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

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

Abstract. Kinyariro MS, Njuguna SG, Macharia G. 2019. Challenges and opportunities of participatory management of Upland Wetland in Kiambu county, Kenya. Bonorowo Wetlands 10: 52-65. 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 that can be applied at the local level to assist in conserving 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 Gihanguri 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 who were 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 63% of respondents had lived in the area for more than 20 years. Farmers drain wetlands primarily for food supply (50%), generate income (25%), while 10% do so to control waterborne diseases. Participation rates are negligible, with only 2.5% of respondents ever 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 supply of water to Nairobi and the surrounding satellite cities.

Keywords: Kiambu, Kenya, participatory management, Ruiri, 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, and 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 man-made, wetlands play many functions such as sources of rivers, replenishing aquifers, and home 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, the economic, social, cultural, biodiversity, and ecological significance of wetlands 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 the most 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 the values of biodiversity are out of control. Such as in Kenya, a study has shown that wetlands are not fully appreciated, and there
is a lack of concerted effort to advocate for sustainable use despite offering ecological, social, and economic benefits (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 in the country, causing adverse effects to this fragile water resource. (Kecha et al. 2007).

Kenya has major 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 of diameter 300mm diameter on the route of Ruiru junction, thereby making the gross yield of the reservoir to 22,700m3/day that is; 98% reliability. The designed capacity is to fulfill 23,000m3 / day in a transmission system that empties its water to the Kabete Water Treatment Plant, which ultimately distributes 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, which ultimately distributes 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 main 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 use it as a food source by collecting duck eggs plus its 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. Lari settlement scheme was therefore 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 land touching wetlands was divided into 50 hectares, and the wetlands were allocated for grazing. Privatization of this area then begun with poor Africans being settled 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-county 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). Mapping of the wetland 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 are known to send a lot of water to 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 such as 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 27871 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 2000–2400 m above sea level, and the total amount of precipitation can vary from 1500–2200 mm. High temperatures occur from January to March with an average of around 220°C, while low temperatures occur in July with 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 good 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 been known for supplying fresh vegetables like spinach, kales, cabbages, and carrots to Nairobi County for a long time. Dairy farming developed rapidly after the introduction of 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 good 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 members of the population to determine the population status of the Ruiru sub-ward (village). The choice was made because the study was focused on the phenomenon of conservation and management of 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. Both make the area good for commercial activities. Sampling design

The reliability of the research instrument was carried out by means of a pre-test pilot study in units that were not included in the study. Recorded ambiguities, weaknesses, and inconsistencies are corrected prior to actual data collection.

The random procedure in selecting sample units is carried out to eliminate bias so that it reflects 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 confirms the validity and reliability of the procedures used. 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 that respondents could not understand. During this period,
interviews were held with local leaders, and ten farmers filled the sample questionnaire.

**Methods of data collection**

**Questionnaires**

Questionnaires were given to 40 farmers within a 1 km radius of the wetland—questions comprised of 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**

**Respondents demographic information**

Respondents who were sampled in this study were aged 10-30 years (10%), 30-50 years (60%), and 50-70 years (27%) and over 70 years (3%) (Figure 3). However, demographic data show that there are very few elderly people 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 either died in detention or were displaced from the area.

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 Ruiru sub-distric 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 as a result of births, which currently threatens natural resources.

The study revealed that the highest level of education of residents was diploma (5%), 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 (χ² = 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 | Percentage |
|-----------------|---------------------------|-------|------------|
|                 | Male          | Female | Frequency |          |
| 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
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% bought their land, and 37% were settled in this place while 3% of respondents lease their land (Figure 5).

A closer look at land acquisition methods shows that residents in the 30-50 year age group have the most diverse ways of owning land ranging 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 to be essential or very important (Mironga 2005).

### Table 5. Current wetland use in relation to 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. 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        |
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 that conducted by FAO, 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 to be an indicator species of wetland conditions.

Other birds were sacred ibises that usually sit still and congregate 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, and they stay 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 associated with 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 can encourage conservation and generate income for residents. Biodiversity in the study area also appears to be under threat, including water quality, as many farmers prefer the use of chemicals in their farms and organic farming, which can lead 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.
Likewise, the water table decreases at an alarming rate as the community's shallow wells dry up. 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 ($X_2 = 2,513, p = 0.133$). 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 for reeds, clay for pottery making, and as 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, which further drains 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, the majority 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, which became known as the Runaway Settlement Scheme 107, included the sub-divided wetlands and was therefore individual.

The majority of residents who obtain land parcels that touch 50 hectares of wetlands per person used 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 that 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 carry out the assessment, together 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. Validation was carried out using Google Earth to identify indistinguishable features from the 30m Landsat Scenes being processed.

To determine the current extent of wetland degradation, remote sensing was carried out for the last thirty years with 10-year duration intervals. The first imagery was obtained in 1986 when the wetlands were still intact, and there was less degradation. At that time, the rice field area reached 235 Ha, 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. On the southern part of the wetland, the settlement was started, and equally, drainage was done too using trees. On 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 major reasons of 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. 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       |

**Color bands used in remote sensing**: (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. Validation was carried out using Google Earth to identify indistinguishable features from the 30m Landsat Scenes being processed.
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 among surveyed landowners, 70% drained wetlands for agriculture (Mironga 2005). Food sources were cited by residents as the main 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 choose 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 such as Nairobi, Kiambu, Limuru, and Githunguri. During the data collection, most of the farmers were implementing an open ditch drainage system that did not require high costs to operate, as shown in Figure 14.

A source of forage is another benefit farmers get from wetland drainage. Direct grazing was not possible because the farmers claim 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 of the 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, too (Figure 15). This is more so because land-based resources are an important asset for the poor in developing countries, who rely on these resources 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 greatly 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 are using 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 have 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 demarcation, 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 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 as a result of the above activities, as shown in Figure 17. Farmers seem to be using their land in a way that provides them with more profit. In Kenya, there are three central tenure systems: 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).
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 major threat to wetland conservation (Akwanzy 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. There is no established agency like WRUA that 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 that can encourage citizens to participate. Community-based participatory groups, such as WRUA as stipulated in the Water Act 2000, also do not exist in this area. 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 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. So developing techniques to increase government acceptance and commitment to co-management is one of the major challenges facing wetland conservation (Claridge and Callaghan 1997). By 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 the conservation of 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 of the 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 Ruiru sub-ward.

![Figure 17. Responses concerning benefits accrued from Upland Wetland](image)

![Figure 18. Wetland loss for the last 30yrs](image)
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 regions of the country, which poses a major conservation challenge. Their proximity to the Nairobi District also provides them with 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 major 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 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 that there were 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 the conservation of their land despite the benefits shown in Figure 20. Those for conservation could encourage both preservation of wetland as well its sustainable use. The study is inconsistent with the one carried 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 as well as generating income for the residents. Irrigation projects that were seen to increase food production in the upper drier area could be started reducing 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, making them produce 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  |
| Crop land              | 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 until now 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 of the residents were ready to conserve the wetland, i.e. \( X^2 = 0.127, p = 0.001 \).

The presence of community-based management programs that advocate for bottom-up management strategies already exists 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, and this 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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KINYARIRO et al. – Participatory management of upland wetland

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