Wetland Degradation Status and Conservation Challenges in Murang'a County, Kenya

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Abstract   Unregulated human activities have resulted in massive degradation and eventual loss of wetlands despite their importance in providing various ecosystem services and habitat to important species of fauna and flora. In Murang'a County, Kenya, wetland degradation has increased at an alarming rate since the 1980s, with no data on their degradation status and challenges facing their conservation. This study aimed to examine the trend of wetland degradation and the main challenges impacting their conservation in Murang'a County between 1986 and 2018. The challenges were identified in a stakeholder workshop involving 39 key stakeholders and ranked in order of importance using the pair-wise ranking technique. Trends in wetland degradation status were assessed through analysis of land use maps obtained from Landsat images of 1986, 2001, and 2018. The most critical challenges affecting the conservation and management of wetlands in the County were inadequate legislation followed by poor planning, lack of community empowerment, scarce resources, corruption, encroachment, and pollution. Correlation analysis between wetland and water areas showed a significant but negative relationship at (P<0.01), indicating that decreasing wetland areas resulted in a significant reduction of water areas. The wetland area in the County decreased by about 48% between 2001 and 2018 and to arrest this trend of declining wetland area, the stakeholders recommended the amalgamation of all laws and policies touching on conservation and management of wetlands in the County. Further, there is a need for community involvement and empowerment to create awareness of the roles of wetlands for their well-being.

Keywords   Wetland policies, Wetland encroachment, Land-use changes, Stakeholder analysis

1. Introduction

Wetlands are among the most important ecosystems in the world due to their high productivity (Constanza et al., 2014; Mitsch and Gosselink 2015). Over the years, numerous goods and services have been derived from wetlands benefiting people, society, and the economy (Mitsch et al., 2015). Wetlands have been known to perform various important ecosystem processes such as decomposition, primary and secondary production, nutrient cycling, and fluxes of nutrients and energy (Millennium Ecosystem Assessment, 2005).

Wetland landscapes are permanently or seasonally saturated with water, therefore exhibiting characteristics of distinct ecosystems (Keche et al., 2007). The Ramsar Convention (1971) defines wetlands as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, including areas of marine water, depth at which low tide does not exceed six meters. Due to their valuable

roles in ecosystem functioning, researchers have termed wetlands as the *kidneys of the landscape* (Ghermandi et al., 2008; Mitsch et al., 2015). In Kenya however, most communities do not understand the passive or indirect benefits of wetlands and often perceive them as *wastelands* and reservoirs for diseases causing organisms, and should therefore be drained (Muema et al., 2019). Wetlands have therefore assumed center stage in the ever-intensifying debate of environmental conservation versus resource use. Inadequate knowledge is the main driver of wetland destruction and poses an important obstacle in their restoration (Sharma and Singh, 2021). However, since the publication of the Millennium Ecosystem Assessment (MEA) in 2005, wetland conservation has hit a critical high point, with numerous researchers developing interest in these crucial ecosystems, and more so in the developing world. As a result, concerned stakeholders and decision-makers have more inferences upon which sound policies and regulations to control the use of wetlands are being based.

Conservation of wetlands is necessary since they buffer impacts from floods and droughts (Sakane et al., 2011). Wetlands play a significant function in water purification, rendering it safe for human use (Rebelo et al., 2018). Wetlands are biodiversity hotspots and they provide habitats to hundreds of wildlife species (Mwangi et al., 2010).

Conserving wetlands ensures that habitats to some of the most endangered species are protected (Green and Elmberg, 2014). Species such as Waterfowl and the Lesser Flamingo are birds of international importance and their existence depends on the well-being of the wetlands where they shelter, feed and breed. Carbon sequestration and storage is another major role played by wetlands which helps to regulate the global climate (Bai et al., 2019).

Developing countries lack regulations to control the continuous loss and degradation of wetlands (Mitsch and Gosselink, 2015). In Africa, up to 49% of the wetlands do not have management plans (NRSCC, 2014). Inadequate data and challenges in human and institutional capacities, therefore, present an unprecedented constraint on effective management of wetlands in Africa (Dixon et al., 2016). Kenyan wetlands are managed through multi-sectoral laws and policies but their degradation continues unabated and at alarming rates (Mwita et al., 2012; Macharia et al., 2010). Conservation of wetlands in Murang'a County is vital as they are the main sources of water to neighboring towns and cities, especially the capital city, Nairobi. A paucity of data on their degradation status and challenges facing their conservation has resulted in very little effort being focused on their conservation and management. This study, therefore, focused on analyzing the trends of their degradation and the challenges facing their conservation with a view of making appropriate recommendations for reversing the degradation trends.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in Murang'a County, a highland area in the Central region of Kenya located within the latitudes 0° 34' S and 1° 7' S and longitudes 36° E and 37°27' E (Fig.1). Administratively, Murang'a consists of 8 sub-counties (Kigumo, Kandara, Gatanga, Maragua, Mathioya, Kangema, Kiharu, and Kahuro) and 35 administrative wards. The county lies between 914 m above sea level (asl) in the east and 3,353 m asl in the west along the slopes of the Aberdares. The total area of the County is 2558.9 km^2 of which 11 km^2 is water mass. About 2135 km^2 is arable land and 163.3 km^2 is non-arable, while 254.4 km^2 is composed of gazetted forest and 20 km^2 is urban area.
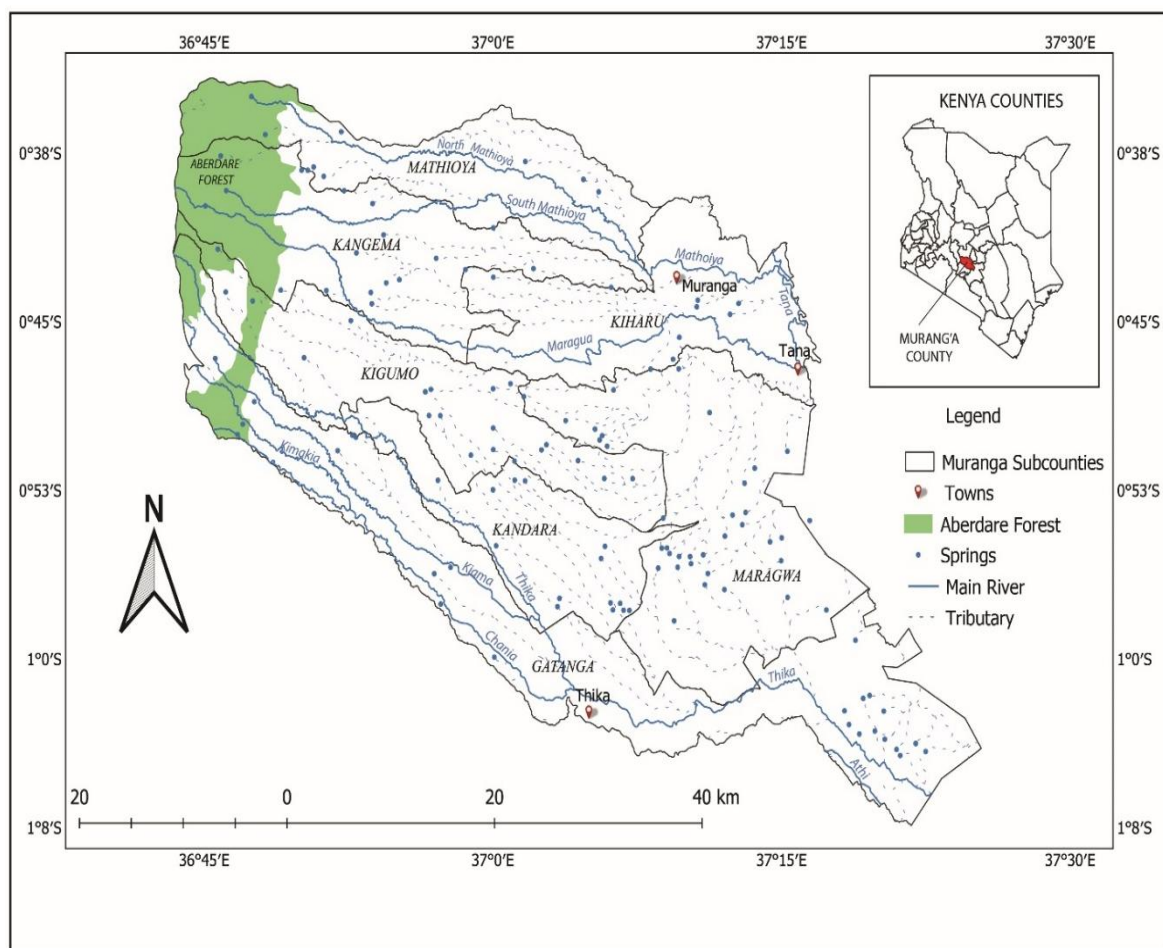

Figure 1. Drainage map of Murang'a County showing the main rivers (Mathioya, Maragua, and Thika) and their many springs and wells that feed them arising from depressional wetlands. The main rivers arise from the Aberdare forest

Murang'a County generally receives bi-modal rainfall with short rains from October to December and the long rains from March to May. According to Murang'a County Integrated Development Action Plan (2018), the County can be divided into 3 climatic zones based on altitude: the upper Tea zone, the middle Coffee zone, and the lower zone dominated by pineapple plantations, grown mainly by Kakuzi and Del Monte multi-national companies. Annual rainfall in the upper zone averages from 1800mm to 2000 mm, and in the middle zone from 1400mm to 1600mm. The lower zone is generally drier receiving an average of 900mm per annum. Maximum temperatures vary from 26℃ to 30℃ at the lower zone and, 14℃ to 18℃ at the higher altitudes.

Murang'a County is characterized by varied land-use systems due to the differing ecological characteristics. The upper zone is marked by natural forests covering the lower zone of the Aberdare ranges, which is the source of many rivers draining the County. The forest then gives rise to a tea zone extending from altitudes of 1800m to 2200m asl. Tea growing is mixed with other crops such as pineapples, avocado, macadamia, maize, and vegetables. Dairy farming is also intensively practiced. Between altitudes, 1400m and 1800m asl is a zone of coffee growing, mixed with other subsistence crops such as maize, beans, cassava, sweet potatoes, banana, French beans as well as dairy farming. The lower zone is characterized by the growing of pineapples mainly by Del Monte and Kakuzi Multi-national companies. Kakuzi Ltd also grows avocados, plantation eucalyptus trees, as well as dairy farming. Local Communities in the area subsist on vegetable growing, maize, beans, mangoes, cassava, as well as extensive dairy farming.

Soils around the edge of Aberdare forest are dominated by volcanic ash giving way to well-structured, nutrient-rich clay soils called Nitosols in the middle zone while in the lower zones the soils are dominated by deep, strongly leached poor clay soils called ferrosols (FAO Legend for the Soil Map of the World 2000). The soils are well-drained and water infiltration is high resulting in a large number of small, locally water-fed wetlands. Thus these wetlands are sources of many small springs and streams that feed the many rivers draining from the Aberdare ranges. These wetlands are classified using the hydrogeomorphic approach as either riverine or depressional (Brinson, 1993). Riverine wetlands occur in floods and riparian corridors in association with stream channels, whereas depressional wetlands occur in topographic depressions on a variety of geomorphic surfaces. The main rivers fed by springs emanating from these wetlands include Mathioya North and South, Maragwa and Thika Rivers.

2.2. Data Collection and Analysis

Stakeholders are those individuals, groups, organizations, and communities involved in or affected by decisions made to conserve and manage wetland resources (Rockloff and Lockie, 2004). This study incorporated national and local government organizations, along with community groups, research institutions, and economic development organizations. A stakeholder analysis was applied as a participatory social research tool to capture the interests, attitudes, and aspirations of stakeholders in enhancing wise use (conservation and management) of wetlands.

The stakeholder analysis was conducted through a meeting of 39 key stakeholders who were divided into 5 groups based on their interests. The 5 groups were the County and National Government Administration, Water providers, Environmental Groups, Fisheries, and Water Resource Users Associations (WRUAS). Each group outlined what they thought were the main challenges facing wetland conservation and management in the County and gave suggestions on causes and possible solutions to the listed challenges. Each group then presented its findings in a plenary of all the groups. All challenges presented by the groups were then listed together and classified into 7 broad challenges. The challenges were then ranked in order of importance using the pair-wise ranking technique (Thurstone, 1927).

The degradation status of the wetlands through time was assessed by examining Landsat images of 1986, 2001, and 2018. Landsat 5 (TM) was used for 1986, Landsat 7 (ETM+) was used for 2001, and Landsat 8 (OLI) for 2018. From each Landsat image, the ArcGIS was used to generate a land use and land cover (LULC) map, where various land use classes were identified. Groundtruthing was conducted to relate the image data to the real features and material on the ground. Data from the land use maps were computed for area coverage of different land use classes, including wetland cover, baresoil/built-up area, and water area. To analyze trends, Pearson's product-moment correlation coefficient was computed to compare the relationship between changes in wetland and water areas.

3. Results

Stakeholder analysis revealed that the main challenges impacting the conservation and management of wetlands in Murang'a County, ranked in order of importance (Table. 1) included weak and uncoordinated legislation, poor planning, and lack of community empowerment, scarce resources, corruption, community encroachment, and pollution, (Fig. 2). Conflicting policies on wetlands and lack of political goodwill are some of the causes for weak and uncoordinated legislation (Table 2). Such laws and policies include the Registered Land Act Cap 300 (revised 2010), the Environmental Management and Coordination Act (Wetlands, Riverbanks, Lakeshores, and Seashore Management Regulation, 2009), National Wetlands Conservation and Management Policy of 2013, National Environmental Policy of 2013 and the Sessional Paper No 3 of 2009 on National Land Policy. Other laws and policies touching on wetland management in Kenya include the Wildlife Conservation and Management Act of 2013, the Water Act (Cap 372) of 2012, the Agriculture Act (Cap 318)

of 2012, Agriculture, Fisheries and Food Authority Act (No   2012 and the Survey (Cap 299) of 2012.
13) of 2013, the National Land Commission Act (No 5) of

Table 1. Challenges ranked from the most significant to the least significant. PL- Planning; EN- Encroachment; L- Legislation; PO- Pollution; CE- Community Empowerment; SR- Scarce Resources; COR- Corruption

	PL	E	L	PO	CE	SR	COR	Frequency	Importance values (%)	Rank
PL		PL	L	PL	PL	PL	COR	4	19	2nd
E			L	E	CE	SR	COR	1	4.8	6th
L				L	L	L	L	6	28.6	1st
PO					CE	SR	COR	0	0	7th
CE						CE	CE	4	19	3rd
SR							SR	3	14.3	4th
COR								3	14.3	5th

Table 2. The table shows the challenges arranged from the most important to the least important as ranked by the stakeholders alongside their sources and possible solutions

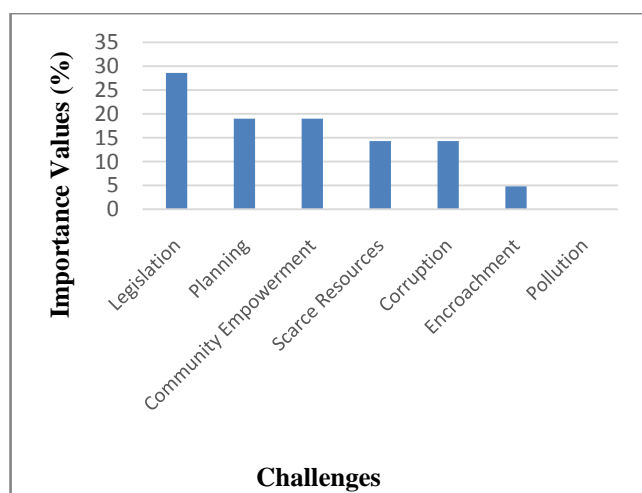| CHALLENGES	SOURCES/CAUSE	SOLUTIONS
Uncoordinated Legislation (**L**)	• National government • County government • Courts • Conflicting policies on wetlands • Lack of political goodwill	• Coordination of operations of laws • Engage all stakeholders and hold them accountable • Clear government policy on wetland protection • Elected representatives to be more responsible
Poor Planning (**PL**)	• No definite body tasked to manage wetlands • Independent development of sectoral laws • Lack of wetland management plans	• Integrated planning by all stakeholders • Development of one common law to manage all resources. • Formulate a management plan for each wetland • Adequate inventorying of wetlands
Lack of Community Empowerment (**CE**)	• Lack of involvement • Unemployment • Lack of knowledge	• Create awareness • Train and employ more personnel from the community • Capacity building • Encourage community participation in conservation
Corruption (**COR**)	• The community • National government • County government	• Heavy fines/punishment
Scarce Resources (**SR**)	• Insufficient allocation by the county and national governments • Misappropriation of the scarce funds	• Mobilization of resources • Provision of resources by both the county and national governments • Efficiency in resource use • Seek donor funding through proposals
Encroachment (**EN**)	• Poverty • Population growth • No clear demarcation of wetland areas • Hotels and other recreation facilities • Agriculture • Invasive and exotic species e.g. *Eucalyptus saligna*	• Re-demarcate all wetlands • Create income-generating programs • Implement laws and regulations • Planting of water-friendly species e.g. bamboo
Pollution (**PO**)	• Urbanization • Poor planning • Poor disposal of wastewater and solid waste • Broken sewer system	• Controlled urbanization • Proper waste management practices • Closure of carwashes along rivers and wetland

Figure 2. Main challenges affecting the conservation and management of wetlands in Murang'a County as determined using Pair-wise Ranking Technique by key wetland stakeholders from Murang'a County, Kenya

The stakeholders were of the view that these policies and laws should be amalgamated to provide a clear guideline on how wetlands should be managed in Murang'a County (Table 2). The Agriculture Act (Cap 318), for example, provides that any person who, except with the written permission of authorized officer, cultivates or destroys the soil, or cuts down any vegetation or depastures any livestock on any land lying within 2 meters of a watercourse more than 2 meters wide, with a distance equal to the width of that watercourse to a maximum of 30 meters, shall be guilty of an offense. This law only recognizes flowing watercourses and does not take into account wells and springs, which form the bulk of wetlands in Murang'a County (Fig.1). The Survey Act (Cap 299) of 2012, on the other hand, only applies to rivers on public land, and that provides a minimum of 30 meters in width above high watermark for tidal rivers only. The Act does not mention anything to do with wells, springs,

and small streams, which are ignored when land is surveyed in Murang'a County. This is the main cause for wetland loss and degradation in Murang'a County. All other laws including the Physical Planning Act of 1996, the Environmental Management and Coordination Act, and The Water Act gives various riparian measurements of 10 meters, 6 meters, and 30 meters respectively, with focus only on rivers and streams, ignoring the wells which form the bulk of their water sources. The provisions by different laws and policies create lots of confusion on the dimensions of the extent of wetland areas for appropriate management.

Another interesting finding from the stakeholder analysis was that no officer felt directly responsible for the conservation and management of wetlands. Most officers believed that the management was the responsibility of the administrative arm of the Government, who on the other hand felt this was a role of other departments. As such, wetlands lack a focused approach for their conservation and management in the County. This dilemma is again created by the various laws and provisions which touch on all areas of Government including water, environment, lands, and the administration.

Further, the stakeholders agreed that encroachment into wetlands and their eventual conversion for agriculture, urbanization, and settlement has taken place because wetlands are inadequately demarcated. Lack of community empowerment which is brought about by lack of involvement, unemployment, and lack of knowledge has led members of the public to carry out unsustainable activities such as sand harvesting, mining, and farming within wetlands. Scarcity of resources due to an insufficient allocation by both levels of government is a major hindrance to wetland management and conservation. Furthermore, misappropriation of the scarce resources through deeds of corruption by government officials has further slowed down efforts to conserve wetlands in Murang'a County.

Table 3. LULC Changes between 1986, 2001 and 2018

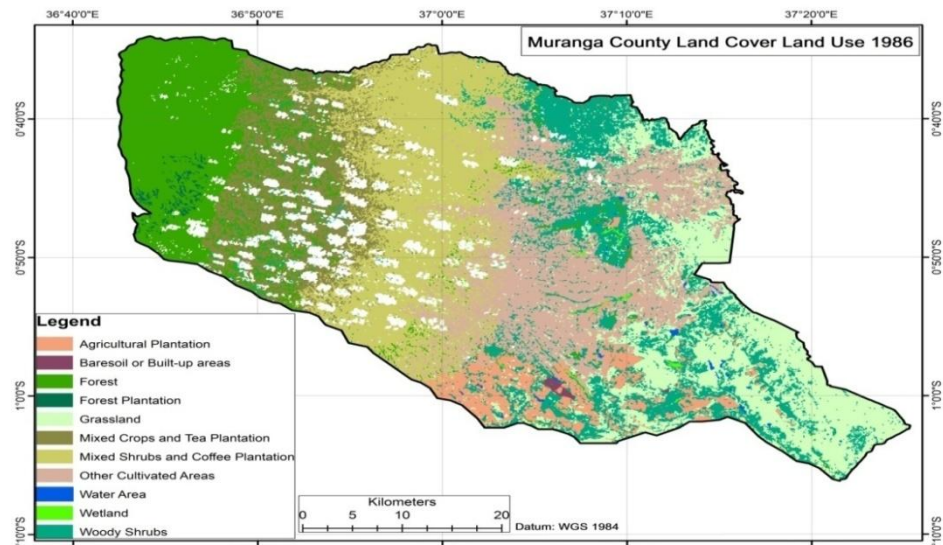| LULC	Area [ha.]			% of County Area		
	Year 1986	Year 2001	Year 2018	Year 1986	Year 2001	Year 2018
Baresoil or Built-up Area	384.48	11682.54	32100.93	0	5	13.3
Forest	38485.8	37631.16001	35267.22	16	16	14.6
Forest Plantation	987.48	0	0	0.4	0	0
Grassland	38633.76	40154.85002	31063.68	16	17	12.9
Lowland Plantation	11610.9	6691.770002	5631.03	5	3	2.3
Mixed Crop and Tea Zone	24095.16	23418.98998	24253.83	10	10	10
Mixed Shrub and Coffee Plantation	46629.72	69009.21	34641.36	19	29	14.3
Other Cultivated Areas	45365.76	44940.51	49070.79	19	19	20.3
Water Area	735.12	1411.2	1059.39	0.3	1	0.4
Wetland Vegetation	430.38	782.6400027	403.56	0.2	0.3	0.2
Woody Shrubs	34340.04	5983.830016	0	14	2	0

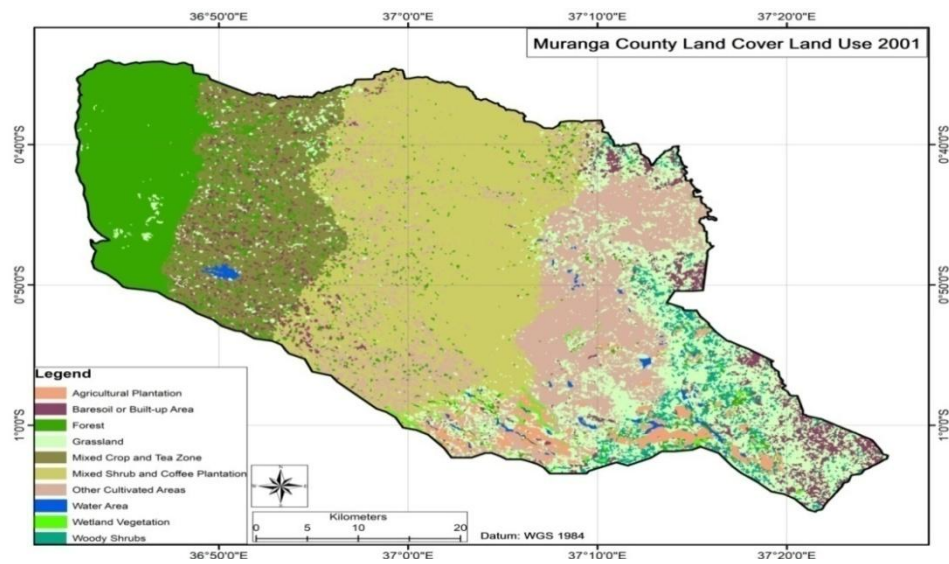**Figure 3.**   Murang'a County Land Use Land Cover Map 1986

Figure 4.   Murang'a County Land Use Land Cover Map 2001
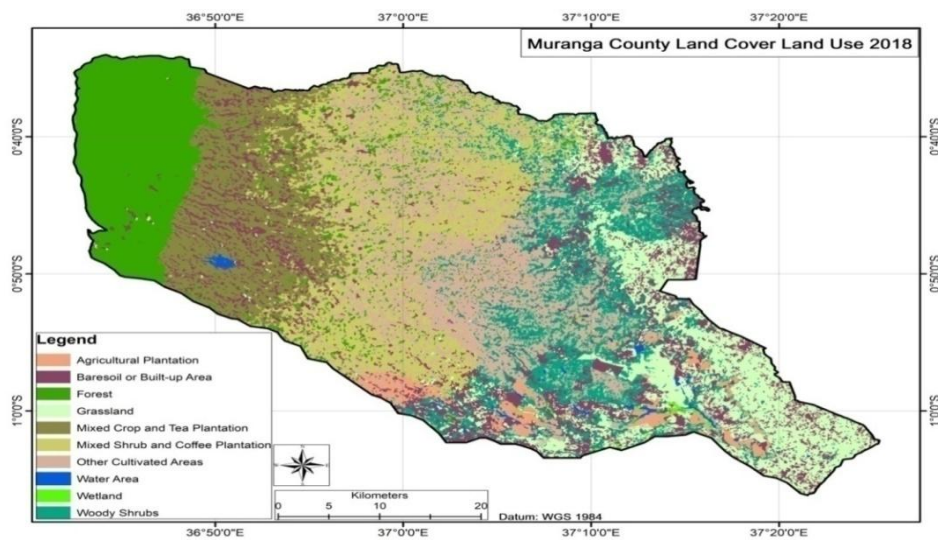

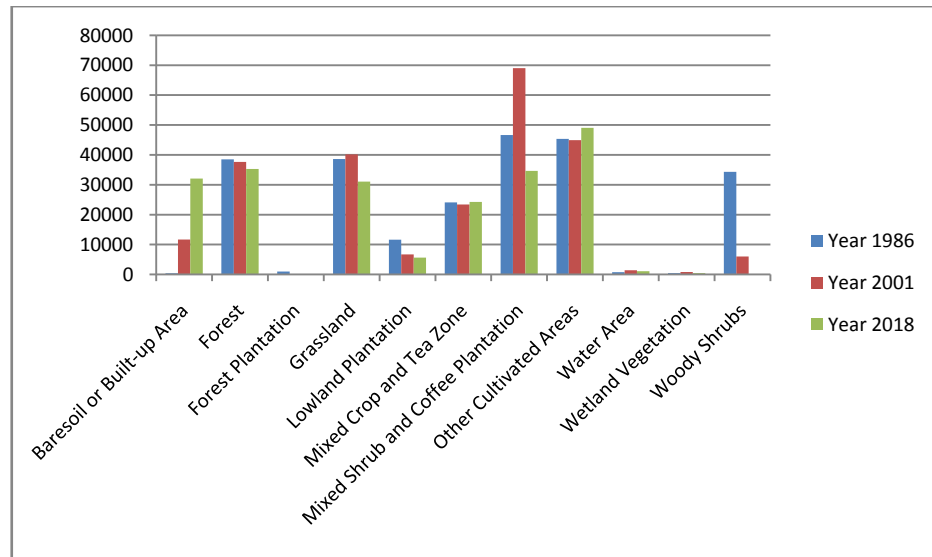**Figure 5.**   Murang'a County Land Use Land Cover Map 2018

Figure 6.   A chart showing change in LULC classes from 1986 to 2018

Analysis of land use maps for 1986, 2001, and 2018 revealed that the greatest change in land use and land cover (LULC) occurred with the built-up area, wetland, and water area (Table 3). The land use map of 1986 (Fig. 3) showed that the wetland area only covered 430.4 km^2 while the water area was 735.1 km^2. However, fifteen years later in 2001, the wetland area had increased to 782.6 km^2 and the water area to 1411.2 km^2 (Fig. 4), owing to the construction of several dams such as Ndakaini Dam and other small man-made reservoirs. Between 2001 and 2018, however, the water area in the County decreased to 1059 km^2 while the wetland area decreased by 48.4% to 403.56 km^2 owing to severe droughts and reclamation of water reservoirs (Fig. 5). Baresoil / built-up area covered 385.1 ha of the County area in 1986, 11682 ha in 2001, and 32101 ha in 2018. Other land-use systems such as forest plantations decreased to almost zero, whilst lowland plantations managed by multinational companies decreased steadily by over 42% in 2001 and 15% in 2018 due to human habitation (Fig. 6). The computation of Pearson's correlation coefficient showed a highly significant but negative correlation, r=0.99; (P<0.00), suggesting that decreasing wetland cover resulted in a significant decrease of the water areas. This indicates that as springs and wells in the County dry up, so did the water area. Groundtruthing of the area revealed that many springs and wells had dried up or decreased in size due to human encroachment for agricultural activities.

4. Discussion

Results from this study have shown that the wetland area in Murang'a County decreased by over 48% from 2001 to 2018, significantly affecting the water area in the County. This finding is in agreement with that of Davidson (2014) who reported that at least 50% of the world's wetlands have been lost since 1900. Similarly, Muema et al. (2019), while studying the status of wetlands in the Maragua watershed in Murang'a County found wetlands declining by over 58% from 1989 to 2018. Elsewhere, Kruger et al. (2015), while studying the importance of wetlands on water quality observed that wetlands retain large sediment particles, thus preventing sedimentation and siltation within a water body which would otherwise reduce its water carrying capacity. Furthermore, according to Leon et al. (2018) wetlands store floodwater during the wet season and release it to water streams during the dry season.

Stakeholder analysis showed that uncoordinated legislation, poor planning, and lack of community empowerment were the main challenges affecting the conservation and management of wetlands in Murang'a County. The issue of wetland conservation and management in Murang'a County is driven by fragmented laws and policies whose implementation mainly relies on political, sectoral, regional, or county interests. According to Joshi (2003), conflicting priorities of different stakeholders discourages sustainable resource management practices. Similarly, Mombo et al. (2011) reported that wetland conservation and management approaches in Tanzania are operated by multi-sectoral organs with diverse interests in wetlands. Wetlands in Murang'a County lack operational management plans, this encouraging encroachment for farming. Mwita et al. (2012), also found small wetlands in Kenya and Tanzania as being encroached at alarming rates owing to lack of management plans. Legal issues are critical in the conservation and management of wetlands as they determine the level of encroachment to wetlands. Materu et al. (2018), while reviewing wetland policies and legislation in Tanzania noted that targeted legislation on wetlands is critical in addressing the problem of human encroachment.

5. Conclusions

Wetlands in Kenya are managed through multi-sectoral policies and laws which have numerous conflicting interests.

It is evident from this study that the lack of specific policies and laws to govern the use of wetland resources and poor planning are the main challenges facing their conservation. As a result, local communities are rarely involved in decision-making processes, and therefore, due to lack of knowledge and awareness wetlands are drained and converted to alternative uses. Urgent interventions are necessary to amalgamate all policies and laws on wetland conservation and management to cut the tide of human encroachment. Further, there is a need to extensively bring on board local governments and communities in all decision-making processes.

ACKNOWLEDGEMENTS

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