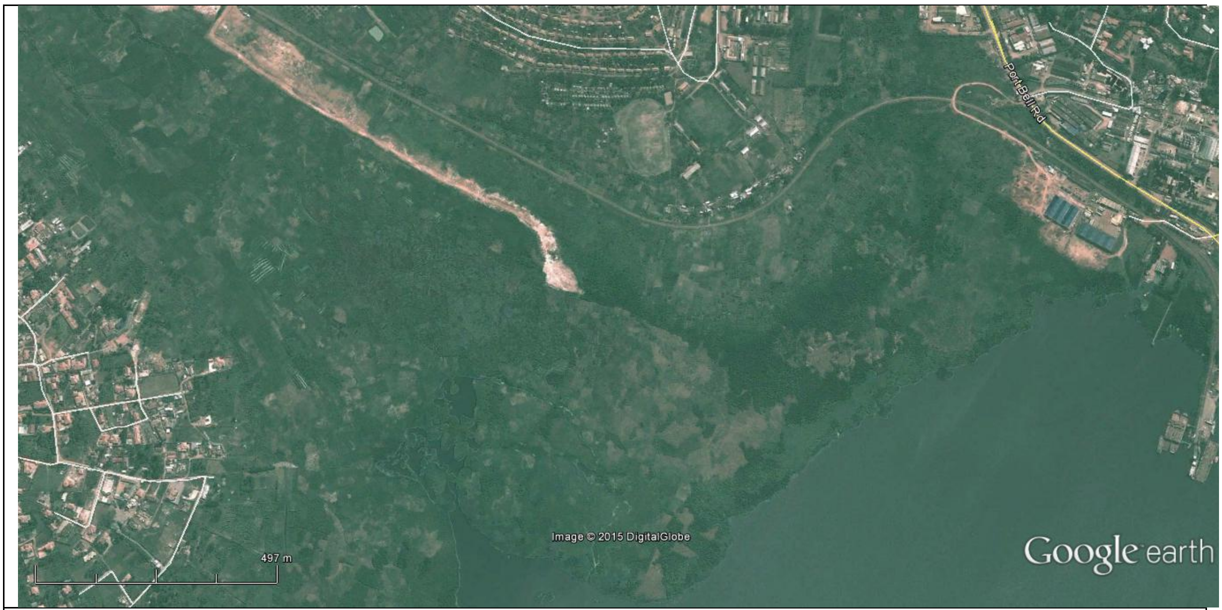


Nov/26/2000

Mar/11/2004

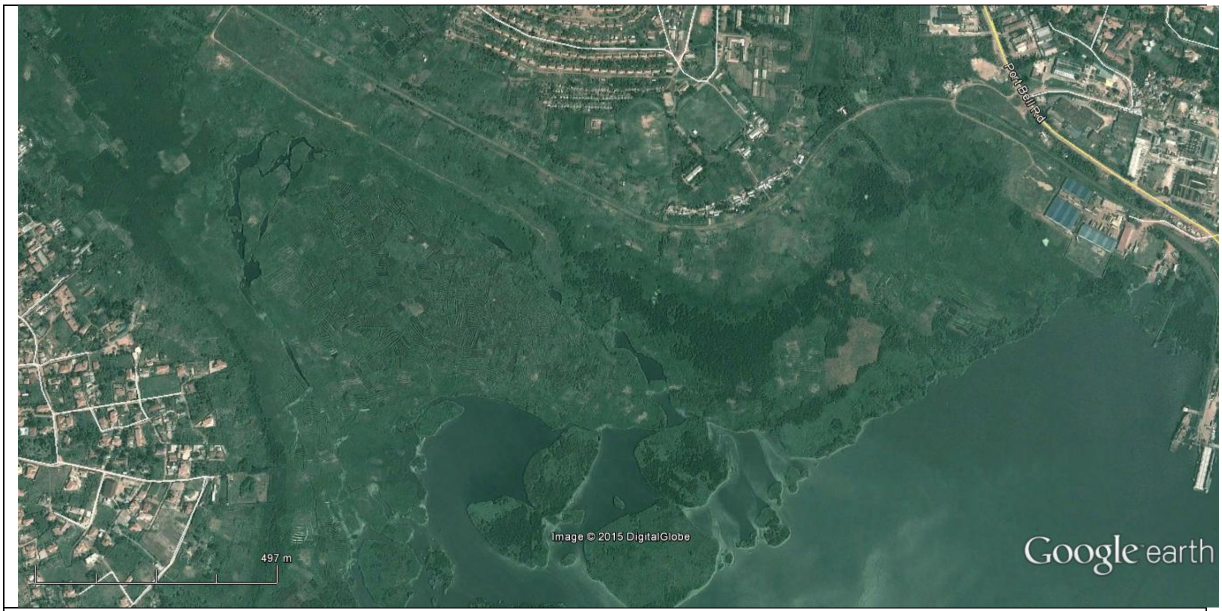
Apr/3/2008

Feb/19/2010

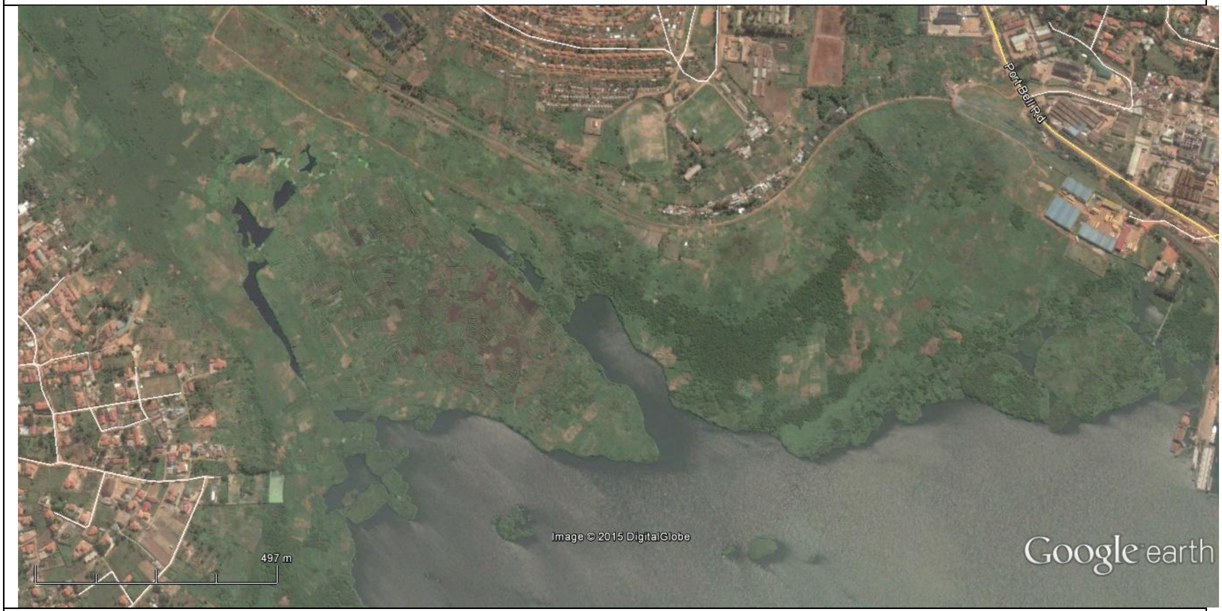


Jul/1/2011

Jan/27/2012

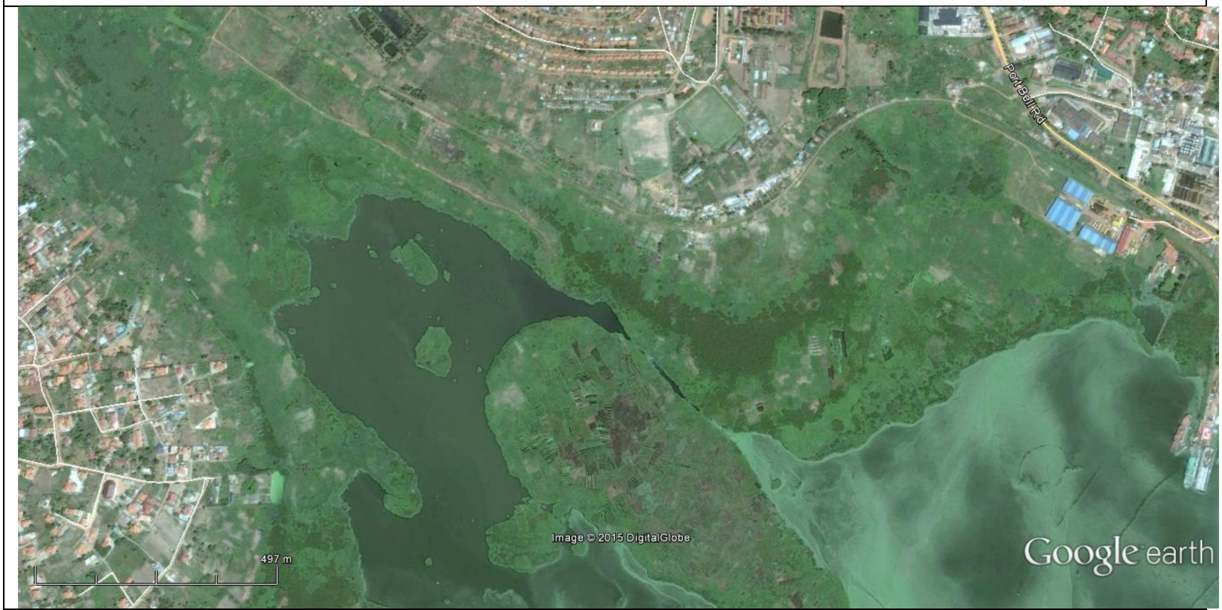


Dec/20/2013



Jul/6/2014

Dec/5/2014



Feb/27/2015