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ASSESSING THE CHANGE OF LAND USE AND LAND COVER IN THE GAMBIA

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Abstract:
Biological annihilation has been influenced by human activities and this has led to changes in land use and land cover, pressure on the ecosystem, biodiversity loss and contribution to global warming. This study assesses the changes in land use and land cover in The Gambia. Satellite images for the period from 2015 to 2019 from Copernicus were obtained and used for the study. ArcGIS Software and Microsoft packages were used for data analysis. Change analysis showed that between the years 2015 to 2019, there was a percentage increase for water bodies, herbaceous wetlands and built-up areas with 23.68%, 8.97% and 0.5% respectively. There was a percentage decline in forest, shrubland, herbaceous vegetation, bare/sparse land and cropland during this period. About 7.86 Km^2 of Gambia became bare/sparse land as a result of climate change.

Keywords: land use, land cover, satellite images, herbaceous wetland, herbaceous vegetation

1. Introduction

The face of the earth over the century has been altered by human beings through population growth, the introduction of machines, and natural and agricultural resource development. The land is a very important resource for the development and survival of humans. Land resources help humans meet their material, spiritual, social and cultural needs. Land provides shelter, food and many goods and services. Forest lands and wetlands are converted for agriculture, urban and industrial activities and infrastructures like roads, airports, dams, mining and so on. The activities of humans have led to vegetation cover loss. Vegetation cover loss further leads to many environmental problems like: air pollution, global warming, biodiversity loss, climate change, desertification, land degradation and changes in hydrological regimes.

Land use and land cover changes occur due to human and natural activities. Land cover (LC) of the earth in the last three centuries has changed drastically. Land cover

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refers to the biological and physical cover over the surface of land which includes: vegetation, bare soil, water and or artificial structures (Ellis, 2007). Land cover can be defined as the description of the physical material at the surface of the Earth or the actual surface cover for a given location. Examples of land cover include: trees, grass, asphalt, soil and water. Land cover is determined by analyzing satellite and aerial imagery. Land use involves the decisions humans employed in the management of land. The purpose land serves varies with the usage of land by humans. Lands are mostly used for the basic necessity of life like: food production, recreation, provision of shelter, mineral extraction, construction and processing of materials.

Land use and land cover changes are safe to extrapolate the rate of changes in spatial extents. Land use and land cover changes are influenced by natural and human activities. Briassoulis (2009) explained that several theories have been made to explain these changes. Land use change occurs at the level of the individual human who decides to change to another land use that is desirable or profitable to him. Land managers' decisions are based on their personal traits and local environmental conditions as well as by the broader environmental, socio-economic, political and institutional settings within which the land unit is buried. The decisions of individual land managers are influenced by organizational decisions at higher levels considering biophysical and societal factors. Local weather conditions affect both regional and global climate and this determines regional soil and ecosystem types. Geographical Information System (GIS) is an important tool which is used for calculating land use and land cover rate change.

Remote sensing is one method of assessing land use and land cover changes. Remote sensing is an important tool of science in land change. It facilitates observations across larger Earth's surface extents than is possible by ground-based observations. It is the measurement of electromagnetic energy as it reflects on the surface of the land through sensors that use images as information. GIS interprets information on natural and anthropogenic-induced resources in spatial domains and this enables the proper planning and execution of policies. Remote sensing data have long been used for deriving land cover maps since it was launched as the first Landsat platform in 1972. Aerial photography is as a primary source of information on the land cover before the availability of satellite imagery and it is a very important source of land cover information till now (Akbari Menon and Rosenfeld, 2003). Land cover maps provide information which helps managers understand the past and current landscape, and make policies for future landscapes.

1.1 Land Use and Land Cover Changes

Initial studies on land use and land cover change focused on the physical aspect of the change but a paradigm shifts to global environmental change that is from simplicity to realism and complexity over the decades. Otterman (1974) recognized that land cover changes modify surface albedo and surface atmosphere which further have an impact on regional climate. It was noticed that worldwide biodiversity impact, soil degradation and the ability of biological systems to support human needs from the impacts of land use and cover change on the ecosystem, goods and services.

Human communities and ecosystems will be influenced by the interaction of land use and land cover with climate changes in future. Climate will also influence how and where humans live (land cover) and how land is to be put to use. Increasing population will affect land use and land cover. Areas with high population density would have small land since forests and grass lands have been converted for urban development. Land use and land cover changes affect local, regional, and global climate processes. They play critical roles in the interaction between the land and the atmosphere, influencing climate at local, regional, and global scales. The following is growing evidence that land use, land cover, and land management affect the U.S. climate in several ways: changes in air temperature and near surface moisture in areas where primary forests are converted for agriculture; rain-fed cropland is converted for irrigated agriculture which intensifies the impacts of agriculture on temperature; global atmospheric concentrations of greenhouse gases are been affected by land use and land cover changes; urbanization and industrialization have impacts on weather and climate and both observational and modeling studies showed that introduction of irrigated agriculture can alter precipitation on a regional scale.

2. Material and Methods

2.1 The Study Area

The Gambia is located in the western part of Africa at a latitude of 13.28^0N, 16.34^0W and longitude of 13.467^0N, 16.567^0W. It is the smallest non-island country in Africa with a total area of 11,295 km^2. The size of the land is 10,000 km^2 while the water is 1,295 km^2. It is bounded in the west by the Atlantic Ocean and it is bounded north, south and east by Senegal. It has many beaches along its small Atlantic coastline and it is characterized by a long narrow strip of land that surrounds the Gambia River. The Gambia River is the dominant feature which flows across a plateau of Miocene-Pliocene stone consisting of compacted quartz grains formed from about 23.7 to 1.6 million years ago. Narrow valleys are separated by flattish hills or broad interfluves in the east while in the west, the smaller and lower sand hills alternate with sand depressions to form a flat plain.

The Gambia has a hot and tropical climate characterized by a rainy season occurring between June to November and a dry season occurring from November to May. The average annual rainfall is 1,300 mm with a mean monthly temperature of the upper 70s F (mid-20s C) and the low 80s F (upper 20s C). The high relative humidity drops from December to April, during the dry northeastern wind called harmattan.

The vegetation cover of The Gambia is savanna on the uplands, a different inland swamp in the low-lying areas, and mangrove swamps alongside the brackish lower Gambia River. Few wild animals are found in the region, and there have been threatened by human and domestic animal populations. Monkeys, warthogs, baboons, antelope, pygmy, hippopotamuses and crocodiles are found in the middle and Upper River areas. More than 500 species of birds are found across the country. Fish, clay, silica, sand, titanium, tin and zircon are the natural resources common in the Gambia. There are

current issues of deforestation, desertification, drought and the prevalence of waterborne diseases.

English is the most frequently spoken language followed by Madinka, Wolof, Pulaar, Serer, Diola and Soninke. Ninety percent are Muslims and there is small number of Catholics, Christians and some traditional worshippers.

2.2 Sampling Techniques

Copernicus Global Land Service (CGLS) was the satellite imagery used. CGLS data at 100 m spatial resolution (CGLS-LC100) were selected and used to find the spatial and temporal changes for the study area from the year 2015 to 2019. CGLS imagery was preferred used for the study because it had the closest resolution to earth observation as compared to other satellite imageries for the period of study and from 1st January 2013, CGLS provided a series of bio-geophysical products describing the status and evolution of land surface at a global scale, for example, Leaf Area Index (LAI), Land Surface Temperature (LST), the soil moisture, the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) and other vegetation indices are gotten on an hourly to 10 days interval from satellite data of Earth Observation. CGLS delivers annual dynamic global land cover products at 100 m spatial resolution (CGLS-LC100). Land cover is important in the biogeochemistry and climate of the Earth system.

Land cover was classified into forests, herbaceous vegetation, herbaceous wetland, bare/ sparse vegetation, cropland, built-up and permanent water bodies for the study area. The land cover classes are displayed with colour, pattern, size, shape and texture on the maps and also, are presented in Table 1. Forests were made up of forest plantation, degraded/open forest. Shrubland included areas with different shrubs and bushes. Herbaceous vegetation areas are areas with flat lands where various food crops are grown either in irrigation or water bodies. Herbaceous wetlands are lands located near plains with frequent flooding and immersed in water and grasses. Most rice and millet farms are found here. Herbaceous vegetation includes farmlands, grazing areas and food crop areas. Bare/sparse lands are areas without vegetation cover during the time of satellite image acquisition but some crops and trees like mango, cashew, orange, flowers and fruits are grown near homes. Cropland had areas with crop land, plantation and fallow/harvested land. There have various food crops grown on them. Built-up areas are areas made of urban/rural settlement.

2.3 Data Collection

Secondary data from CGLS was used for this study. The different land use and land cover classes were identified and data was acquired from 2015 to 2019 on March 25, 2022. The satellite imageries were processed with ArcGIS with post-classification processing method and Land use and land cover change detection technique and analyzed with multi-temporal images.

3. Data Presentation and Analysis

Remote sensing images for land use and land cover changes for Gambia for 2015 and 2019 are shown in Figures 1 and 2 respectively.

Land cover changes for Gambia were analyzed with remote sensing and GIS and it showed that there was a decrease in deforestation, shrubland, herbaceous vegetation, bare or sparse land and crop land from the year 2015 to 2019 while there was an increase in herbaceous wetland, built up areas and permanent water bodies (see Table 2).

From the 2015 image and Table 2, cropland accounts for 36.76 per cent of Gambia which is an area of 3,819.80 Km^2 and it is followed by forest with 28.06 per cent and an area of 2,916.26 Km^2. Shrubland has an area of 2,027.34 Km^2 with 19.51per cent which is followed by herbaceous wetland with 8.21 per cent and an area of 852.96 Km^2 then it is followed by 4.49 per cent of herbaceous vegetation with an area of 466.38 Km^2. Bare/sparse land and permanent water bodies have a percentage of less than 1% with areas of 33.71 Km^2 and 11.24 Km^2 respectively.

From 2016 and from Table 2, cropland accounts for 36.63 per cent with an area of 3,806.31 Km^2 and it is followed by forest with 27.57 per cent and an area of 2,864.70 Km^2. Shrubland has an area of 2,001.49 Km^2 with 19.26per cent which is followed by herbaceous wetland with 9.33 per cent and an area of 969.84 Km^2 then it is followed by 4.24 per cent of herbaceous vegetation with an area of 440.53 Km^2. Bare/sparse land and permanent water bodies have a percentage of less than 1% with areas of 28.1 Km^2 and 15.73 Km^2 respectively.

In 2017, Table 2 shows that cropland accounts for 36.57 per cent with an area of 3,800.69 Km^2 and it is followed by forest with 27.53 per cent and an area of 2,860.70 Km^2. Shrubland has an area of 1,995.87 Km^2 with 19.21 per cent which is followed by herbaceous wetland with 9.51 per cent and an area of 987.82 Km^2 then it is followed by 4.20 per cent of herbaceous vegetation with an area of 436.3 Km^2. Bare/sparse land and permanent water bodies have a percentage of less than 1% with areas of 26.97 Km^2 and 17.98 Km^2 respectively.

From the 2018 image and Table 2, cropland accounts for 36.53 per cent with an area of 3796.20 Km^2 and it is followed by forest with 27.41 per cent and an area of 2,847.71 Km^2. Shrubland has an area of 1,989.13 Km^2 with 19.14per cent which is followed by herbaceous wetland with 9.83 per cent and an area of 1,021.53 Km^2 then it is followed by 4.09 per cent of herbaceous vegetation with an area of 424.8 Km^2. Bare/sparse land and permanent water bodies have a percentage of less than 1% with areas of 25.85 Km^2 and 19.1 Km^2 respectively.

Table 2 shows cropland had the largest land use in 2019. The data is presented as follows: cropland accounts for 36.47 per cent with an area of 3,790.58 Km; forest accounts for 27.33 per cent with an area of 2,839.84 Km^2; shrubland accounts for 19.11 per cent with an area of 1985.75 Km^2; herbaceous wetland accounts for 10 per cent with an area of 1,039.52 Km^2; herbaceous vegetation accounts for 4.04 per cent with an area of 420.3 Km^2; bare/sparse land accounts for 0.25 per cent with an area of 25.85 Km^2, and permanent water bodies account for 0.21 per cent with an area of 21.35 Km^2.

3.1 Land Use Land Cover Change Analysis

The area changes from the two-land use and land cover maps are summarized in Table 3. Percentage change has been provided.

Table 3 shows that forest, shrub land, herbaceous vegetation, bare/ sparse land and crop land had losses of 76.42 Km^2, 41.59 Km^2, 46.08 Km^2, 7.86 Km^2 and 29.22 Km^2 respectively. Herbaceous wetlands, built-up areas and water bodies had increased by 186.56 Km^2, 2.65 Km^2 and 10.11 Km^2 respectively. The size of the forest was 2,916.26 Km^2 but it reduced to 2,839.84 Km^2. Herbaceous vegetation had top second losses from 466.38 Km^2 to 420.30 Km^2 which was followed by shrub land with losses from 2,027.34 Km^2 to 1,985.75 Km^2. Cropland reduced from 3,819.80 Km^2 to 3,790.58 Km^2. The presence of the Ocean and its coast increased water movement into Gambia with herbaceous wetlands increasing from 852.96 Km^2 to 1,039.52 Km^2 and water bodies also increased from increased from 11.24 Km^2 to 21.35 Km^2.

4. Results and Discussion

The result showed that negative changes occurred in the forest, vegetations, and bare/sparse land in the Gambia for the period of 2015 to 2019. Agricultural land comprises of forests, crop Land, shrub land, herbaceous vegetation, herbaceous wetland and bare/ sparse land. Apart from herbaceous wetlands, other agricultural land decreased in size from 89.72% in 2015 to 89.89% in 2019. The decrease in the size of agricultural lands was due to an increase in agricultural activities, conversion of forests for agriculture and built-up areas which were induced by the increase in population. This finding agreed with Sathees and Nisha (2010) that areas of agriculture decreased and settlement areas increased due to population growth.

Deforestation has been a major problem in the World. Figure 3 shows a slight decrease in forest areas from 2015 to 2019. The percentage decrease of forest for the four-year period is 1.35% and it is relatively slow as compared to findings by Senrit and Wongsai (2012) that forest decreased approximately by 20% while from the year 1999 to 2002 it decreased by 15%. It was due to increased agricultural; development (50.48%), conversion to farmlands, climate change affecting plants and increase in size of bare/ sparse land. Forest covers were converted to oil palm and rubber plantations. Population growth has led to an increase in the use of forest resources leading to deforestation for agricultural production and urban growth.

5. Recommendations

The following are recommendations for this study:

1. There is a need for Afforestation. Ministry of Agriculture and Non-Governmental Organizations (NGOs) on Afforestation in Gambia should intensify efforts in afforestation. There is a need to raise nurseries for planting trees.
2. The government of Gambia should introduce irrigation farming in areas of bare/sparse land and shrubland. This will boost more agricultural production.

Water should be made available for small gardens as this will improve the living standard of the people.

3. Government should enforce forestry protection laws. This will help in protecting the biodiversity in the forest.

6. Conclusion

Gambia is a country in West Africa which falls under the savannah region. The area has forests which have been degraded, land use and land cover has changed over a period of time and climate change is a problem. This research assessed land use and land cover changes in The Gambia and it aimed at identifying and calculating the land use and land cover changes between 2015 and 2019. Remote sensing from Copernicus was used as secondary data for the study. Herbaceous wetlands, built-up areas and water bodies had an increase in size between 2015 and 2019 but other land use and land cover classification had a decline in size over the period.

Results from remote sensing for the study showed that cropland is the land use and land cover classification across Gambia with a percentage of 33.99 in 2015 but declined to 33.73 per cent in 2019. This decline had a percentage change of -0.39%. The land mass for cropland was 3,819.80 Km^2 and it declined to 3,790.58 Km^2 in 2019. Increased farming activities in the rural areas and migration of farmers from Sahelian countries into Gambia due to climate change were responsible for the increase in crop land.

Forest areas have been encroached on in Gambia due to farming, urbanization and hunting. Remote sensing analysis showed that a total of 2,916.24 Km^2 of forest in 2015 was reduced by -1.35% to 2,839.84 Km^2 in 2019. Forested area had a percentage of 25.95% and it was depleted to 25.27% in 2019. Climate change is affecting the existence of the forest. There is reduced rainfall and high temperature over this period.

The vegetative areas in the study were divided into three namely: shrub land, herbaceous wetland and herbaceous vegetation. These make up 29.78% of the land mass of the study area in 2015 but increased to 30.67% in 2019 due to increased agricultural activities, migrants from Wulof speaking tribe in Senegal into Gambia and the favorable climate in near the river line areas of Bondali district. Remote sensing showed that shrub land had a cover of 18.04 % which reduced to 17.67%, with a negative percentage of 1.05, herbaceous wetland increased by 8.97 % from 852.96 Km^2 in 2015 to 1,039.52 Km^2 in 2019, and herbaceous vegetation reduced by -1.05% from 466.38 Km^2 in 2015to 420.30 Km^2 in 2019.

Built-up areas, bare/sparse land and water bodies make up less than 4% of the land cover in Gambia. Bare/sparse land has the highest negative percentage increase of -15.20 and this is attributed to climate change and human activities like bush burning, animal rearing and farming practices. Built-up areas are areas with building structures and it had an area of 264.8 Km^2 in 2015 with a percentage of 2.35% but it had a percentage increase of 0.5% to 267.45 Km^2 in 2019 where the percentage increased to 2.38%. There have been more buildings and the opening of new areas like estates, and settlement in

the country. Bare/sparse land reduced in size from 33.71 Km^2 in 2015 with 0.3% to 25.85 Km^2 in 2019 with 0.23%. It had a percentage change of -15.20%. Water bodies include streams, rivers and beaches. The size of the water bodies was 11.24 Km^2 in 2015 which is 0.1% and it increased by 23.68% to 21.35 Km^2 in 2019 which is 0.19%.

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Conflict of Interest Statement
The author declares no conflicts of interest.

About the Author
Dr. Philip Mopnang Ibol was born on May 25, 1976. He hails from Nigeria. He has a Doctorate degree in Geography and Environmental Science (Land Resources Evaluation and Planning), a Master's degree in Environmental Management and a Bachelor's degree in Agricultural Economics and Extension. He has wealth of experience in teaching, banking, consultancy, politics and administration. He is currently a visiting scholar at the University of The Gambia.

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Appendix

Figure 1: Land Cover of Gambia in 2015

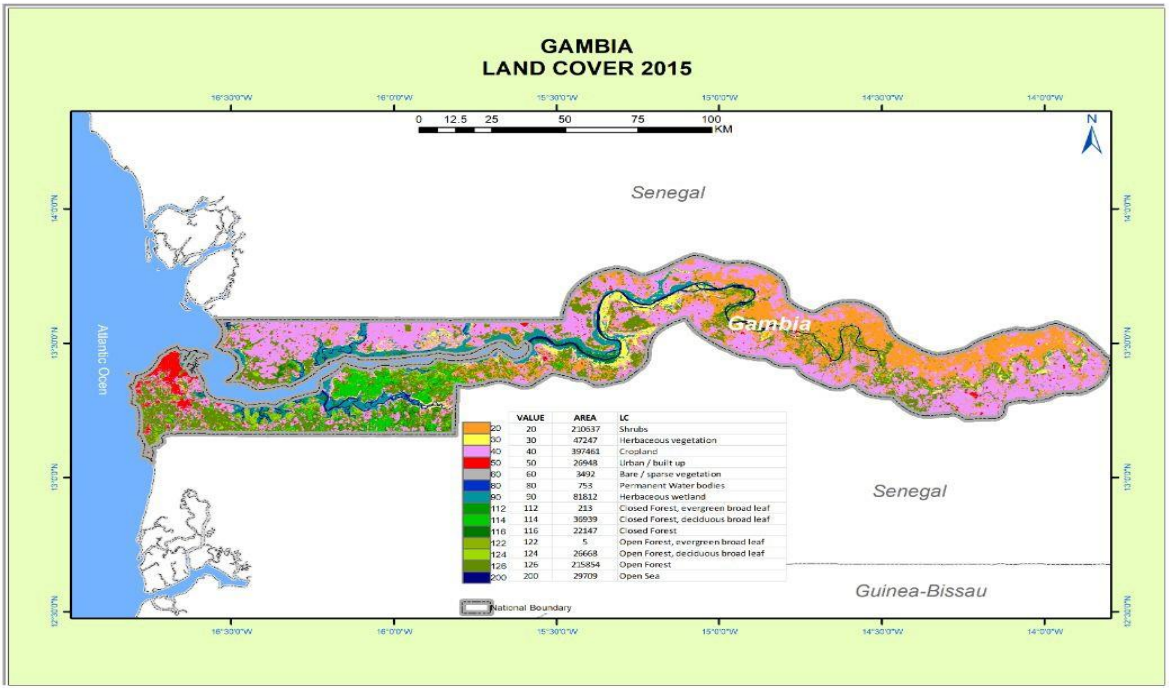

Figure 2: Land Cover of Gambia in 2019

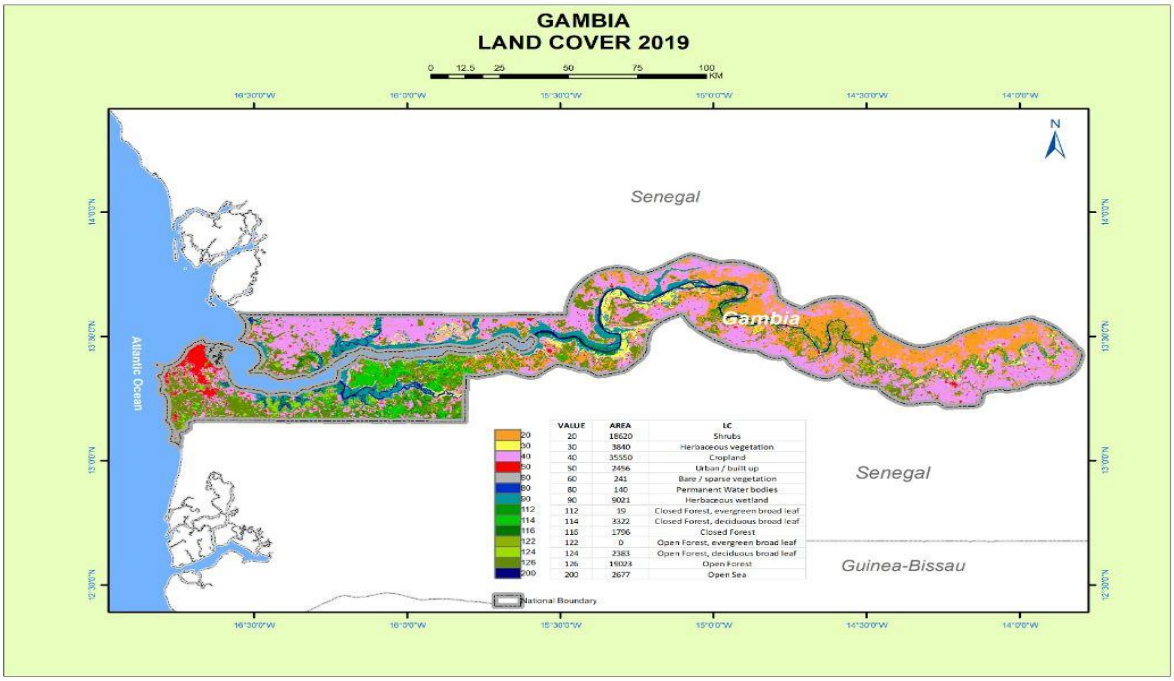

Figure 3: Land Use and Land Cover changes of The Gambia (2015 to 2019)

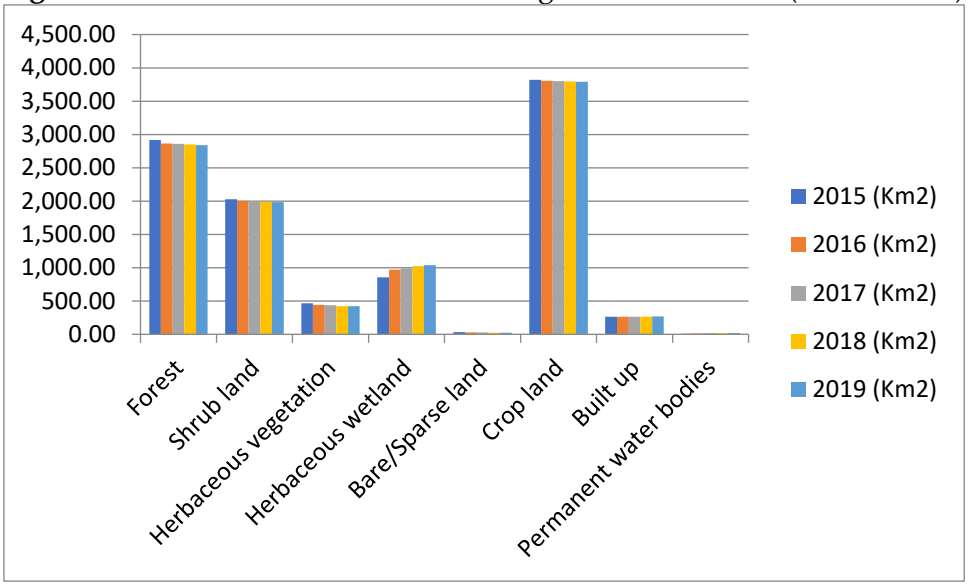

Table 1: Land Use and Land Cover Classification for Gambia

Category	Colour	Class	Sub-Class
01	Green	Forests	Forest Plantation, Degraded/Open Forest
02	Orange	Shrubland	
03	Yellow	Herbaceous vegetation	
04	Blue	Herbaceous wetland	
05	Black	Bare/Sparse vegetation	
06	Purple	Cropland	Crop Land, Plantation, Fallow/Harvested Land
07	Red	Built-up	Urban/Rural Settlement
08	Ash	Permanent water bodies	River/Stream

Table 2: Land use and land cover map for 2015 to 2019

	2015		2016		2017		2018		2019	
LULC CLASS	(Km²)	% Size	(Km²)	% Size	(Km²)	% Size	(Km²)	% Size	(Km²)	% Size
Forest	2,916.26	28.06	2,864.70	27.57	2,860.70	27.53	2,847.71	27.41	2,839.84	27.33
Shrub land	2,027.34	19.51	2,001.49	19.26	1,995.87	19.21	1,989.13	19.14	1,985.75	19.11
Herbaceous vegetation	466.38	4.49	440.53	4.24	436.3	4.20	424.8	4.09	420.3	4.04
Herbaceous wetland	852.96	8.21	969.84	9.33	987.82	9.51	1,021.53	9.83	1,039.52	10.00
Bare / Sparse land	33.71	0.32	28.1	0.27	26.97	0.26	25.85	0.25	25.85	0.25
Crop land	3,819.80	36.76	3,806.31	36.63	3,800.69	36.57	3,796.20	36.53	3,790.58	36.48
Built up	264.8	2.55	264.8	2.55	265.22	2.55	266.33	2.56	267.45	2.57
Permanent water bodies	11.24	0.11	15.73	0.15	17.98	0.17	19.1	0.18	21.35	0.21
	10,392.49	100.00	10,391.50	100.00	10,391.55	100.00	10,390.65	100.00	10,390.64	100.00

Source: Copernicus, 2015, 2016, 2017, 2018, 2019.

Table 3: Change analysis between 2015 and 2019 LULC

LULC	2015		2019		Change	
	Area (Km^2)	**%**	**Area (Km^2)**	**%**	**Area (Km^2)**	**%**
Forest	2,916.26	25.95	2,839.84	25.27	-76.42	-1.35
Shrub land	2,027.34	18.04	1,985.75	17.67	-41.59	-1.05
Herbaceous vegetation	466.38	4.15	420.30	3.74	-46.08	-5.48
Herbaceous wetland	852.96	7.59	1,039.52	9.25	186.56	8.97
Bare / Sparse land	33.71	0.3	25.85	0.23	-7.86	-15.20
Crop land	3,819.80	33.99	3,790.58	33.73	-29.22	-0.39
Built-up area	264.8	2.35	267.45	2.38	2.65	0.5
Water bodies	11.24	0.1	21.35	0.19	10.11	23.68
Total	**11,238**	**100**	**11,238**	**100**		