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Land Use Dynamics and Wetland Management in Bamenda: Urban Development Policy Implications

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Abstract

Wetland ecosystems in the world have been affected by changing land uses brought about by rapid urbanization. The thrust of this study therefore is to examine the trend of land use dynamics and their implications on wetland management. Using land use maps for two periods – 1984 and 2014, aided by the administration of 75 semi-structured questionnaires, we exploited the rate of change of land uses and their effects on wetland management as well as the urban development policy implications for Bamenda. A positive relationship (0.5) was observed for land use change and wetland degradation. Furthermore, the results from land use analysis showed that between 1984 and 2014, significant changes were observed for residential land use which increased in surface area from 42% as of 1984 to 53% in 2014. In addition, agricultural land use increased from 11% to 34%. Conversely, the surface area covered by wetlands reduced from 27% in 1984 to 6% in 2014. The conclusion drawn is that in the face of further wetland degradation, the current trend of land use dynamics can be checked by the application of zoning laws to control the changes witnessed in the land uses (residential and agricultural land uses). In addition, the Bamenda City Council should promote public awareness through sensitization on wetland resources and should actively encourage the participation of the public, local government authorities and institutions in sustainably managing wetlands.

Keywords: land use, dynamics, wetland management, implications, Bamenda

1. Introduction

Very few environments exist on earth today which has not witnessed significant alterations or transformations by humanity for one reason or the other (Balgah, 2007). Land use, the way human employ the land and its resources (Balgah, 2007) continue to witness significant transformations. This occurs especially within urban centres and introduces a challenge to reconcile the often-competing demands of land to accommodate urban functions and environmental protection (UN-Habitat, 2009).

Urbanisation and land use changes in developing countries presents formidable challenges. Of particular concern are the risks of immediate and surrounding environment, its effects on natural resources, health conditions, social cohesion and on individual rights. Each year, cities attract new migrants who, together with the increasing native population, expand the number of squatter settlement and shanty towns, exaggerating the problem of urban congestion and sprawl and hampering local authorities' attempts to improve on basic infrastructures and deliver essential services (Cohen, 2006).

Wetland surface areas are estimated at 12.8 million km^2 with a global annual economic value worth US$ 70 billion (WWF 2004). This value is declining with the ever increasing human pressure on the world's wetlands and justifies the fact that since the 1900s, more than 50% of world wetlands have been lost to other uses like agriculture and/or infrastructural development. It is important to mention that one of the key drivers of wetland degradation is urbanisation which is characterised by infrastructural development.

Wetlands are among the most valuable and productive ecosystems on earth (Castaineda and Herro, 2008) which are affected by land use dynamics leading to their degradation (Tiner *et al*., 2002). Public usage of wetlands is the root cause of wetland loss. Negative views towards wetlands potentially results from misunderstanding of the value and services that they provide for the society and inadequate public policy (Xie *et al.,* 2010). This has led to their conversion to intensive agricultural, industrial and residential lands (Grillas *et al.,* 2004). It has been reported that a large percentage of wetlands have been lost in the last century apparently due to drainage and land clearance as a consequence of land use change - agriculture, urban and industrial development activities (Williams *et al* 2009).

Cameroon, like many other countries in the Inter-tropical zone, is home to a number of significant wetlands such as the Waza logone floodplain, the Limbe and Wouri estuaries, Bakassi and Rio del Rey Creeks, the Ndop plain, Bamendjim dam, Mape dam, Menchum river basin, Mboh and Santchou Floodplains and crater lakes like the lake Oku, Awing, Wum and Barombi; and in the south, they exist around the forested swamps. Bamenda is home to major wetlands such as in Ngomgham, Mulang and Menda-Nkwen. As the town continues to witness rapid multiplication of land uses due to her primacy status, wetland encroachment and degradation has been aggravated. Emerging as a city in the colonial days of the British, French and Germans from around the 19th Century, Bamenda, due to land use dynamics, has transcended from being a traditional monoculture village to becoming a complex heterogeneous city offering many services to its inhabitants as well as to its hinterlands (Nyambod, 2010). The multiplication of urban functions occurs at the expense of wetland conservation – it precipitates the colonisation of wetlands by agricultural, residential and commercial land uses, among others.

2. Problem Statement

Wetlands occupy a central position as far as the earth's natural resource base is concern – they offer numerous ecosystem services as spelt out by the 1971 Ramsar Convention (Ramsar Information Sheet 2009-2012). Land use change, a result of urban development, affects the management of wetlands. The causal mechanisms associated with land-use change remain relatively poorly understood, in part because of the complexity of urban systems. Consequently, urban planners and policy makers are often faced with the difficult task of making land-use decisions without sufficient analyses or vision (Sun *et al.* 2009).

This is the case with the town of Bamenda which is witnessing rapid urbanisation characterised by the multiplication of her major land uses – agricultural, settlement and administrative land uses. Bamenda is home to major wetlands such as in Ngomgham, Mulang and Menda-Nkwen. As the town continues to witness rapid multiplication of land uses due to her primacy status, wetland encroachment and degradation has been aggravated. In other words, this rapid pace of urbanisation in Bamenda ultimately affects its wetland ecosystem as urban development is encroaching onto the wetlands to secure space for multiple urban functions. Anthropogenic activities such as settlement, conversion of wetlands into farm land, waste dump sites reduces the ability of wetlands to build resistance and resilience leading to eventual collapse.

Previous studies on land use dynamics have focused on its connection with population growth and their effect on the environment (Kimengsi, 2011; Lambi & Balgah, 2010; Balgah *et al.*, 2008; Balgah, 2007; Balgah 2005), and land use conflicts (Kimengsi, 2009; Kimengsi, 2008). In addition, the hydro-geomorphological implications of urbanization have also been researched upon including the causes and effects of land use changes (Kometa, and Ndi, 2012). However, their implications for wetland management have received little attention. This is particularly necessary at a time when the Bamenda City Council has embarked on moves towards conserving, restoring and revitalising wetland environments in Bamenda against the backdrop of increasing land use dynamics precipitated by human activities – agriculture, settlement, commerce and waste disposal. The purpose of this study is to examine the trend of land use dynamics exploring two periods – 1984 and 2014, and their implications for wetland management. The study equally seeks to assess the rate of change of land uses and their effects on wetland management on the one hand, and the policy implications for urban development on the other hand.

3. Literature Review

Land use changes involve the transformation of diverse land use activities due to population increase and economic development constitute one of the main stressors of wetland ecosystems (Zorrilla-Miras *et al.,* 2014; Tijani *et al.*, 2011; Ripken, 2009). Added to these forces is the political interference which manifest in cases where governments contradict environmental regulations to encroach and or/watch without interference such encroachments onto wetlands. These eventually lead to the degradation and collapse of wetland ecosystems as its resilience is decreased (Ajibola, *et al.*, 2010). Land use dynamics introduces direct and indirect impacts on wetland quality. Direct impact occurs when a wetland is degraded, filled, drained or otherwise altered by activities occurring within the wetland boundary. Examples of direct impact include drainage of wetlands for agricultural use by constructing drainage ditches or installing underground drainage tiles and filling wetlands to provide useable land on which to build. Indirect impacts are caused by increase storm water and pollution generated by land development within the wetland contributing drainage area (Tiffany *et al*., 2006).

In this regard, the wise use of *Wetlands becomes imperative. The* Millennium Ecosystem Assessments (MEA's) (2005) explains that "wise use of wetlands refers to the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development. Managing wetlands properly requires adequate control of land use activities. Considerations for managing wetlands should include strategies to reduce anthropogenic stresses and those to increase resistance and resilience to climate change. As a first step towards protection, there is a need to make an inventory and classification of wetlands in terms of their physical settings (Ndenecho and Fonteh, 2012). Wetland management requires intense monitoring and increased interaction and co-operation among various agencies such as state departments concerned with the environment, soil, agriculture, forestry, urban planning and development, natural resource managers, public interest groups, citizens and research institutions. Management strategies should involve protection of wetlands by regulating inputs, using water quality standards (WQS) promulgated for wetlands and such surface waters to promote their normal functioning. Equally, monitoring restoration endeavours should include both structural and functional attributes. Monitoring of attributes at the population, community, ecosystem and landscape level is appropriate in this regard and community training (Ramachandra, 2001). In view of these, the institutional support frameworks and regulations, municipal zoning, community ownership and a change in management techniques in the face of extensive pressure from land use multiplications are imminent (Ripkens, 2009; Kometa, 2009)

4. The Study Area

Bamenda is located between latitude 5°56' and 5°58' north of the Equator and longitude 10.09° and 10.11° east of the Greenwich Meridian (Bamenda City Council, 2014). It is the capital of the North West Region with headquarters in Mezam Division. It covers a surface area of about 37,560 km^2 (Bamenda City Council, 2014). Bamenda is bounded to the west and southwest by Momo Division and Bali sub-division respectively. To the north, it is flanked by Bafut sub division, to the north east by Tubah sub division and to the south by Santa sub division. Within Bamenda, the study sites chosen include Mulang, Ngomgham, Mbelem, Menda and Ntenesoh (Figure 1).

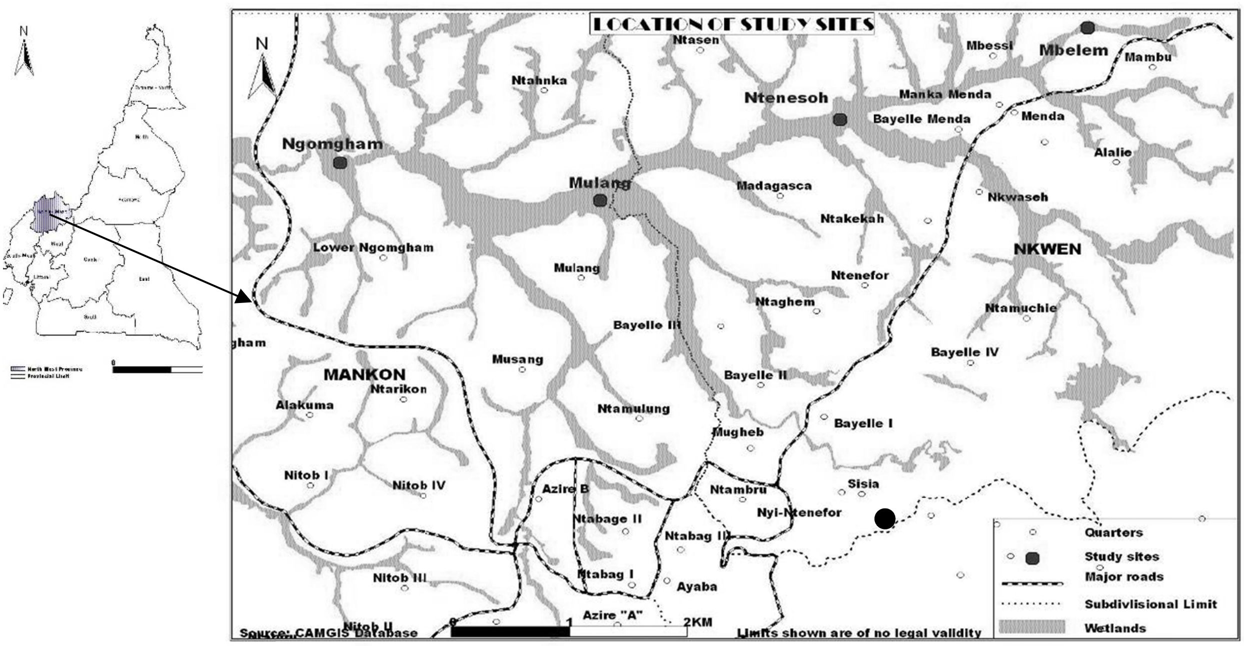

Figure 1. Location of the study sites

Sources: Adapted from CAMGIS, (2013)

5. Materials and Methods

Five targeted sites were identified for the study, they include, Mulang, Ngomgham, Mbelem, Menda and Ntenesoh.

Table 1. Description of the study sites

Zone	Site	Site Description
Mulang	A	This is the most extensive wetland area in Bamenda. This area is experiencing gradual human encroachment. It is covered by savannah vegetation and raffia palms.
Ntenesoh	B	This area is characterised by intensive wetland agriculture. Observable vegetation species here is the raffia palm. This area is also highly settled.
Ngomgham	C	This area is also highly settled and there is equally the practice of urban agriculture.
Mbelem	D	This area is highly encroached mainly by filling of wetlands with soil for housing construction.
Menda	E	This area is characterized by the practice of urban agriculture.

Source: Field work, 2015

These sites were chosen because they were judged to have extensive wetlands whose management is affected by changing land uses. The target population of these areas is estimated at about 2000 inhabitants. From this target population, a 5% sample was drawn involving 100 inhabitants. There was bias in the distribution of the questionnaires as Mulang and Ngomgham which were characterised by intense land use activities on wetlands received 30 questionnaires each while Menda, Ntenesoh and Mbelem received 15, 15 and 10 questionnaires respectively. Random sampling was employed in the distribution of the questionnaires. The targeted respondents consisted of land use actors (agriculturalists, real estate operators, council officers and government representatives). In addition, interviews with municipal and planning authorities, farmers as well as quarter heads were conducted. Data on population evolution for Bamenda between 1976 and 2014 were obtained from the Bamenda City Council including estimates from the quarter heads of the five targeted neighbourhoods.

To determine changes in land uses and wetland degradation, Remotely sensed data (optical multispectral images) was used in the classification of the study area is from Landsat (MSS, TM and ETM+) sensors (Table 2). The data for multispectral images ranged from visible (VIS; 0.45 – 0.9 µm), near-infrared (NIR; 0.76 – 0.98 µm), mid-infrared/short wave infrared (MIR/SWIR; 1.55 – 2.35 µm) to thermal infrared (TIR; 10.4 – 12.5). These images were obtained from the Global Land Cover Facility (GLCF, 2005). These images were processed using Geographic Information System (GIS) and Remote Sensing (RS) softwares.

Table 2. Satellite data acquired, uses and their applications

Sensor	Year	Date of each scene	Operational	Applications
Landsat MSS	1975	1975-06-06	1972 – 1984	Supervised classification to discriminate between settlement and other features.
Landsat TM	1986	1986-01-10	1972–present	Supervised classification to discriminate between settlement and other features.
Landsat ETM+	2000 2002	2000-06-01 2002-01-30	1999–present	Supervised classification to discriminate between settlement and other features

In analysing the optical multispectral images presented in Table 2, different stages were involved based on the feature of interest. These images were acquired already geo-referenced in the WGS84 ellipsoid in UTM32N with the exception of Landsat ETM+ 2002. This image was geo-referenced in ENVI using the Landsat ETM+ 2000 image as reference following the option of image-to-image registration since they came from the same sensor. After geo-referencing, since these images came in separate bands for a single year, these bands were stacked together to give them the same spatial sizes that facilitated false colour composite combinations and other analysis. Two types of false colour composites were made using a combination of bands (321 and 742) to be able to clearly discriminate between settlement and the other observed features on these images. For the Landsat TM and ETM+ spectral bands, bands 1-3 provide increased penetration of water bodies and correspond to the reflectance of green vegetation (Biradar et al., 2003). Band 3 however exhibit more contrast than bands 1 and 2 because the effect of the atmosphere is reduced here (Biradar et al., 2003). Band 4 is also responsive to the amount of vegetation biomass present in a scene and useful for identification of vegetation types, emphasizing soil-crop and land-water contrasts. Band 5 on its part helps to reduce the effect of thin clouds and smoke while band 7 is particularly effective in identifying zones of hydrothermal alteration in rocks because of its increased wavelength (2.08-2.35 µm; Biradar et al., 2003).

Band 321 was used to better observe road infrastructure and other less detailed features. Band 742 of Landsat was used for vegetation analysis. Further image analyses carried out using ENVI included change detection, supervised and unsupervised classification. Results from the supervised classification were the ones represented in the study to show land use dynamics over the years. After classification, these images were saved in geotiff format and imported to ArcGIS where the maps were produced in the final form presented in this thesis. A limiting factor common in all the images used in the classification process is the presence of cloud cover. In cases where this cloud covered settlement, these areas were also classified as settlement. It is impossible to remove these clouds from the images, thus making classification in the tropics very difficult. A general limitation to Landsat images is the fact that they are acquired at intervals of 16 days at best. This time lag between image acquisition and the availability to users, which normally takes from 1-14 days and the high cost incurred in case of on-request data over specific target areas, prevent true real-time monitoring of settlement changes. The land use and land cover maps for 1984 and 2014 were developed by CAMGIS. Also supported by the data from the questionnaires, change maps were used to evaluate the percentage change of land uses between 1984 and 2014 (Appendix I). They were further compared to show the degree of changing land uses and consequent wetland encroachment. A total of 75 semi-structured questionnaires were administered to obtain respondents opinion on the driving forces of land use change and their effects on wetlands. The data was analysed using the Stata 11.1 Statistical Package in which a correlation was established between land use change and wetland degradation in Bamenda. The correlation analysis was done in which the variables of land use change were correlated with those of wetland degradation at 1% and 5% levels of significance (Appendix II).

6. Results and Discussion

Land use dynamics in Bamenda

The land use situation of the Bamenda municipality in 1984 (Figure 2) showed that residential (42%) and forest (19%) land uses were the most dominant (Figure 3a).

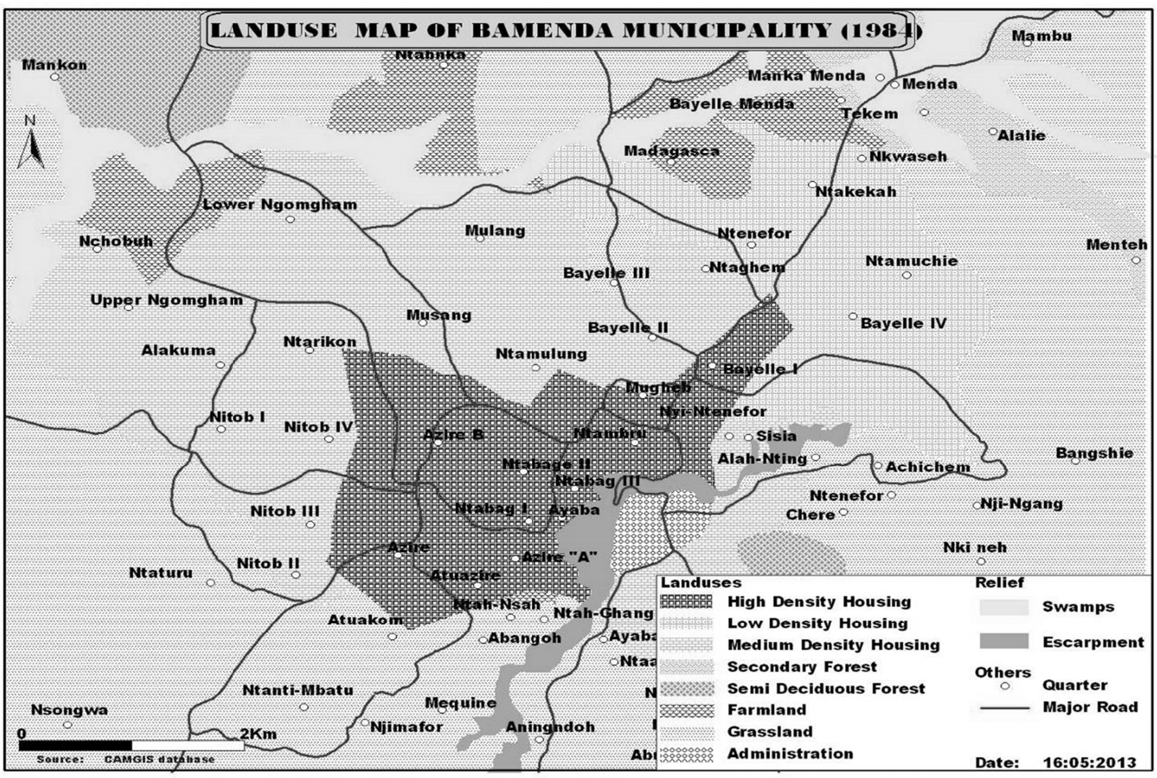

Figure 2. land use of the Bamenda municipality in 1984

During this period, wetlands occupied 27% of the total land use surface area in Bamenda. As a regional headquarter, Bamenda was exposed to significant land use transformation which was brought about by the influx of migrants to work there.

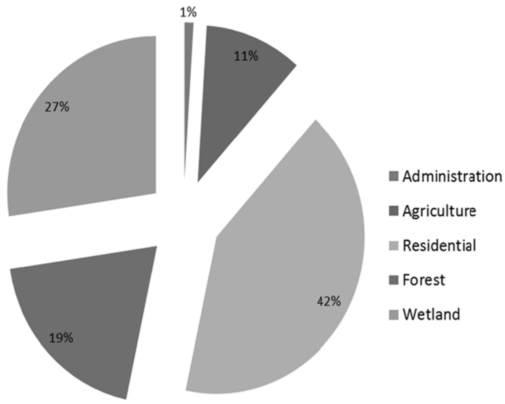

Figure 3a. Proportion of land uses in 1984

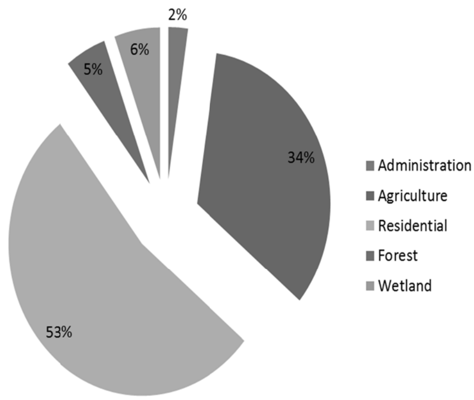

Figure 3b. Proportion of land uses in 2014

By 2014, significant changes were observed for the major land uses – residential land use moved from 42% and now occupies 53% of the total land use area (Fig 3b). This is followed by agricultural land use which occupies 34%. Conversely the surface area covered by wetlands reduced from 27% in 1984 to 6% in 2014. It is evident that residential and agricultural land uses have encroached and converted these wetlands (Figure 4 & Appendix I). Such changes signal the colonisation of wetland environments.

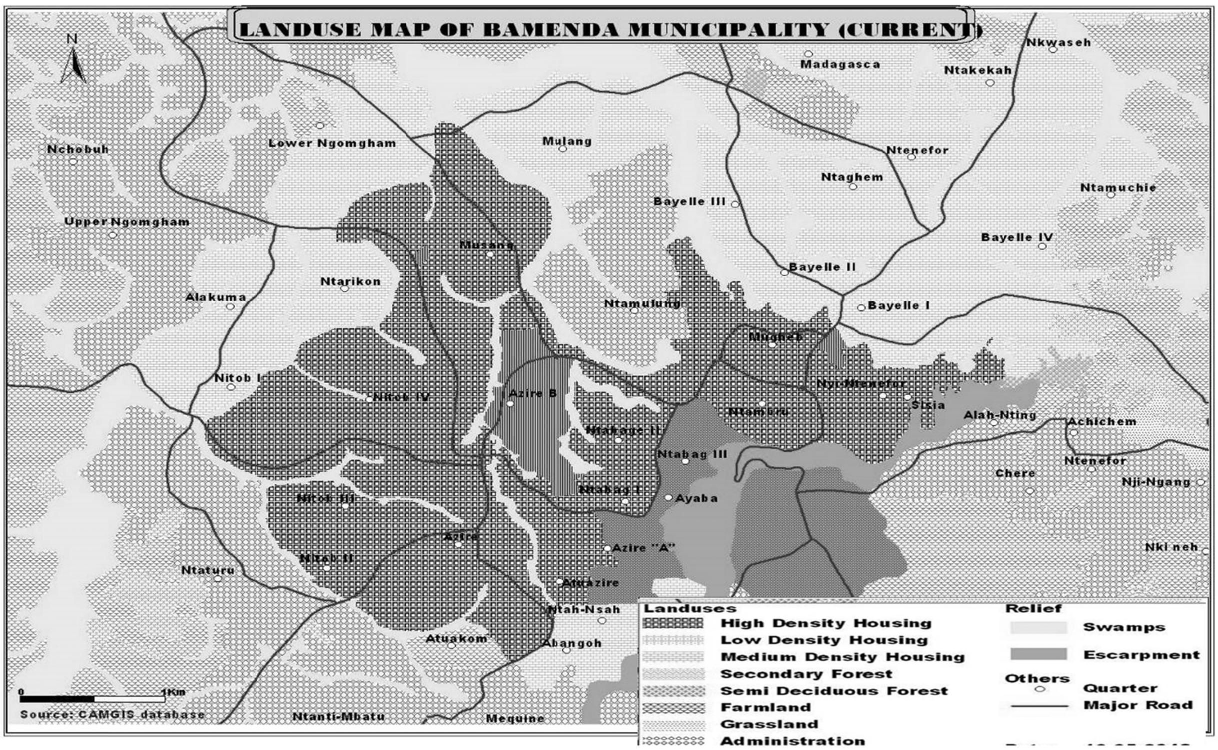

Figure 4. Land use situation of Bamenda municipality (2014)

The key driving force of land use dynamics and wetland degradation in Bamenda is population growth (Figure 5). Such demographic growth has resulted to a change in land uses.

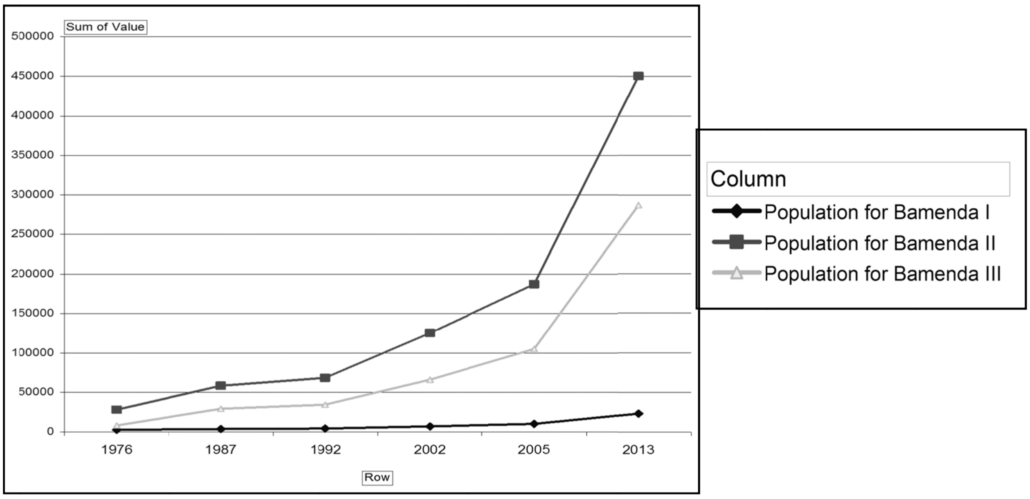

Figure 5. Population growth in Bamenda (Bamenda City Council, 2014)

Population increase has been accompanied by an increase in land speculation resulting to an increase in land value around the city. This has pushed many people to acquire cheap and marginal lands - wetlands. The quest for land from the wetlands is as a result of the necessity to build more houses to accommodate the fast increasing population. In the process of construction, the wetland ecosystem is destroyed through the cutting of trees and the killing of the habitats of some wetlands. Thereafter, the area is drained and backfilled with ground for buildings to be erected. Still in the same way with the rapid growing population these wetlands are over exploited for farmlands and other beneficial activities. Deforestation and wetland exposure (26.3%), increase in construction of houses (25%), drainage and backfilling (17.5%), over exploitation of wetlands (16.3%) and dumping of household waste (15%) were the key forces operating through land use change to cause wetland degradation as revealed from the questionnaires (Table 3).

Table 3. Activities that degrade the wetland ecosystem

	Causes of wetland degradation					
Locality	Increase in housing construction	Dumping of household waste	Over exploitation of wetlands	Drainage and filling	Deforestation and exposure of wetlands	**Total**
Ngomgham	3.8%	6.3%	1.3%	2.5%	3.8%	17.5%
Mulang	6.3%	3.8%	3.8%	5.0%	6.3%	25.0%
Mbelem	8.8%	5.0%	8.8%	5.0%	10.0%	37.5%
Ntenesoh	6.3%		2.5%	5.0%	6.3%	20.0%
Total	25.0%	15.0%	16.3%	17.5%	26.3%	100.0%

Source: Field work, 2015

Mbelem is the most degraded with a degradation rate of 37.5%, closely followed by Mulang with a degradation rate of 25.0%, Ntenesoh with a rate of 20.0% and finally Ngomgham with a degradation rate of 17.5%. Using the Stata 11.1 Statistical Package, a correlation was established between land use change and wetland degradation in Bamenda. The correlation analysis was done in which land use change (mainly agricultural and residential) was correlated with those of wetland degradation (reduction in size of wetlands, waste disposal and drainage and filling of wetlands) at 1% and 5% levels of significance. The correlation results showed a positive relationship between land use dynamics and wetland exploitation and degradation (Appendix II).

Previous studies on land use dynamics and wetland degradation observed agricultural and settlement expansion as the key factors influencing wetland conversion and subsequent degradation (Zorrilla-Miras *et al.,* 2014; Dahl & Johnson 1991; Dahl, 1993). Liu *et al* (2004) observed a similar situation for the Small Sanjiang Plain (SSP) which was formerly the largest wetland complex in China, located in the Northeastern part of Heilongjiang Province, China. Between 1950 and 2000, significant changes were observed for this wetland environment which was largely attributed to human activities. This led to a rapid decline in waterfowl and plant species with the loss and fragmentation of natural wetlands and wetland ecosystem degradation; greater variation in wetland water levels as the result of land-use changes over the years; and a decrease in floodplain area that caused increased flooding peak flows and runoff. In addition, Nyamasyol and Kihima (2014) observed that in Kenya, land use changes over the past three decades characterized by a noticeable increase in the size of farmland, settlement, and other lands and a decline in forestland, grassland, wetland, and woodland have affected the Kimana Wetland ecosystems. Murungweni (2013) using GIS equally observed a decline in the quality of urban wetlands in the Monavale Wetland in Harare.

7. Conclusion and Recommendations

Wetlands in Bamenda provide varied functions and services to the inhabitants ranging from flood control, provision of wetland products, wetland agriculture, habitat for wetland species, natural filter and reserve lands for vegetation. Due to rapid urbanisation these wetlands have been affected through reclamation, deforestation and exposure of wetlands, use of wetlands as dump sites and over exploitation of wetlands.

Between 1984 and 2014, significant changes were observed on land uses in Bamenda wherein residential land use increased from 42% in 1984 to 53%, and from 11% to 34% for agricultural land use. The surface area covered by wetlands reduced from 27% in 1984 to 6% in 2014. Population increase, coupled with an increase in land speculation result to an increase in land value around the city. This has pushed many people to acquire cheap and marginal lands - wetlands.

Based on the above observations, the following recommendations are suggested:

The Bamenda City Council should map out risk zones as well as structure the urban space into various functions with wetlands serving as protected area and green spaces. Penalties should be levied on people who go against this zonation by encroaching into wetlands. Efforts by the city council to discourage encroachment needs to be complemented by other stakeholders involved in environmental management. In addition, there is a need to integrate wetland management in the urban planning strategy of Bamenda. Urban planning in Bamenda should consider wetland environments as natural conservation sites, landscape planning and water resource management.

Given the current trend of land use change and its effects on wetlands, urban development policy should consider the proper zonation to ensure that the multiplication of land uses is contained. The current trend of land use dynamics can be checked by the application of zoning laws which control the changes witnessed in the main land uses (residential and agricultural land uses).

The wetland environments should be carved out and effectively declared as non-encroachment areas. The ecosystem services of these wetlands should be promoted. In addition, the Bamenda City Council should promote public awareness and understanding of wetland resources and actively encourage participation of the public, local government authorities and institutions in sustainable wetland management. This can be achieved by disseminating awareness on the importance of wetlands through leaflets, posters, radio, television and other media as well as periodically monitoring public responds or view on the need to conserve wetlands.

The city council should attempt to value the wetlands by indicating the cost of wetland degradation and the benefits of wetland conservation.

The city council should train extension staff of relevant ministries at District level to equip them with knowledge and skills to facilitate their supervisory role. They should also establish a mechanism and develop capacity for carrying out Environment Impact Assessment on proposed wetland development projects.

Since wetlands are a multi-sectoral resource, there is need to create and establish an appropriate institutional arrangement for their management. Although there are sectoral laws that refer to some aspects of wetlands such as water, or land or prevention of pollution, there is no comprehensive law for management of wetlands as an ecological entity. This can be realised by enacting a national law for regulating the management of wetland resources and encourage local authorities to make bye-laws for the proper management of wetlands.

The Bamenda City Council should establish fully "Protected Wetland Areas" of important biological diversity. No modification, drainage or other impacts will be entertained for the so-protected wetlands. The restoration program should involve all aspects of the ecosystems, including habitat restoration, elimination of undesirable species, and restoration of native species from the ecosystem perspective with holistic approach designed at watershed level.

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Appendix I. Land use and surface area for Bamenda (1984 & 2014)

Domain	**1984 Surface area (M^2)**	**Surface area (M^2) 2014**	**% change**
Administration	511270.7	1822113	256.39
Farmland (Agriculture)	5566952	25988842	366.84
Residential (High density)	591832	6420252	90.78
Residential (Low density)	6150645	8054526	30.95
Residential (Medium density)	15158850	26793169	67.75
Forest	10135329	3827929	-164.77
Wetland	14350072	4275093	-235.67

Source: CAMGIS 2014

Appendix II. Correlation results on land use change and wetland degradation in Bamenda

	Dependent Variables		
	Wetland reduction	Waste disposal	Drainage & filling
Independent Variables	Coefficient	Coefficient	Coefficient
Agriculture	0.6*	0.4*	0.5**
Residential	-0.66**	0.3*	0.6**
Observations			

* significant at 1%; ** significant at 5%

Source: Analysis of questionnaire using Stata 11.1 Package