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Challenges and opportunities of participatory management of Upland Wetland in Kiambu County, Kenya

MWAURA SAMUEL KINYARIRO, STEVEN GICHUKI NJUGUNA♥, GEOFFREY MACHARIA
Department of Environmental Sciences, Kenyatta University. Nairobi, Kenya. ♥email: njuguna.steven@ku.ac.ke

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Abstract. *Kinyariro MS, Njuguna SG, Macharia G. 2020. Challenges and opportunities of participatory management of Upland Wetland in Kiambu county, Kenya. Bonorowo Wetlands 10: 78-91.* Wetlands are continuously degraded through agricultural activities, pollution, and settlements. For example, in the Lari sub-district, increased population pressure decreased soil fertility, unreliable rainfall, and the search for food security forced farmers to encroach on the seemingly idle Upland Wetlands. Opportunities for wetland conservation lie in participatory approaches applied locally to conserve this vital natural resource. The main water of the Ruiru river comes from the Upland Wetlands harvested by the Nairobi Water and Waste Company in the Githunguri sub-district at the Ruiru dam. This research is critical because the water company does not have in-depth information about its catchment area, which leads to encroachment and ultimately rationing of water in the city of Nairobi. This study aims to document the causes of wetland degradation in the highlands, assess the level of community participation, and determine the level of awareness of the importance of wetlands and the possible contribution of farmer involvement in catchment management. The sampling method used to select the research unit was stratified and random sampling where farmers and Ruiru dam workers were given a questionnaire. Purposive sampling was used to determine the WARMA manager, WRUA officer, and six older people interviewed. 40 farmers from the Lari 107 settlement scheme where the wetlands are located, and four workers of the Ruiru dam were given questionnaires. Data analysis was performed using the Chi-square package computer, T-test, and SPSS. Percentages for qualitative data are presented using tables, bar charts, and pie charts. The wetland mapping was carried out using GIS and Google Earth. The study results found that the total land cover of upland rice fields was 129.6 Ha after deducting 105.4. Ha for the last thirty years due to encroachment. The study revealed that 65% of respondents had lived in the area for more than 20 years. Farmers drain wetlands primarily for food supply (50%) to generate income (25%), while 10% control waterborne diseases. Participation rates are negligible, with only 2.5% of respondents participating in wetland conservation. Community-based conservation groups like WRUA still lack in this area. Environmental impacts include loss of biodiversity, destruction of ornithological habitat, and loss of hydro plant species. Social effects include outbreaks of waterborne diseases such as typhoid, water pollution, and weak community conservation infrastructure. However, there is a chance for community involvement, where the majority of the population is ready to carry out conservation ($X2 = 0.127$, $p = 0.001$). The formation of community-based conservation groups such as the Water Resources Users Association, the Association of Riverland Owners, and the Watershed Advisory Committee was proposed as the primary solution. Devolution of water resources is also proposed to ensure local people benefit from selling water to city residents. Such efforts would provide an adequate water supply to Nairobi and the surrounding satellite cities.

Keywords: Kiambu, Kenya, participatory management, Ruiru, Upland Wetland

INTRODUCTION

Global and local water cycles strongly rely on healthy and productive wetlands. The wetland provides clean drinking water, irrigation for agriculture, flood control, supporting biodiversity, and propping up fisheries and tourism industry in many locations (UNEP 2005). Under Ramsar Convention, wetlands are defined as "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, blackish, fresh, salty, including areas of marine water the depth of which at low tide does not exceed six meters" (Howard 1992; Aron et al. 2007).

Whether natural or artificial, wetlands play many functions, such as sources of rivers, replenishing aquifers, and homes for various animals. Wetlands also combine fresh water and dry land and are thus called ecotones (Tobin and Deshek 2001). This ecosystem's vegetation filters silt from agricultural land, providing a source of safe drinking water. Despite the high value of these ecosystems' services, wetlands continue to be degraded or lost rapidly (TEEB 2013). Fortunately, wetlands' economic, social, cultural, biodiversity, and ecological significance are widely acknowledged, and global efforts are being made to prevent further degradation and loss of biodiversity (Canari Policy Brief 2002).

At the same time, change and utilization of land are projected to have an enormous impact on biodiversity, followed by nitrogen deposition, species, and increasing carbon (IV) oxide in the atmosphere (Sexton et al. 2001). The effect of land-use change is expected to be more severe in the tropics. Furthermore, natural habitat destruction resulting from anthropogenic activities has been identified as one of the primary drivers of environmental degradation. This is more prevalent in the developing world, where poverty and ignorance of biodiversity values are out of control. In Kenya, a study has shown that wetlands are not fully appreciated. Despite offering ecological, social, and

economic benefits, there is a lack of concerted effort to advocate for sustainable use (NEMA 2011).

Kenya's vulnerability to the effect of that mismanagement and water catchment degradation has called for significant policy response and action (Cahokia 2000). One important policy change is a shift from centralized to participatory water governance (WRMA 2006). A participatory approach is essential, given that several water catchments are privately owned under self-owned land tenure systems. For example, in the Trans-Nzoia region, 91% of the wetlands that make up the main catchment area in Kenya are privately owned. Due to different tenure systems, there has been recorded loss and degradation of wetlands, causing adverse effects to this fragile water resource. (Kecha et al. 2007).

Kenya has central wetlands such as Lake Nakuru and Naivasha, which have been allocated wetlands of international importance, and small land which offers suitable disposal into rivers (Cahokia 2000). These include the Ruiru river and its associated wetlands. Local communities do not associate themselves with the benefits, which results in their drainage, primarily when they associate wetlands with vices such as malaria, bilharzia, and flooding that constantly destroys their crops. At the same time, the rivers originating from these wetlands are tapped with water to be sold to people living in the city or used to generate electricity without giving any benefit to local people who have acted as custodians of the resource since time immemorial.

The colonial government had built several infrastructures in this area, such as the Ruiru Dam, which was meant to supply water to the Nairobi District and its surroundings. Ruiru dam exploration started in 1926, and after many trials, a 225mm diameter steel pipe was laid to transmit water to Nairobi in 1938 and, by the construction of the dam had commenced. In 1946, another pipe with a diameter of 300mm was laid parallel to the previous pipe measuring 225mm. The dam was completed in 1950 when a pipe of diameter 400mm was applied, which was connected with another diameter 300mm diameter on the route of Ruiru junction, thereby making the gross yield of the reservoir 22,700m3/day that is; 98% reliable. The designed capacity is to fulfill 23,000m3 / day in a transmission system that empties its water to the Kabete Water Treatment Plant, ultimately distributing water to Nairobi. The designed capacity was meant to fulfill 23,000m3 / day in a transmission system that empties its water to the Kabete Water Treatment Plant, ultimately distributing water to Nairobi.

Ruiru Dam has a vast catchment area that covers 6,680 ha. WRMA manages the catchment area with liaison with Athi Water Management Authority (AWMA). Most of this area is in Lari Subdistrict, such as Upland Forest, Kereita Forest, and Upland Wetland. This wetland happens to be the primary source of the Ruiru River, which drains its water into the dam. Locals initially conserved the wetland through taboos and beliefs. Traditionally the local people used it through harvesting reeds for roofing and clay for pottery. Cultural practices such as circumcision were ongoing in this area, and both people used it as a food source by collecting duck eggs and meat.

The wetlands remained intact in use for the above purposes until the arrival of the Europeans. After colonization, the area under wetland and the surrounding were demarcated and allocated to white settlers who started draining it. As Kenya attained independence, Lari Sub-County, a division of Kiambu County, was earmarked as a settlement area for landless Africans. Therefore, Lari's settlement scheme was created to settle the land with fewer citizens. The area was subdivided in 1963 into 107 parcels of land that came to be known as the Lari 107 Settlement Scheme, a name it has retained to date. The touching land wetlands were divided into 50 hectares, and the wetlands were allocated for grazing. This area's privatization began with poor Africans settling in this region.

The inhabitants of Lari do not currently associate these wetlands with many economic benefits, so their immediate alternative is to drain them for farming to increase their income. Although sustainable utilization of this wetland is vital to our country, the battle cannot be won without local "s people's participation. The draining of these wetlands has resulted in the loss of social, economic, and ecological benefits in this area, including neighboring cities such as the metropolitan city of Nairobi, whose water comes from the Ruiru River. Water quality in the wetlands is deteriorating due to siltation, agricultural chemical contamination, and biological pollution originating from the upcoming town of Lari and the rapidly growing factories in the area.

This study was conducted in the newly created Lari sub-county where the wetland is situated, and the Githunguri sub-county hosts Ruiru dam. The two sub-counties were earlier under the former larger Kiambu sub-county. The objective of this study was: (i) To assess the level of awareness of local communities on the importance of wetlands and the organizations that protect them. (ii) To document major causes of Upland Wetland degradation. (iii) To assess the extent of community participation in the management of Upland Wetland and investigate their possible contributions to its conservation. (iv) To define the opportunities and challenges faced in participatory wetland management in the Upland.

MATERIALS AND METHODS

This chapter describes the study area, research design, data collection procedure, method of data analysis, and results presentation.

The study area

The study was carried out in Ruiru sub-ward, Lari/Kirenga ward, in the newly created Lari sub-county part of Kiambu County (Figure 1). The wetland mapping was done using GIS, as shown by Figure 2. The area was selected since being the main catchment area of the Ruiru River, which supplies water to the Nairobi District. Initially, this area was called the Lari 107 Settlement Scheme, created by the colonial government to resettle the Mau Mau victims and landless people. It is bordered by

Limuru sub-county to the south, Githunguri sub-county to the east, and Naivasha sub-county to the west. It is connected to Nairobi by Mombasa-Kisumu Railway and Nairobi-Naivasha Highway.

Lari sub-county is a good water catchment area that includes the Upland Forest and Kereita Forest, which are collectively called the Kikuyu East Slope. Two forests plus wetlands send a lot of water to the Githunguri sub-county, and some of it is dammed at the Ruiru I Dam. The water collected in the dam is then pumped to Nairobi and its surroundings, such as Kiambu. As the river flows downstream, it supplies water to other large cities like Ruiru before joining the Athi River.

Target population

The study targets Upland Wetland adjacent community, community-based wetland conservation groups such as WRUA, WRMA, Ruiru Dam Employees, and local leaders. The sub-ward is found in the Lari-Kirenga ward, a population of 27,871 as per the 2009 census.

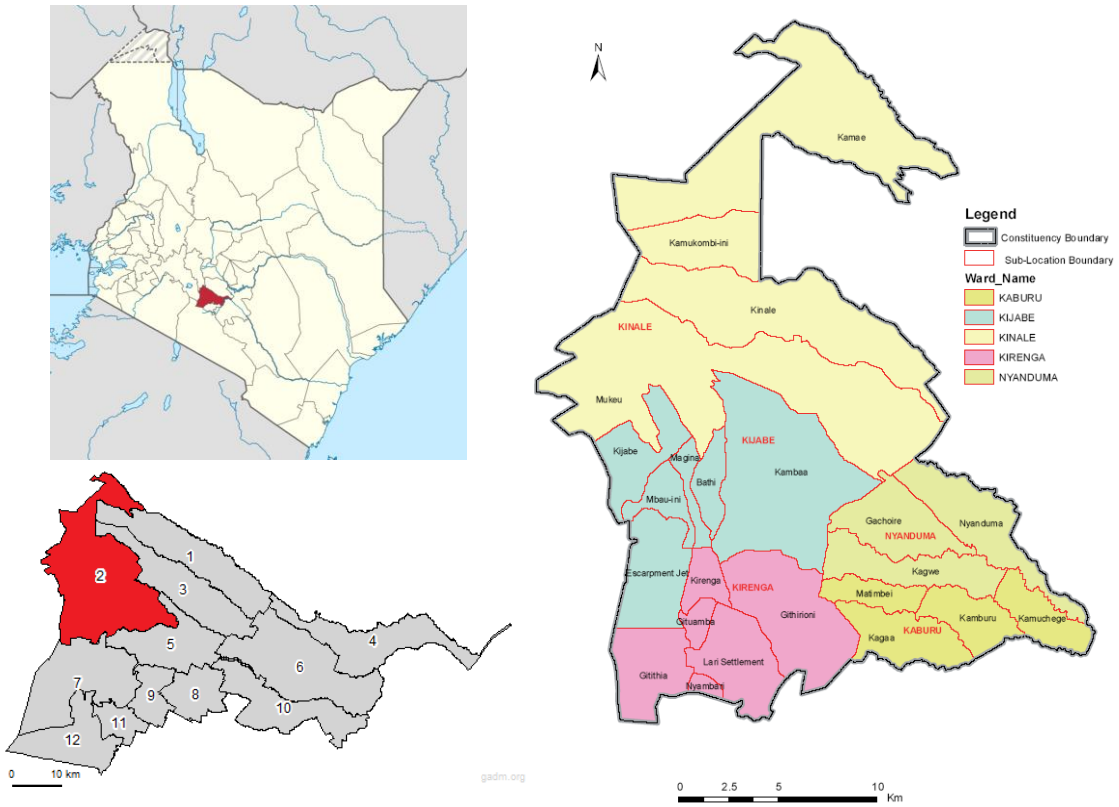

Figure 1. Map of Lari Sub County, Kiambu County, Kenya

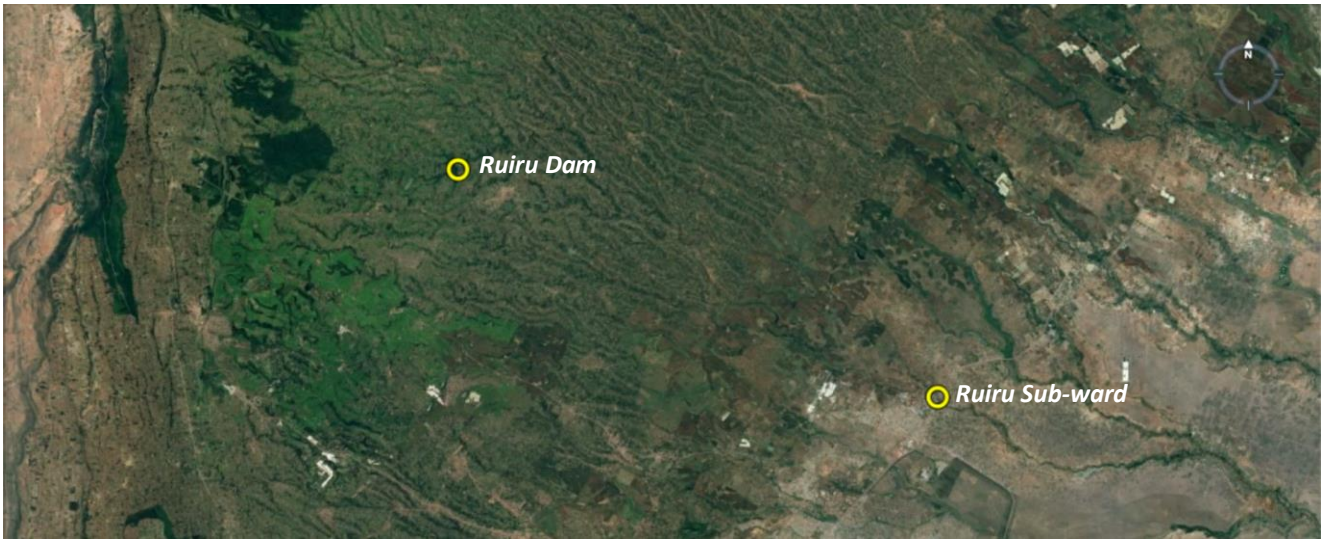

Figure 2. GIS of Upland Wetland in Ruiru sub-ward, Kenya

Climate

The area is in Agroecological Zone II with the type of bimodal rainfall. Long rains are experienced between March-May and short rains between October-November. Altitude ranges from 2000-24mm00 m above sea level, and the total amount of precipitation can vary from 1500-2200 mm. High temperatures occur from January to March at around 220°C, while low temperatures occur in July at 120°C. Lari sub-district has fine loam soils, which are known for vegetable production. Siltation in wetlands introduces it as a thin layer of soil even though the main soil in the study area is clay soil. The ground is suitable for growing vegetables, corn, and potatoes for household use and sale.

Economic activities

The main economic activity of the Lari people is agriculture. Thus, this sub-county has supplied fresh vegetables like spinach, kales, cabbages, and carrots to Nairobi County for a long time. Dairy farming developed rapidly after introducing the milk processing industry called Sundale. The farmer also raises pigs as a Farmer's Choice Company that raises and slaughters pigs in his factory. The Nairobi-Naivasha Highway crosses the sub-county and the Mombasa-Kisumu Railway. Both make the area suitable for commercial activities. Mining also occurs mainly in the Kereita Forest, where the Carbacid Company harvests the carbon IV oxide. Forestry takes place in the forests of the Uplands and Kereita, where softwood trees are mostly planted.

Research design and sampling procedure

Sampling design

This study used a descriptive survey research design. The design is used to collect data from population members to determine the Ruiru sub-ward (village) population status. The choice was made because the study focused on conserving and managing existing wetlands. The head of the household is interviewed, and if they are not available, we substituted with the spouse or child over 18 years of age. This ensured that members of every gender were incorporated.

Sample size

The sample size (Table 1) was determined using Mugenda and Mugenda (1999) proposed formula.

$$n=N/1+ (0.1)^2$$

n: sample size required

N: size of population (Target) e=sampling error (10 % points)

Table 1. Respondent distribution

No of members	N	N	%	ratio	Sample size
Farmers	107	40	80	0.8	39
Others	10	10	20	0.2	10
Total	117	50	100	1	49

Sampling procedure

This study used simple random sampling and systematic sampling to select 40 respondents living within a 1 km radius around the wetlands. The farmers given a questionnaire were obtained using a stratified sampling technique from eight villages in the Ruiru sub-location. The 40 questionnaires distributed in the villages were as follows: Kimotu 5, Kimonditi 5, Upper Scheme 5, Lower Scheme 5, Kibuto 5, Guan B 5, Karia 5, and Gwagacira 5. The 40 farmers represented 37% of the 107 native Lari Settlement Scheme members allocated agricultural land around wetlands. The original list was obtained from the archive of regional heads. Random sampling was also carried out for each 40 farmers to obtain household respondents who filled out the questionnaire. Purposive sampling was carried out to get the elderly because of the historical aspects of the rice fields. A total of six elderly were chosen deliberately, three from each gender. Two focus groups were formed involving local leaders and employees of the Ruiru dam. Purposive sampling was also carried out to select two key respondents from the WRMA and WRUA offices.

Data collection tool

Primary and secondary data collection methods were used to obtain information from the sample unit. Preliminary data were collected using GIS, structured questionnaires, oral interviews, and direct observation. GIS was used to map wetlands, calculate their area, and determine changes in land cover in land use over the last thirty years.

Field recording was one of the qualitative data collection methods used in this study. Direct observations of the activity and the physical environment in the wetlands were carried out for six months. Secondary data was collected from documents, publications, NEMA, NWSC, and WRMA reports. Secondary data were reviewed to complement the respondent's opinions and observations during the field visit.

Reliability and validity

The research instrument's reliability was carried out through a pre-test pilot study in units that were not included in the study. Recorded ambiguities, weaknesses, and inconsistencies are corrected before actual data collection.

The random procedure in selecting sample units is carried out to eliminate bias to reflect the image of the total population. Repetition of statistical tests was used to justify the validity of the study. Performing the test more than once and comparing the results confirm the procedures' validity and reliability. The study findings were compared with previous ones, and there was not much difference between the two.

Pre-test

A pre-test of research was done in January 2012 to check the practicability of the study. Study objectives, achievability, and suitability of research tools were done. Poorly answered questions were redone, plus those respondents could not understand. Interviews were held

with local leaders during this period, and ten farmers filled out the sample questionnaire.

Methods of data collection

Questionnaires

Questionnaires were given to 40 farmers "s 1km radius of the wetland—questions comprised nominal, ordinal, scale, and ratio measurement.

Key informative interviews

This was done by a WRMA official in Kiambu District who explained WRMA activities and the main catchment areas in the district. WRUA officials at the district headquarters also provided a list of WRUA groups officially registered in the district and their main activities. They also offer registration procedures to WRUA and WDC activities. The elderly from the Ruiru sub-ward recounts the history of the wetlands and their early use.

Focus groups discussions

Two focus groups constituted local leaders, and Ruiru Dam employees were involved. Focus groups mainly looked at significant causes of degradation, alternative uses, and what it takes to introduce participatory wetland management in the Ruiru sub-ward.

Data analysis

Data analysis involves the computation of descriptive and inferential statistics. The analyzed findings are presented using pie charts, tables, photos, and bar charts. Qualitative information is obtained through scheduled interviews and observations taken verbatim, and documented photographs of critical areas in the watershed are obtained. Changes in land cover for land use are carried out using a GIS. Inferential statistics were performed using Pearson's (x2) t-test and Chi-square. The t-test is used to determine whether the two data sets collected and analyzed differ significantly from each other. Chi-square helps in testing the independence of the responses given by respondents. Here the SPSS version is used.

RESULTS AND DISCUSSION

Respondent demographic information

Respondents who were sampled in this study were aged 10-30 years (10%), 30-50 years (60%), 50-70 years (27%), and over 70 years (3%) (Figure 3). However, demographic data show very few older adults in Ruiru sub-ward. This can be attributed to the Mau Mau uprising and the Lari Massacre in the early 1950s, resulting in the majority of the population being killed. In contrast, others died in detention or were displaced from the area.

There were slightly more male residents living in the study area (55%) than female residents (45%) who participated in the study. This shows that gender is evenly distributed in the sampling of citizens. More men were recorded because much of the data was taken from farms where men were more involved because of manual labor.

The results of the study found that the population in Riuru sub-district where the wetlands are located, the majority (65.0%) have lived for more than 20 years, (2.5%) have lived between 15-20 years, (20%) have lived between 10 years-15 years while 12.5% of the population has lived in the area for less than five years as shown in Figure 4. Therefore, the low level of immigration in this area is the increase in population due to births, which threatens natural resources.

The study revealed that residents' highest level of education was diploma (5%), and those with a primary level of education were 35%. In comparison, those who had a secondary level of education were 60%, as shown by Table 3.

The highest education level was not significantly different between the male and female populations ($\chi 2$ = 4.887, p = 0.087). However, more men (50.0%) have secondary education while women (77.8%) have a high school education, as shown in Table 4.

Table 3. Education levels of residents of Ruiru sub-ward, Kenya

Education level	Frequency	Percentage (%)
Primary level	24	60
Secondary level	14	35
Diploma	2	5
Total	40	100

Table 4. Level of respondents by gender

Education level	Gender of the respondents		Total Frequency	Percentage
	Male	Female		
Primary	45.5%	77.8%	24	60.0%
Secondary	50%	16.7%	14	35.0%
Tertiary	4.5%	5.6%	2	5.0%
Total	100%	100%	40	100%

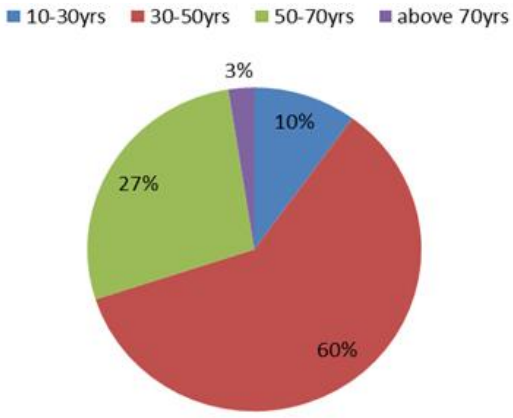

Figure 3. Ruiru sub-ward residents, Kenya

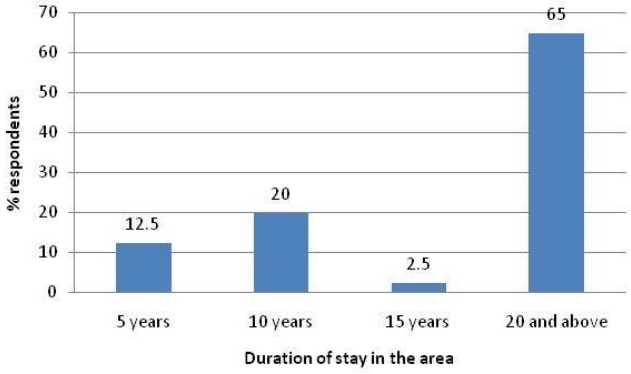

Figure 4. Resident duration of stay at Ruiru sub-ward, Kenya

The current use of wetlands by farmers has no significant relationship with their education level ($\chi 2$ = 10.435, P = 0.236). About 50% of the population has primary school education, 46.2% middle school, and 4.8% tertiary education. In addition, highly educated communities also drain wetlands for farming. However, at the diploma level, the representation level of significance of 50% indicates conservation efforts by practicing preservation. The current use of wetlands by farmers does not depend on their level of education (Table 5).

The study found that people of Ruiru sub-ward had acquired their land differently, with 30% inheriting, 30% buying their land, and 37% were settled in this place while 3% of respondents leased their land Figure 5.

A closer look at land acquisition methods shows that residents in the 30 - 50 age group have the most diverse ways of owning land, from buying inheriting to settlements on their parents' lands (Table 6).

Community awareness on wetland importance

Within this community, 55% are aware of the importance of wetlands, while 45.0% of the population are unaware of the extent of wetlands, as shown in Figure 6. The results showed similarities to those carried out in the Kisii wetland, which showed that 60% of the population considered wetlands essential or very important (Mironga 2005).

Table 5. Current wetland using about the education level of respondents

Wetland use	Primary	Secondary	Tertiary
Crop farming	50%	46.2%	50%
Grazing	29.1%	20.8%	0 %
Tree planting	8.3%	15%	0 %
None	4.3%	10%	50%
Settlement	8.3%	8%	0 %
Total	100%	100%	100%

Table 6. Land acquisition methods

Ages (Years)	Method of land acquisition				
	Buying	Settlement	Inheritance	Other	Total
10–30	100%	0%	0%	0%	100%
30–50	25%	33.4%	37.5%	4.1%	100%
50–70	18.2%	63.6%	18.2%	0%	100%
Over 70	0%	100%	0%	0%	100%

Table 7. The importance attached to wetland by residents

Wetland importance	Percentage
Source of water	45
Supply of forage	27.5
Nature conservation	12.5
Cultural importance	12.5
No importance	2.5
Total	100

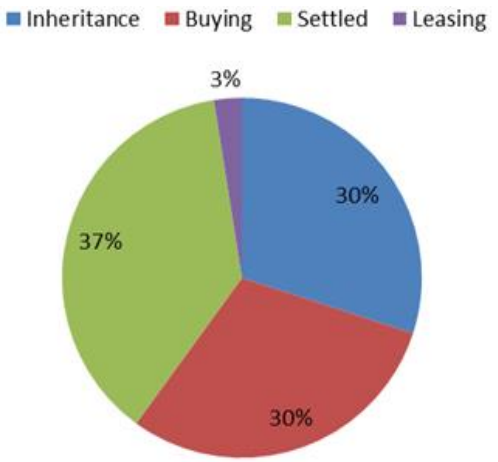

Figure 5. Methods of land acquisition by residents

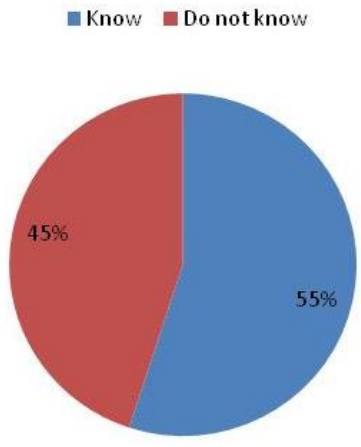

Figure 6. Respondent's knowledge of the importance of Upland Wetland

The inherent interests of wetlands include 45.0% of water sources, 27.5% of forage, 12.5% of nature preservation, 12.5% of cultural attractions, while 2.5% of the population does not attach wetlands to Table 7. By emphasizing the availability of water, preservation of natural and cultural values, residents appreciate the role of wetland services that help community socio-economic development. This study is consistent with FAOs, which shows that Kenya's wetlands play essential roles: providing habitat for wildlife and fish, food, fish, building materials for flood control, and water purification (FAO 2008).

The study found that although the conservation value of biodiversity is up to 12.5%, this area can become an ornithological paradise because birds are often seen to become residential birds. The goliath heron (Figure 7) migrating over many wetland areas in Africa is seen building large nests on reed and papyrus platforms. They are so frequent that respondents consider them an indicator species of wetland conditions.

Other birds were sacred ibises that usually sat still and congregated in different parts of the wetlands. Egyptian geese were only seen during the long rains in April. They were found in pairs swimming in waterlogged agricultural land and grassy plots. On the other hand, Hadada ibises appeared in large groups, staying in the area longer than other birds.

Egyptian geese (Figure 8) were also observed roaming in drained wetlands. These birds are migratory, and they visit many east African wetlands, especially during winter in their residential areas. Respondents indicated that these birds were abundant in wetlands before drainage, and they acknowledged that this is one of the negative impacts of drainage. This study shows similarities to that in Kimana, where year-round agriculture increased human-wildlife conflicts as wildlife from Amboseli National Park was forced to pass through the remaining narrow gaps due to the destruction of their habitat (Claridge and Callaghan 1997).

Therefore, this area can be an excellent tourist attraction, thus providing an alternative land use that encourages conservation and generates income for residents. Biodiversity in the study area also appears to be under threat, including water quality, as many farmers prefer chemicals in their farms and organic farming, leading to eutrophication into rivers and eventually the Ruiru dam. The majority of farmers, by 40.0%, prefer chemicals while 30.0% prefer organic agriculture, as illustrated in Figure 9.

Organic waste generated in farming activities eventually will cause eutrophication in Ruiru Dam. Fish in the dam will suffer from oxygen stress denying NWSC indicator species used to monitor water quality. The river was also experiencing heavy siltation from farming activities, as shown in Figure 10.

Figure 7. Frequenting birds in Upland Wetland, Kenya

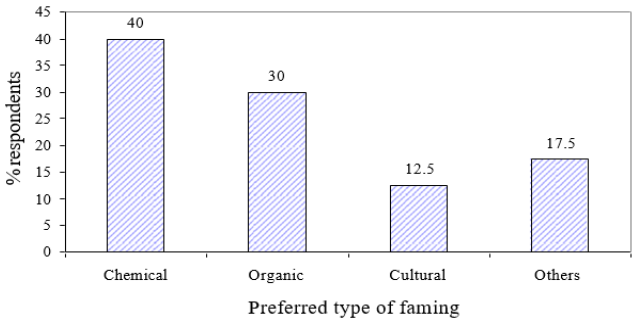

Figure 9. Preferred type of farming in Ruiru sub-ward, Kenya

Figure 8. Migratory Egyptian goose in demarcated Upland Wetland, Kenya

Figure 10. Siltation in Ruiru River, Kenya

Likewise, the water table decreases as the community's shallow well dry up at an alarming rate. The respondents' shallow wells had to be submerged from 40 million to 50 million, making a difference of 10 million in a year. Thus, there is a possibility that future generations will lack water in this area even as the wetlands dry up, making the Ruiru Dam White Elephant project.

Hypothesis (H1): "The number of people who know the importance of wetlands is less than the number of people"). Based on the findings of this study, the researcher cannot accept the null hypothesis, from the statistics showing that although 45% of respondents do not know the importance of wetlands, they consider conservation in their farming activities (X2 = 2.513, p. = 0.133). In this case, ignorance can be one of the factors causing wetland drainage. Natural resource sabotage also appears to be working in this area, especially after residents are fed up with the NWSC harvesting their water selling it without benefiting them.

Causes of wetland degradation

Among the sample population, 92.5% had part of their land under wetlands, while only 7.5% had no land under the wetlands due to inherited demarcation. The study found that the degradation of the Upland Wetlands began after state colonization. Before colonization, the area was used as a source of reeds, clay for pottery making, and an initiation site for the Kikuyu youth. This area was used sustainably until the Europeans arrived when white settlers allocated this area and drained the wetlands to grow wheat and wheat for livestock. A dam was also built on the upper side to supply water to the livestock, further draining this wetland. Uplands Bacon Factory was also established in the hog raising area. The plant drained the lower part of the wetland for dam construction and started dumping waste into the remaining wetlands, a problem that continues today.

After independence, Lari Sub-district was allocated as a residential area for landless Africans. At that time, most of the elderly who could have passed on traditional knowledge of wetland conservation had died during the Mau Mau rebellion. The unity of the local people has also been paralyzed due to the counteroffensive by the Mau Mau under the notorious Lari Massacre. The management of this settlement scheme, known as the Runaway Settlement Scheme 107, included the sub-divided wetlands and was therefore individual.

Most residents who obtain land parcels that touch 50 hectares of wetlands per person use it for grazing. These land uses persisted into the past when population explosions, land fragmentation, and the demand for fresh vegetables from nearby cities increased. Farmers started drying out this wetland to grow crops even though they claimed it was the source of liver worms and poisoning from factory waste that killed their livestock.

To investigate the current extent of degradation, environmental software was used to conduct the assessment, with ArcGIS V.10.2 and the Google Earth program, which provided high-resolution imagery for validation. Radiometric calibration is performed to obtain images based on various factors such as exposure time, plane observation, and dark currents. Then Top of the Atmosphere Calibration (TAC) is performed on the image. Because the view was so big, the sub-setting was done by cutting the plane with a shapefile created with supports around the Ruiru sub-ward. Before selecting a training location, different track combinations were used to assess the best variety for viewing wetlands, as shown in Table 8.

Pseudo-natural colors 7-4-2 have been tested, but (4-3-2) false colors Near Infra-Red, Red, and Green Infra-red combination featuring delineation of wetlands and agricultural land are better used. It is also the most conventional band combination used in remote sensing for vegetation, crop, and wetland analysis. Using Google Earth to identify indistinguishable features from the 30m Landsat Scenes being processed, Validation was carried out.

Remote sensing was carried out for the last thirty years with 10-year duration intervals to determine the extent of wetland degradation. The first imagery was obtained in 1986 when the wetlands were still intact, less degradation. The rice field area reached 235 Ha at that time, as shown in Figure 11.

Encroachment later started taking place, and the wetland was turned into cropland, settlement, and forests. In the northern part of the wetland, farming activities and pockets of forest were sighted. The settlement was started on the southern part of the wetland, and equally, drainage was done using trees. In the western region, the wetland was drained for farming, and even the grassland next to it, as seen in 1986, was cultivated. Wetland declined from 235 Ha to 184.7 Ha, leading to a total loss of 50.3 Ha, as shown in Figure 12.

Degradation accelerated for the next 13 years in that wetland was reduced to 129.6 Ha. The settlement was rampant in the southern parts that divided wetland into two. All around, wetland cultivation was done, as shown in Figure 13.

Data collected on the wetland revealed that primary reasons behind wetland encroachment were: food provision (50%), generating income (25%), settlement (10%), wood fuel provision (10%), and disease control (5%), as shown in Table 9.

Table 8. The color band used in remote sensing

Ground cover type	In natural color (3,2,1), appears	In false-color: (4,3,2), appears:	In Pseudo natural color (7,4,2), appears
Trees and bushes	Olive green	Red	Shades of green
Crops	Medium to light green	Pink to red	Shades of green
Wetland vegetation	Dark green to black	Dark red	Shades of green
Water	Shades of blue to green	Shades of blue	Black to dark blue
Urban areas	White to light blue	Blue to grey	Lavender
Bare soil	White to light grey	Blue to grey	Magenta, lavender, or pale pink

Table 9. Reasons of wetland encroachment at Ruiru sub-ward, Kenya

Factor	Frequency	Percentage
Provide food	20	50%
Generate income	10	25%
Settlement	4	10%
Wood fuel provision	4	10%
Control of diseases	2	5%
Total	40	100%

The findings here are consistent with data collected on the causes of drainage of the Kisii wetlands, revealing that 70% drained wetlands for agriculture (Mironga 2005). Food sources were cited by residents as the leading cause of wetland drainage as this area can provide adequate yields all year round. The community can cultivate crops in the dry season to not limit their farming activities in the dry season. This ensures a good source of food and income throughout the year. The increase in population also forces residents to dry up wetlands to obtain the additional land they badly need for production. Farmers grow potatoes, spinach, and kale which they harvest, sell and consume locally because of the several ways wetlands increase their food security. This community also earns income by carrying out agricultural activities as excess produce is sold to nearby cities like Nairobi, Kiambu, Limuru, and Githunguri. Most of the farmers were implementing an open ditch drainage system that did not require high costs to operate during the data collection, as shown in Figure 14.

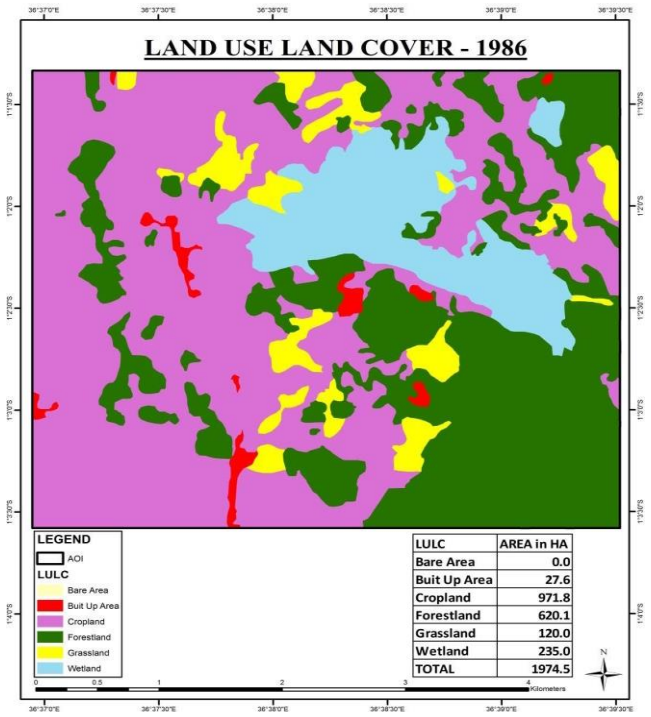

Figure 11. Landsat image of Upland Wetland 1986, Kenya (Source: Remote sensing 2016)

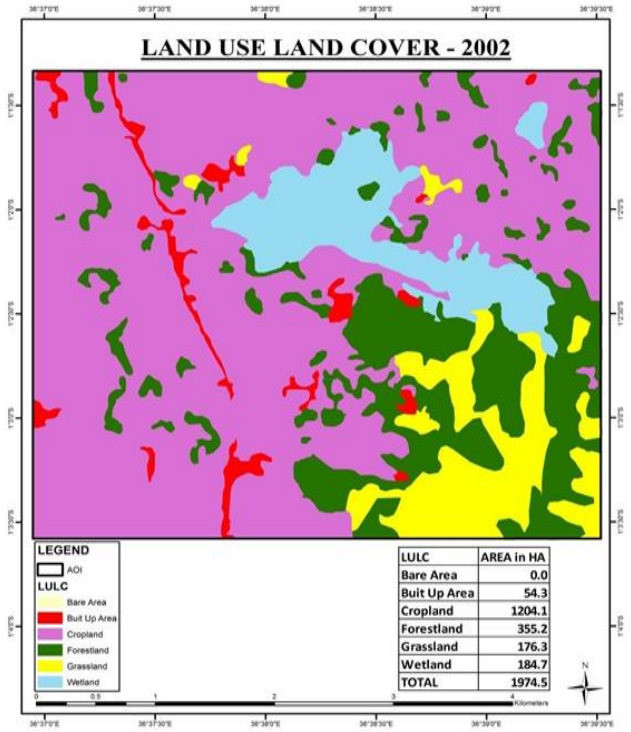

Figure 12. Landsat image of Upland Wetland 2002, Kenya (Source: Remote Sensing 2016)

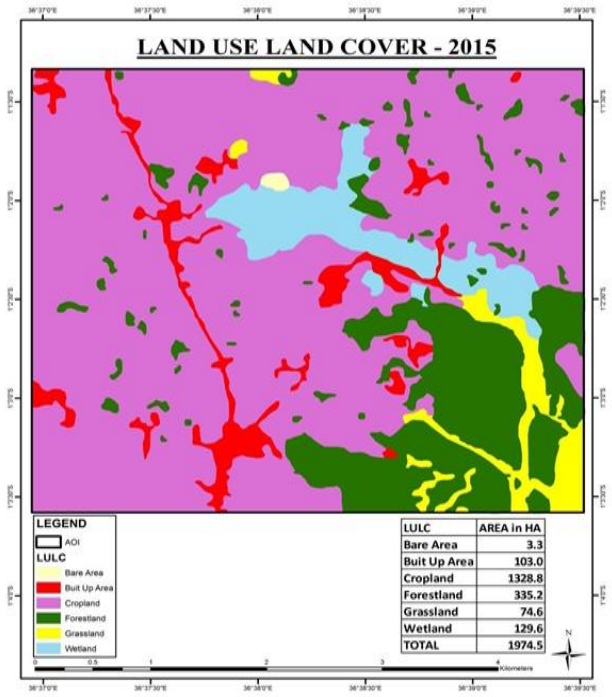

Figure 13. Landsat image of Upland Wetland 2015, Kenya (Source: Remote sensing 2016)

A source of forage is another benefit farmers get from wetland drainage. Direct grazing was not possible because the farmers claimed that pollutants killed their livestock from the factory and the upcoming town of Lari. A respondent admitted that he had lost five cows due to waste from the following factory. Farmers ended up choosing other land uses to avoid this threat. They also said that the Court case against the factory took a long time to resolve even though some farmers were compensated.

Another 10% of respondents indicated that eucalyptus tree planting was carried out due to the closure of the nearby Lari Forest to supply firewood for household needs. A nearby tea factory that wilted tea with a wood fire created a good demand for the tree and the upcoming construction activities in nearby cities. To achieve this goal, farmers intercorporate their food crops with eucalyptus to maximize their land before the trees mature, which helps drain the wetlands (Figure 15). This is more so because land-based resources are an important asset for the poor in developing countries, who rely on them to generate a large proportion of their income and living necessities (IFPRI 2013).

The study also revealed that residential houses that generate immediate income due to proximity to Lari City and future factories in this area have significantly increased. Most of the migrants who became victims of post-election violence turned Lari Subdistrict back into a residential area. Hence, the demand for cheaper housing is rising, and local people use this opportunity to build affordable housing in wetlands, as shown in Figure 16. The construction of the rental house is already alive, and this also speeds up the drainage.

The conversion of wetlands to residential areas endangers the water quality of the Ruiru river due to fecal contamination. Some of these so-called Karia has experienced eruptions of waterborne diseases such as typhus after being diverted to residential areas. Boreholes must be dug with CDF money to try to eliminate this threat. Karia- this is a Kikuyu word that means dam. Initially, the area was a dam built by Europeans to supply water to their livestock. After distinction, it was divided into 250 plots known as Scheme of Lari's Settlements 107. Each farmer was allocated a plot of land because the dam could not be divided among the members.

Farmers dry it and sell it for real estate development, especially after the PEV, which made most internally displaced people come to this area. The presence of Lari forest's encroachers driven out in 1986/1987 also accelerated this problem; they bought a plot of land in this area because it was affordable. Likewise, other rail settlers came to the wetlands after the collapse of the Kenya Railroad. Low land prices are attractive bait for large settlements.

Water-borne diseases such as upland malaria also cause drainage of wetlands. This disease outbreak led to the formation of the Running Malaria Prevention and Control Project. This project received funding from the CDF of Kshs. 200,000, which they used to buy malaria medicine and bed nets. The project also reserves the right to dig drainage ditches into assisting in draining to resolve this problem. Land-use changes should also be adapted to deal with typhus, bilharzia, and river worms that kill livestock.

The threat of accidental heart has been going on for so long that one of the tributaries is named after him, the Gethambara River. More and more people (87.5%) claim to get more benefits from wetlands due to the above activities, as shown in Figure 17. Farmers seem to be using their land to provide them with more profit. There are three central tenure systems in Kenya: public, private, and trust land. Under property rights, the owner is responsible for using the land as it seems right in one's perspective (NEMA 2012).

Figure 14. Drainage activities in Ruiru sub-ward, Kenya

Figure 15. Farming activities in Upland Wetland, Kenya

Figure 16. Settlements in Upland Wetland, Kenya

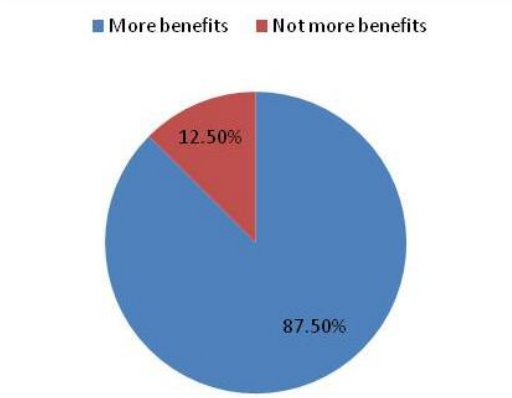

Figure 17. Responses concerning benefits accrued from Upland Wetland

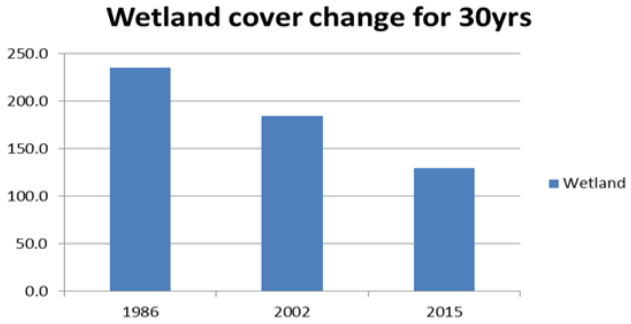

Figure 18. Wetland loss for the last 30yrs

Drainage of Upland Wetlands is mainly caused by agricultural activities, settlements, and tree farming. The findings of this study are in line with other studies conducted in the Lake Victoria wetlands, where it was found that anthropogenic activities such as reclamation for agriculture pose a significant threat to wetland conservation (Akwany 2009). The extent of community participation and their possible contribution to conservation.

The results showed that community participation in upland resource conservation was minimal; only 2.5% of respondents stated that they had participated as members of the National Environmental Management Authority and the Nairobi Water and Sewerage Company. Community members do not participate in any way at the environmental or sub-country level. No established agency like WRUA can link them to WARMA or WDC that serves community-based water conservation groups. This contrasts with the Water Act of 2002, which advocates for a bottom-up management plan that identifies and engages stakeholders in managing adjacent resources (Water Quality Group 2014).

The study found no conservation organizations represented in the area or their agents to encourage citizens to participate. Community-based participatory groups, such as WRUA as stipulated in the Water Act 2000, do not exist. The central government allocated the Lari community's resources without the residents' consent, which led to rebellion against natural resources such as encroachment of wetlands. The above can be supported because government agencies have been slow to embrace participatory wetland management, and their support for co-management may be mere lip-service. So developing techniques to increase government acceptance and commitment to co-management is one of the significant challenges facing wetland conservation (Claridge and Callaghan 1997). Using the one-sample t-test at the participation rate t-56.00, df = 39, p = 0.001, it turns out that the participation rate of the Upland Wetland management is significantly low.

Hypothesis (H3) "There is no significant effect of local community participation in the management and conservation of wetlands in the Highlands." Based on these findings; The researcher accepted this hypothesis because community participation was minimal even in cases where conservation bodies existed. Thus, a participatory approach has not been introduced and camped. Challenges and Opportunities of Participatory Management

Privatization of wetlands from pre-colonial times to the present is a significant challenge for conserving the Upland Wetlands. The farmers have official land titles issued since 1964. This is against government policies that advocate for the protection and conservation of water catchments. For example, the Water Act 2000 supports the creation of riparian lands and the repossession of similar areas for conservation. As a result, the total wetland cover area has decreased, as shown in Figure 18.

Settlements also cause the loss of wetlands, especially in the south. The current payment has divided the wetland into two equal parts. Due to continuous flooding during the long rainy season, most wetlands are drained and then abandoned, leading to loss of biota characteristics. The conversion of wetlands to cropland is also a big challenge as the area is drained from all directions. Farmers also convert some wetlands into forests, primarily eucalyptus, which dries the land faster for crop farming. Therefore, human encroachment is the greatest challenge for the Upland Wetlands as it has caused huge losses over the last thirty years, as shown in Figure 19.

The low level of community participation in managing the Upland Wetlands is also a big challenge because only 2.5% stated that they had participated. The Kiambu County sub-region has effectively engaged various stakeholders such as the Kamiti watershed and the Thiririka River to conserve water resources. However, there is no community-based conservation group on the Ruiru River. The flow of information is also insufficient because this community does not know about WRMA or WRUA. Communities living in this catchment area have not been empowered on participatory wetland management issues to form Sub-watersheds that map ahead for participatory issues.

As a result, other human activities increase at the expense of conservation activities. Changes in land cover and land use during the last thirty years show that the built-up area has increased by 74.4 Ha and agricultural land is 357 Ha. However, the decrease in the area of a conservation area on the forest land decreased by 284.9 Ha, Grassland by 45.4 Ha, and wetland by 105.4 Ha, as shown in Table 10. Therefore, human encroachment is currently threatening conservation activities in the Ruiru sub-ward.

As a sub-district settlement, Lari has a poverty problem that makes residents unable to send their children to school, considering that only 5% of the sample population has tertiary education. So there's lousy enlightenment for people as far as conservation is concerned. The local population is also not ready to be resettled. They claim that the area has good infrastructure and is very developed compared to other country regions, which poses a significant conservation challenge. Their proximity to the Nairobi District also provides good social infrastructures such as hospitals, roads, electricity, and water, giving rise to fears of losing such benefits upon resettlement. The institutional failure of the NWSC and WRMA to campaign for wetland conservation and education of local people about the importance of wetlands is also a significant challenge. These agencies do not assist with conservation issues or even help supplement low levels of education by doing extension work. Most people in this area hold KCPE certificates, so the ecological role of wetlands is unknown. No wonder those with a 50% diploma education practice conservation science. The parastatals that control natural resources in Kenya also appear to be operating at a level where the population cannot reach them.

The study results revealed opportunities for community participation, considering that 77.80% of respondents were ready to be involved in NWSC plus WRMA activities which could encourage them to carry out conservation activities. However, less than a quarter (22.20%) of the population felt that they would not allow their land conservation despite the benefits shown in Figure 20.

Those for conservation could encourage both preservation of wetland and its sustainable use. The study is inconsistent with the one carried out in Lake Victoria wetlands that revealed that raising public awareness, training, formation of conservation groups, and change of attitude can help in wetlands conservation (Akwany 2009).

Members who were ready to embrace conservation once involved suggested Community-Based projects such as fish farming, eco-tourism, and cottage industry as alternative wetland use. Such projects can create sustainable use and generate income for the residents. Irrigation projects that were seen to increase food production in the upper drier area could reduce the probability of farmers encroaching into the wetland. This is true, bearing in mind that the wetland encroachment was due to its moist soil experienced all year long. Farmers could equally be encouraged to embrace intensive farming, producing maximum yields within small areas.

Respondents also noted that while the Kenya Forest Service encourages communities to adopt resource management, such as achieving 10% tree cover on their farms, water resource conservation groups do nothing to motivate the public. Such campaigns can even entice farmers to get compensation for land and thus conserve it. By doing this, farmers can earn money to buy land elsewhere or even get funds to irrigate their highlands to produce food crops.

Table 10. Land use land cover change of Ruiru Sub-ward, Kenya for the last 30 years

LULC in Ha	1986	2002	2015
Bare area	0.0	0.0	3.3
Built-up area	27.6	54.3	103.0
Cropland	971.8	1204.1	1328.8
Forest land	620.1	355.2	335.2
Grassland	120.0	176.3	74.6
Wetland	235.0	184.7	129.6
Total area	1974.5	1974.5	1974.5

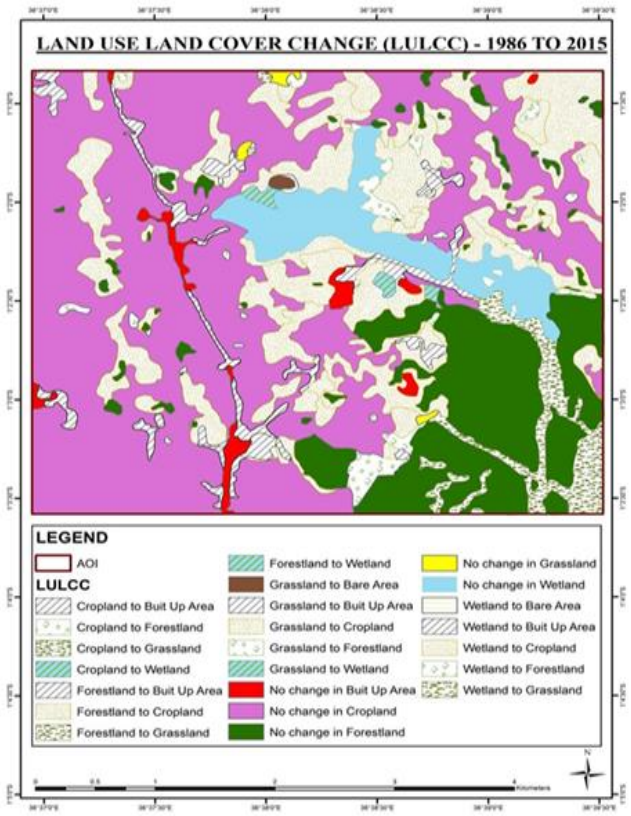

Figure 19. Summarized image of causes of Upland Wetland, Kenya loss for the last 30yrs.

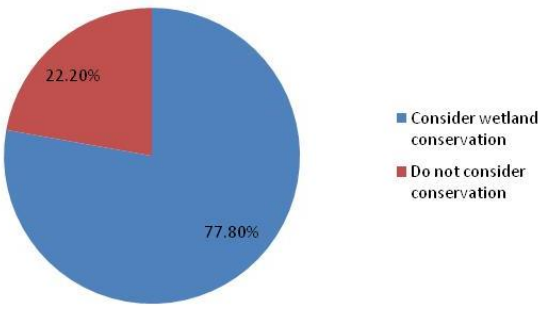

Figure 20. Respondents favoring and not favoring wetland conservation

The lack of involvement of local communities or even distribution of benefits derived from extracting water from their areas since 1935 has generated many negative attitudes in the minds of local communities with conservation. The residents had a lot of hope in the NWSC after taking over from the colonial government in river management. To date, the company has not funded any projects, employed local people, or provided any incentives to harvest and sell water to the people of Nairobi. So that the farmers feel cheated because the company takes resources that come from their land but does not provide any profit in turn. Moreover, ecosystem management is increasingly leading to collaborative management systems with indigenous peoples (Oviedo and Brown 1999).

Hypothesis (H4): "Farmer's involvement in catchment management has a positive effect on wetland management." The researcher accepts the null hypothesis that most residents were ready to conserve the wetland, i.e. (X^2=0.127, p=0.001).

Community-based management programs that advocate for bottom-up management strategies already exist in government policies such as WRUA and SCMP. Therefore, farmers can be encouraged to form community-based conservation groups such as WRUA. Community-based conservation groups can receive funding through WRMA, which can assist in wetland conservation. Therefore, the community needs enlightenment so that they can form an SCMP which can become a forum for obtaining funding from the WDC. Once this is accomplished, this will not only help provide adequate water supply to the existing Ruiru I Dam but also a sustainable water supply to the Nairobi District as well as the proposed Ruiru II Dam construction project.

Conclusions

From these findings, it was revealed that institutional failures such as the WRMA and NWSC to harvest and sell water to the citizens of the city of Nairobi were a challenge because they did not make people aware of the importance of wetlands. There are no organizations protecting wetlands in the Ruiru River catchment or their representatives. Most respondents have never heard of or encountered an organization that creates awareness about wetland issues. Lack of conservation education also contributes to wetland degradation as only 5% of the population has received tertiary education.

The study found that Uplands Wetland degradation had existed since the colonial time when a white settler was allocated this area and immediately started draining the wetland to grow wheat and oats for cattle and pig rearing. It was also found that; privatization of wetlands is a significant challenge for Upland Wetland conservation. It prevents legally mandated conservation groups such as KWF from engaging in its protection. Farmers having legal title deeds have given them rights in determining wetland use, such as settlement and farming, thus degrading the wetland further.

The study found that negative attitudes and a lack of management assistance led to the rebellion of natural resources such as encroachment of wetlands. The above can be supported by the fact that government agencies have been slow to embrace participatory wetland management, and their support for co-management may be mere lip-service. Based on these findings, it is evident that encroachment of wetlands is influenced by low community participation. In addition, community participation in the conservation of the Upland Wetlands is still minimal. Likewise, community-based participatory groups such as WRUA regulated in the Water Act 2000 also do not exist in this area.

The study revealed that wetland privatization hampered participatory efforts because there was no common ground for all communities to justify the formation of community conservation groups such as WRUA and the community missed the opportunities for establishing SCMPs that could be obtained. Funding from the WDC. The loss of wetland services and a functional role is also a major challenge as the area is currently unable to attract funding from conservation groups such as Wetland International. Chances are most residents are ready to be involved in NWSC and WRMA activities that can promote conservation. Members who are prepared to embrace conservation have been involved in suggesting Community-Based projects such as fish farming, ecotourism, and cottage industries as alternatives to wetland use. The existence of a bottom-up management strategy in the Water Act 2002 that received funding from the WDC can also increase and encourage conservation activities in Upland Wetlands through the formation of conservation groups such as WRUA.

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